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BASIC CLINICAL SKILLS

FROM THEORY TO PRACTICE

HIPPOCRATE

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MOTTO: ***„Tell me and I forget.***

Teach me and I remember.

Involve me and I learn.”

Benjamin Franklin

In Memoriam

There are individuals whose mere presence lights up the world of others, and once they disappear from our lives, they leave behind not only memories but also an unforgetable legacy. This book is a homage to all those who passed away and now live on in deeds, teachings and the generous spirit of love they have shown us during their lifetime.

They were parents, teachers, mentors, colleagues – those special people who shaped us, inspired us and gave us the sense of bravery and devotion. Among them, there is Professor Doru Mihai Anastasiu, M.D., PhD, under whose vision and leadership, the Clinical Skills Discipline was created, being one of the essential blocks in the education of tomorrow's physicians within the Faculty of Medicine.

At the same time, this book is also dedicated to the memory of the mathematics teacher Mircea Stoichițoiu, the author’s father, a wonderful educator, who left behind a lot of knowledge and deep morals.

Through this work, we keep their memory alive and honor their contribution, ensuring that what they built and generously shared will never be forgotten.

Contents

Chapter I
Communication with the Patient in Medical Practice

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LIST OF ABBREVIATIONS

AAC – *Augmentative and Alternative Communication*
ATPD – *Acute and Transient Psychotic Disorder*
DM – *Diabetes Mellitus*
DSM-IV – *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition
DSM-V – *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition
FEP – *First Episode Psychosis*
HBV – *Hepatitis B Virus*
HCV – *Hepatitis C Virus*
HIV – *Human Immunodeficiency Virus*
ICD-11 – *International Classification of Diseases, Eleventh Revision*
NICE – *National Institute for Health and Care Excellence*
RIAS – *Roter Interaction Analysis System*
TBC – *Tuberculosis*
VOCA – *Voice Output Communication Aids*
VR-CoDES – *Verona Coding Definitions of Emotional Sequences*
WHO – *World Health Organization*

"Organic pathology does not conform to a standardized model of disease; therefore, the physician must consider the patient's psychological state. In this context, the physician's role extends beyond the alleviation of physical symptoms to include the mitigation of despair and fear, thereby fostering hope in the patient." *(Scripcaru)*

This chapter presents a series of technical considerations intended to support the development of an individualized approach to patient history-taking. Even at an early stage of training, the clinician possesses essential elements for effective patient dialogue, including foundational values acquired through prior experience, empathy derived from personal and social contexts, and a genuine interest in understanding the individual beyond the presenting condition. Communication constitutes a fundamental component of medical practice, encompassing the ability to perceive, interpret, and evaluate information, as well as to respond appropriately to the specific needs of each patient. (1).

During the years of medical training, the acquisition of a comprehensive medical history requires, first and foremost, a systematic evaluation of several key domains. These include the patient's presenting symptoms and the reason for hospitalization; the personal medical history, encompassing chronic conditions (e.g., diabetes mellitus, tuberculosis, bronchial asthma, chronic peripheral ischemia, Crohn's disease), prior surgical interventions, and known allergies (including those to pollen, dust, medication, and mites); the family history, with particular attention to the presence of similar conditions among first-degree relatives (such as neoplasms, hematological disorders, diabetes mellitus, and bronchial asthma); living and occupational conditions, including exposure to toxic environments, social circumstances, and the use of alcohol, tobacco, or psychoactive substances; as well as current and previous therapeutic regimens.

Furthermore, in order to establish correlations between treatment efficacy and potential adverse effects, the clinician adopts an analytical and investigative approach. Each element of the patient's history contributes to clarifying the clinical picture. Particular attention should be directed toward the onset, duration, and characteristics of pain (e.g., sharp, stabbing, constrictive), as well as its radiation to other regions of the body. Nonverbal cues—including body language, gestures, and gait—may also provide valuable diagnostic information.

Subsequently, a systematic clinical examination of the body systems is performed, including the assessment of facial features, weight, height, body habitus, and the musculoskeletal, cardiovascular, respiratory, digestive, urinary, and neurological systems. This examination relies on inspection, palpation, percussion, and auscultation, enabling the clinician to evaluate specific anatomical structures, observe thoracic movements and pulse, and assess respiratory and cardiac sounds using a stethoscope.

Based on the findings, a presumptive diagnosis is formulated, followed by the selection of appropriate clinical and paraclinical investigations aimed at excluding alternative diagnoses and refining diagnostic accuracy. Ultimately, these steps lead to the establishment of a definitive diagnosis. In both clinical practice and academic assessment settings, approximately 15–20 minutes are typically allocated for history-taking and a similar duration for the clinical examination or the review of investigative results, all of which are subsequently presented to the evaluation committee.

Healthcare professionals are capable of establishing and maintaining high-quality therapeutic communication with patients (2), which is associated with improved health outcomes (1). Therapeutic communication is defined as a reciprocal interaction between healthcare providers and patients, aimed at optimizing both emotional and physical well-being (3).

Studies have identified several types of communication in relation to oneself or to others, namely:

- Interpersonal – based on the exchange of ideas, thoughts, feelings, and needs with another person (4);
- Interprofessional – the transmission of information to someone else (5);
- Personal – involves individuals reflecting on themselves and on their communication with others (6).

The reflection of each healthcare professional has led to a better understanding of feelings and moral values, thereby facilitating communication. At the same time, the foundation of effective therapeutic communication lies in the authenticity and honesty of each individual (7). Individual characteristics, personality, and preferences of medical staff can affect their communication skills and may influence the success of the relationship with patients (8,9).

Therefore, healthcare personnel must be able to identify the elements involved in communication with the patient and their role in different situations and contexts (10). Over time, multiple tools, including questionnaires, have been developed to evaluate communication styles and effectiveness in the medical field, alongside instruments designed to assess attitudes and communication skills with patients (11,12,13,14) (for example, the "Four Habits Coding Scheme" – which combines evaluative and descriptive elements of communication behavior) (15). Other tools have focused on person-centered measures, such as the "Verona Coding Definitions of Emotional Sequences (VR-CoDES)" (16) and the "Roter Interaction Analysis System (RIAS)" (17)

Madula et al., in a study on maternal care in Malawi, observed that patients reported feeling happier in situations where nurses and midwives conveyed positive thoughts, empathy, and respect. On the other hand, verbal abuse, lack of respect, and the inability to ask questions negatively affected patients' perceptions of the services provided (18). Therefore, effective doctor–patient communication forms the foundation of high-quality medical practice (19). Individual communication skills can act as a trigger in clinical

practice. All outcomes are the result of achieving the educational objectives of each person (19):

- Training skills (e.g., providing feedback or reflective exercises);
- Communication skills (e.g., communication style).

Dielissen et al. addressed this gap by developing three gender-related criteria that encompass (19):

- Content skills – involving the collection and delivery of information;
- Processing skills – based on verbal and non-verbal communication behaviors sensitive to gender;
- Perception skills – involving the management of emotions and gender-sensitive attitudes.

Furthermore, Sandhu et al. highlighted the influence of gender differences on data obtained from patients (19) regarding:

- Speech content;
- Communication style;
- Non-verbal communication;
- Expression of power and status;
- Consultation duration.

Study results indicated that effective communication can (19):

- Improve patient satisfaction;
- Facilitate recall and understanding of the therapeutic regimen that the patient must follow;
- Promote adherence to treatment, thereby enhancing therapeutic outcomes;
- Reduce the occurrence of symptoms in both the short and long term**.**

Moreover, effective communication can improve satisfaction and well-being in the workplace (19). Early identification of any of the factors below may influence healthcare professional–patient communication and allow for corrective measures (20):

- Professional attitude;
- Interview style;
- Lack of attention or fear;
- Different perspectives, interests, and priorities of the medical staff and the patient;
- The issue of uncertainty;
- Patient suspicion;
- Difficulties related to understanding.

Patient behavior can be influenced by a range of internal and external factors (20). Internal factors (20) include:

- Individual characteristics;
- Personality type;
- Level of understanding;
- Prejudices.
- Religion.

External factors depend on (20):

- Social context;
- Family context;
- Intervention of other healthcare professionals;
- Previous experiences.

A mental disorder is defined as a syndrome characterized by significant difficulties in cognition or in regulating a person's emotions and behaviors, reflecting a dysfunction in psychological, biological, or developmental processes (21). These disorders often affect an individual's ability to function appropriately in social, occupational, or other essential areas of life. A common example of a mental disorder is major depressive disorder, which can profoundly impact mood, behavior, and the ability to function normally in daily life (21).

According to the DSM-V (*Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*), mental disorders may be associated with neurocognitive disorders or with pathophysiological conditions such as cardiac, vascular, pulmonary, renal, diabetic, nutritional, or endocrine disorders, as well as motor dysfunctions (congenital or post-traumatic) (21).

I. Types of patients

I.1. Patient with Cognitive Disorder

Patients with intellectual limitations are individuals who exhibit cognitive or neurocognitive disorders, which are mental health conditions primarily affecting cognitive functions, including learning, memory, perception, and problem-solving (22).

According to DSM-5, six main domains of cognitive functioning are defined (23):

- Executive function – the ability to plan, organize, carry out tasks, and make decisions.
- Learning and memory – the ability to retain and use new information.
- Perceptual-motor function – skills involving perception and motor coordination.
- Language – the ability to comprehend and produce spoken and written language.
- Complex attention – the ability to maintain and divide attention during tasks.
- Social cognition – skills that allow understanding and interpreting social behavior and the emotions of others."

Cognitive impairment can be either congenital or acquired.

Congenital cognitive impairment can be detected during the intrauterine or extrauterine period through screening.

Patients with cognitive disorders are those with genetic alterations, particularly those with associated morpho-functional pathologies. Cognitive disorders include delirium, mild and major neurocognitive disorders (previously known as dementia). They are characterized by acquired cognitive deficits, usually indicating a decline from a previous level of functioning, and may be associated with underlying brain pathology (24)

Characteristics of Types of Neurocognitive Disorders

a) *Delirium* – an acute, short-term disorder marked by confusion and disturbances in consciousness and attention. It can be caused by infections, medications, or other medical conditions (23).
b) *Mild Neurocognitive Disorders* – represent a modest cognitive decline from a previous level of functioning, but do not significantly interfere with daily independence. Patients may have noticeable difficulties with complex cognitive activities but are able to maintain an independent life (23).

c) *Major Neurocognitive Disorders* – characterized by a substantial decline from a previous level of cognitive functioning and significant interference with daily activities. These include various forms of dementia, such as Alzheimer's disease, vascular dementia, frontotemporal dementia, and others (23).

The key to effective and high-quality communication for obtaining information to guide diagnosis and subsequently implement an effective treatment is the accurate identification of the patient's typology and underlying pathology. Therefore, knowledge of the physical and neurocognitive characteristics of the following patients can result in the successful resolution or management of health problems, which can be correlated with the underlying pathology.

Here, we introduce some of the genetic aspects encountered in medical practice to help you develop the skills necessary to identify patient typologies during summer clinical practice:

1. **Young children with 22q11.2 deletion syndrome (22q11DS)** – a genetic disorder most commonly associated with congenital heart anomalies, palatal defects, immune deficiencies, hypocalcemia, developmental delay, learning disabilities, intellectual disability, dysphagia, and mild facial dysmorphisms (25).
2. **Down syndrome or Trisomy 21** – characterized by the partial or complete presence of an extra copy of chromosome 21 (26). Children born with this syndrome display physical features such as a flattened face (particularly at the nasal bridge), upslanting almond-shaped eyes, short neck, small ears, hands, fingers, and feet, a single palmar crease, hypotonia, joint laxity, short stature, congenital heart defects, hearing loss, and obstructive sleep apnea (26).
3. **Trisomy 18 or Edwards syndrome** – newborns with three copies of chromosome 18, identifiable by intellectual disability, low birth weight, and various congenital anomalies including severe microcephaly, heart defects, prominent occiput, malformed low-set ears, and a characteristic "pinched" facial appearance (27).
4. **Autism spectrum disorder** – characterized by persistent deficits in social communication and interaction, alongside restrictive and repetitive patterns of behavior (29). Diagnosis of this disorder requires the assessment of both deficits in social communication and repetitive behaviors (29)

In the interview with a patient with autism, it is recommended to record individual clinical characteristics using certain specifiers (with or without associated intellectual disability; with or without associated structural language disorders; associated with a known medical/genetic or environmental/acquired condition; associated with another neurodevelopmental, mental, or behavioral disorder), as well as specifiers that describe autistic symptoms (age at which first concerns appear – between 12 and 24 months after birth (28); with or without loss of previously acquired skills; severity) (29). These specifiers allow clinicians to individualize the diagnosis and provide a richer clinical description of affected individuals (29).

5. Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by significant difficulties in attention, disorganization, and/or hyperactivity–impulsivity (34). Symptoms of inattention, disorganization, and hyperactivity–impulsivity can impact daily functioning, particularly in educational or occupational settings (34).

In childhood, ADHD is often associated with other behavioral disorders, such as oppositional defiant disorder and conduct disorder. These comorbidities can complicate the diagnosis and management of ADHD (34).

For patients presenting with memory, cognitive, or literacy difficulties, the initiation of each medical history should include an assessment of the patient's level of understanding (29–32). Additionally, discussing the patient's recent activities, preferences, and foods that have triggered symptoms yields two key outcomes. First, it contributes to building a relationship and gaining a deeper understanding of the patient while evaluating their level of comprehension. Second, identifying the patient's vocabulary, clarity of expression, and communication methods can provide valuable diagnostic clues (29–32).

During the interview, it is important to note and observe whether the patient has sensory medical difficulties that may influence communication with the physician (hearing or vision loss, chronic pain, fatigue) and any expressions of frustration that may accompany them (29,32). Identifying these factors allows the physician to adapt their communication style to the patient's typology without speaking 'on behalf' of the patient, which could generate feelings of patronization, confusion, or the use of excessive jargon (29,32).

Obtaining consent from these patients for medication administration or clinical and paraclinical investigations can only be considered legally valid after assessing their mental health status and correlating it with their history

to identify potential cognitive or memory impairments (33). Otherwise, it is recommended to maintain continuous contact with the caregiver at home or a family member, who should be informed and provide signed consent on behalf of the patient (33).

Below are some practical recommendations to facilitate effective communication with your patients who have memory problems (29):

- Recognize the tendency to categorize patients with these deficits and reflect on your own biases.
- Assess your patient's level of understanding and try to adapt your vocabulary and sentence structure to match that used by the patient.
- Arrange the consultation space in a way that is conducive to communication.
- Allow extra time for visits whenever possible.
- Minimize background noise, stay close, speak clearly, and ensure proper lighting.
- If a social worker accompanies the patient, ask the patient for permission to have them present in the consultation room and for how long they wish them to stay (33).
- Their presence can be helpful during the medical history interview, both for identifying issues and later in planning the treatment regimen, if the patient wishes the caregiver to be present. Consent to speak with the companion should be obtained in writing for future consultations (33).
- Address the patient directly first and support them in decision-making, then discuss with the caregiver.
- Ask open-ended questions and allow sufficient time for responses.
- Pay attention to the complaints reported by the patient and treat these as the most significant issues, as the patient wants them to be addressed (33).
- Verify the information conveyed to the patient during the conversation and summarize your understanding of what the patient has communicated.
- Acknowledge and reinforce the patient's strengths, goals, benefits, and adherence**.**
- Present the patient's health status as realistically as possible.
- Use humor when appropriate**.** It can be an effective tool for engagement and diagnosis and is one of the first genuine human attributes. Exercise caution if the patient is from a non-Western culture or is confused (33).

- Treatment options require concrete discussion. Written instructions and simple handouts are also helpful.
- Collaborate with the family doctor, other healthcare providers, psychiatrist, patient's family, psychologist, etc**.,** and establish regular, specific team communication methods to avoid confusion regarding instructions and recommendations (33)

In patient communication, non-verbal language is also important, both from the physician and the patient, as it may reveal certain pathologies.

Patients with neurodevelopmental motor disorders, such as developmental coordination disorder, stereotypic movement disorder, and tic disorders, have conditions that affect control and coordination of movement (29).

Developmental coordination disorder manifests as difficulties in acquiring and executing coordinated motor skills, which can impact performance in daily activities (29). In contrast, stereotypic movement disorder is characterized by repetitive, seemingly purposeless motor behaviors that can affect the individual's social and academic interactions (29).

Tic disorders involve the presence of motor or vocal tics, which are sudden, recurrent, non-rhythmic movements or sounds, depending on the duration and clinical presentation of the tics (29). For example, Tourette's disorder is diagnosed when an individual exhibits multiple motor and vocal tics for at least one year, with symptoms fluctuating in severity over time (29). It is important to identify and manage these neurodevelopmental motor disorders in an individualized manner to support the affected person and improve their quality of life (29).

I.2. Patient with Substance Use Disorder

According to the National Anti-Drug Agency, in 2022, 10.7% of individuals aged 15 to 64 in Romania reported having experimented with at least one illicit drug during their lifetime, and 6% were users in the past year (30). Due to the vulnerability of young people aged 15–34, the use of illicit and psychoactive substances is higher in this age group (30).

Regarding the transmission of infectious diseases related to injectable drug use in the last 30 days, it was reported that 20.9% of individuals admitted to treatment declared being HIV positive, 68.7% were HCV positive, and 7.6% were HBV positive (30).

According to the DSM-5 (*Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*), substance-related disorders result from the use of ten separate classes of psychoactive substances (31). These classes include: alcohol, caffeine, cannabis, hallucinogens, inhalants, opioids, sedatives/ hypnotics/anxiolytics, cocaine, other stimulants, tobacco, and newly

introduced substances of abuse. It is important that assessments and diagnoses are based on the criteria established for each substance class to provide appropriate treatment for patients.

The DSM-5 also allows clinicians to classify the severity of psychoactive substance use (31):

- Mild: 2 or 3 symptoms – mild substance use disorder;
- Moderate: 4 or 5 symptoms – moderate substance use disorder;
- Severe: ≥6 symptoms – severe substance use disorder.

Communication with this type of patient requires consideration of multiple organ system dysfunctions and comorbidities, which may increase with age.

Here are some practical recommendations to consider when constructing a dialogue with the patient (32):

- Discuss openly and honestly with the patient as well as their accompanying persons to agree on a management and discharge plan with clear and achievable objectives.
- Assess the degree of pain and develop strategies to ensure effective analgesia and prevention of withdrawal syndrome.
- Anticipate symptom treatment and behavioral changes that could lead to abandonment of the initial plan.
- Specify safe analgesia administration procedures that minimize the risk of treatment discontinuation.
- Use regional analgesics when indicated, although this may be challenging in immunocompromised patients or those with local/systemic sepsis from injections.
- Ask the patient whether they have an active dependence (currently using the medication/substance) or a controlled dependence (under a clinically supervised replacement/maintenance or abstinence program) at the time of the conversation.
- Speak consistently in a calm, nonjudgmental, and empathetic tone to obtain a complete medical history and encourage adherence to the proposed treatment both in the healthcare facility and after discharge.
- Identify whether a support group, caregiver, or access to a detoxification center is available**.**

I.3. Patient with Personality Disorder

The prevalence of personality disorders in the general population is estimated at 10 to 13% (33). Within primary care settings, this percentage can rise to 20–30%. Treating individuals with medical and psychiatric conditions, particularly those with associated comorbidities and personality disorders, can be more complex. Studies have shown less effective treatment outcomes

in individuals with poorer health, more frequent use of healthcare services, and higher associated costs for these cases (33).

Patients with personality disorders may be perceived as "difficult" in their interactions with physicians. Comorbidities can significantly influence treatment management and the physician–patient relationship. An integrated and personalized approach to these cases is essential to improve treatment outcomes and the quality of life of these individuals (33).

The *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) describes personality types based on their most prominent characteristics, as outlined below (33):

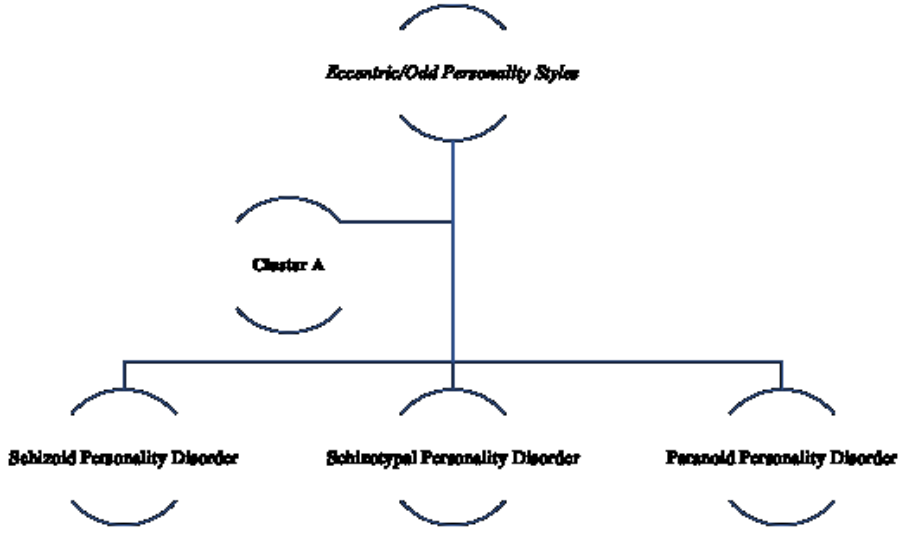

Figure 1. Personality types based on the most prominent characteristics of Cluster A, according to the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (DSM-IV)

Characterization of eccentric/odd personality styles in Cluster A (37):	
Schizoid personality disorder	• detachment from social relationships.
Schizotypal personality disorder	•social and interpersonal deficits; •cognitive or perceptual distortions and eccentricities; •restricted range of emotional expression.
Paranoid personality disorder	•pervasive pattern of distrust and suspiciousness; •begins in early adulthood; •present in a variety of contexts.

Table 1. Personality types based on the most prominent characteristics of Cluster A, according to the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (DSM-IV).

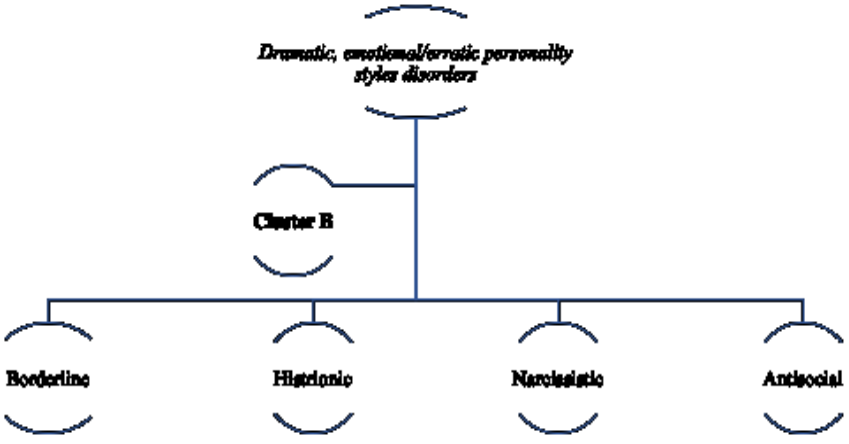

Figure 2. Personality types based on the most prominent characteristics of Cluster B, according to the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (DSM-IV).

Characterization of dramatic, emotional/erratic personality styles in Cluster B (37):	
Borderline	•instability of interpersonal relationships, self-image, and affects; •marked impulsivity.
Histrionic	•excessive emotionality; •attention-seeking behavior.
Narcissistic	•grandiosity; • need for admiration.
Antisocial	•disregard for the rights of others; •violation of the rights of others; • lack of remorse for wrongful acts; • lack of empathy.

Table 2. Personality types based on the most prominent characteristics of Cluster B, according to the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (DSM-IV).

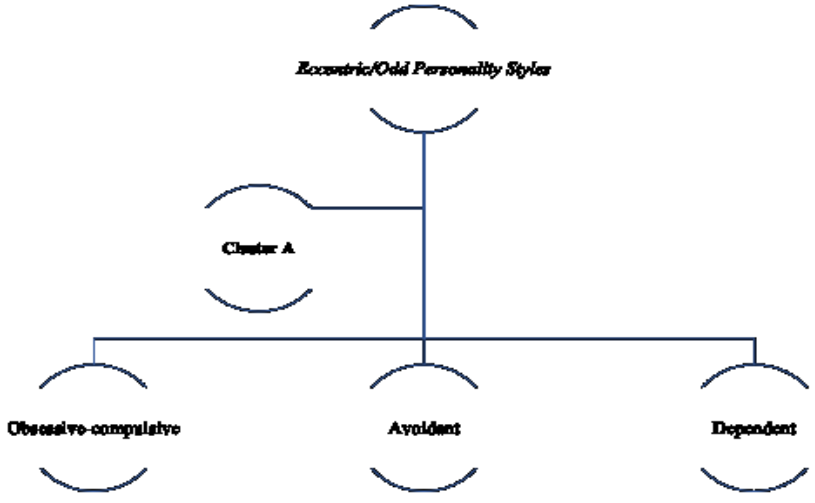

Figure 3. Personality types based on the most prominent characteristics of Cluster C, according to the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (DSM-IV).

Characterization of anxious/fearful personality styles in Cluster C (37):	
Obsessive-compulsive	•preoccupation with order and perfectionism; •mental and interpersonal control.
Avoidant	•social inhibition; •feelings of inadequacy; •hypersensitivity to criticism.
Dependent	•excessive need to be taken care of; •submissive behavior; •fear of separation.

Table 3. Personality types based on the most prominent characteristics of Cluster C, according to the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (DSM-IV).

Management of Patients in Cluster A (33):

Schizoid Personality Disorder:

- Maintain a professional stance.
- Provide clear explanations.
- Tolerate the patient's unusual beliefs and behaviors.
- Avoid becoming overly involved in the patient's personal and social issues.

Schizotypal Personality Disorder:

- Maintain a professional stance.
- Provide clear explanations.
- Avoid becoming overly involved in the patient's personal and social issues.

Paranoid Personality Disorder:

- Maintain a professional stance.
- Provide clear explanations.
- Empathize with the patient's fears.
- Avoid directly challenging paranoid thoughts.

Management of Patients in Cluster B (33):

Borderline Personality Disorder:

- Avoid excessive familiarity.
- Schedule regular visits.
- Provide clear, non-technical explanations.
- Tolerate outbursts of anger, but set limits.
- Maintain awareness of your own feelings.
- Consult a psychiatrist.

Histrionic Personality Disorder:

- Avoid excessive familiarity.
- Show professional concern for the patient's emotions.
- Emphasize objective issues.

Narcissistic Personality Disorder:

- Validate the patient's concerns.
- Provide attentive and concrete answers to questions (33).
- Channel the patient's skills to help cope with their illness.

Antisocial Personality Disorder:

- Carefully investigate the patient's concerns and motives.
- Communicate clearly.
- Establish clear boundaries

Management of Patients in Cluster C (33):

Obsessive-Compulsive Personality Disorder:

- Complete a thorough history and examinations.
- Provide detailed explanations.
- Avoid emphasizing uncertainty excessively.
- Encourage patient participation in treatment.

Dependent Personality Disorder:

- Reassure the patient that everything is under control.
- Schedule regular follow-up visits.
- Explain realistically your availability and schedule.
- Involve others to support the patient.
- Avoid rejecting the patient.

Avoidant Personality Disorder:

- Provide the patient with a sense of safety.
- Validate the patient's concerns.
- Encourage the patient to communicate all symptoms and worries.

I.4. Patient with Psychosis

It is important to recognize that psychotic disorders can be induced by various conditions (34). In substance or medication-induced psychotic disorder, psychotic symptoms are caused by the use of a drug, medication, or exposure to toxic substances. These psychotic symptoms usually resolve once the causative agent is eliminated from the body (34).

On the other hand, in psychotic disorder due to another medical condition, psychotic symptoms are considered a direct consequence of the underlying medical condition, rather than substance use or medications. It is essential to correctly identify the source of psychotic symptoms to provide appropriate treatment and properly manage psychotic disorders associated with other medical conditions (34).

In psychopathology, there are five main domains that define psychotic disorders: level of psychosis, symptom frequency, duration of psychosis, symptom severity, and impact on the individual's functioning (34).

The level of psychosis, the number of symptoms, and their duration are important gradients used to distinguish and differentiate between various psychotic disorders. These characteristics assist in the correct classification and diagnosis of patients presenting with psychotic symptoms, contributing to the establishment of effective and individualized treatment plans tailored to each case (34).

According to the ICD-11 (International Classification of Diseases, 11th Revision) and WHO 2019 [World Health Organization], diagnostic categories of psychosis include: schizophrenia, schizoaffective disorder, schizotypal disorder, acute and transient psychotic disorder, and delusional disorder (35).

I.4.1. Schizophrenia

Patients present with multiple disturbances in (35):

- Thought: delusions, disorganized thinking.
- Perception: hallucinations.
- Self-experience: the feeling that one's thoughts or behaviors are controlled by an external force.
- Cognition: impaired attention.
- Volition**:** loss of motivation.
- Affect: blunted or restricted emotional expression.
- Behavior: bizarre behavior.

These symptoms must be present for at least one month (35).

I.4.2. Schizoaffective Disorder

An episodic disorder in which the diagnostic criteria for schizophrenia and a depressive episode-mixed, moderate, or severe- are met within the same episode of illness (35)

I.4.3. Schizotypal disorder

The patient exhibits symptomatology for at least several years, including eccentricities in behavior, appearance, and speech, accompanied by cognitive and perceptual distortions, unusual beliefs, and discomfort in interpersonal relationships (35).

I.4.4. Acute and Transient Psychotic Disorder (ATPD)

The acute onset of psychotic symptoms occurs without a prodrome and reaches maximum severity within two weeks (35). A set of related delusions develops and persists for at least three months (often much longer). These occur in the absence of a depressive, manic, or mixed mood episode, and other symptoms characteristic of schizophrenia are absent (35).

I.4.5. Delusional disorder

Develops a set of related delusions that persist for at least three months (often much longer). These occur in the absence of a depressive, manic, or mixed mood episode, and other symptoms characteristic of schizophrenia are absent (35).

I.5. Patient with Disorganized Thinking (Speech)

Disorganized thinking is a feature of formal thought disorders and is primarily observed in a person's speech. It manifests as a rapid shift from one topic to another (derailment or loose associations) and responses to questions that may be tangential or entirely unrelated (tangentiality) (36).

In rare cases, speech may become so disorganized that it is nearly incomprehensible, resembling receptive aphasia due to its incoherence ("word salad") (36). To be considered a significant symptom, the level of disorganization must substantially impair the individual's ability to communicate effectively (36).

It is important to carefully assess the severity of this deficit, particularly when the evaluation is performed by professionals from linguistic backgrounds different from that of the patient. Milder but disorganized speech may occur during certain phases of schizophrenia, such as the prodromal or residual stages (36).

Correct diagnosis and management of disorganized thinking require a detailed assessment and understanding of the specific context of the individual to provide appropriate support and treatment (37). A comprehensive approach to psychosis diagnosis should include three components: the individual profile, the dimensional profile, and the categorical description (37).

- **The individual profile** examines factors that influenced the onset, challenge, and maintenance of the psychotic episode, identifying relevant protective and vulnerability characteristics for the patient (37).
- **The dimensional profile** focuses on the extent to which certain symptoms are present.
- **The categorical description** determines whether the symptoms meet the criteria for a specific psychiatric disorder according to DSM–5 (37).

Integrating these components into a personalized diagnosis is crucial for delivering effective treatment. Involving the patient in drafting a letter to the primary care physician is recommended to ensure clear communication and a treatment plan that considers the individual's needs and preferences (37).

Communicating the diagnosis in psychotic disorders can be challenging due to factors such as disease stage and progression, behavioral criteria in the absence of confirmatory tests, cultural biases, and diagnostic labels such as "schizophrenia" (37). Clinicians have identified barriers including diagnostic uncertainty, stigma, and variability in outcomes (37). For this reason, some prefer using the terms **"psychosis"** or **"FEP" (first-episode psychosis)** (37).

Due to the fact that cognitive deficits, impaired metacognition, and altered perspectives can affect communication and interpretation of information, delivering information about FEP differs fundamentally from other severe disorders. It is essential to adapt communication and provide personalized support to facilitate understanding and management of the FEP diagnosis (37).

When communicating the diagnosis to a patient with psychosis, consider the following (37):

- Inform the patient about the diagnosis and treatment options.
- Discuss the patient's reaction to the FEP diagnosis.
- Prepare a written letter to the primary care physician with clear guidance on treatment and patient management.
- Allow the patient time to rest, especially after the acute phase, to provide requested information.
- Guide caregivers to use motivational interviews to encourage patients to discuss their diagnosis and treatment.
- Conduct a structured interview using open-ended questions, for example:
    (a) "Can you tell me a little about who you are?"
    (b) "Why do you think you are being treated here?"
    (c) "What have you been told about the reason you are receiving treatment?"
    (d) "How did you come to know this?"
    (e) "Was the information provided sufficient, too little, or too much?"
    (f) "What are your thoughts about the timing of this conversation regarding your diagnosis?" (37)

I.6. Patient with Neurotic Disorders

Neuroticism can be defined by specific elements, and the way these elements are interconnected and influence emotional reactions highlights the complexity of this aspect of personality (38). Individuals with high levels of neuroticism face challenges related to self-criticism and sensitivity to external criticism, reflecting significant emotional vulnerability (38).

Studies on neuroticism provide a better understanding of how this trait influences individual reactions and perceptions in various contexts, contributing to a deeper exploration of human diversity and how personality shapes emotional responses (38).

Neuroticism is associated with many mental disorders (somatoform disorders, eating disorders, schizophrenia, and substance-related disorders) as

well as physical health problems that are not defined by symptoms overlapping with elements of neuroticism.

The link between neuroticism and various conditions highlights the complexity and profound impact that this personality trait can have on an individual's mental and physical health (38).

Management of the neurotic patient involves practicing six modules that promote the development of a more adaptive attitude toward emotional experiences (39):

1. Psychoeducation – Patients learn about the adaptive and functional nature of emotions, recognizing them as valuable sources of information and avoiding the tendency to reject them (39).
2. Mindfulness training – Patients are guided to engage consciously with their emotions, replacing avoidance with an approach of acceptance and non-judgmental observation (39).
3. Cognitive flexibility – The ability to evaluate emotional situations from different perspectives and to question initial interpretations (39). This is essential in managing emotions and reactions, as it allows individuals not to get stuck in rigid or negative thought patterns (40). For example, they may ask themselves: *"What can I learn from this feedback? Is this an objective or subjective point of view?"* This re-evaluation process helps them remain open to constructive feedback and focus on improvement rather than falling into discouragement (40).
4. Counteracting emotional behaviors – Helps patients identify and counteract avoidance behaviors that prevent them from fully confronting intense emotions (39).
5. Interoceptive exercises – Techniques, often used in cognitive-behavioral therapy, that help individuals become more aware of the bodily sensations and physiological responses associated with their emotions. An example of an interoceptive exercise is controlled hyperventilation, which can be performed by breathing through a thin straw (39).
6. Emotion exposure – Patients engage in a series of activities that elicit strong or uncomfortable emotions. Through this practice, patients' avoidance responses gradually extinguish, facilitating new learning that emotions are temporary and tolerable (39).

Furthermore, in the case of neurotic parents, participation in parenting training programs can be suggested to minimize the amplification of the child's biological tendencies through environmental interactions. Such programs include psychoeducation about the nature of anxiety, traditional

cognitive-behavioral strategies (i.e., exposure and cognitive restructuring) aimed at personal concerns, and training in behavioral management techniques that prevent an overprotective parenting style (38).General Approaches to the Different Patient Typologies Mentioned Above (20):

- Courteous and respectful manner;
- Listening with great interest;
- Respecting the patient's own way of solving problems;
- Providing feedback for change in a manner that offers the patient the possibility to choose or to increase self-confidence;
- Addressing regretful behavior;
- Offering the patient an indirect decision regarding continuation of treatment;
- Highlighting positive aspects and avoiding mention of failures;
- Listening to the patient's instinct for self-preservation.

In the study conducted by Kristen Adams et al., it was found that in two of the three groups, the manner and style of response of the healthcare staff immediately influenced communication and subsequent patterns associated with it, regardless of whether the approach- direct or indirect- was used in communicating with the patient (41).

All responses fell into one of three categories: focused on rejecting the emotion, focusing the discussion on the emotion, or were neutral (41).

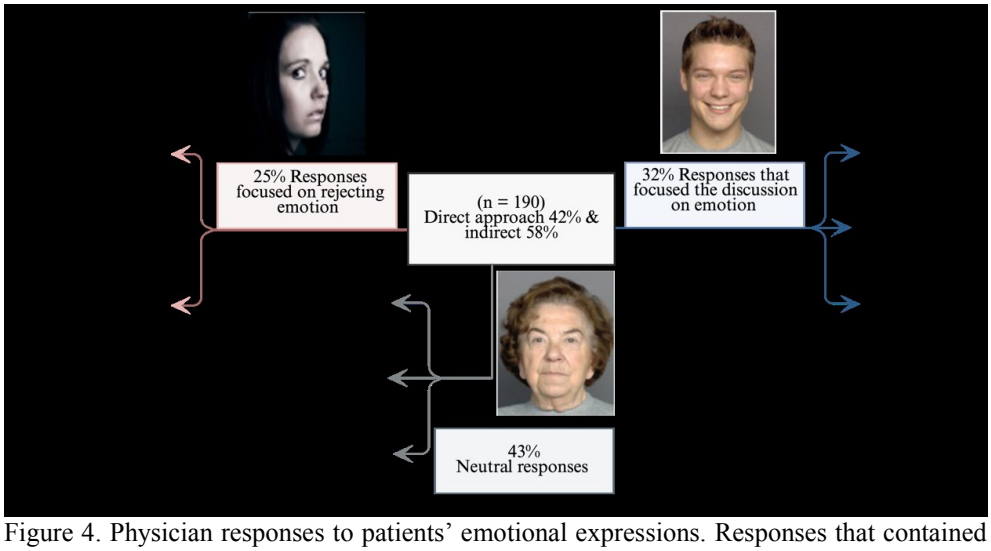

Figure 4. Physician responses to patients' emotional expressions. Responses that contained multiple categories were classified according to the final response (41,42). Figure created in BioRender. Oana, R. (2026) https://BioRender.com/dgthix9

Expressions containing statements that focused the discussion away from emotions are based on (41):

- Clinical explanations for the patient's suffering;
- Attempts to address the source of suffering or justifications for why the problem occurred.

Example: After the general practitioner informed the patient that a lesion had been found on the CT scan, the patient expressed sadness: *"Well, that's kind of sad news, but what's new, too… Anyways, we'll just have to follow up whatever it is. Is this treatable at all or is it a real"* (41).

The physician provided information to address the patient's question regarding treatment, but did not acknowledge or explore the patient's sadness: *"Not to get too far ahead of ourselves because, as you've said … we can't say anything definitively… but if it is kidney cancer – based on the tests we have now — it's just in the kidney and so that is treatable"* (41).

Effect (41):

- The patient did not express sadness again and shifted the conversation to their urologist;
- Physician distancing from the patient;
- Creation of an antagonistic doctor–patient relationship.

Neutral responses did not focus either on emotions or away from them and were based on statements (41):

- Include one-word responses (e.g., "right," "okay," or "absolutely");
- Responses in which the physician restated or clarified the patient's words without specific reference to the emotional content.

Effect (41):

- Neutral statements allow the patient to direct further conversation or continue emotional discussions;
- Support the patient's perspective and encourage them;
- Facilitate understanding of the patient's social and spiritual support;
- Clarify therapeutic goals.

Examples of neutral responses:

PATIENT: **"**Of course not knowing this and all of the sudden you have it, it's a shock" (41).

PHYSICIAN: "Yeah."

PATIENT: "It's like a shock and I don't want to be labeled, you know, you have this…" (41).

Responses that focused the discussion on emotion, based on statements (41):

- Empathic responses, in which the physician attempted to name, understand, or explore the emotion;
- Responses that demonstrated respect, support, and empathy.

Example: "I'm sorry," expressing regret for the patient's suffering.

***Effect** (46):*

- Patients usually responded to statements with further discussion about their emotions;
- Provision of emotional support;
- Achievement of physician–patient agreement;
- Increased patient confidence in the treatment

I.7. Patient with a Language Disorder

Language disorders can be observed in both young children and older adults. Dysarthria refers to a group of motor speech disorders resulting from a deficit in neuromuscular control, which affects breathing, phonation, resonance, articulation, prosody (44). It is caused by impairment of the central or peripheral nervous system. Patients may present developmental disorders due to brain lesions occurring before or during birth, as well as acquired disorders later in life, such as stroke, head injuries, progressive neurological diseases (44).

Communication with these patients is difficult due to abnormal, unintelligible speech and the presence of dysphonia. Based on the symptoms reported by the patient during the medical history, one can often infer the type of neuronal lesion present. A weak voice may suggest involvement of the lower motor neurons, while a strained, strangled voice could indicate possible involvement of the upper motor neurons (44).

Patients with this profile are often subject to ridicule and may experience changes in self-identity, relationships, social and emotional disruptions, and feelings of stigma or perceived stigmatization (44).

In the case of children, the absence of an effective communication method can lead to frustration, which may trigger emotional distress and maladaptive behaviors (44).

During the discussion with the patient, it is recommended to (44):

- Limit background noise (turn off potentially distracting electronic devices) and conduct the medical history without other people present**;**
- Enhance speech with facial expressions and gestures**;**

- Use intra-oral devices that can support and stimulate the soft palate to reduce hypernasality, as well as biofeedback devices to provide precise feedback;
- Utilize any Augmentative and Alternative Communication (AAC) methods**:** from "low-tech" options such as sign systems, drawing and writing, or communication boards, to "high-tech" tools like computerized speech-output communication aids (VOCA).

The creation of a medical opinion can also be facilitated by communicating with caregivers and extracting information from existing medical documents**.**

I.8. Patient with Hearing Impairment

Patients with hearing impairments can be children, adolescents, or adults. The medical condition affecting the patient's hearing may be already known to them or may only be identified during the consultation through careful history-taking.

A primary clue is the type of response given when the physician speaks in a moderate-tone voice. In clinical practice, patients with hearing impairments often respond with a follow-up question or statement, such as "What?","Pardon?", "Excuse me?", "I can't hear you well!", "Please speak louder, I can't hear you!"

Alternatively, they may signal the hearing difficulty directly, for example"I didn't understand you! Could you repeat that?"

In some cases, the patient may not respond at all to the question, indicating the presence of a hearing deficit.

In cases where the patient is known to have a hearing impairment, it is important to identify the level of use, functional ability, and whether the impairment affects one ear (unilateral) or both ears (bilateral) (45).

In communication with the patient, the clinician's interpersonal skills—such as attentive listening, clear expression, and a caring, empathetic manner—have been shown to act as triggers for patient-centered care and for establishing an optimal therapeutic relationship (46).

The emotional reactions of the patient resulting from interactions with the clinician can have a significant impact on auditory rehabilitation and on improving the patient's quality of life (46).

Patients with hearing impairments often experience sadness, disappointment, anxiety, and worry**,** and older adults may perceive themselves as elderly and helpless (46).

A study conducted by Katie Ekberg et al**.** observed that audiologists' responses tended to focus on the overall discussion of hearing aids, rather than

on the patients' expressed psychosocial needs**,** with 51% of patients reporting concerns regarding the devices they used (46).

A study conducted by Poost-Foroosh et al. identified eight key factors that influence a patient's decision to purchase hearing aids following clinician–patient interactions (46):

- Patient comfort**;**
- Understanding and providing hearing aids according to the patient's needs**;**
- Patient-centered traits and actions**;**
- Recognition of the patient as an individual**;**
- Avoidance of undue pressure**;**
- Presentation of device information by the clinician**;**
- Support for choices and shared decision-making**;**
- Patient preparation**.**

Therefore, regardless of the examiner's specialty, the clinician's behavioral conduct should include: a quiet environment without background noise (TV, radio, phone, or conversations between others), avoidance of speaking in overly low or high pitch throughout the conversation, and clear speech that is understandable to the patient (46).

For children under 18 years, the examiner should be friendly and polite, attempting to engage them in conversation along with their legal guardian to obtain a complete anamnesis, in accordance with standard confidentiality rules.

Regarding actual audiological functioning in children, it may not always correlate with the decibel levels at which they hear (47). Some children with hearing difficulties can function very well with spoken language at 80 dB, while others with the same pathology, but with sound recorded at 30–40 dB, may experience significant communication barriers. Knowledge of decibel levels can serve as a guideline, similar to the use of traditional hearing aids or cochlear implants (47).

In communication with pediatric patients, it is essential to determine whether the cochlear implant is turned off and the child cannot hear (47).

It is important to know the age at which the child was diagnosed with hearing loss, as this may indicate their level of literacy and the written character constructs they have memorized through prior reading. For this reason, transcription of medical information by the parents or the child during the consultation may be ineffective (47).

If the spoken language is sign language, a sign language interpreter or a speech-to-text interpreter should be present during the consultation, especially if the auditory pathology developed at older ages, after the child had already acquired normal literacy skills (47).

Communication with hearing-impaired patients can also be challenging during physical examination because the prevalence of sexual abuse is two to three times higher among these children compared to children without hearing loss (47). It is recommended that, for young children, information about upcoming medical procedures are presented even if they do not fully understand whether the experience will be pleasant or unpleasant; they will perceive that "something is going to happen" to them (47).

General Recommendations:

- Discuss with the patient the preferred method of communication and ways to improve it.
- Be aware of cultural and communication barriers.
- Ensure that the patient can reach the hospital in case of emergencies.
- Obtain consent from both the child and the parent.
- Immediately after surgical interventions, replace the hearing device.
- Offer the possibility to schedule appointments or request prescriptions via email.
- Double the consultation time to ensure the patient has enough time to provide all useful information.
- Establish with the patient whether an interpreter can be present during the physical examination.

I.9. The Silent Patient

In medical practice, there are situations that require invasive procedures (such as tracheostomy) to ensure mechanical ventilation in patients with acute respiratory failure, but these interventions often result in the loss of voice and the ability to communicate with family members and clinicians (48). The inability or difficulty to speak is the most common symptom of distress, leading to the development of anxiety, panic, and stress, experienced both by the patient and by physicians and auxiliary staff (48).

These short- and long-term symptoms can contribute to delirium, negatively impacting the patient's physical and mental health and increasing hospitalization costs. Solutions to this medical challenge are grouped under the term "augmentative and alternative communication (AAC) strategies" (48).

These are divided into (48):

- Low-tech: diagrams with points or handwritten notes using pencil and paper.
- High-tech: devices and applications that facilitate communication through portable software (text-to-speech programs, eye-tracking commands, or visual speech recognition).

I.10. Patient with Dental Problems

Communication between the Dentist and the Patient creates an effective communication between the dentist and the patient is essential for delivering personalized care (49). Social status influences emotions such as shame, trust, anxiety, and communication, with these factors often being directly proportional to socio-economic position (49).

Building a strong dentist–patient relationship relies on understanding the patient's values, beliefs, and circumstances, which in turn shape their expectations, needs, and willingness to access dental care (50).

The NICE (National Institute for Health and Care Excellence) 2021 guidelines focus on the following aspects (50):

- Developing an understanding of the patient as an individual, identifying how their condition affects them personally, as well as the circumstances and experiences that may influence their health and treatment;
- Investigating physical, learning, visual, speech, and hearing dysfunctions, as these can affect the patient's level of participation in the consultation;
- Considering living conditions, social and work environment, and prior experiences with healthcare services;
- Assessing their health status and/or any limitations in accessing healthcare services;
- Evaluating the patient's ability to manage their own care, including decision-making regarding self-management and lifestyle choices.

It is essential that healthcare professionals remain attentive and responsive to patients' beliefs, concerns, and health-related needs (50). Open and empathetic communication can strengthen the doctor–patient relationship and improve patient engagement in managing their own health. Through active listening and a sensitive approach to the patient's needs and concerns, the treatment process and outcomes can be optimized (50). Respect the patient's perspective and provide support, if requested, to help identify healthcare services that facilitate self-management of health (50).

It is of critical importance for healthcare providers to avoid making assumptions or judgments based on the patient's appearance or personal characteristics. This is important for maintaining a professional and respectful relationship with the patient, grounded in their individual needs and experiences (50).

Open communication and the provision of holistic support are fundamental to patient care. Referring patients to specialized resources and services across various domains can significantly contribute to improving

their health and quality of life. By periodically reassessing the patient's needs and circumstances, continuous and appropriate support can be ensured throughout the treatment and recovery process (50).

I.11. The Oncologic Patient

One of the most difficult and emotionally challenging tasks for a physician is to communicate a less favorable prognosis to a patient. Emotional involvement is a trigger that can influence the comfort and well-being of the treated patient

It is important for the physician to approach this discussion with empathy and compassion, to provide the information clearly, and to ensure that the patient understands the meaning and consequences of the prognosis (51). It is also essential for the physician to be honest and to offer support and encouragement to the patient during these difficult moments.

In addition, it is important to give the patient time to process this information and to discuss possible treatment options or palliative care (51).

The study conducted by Hagerty RG et al. showed that patients want physicians to be able to openly discuss palliative care, dying, and death. This would give patients the opportunity to express their wishes and needs regarding end-of-life care, while physicians could provide emotional support and useful information to help them plan ahead.

Through understanding and openly accepting these sensitive aspects, patients may feel less alone and better prepared for what lies ahead (52). This can lead to an improvement in the quality of care and in communication between physicians and patients, contributing to a more humane and empathetic experience at the end of life. It is important that discussions are patient-centered and that the patient's wishes and values are taken into account when making decisions related to palliative care (52).

In some cases, the patient or their family may feel that discussing palliative care takes away any chance of cure or improvement in health status. This can create a barrier between the physician and the patient or the physician and the family, as they may perceive discussions about palliative care as meaningless or even as giving up on treatment (52).

Discussions can take place in implicit terms, using euphemisms and indirect language, or by weaving in phrases full of hope that have a positive effect on understanding, managing ongoing uncertainty, and mitigating the impact of the message (51).For example, instead of directly saying that something did not turn out as expected, we can say that the outcome was different from what was anticipated

Or, instead of saying that a situation is very difficult, we can say that it is a challenge that requires a careful and strategic approach. Another example would be to say that we have certain uncertainties or ambiguities instead of saying that we are confused or do not know what to do. These strategies allow us to communicate in a polite and delicate manner, without affecting the relationship with the interlocutor or creating panic or fear. In addition, using indirect language can facilitate mutual understanding and help maintain a positive tone in the discussion.

Ultimately, it is important for the physician to be aware of their own emotional involvement and to seek support and consultation when they feel unable to cope with the situation. This can help maintain emotional balance and provide quality care for the affected patient (51).

Key insights and approaches:

1. Greet the patient and make eye contact upon entering the consultation room (46).
2. State each person's identity and verify the patient's identification documents (ID card/passport and health insurance card/certificate of insurance) (45).
3. Confirm the patient's nationality and the language in which they prefer to communicate, or which is more comfortable in both cases. If you do not know the patient's native language, you can use online translation apps on your phone to translate text (51).
4. Create structured notes of the interview and build a relationship with the patient in your own style or by using a structured interview method based on the Calgary-Cambridge model (see Fig. 5) (52).

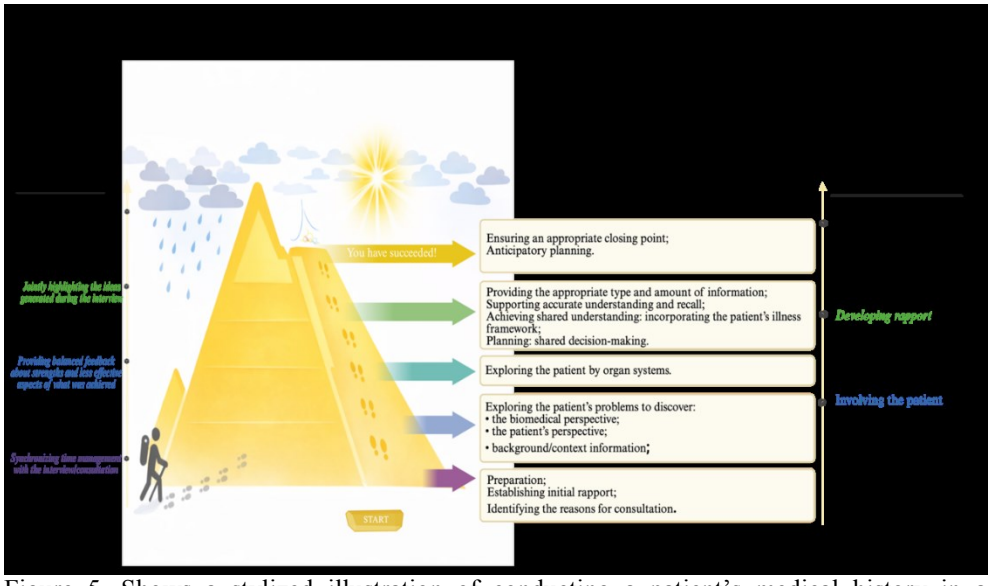

Figure 5. Shows a stylized illustration of conducting a patient's medical history in a healthcare setting, using a clear and logical structure according to the Calgary-Cambridge model, regardless of the patient's type. Figure created in BioRender. Oana, R. (2026) https://BioRender.com/j7boib9

5. During the medical history-taking, you can practice using memory techniques to ensure that no details are omitted when investigating the patient's symptoms:
   a) Where – the location and radiation of a symptom
   b) When – onset, time fluctuations, duration
   c) Quality – how it feels (e.g., pain characteristics)
   d) Quantity – intensity, extent, degree of impairment
   e) Aggravating and alleviating factors – what worsens or improves the symptoms
   f) Associated manifestations – other accompanying symptoms
   g) Beliefs – the patient's beliefs or perceptions about the symptoms
6. Ask the patient what expectations they have of you during that particular consultation session.
7. Insert pauses in the dialogue and make open statements to give the patient time to respond and share: "We need to work on this together," or "I will speak with a specialist on your behalf, if you allow me...," or "I won't let you face this event alone… how can we move forward now?"

8. Many patients in medical practice begin with stories because of the loneliness they feel. By listening, you gain their trust and, in a way, also "heal" their loneliness.
9. Prepare and explain to the patient what to do if the recommended home treatment does not produce the expected results
10. Outline with the patient a backup plan in case they do not respond to medication or in the event of complications from medical or surgical treatment.
11. Encourage the patient to ask any questions regarding their illness, treatment, and home care recommendations
12. Check if the patient has someone to assist with treatment administration and care; if not, request support from the social services of your healthcare facility.
13. Verify the patient's medication by having them show you the original medication boxes and how they administer them. If they do not have them, recommend that they bring them next time, or speak with a caregiver/neighbor on the phone who is at home, or with the family doctor during the consultation.
14. Avoid making medication recommendations if neither you nor the patient are certain about what medications they are taking, as this could do more harm than good.
15. Agree with the patient, before leaving, on when to follow up and give them the opportunity to call before the scheduled appointment to confirm that everything is according to plan, or inform them that they will receive an SMS with the date, address, and time of the appointment.
16. Review and apply all the above steps to perfect your style and efficiency in conducting patient interviews at each clinical rotation.
17. Explore the patient by analyzing the following aspects:
    - Their beliefs regarding causality;
    - Cultural expectations regarding treatments;
    - Family, marital, religious (some religions do not accept blood transfusions), and social habits;
    - Understanding of social and community networks;
    - Use of complementary or alternative medical care methods.
18. Ask for permission if you want to pose a sensitive question:
    - "Would it be okay if I asked you about this, or not?"

19. Ask what would help them:

    - "You need to… Is there anything that would help you with this?"

20. Explain the "why":

    - "This may be difficult for you – the reason I need to ask/do this is…
    - "Sometimes people have their own explanations for things, and it helps to understand the patients' perspectives."
    - "I know that sometimes women may prefer to be examined by a female doctor – is this important to you?"

21. The information in this chapter represents the branches, leaves, and fruits of the tree you are designing—use your imagination to illustrate it. Don't hesitate to use other sources to embellish it as you see fit!
22. *Take home forever!:* As a piece of advice for the future, shared by a mentor, Dr. Georgel Țăranu (Primary Care Physician, Vascular Surgery, Timișoara), which I want to pass on to you: "Trust only the information you have personally gathered when it comes to your patients, and ALWAYS verify the information provided by another colleague".

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Chapter II
Asepsis and Antisepsis

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List of Abbreviations and Symbols

DNA – Deoxyribonucleic Acid
ACCP – American College of Chest Physicians
COVID 19 – Coronavirus Disease 2019
HEPA – High efficiency particulate air
SARS – Severe acute respiratory syndrome
SCCM – Society of Critical Care Medicine (SCCM)
SSI – Surgical site infection

The definition of sepsis has become broader with the improved understanding of its complex pathophysiology. The first documented use of the term is attributed to Homer, in his poems approximately 2,700 years ago. The word sepsis is derived from the Greek word for "decay" or "decomposition." In the following centuries, it was used by Hippocrates and Galen in their works (1). Even in ancient times, people recognized the importance of preventing infections in open wounds. **Before Hippocrates,** various methods were used, such as:

- Washing the wound with warm water: Warm water helped remove dirt and debris, reducing the risk of infection.
- Dressing the wound with pieces of white cloth: White cloth was used to absorb blood and protect the wound from dust and contamination. The use of white cloth was important because it allowed easy observation of any signs of infection, such as redness or discharge (2).

Between the 5th and 4th centuries BC**,** Hippocrates, considered the father of medicine, laid the foundations of basic surgical principles. He emphasized the importance of asepsis, hemostasis, and proper bone alignment during surgical procedures. He also recommended the use of sterile instruments and clean dressings**.**

In the 16th century, Ambroise Paré**,** a renowned French surgeon, was the first to argue that infections are contagious. He observed that patients treated by surgeons who did not wash their hands had a much higher mortality rate than those treated by surgeons who took hygiene precautions. Paré recommended that physicians and surgeons wash their hands and instruments before treating patients (3).

As the scientific understanding of diseases grew, the concept of infection also emerged. It was discovered that certain microorganisms, such as bacteria and viruses, can cause disease. Advances in the scientific understanding of illnesses, combined with the development of new techniques and instruments, have significantly contributed to improving patient safety and outcomes in modern surgery.

The implementation of individual patient hospitalization has significantly contributed to reducing the transmission of diseases in the hospital setting. This practice separated infected patients from those who were not, thereby limiting the spread of pathogens**.**

The invention of the microscope by Antoni van Leeuwenhoek in the 17th century allowed scientists to observe and study microorganisms for the first time. This discovery revolutionized the understanding of the causes of infections and led to the development of new methods for their prevention and treatment.

Ignaz Semmelweis (1818–1865), a Hungarian physician, observed that mortality rates among women giving birth in the maternity ward where he worked were significantly higher than those in other maternity wards. He deduced that this was due to "contact infections" transmitted from doctors performing autopsies to the women in labor. Semmelweis mandated the compulsory washing of hands with a chlorinated lime solution for doctors and students, leading to a dramatic reduction in maternal mortality (4).

Louis Pasteur (1822–1899), a French microbiologist, made groundbreaking discoveries that revolutionized the understanding of the causes of diseases. He identified various families of germs, including bacteria, viruses, and fungi, and demonstrated the causal relationship between these microorganisms and the onset of different diseases. Pasteur also developed the first effective vaccines against devastating illnesses such as cholera, rabies, and anthrax. His vaccines contributed significantly to reducing morbidity and mortality caused by these diseases.

Robert Koch is another giant of that era, who formulated a generalized set of criteria for microbial infections, now known as Koch's postulates.

Joseph Lister (1822–1912), an English surgeon, is considered the **father of antisepsis.** He demonstrated that the use of a carbolic acid antiseptic solution during surgical procedures could significantly reduce the risk of infection**.**

Lister advocated the idea that microorganisms are responsible for infections and promoted the use of aseptic techniques to destroy or eliminate them from the surgical environment. He introduced a series of practices that

became fundamental to modern surgery, including handwashing, instrument sterilization, and wound dressing.

The “germ theory” of disease was developed in the 1800s, and there was growing recognition that harmful microorganisms cause sepsis. Hugo Schottmüller was the first to propose a modern definition in 1914, describing sepsis as: “Sepsis is present if a focus has developed from which pathogenic bacteria, constantly or periodically, invade the bloodstream in such a way that it produces subjective and objective symptoms” (5). Sepsis, as a manifestation of the importance of the host’s immune response, was demonstrated by numerous experimental and clinical studies throughout the 20th century. Nevertheless, it posed significant challenges in recognition, treatment, and research due to the heterogeneity of the disease process (5).

Victor Babeș, a renowned Romanian physician, made significant contributions to the advancement of **bacteriology and asepsis.** He studied various infectious diseases and identified the pathogens responsible for them. He also promoted the use of aseptic methods in hospitals and medical clinics.

His monumental work, "Bacteria and Their Role in the Anatomy and Pathological Histology of Infectious Diseases," represented a major contribution to the understanding of the pathogenesis of infectious diseases.

Babeș also had a significant influence on the development of veterinary medicine. He studied infectious diseases in animals and developed methods for their prevention and control. Additionally, he played a key role in introducing rabies immunization in Romania. He founded the country’s first rabies institute and contributed to the development of large-scale vaccination programs.

Babeș was also among the early pioneers of concepts that later developed into modern antibiotic therapy. He observed that certain natural substances could inhibit bacterial growth and suggested their potential use as antimicrobial agents (6,7). These are just a few of the key moments in the history of infection prevention in surgery. Over time, advances in the scientific understanding of diseases, combined with the development of new techniques and instruments, have significantly contributed to improving patient safety and outcomes in modern surgery.

The first consensual definition of sepsis was established by Roger Bone and colleagues in 1991 at an SCCM-ACCP conference. Significant progress in the pathobiology of sepsis has been made over the last two decades. A better understanding of cellular biology, circulatory and organ function changes, biochemistry, immunology, and morphology has contributed to improved sepsis management, leading to changes in its epidemiology (8).

II.1. General Pathology of Infections

Infections are a major public health problem, significantly affecting quality of life and causing considerable morbidity and mortality. Understanding the causes and the factors that promote infections is essential for the effective prevention and control of infectious diseases.

The systemic immune response of the body during an infectious process, which can lead to organ dysfunction and even organ failure resulting in death, constitutes a medical emergency known as sepsis. Sepsis is described as one of the leading causes of morbidity and mortality in critically ill patients, even though remarkable progress has recently been made in understanding the pathophysiology of this clinical syndrome, improving hemodynamic monitoring tools, and advancing resuscitation measures (9).

Representing one of the major challenges in the United States healthcare system, severe sepsis and septic shock have an annual incidence of up to 300 cases per 100,000 people. The cost of treating these conditions exceeded 20 million dollars in 2011 alone, accounting for approximately 5.2% of total hospitalization expenses (10).

Sepsis was recognized as a global health priority in 2017 by the World Health Organization, precisely because of the high morbidity and mortality associated with the condition (11).

II.1.1. Sources of Infection

Infections can originate from diverse sources, often invisible to the naked eye. From saprophytic germs that coexist with us on the skin and mucous membranes, to soil-borne microbes hidden in the earth and air, to surgical instruments and the hands of the surgeon, the surrounding environment can expose us to a multitude of microorganisms. Even the atmosphere in the operating room, though seemingly sterile, may contain microorganisms that can threaten the patient's health. A detailed understanding of these sources of infection provides us with the key to effectively preventing and combating infectious diseases, protecting both our own well-being and that of those around us:

- *Saprophytic germs:* Microorganisms that coexist with the host organism without causing harm.
- *Telluric germs:* Microorganisms present in the external environment, which are more resistant to environmental factors.
- *Surgical instruments and the surgeon's hands:* Can serve as sources of contamination if not properly sterilized.
- *Operating room hygene:* May be more or less contaminated with microorganisms (12,13)

II.1.2. Factors Favoring Infection

Although our body has several natural defense mechanisms against infections-such as skin and mucosal barriers, phagocytosis, and antibacterial secretions- there are factors that can weaken this natural resistance and make us more vulnerable to infectious diseases. Advanced age, chronic illnesses, certain medical therapies, surgical shock, and trauma can create an environment favorable to the proliferation of pathogenic microorganisms, significantly increasing the risk of infection. A detailed understanding of these risk factors allows us to take appropriate preventive measures to maintain health and protect ourselves from infections.

II.1.3. Prevention of Infections

There are a number of measures that can be taken to prevent infections, such as hand hygiene, immunization, the use of personal protective equipment, and aseptic practices.

- *Hand hygiene* is the most important way to prevent the spread of infections.
- Wash your hands thoroughly with soap and water, especially before eating and after using the toilet, etc.
- *Vaccination (immunization*) is one of the most effective ways to prevent infectious diseases. Get vaccinated according to the schedule recommended for your age and risk factors.
- *Use personal protective equipment,* such as gloves, gowns, and masks, when in contact with body fluids or other potentially infectious materials.
- *Aseptic practices are procedures* used to prevent the spread of infections in healthcare settings. These practices include proper sterilization of equipment, hand hygiene, and the use of barriers such as drapes and gowns (12,13*)*.

II.2. Asepsis and Antisepsis

Asepsis, antisepsis, disinfection, and sterilization are complementary methods and must be used in combination to ensure effective infection control in medical and surgical settings.

II.2.1. Asepsis

Asepsis is a prophylactic measure consisting of a set of preventive methods and techniques designed to prevent the contact of pathogenic agents with a wound or a sterile surgical field. The aim of asepsis is to create an

environment free of microorganisms, thereby reducing the risk of infection. The word *asepsis* comes from the Greek *asepsis* (*a* = without, *sepsis* = putrefaction).

Washing hands with antibacterial soap, wearing sterile gloves and gowns, using sterile instruments and materials, completely covering wounds with sterile dressings, air filtration, etc., are some of the measures used to prevent the introduction of microbes into the body (14).

II.2.2. Antisepsis

Antisepsis is a curative method that consists of responding to an already established infection through a set of measures intended to destroy or inactivate pathogenic agents that have already come into contact with a wound or a surgical field. The purpose of antisepsis is to reduce the number of microorganisms in the contaminated area and to prevent their proliferation. Examples include the application of antiseptic solutions to the wound, the skin surrounding the wound, or instruments, as well as the use of povidone-iodine, chlorhexidine, or alcohol for disinfection (15).

II.2.3. Disinfection

Disinfection is an intermediate method between asepsis and antisepsis, encompassing elements of both techniques. The purpose of disinfection is to significantly reduce the number of microorganisms on objects or in the surrounding environment, eliminating pathogenic agents and lowering the risk of infection. Examples include cleaning and disinfecting surfaces in hospitals, medical clinics, and public spaces, as well as using chemical or physical disinfectants (heat, ultraviolet radiation) to reduce the number of microorganisms (14). Types of disinfection include prophylactic disinfection, routine disinfection, and terminal disinfection.

- *Prophylactic disinfection* is carried out preventively, aiming to prevent the occurrence and spread of diseases, targeting the environment, objects, and surfaces in areas with a high risk of infection (for example, hospitals and medical clinics).
- *Routine disinfection* is carried out periodically throughout the patient's hospitalization, targeting objects and surfaces in the immediate vicinity of the patient (bed, bedside table, bed linens, etc.).
- *Terminal disinfection* is carried out after the patient's discharge or death, targeting the room where the patient was hospitalized, as well as objects and surfaces in the area, with the aim of eliminating pathogenic agents that could persist and contaminate other patients.

Disinfection is carried out using special chemical substances (disinfectants) applied exclusively to objects, with the aim of eliminating microorganisms. Unlike disinfectants, antiseptics are milder agents used on living tissues (skin, mucous membranes) to destroy microorganisms, having a less aggressive effect on human cells (16).

Examples of disinfectants:

- *Propylene glycol and triethylene glycol* – can be used as aerosols or vapors which, at sufficient concentrations, disinfect the air in patient rooms.
- *Aldehydes (formaldehyde and glutaraldehyde)* – used as disinfectants with strong bactericidal effects, also destroying fungi and certain spores.
- *Chlorine and ozone* – strong oxidizing agents used for surface disinfection.
- *Quaternary ammonium compounds (e.g., benzalkonium chloride).*
- *Biguanide polymers (e.g., polyaminopropyl biguanide)* – powerful bactericides, effective even at low concentrations (14,16)).

II.2.4. Sterilization

Sterilization is a physical or chemical process that destroys all microorganisms, including bacterial spores, on an object or in an area. It is considered the most effective method for eliminating pathogenic agents and achieving a completely sterile environment.

Examples**:** autoclaving surgical instruments, boiling water, using gamma radiation, or sterilizing gases. Common objects subjected to sterilization include gloves, gowns, soft materials such as dressings and sheets, as well as surgical instruments, syringes, and other medical tools.

Sterilization ensures a safe and aseptic environment for medical procedures, preventing the transmission of infections and protecting both patients and healthcare personnel

II.2.4.1. Methods of Material Sterilization

There are a variety of methods for sterilizing medical and surgical materials, each with its own advantages and disadvantages. Sterilization can be performed using physical methods (heat, radiation, filtration) or chemical methods (liquid or gaseous chemical agents). The choice of the appropriate sterilization method depends on several factors, including the type of material, the desired level of decontamination, and the material's compatibility with the chosen method (3).

II.2.4.1.1. Sterilization by Physical Methods

Heat is the most efficient and fastest method of sterilization. High temperatures act by coagulating proteins, destroying bacteria (including spores), viruses, and fungi. Sterilization can be performed using either dry heat or moist heat.

II.2.4.1.2. Heat Sterilization

II.2.4.1.2.1. Steam Sterilization – Autoclaving

Autoclaving uses saturated steam under pressure to destroy micro-organisms, including bacterial spores, by coagulating proteins and denaturing nucleic acids. The steam autoclave was introduced in 1881. It is the standard procedure commonly used in hospital settings for reusable textile materials (surgical drapes, surgical clothing), dressings (woven and non-woven), stainless steel surgical instruments, glassware, rubber, polymers, and elastomers.

- Advantages: efficiently sterilizes a variety of materials, including textiles, medical instruments, and plastics. Effectively destroys bacterial spores.
- Disadvantages: may damage certain materials sensitive to moisture. The sterilization cycle can take longer than other methods.

The theoretical sterilization times are 15 minutes at 121°C, 10 minutes at 126°C, and 3 minutes at 134°C; however, for safety reasons, practical times should not be less than 20 minutes at 121°C and 10 minutes at 134°C (18 minutes at 134°C for prions).

The items to be sterilized are exposed to steam (at 121–134°C) under pressure (between 1 and 2 atm) for a short period (10 to 20 minutes) in a closed chamber called an autoclave.

The sterilization cycle consists of four distinct stages:

Loading the autoclave: trays with the materials to be sterilized are placed with their openings facing upward to allow the steam to penetrate.

Sterilization: the temperature and duration of sterilization vary depending on the type of material and the level of contamination. Typically, sterilization is carried out at temperatures of 121–134°C for 15–45 minutes.

Drying: at the end of sterilization, a vacuum drying phase is carried out to remove excess moisture from the materials.

Sealing: the trays are sealed after drying, with the date, time, and the name of the person who performed the sterilization recorded.

The parameters and duration of each stage vary depending on the autoclave used and the type of product being sterilized (textiles, instruments, etc.).

Autoclaving is recognized as the most efficient and controllable method of sterilization, with minimal impact on materials and broad applicability (metals, textiles, rubber, certain types of plastic). Because of these advantages, autoclaving should be the preferred method in the sterilization process (14,16).

II.2.4.1.2.2. Dry Heat Sterilization (Hot Air Oven – Pupinel)

This method uses hot air at high temperatures (160–180°C) to destroy microorganisms through dehydration and protein denaturation. It effectively sterilizes metal instruments, including delicate items that cannot be sterilized by other methods. It leaves no chemical residues but may take longer than other sterilization methods. It is not suitable for heat-sensitive materials such as plastics or rubber. Examples of sterilized materials include metal surgical instruments and metal implants

II.2.4.1.3. Sterilization by Radiation:

Industrial sterilization of single-use materials (sterile gloves, sterile gowns, catheters, syringes, needles, collection bags, etc.) is carried out using gamma or X-ray radiation. *Gamma irradiatio*n is a method that uses high-energy electromagnetic radiation (gamma rays) to destroy the DNA of microorganisms, rendering them incapable of reproduction. *Ultraviolet (UV) radiation* is used to sterilize the environment in operating rooms. Short-wave ultraviolet radiation with a wavelength between 2500 and 3500 Ångströms should be used. These lamps are intended for room sterilization and are different from lamps used for tanning (17,18).

II.2.4.1.4. Chemical sterilization methods

II.2.4.1.4.1. Exposure to ethylene oxide

Ethylene oxide is a gas with high permeability that penetrates paper, plastic, and textile packaging, destroying pathogens through alkylation. It effectively sterilizes a wide range of materials, including heat-sensitive ones. It does not leave chemical residues. The process may take longer than other sterilization methods. Aeration periods may be required to eliminate residual gas. Examples of sterilized materials include endoscopic instruments, catheters, and electronic devices (19)

II.2.4.1.4.2. Germicides

Germicides are chemical substances that destroy or inactivate microorganisms on surfaces or objects. They are easy to use and readily available. They can be applied to a variety of surfaces. They may damage certain materials and can be irritating to the skin and eyes. Examples of

sterilized materials include small medical instruments and surfaces in healthcare settings.

Types of germicides:

- Ethanol and isopropanol are effective germicides against bacteria, viruses, and fungi.
- Chlorine is a strong germicide commonly used for disinfecting surfaces and water.
- Hydrogen peroxide is an oxidizing germicide that destroys microorganisms by damaging their cell walls (20).

II.2.4.1.4.3. Exposure to formaldehyde vapors

This method uses formaldehyde (formalin) vapors to destroy microorganisms, including bacterial spores, by alkylating proteins and nucleic acids. It penetrates porous materials well and effectively destroys bacterial spores. It can be used for sterilizing materials or rooms that cannot be sterilized by other methods.

Its disadvantages include the potential to damage certain materials, a strong and irritating odor, and the need for prolonged ventilation after sterilization. Sterilization parameters:

- Temperature: 17°C, 25°C, or 50°C
- Duration: 24 hours at 17°C, 2 hours at 25°C, or 45 minutes at 50°C
- Sterilizing agents: normal formic aldehyde (40% by volume) and paraformaldehyde tablets (21).

II.2.4.1.4.4. Sterilization control aims to ensure the effectiveness of the sterilization process and to prevent contamination of sterilized materials.

Methods of control:

- *Physical indicators:* monitor sterilization parameters such as temperature, pressure, and exposure time.
- *Chemical indicators:* change color or release vapors in the presence of specific chemicals, indicating complete sterilization.
- *Biological indicators*: use microorganisms known to be resistant to the specific sterilization method. The absence of microbial growth indicates complete sterilization.

Monitored parameters:

- Total radiation dose (in the case of radiation sterilization)
- The amount of ethylene oxide or formaldehyde vapors
- Temperature and duration of heat exposure

Important: Following the manufacturer's instructions and the specific protocols of the medical field is essential to ensure effective and safe sterilization of materials (22,23).

II.2.5. Asepsis – Operating Room

Asepsis in the operating room refers to a set of strict measures and practices aimed at preventing contamination by pathogens, ensuring a sterile and safe environment for surgical procedures. The goal of asepsis is to minimize the risk of postoperative infections, increase the success rates of surgeries, and improve patient safety. Strict adherence to aseptic principles is the responsibility of the entire medical team and contributes to the delivery of high-quality medical care. Measures aimed at preventing pathogen contamination in the operating room include:

- *Absence of bacterial contamination*: All surfaces, instruments, and personnel in the operating room must be free of pathogens.
- *Minimum size:* The operating room must have a sufficient area (at least 20 m²) to allow smooth personnel movement and proper equipment storage while maintaining a sterile environment.
- *Proper ventilation*: Adequate ventilation of the operating room is essential to remove contaminated air and maintain a constant flow of fresh, filtered air.
- *Airtight door closure*: The operating room doors must be tightly sealed to prevent the entry of pathogens from outside.
- *Positive atmospheric pressure:* The operating room must maintain positive atmospheric pressure relative to the outside environment, reducing the risk of contaminated air infiltration. Continuous monitoring of parameters such as temperature, humidity, and air pressure in the operating room is important.
- *Operating room as a minimal germ source*: All surfaces, equipment, and personnel in the operating room must undergo rigorous cleaning and disinfection procedures to minimize the risk of becoming sources of contamination. Operating room personnel must follow strict hygiene rules, including wearing sterile gowns, gloves, masks, and shoe covers. The patient must be prepared preoperatively through antiseptic showers and hair removal in the incision area (24–26).

II.2.5.1. Ventilation systems in operating rooms: Evidence and recommendations

Operating rooms generally use either laminar or conventional/turbulent ventilation systems. Laminar ventilation systems, pioneered by Sir John

Charnley in the 1960s, are widely used in orthopedic surgery to reduce the risk of surgical site infections (SSI) by maintaining a continuous flow of filtered air over the surgical field (27). In contrast, conventional ventilation systems introduce filtered air through ceiling diffusers, creating a turbulent flow that dilutes airborne contaminants (28).

II.2.5.1.1. Laminar airflow

Laminar ventilation systems use high-efficiency particulate air (HEPA) filters to supply clean air that flows in a uniform direction and speed from the surgical field toward the periphery, removing contaminants under positive pressure (29). These systems can achieve up to 300 air changes per hour and are highly effective in reducing microbial contamination during orthopedic procedures (30). However, evidence supporting their use in general surgery is limited, where other factors, such as the sterility of surgical instruments and prophylactic antibiotics, play a more significant role in preventing surgical site infections (SSI) (31).

II.2.5.1.2. Conventional Airflow

Conventional ventilation systems, also known as turbulent ventilation systems, introduce filtered air through multiple ceiling points at different angles, creating a turbulent flow that dilutes airborne contaminants. These systems rely on positive pressure to move air from clean areas toward less clean areas, achieving up to 25 air changes per hour. Although they are effective in reducing airborne contaminants, there is less evidence to support their superiority over laminar ventilation systems in preventing surgical site infections (SSI) (32).

II.2.5.1.3. Negative Pressure Environments

Negative pressure environments, initially introduced during the 2003 SARS epidemic, aim to reduce the release of infectious particles into adjacent areas by maintaining lower pressure in the operating room compared to surrounding spaces (28). During the COVID-19 pandemic, the use of negative pressure operating rooms was recommended to protect healthcare personnel during aerosol-generating procedures (AGPs) and other high-risk interventions (33). However, the costs and logistical challenges associated with converting existing operating rooms into negative pressure environments limit their widespread implementation (28).

II.2.6. The Patient Pathway in the Hospital and Preparation for Surgical Interventions

The patient pathway in the hospital, particularly in the context of preparation for a surgical intervention, is essential for ensuring optimal care and minimizing the risk of postoperative complications. This process involves several critical stages, each playing a well-defined role in ensuring the success of the surgical procedure and the patient's recovery.

II.2.6.1. Admission and Preoperative Assessment

The first step in the patient pathway is hospital admission. At this stage, the patient is evaluated by the medical team to ensure readiness for the surgical intervention. This includes a comprehensive assessment of the patient's health status, medical history, allergies, and current medications. In addition, laboratory tests, imaging investigations, and specialist consultations are performed when necessary. The purpose of this evaluation is to identify and manage any risk factors that could complicate the surgical procedure or postoperative recovery (34).

II.2.6.2. Preoperative Preparation

At this stage, the patient is informed about the surgical procedure and provides informed consent. Physical preparation may include the administration of preoperative medication, thorough personal hygiene, and, in certain cases, fasting prior to surgery. Additionally, the patient is given guidance on what to avoid before the operation, such as smoking or taking certain medications (34).

II.2.6.3. Transport to the Operating Room

The patient is transported to the operating room by the medical staff, following a well-defined route to minimize the risk of contamination. In the operating room, the medical team performs final checks to ensure that all details are in order and that the patient is ready for the procedure (35,36).

II.2.6.4. The Surgical Procedure

Once in the operating room, the patient is prepared for the procedure through the implementation of strict aseptic measures. This includes disinfecting the skin at the incision site and using sterilized equipment. Throughout the intervention, the surgical team continuously monitors the patient's vital signs and maintains a sterile environment to prevent infections (36).

II.2.6.5. Postoperative Recovery

After the completion of the procedure, the patient is transported to the recovery area, where they are closely monitored until full emergence from anesthesia. At this stage, the patient's overall condition, pain control, and potential complications are assessed. The medical staff provides instructions regarding postoperative care and the recovery schedule (37,38).

II.2.6.6. Discharge and Continued Care

The patient is discharged once their health condition allows. Before discharge, the patient receives detailed instructions regarding home care, necessary medications, and signs that may indicate a postoperative complication. A follow-up schedule is also established to monitor postoperative progress and ensure complete recovery (38).

II.2.7. ASEPSIS – The Surgical Team

The surgical team plays an important role in maintaining asepsis during surgical procedures. Strict adherence to protective measures is essential to prevent contamination of both the patient and the medical staff. Protective measures for the surgical team include:

- *Use of face masks and caps:* Face masks and caps serve as a barrier to prevent the spread of contaminated respiratory droplets from the medical staff to the patient.
- *Surgical handwashing:* Surgical handwashing is a rigorous procedure that uses specific antiseptic solutions to completely eliminate microorganisms from the hands and forearms of the medical staff.
- *Use of sterile impermeable gowns:* Sterile impermeable gowns protect the skin and clothing of medical staff from pathogens present in the operating environment.
- *Use of surgical gloves:* Sterile surgical gloves provide a physical barrier between the hands of the medical staff and the patient, preventing direct contamination.
- *Use of sterile drapes:* Sterile drapes are special materials used to define the surgical field and isolate the incision area from the rest of the patient's body. Key features of sterile drapes include: impermeability to liquids and microorganisms to prevent contamination of the incision site; unidirectional application from clean areas toward contaminated areas to avoid accidental contamination; and maintenance of sterility throughout the procedure.
- *Sterilization of instruments:* Surgical instruments must be carefully sterilized before each use to completely eliminate pathogenic microorganisms (39–41).

II.2.7.1. Personal Hygienic Behavior in the Medical Environment

Medical staff are advised to follow strict personal hygiene rules to prevent contamination and ensure a clean environment in healthcare facilities.

II.2.7.1.1.Clothing

In the absence of other specific requirements, medical staff should wear a white coat that is comfortable and properly fastened, either with buttons, a zipper, or Velcro. The coat should be changed daily or whenever it becomes contaminated.

II.2.7.1.2. Hair Care

Long hair should be tied back to prevent accidental contamination. It is important that hair is fully covered during sterile procedures.

1. **Jewelry and accessories:**
   It is recommended to avoid wearing jewelry on the fingers and forearms, as these can be a source of contamination.
2. **Nail Care:**
   Nails should be short, clean, and well-groomed. Artificial or decorative nails are not allowed in the medical environment, as they pose a significant infection risk. Additionally, nail polish should be avoided, especially in situations involving a high risk of infection.
3. **Skin Lesions:**
   Minor skin lesions should be prevented, as they can serve as entry points for pathogens. If they occur, contact with potentially contaminated environments should be avoided, and the lesions must be properly protected (42).

II.2.7.1.3. Hand Hygiene of Medical Staff

Hand hygiene of medical staff is an essential component of hygiene practices and the prevention of healthcare-associated infections. Before performing procedures such as administering an injection, it is imperative that hands are properly washed to reduce the risk of contamination. Handwashing should be performed with soap and water, using an appropriate technique that covers all areas of the hands, including the radiocarpal joints and fingers. After washing, hands should be dried with gauze pads or single-use paper towels, followed by the application of an alcohol-based solution for disinfection. Immediately after hand hygiene, medical staff should put on non-sterile gloves to provide an additional protective barrier during the procedure. Non-sterile gloves are suitable for procedures that do not involve

a high risk of infection, such as intramuscular injections or peripheral venipuncture, and serve as an essential protective measure for both the patient and the staff.

II.2.7.1.4. Surgical Handwashing

Surgical handwashing is an essential procedure for preventing postoperative infections and is considered the most important aseptic measure in the operating room. It also significantly reduces the risk of transmitting pathogenic microorganisms from medical staff to the patient, contributing to the safety of the surgical procedure. Unlike routine hand hygiene, which is intended for standard procedures (such as injections or clinical examinations), surgical handwashing involves a more elaborate and rigorous process. The objectives of surgical handwashing are the complete elimination of transient microorganisms, the reduction of the resident flora on the hands and forearms of medical staff, and the maintenance of a sterile surgical field, preventing contamination of the surgical wound. The hands of medical personnel represent the main means of transmitting nosocomial infections.

II.2.7.1.4.1. Required Materials

To perform proper surgical handwashing, the following materials are required:

- **Hands-free sanitary installation:** Faucets and soap dispensers should be operated by the elbow, foot, or sensor to prevent cross-contamination.
- **Sterile water:** used for rinsing.
- **Antiseptic soap:** often povidone-iodine-based or other antimicrobial preparations with a broad spectrum of activity.
- **Skin disinfectants:** antiseptic solutions based on alcohol or other substances with antimicrobial properties.
- **Sterile gauze pads:** for drying hands after washing.
- **Sterile gloves:** applied after completing the washing and disinfection procedure.

II.2.7.1.4.2. Preparation for Surgical Handwashing

Before beginning the surgical handwashing procedure, medical staff must follow several preparatory measures. First, wearing jewelry, including rings, bracelets, and watches, is strictly prohibited, as these can harbor microorganisms that may compromise hand sterility. Additionally, wearing a mask and cap that cover the nose, mouth, and hair is mandatory to prevent contamination of the operating environment with respiratory particles or hair.

II.2.7.1.4.3. Surgical Handwashing Technique (Figure 1)

1. **Initial washing:** The hands and forearms should be washed up to the elbow for 2–3 minutes using an antiseptic soap, such as a povidone-iodine-based soap. Special attention should be given to areas between the fingers, the nails, and the palms, as these are common sites for microorganism accumulation. Rinsing is performed with sterile water, ensuring that it flows from the fingertips toward the elbow to prevent retrograde contamination.
2. **Repetition of the procedure:** After the first wash, the procedure is repeated, this time up to the mid-forearm, maintaining the same cleaning and rinsing method. Movements should always be directed from the hands toward the elbow to adhere to the principles of surgical handwashing.
3. **Third stage of washing:** The washing procedure is performed again, but this time focusing only on the distal third of the forearm and the hand, maintaining the same rigorous technique.
4. **Drying the hands:** After washing is complete, the hands and forearms are dried with sterile gauze pads. It is important to dry by patting rather than rubbing, to prevent any potential skin damage and to maintain sterility.
5. **Additional disinfection:** After drying, a skin disinfectant (usually alcohol-based) is applied using a device that can be operated by the elbow, foot, or sensor. This additional disinfection ensures the efficient elimination of any residual germs and provides prolonged antimicrobial protection.
6. **Donning the sterile gown:** After putting on the sterile gown, it is essential not to touch any non-sterile surfaces or objects until the start of the procedure.
7. **Donning sterile gloves:** Once the hands are completely dry and disinfected, sterile gloves are carefully put on. They serve as the final protective barrier against direct contamination of the surgical field and must be handled with care to avoid compromising their sterility (42).

Figure 1. Surgical Handwashing

Whether it concerns *regular handwashing* or *surgical handwashing and disinfection*, the following principles apply:

- **Variations in technique:** This depends on the use of different sanitary systems and the purpose of the handwashing, such as in kitchens, operating rooms, laboratories, etc.
- **Monitoring results:** Each healthcare professional has the ethical responsibility to ensure that their hands are properly washed (e.g., through microbiological testing). Additionally, public health regulations establish acceptable limits for the number of microorganisms on medical personnel's skin.
- **What not to do:** Ignoring or neglecting recommendations regarding proper hand hygiene and the correct use of hand protective equipment can lead to significant risks (42).

Strict adherence to the steps of the procedure, the use of appropriate antiseptic products, and continuous monitoring of medical staff contribute significantly to maintaining asepsis and improving the quality of medical care (43,44).

II.2.7.1.5. Use of the Sterile Gown.

Indications: The sterile gown is used during surgical interventions and procedures that require strict asepsis, such as punctures and the insertion of a central catheter.

Contraindications: There are no specific contraindications for the use of a sterile gown.

Required materials: Sterile gown (Figure 2).

Technique:

1. **Surgical handwashing:** Before donning the gown, the specific steps of surgical handwashing are followed to reduce the risk of contamination.
2. **Donning the gown:** The sterile gown is carefully unfolded without touching clothing or other potentially contaminated surfaces. It is essential to maintain an aseptic technique to preserve the sterility of the gown.
3. **Adjusting the gown:** Assistance from a colleague is required to adjust the gown on the back and tie the straps, ensuring that the front of the gown remains sterile.

Precautions:

After donning the sterile gown, it is essential not to touch any non-sterile surfaces or objects until the start of the procedure (42).

Figure 2. Sterile Gown

II.2.7.1.6. Use of Sterile Gloves Indications:

Sterile gloves are used in various medical procedures, such as catheterizations, punctures, wound care, or other interventions that require an aseptic environment

Contraindications: There are no specific contraindications. However, precautions should be taken for individuals with allergies to latex or talc.

Precautions: Individuals allergic to talc or latex should use gloves free of these components to avoid allergic reactions.

Required Materials:

- Individually packaged sterile gloves, in the appropriate size
- A clean surface for unfolding and handling the gloves if they cannot be opened without touching other surfaces.

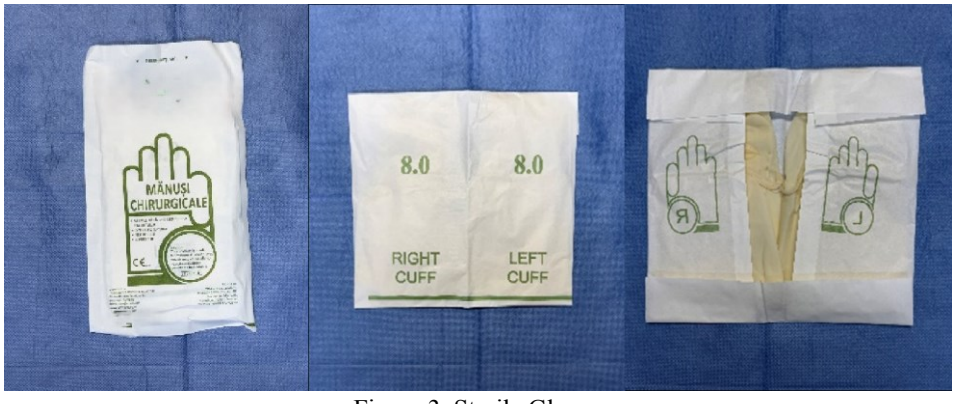

Figure 3. Sterile Gloves

Technique:

1. **Removal of jewelry:** Before donning gloves, all jewelry (rings, bracelets, watches) must be removed to prevent contamination and damage to the gloves.
2. **Handwashing and disinfection:** Hands are thoroughly washed, and an antiseptic solution is applied, following the surgical handwashing protocol.
3. **Choosing the gloves:** It is essential to select gloves of the correct size to maintain tactile sensitivity and comfort during medical procedures.
4. **Donning the gloves:**
    - Hold the first glove by the inner edge at the folded cuff and apply it to the left hand without touching the outside of the glove.
    - With the gloved hand, grasp the outer edge of the other glove (under the cuff) and apply it to the right hand.
    - Adjust the gloves on the fingers and fully unfold the cuffs, taking care to maintain aseptic technique (42).

Figure 4. Donning Sterile Gloves

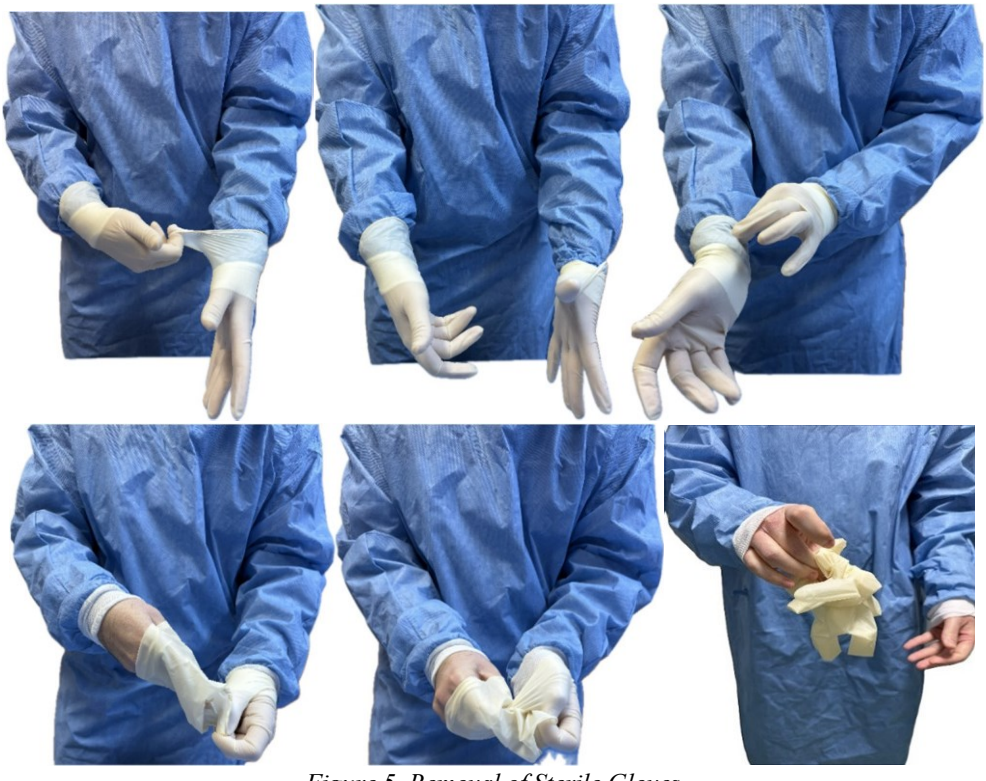

Figure 5. Removal of Sterile Gloves

II.2.8. ASEPSIS – The Patient

The presence of pathogenic microorganisms in the surgical field after an intervention can lead to a range of complications, such as postoperative infections. Postoperative infections may be caused by:

- *Patient-related factors:* the patient's overall health, comorbidities, and poor hygiene.
- *Procedure-related factors:* the duration of the intervention, the complexity of the procedure, and intraoperative contamination.
- *Team-related factors:* insufficient adherence to aseptic principles by the medical staff.

Postoperative infections are caused by the presence of pathogenic microorganisms on the patient's skin or in anatomical cavities, with *Staphylococcus aureus* being the most commonly involved.

Among the causes of wound infections, we can mention:

- Disruptions of the skin continuity (e.g., trauma, surgical wounds)
- Contamination of the wound with pathogens from the external environment or the patient.

- Lack of vascularization in the affected area
- Factors that delay wound healing (e.g., diabetes, malnutrition) (45)

Skin preparation is carried out as follows:

- Shaving the area to be operated on
- Washing with antibacterial agents (e.g., chlorhexidine)
- Disinfecting the area surrounding the wound (46)

Prophylactic Measures:

- Shaving the area to be operated on: removes hair that can promote bacterial growth.
- Washing with antibacterial agents: reduces the number of microorganisms on the skin.
- Pressure irrigation with 0.9% saline solution: mechanically removes bacteria from the wound and reduces the risk of infection
- Use of sterile dressings: provides a clean environment and promotes wound healing.
- Administration of prophylactic antibiotics: recommended in certain cases with a high risk of infection.
- Maintaining a clean and hygienic environment: prevents contamination of the wound with pathogens from the external environment.

Postoperative and wound infections represent a significant problem in the medical field, with serious consequences for the patient. Strict adherence to aseptic principles, implementation of appropriate prophylactic measures, and continuous patient monitoring contribute significantly to reducing the risk of infection and improving the quality of medical care (47,48).

II.2.9. ANTISEPSIS

Antiseptics are chemical substances applied to the skin or mucous membranes to destroy or inhibit the growth of microorganisms, thereby preventing infections. They do not have significant toxicity for living tissues. Disinfectants are stronger chemical substances used to destroy microorganisms on surfaces. They can be irritating to the skin and mucous membranes and are not suitable for direct application on the body. They are classified as follows:

1. **Broad-spectrum disinfectants:** These are capable of destroying both spores and the vegetative forms of microorganisms.
2. **Limited-spectrum disinfectants:** These destroy only the vegetative forms of microorganisms, without affecting spores.

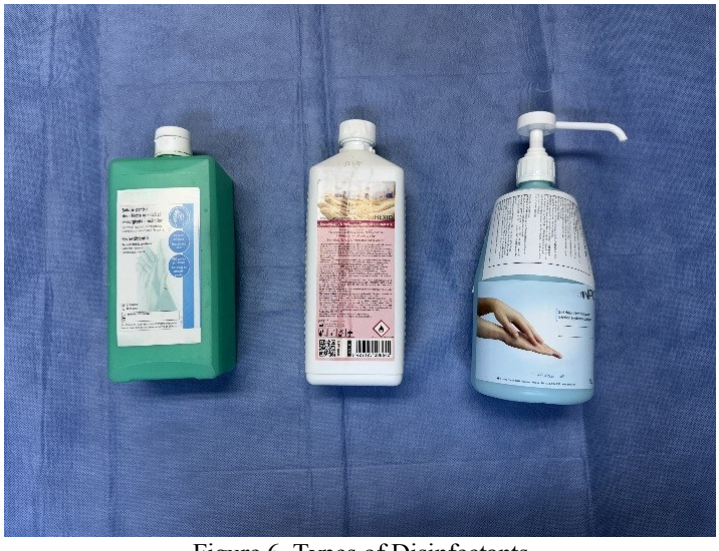

Figure 6. Types of Disinfectants

Essential Properties of Antiseptics:

- **Bactericidal capacity:** effectively destroys bacteria, including bacterial spores.
- **Odorless:** an unpleasant smell can be inconvenient for the patient and may interfere with other medical procedures.
- **Chemical neutrality:** does not damage objects it comes into contact with and does not affect the properties of other medications applied to the same area.
- **Effectiveness in various environments:** maintains antiseptic properties regardless of the pH of the medium or the presence of other substances.
- Local action: does not affect the tissues to which it is applied, preventing irritation or damage to the skin or mucous membranes.
- **Preservation of tissue defense capacity:** does not interfere with the body's natural defense mechanisms against infections (49,50).

II.2.9.1. Main Groups of Antiseptics

II.2.9.1.1. Iodine-Based Substances

Iodine destroys microbial cells by oxidizing proteins and nucleic acids. It also disrupts microbial metabolism and damages cell membranes. It has broad efficacy against bacteria (including bacterial spores), fungi, viruses, and protozoa.

Examples:

- **Iodine tincture:** 2% iodine + 2% sodium iodide in an alcohol solution (for external use).
- **Lugol's solution:** 5% iodine and 10% potassium iodide dissolved in water (mild antiseptic activity).
- **Iodophors:** Combinations of iodine with detergents or polyvinylpyrrolidone (e.g., Betadine).

II.2.9.1.2. Alcohols

The most commonly used antiseptic is ethyl alcohol (ethanol) at concentrations of 70–90%. Ethyl alcohol denatures microbial proteins and disrupts cell membranes, providing rapid efficacy against bacteria (including mycobacteria), viruses, and fungi. It also has a rapid dehydrating effect. It can be irritating to the skin and mucous membranes. It is not effective against bacterial spores and is not recommended for use on open wounds.

II.2.9.1.3. Chlorine-Based Substances

Chlorine destroys microbial cells through oxidation and enzyme inactivation. It has broad efficacy against bacteria (including bacterial spores), fungi, viruses, and protozoa.

Advantages: rapid and persistent efficacy; broad spectrum of action; sporicidal activity; affordable cost.

Disadvantages: can be corrosive and irritating to the skin and mucous membranes; has an unpleasant odor; interacts with certain medications; not recommended for use on open wounds.

Examples:

- **Sodium hypochlorite:** aqueous chlorine solution buffered with calcium bicarbonate (strong disinfectant, not for skin use).
- Chloramine B: powder or 500 mg tablets (0.2–2% solutions for disinfection). Substances used on inanimate surfaces to eliminate harmful microorganisms or inhibit their activity are known as disinfectants. These can be classified as broad-spectrum disinfectants, which destroy both spores and vegetative forms of microorganisms, and limited-spectrum disinfectants, which eliminate only the vegetative forms. Unlike disinfectants, antiseptics are local anti-infective agents used on humans and animals (51).
- **Chlorhexidine:** a compound of chlorine with acetic acid (good local tolerance, e.g., Betasept). Chlorhexidine is a broad-spectrum antimicrobial, effective against Gram-positive

and Gram-negative bacteria, yeasts, and viruses. Its antimicrobial efficacy depends on the dose – at lower concentrations (0.02%–0.06%), it has a bacteriostatic effect, while at higher concentrations (>0.12%), it becomes bactericidal. Pharmacokinetic studies show that approximately 30% of chlorhexidine from oral rinses remains in the oral cavity after use, being slowly released into oral fluids. Allergic reactions to chlorhexidine, including anaphylaxis, have been reported (52).

II.2.9.1.4. Oxygen-Releasing Substances

Hydrogen peroxide produces oxygen free radicals that destroy microbial cells. It is effective against bacteria (including anaerobes), fungi, and viruses.

Advantages: bactericidal, fungicidal, and virucidal activity; does not irritate the skin or mucous membranes; odorless.

Disadvantages: low stability, decomposes rapidly in light and heat; can damage living tissues; not effective against bacterial spores.

Examples:

- **Hydrogen peroxide:** 3% aqueous solution of hydrogen peroxide. Hydrogen peroxide can eliminate most microorganisms, including latent forms known for their high resistance, such as bacterial spores and protozoan cysts. It acts as an oxidative biocide, producing reactive oxygen species that damage DNA, proteins, and membrane lipids through oxidative processes. These substances, used on humans and animals, destroy or inhibit the activity of harmful microorganisms, and are distinct from disinfectants, which are intended for use on objects (53).
- **Boric acid:** 2–3% solutions for wound washing. Boric acid has mild bacteriostatic and antifungal activity. It may exhibit antifungal effects when used at high concentrations and for prolonged periods (52).
- **Potassium permanganate**: an oxidizing agent recognized for its bactericidal action, which occurs by altering the cell wall structure of pathogenic organisms. Potassium permanganate solution is considered a mild antiseptic with astringent properties and is frequently used for cleaning wounds, ulcers, or abscesses. Additionally, this solution is applied as wet compresses or baths to treat skin conditions such as eczema and acute dermatoses, especially when these conditions are accompanied by secondary infection (54).

II.2.9.1.5. Mercury

Mercury inhibits microbial metabolism and disrupts cell membrane permeability. It is effective against bacteria (including mycobacteria) and fungi.

Advantages: persistent bacteriostatic and fungicidal activity; not irritating to the skin or mucous membranes.

Disadvantages: toxic to the body, risk of poisoning; not recommended for frequent or prolonged use; may cause allergic reactions.

Examples:

- **Merbromin (Mercurochrome):** 2–4% aqueous and hydroalcoholic solutions.
  Merbromin is an organic sodium salt compound that serves as an antiseptic, fluorochrome, and histological stain. Mercurochrome is the commercial name for merbromin, commonly used as a topical first-aid antiseptic. It is a disodium organomercuric compound available in many countries, except Switzerland, France, Germany, and the United States, where it has been withdrawn from the market due to the risk of mercury poisoning (no longer recommended).
- **Fenosept:** 0.2% aqueous solution of phenyl mercuric borate (no longer recommended) (55).

II.2.9.1.6. Colorants

Colorants bind to microbial DNA and inhibit its replication. They have antibacterial and antifungal activity.

Advantages: selective antibacterial and antifungal activity; do not irritate the skin and mucous membranes; can be used to stain treated areas, facilitating their identification.

Disadvantages: limited spectrum of activity; may stain the skin and clothing; may cause allergic reactions.

Examples of antiseptic dyes:

- Gentian violet: used to treat fungal infections of the skin and mucous membranes.
  Crystal violet is an organic chloride salt, representing the monochlorinated form of the crystal violet cation. It has been used in creams for the local treatment of bacterial and fungal infections, being effective against certain Gram-positive bacteria (especially *Staphylococcus* species) and some pathogenic fungi (including *Candida* species). However, its use

has declined following reports indicating its carcinogenic potential in animals. It has multiple roles, including as a histological stain, antiseptic, antibacterial agent, antifungal agent, and antihelminthic drug (56).

- Eosin: used as an antiseptic for wounds and burns.

II.2.9.1.7. Detergents

Detergents destroy microbial cells by disrupting their cell membranes. They can also have a mechanical cleaning effect. They are effective against bacteria, viruses, and fungi.

Examples:

- Bromocet: hydroalcoholic solution of 0.1% cetylpyridinium bromide.
- TEGO 103G: 0.1% solution.
- Deconex: products with virucidal, bactericidal, fungicidal, and parasiticidal action.
- Surfanios: 2% solution.
- Hexanios: 0.5% diluted solution.
- Anyosime: bactericidal, fungicidal, and virucidal effect.

Advantages: bactericidal, virucidal, and fungicidal activity; can be used for cleaning and disinfecting surfaces; do not irritate the skin and mucous membranes.

Disadvantages: may be inactivated in the presence of proteins or fats; may be ineffective against bacterial spores; may cause skin dryness.

Examples of antiseptic detergents:

- Chlorhexidine gluconate: used for disinfecting the skin and mucous membranes.
- Povidone-iodine: used for disinfecting the skin and mucous membranes.
- Cetylpyridinium bromide: used for disinfecting the skin and mucous membranes.

A detailed understanding of the main groups of antiseptics, their actions, and properties allows for the correct selection of the appropriate product for each situation, significantly contributing to health maintenance and the reduction of complication risks.

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Chapter III
Evaluation and Monitoring of Body Functions

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List of Abbreviations and Symbols

ABPM – Ambulatory Blood Pressure Monitoring
ADA – American Diabetes Association
ARDS – Acute Respiratory Distress Syndrome
COPD – Chronic Obstructive Pulmonary Disease
MCH – Mean Corpuscular Hemoglobin
CPAP – Continuous Positive Airway Pressure ventilation
CO_2 – Carbon Dioxide
DM – Diabetes Mellitus
ECG – Electrocardiogram
RR – Respiratory Rate
HbA1c – Glycated Hemoglobin
MCH – Mean Corpuscular Hemoglobin
Hct – Hematocrit
HTN – Hypertension
FiO_2 – Fraction of Inspired Oxygen
VF – Ventricular Fibrillation
BMI – Body Mass Index
O_2 – Oxygen
PEEP – Positive End-Expiratory Pressure
RDW – Red Blood Cell Distribution Width
RAAS – Renin-Angiotensin-Aldosterone System
BP – Blood Pressure
DBP – Diastolic Blood Pressure
SBP – Systolic Blood Pressure
PSVT – Paroxysmal Supraventricular Tachycardia
OGTT – Oral Glucose Tolerance Test
TV – Tidal Volume
MCV – Mean Corpuscular Volume

III.1. Nutritional Status

Nutritional status has always been a central topic in medicine, given its direct impact on human health and longevity. Throughout history, the way societies have approached nutrition has varied significantly, reflecting changes in agriculture, economy, and medical knowledge. Obesity has become a major public health issue in the 21st century, being associated with numerous chronic conditions, including type 2 diabetes, cardiovascular diseases, and certain types of cancer. At the same time, malnutrition remains a severe problem in many parts of the world, particularly in developing countries. In contrast, in developed countries, excess calorie intake and a sedentary lifestyle contribute significantly to the prevalence of obesity, highlighting the need for integrated strategies to address both extremes of the nutritional spectrum (1).

A person's nutritional status reflects the balance between energy intake and energy expenditure. An imbalance between intake and expenditure leads to weight loss or gain. Adequate nutrition plays a crucial role in maintaining health and preventing disease. A balanced intake of essential nutrients (proteins, carbohydrates, fats, vitamins, and minerals) is vital for the body's optimal functioning. A healthy diet can reduce the risk of chronic diseases such as cardiovascular diseases, diabetes, obesity, and cancer (2).

The assessment of a person's nutritional status can be carried out using several methods. These may include measuring skinfold thickness, body weight and height, calculating the Body Mass Index (BMI), and measuring waist circumference. Measuring skinfold thickness is a reliable, simple, and non-invasive method for estimating body fat and is performed using a caliper at specific sites (e.g., abdomen, triceps area of the arm) (3).

Body weight represents the sum of all body compartments (e.g., muscle mass, adipose tissue) but does not distinguish between them. Therefore, changes in body weight may reflect alterations in muscle, fat, water, or a combination of these, and from a nutritional perspective, provide limited information. Despite this, body weight is routinely measured in healthcare settings to determine optimal medication dosages, establish daily caloric requirements, plan dietary regimens, and monitor and evaluate weight changes (e.g., patients with decompensated heart failure, pediatric patients) (3).

Height is used in public health to assess the risk of undernutrition and obesity. BMI, also known as the Body Mass Index, is a tool used to evaluate body weight in relation to height. Through BMI, an individual's weight category can be determined (4).

$$\textbf{BMI} = \frac{\boldsymbol{Weight\ (kg)}}{\boldsymbol{Height^2\ (m^2)}}$$

Table 1. BMI Classification

BMI	Result Interpretation	Disease Risk
≤18,49	Underweight	✓
18,5-24,99	Normal Weight	
25-29,99	Overweight	✓
30-34,99	Obesity Class I	✓
35-39,99	Obesity Class II	✓
≥40	Obesity Class III (Morbid Obesity)	✓

Depending on the distribution of adipose tissue, obesity can be classified into several types: abdominal obesity, gynoid-type obesity, and android-type obesity.

Waist circumference is an additional measure used to assess the risk of various conditions, such as cardiovascular diseases and type 2 diabetes. It is measured with the patient in a standing position, and elevated values are associated with an increased risk for these conditions (5).

Table 2. Classification of Patients into Overweight or Obesity Categories Based on Waist Circumference

	WOMEN	MEN
Normal Values	<80 cm	<94 cm
Overweight	80-88 cm	94-102 cm
Obesity	>88 cm	>102 cm

Tips and Tricks

- ✓ **Managing obesity should involve a multidisciplinary approach, including dietary counseling, physical activity, behavioral therapy, and medical or surgical interventions when appropriate.**
- ✓ **Interpret BMI in an individual context: BMI does not distinguish between muscle mass and fat tissue, and reference values may vary depending on age and sex.**

III.2. Temperature

Monitoring human body temperature is a fundamental aspect of medical practice, with a long and significant history. Major progress in temperature monitoring was made in the 19th century with the invention of the clinical thermometer by Sir Thomas Clifford Allbutt in 1867. This invention allowed for precise and rapid measurements of body temperature, thereby revolutionizing the diagnosis and management of fever (6).

Normal body temperature is an individual variable, with a normal range between 36.1°C and 36.8°C. This variation can be influenced by factors such as the time of day, physical activity, age, hormones, and pregnancy.

Technique: Temperature is measured using a thermometer, either centrally (e.g., rectal) or peripherally (e.g., axillary, forehead region) (7).

Hyperthermia refers to a body temperature above 37°C (axillary), with possible causes including fever (a natural response of the body to infection), heatstroke (prolonged exposure to high temperatures), intense physical exercise (excessive physical effort), and certain medications (e.g., antidepressants, antipsychotics) (7).

Fever, a specific form of hyperthermia, is characterized by a body temperature above 38°C and is most commonly caused by an infection. Fever can be classified according to temperature values as follows: moderate fever (38–39°C), high fever (39–40°C), pyrexia (40–41°C), and hyperpyrexia (>41°C). Associated symptoms include chills, sweating, weakness, and muscle aches (7).

Possible Causes of Fever

- Viral infections: cytomegalovirus, herpes virus, Epstein-Barr virus, etc.
- Bacterial infections: otitis, abscess, pneumonia, infective endocarditis, urinary tract infections, tuberculosis, etc.
- Parasitic infections: malaria, etc.
- Vaccines: possible adverse reactions following specific vaccinations.
- Inflammatory conditions: rheumatoid arthritis, Crohn's disease, etc.
- Neoplasms: specific types of malignant tumors.

Complications of Hyperthermia and Fever:

- Dehydration: excessive loss of body fluids, which can lead to lethargy, confusion, and seizures.
- Seizures: involuntary muscle contractions, more common in infants and young children.
- Delirium: a state of confusion and disorientation.
- Organ damage: in rare cases, severe fever can cause damage to organs such as the liver, kidneys, or brain (8).

Hypothermia, the opposite of hyperthermia, is defined as a prolonged decrease in core body temperature below 36°C or peripheral temperature below 35°C.

Acute hypothermia occurs following immersion in cold water or exposure to low temperatures. Chronic hypothermia develops with certain diseases (e.g., hypothyroidism, diabetes mellitus, chronic alcoholism), aging,

or prolonged exposure to cold. Hypothermia causes major dysfunctions of vital organs: heart – arrhythmias; kidneys – renal failure; brain – confusion or loss of consciousness. Additionally, liver damage, coagulation disorders, and muscle tissue destruction may occur. These impairments arise when the body's temperature-regulating mechanisms begin to fail as core body temperature continues to drop (9).

Table 3. Classification of Hypothermia.

TEMPERATURE (°C)	SYMPTOMS
Mild Hypothermia (32-35ºC)	Patient conscious, shivering, tachypnea, tachycardia
Moderate Hypothermia (28-32ºC)	Loss of thermal control, absence of shivering, exhaustion, drowsiness progressing to loss of consciousness, bradypnea, bradycardia.
Severe Hypothermia (24-28ºC)	Muscle rigidity, hyporeflexia, hypotension, mydriasis, apnea.
Profound Hypothermia (<24 ºC)	Usually with absence of vital signs; ventricular fibrillation (VF) or asystole.

Tips and tricks

- ✓ **Monitoring a febrile patient includes measuring temperature every 2 hours and recording a fever curve, which provides valuable insight into treatment effectiveness and helps guide subsequent therapeutic decisions.**
- ✓ **Use proper temperature measurement techniques and recognize specific clinical signs – measure core temperature using accurate devices, such as a rectal thermometer. Peripheral temperature measurements (oral, axillary) may be inaccurate, especially in severe cases of hypothermia.**

III.3. Respiration

The study of respiration and understanding its mechanisms has seen remarkable development throughout the history of medicine. As early as antiquity, Greek physicians such as Galen and Hippocrates observed the connection between respiration and health, attempting to explain respiratory physiology. One of the most significant innovations in monitoring respiratory function was the invention of the pulse oximeter

Its introduction in the 1970s allowed for non-invasive, continuous measurement of blood oxygen saturation, providing physicians with an essential tool for monitoring respiration. Additionally, the evolution of mechanical ventilation technologies has had a major impact on the treatment of patients with respiratory failure. The first modern mechanical ventilator,

called the "pulmonary ventilator," was developed in the 1920s, but its use expanded significantly during the 1952 polio epidemic, when the "iron lung" saved countless lives. Since then, mechanical ventilation has become an essential component of intensive care, and advanced technologies, such as Continuous Positive Airway Pressure (CPAP), have dramatically improved the prognosis of critically ill patients (10).

Respiration is a complex and essential process for life, allowing the body to obtain oxygen from the atmosphere and release carbon dioxide, a metabolic waste product. Proper respiratory function is crucial for maintaining homeostasis and providing cells with the energy needed to perform various functions.

Respiration can be divided into two main components:

External respiration is the process by which air is inhaled into and exhaled from the lungs. This component involves the following elements:

- **Respiratory airways**: a system of tubes that filter, warm, and humidify the air before it reaches the lungs; these include the nose, pharynx, larynx, trachea, bronchi, and bronchioles.
- **Lungs**: spongy organs that allow the exchange of gases between the air and the blood.
- **Respiratory muscles**: the diaphragm and intercostal muscles, which contract and relax to create the pressure needed for ventilation.

Internal (or tissue) respiration is the process by which oxygen is transported from the blood to the cells, and carbon dioxide is transported from the cells to the blood. This component involves the following elements:

- **Blood capillaries**: allow the exchange of gases between the blood and the tissues.
- **Hemoglobin**: a complex, iron-rich protein found in the cytoplasm of erythrocytes that transports oxygen and carbon dioxide. (11).

Monitoring Methods

a) **Clinical Observation**

This includes assessing respiratory rate, breathing patterns, the use of accessory respiratory muscles, and skin coloration. The normal respiratory rate for a resting adult is 12–20 breaths per minute. In the elderly population, an individual with more than 28 breaths per minute is considered tachypneic. Children have a higher respiratory rate than adults. The average respiratory rate during the first two years of life decreases from 44 breaths per minute at birth to 26 breaths per minute by the second year of life.

It is important to note that these values are averages and can vary individually depending on factors such as: activity level (respiratory rate increases significantly during physical exercise), body position (breathing is generally faster when standing than when lying down), emotional state (anxiety, stress, or fear can increase respiratory rate), and medical conditions (various respiratory, cardiac, metabolic, or neurological disorders can affect respiratory rate). (12).

Respiratory disorders can arise from abnormalities in any component of the respiratory system, including the airways, alveoli, central nervous system, peripheral nervous system, chest wall, and respiratory muscles. Breathing is influenced by various factors, including blood pH (acidosis or alkalosis), carbon dioxide levels (hypercapnia or hypocapnia), and oxygen levels (hypoxia) (13).

Pathological changes in respiration that are clinically significant include the following:

- **Dyspnea** is the sensation of difficult or labored breathing, often characterized by insufficient airflow. Paroxysmal nocturnal dyspnea is the sudden onset of severe breathing difficulty that occurs during the night, usually waking the patient from sleep.
- **Bradypnea** is an abnormally slow respiratory rate, notably slower than the average resting respiratory rate of an individual. Bradypnea is commonly defined as a respiratory rate of fewer than 12 breaths per minute in adults, although this reference range may vary slightly depending on the source.
- **Tachypnea** is an abnormally rapid respiratory rate, defined as a respiratory rate that exceeds the normal range for a person's age and physiological state. The exact threshold may vary, but a common reference for adults is a respiratory rate exceeding 20 breaths per minute at rest.
- **Hyperventilation** describes an abnormal increase in the rate and depth of breathing, leading to a decreased concentration of CO_2 in the blood. Anxiety, panic attacks, fever, or certain medical conditions can trigger hyperventilation. Additionally, stimulation of chemoreceptors due to metabolic acidosis can induce this condition.
- **Hypoventilation** is insufficient ventilation that fails to adequately remove CO_2 from the body. Hypoventilation can be a sign of various underlying medical conditions, including respiratory diseases (e.g., COPD, sleep apnea syndrome), central nervous system disorders, certain medications (e.g., opioids), or neuromuscular conditions that affect the respiratory muscles. (13).
- **Cheyne-Stokes respiration** refers to a cyclical breathing pattern characterized by periods of apnea, followed by a gradual increase in

respiratory rate and tidal volume, then a decrease, leading up to the next apneic period. This pattern is commonly observed in patients with congestive heart failure. (14).

- **Kussmaul respiration** is characterized by deep, rapid, and labored breathing. This pattern occurs in conditions that cause metabolic acidosis, prompting the body to increase the depth and rate of respiration to expel CO_2 and reduce blood acidity. Kussmaul respiration can result from toxic ingestions, such as alcohol and salicylates. (15).
- **Biot's respiration pattern** consists of deep breaths interspersed with periods of apnea, typically resulting from brain injuries caused by stroke or trauma. Opioid intoxication can also trigger the Biot pattern.
- **Agonal respiration** is characterized by infrequent, irregular, and labored breaths, often resulting from anoxic brain injury. Agonal breathing is frequently a critical sign of a life-threatening emergency, such as cardiac arrest. In a patient exhibiting agonal respiration, cardiopulmonary resuscitation (CPR) should be initiated immediately. Rapid intervention significantly increases the chances of survival and recovery for these patients (13).

b) **Pulmonary Auscultation**

Pulmonary auscultation is a simple yet essential medical technique that involves listening to the airflow through the tracheobronchial tree and lung parenchyma.

Technique: The patient is asked to assume a comfortable position with the chest exposed; the clinician places the stethoscope on the chest wall, systematically auscultating all lung areas, both anterior and posterior. It is important that the patient breathes deeply and regularly throughout the examination.

Respiratory sounds can be physiological, such as tubular breath sounds, broncho-vesicular breathing, and vesicular murmur, or pathological, including alterations of the vesicular murmur and added respiratory sounds. (16).

c) **Pulse Oximetry**

Pulse oximetry is a rapid and non-invasive method for measuring peripheral blood oxygen saturation (SpO_2), providing an estimate of arterial oxyhemoglobin saturation (SaO_2). The normal SpO_2 value in adults is 95–100%. An SpO_2 below 90% indicates hypoxemia, a condition characterized by an insufficient amount of oxygen in the blood.

Hypoxemia can result from a variety of conditions, including: Pulmonary disorders (e.g., pneumonia, bronchial asthma, chronic bronchitis,

pulmonary fibrosis), Cardiac conditions (e.g., congestive heart failure, pulmonary embolism), Neurological disorders (e.g., stroke, brain trauma), Toxic **exposures**, such as carbon monoxide poisoning, among others (17).

Pulse oximetry should be used continuously for the monitoring of (18):

- Patients with dyspnea, of cardiac or respiratory origin;
- Surgical patients, both preoperative and postoperative;
- Patients undergoing invasive procedures (e.g., bronchoscopy);
- Critically ill patients;
- Patients undergoing an exercise test to detect oxygen desaturation;
- Patients during sleep – for sleep apnea syndrome;
- Patients with acute pain receiving opioid analgesics (risk of respiratory distress);
- Critically ill patients during intra-hospital or inter-hospital transfer;
- Patients undergoing hemodialysis.

Limitations of pulse oximetry: oxygen dissociation curve shape, peripheral hypoperfusion, skin hyperpigmentation, anemia, dark-colored nail polish, motion artifacts, and limited knowledge of the technique (17).

d) **Arterial Blood Gas Analysis (ABG)**

Arterial blood gas (ABG) analysis involves the direct measurement of partial pressures of gases (O_2 , CO_2) and blood pH from arterial blood obtained via arterial puncture using a heparinized Astrup syringe (18).

The generally accepted normal ranges for ABG components, which may vary depending on the laboratory and age (from newborn to elderly), are: pH: 7.35–7.45, PaO_2 : 75–100 mm Hg, $PaCO_2$: 35–45 mm Hg, HCO_3^- : 22–26 mEq/L, Base excess/deficit: –4 to +2, SaO_2 : 95–100% (19).

e) **Spirometry**

Spirometry is a simple, non-invasive procedure that evaluates lung function by measuring lung volumes and flow rates during forced inhalation and exhalation maneuvers.

Indications (20):

- Assessment of lung function, and diagnosis and staging of pulmonary diseases;
- Monitoring patients with pulmonary conditions, evaluating treatment effectiveness, and identifying exacerbations;
- Preoperative assessment, predicting the risk of respiratory complications following surgical procedures;
- Screening for pulmonary diseases and early identification of patients at risk for COPD;

Contraindications:

- Hemodynamic instability (e.g., patients with acute myocardial infarction, congestive heart failure);
- Pneumothorax;
- Hemoptysis;
- Acute respiratory infections (e.g., bronchopneumonia);
- Recent thoracic trauma (e.g., rib fractures, lung injuries).

f) **Mechanical Ventilation Monitoring**

Mechanical ventilation is a life-saving intervention used in the management of patients with respiratory failure. It involves the use of a ventilator to assist or replace spontaneous breathing. Mechanical ventilation is a cornerstone of critical care, and its application requires a comprehensive understanding of respiratory physiology, ventilator mechanics, and patient management.

Indications for mechanical ventilation (21):

- Acute respiratory failure – conditions such as acute respiratory distress syndrome (ARDS), pneumonia, and acute exacerbations of chronic obstructive pulmonary disease (COPD) often require mechanical ventilation;
- Hypoxemic respiratory failure – patients with severe hypoxemia that cannot be corrected with supplemental oxygen alone require mechanical ventilation to ensure adequate oxygenation;
- Hypercapnic respiratory failure – elevated CO_2 levels due to hypoventilation, commonly seen in conditions such as COPD and neuromuscular disorders, require ventilatory support to remove CO_2 and maintain acid-base balance;
- Airway protection – patients with neurological disorders, drug overdose, or trauma may require intubation and mechanical ventilation to protect the airway and prevent aspiration;
- Surgical and procedural support – mechanical ventilation is used during general anesthesia.

Mechanical ventilation works by delivering controlled breaths to the patient via an endotracheal tube or tracheostomy. The main objectives are to ensure adequate gas exchange and to prevent ventilator-induced lung injury. Key principles include: (21,22):

- Tidal volume (VT) – the volume of air delivered to the lungs with each breath;
- Respiratory rate (RR) – the number of breaths delivered per minute. It is adjusted according to the patient's baseline condition and blood gas values;

- Fraction of inspired oxygen (FiO_2) – the concentration of oxygen in the delivered air, set to maintain adequate oxygenation;
- Positive end-expiratory pressure (PEEP) – the pressure maintained in the lungs at the end of exhalation to prevent alveolar collapse and improve oxygenation;
- Inspiratory flow and duration – the flow rate and duration of the inspiratory phase, which can affect patient-ventilator synchrony.

Tips and tricks

✓ **Breathing should be even and regular, without difficulty, at a rate of 12–20 breaths per minute. Normally, inhalation is about twice as long as exhalation, and chest expansion is symmetrical.**

✓ **If the patient appears anxious or shows perioral cyanosis, intercostal retractions, or uses accessory respiratory muscles, they may be experiencing respiratory distress.**

III.4. Pulse

Pulse monitoring is one of the oldest and most fundamental practices in medicine, with a history dating back to Antiquity. Hippocrates and Galen, the ancient Greek physicians, were among the first to recognize the importance of the pulse as an indicator of health. Significant progress in understanding and measuring the pulse came with the development of modern technology. In the 17th century, the English physician William Harvey revolutionized medicine by describing blood circulation and the heart's role in pumping blood, laying the foundations of modern cardiology (23).

The pulse is the rhythmic wave produced by the expansion of the arterial wall as a result of blood being ejected from the left ventricle of the heart. Measuring the pulse is an essential part of the physical examination, providing valuable information about the functional status of the heart and the circulatory system

Technique: The examiner palpates the artery using three fingers (index, middle, and ring) pressed against a firm (bony) surface. The beats can be counted for 30 seconds and then multiplied by 2 if the heart rhythm is regular. If the rhythm is irregular, the beats should be counted for a full 1 minute (24).

When palpating, the following characteristics of the pulse are evaluated:

- Rate: In a resting adult, it should be 60–100 beats per minute (bpm). A rate below 60 bpm indicates bradycardia, while a rate above 100 bpm indicates tachycardia.

- Rhythm: Normally, the pulse should be regular and uniform. If an irregular rhythm is detected, it may indicate the presence of a cardiac arrhythmia, such as atrial fibrillation.
- Pulse symmetry and synchrony: Normally, the arterial pulse wave occurs simultaneously at two symmetrical arterial points.
- Amplitude: Reflects the strength of the heart's contraction. This force directly influences cerebral blood flow and the volume of blood the heart pumps with each beat.
- Pulse quality: Characterized by tension, speed, and amplitude (24).

To palpate the pulse accurately, it is essential to know the anatomical location of superficial arteries, where the pulse can be easily detected (25):

- Temporal artery: located in the temporal regions, palpated symmetrically;
- Carotid artery (central pulse): located in the anterior cervical region, between the trachea and the sternocleidomastoid muscle. The carotid arteries are palpated successively, compressing the artery against a transverse process of the cervical spine. Excessive pressure on the carotid sinus should be avoided, as it can trigger vagal stimulation, potentially causing bradycardia, especially in elderly patients;
- Axillary artery: palpated at the apex of the axilla;
- Brachial artery: the pulse is palpated on the anterior surface of the elbow joint (antecubital fossa); the pulse lies medial to the biceps tendon;
- Radial artery: palpated in the radial groove; the radial pulse is often assessed to determine rate and rhythm due to its easy accessibility.
- Ulnar artery: palpated in the cubital groove;
- Femoral artery: palpated in the inguinal region, at the midpoint between the anterior superior iliac spine and the pubic symphysis, inferior and medial to the inguinal ligament.
- Popliteal artery: palpated deep in the popliteal fossa, with slight flexion of the lower leg on the thigh.
- Posterior tibial artery: palpated posterior to the medial malleolus.
- Dorsalis pedis artery: palpated in the first intermetatarsal space.

Tips and tricks

✓ **Special attention should be paid to pulse quality, in addition to rate and rhythm. Changes in pulse amplitude, such as weak pulses, can provide critical clues about cardiac function, volume status, or**

peripheral perfusion, guiding diagnostic and therapeutic interventions;

✓ **Carotid sinus massage is a vagal maneuver used to slow the heart rate and can be effective in terminating episodes of paroxysmal supraventricular tachycardia (PSVT). The technique should be performed with the patient in a supine position, and the head slightly rotated to the side to expose the carotid arteries;**

III.5. Blood Pressure

The history of measuring blood pressure represents an essential chapter in the development of modern medicine. The first attempts to understand blood pressure were made in the 18th century, when Stephen Hales, an English scientist, conducted experiments on horses by inserting glass tubes directly into their arteries to observe the level of pressure exerted by the blood (26).

From the 20th century to the present, technologies for monitoring blood pressure have evolved considerably. Automatic and digital devices have become available, providing fast and accurate measurements. Ambulatory blood pressure monitoring (ABPM) and wearable devices have offered new insights into blood pressure variations throughout the day and night, thus contributing to better management of hypertension (27).

Blood pressure (BP) is a critical vital sign that provides essential information about patients' cardiovascular health. Accurate measurement of blood pressure is fundamental in the diagnosis and management of hypertension (HTN) and other cardiovascular conditions.

Proper patient preparation to obtain an accurate blood pressure reading includes the following recommendations (28):

- The patient should avoid caffeine, smoking, and physical exercise for at least 30 minutes before the measurement;
- The patient should empty their bladder before the measurement to avoid any potential increase in blood pressure due to bladder distension;
- The patient should be seated comfortably with their back supported;
- The arm should be positioned at heart level, resting on a flat surface
- The cuff should be placed on the bare arm, with the lower edge of the cuff 2–3 cm above the antecubital fossa (using a properly sized cuff is recommended to avoid measurement errors)
- The patient must remain silent and motionless during blood pressure measurement.

Blood pressure represents the force exerted by the blood circulating through the walls of the blood vessels. It is expressed as two values: systolic blood pressure (SBP) and diastolic blood pressure (DBP). SBP is the pressure exerted on the arterial walls during the contraction of the left ventricle (LV). During systole, the LV contracts, pumping blood into the aorta and subsequently into the systemic circulation. DBP is the pressure exerted on the arterial walls during the relaxation phase of the cardiac cycle, representing the pressure that keeps blood flowing through the arteries during ventricular diastole (29).

Technique:

a) The Riva-Rocci Method:

The Riva-Rocci technique, described by Scipione Riva-Rocci in 1896, was one of the first methods for indirect measurement of blood pressure. This technique involves the use of a mercury sphygmomanometer and an inflatable cuff (30).

To determine blood pressure using the Riva-Rocci method, the cuff of the sphygmomanometer is applied to the patient's arm, 2–3 cm above the elbow crease. The radial pulse is palpated, and the cuff pressure is increased by 30 mmHg above the point at which the radial pulse disappears. The cuff is then gradually deflated in 2–3 mmHg increments until the first pulse wave reappears, at which point the systolic blood pressure value is recorded. (31).

b) The Korotkoff Method:

Developed by Dr. Nikolai Korotkoff in 1905, the Korotkoff technique improved upon the Riva-Rocci method by introducing the auscultatory approach to measure blood pressure using distinct sounds heard through a stethoscope (32).

To accurately measure blood pressure using the Korotkoff method, the patient should be positioned comfortably with the arm supported at heart level. The cuff of the sphygmomanometer is then applied to the upper arm, and the radial pulse is palpated. The cuff pressure is raised 30 mmHg above the point at which the radial pulse disappears. The cuff is then gradually deflated at a rate of 2–3 mmHg while listening for Korotkoff sounds by placing the stethoscope diaphragm over the brachial artery. The appearance of the first clear tapping sounds indicates the systolic blood pressure (SBP), while the disappearance of the Korotkoff sounds corresponds to the diastolic blood pressure (DBP) (31).

Hypertension (HTN) is defined as a persistent increase in systolic blood pressure (SBP) above 140 mmHg and/or diastolic blood pressure (DBP) above 90 mmHg. Blood pressure is measured in millimeters of mercury (mmHg). The 2023 ESC/ESH guidelines provide the following classification

Table 4. Classification of Hypertension – adapted from (33)**.**

Category	TAS (mmHg)	TAD (mmHg)
Optimal	<120	<80
Normal	120-129	80-84
High-Normal	130-139	85-89
Stage 1 Hypertension	140-159	90-99
Stage 2 Hypertension	160-179	100-109
Stage 3 Hypertension	≥180	≥110
Isolated Systolic Hypertension	≥140	<90
Isolated Diastolic Hypertension	<140	≥90

The blood pressure category is defined by the higher value of blood pressure, either systolic or diastolic.

Isolated systolic or diastolic hypertension is classified as stage 1, 2, or 3 based on the SBP and DBP values within the specified ranges.

The classification of hypertension into essential and secondary HTN serves as a fundamental framework for understanding its etiology, diagnosis, and management.

a) **Essential Hypertension** represents the majority of hypertension cases, affecting approximately 90–95% of individuals diagnosed with the condition. This form of hypertension develops gradually over time and is multifactorial in nature, influenced by a complex interaction of genetic factors, environmental factors, and lifestyle. Risk factors associated with essential hypertension include advanced age, family history, obesity, physical inactivity, smoking, and psychosocial stress. Additionally, other conditions such as diabetes mellitus, dyslipidemia, and chronic kidney disease synergistically contribute to its pathogenesis. The pathophysiology of essential hypertension involves dysregulation of multiple physiological mechanisms, including changes in vascular tone, endothelial dysfunction, sodium and water retention, activation of the renin-angiotensin-aldosterone system (RAAS), sympathetic nervous system hyperactivity, and inflammation. Genetic predisposition also plays a crucial role, with numerous genes involved in blood pressure homeostasis. The diagnosis of essential hypertension is based on accurate blood pressure measurement using standardized techniques and classification criteria established by professional organizations such as the European Society of Cardiology (ESC). Management strategies include lifestyle modifications, such as dietary sodium restriction, weight reduction, regular physical activity, moderation of alcohol intake, and smoking cessation. Pharmacological interventions, tailored to the individual patient's characteristics and comorbidities, often involve antihypertensive medications targeting various pathways involved in blood pressure regulation. (34).

b) **Secondary Hypertension** accounts for approximately 5-10% of hypertension cases and requires thorough evaluation to identify the underlying cause. Secondary HTN arises from a diverse range of etiologies, such as renal parenchymal diseases, renovascular disorders, endocrine disorders (example, primary aldosteronism, Cushing's syndrome, pheochromocytoma, hyperthyroidism), obstructive sleep apnea, coarctation of the aorta, and certain medications (example, nonsteroidal anti-inflammatory drugs, oral contraceptives). The diagnosis of secondary hypertension requires a detailed medical history, physical examination, laboratory tests, and imaging studies to determine the underlying cause. Management strategies are focused on addressing the specific etiology while simultaneously controlling blood pressure to prevent target organ damage. Treatment approaches may include surgical interventions, pharmacological therapies, and lifestyle modifications. Secondary hypertension is particularly encountered in young patients at diagnosis or in patients with resistant hypertension, as these scenarios often raise suspicion for an underlying secondary cause. (35).

Tips and tricks

- ✓ **At the first medical visit, blood pressure should be measured in both arms to identify any significant inter-arm difference; subsequent measurements should be taken on the arm with the higher value;**
- ✓ **Inter-arm blood pressure difference (≥ 20 mmHg) may indicate an obstruction at the aortic arch (coarctation of the aorta) or its branches (subclavian artery stenosis).**

III.6. Diuresis

Today, urine is studied to diagnose certain conditions, but from ancient times up to the Victorian era, it was used as a primary diagnostic tool, marking the beginnings of laboratory medicine (36).

Urine examination was historically called uroscopy, and today it is known as urinalysis. Uroscopy was a diagnostic method used for thousands of years. Physicians referred to urine as a "divine fluid" or a window into the body. Over time, the importance of urinary diagnosis became exaggerated and increasingly complex, to the point where doctors sometimes needed only the presence of urine-not the patient- to diagnose a disease.

Babylonian and Egyptian physicians pioneered the art of uroscopy. The term uroscopy means "scientific examination of urine." It derives from the Greek words *ouron*, meaning "urine," and *skopeo*, meaning "to look, contemplate, examine, or inspect."

Thomas Brian led a medical rebellion against all uses of uroscopy and published *The Pisse Prophet*, a book that critically dismantled uroscopy.

Although uroscopy is no longer practiced today, urinalysis remains an effective diagnostic tool with a long and colorful history

Diuresis refers to the amount of urine excreted over a 24-hour period.

The renal system is composed of the kidneys, ureters, and urethra. Its primary function is to filter approximately 200 liters of fluid daily from the renal blood flow, allowing the elimination of toxins, metabolic wastes, and excess ions while retaining essential substances in the blood. The kidney regulates plasma osmolarity by modulating the amount of water, dissolved substances, and electrolytes in the blood.

Regulation of body fluid balance is a key concern in health. Water is necessary for temperature regulation, cellular homeostasis, substrate transport across membranes, metabolism, and circulatory system performance. The 24-hour water requirement varies according to anthropometric characteristics (especially weight and height). Fluid intake should range between 6–8 glasses of water per day (1 glass ≈ 300 ml) to prevent dehydration.

Urine volume varies depending on the individual and is influenced by normal kidney function, fluid intake, diet, ambient temperature, fluid needs of other organs, presence of open wounds, losses through skin, intestines, respiration, and medications such as diuretics. An intact neuromuscular system and the action of antidiuretic hormone also affect urinary output.

Inadequate urine output may result from a kidney that fails to produce urine (suppression) or from a blockage in urine flow (retention) somewhere between the kidney and the external urinary meatus. Suppression can be caused by renal disease or other conditions and may also be secondary to insufficient fluid intake.

Retention may be mechanical or functional. Mechanical retention occurs due to obstructive causes such as stenosis or a urinary stone. Functional retention refers to any non-mechanical retention, which can include neurogenic problems.

Reference ranges for urination frequency in healthy women are typically 2–10 times during the day and 0–4 times at night. Women aged 45–64, but not those over 65, report a higher number of daytime voids compared to women aged 31–44, whereas women over 65 report more voids. Black women report fewer daytime voids and more nighttime voids than Caucasian women. (42)

Abnormalities of Urine Volume (43):

Urine output can undergo changes. Urine volume varies depending on fluid intake, kidney function, and the individual's physiological needs:

- **Polyuria –** increased urine production
- **Oliguria –** decreased urine production
- **Anuria –** absence of urine production;

The most common urinary disorders are frequent urination, urinary incontinence (involuntary and unconscious urination), and nocturia. Therefore, urinary disorders should not be overlooked;

- **Dysuria –** painful or difficult urination (commonly associated with urinary tract infections).
- **Pollakiuria –** frequent urination with small volumes.
- **Ischuria (urinary retention) –** the inability of the bladder to empty its contents, resulting in a distended bladder (bladder globe).
- **Nocturia –** a reversal of the normal urination pattern, with increased urination at night compared to daytime**.**
- **Tenesmus –** difficulty or straining during urination.

Urine Abnormalities (43):

- ***Proteinuria* –** elevated levels of protein in the urine; it can occur secondary to relatively benign conditions such as dehydration or intense physical exercise, or more serious conditions such as kidney disease
- ***Hematuria* –** the presence of two to five red blood cells per microscopic field; common causes of isolated hematuria include kidney stones, neoplasms, tuberculosis, trauma, or prostatitis
- ***Pyuria* –** indicates the presence of bacteria in the urinary tract; it is often associated with hematuria and signifies a urinary tract infection.

Urine Color (44):

The normal color of urine ranges from clear (overhydration) to pale yellow (optimal hydration). However, it can change. Certain foods, such as beets, blackberries, and beans, can turn urine pink or red. Some medications can also impart vivid colors, such as orange or bluish-green. Pink or red urine is usually due to the presence of blood. Dark brown or orange urine accompanied by jaundiced skin and sclera, along with pale-colored stools, may indicate liver pathology.

Suspected urinary tract infections in children should be carefully investigated, as they may signal underlying anatomical abnormalities (45).

Collection Guidelines

Standard Information:

- Hand and genital washing is mandatory before collection.
- The use of sterile, single-use containers is recommended.
- The first stream is discarded in the toilet - subsequently, the midstream will be collected.
- Urine samples are not collected in the presence of menstrual flow - if necessary, an intravaginal tampon will be used.

1. Urinalysis is a comprehensive urine test that examines physical and chemical characteristics as well as a microscopic evaluation; it is recommended to collect a sample from the first morning urine.

2. Urine Culture is a laboratory test that detects urinary tract infections. It is recommended to collect the sample from the first morning urine or at least 3 hours after the previous voiding. The sample should ideally be collected before starting antibiotic treatment or at least 5–7 days after completing a course of antibiotics.

3. 24-Hour Urine Collection – Some laboratory tests require a 24-hour urine collection, allowing quantitative measurement of substances present in urine (e.g., glucose, proteins). The first morning urine is not collected. All subsequent urine over the next 24 hours is collected in clean containers, which should be stored in the refrigerator inside a bag. After 24 hours, the total urine volume is measured, and the volume is noted on the container used for the sample. The collected urine is then mixed thoroughly, and 50–100 ml is set aside for examination.

III.6.1. Urinary Catheterization

The term "catheter" comes from the Greek word meaning "to let down" or "to send down." Emptying a painfully overfilled bladder has likely been a concern for humanity since ancient times. Catheterizations have been reported using reeds, straws, and coiled palm leaves.

Urinary catheterization is a commonly performed procedure in all hospitals. It can be carried out using external, urethral, or suprapubic techniques. While generally safe, it is associated with complications, most notably urinary tract infections, which are the most common hospital-acquired infections. Urinary catheterization is performed for both therapeutic and diagnostic purposes. Catheters can be used for short-term or long-term management but should be replaced at intervals not exceeding 21 days to prevent urinary tract infections.

There are three types of urinary catheters based on the route of insertion:

1. **External catheters** adhere to the external genitalia in men or the pubic area in women and collect urine. They are useful for managing urinary incontinence.
2. **Urethral catheters** are inserted through the urethra, with the tip advanced to the base of the urinary bladder.
3. **Suprapubic catheters** are surgically inserted into the bladder through a suprapubic approach.

Urinary catheterization is the most commonly performed procedure in routine clinical practice. Normally, the bladder is not palpable unless it contains more than 150 ml of urine. Suprapubic percussion produces a hollow sound; a dull or flat sound indicates bladder distension. Edema in the suprapubic area may be observed when the bladder contains around 500 ml of urine. Pain can be felt when the bladder is distended up to the level of the umbilicus (approximately 1,400–1,900 ml). Subjective symptoms are not reliable indicators of bladder fullness

The kit required for this procedure contains the following items:

1. Antiseptic solutions for genital cleansing;
2. Kidney tray
3. Two sterile hemostatic forceps
4. Sterile drape; sterile drape with a central opening
5. Medical mask
6. Sterile gloves
7. Sterile gauze pads
8. Sterile lubricating gel
9. Sterile Foley catheter
10. Saline solution for inflating the balloon
11. Graduated collection bags for measuring urine output
12. Plastic catheter
13. Absorbent underpad
14. Biohazard waste bag
15. Containers for urine culture

1. External Catheters.

Insertion of the external catheter in women

Hand washing and disinfection are mandatory before performing this procedure. Urinary catheterization in women begins with patient preparation - the procedure is explained in detail, and privacy is ensured by covering the pelvic region and lower limbs with a sheet.

The patient is placed in the supine position, with the legs slightly flexed, thighs apart, and feet resting on the mattress; placing a pillow under the buttocks is recommended. This position allows good visualization of the urinary meatus. The sheet is folded so that the perineum is adequately exposed for the procedure.

Perineal care is performed if necessary, using soap and water with clean gloves, after which the perineum is thoroughly dried.

The external catheter will be secured in the following steps (48)**:**

1. Opening the sterile packaging of the urinary catheterization kit by tearing the package at the edge lined with plastic film
2. Placing the biohazard waste bag next to the bed for disposal of waste;
3. Placing the urinary catheterization kit on the bed, between the patient's legs;
4. The sheet is folded so that the perineum is adequately exposed for the procedure to be performed
5. Putting on sterile gloves;
6. Removing the sterile items from the tray and arranging them conveniently on the sterile field;
7. Opening the sterile package and soaking the sterile gauze pads with antiseptic solution;
8. Opening the lubricant, then lifting the catheter tip and generously lubricating the tip of the catheter;
9. If a sample is required, remove the cap of the urine culture container;
10. Move the catheter tray close to the patient, onto the sterile field;
11. Preparing the patient's urinary meatus:
    a) Using the nondominant hand, separate the patient's labia minora from the labia majora (maintain this separation throughout the preparation)
    b) With the dominant hand, use a hemostatic forceps to pick up a sterile gauze pad soaked in antiseptic solution
    c) Clean the urinary meatus with the gauze pad using a single downward stroke; repeat this step 3–4 times using a new sterile pad each time.
    d) The compress will be discarded in the biological waste bag;
    e) Keep the patient's labia separated until the catheter is inserted.

12. With the dominant hand, lift the lubricated catheter, directing the flow into the collection container, and insert it approximately 1 cm or until urine begins to flow;
13. The nondominant hand holds the catheter in position;
14. Place the urine culture container under the catheter drainage if a sample is needed, filling the container with approximately 30 ml of urine
15. Reposition the catheter drainage tip into the collection container and allow the urine to flow;
16. Close the catheter at the end and remove it slowly and gently.
17. Remove the sheet and dry the perineal area.
18. Measure and record the urine volume in the appropriate log or chart;
19. Dispose of gloves and equipment properly;
20. Perform hand hygiene;
21. Label the sample, place it in the transport bag, and send it to the laboratory;
22. Document the procedure in the patient's medical record.

Insertion of the external catheter in men

Hand washing and disinfection are mandatory before performing this procedure. Urinary catheterization in men begins with patient preparation - the procedure is explained in detail, and privacy is ensured by covering the pelvic region and lower limbs with a sheet. The patient is placed in the supine position, with the legs flexed and thighs apart, and feet resting on the mattress. The sheet is folded so that the perineum is adequately exposed for the procedure. Perineal care is performed if necessary, using soap and water with clean gloves, after which the perineum is thoroughly dried.

The external catheter will be secured in the following steps: (48)**:**

1. Open the sterile packaging of the urinary catheterization kit by tearing the package at the edge lined with plastic film;
2. Place the biohazard waste bag next to the bed for disposal of waste;
3. Place the urinary catheterization kit on the bed, between the patient's legs;
4. Fold the sheet so that the perineum is adequately exposed for the procedure to be performed;
5. Put on sterile gloves;

6. Remove the sterile items from the tray and arrange them conveniently on the sterile field.
7. Place the sterile drape over the thighs and under the penis
8. Place the sterile drape with a central opening over the penis;
9. Open the sterile package and soak the sterile gauze pads with antiseptic solution;
10. If a sample is needed, remove the cap from the urine culture container;
11. Hold the penis upward with the nondominant hand;
12. With the dominant hand, use a hemostatic forceps to pick up a gauze pad soaked in antiseptic solution;
13. Clean the urinary meatus with the gauze pad using a circular motion; repeat this step 3–4 times with a new sterile pad each time;
14. Dispose of the sterile gauze pad in the biohazard waste bag;
15. Continue holding the penis upward with the nondominant hand;
16. Open the lubricant, then lift the tip of the catheter and generously lubricate it;
17. Grasp the catheter approximately 8–10 cm from its tip;
18. Lift the penis to a 90° angle and apply gentle upward traction;
19. Retract the foreskin (decalot the penis);
20. Insert the catheter approximately 24–25 cm.
21. If the catheter meets resistance, lower the angle of the penis to 45° or less and ask the patient to take a deep breath to promote relaxation; if resistance persists, remove the catheter.
22. Place the urine culture container under the catheter drainage if a sample is needed, filling it with approximately 30 ml of urine
23. Reposition the catheter drainage tip into the collection container and allow the urine to flow
24. Close the catheter and remove it slowly and gently.
25. Remove the sheet and dry the penis.
26. Measure and record the urine volume in the appropriate log or chart
27. Dispose of gloves and equipment properly;
28. Perform hand hygiene.
29. Label the sample, place it in the transport bag, and send it to the laboratory.
30. Document the procedure in the patient’s medical record.

2. Urethral Catheters

For urine collection, single-use catheter kits are used, containing retention catheters of appropriate sizes (size 14- 16 for females and 16–18 for males) and a preconnected closed system of 2000 ml. The procedure follows the same hygiene measures as for external catheter insertion. The catheter is selected using a sterile hemostatic forceps, and the tip is then lubricated. The catheter is held like a pencil and inserted into the urinary meatus with gentle movements. If resistance is encountered, withdraw the catheter 2–3 cm and reinsert it using a circular motion. Entry into the bladder is indicated by the flow of urine. The catheter is then connected to the drainage tube and attached to the collection bag. For long-term catheterization, the catheter can be secured in the bladder by inflating the balloon with 10–15 ml of saline through the corresponding tube.

Indications for Urinary Catheterization:

Therapeutic Purpose

a. **Urinary retention**, which can be acute or chronic. Causes of urinary retention may include:
    1. **Obstructive – intrinsic obstruction** - for example, benign prostatic hyperplasia, strictures, tumors / **extrinsic obstruction** - extrinsic obstruction of the ureter occurs when surrounding organs press on the ureter, causing a blockage; this affects urine flow from the ureter, and over time, urine can accumulate, potentially damaging the kidneys.
    2. **Infectious and inflammatory causes:** cystitis, urethritis, prostatitis (a common infectious cause in men), and vulvovaginitis in women can lead to urinary retention.
    3. **Pharmacological causes:** medications with anticholinergic properties (affecting the central nervous system).
    4. **Neurological causes (49):** brain or spinal cord injuries, strokes, multiple sclerosis, Parkinson's disease, and dementia can lead to urinary retention.
b. ***Preoperative –*** Urinary catheterization is performed preoperatively in most abdominal surgeries, such as urological and gynecological procedures. Bladder catheterization is also useful in surgical patients who require strict intraoperative urine drainage. In addition, it helps manage postoperative urinary retention caused by anesthesia and allows better control of postoperative pain. (50).
c. Neurogenic bladder dysfunction
d. Urinary incontinence

e. For social and hygiene reasons

f. Patients with acute conditions requiring close monitoring of urine output

DIAGNOSTIC PURPOSE

a) Collection of samples for urine analysis (51)

The NICE guidelines (2003) suggest that the clinical need for catheterization should be regularly reviewed, and the catheter should be removed as soon as possible (52). However, long-term maintenance of urinary catheters is associated with the following complications: urinary tract infections, urethral sphincter damage, urethral erosion, epididymitis, prostatitis, vesicle or renal calculi, and others.

Urinary catheterization should not be performed in the presence of hematuria, urethral infection, pain, or if the patient refuses.

Tips and tricks

- ✓ **When urine tests are recommended, it is especially important to know both the most commonly used tests performed on urine samples and the necessity of performing them;**
- ✓ **Urinary catheterization should not be performed without knowledge of the anatomy and physiology of the genitourinary tract;**
- ✓ **The examiner must be familiar with the most common conditions that can occur in this area;**
- ✓ **Demonstrate professionalism**

III.7. Stool

Since the early 20th century, scientists have been seeking methods to improve stool examination, aiming for greater sensitivity and more accurate indicators (53).

Starting in 1908, several qualitative techniques were developed to improve the parasitological diagnosis of stool. These methods were based on separating solids and liquids in the fecal suspension to remove excess debris and obtain a concentrated sediment containing parasites. The principle of centrifugation - sedimentation, used in laboratories to recover intestinal parasites from stool samples, was first reported by Telemann

The first technique developed for the identification of nematode larvae was described in 1917 by Baermann.

In the 1940s, Lawrence Ritchie introduced an alternative strategy for stool sample preparation compared to the method reported by Telemann. In this procedure, feces without preservatives were diluted in saline solution and filtered through two layers of gauze, followed by repeated washes via centrifugation and resuspension of the sediment.

In 1953, Maldonado and Acosta-Matienzo added a neutral detergent to the procedure described by Ritchie in 1948.

In 1970, Allen and Ridley, due to the flammability, volatility, explosion risk, and environmental toxicity of ethyl ether, proposed further modifications to simplify Ritchie's method. Their approach involved centrifuging the sample at 3,000 revolutions per minute for one minute, with improved filtration.

Due to the high daily demand for stool examinations in clinical laboratories, the use of commercial kits has become common, offering a practical and cost-effective option (53).

Stool Examination:

Stool examination is a medical diagnostic technique that involves the collection and analysis of fecal matter. Tests performed on stool samples include microbiological analysis (culture), microscopy, and chemical tests

- **Coproparasitological examination** - testing fecal matter to identify intestinal parasites
- **Stool culture (coproculture)** - testing fecal matter to identify pathogens responsible for gastrointestinal disorders;
- **Occult blood test** - testing fecal matter to detect gastrointestinal bleeding.

Defecation (41,43) is triggered by distension of the rectum, which, through parasympathetic innervation, causes partial and temporary relaxation of the internal anal sphincter. Sigmoid and rectal contractions increase the pressure within the rectum. Contraction of the external anal sphincter can delay defecation until a socially appropriate time. Simultaneous relaxation of both the internal and external anal sphincters then allows the expulsion of feces, which can be aided by increased intra-abdominal pressure generated through the Valsalva maneuver. Daily, approximately nine liters of fluid enter the gastrointestinal tract: two liters from direct ingestion, one liter as saliva, two liters as gastric juices, and four liters from biliary, pancreatic, and small intestinal secretions. In the small intestine, four to five liters of fluid are reabsorbed in the jejunum and three to four liters in the ileum. Consequently, the remaining fluid, about one liter, enters the large intestine, and around 800 ml is reabsorbed before reaching the rectum and being evacuated. Globally, the normal amount of fluid excreted in feces is approximately 200 ml per day.

The normal frequency of bowel movements ranges from 3 times per week to 3 times per day. Factors that influence stool weight, consistency, and frequency include dietary fiber intake, physical activity, stress exposure, and sex (the average daily stool weight is lower in women than in men).

Diarrhea is defined as a stool frequency of more than 3 times per day or an increase in stool weight of over 200 g per day. It should be distinguished from pseudodiarrhea, which is characterized by increased frequency of defecation without an increase in stool weight above normal (for example, in irritable bowel syndrome). Diarrhea must also be distinguished from fecal incontinence, which is the involuntary release of rectal contents.

Diarrhea can be acute (lasting 7–14 days) or chronic (persisting for weeks or even months, and can be constant or intermittent).

Constipation is defined as a stool frequency of fewer than 3 times per week.

III.7.1. Rectal Examination

The rectal examination is often a neglected part of the physical exam. For practitioners who know how to interpret it, this examination can provide a wealth of information.

Rectal examination is not performed on every patient, although it has many uses and is certainly underutilized. It is a valuable diagnostic procedure in cases including, but not limited to, gastrointestinal bleeding, inflammatory bowel disease, hemorrhoids, constipation, trauma, and neurological disorders (54).

Most often, the rectal examination is performed in the presence of **melena** (dark-colored stool caused by the presence of blood in the stool, resulting from bleeding in the upper gastrointestinal tract).

Hand washing and disinfection are mandatory before performing this procedure.

At the start of the examination, the examiner can identify any condition that might make continuation of the exam difficult for the patient (such as pain on palpation). In such cases, the rectal examination can be postponed until symptoms are initially managed.

The steps of the rectal examination include the following stages (41):

1. Take the patient's medical history (anamnesis).
2. Prepare the necessary equipment: sheet, gloves (one or two pairs), lubricant, commode chair, towel, toilet paper.
3. Put on gloves (two pairs can be used simultaneously to prevent contamination if one pair tears).
4. Inspect the anal region.

5. Palpate the anal region.
6. Lubricate the index and middle fingers of the nondominant hand.
7. Perform the rectal examination – after palpation, the examiner conducts a digital examination. During the rectal exploration, any existing conditions can be better evaluated, and the contraction and relaxation of the sphincter muscles can be assessed.
8. Perform **rectoscopy** and **anoscopy** if necessary.

Tips and tricks

- **When stool examinations are recommended, it is important to be familiar with the most commonly used tests performed on stool samples.**
- **The rectal examination should not be performed without knowledge of the anatomy and physiology of the rectum.**
- **The examiner must be familiar with the most common conditions that can occur in this area.**
- **Demonstrate professionalism.**

III.8. Vomiting

Nausea and vomiting are common symptoms encountered in medicine (55). They have traditionally been considered as part of the same pathophysiological mechanism, triggered by similar stimuli and involving the same neural circuits, but with variable intensity and duration.

However, the two symptoms can also occur independently. Consequently, nausea and vomiting have traditionally been studied together, with the assumption that managing one would effectively control the other. Since vomiting is more overt and objective, most studies have focused on it.

Although most acute cases of nausea and vomiting with a specific cause can be easily managed, chemotherapy-induced nausea and vomiting**,** and especially chronic unexplained nausea and vomiting**,** can be difficult to control, leading to a significant reduction in patient quality of life and increased medical costs due to repeated hospitalizations.

Nausea and vomiting can occur separately, but they are usually closely related and are thought to be regulated by the same neural pathways (43). Nausea is the sensation of an imminent need to vomit, typically felt in the epigastric region. Vomiting (emesis**)** is the forceful and explosive expulsion of gastric contents through the mouth. The act of vomiting involves rhythmic

contractions of the respiratory and abdominal muscles, which often precede or accompany the expulsion.

Nausea and vomiting are frequent symptoms in a wide range of organic and functional disorders**.**

Vomiting can occur in (43):

- ***Disorders of the digestive tract***
- ***Infections of the intestinal tract***
- ***Disorders of the central nervous system***
- ***Metabolic disorders***
- ***Endocrine disorders***
- ***Emotional disorders***

Vomiting should be distinguished from **regurgitation**, which involves the expulsion of food without the sensation of nausea and without the abdominal and diaphragmatic muscle contractions associated with vomiting.

The characteristics of vomiting (43) provide important diagnostic clues (see Table 1)

Table 5. Characteristics of vomiting – adapted after (56)**.**

Duration	Acute/Chronic
Character	Persistent/Intermittent
Intensity	Low/Moderate/High
Volume	In accordance with the amount of food ingested
Associated symptoms	Headache, abdominal pain
Aggravating factors	Ambient smell/movement
Relieving factors	Antiemetic medication
Ongoing oncologic treatment	Chemotherapy/Radiotherapy

If the vomitus contains large amounts of free hydrochloric acid, a gastric emptying obstruction secondary to an ulcer or a hypersecretory state may be suspected. The absence of free hydrochloric acid may indicate a malignant gastric condition. A fecal odor reflects bacterial activity on the intestinal contents and may occur in cases of distal intestinal obstruction, peritonitis, or gastrocolic fistula. The presence of bile is often observed in gastric contents in cases of prolonged vomiting; it is only significant if it is consistently present in large amounts. The presence of blood (hematemesis) in the gastric contents usually indicates bleeding from the esophagus, stomach, or duodenum. (43).

Tips and tricks

- ✓ **It is important to distinguish the characteristics of vomiting.**
- ✓ **The examiner should be familiar with the most common situations in which vomiting may occur.**

III.9. Nasogastric tubing

The use of nasogastric feeding tubes dates back to the second half of the 19th century (57). Nasogastric tubes are, as their name suggests, tubes that are inserted through the nasal passages, pass through the posterior part of the oropharyngeal cavity, into the lower esophagus, and then into the stomach. Dr. Abraham Levin first described their use in 1921.

Nasogastric tubes are part of the standard of care in treating intestinal obstructions and can also be used to provide nutritional support. They are most commonly encountered in surgical patients but are useful for all patients who require gastric decompression or nutritional support (58).

Washing and disinfecting hands is mandatory before performing this procedure.

The kit required for this procedure contains the following items:

1. Sterile gastric tube;
2. Water-based lubricant gel
3. Kidney tray
4. Absorbent underpad
5. Medical mask;
6. Disposable gloves
7. Syringes
8. Collection container;
9. 9. Stethoscope
10. Biohazard waste bag
11. Chair with backrest

The nasogastric tube should be secured in the following steps: (41):

1. The patient will be informed about the procedure to be performed;
2. The patient will be positioned at a 45-degree angle;
3. Initially, the nostrils will be examined, and the more patent nostril will be chosen for tube insertion;
4. The kidney tray will be placed under the patient's chin and kept in position throughout the procedure

5. Next, a measurement will be taken - the end of the tube will be held from the tip of the nose to the earlobe, and then the distance to the tip of the xiphoid process will be measured; this distance estimates how far the tube needs to be advanced and will be appropriately marked;
6. The tip of the tube (first 2 cm)
7. The patient's head will be positioned in slight hyperextension, and the tube will be carefully inserted through the more patent nostril toward the nasopharynx
8. By swallowing, the tube will advance into the stomach up to the previously marked measurement;
9. Perform auscultation to verify that the tube is correctly positioned;
10. Aspirate the gastric contents with a 50 ml syringe to check the color and pH.;
11. If the patient experiences discomfort, the tube will be repositioned; if it is still not tolerated, it will be removed.

Indications:

- Gastric decompression
- Exclusion of a source of upper gastrointestinal bleeding;
- Treatment of intestinal obstructions - for example, intestinal occlusion (absence of intestinal transit of feces and gas);
  Enteral access for administering medication or nutrients to patients with a functional gastrointestinal tract but who cannot tolerate oral intake.

Contraindications:

- Presence of significant facial trauma or basal skull fractures

Complications:

- Discomfort;
- Sinusitis;
- Epistaxis, although these usually resolve spontaneously once the nasogastric tube is removed.

Whether used for gastric decompression, to provide enteral access for nutrition and medication in a patient intolerant to oral intake, or to exclude a source of upper gastrointestinal bleeding in the context of massive hematochezia, nasogastric tubes are part of the standard of care for many routine health issues (59).

Gastric lavage helps (41) to stop bleeding and to remove fluid from the stomach. It is also used to eliminate unabsorbed substances from the stomach.

Gastric lavage in cases of drug ingestion is generally ineffective if more than 60 minutes have passed. It is not used for corrosive agents or petroleum distillates due to the risk of aspiration.

Tips and tricks

- ✓ **Frequent examination of the patient to ensure that the tube is securely fixed and correctly positioned**
- ✓ ***Activated charcoal* absorbs significant amounts of certain medications; the earlier it is administered, the more effective it is.**

III.10. Blood Glucose

Being one of the most frequently measured parameters, glucose evaluation dates back to the time of the ancient Egyptians (60). Blood glucose self-monitoring began fifty years ago. Until then, metabolic control was assessed through qualitative measurements of urinary glucose, which were often unreliable. Test strips were the first semi-quantitative tests for glucose monitoring, and by the late 1970s, glucometers were introduced to the market. Initially, these devices were intended for medical personnel, but with improvements in ease of use, they became increasingly suitable for patients and are now an essential tool for blood glucose self-monitoring (61).

Achieving and maintaining good glycemic control is a cornerstone of diabetes care. Current glycemic control monitoring relies on blood glucose self-monitoring and laboratory testing of glycated hemoglobin (HbA1c), which is a biochemical surrogate marker of the average blood glucose level over the past 2–3 months (62).

Blood glucose monitoring helps identify patterns of blood glucose fluctuations that occur in response to diet, exercise, medications, and pathological processes associated with glucose variability, such as diabetes mellitus. (63).

Diabetes mellitus (DM), the most common endocrine disease, is characterized by metabolic disorders and long-term complications affecting the eyes, kidneys, nerves, and blood vessels (64). Diagnosing symptomatic diabetes is not difficult. If a patient presents signs and symptoms consistent with osmotic diuresis and hyperglycemia is detected, the diagnosis is confirmed.

Asymptomatic patients, however, who are suspected of having diabetes but have normal blood glucose levels, are often subjected to an oral glucose tolerance test (OGTT). If abnormal glucose levels are found, they are diagnosed with impaired glucose tolerance or diabetes (64).

Most cases of diabetes can be classified into two categories: type 1 diabetes and type 2 diabetes, although some cases are difficult to classify. Gestational diabetes refers to glucose intolerance that begins during pregnancy.

The International Diabetes Federation estimates that 537 million people, or 10.5% of the global adult population, were diagnosed with diabetes in 2021; this number is expected to rise to 783 million, or 12.2% of adults, by 2045 (65,66).

The 2019 guidelines of the European Society of Cardiology (ESC) recommend that the diagnosis of diabetes mellitus (DM) should be based primarily on fasting blood glucose or glycated hemoglobin (HbA1c) values, with the oral glucose tolerance test being used subsequently when these results are uncertain**.**

Table 6. Diagnostic Criteria for Diabetes Mellitus – adapted from (66,67)**.**

1. HbA1c ≥ 6,5%
2. Glicemia à jeun ≥ 126 mg/dl
3. 2-hour blood glucose (during OGTT) ≥ 200 mg/dL
4. Random blood glucose ≥ 200 mg/dL

Blood glucose monitoring is generally performed by measuring capillary blood glucose using glucometers, and these devices must be checked periodically. To test blood glucose levels, the following are needed:

- Examination gloves
- Glucometer;
- Test strips
- Lancing device;
- Sterile lancets – these must not be used for multiple patients
- Sterile gauze pads
- Kidney tray
- Antiseptic for disinfection

Blood glucose should be measured before each main meal. Using the glucometer:

1. Washing and disinfecting hands and putting on examination gloves is mandatory before performing this procedure.
2. The patient will be informed about the procedure to be performed
3. The patient will be positioned comfortably.
4. Turn on the glucometer and set it to testing mode.
5. Adjust the lancing device to a suitable depth to penetrate the patient's skin.

6. Disinfect the skin with antiseptic.
7. Collect the blood using the lancing device.
8. Prick the fingertip; the first drop of blood should be wiped away with a sterile gauze pad.
9. The next drop of blood is applied to the test strip.
10. Within a few seconds, the test result will be displayed on the device.
11. Meanwhile, gently press the tested area with a sterile gauze pad.
12. The used test strip and lancet should be disposed of in a designated biohazard container.
13. Record the blood glucose value in the patient's chart

Tips and tricks

- ✓ **Hypoglycemia (blood glucose < 60 mg/dL) is the most common adverse effect of insulin. The patient should be instructed to always have at least 15 g of sugar on hand in case of a hypoglycemic reaction.**
- ✓ **A sudden rise in blood glucose in a stable patient is an indication of sepsis**

III.11. Fluid and Electrolyte Balance

Fluid and electrolyte balance is essential in both healthy and ill patients (68,69). The history of fluid and electrolyte balance refers to the development of understanding and management of water and electrolytes in the human body. This field has evolved significantly over time, beginning with early observations on the importance of water and salts in bodily functions. Ancient civilizations recognized the importance of hydration, often using natural water sources for health and survival (70).

In the 19th and early 20th centuries, scientific advances in physiology led to a deeper understanding of the role of electrolytes such as sodium, potassium, and chloride in cellular functions and fluid balance. The concepts of osmolality and osmotic pressure became fundamental in explaining how water moves between different compartments of the body according to solute concentrations.

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Potassium was isolated in 1807 by Sir Humphry Davy, a British chemist, becoming the first metal isolated by electrolysis. Later that same year, Davy similarly isolated sodium, and in the following year, he isolated calcium, strontium, barium, magnesium, and boron. Davy is also renowned for discovering the elemental nature of chlorine and iodine.The information presented below highlights fluid and electrolyte balance with reference to the

normal physiology of body fluids and focuses on common conditions associated with fluid imbalance (72).

Water (43) is the most abundant constituent of the body, accounting for approximately 60% of body weight in men and 50% in women. This difference is due to varying proportions of adipose tissue between men and women. Total body water is distributed into two major compartments: 55–75% is intracellular and 25–45% is extracellular. Extracellular fluids are further divided between the intravascular and extravascular spaces.

To maintain a stable balance, water intake must equal water excretion (43,73). Disruptions in water homeostasis can lead to hyponatremia or hypernatremia. Healthy individuals lose water through urine, stool, and evaporation via the skin and respiratory tract. Normally, gastrointestinal excretion represents a small fraction of total water balance, except in cases of vomiting or diarrhea.

Thirst is the primary stimulus for water intake and is mediated both by increased effective osmolality and by decreased extracellular fluid volume or reduced blood pressure. In contrast to water intake, excretion is tightly regulated by physiological factors. The main factor determining renal water excretion is antidiuretic hormone (ADH).

Sodium (Na^+) Balance

Individuals following a typical Western diet consume approximately 150 mmol of NaCl per day, which exceeds physiological requirements. Consequently, sodium intake leads to an expansion of extracellular fluid volume, which in turn promotes increased renal excretion to maintain sodium balance (43).

Regulation of sodium excretion is a multifactorial process and is the primary determinant of sodium balance. A deficiency or excess of sodium can cause a decrease or, respectively, an increase in effective circulating volume (43).

Hypovolemia

It generally refers to a situation in which the simultaneous loss of water and salt exceeds intake, leading to a decrease in extracellular fluid volume. Sodium loss can be renal (secondary to diuretic administration) or extrarenal (via the gastrointestinal tract, respiratory system, or skin) (43).***Hyponatremia***

It reflects a serum sodium concentration below 135 mmol/L. Hyponatremia indicates increased water intake and decreased renal excretion, but it can also be caused by hormonal excess or deficiency.

Hypernatremia

It reflects a serum sodium concentration above 145 mmol/L. Most causes of hypernatremia are secondary to water losses (which must be corrected slowly) and can be either renal (the most common cause of hypernatremia) or extrarenal.

<u>Potassium (K^+) Balance Hypokalemia</u>

It reflects a serum potassium concentration below 3.5 mmol/L, secondary to decreased intake, intracellular shift of K^+ , or increased losses. Symptoms appear when serum K^+ falls below 3 mmol/L and may include fatigue, muscle pain, or muscle weakness in the lower limbs (43).

Hyperkalemia

It reflects a serum potassium concentration above 5.5 mmol/L and occurs secondary to the release of K^+ from cells or decreased renal excretion. The most common symptom is muscle weakness, which can progress to flaccid paralysis and hypoventilation. Cardiac toxicity is one of the most serious manifestations of hyperkalemia. Severe hyperkalemia is defined as a serum K^+ concentration above 7.5 mmol/L and requires emergency treatment (43).

Tips and tricks

- ✓ **To correct a fluid and electrolyte imbalance, it is important to understand and manage the body's water and electrolyte balance.**
- ✓ **One of the most serious manifestations of hyperkalemia is cardiac toxicity, and the associated electrocardiogram (ECG) changes appear once the serum K^+ concentration exceeds 6 mmol/L.**

III.12. Methodical approach to interpreting the parameters of the complete blood count (CBC)

Blood cells were identified by Marcello Malpighi in 1661, 1664, and 1665. In 1678, the red corpuscles of blood were described by Jan Swammerdam of Amsterdam, a Dutch physician. The first complete description of red blood cells was made by Anthony van Leeuwenhoek of Delft at the end of the 17th century (74). In 1852, Karl Vierordt published the first procedure for blood analysis, which involved spreading a known volume of blood on a microscope slide and counting each cell individually (75).

The invention of the hemocytometer in 1874 by Louis-Charles Malassez simplified the microscopic analysis of blood cells (76), and at the

end of the 19th century Paul Ehrlich and Dmitri Leonidovich Romanowsky developed staining techniques for white and red blood cells that are still used today for examining blood smears (77).

In the 1920s, automated methods for measuring hemoglobin were developed, and Maxwell Wintrobe introduced the Wintrobe hematocrit in 1929, which in turn allowed him to define the red blood cell indices (78). A milestone in the automation of blood cell counting was the Coulter principle, patented by Wallace H. Coulter in 1953 (79). The Coulter principle uses electrical impedance measurements to count blood cells and determine their size; it remains a technology still used in many automated analyzers.

A complete blood count is used to help diagnose and monitor many conditions. The complete blood count is the first investigation routinely performed both in inpatient and outpatient settings. The peripheral blood smear is an investigation through which the constituent elements of the blood are examined microscopically; it should not show the presence of morphological abnormalities in any of the examined cell lines (white, red, platelet). In the presence of cellular abnormalities, these will be reported individually for each cell line, according to the observed pathological features**.**

The complete blood count (CBC) represents the quantification of the number of red blood cells, white blood cells, and platelets in the blood (80). It also measures the amount of hemoglobin (the most important component of red blood cells, a protein that transports molecular oxygen from the lungs, gills, and skin to the capillaries in tissues) and the hematocrit (the proportion of total blood volume composed of red blood cells).

Most automated analyzers generate numerical data presented as measurements of various parameters - leukocytes, erythrocytes, and platelets. Automated analyzers also provide information regarding leukocytes, erythrocytes, and platelets through histograms, derived from graphically plotting cell size on the X-axis and their relative number on the Y-axis. Interpretation of these parameters and histograms helps evaluate the presentation and etiology of the observed changes without requiring other costly investigations (81).

Circulating blood cells, including red blood cells, white blood cells, and platelets, are counted and sized electronically using modern instruments (82,83). One such instrument, the Coulter counter, generates an electrical pulse when a blood cell passes through a small aperture surrounded by electrodes. Each electrical pulse represents an individual cell, and the pulse height indicates the cell volume. Therefore, the electronic counter not only records the total number of cells but also estimates the mean cell volume and

the variation in cell size. In the context of red blood cells, these measurements are called the mean corpuscular volume (MCV) and the red cell distribution width (RDW), respectively. Modern electronic counters are also capable of multimodal evaluation of cell size and content, thus providing additional information about different categories of white blood cells, including neutrophils, lymphocytes, monocytes, eosinophils, and basophils (Table 1).

Two other parameters included in the complete blood count are hemoglobin (Hb) and hematocrit (Ht); they provide equivalent information, depend on the red blood cell count, and are interchangeable (84,85). Hb is calculated using a spectrophotometer after erythrocytes are lysed in a specific blood volume and chemically converted into a stable pigment. Ht is determined using a microhematocrit centrifuge and represents the percentage of red blood cells in the total blood volume (86). However, Ht can also be calculated by multiplying the red blood cell count by the mean corpuscular volume (MCV).

In routine practice, the variables investigated when examining the complete blood count are: red blood cell count; Hb (as a general indicator of anemia or polycythemia); Ht; MCV (a key parameter for the morphological classification of anemias); mean corpuscular hemoglobin (MCH) - the average hemoglobin content of an erythrocyte; mean corpuscular hemoglobin concentration (MCHC) - measuring the average hemoglobin concentration in a given volume of red blood cells (the ratio between Hb and red cell volume); red cell distribution width (RDW); platelet count (to detect either thrombocytopenia or thrombocytosis); and white blood cell count (leukocytosis and neutrophilia - found in infections, respectively leukopenia and neutropenia, also encountered in viral infections or various hematologic disorders).

Automated analyzers (81) provide information about red blood cell parameters used to assess the type of anemia, treatment response, and long-term patient monitoring. Anemias are classified according to MCV as normocytic (normal MCV), microcytic (low MCV), and macrocytic (high MCV). All macrocytic anemias are evaluated and treated for vitamin B12 and vitamin B9 deficiency.

Assessment of the reticulocyte count is necessary for investigating normocytic normochromic anemia. When it is <3%, megaloblastic anemia, liver disease, and hypothyroidism must be excluded. However, when the reticulocyte percentage is greater than 3%, further evaluation of white blood cells and platelets is required, followed by bone marrow assessment (87).

The World Health Organization has recognized iron deficiency anemia as the most common nutritional deficiency worldwide, with 30% of the

population affected (88); it is characterized by low Hb, Ht, and MCV. To support the diagnosis, evaluation of iron stores is required.

Finally, an "abnormal" complete blood count must be interpreted in the context of an individual's reference values, since up to 5% of the general population without known pathology may present laboratory values outside the statistically assigned "normal" reference range (80).

An individual may also show a substantial change from baseline without exceeding the "normal" reference interval. Likewise, sex-related differences must be considered when interpreting results. In general, reference values for red blood cells are lower in women compared to men.

Table 7. Parameters of the complete blood count and the leukocyte differential Biological reference intervals — adapted from (80)**.**

Parameters	Reference values – women	Reference values – men
Leukocytes	4.0–10.8 × 10^3/μL	4.0–10.8 × 10^3/μL
Erythrocytes	4.0–5.4 × 10^6/μL	4.5–6.1 × 10^6/μL
Hemoglobin	12.0–16.0 g/dL	13.0–17.0 g/dL
Hematocrit	37.0–47.0%	40.0–52.0%
VEM	80–98 fL	80–98 fL
HGB	27.0–33.0 pg	27.0–33.0 pg
CMP	31.5–37.0 g/dL	31.5–37.0 g/dL
RDW	11.5–14.5%	11.5–14.5%
Platelets	150–400 × 10^3/μL	150–400 × 10^3/μL
Neutrophils %	40–73%	40–73%
Lymphocytes %	19–48%	19–48%
Monocytes %	0.4–10.0%	0.4–10.0%
Eosinophils %	0–7.0%	0–7.0%
Basophils %	0–2.0%	0–2.0%
Reticulocytes	0.5-2.5%	0.5-2.5%

A complete blood count with white blood cell breakdown is used to check for and monitor various health issues, such as anemia and infections

Tips and tricks

- ✓ **Knowing the reference values is particularly important for establishing a definitive diagnosis.**

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Chapter IV
Injections

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IV.1. Intramuscular Injections

IV.1.1. History

There are suppositions that intramuscular injections were performed as early as 500 AD; however, clear evidence of this procedure exists only from the 1800s, when the procedure and technique were described in detail. During that period, intramuscular injections were predominantly performed by physicians (1–6). Things began to change in the 20th century with the widespread introduction of antibiotics, at which point nurses took on the role of preparing the necessary equipment for injections. In 1961, the responsibility for performing intramuscular injections was entirely assigned to nurses, but this also brought consequences-complications arising from improper administration (position, aseptic and antiseptic rules) (6).

Intramuscular injections began to be used for vaccination, such as the diphtheria vaccine (1923), and the vaccines for whooping cough and tetanus (1927) (6). From the 1970s onward, instructors were trained to ensure the correct administration of intramuscular injections, minimizing the occurrence of side effects and complications. Also, in the early 1970s, therapeutic injections of botulinum toxin into muscles began (7). After 2000, aspiration after needle insertion into the vein became recommended to prevent procedural errors (8).

Injections serve as the vector through which medications enter the body directly, a one-way action-once they reach the bloodstream, they cannot be recovered. Therefore, it is essential to identify safe administration sites for injections and exercise caution when introducing drugs parenterally. In intramuscular injections, substances are introduced directly into the muscle. Muscles have a rich blood supply, allowing absorption of 1 ml to 5 ml of the injected substance, depending on the puncture site, while innervation is insufficiently developed-resulting in minimal pain at the puncture site (1,2).

Warnings: Before performing an intramuscular injection, several aspects must be taken into consideration, namely:

a) **Patient's age:** Elderly patients may present varying degrees of muscle atrophy, which creates a primary limitation regarding the choice of injection site, while infants in the first months of life may have underdeveloped muscles, especially in the gluteal region (1).

b) **General physical condition:** Underweight or even cachectic patients may also have varying degrees of muscle mass loss or poor skin condition. Edema in the limbs can lead to inadequate absorption of the administered substances.

c) **Medication therapy:** The amount of medication to be administered, the frequency, and the consistency of the medication will influence the choice of the preferred site for injection (1).

There are five preferred sites for intramuscular injections

a) Deltoid region (Figure 1)

- The acromial process on the lateral aspect of the arm is identified, and the needle is inserted approximately 2.5 cm below it, in the area where the deltoid muscle is densest. To help relax the muscle, the patient's hand can be placed on the hip. The usual absorption volume is 1–2 ml.

b) Dorsogluteal region (Figure 1)

- The patient is positioned in the lateral decubitus position, either with the legs slightly flexed or slightly tilted with the toes pointing inward. Two imaginary lines are drawn: a horizontal line connecting the upper portion of the intergluteal line to the greater trochanter of the femur, and a vertical line through its midpoint, thus defining the upper outer quadrant. The purpose of this delimitation is to provide easy access to the gluteus maximus muscle while avoiding the sciatic nerve and the gluteal artery. The usual absorption volume is 2–4 ml.

c) Ventrogluteal region

d) The patient is positioned in the lateral decubitus position, with the legs slightly flexed. Place the palm of the right hand on the patient's left greater trochanter (or the left hand on the right hip) and extend the index finger toward the anterior superior iliac spine. Extend the middle finger outward so that a "V" is formed between the two fingers. The substance is administered in the center of the "V" formed, into the gluteus medius and minimus muscles. Using this intramuscular injection technique, very few complications have been reported. The usual absorption volume is 2–4 ml (2,3).Vastus lateralis and rectus femoris regions (Figure 1)

- These muscles are part of the quadriceps and are located in the middle third of the anterolateral aspect of the thigh (vastus lateralis) and on the anteromedial aspect (rectus femoris). They are most commonly used on children or on patients with flaccid musculature,

as the risk of femoral nerve injury or muscle mass atrophy in this area is minimal. They can be located one hand's breadth below the greater trochanter or one hand's breadth above the knee (the hand should be open with fingers spread). The ideal site for injection is the middle third of the vastus lateralis muscle. The typical absorption volume is 1–4 ml.

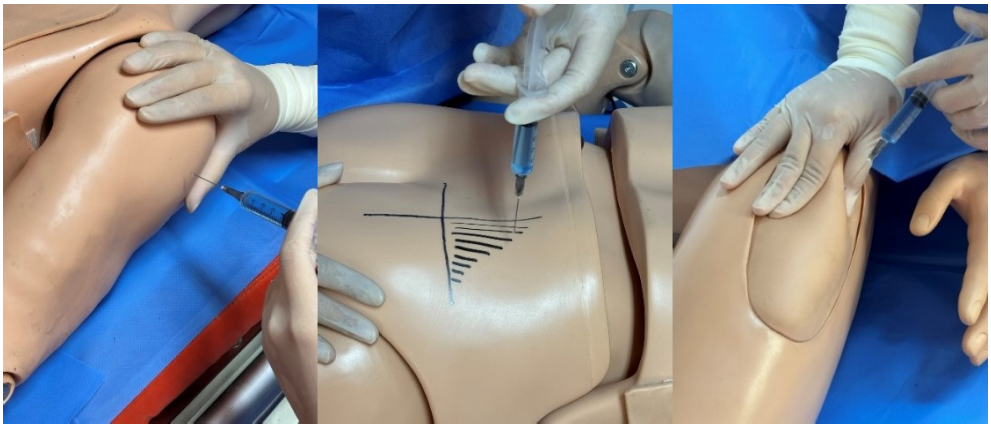

Figure 1. Preferred sites for intramuscular injection (deltoid region – left, dorsogluteal region – center, vastus lateralis region – right)

Before injection, the chosen site should be inspected for signs of inflammation, edema, or infection. Areas with skin lesions should be avoided. If the patient will undergo repeated intramuscular injections, it is very important to avoid frequent use of the same site, as complications may occur. The most common complications include muscle atrophy, phlegmon, and aseptic necrosis (1).

IV.1.2. Materials Needed for Intramuscular Injection

- 2-ml or 5-ml syringes (depending on the injection dose)
- Needles 50–80 mm long, 0.7–0.8 mm thick, long bevel.
    - **Note:** Large needles should be used for adults, ensuring they are long enough to reach the muscle layer. Short needles or improper selection of needle size may result in the substance being deposited in the subcutaneous tissue, leading to reduced efficacy (2,4).
- Alcohol/antiseptic swab
- Sterile gauze pads
- Kidney tray
- Injectable substance and prescription form

- Gloves - to prevent contamination of the medication and to protect against contact with the patient's bodily fluids
- Protective equipment
- Adhesive tape/dressing

IV.1.2.1. Preparation of the Injection

This is an aseptic procedure, and therefore all equipment must be sterile. Any actions that could lead to contamination of the equipment during the procedure must be avoided.

- Before administration, ensure that all materials are sealed and used before their expiration date.
- Disinfect your hands and use disposable gloves.
- Prepare the medication vial, disinfecting it before use. If using a glass vial, a special file is needed to cut or break the vial cap. Insert the needle into the vial, carefully aspirate the contents, remove air from the syringe, and replace the needle.

Note: *Each prescribed medication must be checked for dose, time, date, route of administration, and the physician's signature. It should be noted that for parenterally administered medications, the dose is calculated per kg of body weight (2).*

IV.1.2.2. Administration Technique

- Before administering any injection, ensure the patient has been correctly identified and obtain their consent once again.
- Try to provide the patient with as much privacy as possible, and help them assume an appropriate position depending on the chosen injection site.
- Locate the selected injection site by identifying anatomical landmarks, and encourage the patient to relax.
- Do not forget or ignore hand hygiene and aseptic rules during the procedure – wash hands with soap and water, dry them with a clean towel, disinfect, and then put on disposable gloves.
- The skin should be disinfected with alcohol, rubbing for 30 seconds, and then allowed to air dry for 30 seconds.
- Remove the needle cap and stretch the skin between the thumb and index finger of the non-dominant hand.
- Position the needle directly above the skin at a 90° angle.
- Insert the needle to approximately three-quarters of its length.

- Before injecting the substance/medication, aspirate slightly to check that a blood vessel has not been punctured. If blood is seen during aspiration, withdraw slightly and reattempt in a different direction. Repeat the procedure as necessary (1,3).
- If no blood is aspirated, proceed with the injection, administering slowly at a rate of approximately 1 ml per 10 seconds. At the end, wait a few seconds before withdrawing the needle to allow the muscle to absorb the substance.
- Withdraw the needle at a 90° angle. Apply gentle pressure to the injection site using a gauze pad.
- The procedure is complete once all used equipment has been collected and sharp objects have been disposed of in the designated sharps container (yellow container with red lid).

a. *Medication Administration*
   - It is extremely important to record the dose and substance used in a prescription chart. The site of administration and any adverse effects (if they occur) can also be documented (1).

b. *The Z-track technique* was initially used for irritating medications; this method is recommended to reduce pain and prevent leakage of substances from the intramuscular injection site (1).
   - After selecting the injection site, use the thumb to pull the skin approximately 3 cm to one side.
   - Insert the needle at a 90° angle and release the thumb.
   - The injection administration is performed as described above.
   - Withdraw the thumb, remove the needle, and allow the skin to return to its original position.

c. *Contraindications:*
   - Administration of intramuscular injections to patients on chronic anticoagulant therapy.

Tips and tricks

a. Properly and adequately inform the patient before the procedure to help them understand the protocol and cooperate.

b. Any procedure performed on the patient requires signing of the informed consent.

c. Change the needle after preparing the medication and before administration to ensure it is sterile, intact, and the correct length to reach the muscle layer.

d. To ensure the medication reaches the muscle layer, the ventrogluteal region can be used as the preferred site.

e. **Position the patient so that the chosen injection site is easily accessible.**
f. **Disinfect the skin before injection and ensure it is dry, as alcohol can cause a stinging sensation.**
g. **Consider using ice or a freezing spray to numb the skin before injection, especially for children and patients with needle phobia. Ice should never be placed directly on the skin; it should first be wrapped in a gauze pad.**
h. **Use the Z-track technique.**
i. **Utilize different injection sites and document this to avoid overusing any single site.**
j. **Insert the needle firmly into the skin at a 90° angle, preventing shearing or displacement of the needle.**
k. **Inject the substance steadily and slowly—approximately 1 ml per 10 seconds—to allow the muscle to absorb the liquid.**
l. **Wait a few seconds after completing the injection to allow diffusion into the muscle. Then withdraw the needle at the same angle it was inserted.**
m. **Apply gentle but firm pressure to prevent local tissue irritation. Do not massage the injection site afterward.**
n. **When drawing the substance from the vial, always keep the needle tip below the liquid level to minimize air being aspirated into the syringe.**
o. **Aspirate only the required amount into the syringe. After filling the syringe, hold it with the needle pointing upward and tap it gently but firmly to move any air bubbles to the top for expulsion.**
p. **Change the needle after aspirating the substance.**
q. **Before administration, recheck the dose in the syringe to ensure it is correct (1,2).**

IV.2. Subcutaneous Injections

IV.2.1. History

The history of subcutaneous injections dates back to the early 19th century, when the effects of snake bites and poisonous arrows highlighted the fact that medications could be administered through a “hole” in the skin to achieve systemic effects (9). In 1830, populations in South America experimented with a painful method involving the removal of a small piece of skin and dripping medication-usually opium-onto that site. The method

was also known in France, where it was referred to as the "méthode endermique" by 1947 (9–11).

In 1836, in France, a less painful method was attempted using a lancet for vaccination, with opium paste on its tip, producing multiple punctures along a nerve (9–11). In 1844, Francis Rynd in Dublin treated a woman with trigeminal neuralgia using morphine acetate, which was introduced via punctures along the course of the supraorbital nerve (9–17). Rynd's instrument, which he did not fully describe until 1861, consisted of a trocar and a cannula with a screw-on reservoir through which the morphine solution was introduced by gravity.

The French veterinarian Charles-Gabriel Pravaz created a metal syringe with a screw piston and a hollow needle, which he used to inject ferric chloride into the arteries of horses and sheep to induce blood coagulation. He suggested that this method could potentially be applied to humans for treating aneurysms (11–17).

The first subcutaneous injection with what we would recognize as a syringe-distinct from Rynd's gravity-fed apparatus- was performed by Dr. Alexander Wood. Wood used a syringe made by the London instrument maker Ferguson to inject morphine along the path of a nerve (13–17). Wood clearly intended to achieve local anesthesia, although he observed that some of his patients became extremely drowsy, suggesting that the morphine had reached the brain. Wood's original paper in the *Edinburgh Medical and Surgical Journal* in 1854 attracted little attention, but after its publication in the *British Medical Journal* in 1858, he received numerous letters from physicians inquiring where the equipment could be obtained. The syringe Wood used, though heavily worn and missing its needle, is preserved at the Royal College of Surgeons of Edinburgh (14–17).

This type of injection delivers small amounts of medication (0.2–2 ml) into the subcutaneous tissue to allow slow and sustained absorption. It is an ideal route for insulin administration (which requires frequent injections) and is also regularly used for anticoagulant therapy such as heparin. Subcutaneous injections can be performed over most areas of the body, except for regions overlying bony prominences, major blood vessels, or nerve trunks, the inner aspects of limbs, the anterior cervical region, the head, and areas subject to pressure.

The preferred sites for subcutaneous injections (most often self-administered) are: the upper outer arms, the upper thighs, the lateral chest, and the anterolateral abdominal wall (where the hypodermis is thicker and the skin is more mobile over the underlying planes).

IV.2.2. Materials Needed for Subcutaneous Injection:

- Syringes (e.g., insulin syringe)
- Needles 25–30 mm long, 0.6–0.8 mm thick, long bevel
- Sterile gauze pads
- Kidney tray
- Injectable substance and prescription form
- Gloves – to prevent contamination of the medication and to protect against contact with the patient's bodily fluids
- Protective equipment
- Adhesive tape/dressing

IV.2.3. Preparation of the Injection

- Mount the syringe and attach the needle.
- Fill the syringe, following aseptic and antiseptic rules: disinfect the vial with alcohol, cut the vial top with a special file, or break the vial cap.
- Insert the needle into the vial and carefully aspirate the contents.
- Remove air from the syringe.
- Change the syringe needle.

IV.2.4. Technique for Administering a Subcutaneous Injection (Figure 2)

- Reconfirm the patient's identity.
- Provide a private space to ensure confidentiality.
- Identify the preferred site for the subcutaneous injection. Do not inject if there is edema, redness, or bruising at the site. Patients using insulin should be taught to systematically select a different anatomical site for each injection, as absorption rates vary depending on the chosen location. Other subcutaneously administered medications, such as heparin, should also be injected at different sites each time to reduce the risk of bruising (2).
- Create a skin fold between the index finger and thumb of the left hand, and insert the needle at the base of the fold, parallel to its surface. The needle is inserted at a 45° angle. Use lateral movements to verify that the needle is in the subcutaneous tissue (1,2).
- Aspirate slightly to ensure the needle tip has not entered a subcutaneous vessel, then slowly inject the solution to avoid pain from sudden skin distension.
- Withdraw the needle, and if bleeding occurs, apply gentle pressure using a gauze pad.

- Conclude the procedure by ensuring all used materials are disposed of in the designated container (example: needles in a sharps container).
- Document the injection site and record the time and dose of the administered medication.

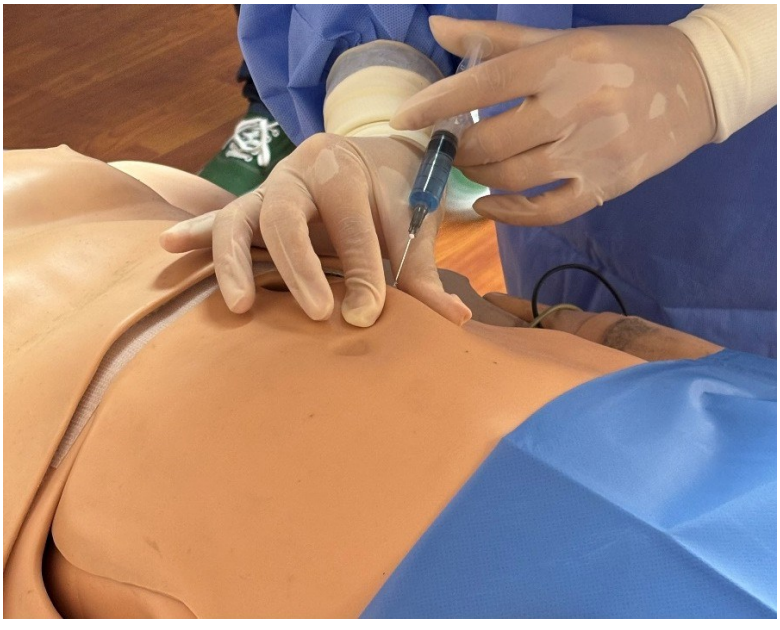

Figure 2. Subcutaneous Injection

Contraindications:

- Local infections, patients in collapse or shock, or with hypotensive states

Tips and tricks

For subcutaneous injections, the needle is longer, and therefore it should be inserted at a 45° angle (1,2,5). Attention should be paid to:

a) **Puncturing a nerve bundle, which causes pain at the injection site; slightly withdraw the needle tip and recheck its position.**
b) **Puncturing a blood vessel, which results in blood entering the syringe during aspiration; slightly withdraw or advance the needle, aspirate again, and at the end, massage the site more to prevent hematoma formation.**
c) **Needle breakage – a very rare event that is resolved by immediately withdrawing the needle.**
d) **Abscesses or phlegmons due to lack of asepsis at the injection site.**

IV.3. Intradermal Injection

The intradermal route of administration provides a local effect rather than a systemic one and is primarily used for diagnostic purposes, injecting various substances suspected of being antigens or allergens. When these substances come into contact with antibodies in the body, they produce a localized maculopapular reaction (intradermal reaction), directly proportional to the degree of sensitization, such as in allergy testing or tuberculin testing, as well as in the administration of local anesthetics (2,3). The reaction is read between 30 minutes and 72 hours, depending on the antigen introduced (tuberculin, hydatid antigen, diphtheria, etc.).

For therapeutic purposes, medications may be introduced for desensitization or to initiate local anesthesia through infiltration.

Intradermal injection follows the same preliminary procedures as intramuscular injection, except that very small, thin needles with a short bevel are used, inserted at a 10°–15° angle beneath the epidermis (2,5).

Up to 0.5 ml of substance is injected, or until a papule appears on the skin surface-the same procedure is followed when administering a local anesthetic. It should be noted that absorption of the medication administered intradermal occurs very slowly (1,3–4).

IV.3.1. Materials Needed

a) 1 ml syringe
b) Very small, thin needles
c) Injectable substance
d) Antiseptics
e) Gauze pad
f) Adhesive tape/dressing

IV.3.2. Technique

Mounting the syringe, attaching the needle, and filling the syringe are performed following aseptic and antiseptic rules. Take a vial, disinfect it with alcohol, cut the vial top with a special file or break it, carefully insert the needle into the vial, and aspirate the contents. Then remove the air from the syringe and change the syringe needle.

After disinfecting the skin, stretch it slightly and insert the needle almost parallel to the skin surface, strictly intradermal, injecting 0.1–0.3 ml.

The preferred sites for intradermal injection are: the anterior surface of the forearm, the outer surface of the forearm or thigh, or any area requiring local anesthesia (1,4)

a. Contraindications: None

Administering intradermal injections requires a minimum set of equipment:

- Kidney tray
- Gauze pads and rubbing alcohol
- Disposable gloves
- Sterile 1 ml syringe with a short-bevel needle (2,4,5)

b. Patient Preparation for Administering an Intradermal Injection:

- Verify the patient's identity.
- Explain each step of the procedure and explicitly obtain the patient's consent.
- Ensure that the patient is positioned comfortably.
- Ensure that the area intended for injection is free of edema, erythema, or skin lesions

c. Steps for Administering an Intradermal Injection (Figure 3):

- Verify the patient's prescription before administration.
- Do not forget or ignore hand hygiene and asepsis during the procedure – wash hands with soap and water, disinfect them, and then use disposable gloves.
- Disinfect the skin against the direction of hair growth and wait 10 seconds for the alcohol to evaporate.
- Draw the substance into the syringe, preparing it for administration.
- Change the needle before administration and select an area with few or no hair follicles, usually the anterior surface of the forearm.
- Hold the syringe in the dominant hand, between the index finger, thumb, and little finger. Insert the needle into the dermis at a 10–15° angle.
- Inject the substance very slowly.
- Observe whether a papule forms at the injection site, with an "orange peel" appearance, measuring up to 5–6 mm in diameter; this reaction occurs after injecting 0.1 ml of the substance (2,5).
- Withdraw the needle sharply and apply a gauze pad to the puncture site afterward.

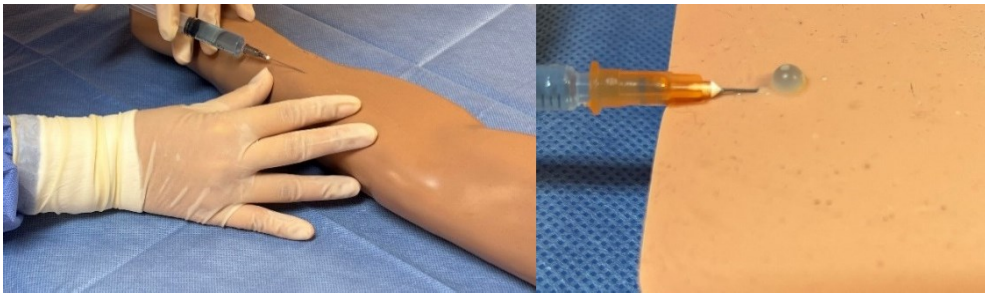

Figure 3. Intradermal Injection (formation of the papule – right)

Tips and tricks

a) **Technique error – injecting the substance subcutaneously. Incidents and accidents following intradermal injections are very rare.**
b) **Signing of informed consent.**
c) **Do not use large needles or syringes.**

IV.4. Venous Puncture

IV.4.1. History

Venous puncture has its origins in ancient civilizations, where blood was believed to possess mystical and healing properties. For the ancient Greeks, Hippocrates theorized the humoral theory, which stated that the health of the body depended on the balance of the four body fluids - blood, spit, yellow bile, and black bile. Being ill during this period meant that there was a disturbance in the balance of these four fluids. Thus, treatment involved draining one of the four to restore balance (18,19).

The dominant medical voice in Rome around 200–300 AD, Galen of Pergamum, modified this idea by asserting that humoral imbalances originated from specific organs as well as from the body in general. Along with this, he proclaimed that blood was the most important fluid and discovered that arteries carry blood- not air, as had been believed for over 400 years (19,20).

Venous puncture evolved from the practice of phlebotomy. The word “phlebotomy” comes from two Greek words referring to “veins” and “cutting”; thus, phlebotomy can be defined as the incision of a vein for the purpose of bleeding or blood collection. Since ancient times, humans recognized the association between blood and life itself. From this belief emerged the practice of bloodletting - the first form of phlebotomy.

In the 17th and 18th centuries, phlebotomy was a major therapy for those practicing the healing arts. Lancets were among the first instruments

used by clinicians in the 18th century (21). Today, phlebotomy methods and procedures have improved significantly. Phlebotomy is now rarely used therapeutically (for example, in patients with polycythemia). Instead, the main purpose of phlebotomy is to obtain a blood sample for diagnostic tests.

The development of sophisticated laboratory equipment has reduced the need for venous puncture, requiring smaller amounts of blood for diagnostic evaluations- amounts that can often be obtained through simple skin puncture without direct access to veins. There are several methods for obtaining a blood sample via venous puncture (21).

IV.4.2. Anatomy

Blood accounts for between 6% and 8% of total body weight and is composed of blood cells suspended in a fluid called plasma. Serum refers to the substrate remaining after fibrinogen has been removed from plasma. The three main types of blood cells are red blood cells, called erythrocytes; white blood cells, called leukocytes; and platelets, called thrombocytes. The primary function of blood is the transport of oxygen via hemoglobin molecules within erythrocytes (21).

In addition, blood serves to transport nutrients, waste products, components of the immune system, hormones, and other specialized materials throughout the body. It also plays a vital role in regulating body temperature, fluid balance, and acid-base equilibrium. Finally, platelets are responsible for preventing blood loss in the event of hemorrhage, exerting a major influence on the walls of blood vessels. Veins serve as structures that carry deoxygenated blood back to the heart and, ultimately, to the lungs (21).

The upper limbs are the primary sites of choice for venous puncture. The ideal veins for venipuncture are located in the antecubital fossa, meaning the inner aspect of the elbow joint. In this area, the median cubital and cephalic veins are usually easily accessible. Due to the proximity of the basilic vein to the brachial artery and median nerve, this vein should only be considered if no other vein is more prominent. Another suitable site for venipuncture is the dorsal portion of the hand, where the metacarpal veins and dorsal venous arch are located. Venipuncture in this area is more painful because it contains smaller and more fragile veins (21).

IV.4.3. Indications for Venous Puncture

This procedure is indicated whenever it is necessary to collect a venous blood sample in larger quantities than those easily obtained through fingerstick methods (21). The most common use of blood collection is for laboratory tests to evaluate the clinical-biological status and overall health of the patient (22).

Certain categories require specialized collection, including:

- **Blood gas analysis** (arterial blood gases - ASTRUP parameters) for patients on mechanical ventilation, to monitor tissue oxygenation;
- **Blood collection in neonatology**;
- **Blood sampling from scalp veins in pediatrics**;
- **Capillary blood sampling** (example: finger or heel pricks, or, less commonly, earlobe puncture) for analysis of capillary blood samples at all ages. Examples include testing hemoglobin levels prior to blood donation, monitoring blood glucose, and rapid tests for HIV, malaria, and syphilis.

Blood collection through donation is used to obtain blood from donors for therapeutic purposes for recipient patients (22).

IV.4.4. Contraindications

Once the decision to perform a venous puncture has been made, the next and most important step is selecting the site from which the sample will be collected. Venipuncture should be avoided in certain areas:

- Areas with **skin infections** (example: cellulitis, rashes, tattoos, etc.).
- Areas with **extensive scarring** (from burns, surgeries, injuries, or repeated venipunctures).
- Veins on the **upper limb on the side of a mastectomy** (using this site may affect test results due to the presence of lymphedema, which occurs after dissection and removal of the lymphatic system).
- Regions with a hematoma, which could produce erroneous results in certain types of tests; if no other site is available, the sample should be taken from the distal portion of the hematoma (21).
- The arm with an intravenous (IV) line for fluids or blood transfusions; it is essential to use the opposite arm for venipuncture. If this is not possible, satisfactory samples can usually be obtained distal to the IV line. When performing this procedure, the IV line should be stopped for at least 2 minutes, if possible. Blood must then be drawn from a vein other than the one with the IV line above the selected site. The first 5 ml of blood should be discarded before collecting samples for testing. Blood samples taken for glucose levels from the same limb as the IV infusion may be inaccurate, even when obtained distal to the infusion site (21).
- An arm with a fistula or cannula placed without specific instructions from the supervising physician; if the limb is edematous, another site should be chosen.

Patients with **disseminated intravascular coagulation, hyperfibrinolysis, thrombocytopenia, or qualitative platelet disorders** typically bleed for an extended period after a venipuncture, which is why prolonged manual hemostasis is recommended (21).

IV.4.5. Complications

Several complications can occur during venipuncture, including:

- **Skin infection** (cellulitis) or vein infection (phlebitis)
- **Thrombosis**
- **Vein laceration**
- **Bleeding or hematoma** at the puncture site
- **Vasovagal syncope or fainting**, which can occur during venipuncture. In this case, the tourniquet and needle should be removed, pressure applied at the site, and the area secured with adhesive tape. Carefully position the patient and take appropriate measures to help the patient regain consciousness. This potential complication is one of the main reasons why the best position for venipuncture is **supine**, especially in patients with a history of fainting episodes or those who are anxious (21).

The risk of complications increases proportionally with repeated punctures in the same anatomical area. The most common complication is **bleeding or hematoma** at the puncture site, which occurs when blood leaks into surrounding tissues after the distal wall of the vein is pierced during needle insertion. Using the correct needle insertion angle can minimize the likelihood of this complication. Additionally, slower needle insertion reduces the chance of penetrating too deeply. A smaller-gauge needle also decreases the risk of bleeding or hematoma.

If a hematoma occurs, remove the tourniquet, withdraw the needle, and maintain pressure on the area for at least 10 minutes. Apply an additional 5 minutes of pressure for patients receiving **anticoagulant therapy** (21).

IV.4.6. Equipment Required for Venipuncture

The selection of equipment used for venipuncture depends on the chosen vein and the ordered blood tests (22). The list of necessary equipment includes:

- **Blood collection system** (vacutainer or syringe)
- **Blood collection tubes**
- **Sterile gloves**
- **Alcohol and 2% chlorhexidine pads** (including when collecting blood cultures)

- **Gauze pads**
- **Latex-free tourniquet**
- **Adhesive tape**
- **Yellow sharps container** for the disposal of sharp objects and biologically hazardous materials

The **vacutainer blood collection system** consists of a needle holder, a needle with an attached safety shield, or a blood collection set. The blood collection set is often used for smaller veins located in the upper or lower limbs and provides a visible return of blood, allowing the nurse to confirm proper placement in the vein.

IV.4.7. Performing the Venipuncture Procedure

Venipuncture is performed both for diagnostic purposes (collecting biological samples for establishing a diagnosis, Figure 4) and for therapeutic purposes (administering medications intravenously, Figure 5) (23). The procedure for performing venipuncture includes the following steps (22):

a) **Preparation of equipment, blood tubes, and collection labels:**
   - Check to ensure all labels are legible and complete;
   - Determine the timing if timed blood tests are required;
   - Select the appropriate tubes according to the test requirements and arrange them in the correct order for easy access during collection.

b) **Verify patient identification data** (name, surname, personal identification number, medical record number).

c) **Explain the procedure to the patient**. Position the patient comfortably, providing support for the arm/forearm. Place the arm slightly lower than heart level.

d) **Perform hand hygiene** and put on single-use/sterile gloves.

e) **Select the venipuncture site**, ask the patient to make a fist, and then apply the tourniquet above the antecubital fossa. If the patient has skin issues, the tourniquet should be applied over a material (example: gauze) to avoid injuring the skin.

f) **Disinfect the venipuncture site** with alcohol using a circular motion from the center outward. Allow enough time for the area to air dry. This prevents a burning sensation during venipuncture and prevents hemolysis of the collected specimen. If puncturing another vein is necessary, that area must also be disinfected.

g) **Hold the skin taut** below the venipuncture site to anchor and stabilize the vein.

h) **Grasp the needle holder** near the end of the needle, with the safety shield facing up. The needle is always inserted with the bevel up. Puncture the vein at an insertion angle of 30 degrees or less, keeping the needle as stable as possible; insert the first tube onto the needle. If the needle is in the vein, blood will flow immediately into the tube. Once blood flow starts, instruct the patient to open their fist.
i) **Allow the tube to fill** until the vacuum is exhausted and blood flow stops.
j) **Release the tourniquet** as soon as blood flow is established.
k) **Remove the last tube** from the holder before withdrawing the needle from the patient's arm.
l) **Apply gauze** to the insertion site before withdrawing the needle. Cover the needle by pushing the safety shield forward with your thumb until a click is heard.
m) **Apply continuous pressure immediately** to the site until active bleeding stops; then secure the gauze with adhesive tape.
n) **Dispose of the needle and holder** directly into the yellow sharp's container.
o) **Label all blood tubes** with sample collection labels. Verify that the patient's name on the label is correct.
p) **Place the blood tubes** in a biohazard bag and arrange transport to the laboratory.

Note: A nurse/laboratory personnel member may attempt venipuncture **a maximum of two times**. If unsuccessful after two attempts, blood collection should be postponed. Subsequently, it is necessary to consider whether all appropriate venipuncture sites have been exhausted and whether the physician should be informed before subjecting the patient to another attempt.

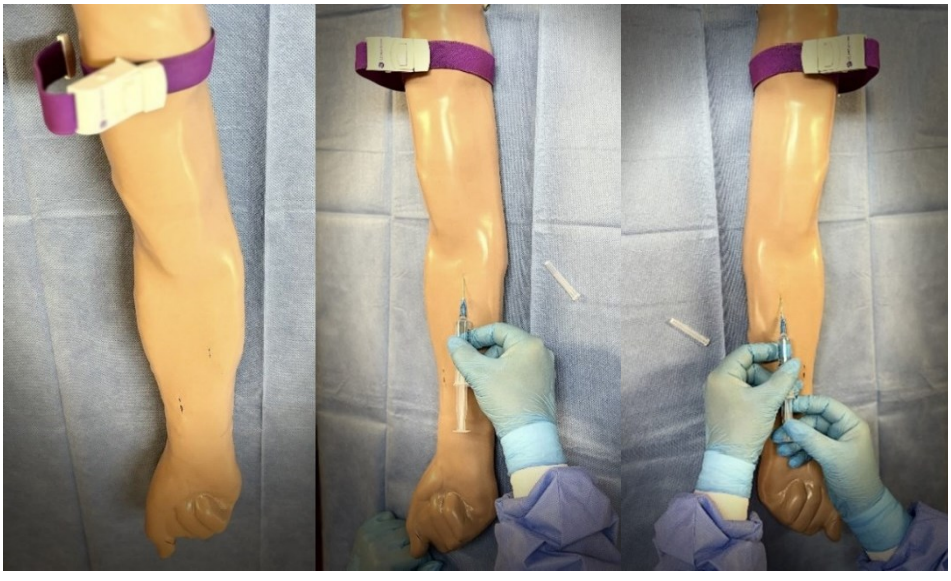

Figure 4. Intravenous injection—for diagnostic purposes (intravenous blood collection))

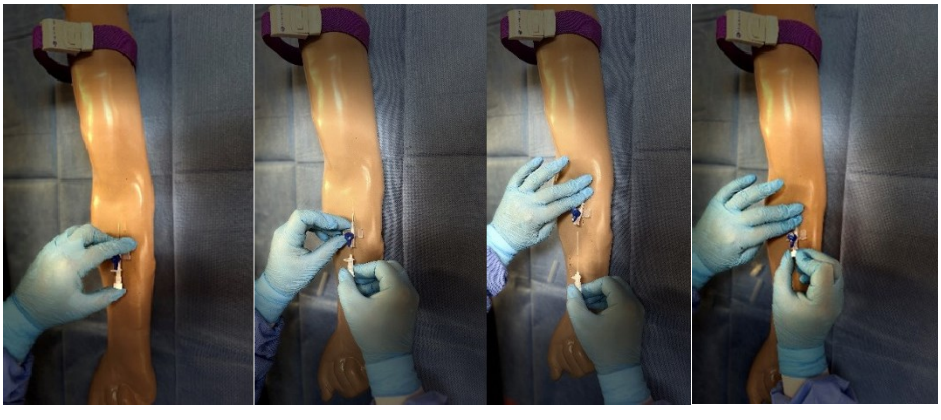

Figure 5. Intravenous injection – for therapeutic purposes (cannula insertion)

IV.4.7.1. Vacuum Extraction Systems

The use of vacuum tube systems as closed systems for blood collection reduces the risk of direct blood exposure and facilitates the collection of multiple samples from a single venipuncture. Vacuum extraction systems are widely available in most resource-rich countries. Although vacuum tube systems are safe, proper staff training and proficiency in their use are essential (22).

Double-ended needles are available in various gauge sizes as recommended. The end covered by a rubber sleeve is screwed into the tube holder (also known as a tube adapter, vacuum blood collection needle, or "bulldog"). The holder stabilizes the collection tube and protects the healthcare worker from direct contact with blood.

The needle is inserted with the bevel facing upwards. Once the needle is in the vein, the tube is pressed onto the needle, and blood is automatically drawn into the vacuum collection tube until the required volume is collected. This system comes complete with the needle, holder, and laboratory sample tubes with color-coded caps corresponding to different test types. Collection tubes are available for both adult and pediatric samples (22).

IV.5. Blood Donation

IV.5.1. History

In 1900, Karl Landsteiner from the University of Vienna discovered why some blood transfusions were successful while others could be fatal. Landsteiner identified the ABO blood group system by mixing the red blood cells and serum of each member of his staff. He demonstrated that the serum from some individuals agglutinated the red blood cells of others. From these early experiments, he identified three types, named A, B, and C (the letter C was later renamed group O). A fourth, less common blood type, AB, was discovered a year later. In 1930, Landsteiner was awarded the Nobel Prize in Physiology or Medicine for his discoveries (24).

The purpose of a blood transfusion is to rapidly increase oxygen delivery to tissues. It is the most effective method for replacing acute blood loss. The demand for blood and blood components is the sole responsibility of medical personnel, except when local guidelines specify otherwise.

Blood banks employ various procedures to prevent infections that could be transmitted through infected blood donations. One important measure is recruiting donors from populations known to have low rates of transmissible blood borne diseases, such as voluntary, unpaid donors without a history of intravenous drug use or certain medical conditions (22). A second measure involves asking donors additional screening questions (which may vary by region) to help identify individuals at higher risk of infection. Physicians must strictly follow donor inclusion and exclusion criteria. A third measure is testing donated blood for infections common in the relevant geographic region before processing it for therapeutic use (22).

The process of collecting blood from donors is similar to standard blood sampling; however, additional measures are required for donated blood. These measures primarily ensure patient safety and minimize exogenous

contamination of the donated unit or its derived components, particularly contamination from the donor's skin flora. Due to the volume of blood collected and storage duration, pathogens can multiply during storage. Safe collection ensures that blood products remain safe for use throughout their shelf life (22).

Skin flora is a frequent source of pathogens; therefore, it is important to use an effective antiseptic to disinfect the donor's arm prior to donation. Transfusion of blood components contaminated with exogenous bacteria or other pathogens can result in fatal complications (22).

IV.5.2. General Rules to Follow During Blood Donation

a) **Identify the donor and label the blood collection bag and necessary tubes**
   - Ask the donor to state their full name.
   - Ensure that: the blood collection bag is correct; the labels on the blood collection bag, all satellite bags, sample tubes, and donor forms have the correct name and number;
   - The information on the labels corresponds with the donor's information.

b) **Vein selection**
   - Select a large, firm vein, preferably in the antecubital fossa, from an area free of lesions or scars.
   - Apply a tourniquet or blood pressure cuff inflated to 40–60 mm Hg to make the vein more prominent.
   - Ask the donor to open and close their hand several times. Once the vein is selected, release the tourniquet or cuff before preparing the puncture site.

c) **Skin disinfection – the procedure is performed in a single step (recommended to last approximately one minute)**
   - If the selected puncture site is visibly contaminated, cleanse the area with soap and water and then dry it with single-use towels.
   - Use a product combining 2% chlorhexidine gluconate in 70% isopropyl alcohol to disinfect the area.
   - Cover the entire area and ensure that the skin to be punctured is in contact with the disinfectant for at least 30 seconds.
   - Allow the area to air-dry completely or for at least 30 seconds.

d) **Performing the venipuncture**
   - In general, use a 16-gauge needle, usually attached to the blood collection bag. The use of a retractable or safety needle with a cap is preferred if available.

- Ask the donor to open and close their fist slowly every 10–12 seconds during collection.
- Collect the samples for analysis and release the tourniquet once blood flow is established.
- At the end of donation, detach the donor from the blood bag; then mix the blood bag with circular motions and remove the needle using the safety device.

e) **Monitor the donor and the collected unit**
- Closely monitor the donor and the puncture site throughout the donation process, as the following may occur: sweating, pallor, or discomfort preceding fainting; hematoma formation at the puncture site; changes in blood flow indicating that the needle has moved in the vein and may need repositioning.

f) **Post-donation care for the donor**
- Provide the donor with refreshments.
- Ask the donor to remain seated and relax for a few minutes.
- Inspect the puncture site; if there is no bleeding, apply a bandage; if bleeding occurs, apply additional pressure.
- Ask the donor to stand up slowly and check how they feel.
- Before the donor leaves the donation area, ensure they can safely stand.

g) **Handling the blood unit and samples**
- Transfer the blood unit to an appropriate storage area according to the requirements of the blood center and the collected product.
- Ensure that collected blood samples are stored and delivered to the laboratory with complete documentation, at the recommended temperature, and in a closed container.

IV.6. Arterial Parameter Collection (ASTRUP)

An arterial blood sample is collected from an artery, primarily to determine arterial blood gases. Arterial blood sampling should only be performed by physicians for whom the procedure falls within their legally authorized scope of practice in their country and who have demonstrated competence through formal training (25–27). The sample can be obtained either via a catheter placed in an artery or by using a needle and syringe to puncture an artery. These syringes are pre-heparinized and handled to minimize exposure to air, which could alter blood gas values. This chapter describes only the procedure for obtaining a blood sample from the radial artery (22,25).

IV.6.1. Site Selection

Multiple arteries can be used for arterial blood collection. The first choice is the radial artery, located on the radial border of the forearm in the distal third. Due to its small size, using this artery requires advanced skills **in** arterial blood sampling.

Alternative access sites include the **brachial** or **femoral arteries**, but these have several disadvantages:

- They may be **more difficult to locate** because they are less superficial than the radial artery.
- They have **weaker collateral circulation.**
- They are **surrounded by structures** that could be damaged if the collection technique is incorrect.

IV.6.2. Equipment and Consumables

- **Pre-heparinized syringe** (with green cap).
- **Needles** (gauges 20, 23, and 25, of varying lengths).
    - Choose an appropriate size (smaller gauges are more likely to cause sample hemolysis).
- **Safety syringe** with a needle cap that allows sealing the syringe before transport (this is considered best practice for radial artery blood sampling).
- **Bandage** to cover the puncture site after collection.
- **Container with crushed ice** for transporting the sample to the laboratory (if analysis is not performed at the point of care).
- **If needed**, local anesthetic with an additional sterile single-use syringe and needle.

IV.6.3. Procedure for Radial Artery Blood Sampling (22,25)

For arterial blood sampling from the radial artery using a needle and syringe, follow the steps below:

a) Approach the patient, introduce yourself, and ask the patient to state their full name.

b) Place the patient in a supine position. Ask for the nurse's assistance if the patient's position needs adjustment for comfort. If the patient clenches their fist, holds their breath, or cries, this may alter breathing and affect test results.

c) Locate the radial vein by performing an Allen test: the patient raises the hand and clenches the fist for 30 seconds; the clinician compresses both the ulnar and radial arteries. Upon releasing the ulnar artery while maintaining compression on the radial artery, if

the hand regains color, the test is negative. If the hand remains pale, the Allen test is positive, and arterial puncture should **not** be performed. If the artery is not easily located, repeat the test on the opposite hand. Once identified, mark anatomical landmarks for future reference. If palpation is needed again, use sterile gloves.

d) Perform hand hygiene, clear the working area near the bed, and prepare materials. Wear a gown or waterproof apron and facial protection if blood exposure is anticipated.

e) Disinfect the sampling site with 70% alcohol and allow it to dry.

f) If the needle and syringe are not preassembled, assemble the needle and heparinized syringe and pull the plunger to the recommended fill level indicated by the laboratory.

g) Holding the syringe and needle like an arrow, use the index finger to locate the pulse again. Inform the patient that the skin will be punctured. Insert the needle at a 45° angle about 1 cm distal to the index finger (example., away from it) to avoid contaminating the insertion site.

h) Advance the needle into the radial artery until blood appears, then allow the syringe to fill to the required level. **Do not** pull back the plunger forcefully.

i) Withdraw the needle and syringe; apply a compress and have the patient or an assistant apply firm pressure until bleeding stops. Check hemostasis after 2–3 minutes. For patients with hypertension, coagulopathy, or anticoagulant therapy, 5 minutes or more may be required.

j) Remove air bubbles, cap the syringe, and gently mix the sample by rocking left and right. Place the syringe cap to prevent arterial blood contact with air and avoid spillage during transport to the laboratory.

k) Label the syringe with the sample information.

l) Properly dispose of all used materials and personal protective equipment.

m) Remove gloves and wash hands thoroughly with soap and water, then dry using single-use towels; alternatively, use an alcohol-based hand rub.

n) Check the puncture site for bleeding (apply additional pressure if needed) and thank the patient.

o) Transport the sample immediately to the laboratory, following standard laboratory handling procedures.

IV.6.4. Complications Related to Arterial Blood Sampling (22,25)

There are several potential complications associated with arterial blood sampling. The points below list some procedure-related complications and ways to prevent them:

- **Arterial spasm** or involuntary contraction of the artery can be prevented by simply keeping the patient relaxed; this can be achieved, for example, by explaining the procedure and positioning the patient comfortably.
- **Hematoma or excessive bleeding** can be prevented by inserting the needle without puncturing the far wall of the vessel and applying immediate pressure after withdrawal. Due to the higher pressure in arteries, pressure must be applied for a longer duration than with venous sampling and should be monitored closely to ensure bleeding has stopped.
- **Nerve injury** can be prevented by selecting an appropriate sampling site and avoiding unnecessary repositioning of the needle.
- **Lipotimia or vasovagal response** can be prevented by ensuring the patient is in the dorsal decubitus position with legs elevated before beginning blood sampling. Patients requiring arterial blood sampling are usually hospitalized or in the emergency department, so they are typically already in a dorsal position. Children may feel a loss of control and resist more if placed supine; in such cases, it may be preferable to have the child seated in a parent's arms so the parent can gently restrain them.
- **Other issues** may include: low blood pressure, sweating, or pallor, which can precede syncope.

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Chapter V
Pericardiocentesis. Thoracentesis. Paracentesis. Bone marrow aspiration and biopsy.

Samfireag Miruna, Mânea Horațiu, Hoinoiu Teodora

List of Abbreviations and Symbols
WHO – World Health Organization

V.1. Pericardiocentesis

Pericardiocentesis (1), also known as pericardial puncture, is an invasive medical procedure used to drain fluid that has accumulated in the pericardial sac surrounding the heart. This intervention is essential in the management of patients with cardiac tamponade, a potentially life-threatening medical emergency in which the excessive pressure exerted by the pericardial fluid interferes with the heart's normal function (1).

Pericardiocentesis has a long and rich history, beginning with the first descriptions of the procedure in the medical literature. The first blind pericardiocentesis was performed in 1840 by a Viennese physician, Franz Schuh, who conducted the procedure via a left parasternal approach on a 24-year-old woman diagnosed with terminal cancer (2). Although initially associated with high mortality, this lifesaving procedure has evolved over time, becoming the standard routine care for patients diagnosed with life-threatening cardiac tamponade (2).

Pericardiocentesis has a variety of applications in medical practice, primarily for the diagnosis and treatment of cardiac tamponade.

The main indications for pericardiocentesis include (3):

- Diagnosis and treatment of cardiac tamponade, a medical emergency characterized by excessive compression of the heart by pericardial fluid;
- Evaluation and management of pericardial effusions of various etiologies, including infectious, inflammatory, malignant, or traumatic causes.

Although pericardiocentesis is generally a safe and effective procedure, there are certain relative contraindications and associated complications.

Relative contraindications for pericardiocentesis include:

- Coagulopathy or bleeding disorders, which can increase the risk of excessive bleeding during the procedure;

- Active cutaneous or pericardial infections at the puncture site, which can increase the risk of infection of the pericardial sac;
- Abnormal cardiac or pericardial anatomy, which may make pericardiocentesis difficult or increase the risk of complications.

The main complications associated with pericardiocentesis include:

- Excessive bleeding at the puncture site;
- Perforation of the heart or adjacent vascular structures;
- Infection of the pericardial sac or other anatomical structures.

A summary of the indications, relative contraindications, and complications of pericardiocentesis is presented in Table 1.

Table 1. Indications, Relative Contraindications, Complications. Adapted from (2)

Indications	Relative contraindications	Complications
Cardiac tamponade	Coagulopathies (INR > 2)	Cardiac perforation
Pericardial effusions	Thrombocytopenia (PLT < 50,000/mm^3)	Pneumothorax
	Myocardial rupture	Arrhythmias
	Aortic dissection	Injury to underlying tissues
	Severe pulmonary hypertension	Bleeding
		Acute pulmonary edema

Pericardiocentesis requires specialized instruments to be performed safely and effectively (4). Handwashing and disinfection are mandatory before performing this procedure.

Pericardiocentesis should be carried out in an operating room or intensive care unit, where the patient can be continuously monitored (3). The operator will need an ultrasound device for image-guided assistance. Additionally, the clinician should prepare sterile fields, local anesthetic, syringes, needles, and a pericardiocentesis kit. Operators should be ready to place a pericardial drain; drainage is often necessary even if initial needle aspiration results in significant clinical improvement (3).

Pericardiocentesis should only be performed by clinicians familiar with cardiac anatomy and with prior procedural experience. Initial training for clinicians can be conducted in simulation laboratories. This is not a learning procedure, as it can cause severe injuries (3).

The performance of pericardiocentesis is carried out in the following steps (3):

1. Explain the purpose of the procedure to the patient;
2. Obtain informed consent;
3. Open the sterile package by tearing along the edge lined with plastic film;
4. Put on sterile gloves;
5. Remove the sterile materials from the tray and arrange them conveniently on the sterile field;
6. Open the sterile pack and soak sterile gauzes with antiseptic solution;
7. The procedure can be performed under ultrasound or fluoroscopic guidance, allowing the physician to accurately visualize the fluid accumulation and precisely position the needle;
8. Perform a subxiphoid approach using an 18–22 Gauge (G) needle attached to a syringe of at least 50 ml;
9. Insert the needle between the xiphoid process and the left costal margin;
10. Direct the needle toward the left shoulder at a 40-degree angle to the skin;
11. Apply continuous aspiration as the needle approaches the right ventricle;
12. Once the pericardial fluid is aspirated, a cannula can be introduced into the pericardial space;
13. Finally, attach a three-way stopcock, and aspirate the fluid while improving hemodynamics;
14. Dispose of gloves and equipment properly;
15. Perform hand hygiene;
16. Label the sample, place it in a transport bag, and send it to the laboratory;
17. Document the procedure in the patient's medical record.

Pericardiocentesis is a potentially life-saving procedure. Failure to recognize decompensation in a critically ill patient and not performing the procedure when indicated will lead to cardiac tamponade and death (3).

Pericardiocentesis provides essential information about the composition and characteristics of pericardial fluid, which is crucial for the diagnosis and management of patients with pericardial effusions.

Interpretation of pericardiocentesis results includes analyzing the appearance, color, consistency, and chemical composition of the obtained

pericardial fluid. A clear, transparent, or serous appearance often indicates a benign effusion, whereas a cloudy, purulent, or bloody appearance may suggest an infectious or inflammatory etiology. Analysis of the chemical composition of pericardial fluid, including protein levels, cells, and inflammatory markers, can provide important clues about the underlying cause of the pericardial effusion (5).

Future perspectives in pericardiocentesis include the continued use of advanced imaging technologies and minimally invasive approaches to improve the precision and safety of the procedure.

Advances in ultrasound technology allow for more accurate, real-time guidance of the pericardial needle, reducing the risk of complications and enhancing procedural effectiveness. New methods for analyzing pericardial fluid, including the use of biological markers and genetic tests, are being investigated to enable faster and more accurate diagnosis of pericardial conditions. In the future, pericardiocentesis is expected to continue evolving as an essential tool in the diagnosis and management of patients with pericardial diseases, contributing to improved clinical outcomes and reduced morbidity and mortality associated with these conditions.

These future perspectives reflect the ongoing commitment of the medical community to research and develop more efficient and precise methods for the diagnosis and treatment of pericardial diseases, aiming to improve patient quality of life and reduce the negative impact of these conditions on human health (4).

V.2. Thoracentesis

Thoracentesis, also known as thoracic puncture or pleural drainage, is an invasive medical procedure used to evacuate fluid accumulated in the pleural cavity.

The primary purpose of thoracentesis is to relieve symptoms associated with pleural effusions, establish a diagnosis, and improve the patient's respiratory function (6).

Thoracentesis has a long and rich history, dating back to antiquity (7). The first descriptions of the procedure come from Roman and Greek periods, when physicians used rudimentary techniques to evacuate pleural fluid in cases of pneumothorax or pleurisy. However, the modern technique of thoracentesis was developed and refined in the 19th century, alongside advancements in medical knowledge and technology. The procedure was first performed by Morrill Wyman in 1850 and later described by Henry Ingersoll Bowditch in 1852 (8).

Thoracentesis is used in a variety of medical situations for both diagnostic and therapeutic purposes. The main indications for thoracentesis include (9):

- Diagnosis and treatment of pleural effusions of various etiologies, including infectious, inflammatory, malignant, or traumatic causes;
- Relief of symptoms associated with tension pneumothorax or massive pleural effusions that interfere with respiratory function.

Although thoracentesis is considered a safe and effective procedure in most cases, there are certain contraindications and associated complications (10).

Contraindications for thoracentesis include:

- Coagulation disorders or anticoagulant therapy, which may increase the risk of excessive bleeding at the puncture site;
- Active skin infections or severe pulmonary conditions at the puncture site, which may increase the risk of infection of the pleural cavity;
- Abnormal anatomy of the pleural cavity or adjacent thoracic structures, which may make thoracentesis difficult or increase the risk of complications.

The main complications associated with thoracentesis include:

- Excessive bleeding at the puncture site or into the pleural cavity;
- Iatrogenic pneumothorax or perforation of the pulmonary parenchyma;
- Infection of the pleural cavity or other anatomical structures.

A summary of the indications, relative contraindications, and complications for thoracentesis is presented in **Table 2**.

Table 2. Indications. Contraindications. Complications. Adapted from (11).

Indications	Contraindications	Complications
Diagnostic	Coagulation disorders	Excessive bleeding at the puncture site
Therapeutic	Anticoagulant therapy	Excessive bleeding in the pleural cavity
	Active skin infections	Iatrogenic pneumothorax
	Severe pulmonary conditions	Perforation of the lung parenchyma
	Abnormal pleural cavity anatomy	Infection of the pleural cavity
	Abnormal anatomy of adjacent thoracic structures	Infection of other anatomical structures

Thoracentesis requires specialized instruments to be performed safely and effectively (10). The patient's hemodynamic status should be assessed. The patient should be seated on the edge of the bed, with arms crossed and resting on the table above the bed, as this position provides optimal access to the intercostal spaces and facilitates fluid removal. Handwashing and disinfection are mandatory before performing this procedure.

Procedure safety is improved when performed under ultrasound guidance. If available, a linear probe with a sterile cover should be used (10), but a chest X-ray should always be performed both before and after the procedure.

This is an invasive procedure. The following personal protective equipment and sterile field preparations should be used to avoid iatrogenic infections: sterile gloves, eye protection, face mask, sterile drapes, and povidone-iodine solution.

Before the thoracic puncture, it is customary to administer a local anesthetic at the puncture site to reduce discomfort and pain associated with inserting the thoracic needle into the pleural cavity (10). The local anesthetic is usually administered as a subcutaneous injection over the skin at the puncture site. The choice of anesthetic and the dose used should be tailored to each patient, taking into account factors such as known allergies, body weight, and individual sensitivity.

Thoracentesis requires specialized instruments to be performed safely and effectively (10).

The main components of the instrument set used in thoracentesis include:

- A specialized thoracic needle, of appropriate size and length, to allow efficient puncture of the pleural cavity;
- A guidance system, such as ultrasound or fluoroscopy, to ensure correct needle placement and guide the pleural fluid drainage process;
- A drainage or suction system that can be connected to the needle to allow efficient removal of the accumulated pleural fluid.

The thoracentesis procedure is performed in the following steps (12):

1. Explain the purpose of the procedure to the patient;
2. Obtain informed consent;
3. Perform a chest X-ray prior to the procedure;
4. Assess for allergies to topical anesthetic agents;
5. Drape the patient appropriately to expose the area while ensuring adequate coverage;

6. Open the sterile package by tearing at the edge lined with plastic film;
7. Put on sterile gloves;
8. Remove sterile items from the tray and arrange them conveniently on the sterile field;
9. Open the sterile package and soak sterile gauze with antiseptic solution;
10. Insert the needle into the pleural space to remove fluid, either for diagnostic tests or to relieve pleural pressure;
11. Ensure the patient does not move or cough during the procedure to prevent lung or pleural injury;
12. After needle insertion, monitor the patient for pallor, dyspnea, tachycardia, chest pain, or dizziness (pneumothorax);
13. Connect the tubing to a vacutainer, allowing fluid to be aspirated;
14. Apply a compressive dressing after the fluid and needle are removed;
15. Dispose of gloves and equipment properly;
16. Perform hand hygiene;
17. Record the color, quantity, consistency, and characteristics of the fluid samples obtained;
18. Complete laboratory forms, label the sample, place it in a transport bag, and send it to the laboratory;
19. Document the procedure in the patient's medical record;
20. Monitor the patient every 5 minutes for 30 minutes;
21. Position the patient on the unaffected side with the head elevated at 30 degrees for at least 1 hour;
22. Monitor vital signs and breath sounds for 2 hours;
23. Perform a post-procedure chest X-ray to check for pneumothorax.

The interpretation of thoracentesis results is essential for the diagnosis and management of patients with pleural effusions (13). Analysis of the obtained pleural fluid can provide valuable information about the underlying etiology and severity of the condition, as well as the need for additional treatment. The main aspects considered when interpreting thoracentesis results include:

- **Appearance of pleural fluid:** Clear, transparent, or serous fluid often indicates a benign effusion, whereas cloudy, purulent, or bloody fluid may suggest an infectious or inflammatory etiology;
- **Chemical composition analysis:** Levels of proteins, cells, and inflammatory markers in the pleural fluid can provide important clues about the underlying cause of the pleural effusion and help guide therapeutic decisions.

Thoracentesis (10) often requires an interdisciplinary approach, involving specialists from fields such as pulmonology, interventional radiology, or thoracic surgery. Close collaboration between these specialties ensures a thorough evaluation and proper management of patients with complex or recurrent pleural effusions. For example, in complicated or challenging cases, an interventional radiology specialist can provide expertise in ultrasound- or fluoroscopy-guided needle placement, facilitating the procedure and reducing the risk of complications.

Future perspectives in thoracentesis include the continued use of advanced imaging technologies and minimally invasive approaches to improve the accuracy and safety of the procedure. Advances in ultrasound technology allow real-time, precise guidance of the thoracic needle, reducing the risk of complications and enhancing procedural efficacy. Additionally, new methods for analyzing pleural fluid are being explored, including the use of biomarkers and genetic tests, for faster and more accurate diagnosis of thoracic conditions. In the future, thoracentesis is expected to continue evolving as a key tool in the diagnosis and management of patients with pleural effusions, contributing to improved clinical outcomes and reduced morbidity and mortality associated with these conditions (7).

V.3. Paracentesis

Paracentesis is a minimally invasive medical procedure used to remove fluid accumulated in the abdominal cavity, known as ascites (14).

This intervention is performed by inserting a specialized needle into the peritoneal cavity, under ultrasound or fluoroscopic guidance, to extract the fluid and reduce intra-abdominal pressure. Ascites (15) is a common condition encountered in various medical situations, such as liver cirrhosis, congestive heart failure, abdominal cancers, and pancreatitis.

The first mentions of this procedure appear in medical texts from ancient Greek and Egyptian physicians. However, modern techniques and instruments for paracentesis were developed in later centuries, with significant contributions from physicians in the 19th and 20th centuries. Today, paracentesis is a common and well-established procedure in modern medical practice, widely used for the diagnosis and treatment of ascites (16).

Paracentesis is used in a variety of conditions that cause fluid accumulation in the abdominal cavity.

The main indications for paracentesis include the diagnosis and treatment of ascites associated with liver cirrhosis, congestive heart failure, abdominal cancers, pancreatitis, and other medical conditions. Additionally, paracentesis can be used therapeutically to relieve symptoms associated with

excessive fluid accumulation, such as abdominal discomfort and difficulty breathing (14).

Although paracentesis is considered safe and effective in most cases, there are certain contraindications and complications associated with the procedure.

Contraindications for paracentesis can be absolute or relative; during the procedure, areas with active skin infections at the puncture site should be avoided. Complications associated with paracentesis may include bleeding, infection, perforation of abdominal viscera, and pneumoperitoneum (accidental introduction of air into the peritoneal cavity). Despite these risks, paracentesis is considered a safe and effective procedure when performed by experienced medical personnel under proper aseptic and antiseptic conditions (14).

A summary of the indications, contraindications, and complications of thoracentesis is presented in Table 3**.**

Table 3. Indications. Contraindications. Complications. Adapted from (14)

Indications	**Absolute contraindications**	**Relative contraindications**	**Complications**
Diagnostic	Disseminated intravascular coagulation	Pregnancy	Excessive bleeding at the puncture site
Therapeutic	Acute surgical abdomen	Organomegaly	Infections
		Ileus	Pneumoperitoneum
		Intestinal obstruction	Perforation of abdominal viscera
		Coagulation disorders	Infection of other anatomical structures

Paracentesis requires specialized equipment to be performed safely and effectively (14). The patient's hemodynamic status must be assessed. Hand washing and disinfection are mandatory before performing this procedure.

To perform paracentesis, a specific set of sterile instruments and materials is needed. These include a puncture needle, a drainage set for fluid collection, antiseptics for skin preparation, and sterile gloves for the protection of medical personnel. The procedure can be performed under ultrasound or fluoroscopic guidance, allowing the physician to accurately visualize the fluid collection and precisely position the needle.

Standard paracentesis kits are available, featuring plastic-sheathed cannulas attached to a syringe and a three-way stopcock. Alternatively, intravenous catheters—either traditional large-diameter or standard needles—can be used. These can be connected to a syringe for aspiration and to tubing for fluid drainage. If standard kits are not available, the following materials should be prepared:

1. Sterile gloves
2. Medical mask
3. Antiseptic solutions
4. Scalpel
5. Sterile compresses
6. Chlorhexidine or Betadine
7. 1% lidocaine, 5 ml vial
8. Puncture needles
9. Plastic catheter with a three-way stopcock and self-sealing valve
10. 20 ml or 60 ml syringe for collecting a fluid sample
11. Drainage tubing
12. Containers for cultures
13. Biohazard collection bag

Paracentesis is performed in the following steps (12):

1. Explain the purpose of the procedure to the patient.
2. Obtain informed consent.
3. Position the patient on a chair or at the edge of the bed with legs apart.
4. Cover the patient appropriately and monitor hemodynamics during the procedure.
5. Put on sterile gloves.
6. Remove sterile materials from the tray and arrange them conveniently on the sterile field.
7. Open the sterile package and soak the sterile compresses with antiseptic solution.
8. Prepare the skin with antiseptic solution and apply topical anesthesia.
9. Insert the cannula through a small incision.
10. Attach the plastic tubing to the cannula, placing the other end in the collection container.
11. A Vacutainer can be used to facilitate gentle aspiration of fluid from the cavity.
12. Observe the total amount of fluid aspirated; removing more than 1000 ml at once may cause hypotension.
13. Apply a compressive dressing after removing the needle.

14. Measure and record the aspirated volume in the appropriate register.
15. Dispose of gloves and equipment properly.
16. Perform hand hygiene.
17. Label the sample, place it in the transport bag, and send it to the laboratory.
18. Document the procedure in the patient's medical record.
19. Position the patient in bed at a 45–60° incline.
20. Monitor vital signs for 24 hours.

The interpretation of paracentesis results is crucial for establishing a diagnosis and planning appropriate treatment. The main aspects evaluated in the analysis of abdominal fluid obtained through paracentesis include (15):

- Chemical composition: Determining the concentrations of proteins, albumin, glucose, and other chemical substances in the abdominal fluid can provide important clues about the etiology of ascites and the severity of the underlying condition.
- Quantity and appearance of the fluid: The total volume of aspirated fluid, its color, and clarity can give additional information about the cause of ascites. For example, the presence of cloudy fluid may indicate an infection or the presence of malignant cells.
- Presence of malignant cells and tumor markers: Identifying malignant cells in the abdominal fluid or the presence of other tumor markers may suggest a malignant process within the abdominal cavity.

Culture and sensitivity: If an infection is suspected, performing a bacterial culture of the abdominal fluid is important to identify the pathogen and determine its antibiotic sensitivity.The correct interpretation of these results can guide therapeutic decisions and the patient's prognosis

Future perspectives in the field of paracentesis include the ongoing development of technologies and methods for analyzing abdominal fluid, as well as improvements in the safety and effectiveness of the procedure. Some research and innovation directions include (16):

- Use of biomarkers and genetic tests: Identifying and validating specific biomarkers for various abdominal conditions could enable faster and more accurate diagnosis. Additionally, genetic tests for detecting mutations associated with abdominal cancers can provide valuable information for treatment planning.
- Development of advanced analytical techniques: The use of advanced technologies, such as mass spectrometry and proteomic analysis, to

study the composition of abdominal fluid could provide detailed insights into molecular profiles associated with different abdominal conditions.

- Integration of artificial intelligence: Using artificial intelligence algorithms to analyze paracentesis data could enhance the diagnostic capability for abdominal conditions by identifying patterns and correlations that are not visible to the naked eye.
- Optimization of guidance techniques and instruments: Continued development of technologies for ultrasound or fluoroscopic guidance, along with improvements in instruments and procedural techniques for paracentesis, aims to reduce risks and increase the efficacy and precision of the procedure.

These future perspectives could contribute to improving the management and outcomes of patients with abdominal conditions and advance the field of paracentesis in modern medical practice.

V.4. Bone Marrow Aspiration and Biopsy.

Hematopoiesis is the process of creating a wide variety of blood and bone marrow cells, namely erythrocytes, platelets, granulocytes, lymphocytes, and monocytes (17). The process of hematopoiesis, through which blood cells are formed, has been extensively studied for over a century (18).

This process begins with multipotent hematopoietic stem cells, which have the capacity to either divide into a multipotent progenitor cell or self-renew. Progenitor cells can then divide into increasingly specialized cells, a process that continues until mature white blood cells, red blood cells, or platelets are formed (17). Studies of hematopoiesis provide essential insights with broad relevance to various areas of stem cell biology, including the role of cell–cell interactions in development and tissue homeostasis, the programming and reprogramming of lineages by transcription factors, and differences in cell phenotypes specific to developmental stage and age (19).

Bone marrow aspiration and biopsy are frequently performed for the diagnosis of a wide range of hematologic disorders. The palpation-guided method is commonly used for these procedures, offering high accuracy and a low complication rate (20).

The study of bone marrow is essential for diagnosing hematologic conditions. Giovanni Ghedini (1877–1959), an Italian physician who first introduced bone marrow sampling in 1908, laid the foundation for this

investigation in clinical hematology (21). Assessment of the bone marrow marked a turning point in the history of clinical hematology, allowing a better understanding of both normal and pathological hematopoiesis as well as improved classification of blood disorders (22).

Bone marrow aspiration and biopsy are usually performed by hematologists or onco-hematology specialists. These procedures can also be carried out in hospitals by resident physicians under the close supervision of a specialist hematologist. They may be performed in specialized units or hematology/oncology departments, depending on the medical institution and available resources.

The physician performing bone marrow aspiration and biopsy must have thorough knowledge of bone marrow anatomy and expertise in collection techniques to minimize risks and complications. The preferred technique for reducing pain in patients undergoing these procedures is now general anesthesia (23), although local anesthesia can also be used. When general anesthesia is chosen, the procedural team should include both the hematologist and an anesthesiologist. This structure ensures the procedure is carried out safely, both in terms of patient monitoring under anesthesia and proper collection of bone marrow samples.

The indications for bone marrow aspiration and biopsy include, but are not limited to, the definitive diagnosis of hematologic disorders such as acute leukemias, myelodysplastic syndromes, myeloproliferative neoplasms, Hodgkin lymphoma, non-Hodgkin lymphomas, lymphoproliferative diseases, and monoclonal gammopathies. Other indications include aneuploidy in newborns and fever of unknown origin (24). This procedure can also assist in diagnosing atypical fungal and parasitic conditions, such as histoplasmosis, leishmaniasis, and Q fever (25–27). Many of these conditions require both aspiration and biopsy to provide a complete hematologic assessment, establish a diagnosis, and plan treatment (20).

Absolute contraindications for bone marrow aspiration and biopsy include bleeding disorders, such as severe disseminated intravascular coagulation or severe hemophilia. Thrombocytopenia is not an absolute contraindication but rather a relative one; if clinically necessary, a platelet transfusion may be administered before the procedure, often when the platelet count is below 20,000/mm^3. Bone marrow aspiration can be performed at the sternal or iliac level, although the sternal site is generally reserved for patients older than 12 years (28). Because of the risk of perforating the sternum and mediastinum, individuals with diffuse bone resorption caused by metabolic or lytic processes should undergo aspiration at the iliac crest instead; bone biopsies at the sternal site are always contraindicated due to the same risks (20).

One of the most common complications is post-procedural bleeding, as the collected tissue is highly vascularized. Manual pressure or a compressive dressing can be applied until bleeding stops. Rarely, retroperitoneal or gluteal hemorrhage may occur, usually due to injury to the superior gluteal artery or internal iliac artery (29,30). When the biopsy needle is accurately directed toward the ipsilateral anterior superior iliac crest and does not pass through the cortex, these complications are less frequent (31). Extreme caution must be used when sampling from the sternal site, as a misdirected needle can lead to hemorrhage, cardiac tamponade, and death (20).

A summary of the indications, contraindications, and complications for bone marrow aspiration and biopsy is presented in Table 4.

Table 4. Indications. Contraindications. Complications. Adapted from (20).

Indications	**Absolute contraindications**	**Relative contraindications**	**Complications**
Diagnostic	Severe disseminated intravascular coagulation	Thrombocytopenia	Post-procedural bleeding
	Severe hemophilia		Retroperitoneal/gluteal hemorrhage
			Cardiac tamponade (sternal bone marrow aspiration)
			Hemorrhage (sternal bone marrow aspiration)
			Death (sternal bone marrow aspiration)

Bone marrow aspiration and biopsy require specialized equipment to be performed safely and effectively. The patient's hemodynamic status must be assessed. Hand washing and disinfection are mandatory before performing these procedures.

To carry out these procedures, a specific set of sterile instruments and materials is required. This includes a specialized kit for the procedures, as well as equipment for the protection of medical personnel. The kit for these procedures contains the following items:

1. Antiseptic solutions for local skin preparation
2. Sterile compresses

3. Anesthetic solutions – e.g., Xylocaine 10 mg/ml vial or Lidocaine 2% vial
4. 10% Betadine solution / 0.1% Rivanol solution
5. Sterile needles
6. Sterile syringes
7. Kidney tray
8. Sterile drape
9. Medical mask
10. Sterile gloves
11. Puncture needles
12. Biopsy needles
13. Microscope slides for specimens
14. Slide holders (for preparing specimens already placed on slides)
15. Containers for biopsy material
16. Biohazard waste collection bag

Bone marrow aspiration is performed in the following steps (12,20):

1. Identify the patient.
2. Explain the purpose of the procedure to be performed.
3. Inform the patient that there will be slight discomfort when the needle is inserted.
4. Obtain consent for the procedure.
5. Review hemostasis tests and report any abnormalities.
6. Place the kit on the patient's bed.
7. Put on sterile gloves.
8. Remove sterile items from the tray and arrange them conveniently on the sterile field.
9. Soak sterile compresses with antiseptic solution.
10. Position the patient according to the preferred site: supine or prone (sternal bone marrow aspiration), or lateral (iliac crest aspiration) – in the lateral position, the patient lies on their side with knees slightly flexed and back relaxed; this allows optimal access to the posterior iliac crest.
11. Administer local anesthesia.
12. Insert the aspiration needle, penetrating the skin and bone into the bone marrow cavity.
13. Attach a syringe to the puncture needle to aspirate a small amount of bone marrow, which is then transferred onto slides for examination.
14. After removing the needle, apply pressure to the puncture site for 5–15 minutes to prevent bleeding, then apply a sterile dressing impregnated with 10% Betadine or 0.1% Rivanol solution.

15. Monitor vital signs and the puncture site for possible complications, such as bleeding, infection, or local discomfort.
16. Dispose of gloves and equipment properly.
17. Perform hand hygiene.
18. Label the sample, place it in the transport bag, and send it to the laboratory.
19. Document the procedure in the patient's medical record.

Bone marrow biopsy is performed in the following steps (12,20):

1. Identify the patient.
2. Explain the purpose of the procedure to be performed.
3. Inform the patient that there will be slight discomfort when the needle is inserted.
4. Obtain consent for the procedure.
5. Review hemostasis tests and report any abnormalities.
6. Place the kit on the patient's bed.
7. Put on sterile gloves.
8. Remove sterile items from the tray and arrange them conveniently on the sterile field.
9. Soak sterile compresses with antiseptic solution.
10. Position the patient in the lateral position – the patient lies on their side with knees slightly flexed and back relaxed; this allows optimal access to the posterior iliac crest, where the biopsy will be performed.
11. Administer local anesthesia.
12. Insert a special biopsy needle through the skin and bone into the bone marrow; the needle is designed to obtain a cylindrical core of bone marrow for examination.
13. Using gentle twisting motions, obtain a cylindrical bone marrow sample; carefully remove the needle to avoid damaging the specimen.
14. After needle removal, apply pressure to the puncture site for 5–15 minutes to prevent bleeding, then apply a sterile dressing impregnated with 10% Betadine or 0.1% Rivanol solution.
15. Monitor vital signs and the puncture site for possible complications, such as bleeding, infection, or local discomfort.
16. Dispose of gloves and equipment properly.
17. Perform hand hygiene.
18. Label the sample, place it in the transport bag, and send it to the laboratory.
19. Document the procedure in the patient's medical record.

It is possible to perform both iliac bone marrow aspiration and bone marrow biopsy simultaneously (32). If this approach is chosen, the aspiration is performed first, followed by the biopsy.

Bone marrow aspiration requires a smaller amount of tissue and can be completed more quickly. A thinner aspiration needle is used, making the procedure less invasive. Performing the aspiration first helps reduce the risk of complications, such as bleeding or infection, before introducing a larger needle for the biopsy (33).

The diagnosis of hematologic disorders depends on the interpretation of bone marrow aspiration and biopsy results.

Cellular appearance (32) is one of the most important elements to investigate. Cellular morphology can be assessed through microscopic analysis of bone marrow cells. A variety of pathologies may be present, including acute leukemias, myelodysplastic syndromes, myeloproliferative neoplasms, Hodgkin lymphoma, non-Hodgkin lymphomas, lymphoproliferative diseases, and monoclonal gammopathies.

Hematopoietic efficiency can be determined by quantitatively evaluating hematopoietic cells (platelets, red cells, and white cells). This assessment provides information about the architecture of the marrow tissue: a fibrous environment may indicate marrow fibrosis or malignant disease, while an increased percentage of blasts (immature cells) may indicate a malignant hematologic pathology, and a decreased percentage of cells may suggest marrow insufficiency.

For evaluating cytomorphology, differential cell counts, and ancillary studies such as flow cytometry, cytogenetics, and molecular tests, bone marrow aspiration is more appropriate (32).

Cellularity and overall marrow architecture, which are particularly sensitive for identifying focal lesions, are evaluated through bone marrow biopsy (32).

The information that should be included in a complete bone marrow examination report is presented in **Table 5**.

Table 5. Information included in a complete bone marrow examination report. Adapted from (32).

Institutional information	Name of the Institution
Patient details	Patient's full name, date of birth, and registration number / general medical record number
Requesting physician	Requesting physician's name and stamp/code
Procedure details	Date of the procedure, indications for the procedure, type of procedure performed – bone marrow aspiration / bone marrow biopsy, and procedure site – sternum or posterior iliac crest
Complete blood count and peripheral blood smear details	Complete blood count parameters and description of the peripheral blood smear
Bone marrow aspiration examination	***Morphological aspects:*** *cellularity, differential count of nucleated cells, myeloid-to-erythroid ratio, blast percentage, erythropoiesis, myelopoiesis, megakaryocytes, lymphocytes, plasma cells, other hematopoietic cells, abnormal cells;* ***Special stains*** ***Other investigations performed***
Bone marrow biopsy examination	***Morphological aspects:*** *length of the biopsy fragment, cellularity, bone architecture, localization, number, morphology, and maturation of erythroid, myeloid, and megakaryocyte lineages, plasma cells, lymphocytes, and macrophages; presence of abnormal cells or infiltrates.* ***Special stains*** ***Immunohistochemistry results:*** *a diagnostic method combining histological, immunological, and biochemical techniques*

Diagnosis according to World Health Organization (WHO) criteria	Summary of the analyzed information
Additional notes	If applicable
Signature and date of report completion	After report completion

Bone marrow analysis is an essential technique for diagnosing and post-therapeutic monitoring of hematologic disorders. It is crucial to establish a standardized reporting process that includes molecular investigations and a methodical approach to bone marrow examination (32).

By improving knowledge of the nomenclature and characteristics of hematologic neoplasms, these procedures facilitate effective collaboration among multidisciplinary teams managing patients with blood disorders.

Hematologists, oncologists, pathologists, primary care physicians, nurses, and pharmacists are among the members of such multidisciplinary teams. Based on bone marrow sample results, pathologists provide precise diagnostic assessments, while hematologists are responsible for patient management and developing treatment plans for specific blood conditions.

Tips and tricks

- ✓ **All maneuvers performed on the patient require signing an informed consent.**
- ✓ **Punctures should only be performed by specialized physicians.**
- ✓ **While the basic concepts of pericardiocentesis remain unchanged, high-quality imaging and new interventional techniques have led to contemporary approaches for this procedure.**
- ✓ **Thoracentesis can be safely performed at the patient's bedside or in an outpatient setting.**
- ✓ **Some patients require repeated paracentesis. The insertion site must be identified to estimate the volume of fluid that can be safely removed.**
- ✓ **For bone marrow aspiration and biopsy, to optimize patient comfort, sample quality, and procedural efficiency, proper patient positioning should be observed, appropriate equipment should be used for the procedure, and post-procedural care steps must be followed.**
- ✓ **Patients require hemodynamic monitoring before and after these procedures.**

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Chapter VI
Hemorrhage and Hemostasis

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VI.1. Brief History

The term **hemostasis** comes from the Greek words *haima* (blood) and *stasis* (to stop) and refers to the biological process encompassing all mechanisms involved in stopping a hemorrhage (1). When this biological process (spontaneous hemostasis) fails to stop bleeding, all methods and techniques of **temporary hemostasis** are employed, followed, if necessary, by **definitive hemostasis** (1).

The study of hemostasis dates back to prehistoric times, when uncontrolled bleeding was recognized as fatal, progressing through experiments by Lister, who developed the modern absorbable ligature. The ancient Greeks and Romans used vegetable and mineral salts to treat wounds sustained in battle; Machaon reportedly treated Menelaus with such remedies outside the walls of Troy. Early surgeons began performing intentional incisions while avoiding blood vessels as they were discovered (2).

Seeking more knowledge, the Greeks invaded Egypt and became familiar with the dissection techniques known to the Egyptians. Herophilus described veins as full of blood and arteries as containing blood and *pneuma* (air), noting differences in the vessel walls. By Celsus's time, ligature was used only as a last resort, after cauterization and herbal agents failed. During the decline of the Roman Empire, Galen described the circulation of blood in a way approaching modern understanding and advocated cauterization for hemostasis.

In Western Europe, little progress was made until the 15th century, when the invention of gunpowder led to an increase in war wounds. The advent of the printing press disseminated medical, surgical, and scientific texts, allowing surgeons to study the work of others. Different schools of thought emerged: some advocated healing wounds by suppuration, others by primary intention. Ambroise Paré, a pioneer in surgery, accidentally discovered that a digestive ointment promoted healing more effectively than painful cauterization, modestly noting: "I dressed him, and God healed him." He also described the *bec de corbin* (bird-beak appearance) an instrument for grasping blood vessels (2).

In 1674, Morel is credited with inventing the tourniquet on a twisted stick. A bow was added to the *bec de corbin*, and bandage rolls were placed

under the tourniquet to compress major vessels. Limb amputations became more common, and blood coagulation was described by Jones and Lawson (2).

Physick and Nathan Smith were among the first to shorten the ends of their ligatures made from deer hide, contrary to Liston's advice. Forceps were gradually improved, with Kocher and Halstead giving their names to specific models. It was soon realized that more than one or two forceps were needed for surgery, improving technique further. Lord Lister then introduced asepsis and perfected ligature through sterilization in dilute carbolic acid. The theory of asepsis was supported by Pasteur and Koch, and Lister's experiments demonstrated effective and reproducible results that underpin modern surgical procedures (2).

VI.2. Hemostasis

Hemostasis represents the totality of mechanisms and techniques used to stop any source of bleeding from small vessels (capillaries) or large vessels (arteries/veins).

Spontaneous hemostasis can be divided into two phases: **primary hemostasis** and **secondary hemostasis**. Primary hemostasis involves the formation of a platelet plug. Secondary hemostasis involves the coagulation process and the formation of a blood clot, commonly called a thrombus. Functionally, hemostasis includes several stages: vasoconstriction, platelet plug formation, coagulation, and clot formation. Excess clots are later removed through **fibrinolysis** (3).

This process primarily addresses bleeding from small vessels or minor venous injury. Hemostasis can also be achieved by other means if the body cannot perform it naturally during surgery or medical treatment. Hemostasis is more difficult under shock or stress conditions.

During surgical procedures, different types of hemostasis can be used to control bleeding while minimizing tissue damage. Hemostasis can be achieved **chemically, mechanically, or physically**, depending on the situation (4).

The most common indication for **blood transfusion** in surgical patients is restoration of circulating blood volume. Hemoglobin or hematocrit levels are used to interpret the severity of hemorrhage. Both the volume and rate of bleeding determine the development of signs and symptoms. A healthy person can lose 500 mL in 15 minutes (**Grade I hemorrhage**) with minor circulatory effects and minimal changes in blood pressure or pulse. Loss of 15–30% of blood volume (**Grade II hemorrhage**) is associated with tachycardia. Loss of 30–40% of blood volume (**Grade III hemorrhage**) generally leads to tachycardia, tachypnea, and hypotension.

A careful **history and physical examination** are the most important evaluations of hemostasis. Key questions should determine whether the patient experienced refractory bleeding during major surgery, bleeding after minor procedures, or spontaneous bleeding. The history should also include exposure to toxins, oral anticoagulants, or medications interfering with hemostasis (for example, aspirin, ibuprofen). Recent broad-spectrum antibiotic therapy may suggest a deficiency of vitamin K–dependent clotting factors. Patients with malignancy may present with various hemostatic abnormalities. Complex hemostatic disorders may accompany liver or kidney failure.

Thrombocytopenia is the most common hemostatic abnormality in surgical patients. Assessing circulating platelet levels is a critical screening test. Spontaneous bleeding is more likely when platelet counts are below 40,000/mm³. Counts of 60,000–70,000/mm³ are usually sufficient for adequate hemostasis after trauma or surgery if other coagulation factors are normal. Abnormal counts are confirmed by examining the peripheral blood smear.

Bleeding time evaluates both platelet interaction with the injured vessel and platelet plug formation. Bleeding time may be prolonged in patients with thrombocytopenia.

Prothrombin time (PT) measures the extrinsic pathway of coagulation and cannot be determined in patients on heparin until at least 5 hours after the last dose. **Activated partial thromboplastin time (APTT)** is a screening test for the intrinsic coagulation pathway. **Thrombin time** detects qualitative fibrinogen abnormalities and is prolonged during fibrinolysis (5).

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VI.3. Hemorrhage

The management of hemorrhage involves the actions taken to control bleeding in a patient who has suffered a traumatic injury or has a medical condition causing bleeding (6). Many hemorrhage control techniques are taught as part of first aid worldwide. Advanced techniques, such as **t**ourniquet**s**, are included in advanced first aid courses and are used by healthcare professionals to prevent blood loss from arterial bleeding (7). Effective management of bleeding requires the ability to quickly identify the types of wounds and the types of hemorrhage (6,7).

The type of lesion (incision, laceration, puncture, etc.) has a major effect on how a wound is managed, as does the area of the body affected and the presence of any foreign objects in the wound. A severe wound or any complication may require a call to emergency medical services. Any wound requires abundant lavage with antiseptic solutions after the bleeding has stopped. Eyes and other delicate tissues require special products for disinfection (8)

Hemorrhage is classified into three main types depending on the injured vessel: capillary, venous, and arterial hemorrhages. The main difference between the three is the type of blood vessel affected, which determines the severity of the hemorrhage. Arterial bleeding occurs in the arteries, which carry blood from the heart to the periphery. Venous bleeding refers to injury to the veins, which carry blood from the periphery back to the heart. Capillary bleeding occurs in the capillaries, which are small blood vessels that connect arteries to veins. Specifically, arterial bleeding is pulsatile, venous bleeding has a steady flow, and capillary bleeding is slow. Arterial and venous hemorrhages can be severe, in which case it is important for the patient to receive immediate medical care. Capillary bleeding is the most common type of hemorrhage and is usually easily controlled by applying pressure (9). Arterial hemorrhage is the most severe and urgent type of bleeding. It can result from a penetrating injury, blunt trauma, or damage to organs or arterial vessels. Because the blood comes from the arteries, it differs from other types of bleeding. For example, the blood is bright red due to its oxygen content. It also has a pulsatile character, corresponding to the heartbeat.

The treatment approach may involve the following:

1. The initial step is to apply pressure directly to the wound, achieving hemostasis with one hand, using latex gloves and sterile gauze. It is also important to contact an emergency number to obtain medical assistance.
2. If this stops the bleeding, the next step is to cover the wound with a circular bandage.
3. When the bleeding comes from an artery in the arm or lower limb, temporary hemostasis can be achieved by elevating the limb above the level of the heart.
4. If all efforts to stop the bleeding fail, the last resort involves applying a tourniquet proximal to the hemorrhagic wound.

Venous hemorrhage is less severe than arterial bleeding but can still be life-threatening. For this reason, it requires immediate medical attention. Because the blood comes from a vein, it is dark red. This is due to the fact that it does not contain as much oxygen. Also, because veins are not under direct pressure, the blood has a steady flow but moves more slowly than in arterial bleeding. Treating venous bleeding involves the same procedures as treating arterial bleeding, but the tourniquet is applied distal to the bleeding (10).

Capillary bleeding usually occurs as a result of skin injuries and is more common than the other types. It has a slow flow and bright red color, being a combination of venous and arterial blood. Not only is capillary bleeding the least severe, but it is also the easiest to control, since it comes from superficial blood vessels.

VI.3.1. External vs. Internal Hemorrhage

External bleeding refers to hemorrhage that flows outside the body, whereas internal bleeding refers to hemorrhage that occurs inside the body. This can happen as a result of damage to an organ or an internal part of the body. Anatomical areas where internal bleeding frequently occurs include the hip, knee, elbow, and ankle joints. Internal bleeding can also occur in the brain, large muscles, intestinal tract, or the space around the lungs. Minor internal bleeding is common and may produce only small red spots on the skin or minor bruising. However, severe internal hemorrhage can be life-threatening. This usually occurs in a patient who loses a significant volume of blood and suffers hypovolemic shock or, more specifically, hemorrhagic shock (11)

VI.3.2. Hypovolemic Shock

It is the most frequently encountered clinical form of shock and represents the prototype of the hemodynamic syndrome of shock. In hypovolemic shock, tissue hypoperfusion is a consequence of the relative or absolute reduction of circulating volume, followed by decreased venous return and preload.

As a result, cardiac output decreases, and compensatory mechanisms increase heart rate and peripheral vascular resistance. At the cellular level, hemorrhagic shock can be defined as a state of altered oxidative metabolism and homeostasis, due to inadequate oxygen supply and insufficient removal of waste products generated during hypoperfusion. Loss of circulating blood volume leads to decreased arterial blood pressure, venous return, and stroke volume.

Clinical situations that can cause hypovolemic shock are multiple and include trauma, hemorrhage, burns, intestinal obstruction, pancreatitis, and dehydration due to diarrhea, vomiting, or excessive renal fluid losses.

Depending on the type of fluid lost (blood, plasma, digestive fluids), one of the variants of hypovolemic shock occurs: hemorrhagic, traumatic, burn-related, obstructive, or dehydration-related.

The primary pathophysiological change is a reduction in blood volume, a critical homeostatic constant for survival. A decrease in blood volume of more than 25% triggers compensatory hemodynamic mechanisms initiated by a neuroendocrine response. If no therapeutic intervention occurs and hypovolemia persists, prolonged reduced perfusion diminishes oxygen delivery to tissues. Initially, O_2 consumption is maintained by increased O_2 extraction, but soon this compensatory mechanism becomes insufficient, leading to tissue hypoxia associated with lactic acidosis. Hypoxia and

acidosis cause severe disturbances in cellular activity and vascular wall function. Clinically, this manifests as hemodynamic instability and visceral suffering in shock, which may be accompanied by signs revealing the underlying condition that caused the shock (12):

1. Arterial hypotension is associated with: tachycardia, rapid breathing, cold cyanotic extremities with absence of capillary refill, oliguria;
2. Central venous pressure is low, indicating reduced preload;
3. Cardiac output is low;
4. The patient in hypovolemic shock is hypothermic, complaining of a sensation of cold;
5. Mottling of the skin may appear early, especially over the skin covering the knees, with extension to generalization indicating severe shock with pronounced tissue hypoperfusion;
6. Visceral suffering occurs late and mainly affects kidney function;
7. Severe or prolonged vasoconstriction leads to acute renal failure, through reduction of glomerular filtration followed by tubular necrosis;
8. Other viscera affected by prolonged splanchnic vasoconstriction in hypovolemic shock are the intestines and liver;
9. Hyperventilation occurring early in hypovolemic shock is produced by stimulation of peripheral chemoreceptors and later by metabolic acidosis;
10. Preexisting respiratory diseases, thoracic trauma, and heart failure may contribute to early development and/or worsening of respiratory failure;
11. The level of consciousness progressively deteriorates;
12. Anxiety, agitation, and fear characterize the early response to hypovolemia;
13. Apathy, drowsiness, and coma occur late as a result of massive fluid loss, failure of compensatory mechanisms, and associated (usually vascular) brain pathology, and their presence outside of a concomitant cranio-cerebral trauma has a limited prognostic significance.

The evaluation of the clinical picture allows assessment of the severity of shock. In general, in hemorrhagic shock: losses up to 750 ml (15% of circulating blood volume) do not generate pronounced symptoms - patient slightly anxious; losses between 750–1500 ml produce symptoms caused by catecholamine release, thirst, weakness, tachypnea – patient moderately

anxious; losses between 1500–2000 ml - patient anxious and confused; a loss of over 2000 ml (over 40% of circulating blood volume) results in absence of the radial artery pulse and unmeasurable blood pressure - patient confused/lethargic.

The main objective of therapy for hypovolemic shock is to correct the state of hypoperfusion through aggressive restoration of circulating volume. However, in severe cases (massive hemorrhage), initial resuscitation is required, which, like any resuscitation, assumes from the outset securing the airways and ensuring effective ventilation. Moreover, severe cases require priority application of etiological therapeutic measures to achieve hemostasis.

Treatment of shock includes (12):

1) Ventilation and oxygenation

Most patients in shock require endotracheal intubation and mechanical ventilatory support even if they do not present respiratory failure. This allows rapid correction of tissue hypoxemia through administration of 100% oxygen.

2) Circulatory resuscitation

To combat hypoperfusion, administration of fluids through two or more intravenous lines is required. If peripheral access is possible, placement of one or more large-bore peripheral intravenous cannulas is more efficient than emergency central venous catheterization.

As an alternative, a large-diameter central venous catheter should be inserted into the internal jugular, subclavian, or femoral vein. Placement of a central venous catheter must always be followed by a chest X-ray as soon as possible, not only to confirm correct catheter positioning but also to detect any presence of pneumothorax or hemothorax. As a general rule, intravenous catheters should preferably be avoided in limbs with major soft tissue or bone injuries.

Any source of external hemorrhage must be controlled by external compression, avoiding blind clamping or garrote application. Once intravenous access is established and fluid therapy initiated, definitive hemostasis should be attempted, preferably in the operating room. In cases of hemorrhagic or traumatic shock without signs of external bleeding, bleeding from pelvic or extremity fractures should be considered.

3) Fluid therapy

As a general rule, for restoring blood volume, the choice of fluids should take into account the nature of the fluids lost. Currently, it is

considered that both solutions should be used: initially colloid solutions, to increase blood volume, combined with the infusion of crystalloid solutions.

The colloid solutions used include:

- Whole blood: Blood should only be administered in severe hemorrhagic shock, after a one-third reduction of circulating blood volume; another indication for blood administration is hemorrhagic shock due to coagulation disorders.
- Stable plasma protein solution
- Fresh frozen plasma: Contains all coagulation factors and is useful when hypovolemia is associated with coagulation abnormalities.
- In patients requiring massive transfusion (replacement of circulating volume within 24 hours), it is preferable to administer red blood cell mass and fresh frozen plasma instead of stored whole blood.
- Dextran: A synthetic colloid; when administered in large amounts, it causes a decrease in fibrinogen, factors VIII and V, and platelet aggregation function; since it interferes with the agglutination reaction, blood typing must be performed before administering Dextran.

The crystalloid solutions used are:

- Isotonic saline solutions (Ringer's lactate, 0.9% NaCl solution) with an ionic composition close to that of plasma and interstitial fluid. When administered in large amounts, they can temporarily restore circulating volume and have been used for volume therapy in shock.

Circulatory resuscitation of hemorrhagic and traumatic shock (in which the cause of hypovolemia is usually bleeding) requires rapid infusion of colloids and/or crystalloids (3 liters of warmed physiological saline at body temperature over 20 minutes) until compatible blood is available. Vasoactive therapy is used only if the administration of a large volume of fluids does not ensure volume replenishment and will be stopped immediately once volemic restoration and hemostasis allow it.

4) Monitoring

- The fluid requirement and the rate of administration are established according to the hemodynamic response, assessed by frequent measurement of arterial pressure (AP), central venous pressure (CVP), and urine output;

- Respiration, mental status, and body temperature must also be monitored;
- Measurement of arterial oxygen saturation using a pulse oximeter should not be omitted;
- Initially, good guidance can be provided by the presence of radial, femoral, and carotid pulses;
- Restoration of normal values of the aforementioned parameters indicates normalization of the hemodynamic syndrome;
- Laboratory determinations should include blood gases, electrolytes and acid-base balance, blood glucose, coagulation, hematocrit (Ht), and hemoglobin (Hb).

5) Inotropic medication

The administration of vasoactive substances is rarely necessary in hypovolemic shock. Exceptionally, they may be used during transport, in the absence of infusible solutions, or in a patient imminently exsanguinating toward cardiac arrest. The use of inotropic agents is considered in the advanced phases of shock, when volume resuscitation does not result in an adequate hemodynamic response.

6) Correction of hydroelectrolytic and acid-base imbalances

Metabolic acidosis is present in all forms of shock and is frequently associated with hyperkalemia and hyponatremia. Volume restoration with colloids and crystalloid solutions reestablishes diuresis and helps counteract acidosis and electrolyte disturbances.

7) Treatment of organ failure

The onset of acute renal failure requires initiating treatment with diuretics. The prognosis of hypovolemic shock depends on the cause, severity and duration of the shock, age, and comorbidities. In cases of traumatic shock, death can occur within minutes of the traumatic event, caused by extensive injuries to the central nervous system (CNS) or rapid exsanguination from major injuries.

The types of internal hemorrhages can vary depending on the location of the bleeding and may include the following (11):

1. **Intracranial bleeding:** This occurs when a blood vessel inside or at the level of the skull is damaged and bleeds around or into the brain. It is usually caused by long-term arterial hypertension, which weakens the arterial walls. Symptoms include: weakness on one side of the

body, nausea, vomiting, headache, fatigue, and a change in mental status.

2. **Pleural cavity bleeding:** The pleural cavity is the space around the lungs. When bleeding occurs here, it interferes with normal lung expansion, which can affect oxygen and carbon dioxide transfer between the lungs and the blood. Symptoms may include: chest pain, difficulty breathing, fatigue.
3. **Abdominal bleeding:** This refers to bleeding in the peritoneal cavity, which contains organs such as the stomach, liver, kidneys, intestines, ovaries, uterus, and prostate. Common causes of internal abdominal bleeding include: injury to the liver, kidneys, or spleen; damage to a blood vessel in the abdomen; rupture of a cyst. Signs and symptoms may include: low blood pressure, abdominal pain, hemoptysis, fatigue up to loss of consciousness, hematuria, bruising, hematomas, rapid pulse, cold sweat, pale skin.
4. **Bleeding from bone fractures:** Bones have an extensive network of blood vessels. This means that a bone fracture can lead to life-threatening bleeding-especially if the fracture occurs in a long bone, such as the humerus, radius, ulna, femur, fibula, or pelvis (13).
5. **Gastrointestinal tract bleeding:** This has many possible causes, such as a tumor or inflammation of the colon, stomach, or esophagus.

Symptoms may include: abdominal pain, abdominal distension with muscular guarding, melena (dark-colored stool - bleeding from the upper gastrointestinal tract), stool with fresh blood (bleeding from the lower gastrointestinal tract - hemorrhoids, anal fissures), hematemesis (vomiting with coffee-ground appearance), fatigue, pale skin, dyspnea.

VI.4. Classification of Hemostasis

VI.4.1. Spontaneous Hemostasis

It is achieved through the physiological mechanisms of efficient hemostasis, as a natural mechanism, only in injuries of small vessels; it is the normal response of the organism to an injury. This is divided into four stages: vasoconstriction of the blood vessel; formation of the temporary platelet plug; activation of the coagulation cascade; formation of the final clot, the "fibrin plug".

VI.4.2. Temporary Hemostasis

Represents the sum of actions or procedures intended to temporarily stop a hemorrhage until definitive hemostasis can be achieved. Temporary hemostasis, due to the urgent nature of the required maneuvers, does not

require standard materials or instruments. Moreover, sometimes improvesations by the physician, depending on the situation, are of great importance. It does not require specific conditions. The available conditions of the environment in which the patient with hemorrhage is located will be used to the maximum extent.

IV.4.3 Definitive Hemostasis

It is characterized by the permanent cessation of bleeding and any risk of local recurrence of hemorrhage, and it is achieved surgically.

IV.4.1. Spontaneous Hemostasis

Hemostasis is a complex process that prevents or stops bleeding from a damaged intravascular space, provides a fibrin network for tissue repair, and ultimately removes fibrin when it is no longer needed (5).

Functionally, endothelial cells act to prevent coagulation. They interfere with platelet recruitment by inactivating adenosine diphosphate (ADP). They provide an environment in which thrombin is inactivated through the formation of antithrombin III complexes.

Endothelial cells release thrombomodulin, which inhibits and modulates the coagulation process.In the coagulation process, 13 factors are involved (I–XIII, with their activated forms denoted by “a”):

- **Factor I**: Fibrinogen
- **Factor II**: Prothrombin
- **Factor III**: Thromboplastin (tissue or platelet factor)
- **Factor IV**: Calcium
- **Factor V**: Proaccelerin
- **Factor VI**: Accelerin
- **Factor VII**: Proconvertin
- **Factor VIII**: Anti-hemophilic factor A
- **Factor IX**: Plasma component of thromboplastin – Christmas factor
- **Factor X**: Stuart-Prower factor
- **Factor XI**: Plasma thromboplastin antecedent
- **Factor XII**: Hageman factor
- **Factor XIII**: Fibrin-stabilizing factor

The physiological processes can follow either the intrinsic pathway or the extrinsic pathway, both pathways ending with the activation of factor X. In the process of hemostasis, four main physiological events occur, all independent and unfolding in a cascade (5):

a) Vascular constriction

Vascular constriction represents the initial vascular response to injury, even at the capillary level. It depends on the local contraction of smooth muscle, which is a reflex response to various stimuli. Initial vascular constriction occurs before any platelet adhesion at the site of injury. Adhesion of endothelial cells to adjacent endothelial cells may be sufficient to stop bleeding from an intravascular space. Vasoconstriction is subsequently coupled with the formation of the platelet plug and fibrin.

b) Platelet plug formation

Platelets are fragments of megakaryocytes with a diameter of 2 μm. They number 200,000–400,000/mm³ in circulating blood, with a lifespan of 7–9 days. They play an integrative role in hemostasis through two pathways.

Platelets, which normally do not adhere to each other or to the normal vascular wall, form a plug that stops bleeding when a vessel is ruptured. Consequently, a free aggregate of platelets forms, obstructing the ruptured blood vessel. Up to this point, aggregation is reversible. This process is known as primary hemostasis.

Administration of heparin does not interfere with this reaction-hemostasis can occur in a heparinized patient. Adenosine diphosphate (ADP) and serotonin are the main mediators in this adhesion and aggregation process. ADP released from damaged tissues and from platelets, along with platelet factor IV and traces of thrombin, stimulates a platelet release reaction, discharging the contents of the platelets and their granules. Fibrinogen is required in this process. Thrombin plays a central role by stimulating platelet degranulation and activating thromboxane A2 generation. The release reaction causes platelet compaction and the formation of an amorphous plug, which is no longer reversible.

c) Fibrin formation

Coagulation is the process by which prothrombin is converted into the proteolytic enzyme thrombin, which cleaves the fibrinogen molecule to transform it into insoluble fibrin in order to stabilize and add to the platelet plug.

Coagulation consists of a series of zymogen activation stages in which circulating proenzymes are sequentially converted into activated proteases in a cascade.

The traditional concept of the coagulation system follows two pathways: the intrinsic pathway (which involves components normally present in the blood) and the extrinsic pathway (which is initiated by tissue lipoprotein).

d) Fibrinolysis

Fibrinolysis is a natural process aimed at maintaining the patency of blood vessels by lysing fibrin deposits. It is initiated simultaneously with the coagulation mechanism. It depends on the enzyme plasmin, which is derived from a plasma precursor protein (plasminogen).

VI.4.2. Temporary Hemostasis (14)

VI.4.2.1. Temporary Hemostasis by Direct Compression

VI.4.2.1.1. Digital Compression

Correctly performed compression on the injured vessel must be applied **above the wound** in the case of arterial bleeding and **distal to the wound** in the case of venous bleeding, taking into account the direction of circulation. When bleeding cannot be stopped through remote hemostasis, **direct compression** is applied with the finger on the injured vessel. This is usually done by compressing with the thumb upstream of the vascular wound or by pinching between the thumb and index finger (**digital forceps**). Compression can be applied to all vessels that have a **semi-hard (cartilage or ligament) or hard (bony) tissue** underneath, which allows hemostatic pressure to be exerted on the vessels. This technique is of **short duration**, applied in cases of arterial or venous wounds with a clearly identifiable bleeding site, and is **contraindicated in arterial or venous wounds that bleed diffusely**.

Anatomical areas where digital compression can be applied: hemostasis at the temporal region - compression of the superficial temporal artery; hemostasis at the head – compression on the lateral edges of the wound; hemostasis at the anterior cervical region – compression on the carotid artery (this compression is never performed bilaterally); hemostasis at the shoulder and axilla - performed by compressing the subclavian artery; hemostasis at the arm and forearm - by compressing the brachial, radial, or ulnar artery; hemostasis at the inguinal region - by compressing the femoral artery; bleeding at the leg - compression of the popliteal artery is performed by pressing the tissues in the popliteal fossa with the knee joint in a semi-flexed position.

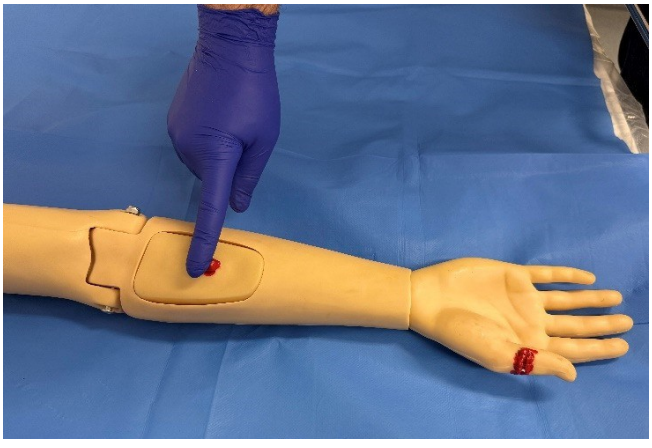

Figure 1. Digital hemostasis

VI.4.2.1.2. Manual compression

Manual compression is an effective technique used to control bleeding, particularly in cases of hemorrhage resulting from ruptured internal organs. The patient must be positioned in the supine or prone position on a hard surface, depending on the case. Compression is applied with a closed fist over the site of the injured organ: right hypochondrium for liver ruptures, left hypochondrium for spleen ruptures, hypogastrium for metrorrhagia, and renal areas for kidney ruptures.

VI.4.2.2. Temporary hemostasis by circumferential compression

VI.4.2.2.1. Circumferential compression performed using a dressing

The compressive dressing is one of the most effective methods used to achieve temporary hemostasis. The materials required for this are: sterile dressing, clean textile materials, etc. A few gauze pads applied to the wound, a piece of cotton wool, and lightly compressive bandages are sufficient to stop moderate bleeding. If the bleeding does not stop, compression of the affected vessel using another method is necessary.

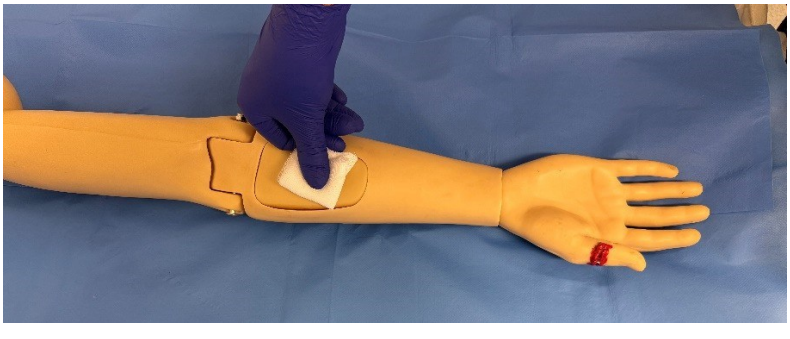

Figure 2. Hemostasis with compresses

VI.4.2.2.2. Circumferential compression performed using a tourniquet

Circumferential compression is performed using a tourniquet or a compressive bandage; it is the most effective method, but it must be applied correctly and for as short a duration as possible. It can be improvised using a belt, tie, scarf, cord, elastic rubber tourniquet, handkerchief, Esmarch bandage, blood pressure cuff, other improvised items. It is used only in extreme cases and in situations in which the hemorrhage could not be controlled by other methods. The patient is preferably positioned in the supine position. At application, two essential conditions must be respected: 1. correct positioning depending on the type of injured vessel: vein ⇒ between the extremity of the limb and the venous wound; artery ⇒ between the base of the limb and the arterial wound, mixed vascular injuries ⇒ two tourniquets are applied or a compressive bandage over the wound; 2. a note is attached with the hour and minute of tourniquet application in order to observe the release times. The tourniquet (or bandage) is applied as close as possible to the vascular wound, but not over joints, only in areas where the artery can be compressed against a hard (bony) plane. It must be performed in such a way as to compress the injured artery without producing only venous stasis and without crushing the tissues in the area of application. This type of compression is not maintained for more than 2 hours, due to tourniquet-release shock, which is the reason why loosening the tourniquet every 20–30 minutes, for 3–5 minutes, with digital compression applied is indicated. Maintaining circumferential compression for more than 2 hours can lead to particularly severe complications; and removal of the tourniquet is performed only by medical personnel, preferably in a hospital. Many studies that have been carried out have established that 2 hours is the maximum time in which the risk of permanent ischemic injury is low, the use of the tourniquet may also cause a reperfusion injury that may occur after 60 minutes of reduced perfusion. The benefits of preventing death from hypovolemic shock are greater than the risk of injury or loss of limbs that may be caused by the onset of ischemia (14,15).

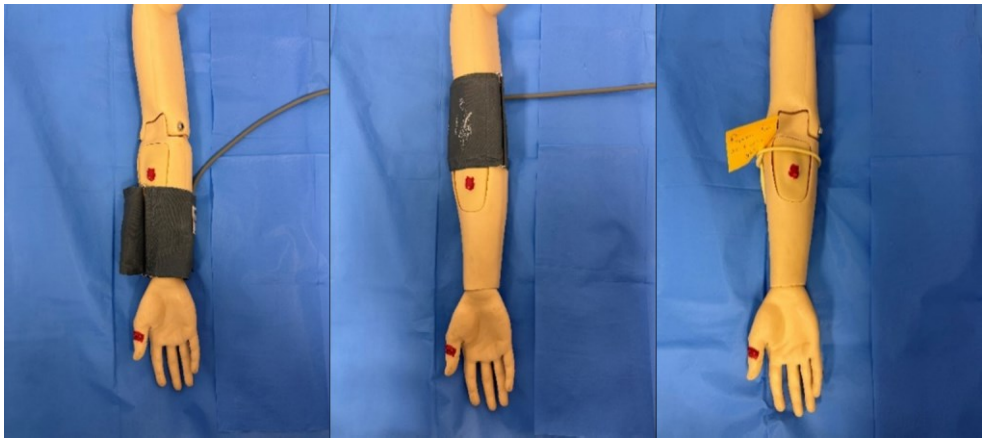

Figure 3. Hemostasis by circumferential compression. Application of the tourniquet

VI.4.2.3. Temporary hemostasis by positioning the injured segment

Temporary hemostasis by positioning the injured segment is achieved by strongly flexing the forearm on the arm, the lower leg on the thigh, or the thigh on the abdomen, which stops arterial bleeding occurring distal to the flexion crease. If the bleeding is located in the lower limbs, the patient is placed in the supine position, direct pressure is applied using a compress over the site of hemorrhage, and then the limb is positioned, if possible, above the level of the heart.

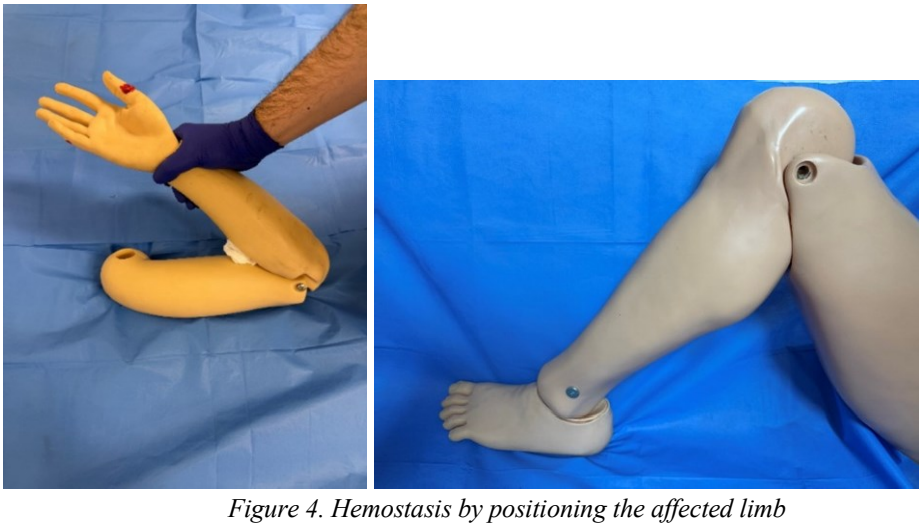

Figure 4. Hemostasis by positioning the affected limb

VI.4.3. Definitive hemostasis (16)

Definitive hemostasis is characterized by the permanent cessation of bleeding and any risk of local recurrence of hemorrhage, and it is achieved surgically. Surgical hemostasis consists of sealing the bleeding vessels through electrocautery, tamponade, application of Gelaspon, ligation of the bleeding vessels with sutures, and performing vascular anastomosis. It is preferably carried out in an operating room by specialized medical personnel. Definitive surgical hemostasis is achieved through the permanent and final obliteration of the bleeding vessel, the most commonly used procedure being suture ligation, applied differently depending on the anatomical region involved.

The definitive methods of surgical hemostasis are:

1. **Mechanical methods:** are performed through ligation, suturing, or surgical anastomoses, which can be carried out with either absorbable or non-absorbable materials.
2. **Thermal methods:** are carried out by contact: cauterization, electrocautery (monopolar/bipolar), laser photocoagulation, argon plasma radiofrequency, ultrasound.
3. **Chemical methods:** are characterized by the application of a topical agent that is used in surgical interventions to stop bleeding, but can also be used in emergency medicine. Types of chemical methods: active hemostatic agents – thrombin and fibrin adhesive (coagulation proteins that lead to tissue necrosis and scab formation); passive hemostatic agents – collagen-based products, sterile absorbable gelatin sponges, bone wax.

Tips & Tricks

a. **Identify the hazards in the accident area to avoid becoming a victim yourself (ensuring the rescuer's safety);**
b. **Evaluate the severity and type of bleeding (venous, arterial, capillary);**
c. **Ensure that you have help: look around for someone to assist you, call 112;**
d. **Identify the source of bleeding and apply the appropriate type of hemostasis;**
e. **Monitor the body's functions;**
f. **Manage hemostasis; change the method if the bleeding does not stop;**
g. **Use the tourniquet as a last resort; note the date and time of application.**

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Chapter VII
Surgical Knots and Sutures

Caizer – Găitan Isabela, Mânea Horațiu, Hoinoiu Teodora

List of Abbreviations and Symbols

	The needle type is triangular, traumatic
	The needle type is round, atraumatic
RC Joint	Radiocarpal joint

VII.1. Surgical Knots

VII.1.1. History

The first historical data related to surgical knots and sutures belong to Hippocrates, the "father of medicine," and are documented as early as 3000 B.C. The materials used at that time were derived from plants (flax, hemp, cotton) as well as from animals (tendons, hair, bundles of muscle or nerves), evolving over time to today's synthetic materials (1).

This chapter will cover information related to performing surgical knots, their use in medical and surgical practice, as well as the techniques of surgical suturing, step-by-step procedures, and their application across various specialties, depending on necessity.

The aim of this chapter is for students to acquire the minimum necessary knowledge to develop basic surgical skills.

VII.1.2. General Rules

- Surgery is a team effort.
- Maintaining a good overall condition, both physical and mental, is mandatory.
- Practical skills are acquired through repetition, repetition, and repetition.
- Performing a surgical procedure in a calm environment is essential for its proper execution.
- The best initial response is to pause and assess the situation.
- Avoid unnecessary procedures.
- Surgeons do not naturally have unusually steady hands; for this, a support point as close as possible to the fingers is needed (see Fig. 1).
- A surgeon's success is not determined solely by talent, but rather by how much effort they are willing to put into developing these skills.

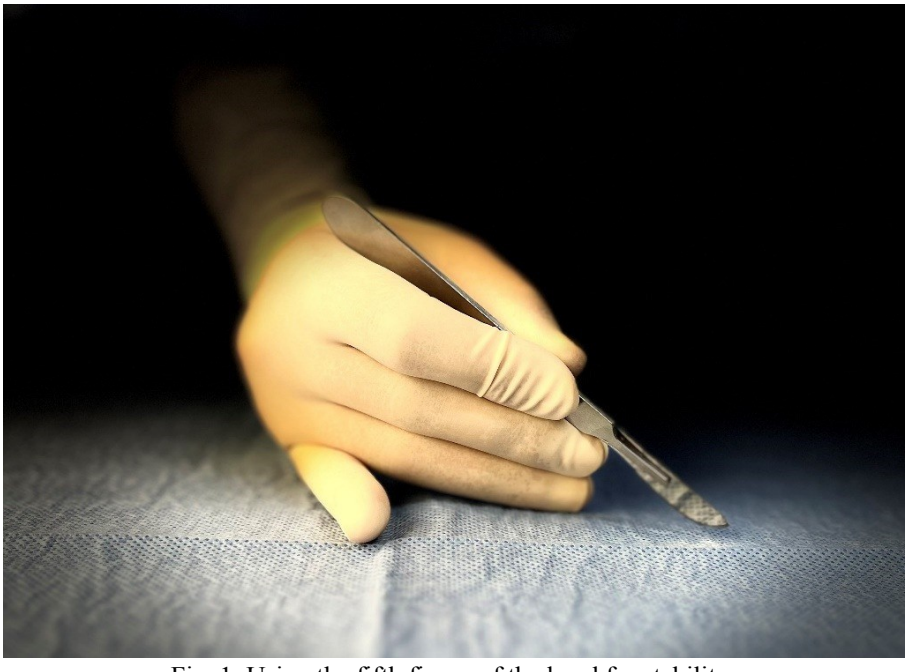


Fig. 1. Using the fifth finger of the hand for stability.

VII.1.3. Anatomy and Fundamental Elements in Performing Surgical Knots

To correctly perform surgical knots, it is first necessary to understand the terminology used in order to have a common language (2). Thus, when we refer to anatomical position, we mean the position of the hand and body in the upright stance, with the upper limbs alongside the body, palms facing upward, and thumbs pointing outward (3). The median or midsagittal plane refers to the vertical plane that divides the body into two halves: right and left. The terms medial and lateral are used to describe the proximity or distance of various structures from the median plane. The terms proximal and distal indicate a direction of the structures closer to or farther from the extremities of the limbs or from the center of the body. The terms palmar and dorsal refer to the anterior and posterior surfaces of the hand.

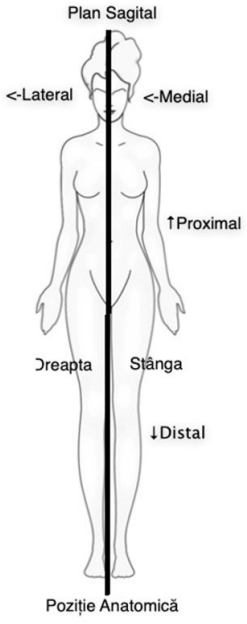


Fig. 2. Anatomical plane. Adapted from (2).

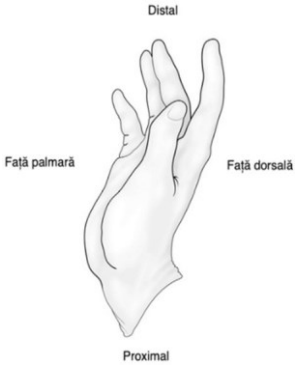


Fig. 3. Lateral position of the hand. Adapted from (2).

Fig. 3. Lateral position of the hand. Adapted from (2).

The terms describing the actions of the hand and fingers are illustrated and described below.

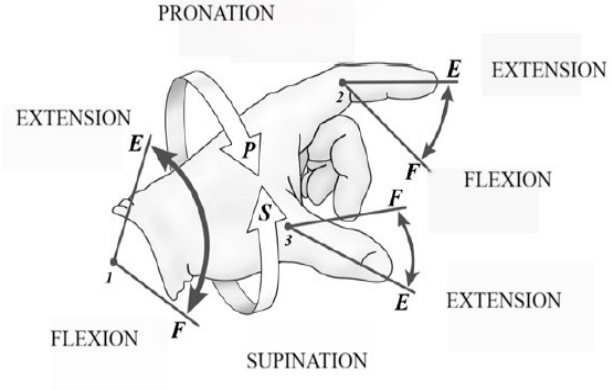


Fig. 4. Actions of the hand. Adapted from (2).

Pronation is the movement of the hand that involves rotating the palmar surface inward so that the dorsal surface of the hand faces upward.

Supination is the movement of the hand that involves rotating the hand outward so that the palmar surface faces upward.

Flexion is the joint movement that involves bending the joint, while extension involves straightening the joint.

In Fig. 3, three joints are shown as follows: the radiocarpal joint of the hand, the interphalangeal joints of the fingers, and the metacarpophalangeal joint of the thumb.

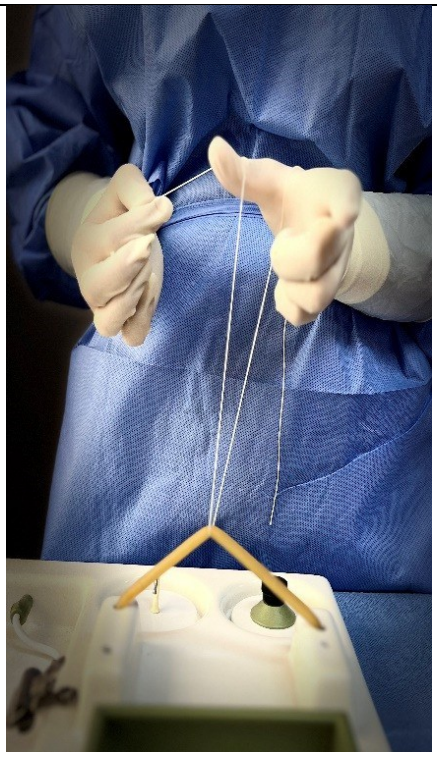
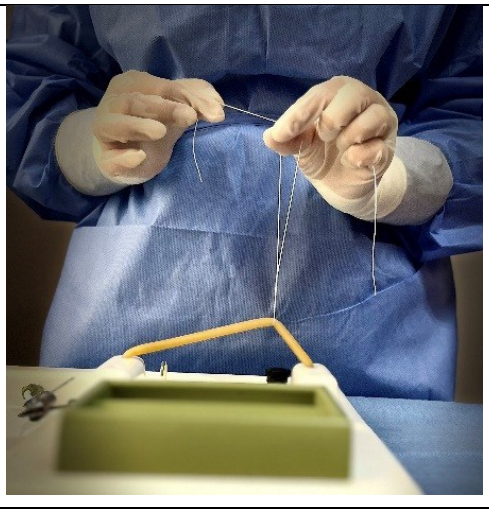
VII.1.4. Types of Surgical Knots

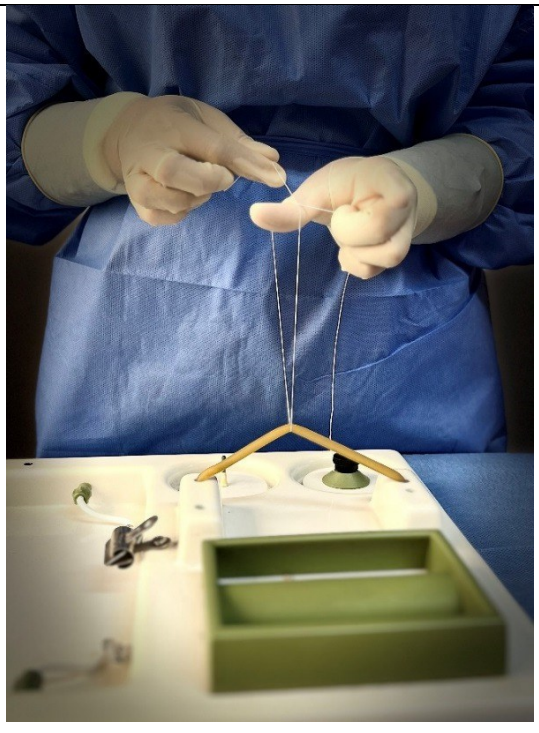
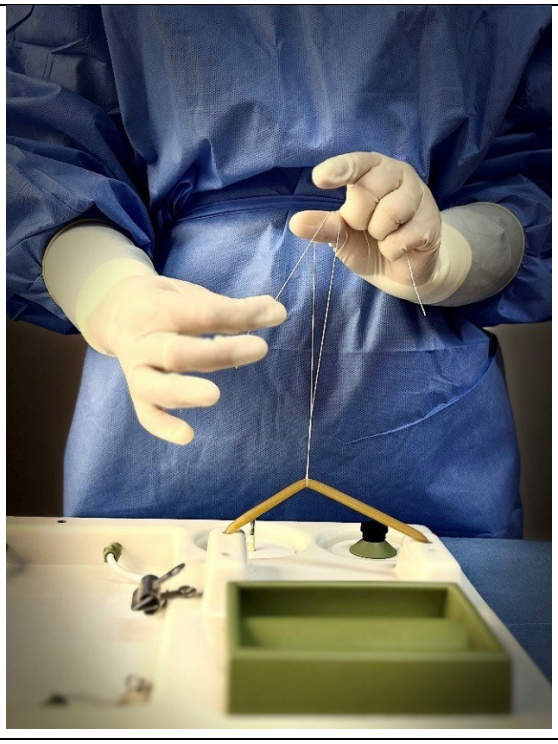
Surgical knots can be performed with one hand, with two hands, or using surgical instruments. In all these variants, there is one hand that performs the knot (most often the dominant hand) and one hand that helps tighten the knot (most often the non-dominant hand). For example, if the right hand is dominant, then the left hand will be the one that tightens the surgical knot (4).

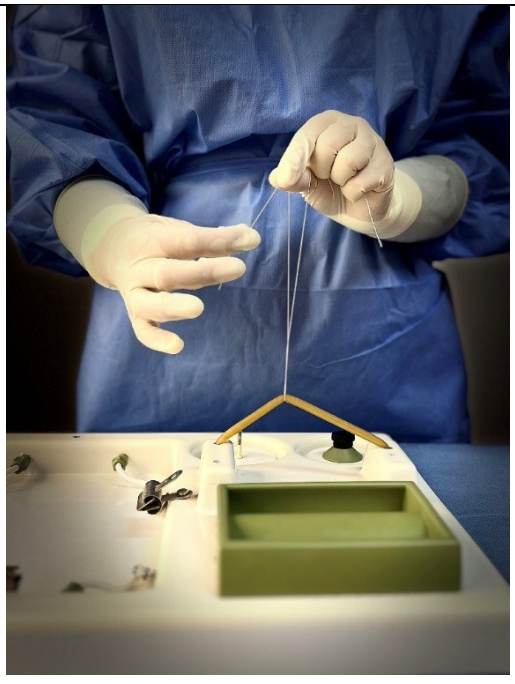
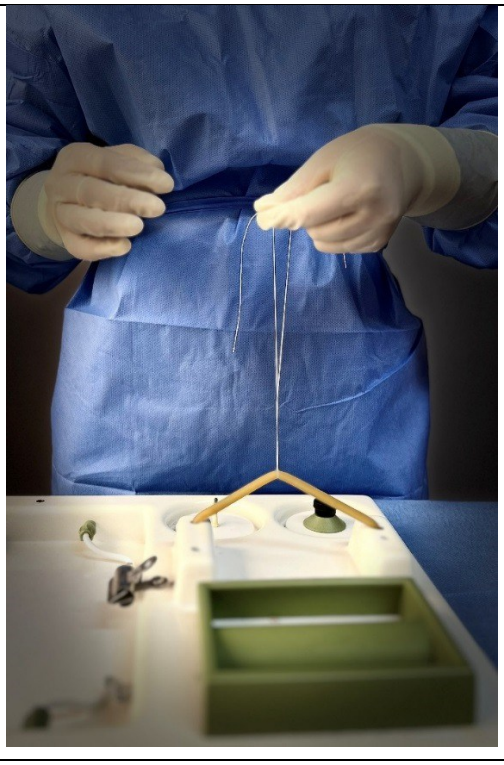
It is also important to note the difference between asepsis and sterility. Asepsis represents the complete absence of living microorganisms, achieved by physical means, for example using an autoclave. Sterility also means the absence of living microorganisms, but it is achieved through chemical means, for example using disinfectants (5). In all conditions in which surgical knots and sutures are performed, both asepsis (surgical instruments used, disposable materials) and sterility (measures taken by the surgeon before performing a procedure – surgical handwashing, use of protective equipment) are extremely important.

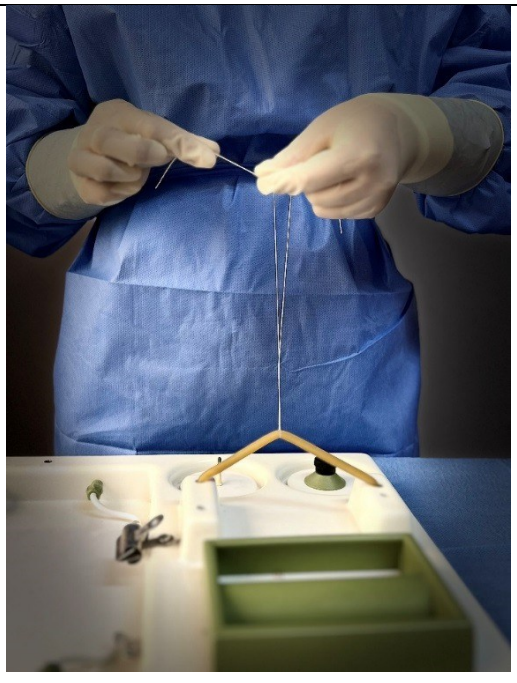
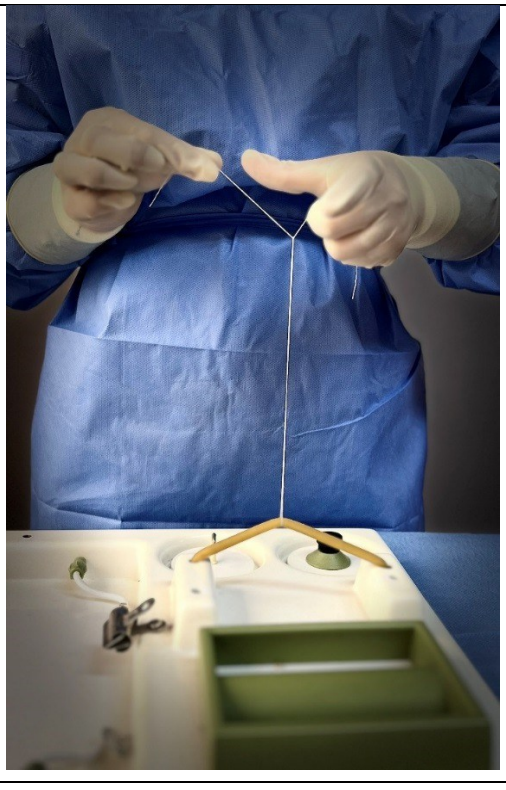
The materials used to perform knots must also be sterile. Multiple types of materials can be used, which are detailed in the section covering types of surgical sutures. In our case, to illustrate the types of surgical knots, a size 5 surgical thread (No. 5, nylon composition) was used.

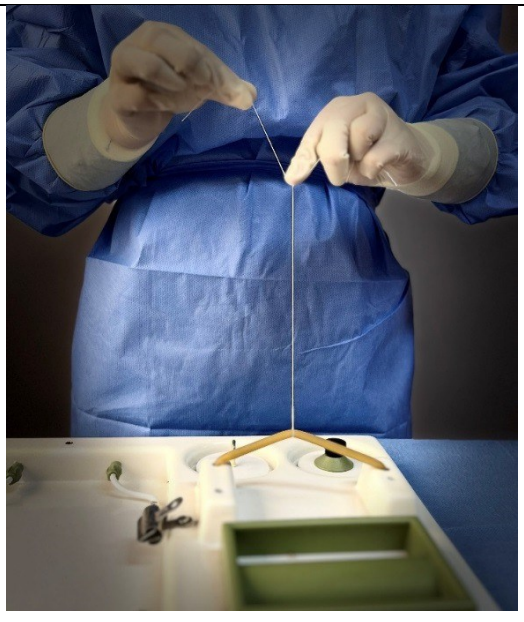
VII.1.4.1. Techniques of Surgical Knots
VII.1.4.1.1. Simple Surgical Knot Using the Thumbs (Square Knot)

	*Step 1: Maintain tension on the surgical thread. Form a square using the index finger and thumb. Then pass the thumb under the thread on the right, loading the thread.*
	*Step 2: Form a pinch between the thumb and index finger, and rotate the hand into pronation.*

	*Step 3: Insert the thumb through the loop and release the index finger from the pinch.*
	*Step 4: Position the thread in the right hand over the pad of the thumb.*

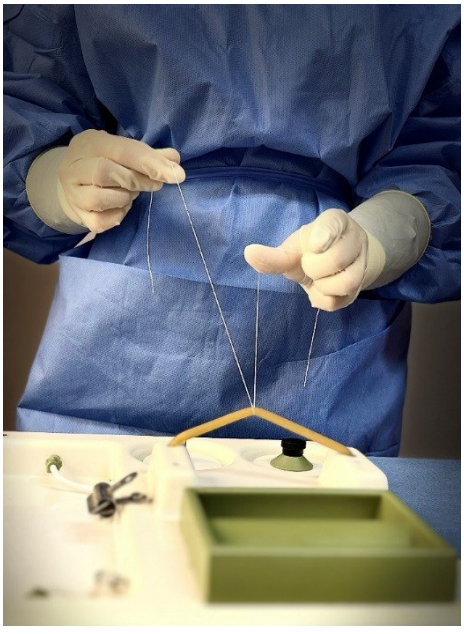
	*Step 5: Pinch the index finger over the thumb, securing the thread between them.*
	*Step 6: Rotate the hand from the ARC, pushing the thread through the loop with the help of the index finger.*

	*Step 7: After the thread has been completely pushed through the loop, grasp it again using the right hand.*
	*Step 8: Move the right hand distally and flex it at the ARC. The left hand extends from the ARC. This is the knot-tightening position.*

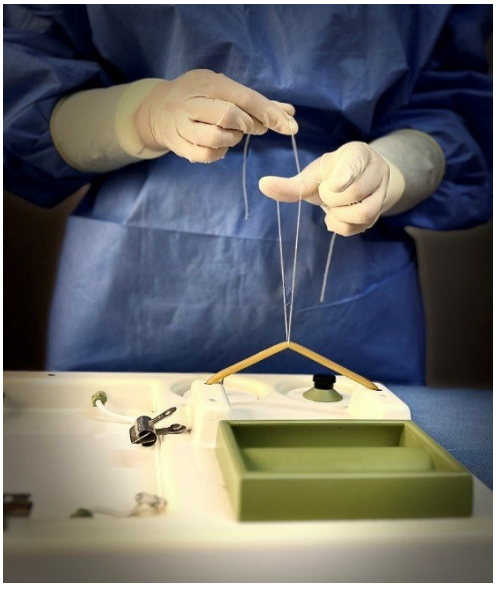
	*Step 9: Use the left index finger to tighten the knot. Keep the thread under tension. The left hand slides downward with the pad of the index finger on the knot, while the right hand pulls the thread upward, away from the knot.*

VII.1.4.1.2. Simple Surgical Knot Using the Index Finger (Square Knot with the Index Finger)

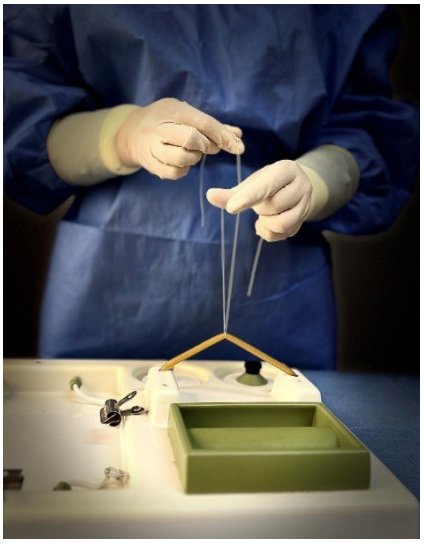
This type of knot is also a form of square knot, but unlike the one described previously, the index finger is the finger used to perform the maneuver. This type of knot can be used to secure the first knot. The following images illustrate the steps for performing it.



Step 1: Keep the thread under tension. Form the square again. By extending the thumb, maintain tension on the thread in the left hand..

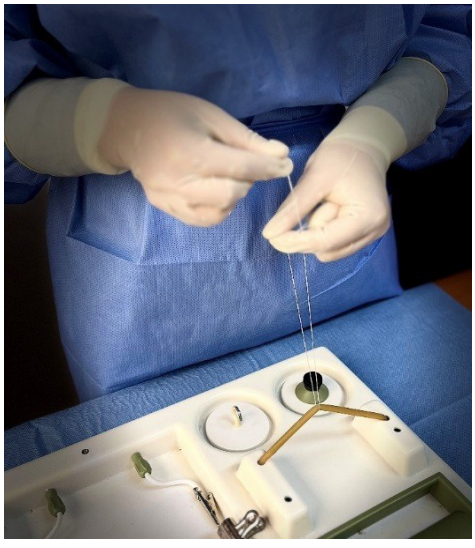


Step 2: Using the right hand, with the thread held between the pad of the thumb and the index finger, bring it over the base of the thumb.

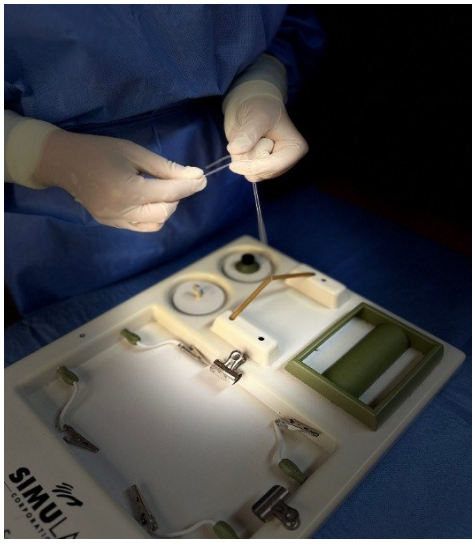


Step 3: Insert the left index finger through the loop.

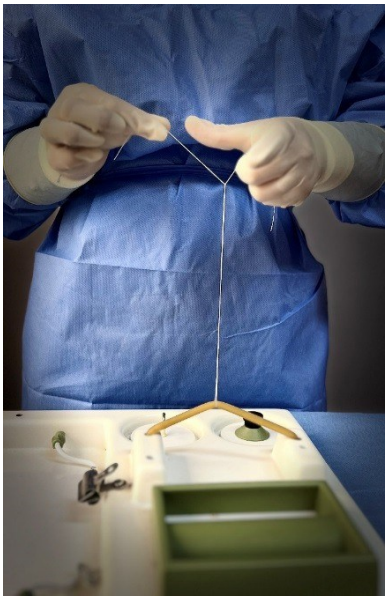
Step 4: Using the right hand, position the thread at the pad of the index finger.



Step 5: Form a pinch between the thumb and index finger, holding the thread at the pads of these fingers..



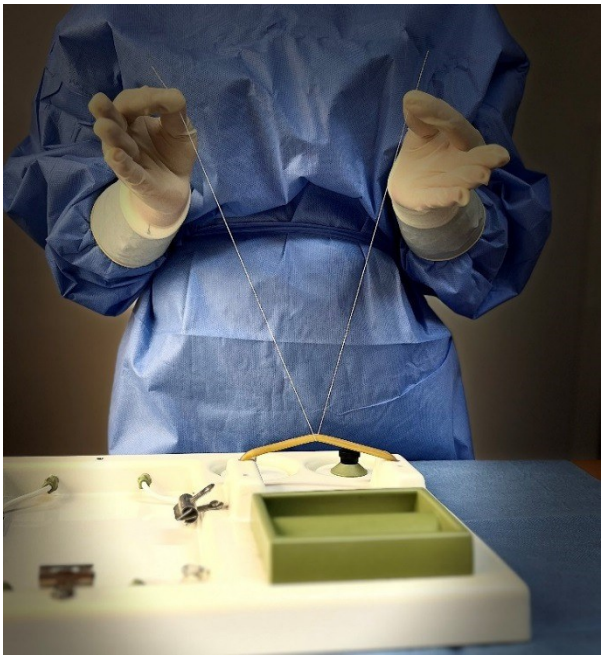
Step 6: Perform an extension movement at the wrist joint, passing the thread through the loop.



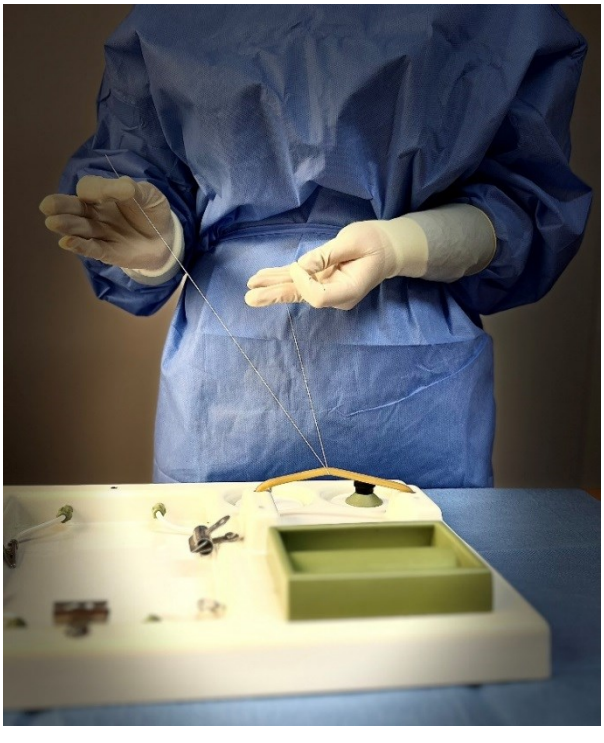
Step 7: Perform a pronation movement at the wrist, keeping the threads under tension.

Step 8: To complete the knot, place the tip of the index finger at the knot and, following the steps described above, tighten the knot

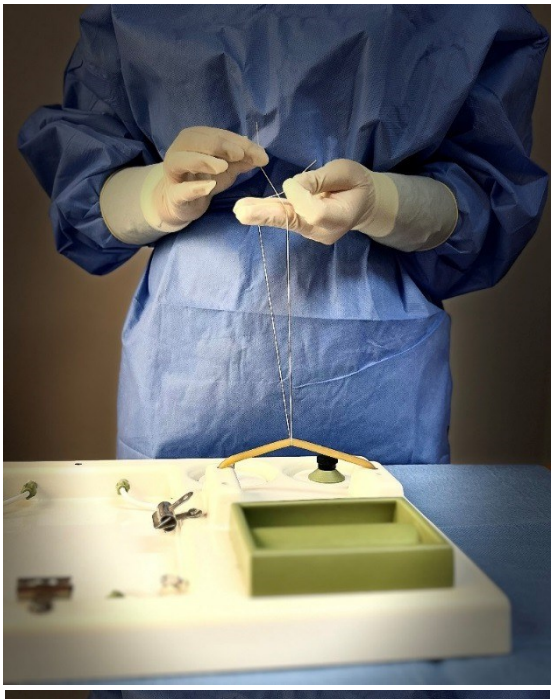
VII.1.4.1.3. Pauchet Knot (Gynecological Knot)



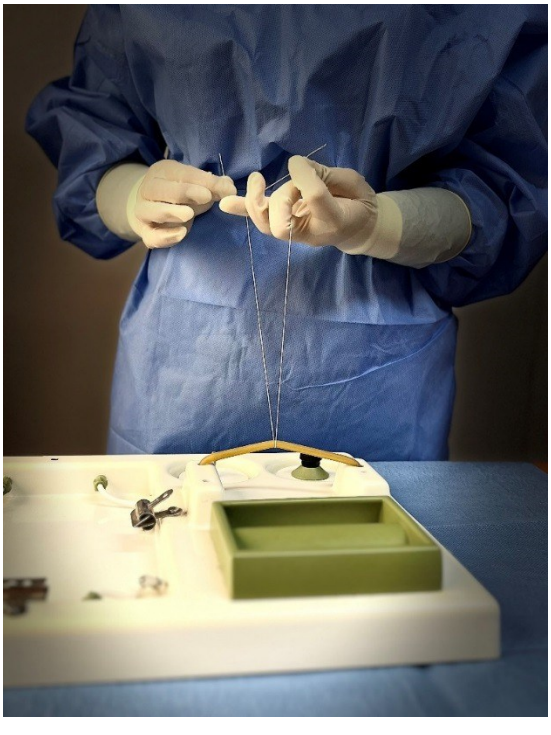
Step 1: With the hand in supination, hold the end of the thread between the thumb and index finger, the thread passing along the palmar surface of fingers 3, 4, and 5.



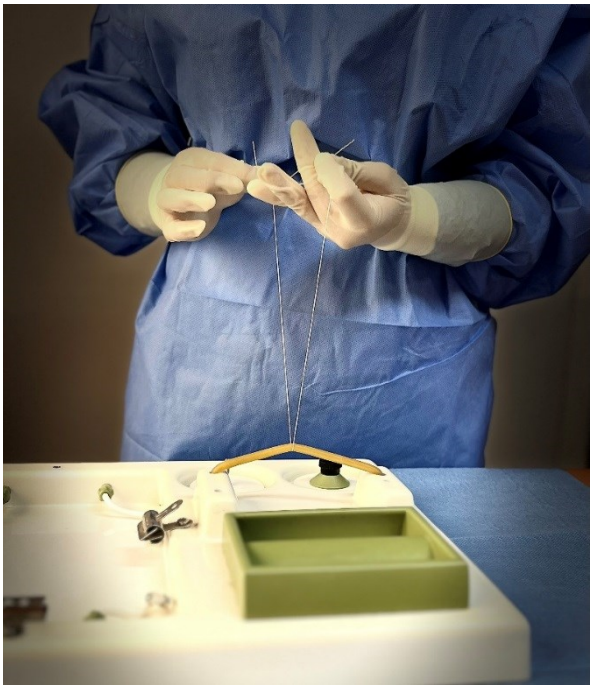
Step 2: Hold the thread in the right hand between the thumb and index finger at the fingertip, and pass it over the radial border of the third finger at the distal joint.



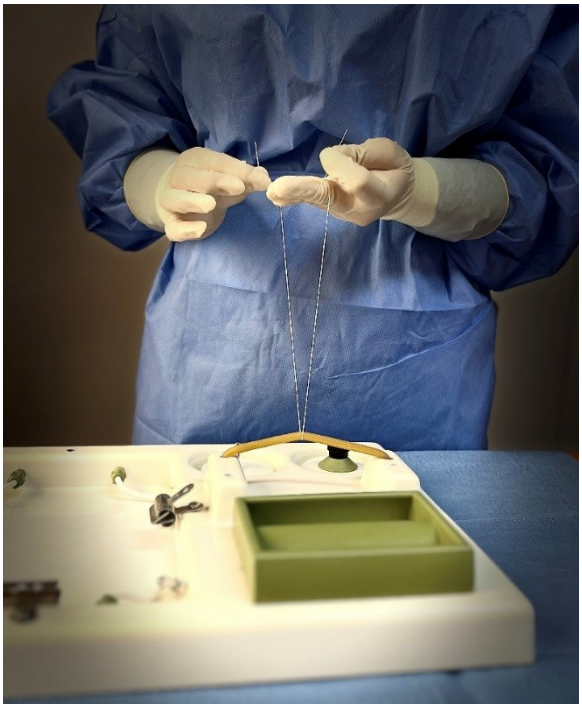
Step 3: Flex the third finger to encircle the thread.



Step 4: The distal phalanx of the third finger is further flexed to capture the other surgical thread along its dorsal surface.

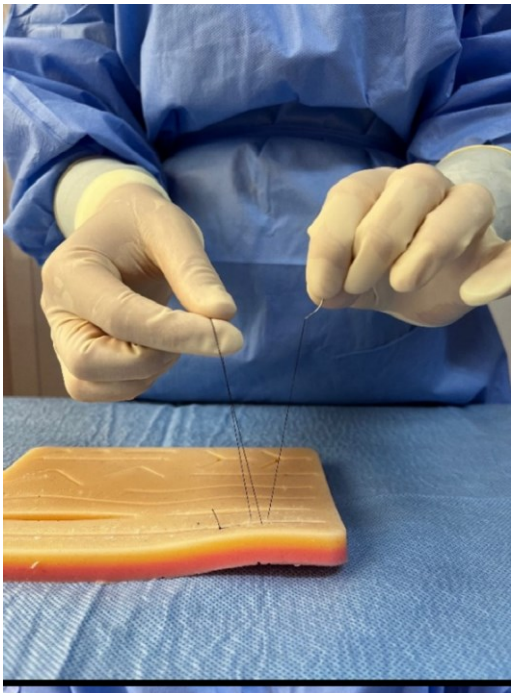


Step 5: While holding the thread in the right hand between the thumb and index finger, perform an extension movement of the third finger along with the loaded thread.

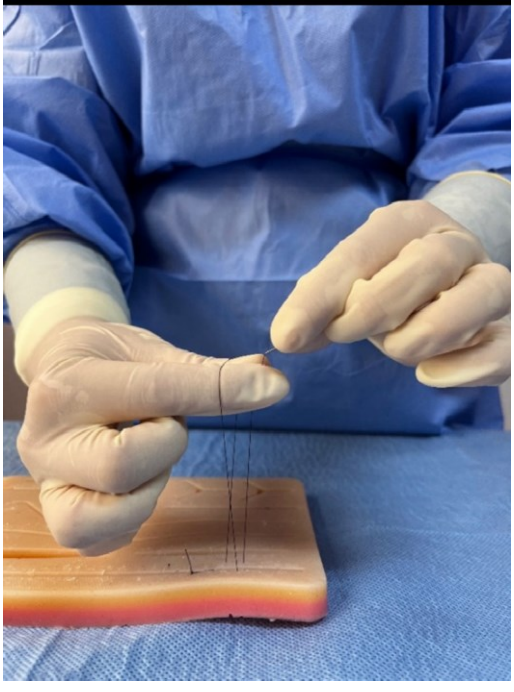


Step 6: The thread is pulled through the loop, being held between the third and fourth fingers. The other thread is held between the thumb and index finger of the right hand.

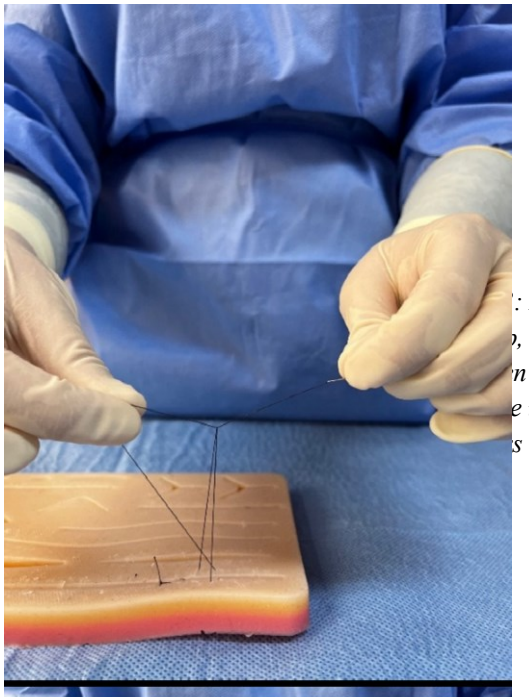
VII.1.4.1.4. Aberdeen Knot



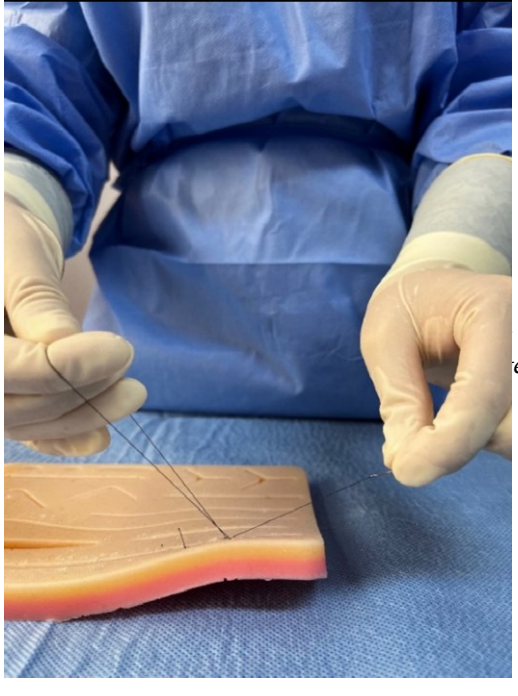
Step 1: Complete the suture by forming a loop.



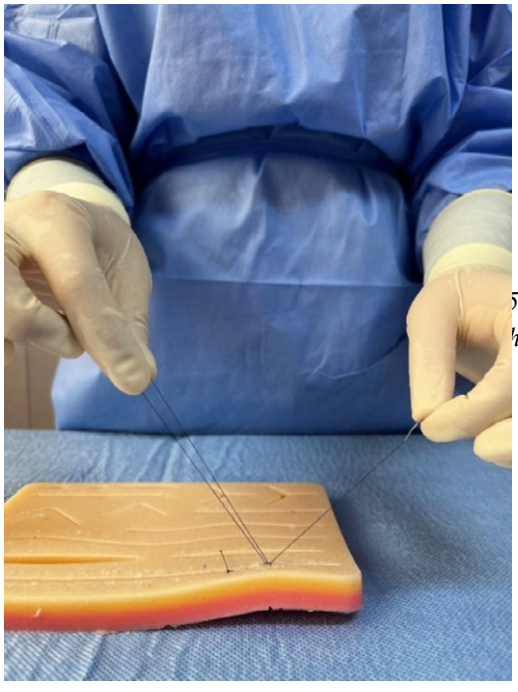
Step 2: Grasp the thread through the loop between the thumb and index finger.



*: Pull the thread through the
, holding the thread firmly
n the thumb and index finger,
e using the third and fourth
s to tension the lower part of
the loop.*



*Using the third, fourth, and
ers together, tighten the loop.*

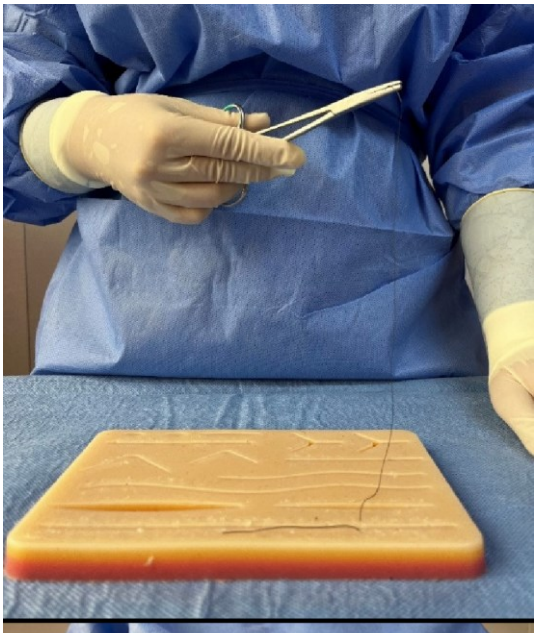


5: Keep the loop fairly wide
he free needle accessible.

Repeat steps 2–5 at least twice before passing the
lle through the loop and completing the suture.
Adapted from (2).

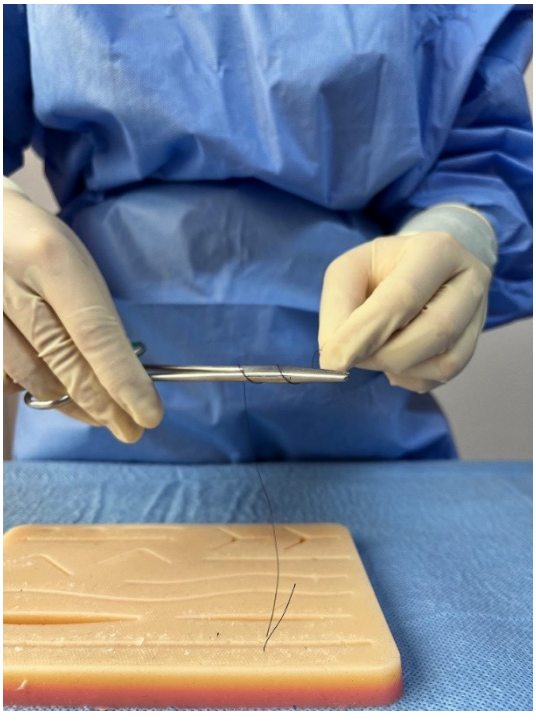
This type of surgical knot is used when performing a continuous suture and wanting to close the suture at the end. It can be done either by hand, as described in the steps above, or using a needle holder if you wish to perform it with surgical instruments.

VII.1.4.1.5. Surgical Knot Using Surgical Instruments

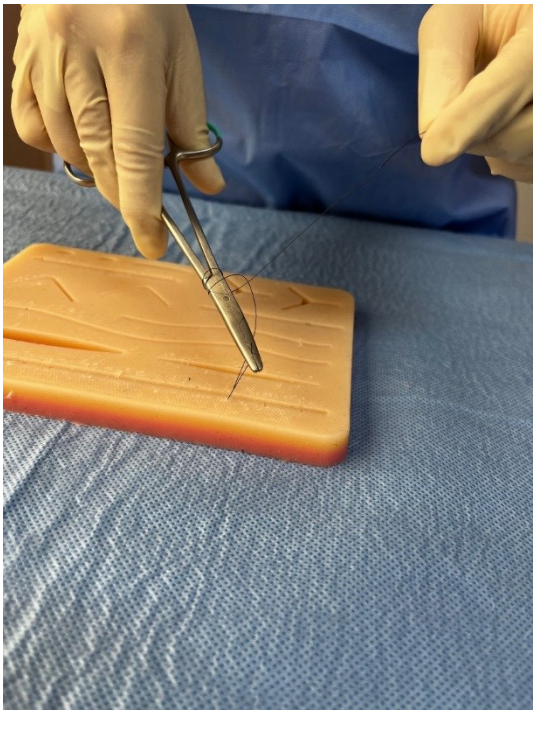


Step 1: With the needle holder closed, pull the needle until approximately 2 cm of the thread remain from the end

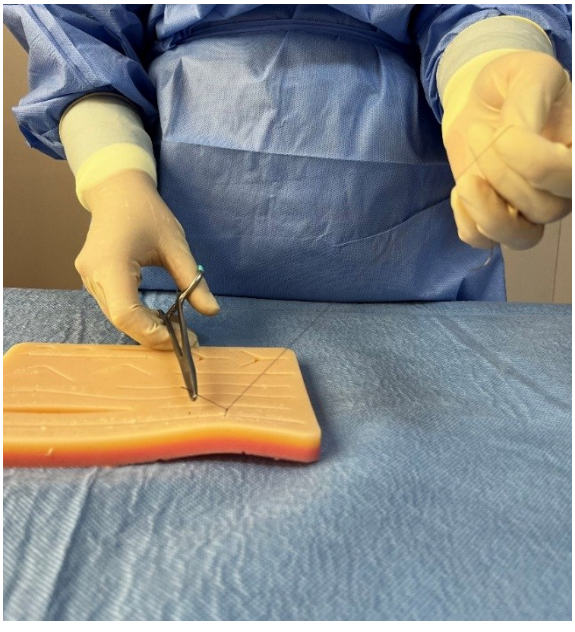
Step 2: Hold the end of the thread with the needle in the left hand. The needle holder, held in the right hand, is positioned with its tip on the thread approximately at the midpoint.



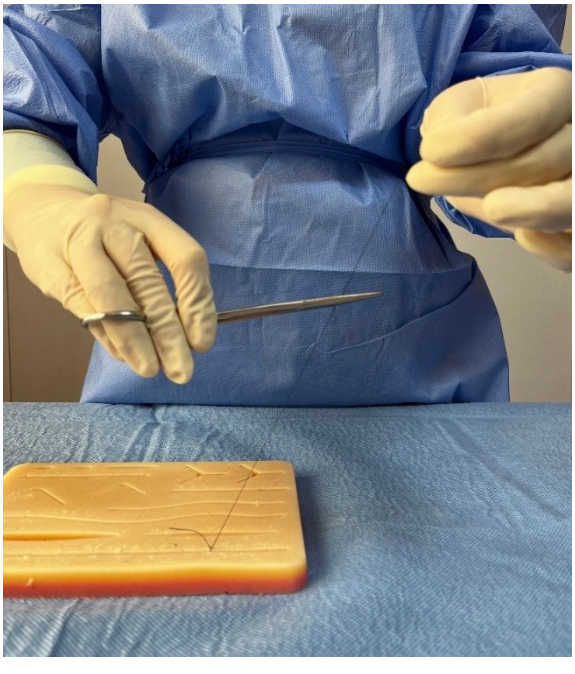
Step 3: With the needle holder closed, form the first loop at the tip of the needle holder.



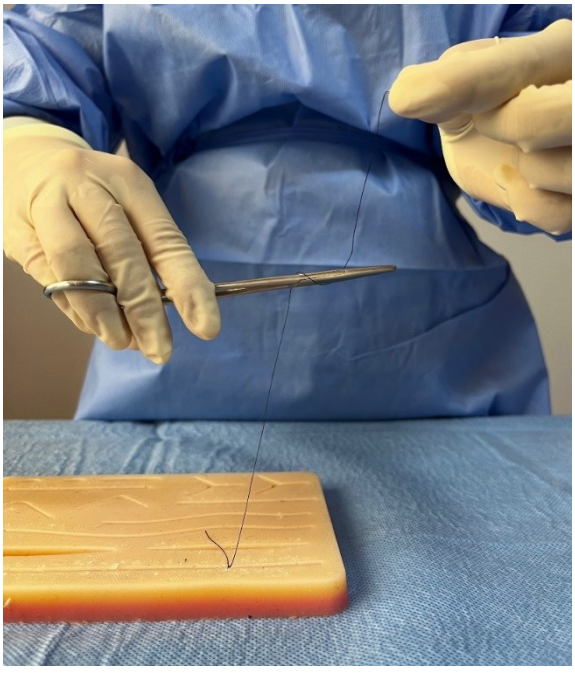
Step 4: Open the needle holder and use its tip to grasp the end of the thread.



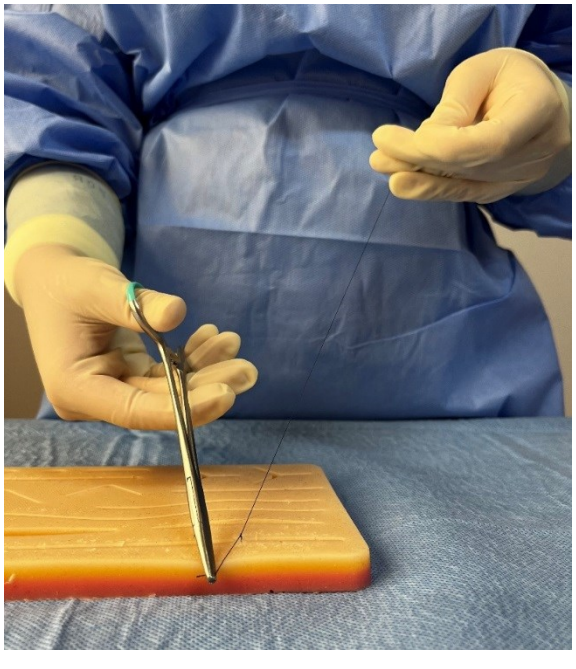
Step 5: Close the needle holder and pull the thread through the loop, drawing it toward you.



Step 6: Position the tip of the back of the needle holder on the thread approximately at the midpoint.



Step 7: Open the tip of the needle holder and grasp the end of the thread.



Step 8: Pull the tip of the needle holder along with the thread through the loop and draw it in the opposite direction from you.

Tips and tricks

1. **Surgical knots are always performed in a minimum of three.**
2. **The first knot is also called the tightening knot.**
3. **The second knot is the supporting knot.**
4. **The third knot is the safety knot.**
5. **Knots are performed with the threads under tension.**
6. **Knots must be reversed.**
7. **The first and second knots must be made using two different techniques.**
8. **Pay attention to the suture material – the possibility of hypersensitivity reactions in addition to the normal inflammatory response of the body in the first 5–7 days (5,6).**
9. **Use of surgical instruments in performing knots, as it is much faster and prevents wastage of suture material (7).**
10. **Knots applied in deep tissues must be made under tension, unlike those located superficially, which are performed with minimal tension (8).**
11. **Performing a surgical knot using a needle holder requires holding the thread with the non-dominant hand approximately 6 cm from the needle (8).**
12. **Surgical knots are a central element in performing any suture, which can have disastrous consequences for a surgical procedure (9).**
13. **The tension applied to the threads when performing surgical knots is more a matter of the surgeon's perception than an issue of experience (10).**
14. **According to studies, the square knot has a 20% slippage rate, regardless of the suture material used (11).**

In conclusion, in order to acquire the necessary skills for surgical maneuvers as well as the use of surgical instruments, it is important to allocate numerous hours in the experimental surgery laboratory, as well as the student's determination in correctly performing these maneuvers.

VII.2. Surgical Sutures

Sutures represent a fundamental part of surgical practice, playing an essential role in the wound healing process and in achieving optimal aesthetic and functional results. In this chapter, we will explore the diversity of suture thread types, suturing techniques, and relevant aspects regarding their selection and use in various medical contexts.

Throughout the history of medicine, sutures have evolved considerably, from rudimentary threads to advanced materials and sophisticated techniques. Today, surgeons have at their disposal a wide range of options, each with its own advantages and limitations, adapted to the specific needs of each patient and surgical procedure.

In this context, we will examine the different types of suture threads, such as absorbable and non-absorbable, natural and synthetic, monofilament and multifilament, and we will discuss the criteria for selecting the appropriate suture threads for various types of injuries and surgical procedures. Additionally, we will explore suturing techniques, ranging from simple and interrupted to complex and continuous, offering a perspective on how these influence wound healing and aesthetic outcomes.

Through the understanding and correct application of suturing principles, surgeons can achieve excellent results in wound treatment and in the recovery process of patients.

VII.2.1. History

In early antiquity, the Hippocratic physicians played a significant role in defining the principles of surgery, based on observation and measurement. However, surgical thinking during the first three quarters of the "modern era" was strongly influenced by Galen of Pergamum (129–210 AD), an eminent surgeon of the Roman Empire. Galen's ideas dominated Western medicine for nearly 1,300 years, even though they were often misinterpreted (12).

The exposure of Galen's errors by Vesalius in 1543 and Harvey in 1628 marked the beginning of a period of reevaluation of medicine, which extended into the 19th century. This period of reexamination marked a turning point in the evolution of surgery, paving the way for the next era of medical discoveries (12).

It was not until the 1930s, with the technological and scientific advances of that time, that Galen's misconceptions were finally rejected, and surgery began to develop in a new and more precise direction. This radical shift represented a crucial moment in the evolution of medicine, opening the path for subsequent progress in the surgical field (12).

VII.2.2. Basic Instruments for Sutures

For the successful performance of a surgical suture, it is necessary to know the instruments and appropriate surgical options, the suture needles, as well as the materials from which the suture threads are made. The surgical instrumentation required for suturing the skin and soft tissues can consist of a set formed of 4 or 5 units up to a considerable number of specially calibrated surgical instruments (13,14).

Thus, the basic surgical tray for sutures consists of the following elements:

- Scalpel handle: material: stainless steel, plastic (single-use).
- Scalpel blade: material: stainless steel or carbon (increased resistance when touching hard tissues, higher cost).
- Needle holder: entirely stainless steel or stainless steel and tungsten (plates attached to the active part of the needle holder).
- Anatomical forceps: entirely stainless steel or stainless steel and tungsten on the active parts.
- Surgical forceps: stainless steel, used for approximating the wound edges.
- Retractor: stainless steel, used for retracting tissues in the case of deeper wounds that require multi-layer suturing.
- Dissection scissors (sharp tip): entirely stainless steel or stainless steel and tungsten on the active parts; used for cutting or dissecting tissues.
- Suture scissors (blunt tip): stainless steel, used for cutting suture threads.

A. Surgical Blade

Modern surgical blades are primarily manufactured from stainless steel or carbon steel. Those made of stainless steel are known for their sharpness and resistance to dulling, due to repetitive friction on tissues, while those made of carbon steel are slightly sharper but more prone to dulling. For situations where a small number of interventions are performed or access to an autoclave is limited, scalpel handles with permanently fixed blades are sometimes used, however, these are not as common in busy surgical practice. In skin and soft tissue surgery, the most commonly used scalpel handle is the heavy Bard-Parker no. 3, which allows the use of different blades, especially the no. 15 blade, the most frequently used in cutaneous surgical interventions. There are other types of scalpel handles, such as the no. 7 handle, which accepts the same blades as the no. 3, or Beaver handles, which require special

blades. In addition to the no. 15 blade, the no. 11 blade is sometimes preferred for delicate excisions around the eyes and ears, and the no. 10 blade is suitable for areas with thicker dermis, such as the posterior thorax. Despite the varied options, simple no. 3 handles and a no. 15 blade can be used for most skin and soft tissue surgical interventions without affecting the outcome.

B. Needles

The surgical needle is made up of three sections: the tip, the body, and the needle base. These needles are classified based on their radius, curvature, and shapes. Commonly, the suture needles used in surgery have a 1/2 or 3/8 circle curvature.

The components of a needle are:

- Tip
- Body
- Base

Classification of the needle based on its three components:

1. Needle Tip

A. Traumatic Needles

Diamond Tip: triangular cross-section, 3 cutting edges on the outer curve.

Conventional Cutting: 3 cutting edges on the inner curve

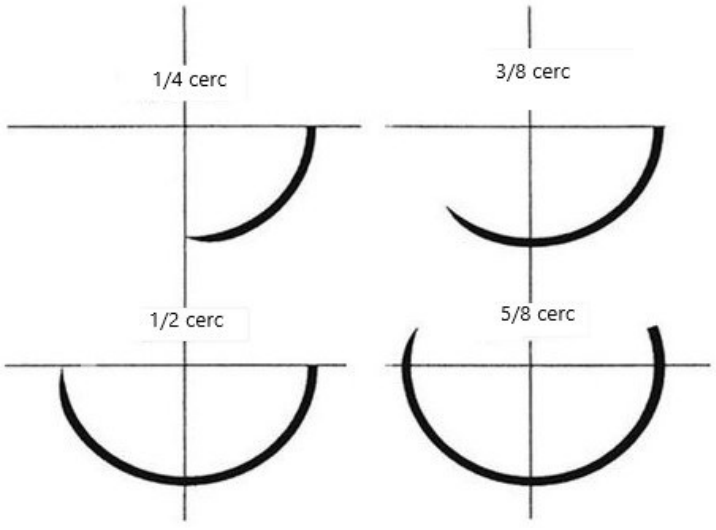
B. Atraumatic

Circular Cross-Section of the Needle Tip, Atraumatic

2. Needle Body (curvature described by it)

A. Straight: less commonly used due to the inability to access hard-to-reach areas

B. Curved



- **¼ circle** – the curvature described by the needle represents one quarter of a circle's radius.
- **3/8 circle** – the curvature described by the needle represents three eighths of a circle's radius**.**
- **½ circle** – the curvature described by the needle represents half of a circle's radius.
- **5/8 circle** – the curvature described by the needle represents five eighths of a circle's radius.

C. Scalpel Handle

It represents the basic surgical instrument and comes in two types: reusable or single-use. When using single-use scalpel blades attached to reusable handles, they should be mounted avoiding the sharp edge and preventing damage, using forceps rather than fingers. To avoid excessive tissue trauma, do not press hard with the scalpel, as the depth of the incision cannot be controlled precisely. For skin incisions, hold the scalpel like a table knife, keeping the blade horizontal above the dominant hand, between the thumb and middle finger, with the index finger positioned at the base of the cutting edge to control the incision depth. For punctures or short, precise incisions, hold the scalpel like a pen. It is recommended not to use scalpel blades that have lost quality due to contact with hard surfaces—such as bone or metal—as this can result in uneven incisions.

D. Tissue Scissors

Scissors used for cutting tissues should be extremely sharp to avoid tearing and to minimize tissue trauma. Stiffening of the scissors not only makes them difficult for the surgeon to use but also increases the risk of tissue damage, as it is forced between the scissor blades. In many surgical sets, a variety of scissors for skin are included, each with a specific purpose: for example, fine Iris scissors, straight or curved, are used to cut "dog ears," blunt-tipped scissors used in blepharoplasty are used for undermining, and Metzenbaum scissors are used for wider undermining and other purposes. For small skin surgical procedures, 4-inch Iris scissors are usually sufficient. Tissue scissors may be equipped with a SuperCut edge, designed for precise and sharp tissue cutting. However, these are prone to stiffening if used on anything other than tissue, so it is important to avoid cutting suture material or contact of the sharp edge with other surgical instruments.

E. Hemostatic Forceps

Hemostatic forceps are used to grasp vessels and allow either ligation with a suture (generally preferred for larger vessels) or electrocauterization. There are various small hemostatic forceps available, with both curved and straight tips, such as the Mosquito Halstead hemostatic forceps. A minimalist approach could also involve using a surgical clip as a hemostatic tool; however, considering the cost difference between these instruments—with hemostatic forceps being less expensive than clips—this approach is not frequently used.

VII.2.3. Sutures

Wound suturing is performed with any suture material used to approximate the tissue edges in order to restore continuity in the targeted area and to provide temporary or permanent artificial support while the tissue heals naturally.

When deciding on a specific type of suture, there are three factors that must be considered.

- Absorbable or non-absorbable
- Natural or synthetic material
- Monofilament or multifilament

VII.2.3.1. Absorbable Sutures

There are two main types of absorbable sutures, depending on the time required for their breakdown:

- Rapidly absorbable sutures are absorbed within up to 7 days.
- Normally absorbable sutures take between 14 and 60 days to fully break down.

These sutures are preferred in situations where temporary support for a wound is needed and when the wound has the ability to heal on its own. For example, in minimally invasive surgeries or superficial injuries, absorbable sutures are ideal to facilitate the healing process and minimize the need for later suture removal.

The absorption process of absorbable sutures can occur through two main mechanisms:

- For sutures made of natural materials, decomposition occurs through proteolysis, in which the body's enzymes gradually break down the chemical bonds of the suture.
- For sutures made of synthetic materials, decomposition occurs through hydrolysis, the process of breaking chemical bonds through reactions with water in the body.

These absorption mechanisms are essential for the elimination of sutures after they have fulfilled their purpose of temporarily supporting the wound during healing.

VII.2.3.2. Non-absorbable Sutures

They are designed to remain permanently in the body or to be removed after a certain period following healing. These sutures are used in various surgical situations, depending on the specific needs of the patient and the nature of the wound.

There are two main categories of non-absorbable sutures:

- Permanent non-absorbable sutures are intended to remain in the body long-term. They are especially used in tissues where the healing process may be slow or compromised, and the new tissue will never have enough strength to withstand stress on its own. For example, in orthopedic surgeries or ligament reconstruction, which require permanent and durable support.
- Temporary non-absorbable sutures are used when temporary support of the tissue is needed during healing, but the sutures are intended to be removed later. They are used, for example, in skin sutures, where the sutures are typically removed within 7–10 days, depending on the location and progress of the wound.

Regardless of their type, non-absorbable sutures are essential in surgery to ensure proper healing and adequate support of the affected tissues. It is important for the surgeon to choose the appropriate type of suture based on the patient's needs and the specific characteristics of the surgical procedure.

VII.2.3.3. Natural Sutures

Natural sutures are made from materials of animal or plant origin. They are used in surgery but have some significant disadvantages due to their protein composition, which can trigger a strong inflammatory reaction in the patient's tissues.

The disadvantages of natural sutures include:

- Pronounced tissue reactions: Due to their protein composition, natural sutures can trigger a stronger inflammatory response in the tissues surrounding the wound, which may affect the healing process and lead to complications.
- Variable strength: The durability of natural sutures can vary considerably, from a few days to several months, depending on the type of material and its degree of breakdown. For example, silk sutures may last longer in tissue compared to other natural materials.

However, natural sutures can still be used in certain surgical situations, especially where tissue reaction is minimal and the sutures are expected to be removed relatively soon. It is important for the surgeon to consider the potential risks and benefits associated with using natural sutures and to choose an option that provides the best chance for effective, complication-free wound healing.

VII.2.3.4. Synthetic Sutures

They are made by synthesizing a wide range of polymers. These materials are preferred in surgery due to their ability to induce a much lower tissue reaction than natural sutures. As a result, synthetic sutures have more uniform and predictable strength and absorption rates across all patients.

The main characteristics of synthetic sutures include:

- Reduced tissue reaction: Due to their synthetic composition, these sutures cause a lower inflammatory response around the wound, which can contribute to faster healing and reduce the risk of complications.
- Uniform strength and absorption: Synthetic sutures are designed to have more consistent and predictable strength and absorption rates compared to natural sutures. This makes the healing process more controlled and uniform.
- Various options: Synthetic sutures are available in a variety of materials and forms, including monofilament and multifilament sutures, each with its specific advantages and limitations.

In general, synthetic sutures are preferred in many surgical procedures because of their reliability and consistency in the healing process. However,

the surgeon must take into account the specific needs of the patient and the type of surgical procedure when selecting the appropriate suture type (13,14).

VII.2.3.5. Braided Sutures

Multifilament sutures are made of multiple filaments or threads twisted or braided together, providing increased strength and flexibility. This type of suture produces a strong suture that is also easy to handle during surgical procedures.

Because multifilament sutures are composed of several threads, they can be less smooth and may pass through tissue less easily compared to smooth monofilament sutures. This can lead to postoperative tissue trauma, especially when passing sutures through sensitive or delicate tissues.

To reduce this effect and minimize tissue trauma, some multifilament sutures are coated with a smooth material. This additional layer helps reduce friction and facilitates passage through tissues, contributing to faster recovery and lower risk of postoperative complications.

VII.2.3.6. Monofilament Sutures

Monofilament sutures are composed of a single thread or filament, with a smooth contact surface. This feature allows them to pass easily through tissues without causing trauma or tissue damage during surgical procedures.

However, there are some disadvantages associated with monofilament sutures. They can be more difficult to handle compared to multifilament sutures and tend to untie immediately after the first knot. Therefore, any suture using them becomes stable only after the second knot.

It is important that the suture surface is compatible with the tissues it will approximate and that it has adequate knotting characteristics and handling properties. A rough suture surface can cause tissue trauma or damage and may cut surrounding tissues. Therefore, both the tissue structure and the suture surface must be considered during selection.

In general, sutures with a rough surface require fewer knots than smooth ones, as there is a lower likelihood of the knots slipping. However, most monofilament sutures are now coated with a smooth material to prevent additional tissue trauma and to facilitate the suturing process. (13,14).

VII.2.3.7. Suture Selection

The choice of sutures and the wound closure technique is influenced by a variety of factors, with the final selection representing a compromise between these factors and the surgeon’s preferred suturing technique based on prior experience.

VII.2.3.8. Skin Wound Suturing

The skin is the area where the patient most clearly observes the final outcome of the chosen suturing technique and suture material. For example, a wound sutured under tension may result in unsightly scars, even at the points where the needle penetrated the skin, due to postoperative edema, which will be more noticeable to the patient than the scar itself.

A. Simple Surgical Suture

Recommendations:

- Synthetic, non-absorbable, monofilament sutures
- Synthetic, absorbable, monofilament sutures

Not recommended:

- Organic sutures (silk)
- Uncoated synthetic multifilament sutures

B. Continuous Suture (Surgeon's Stitch / Running Suture)

Recommendations:

- Synthetic, non-absorbable, monofilament sutures
- Synthetic, absorbable, monofilament or multifilament sutures

Nerecomandate:

- Organic sutures (silk)

VII.2.3.9. Subcutaneous Sutures:

Recommendations:

- Synthetic, absorbable sutures

Manipularea țesuturilor:

For optimal wound healing, the most important factor is minimizing tissue trauma during and after suturing. To achieve this, the following aspects must be considered:

- Tissue handling should be done with the finest and least aggressive instruments possible to prevent damage before wound closure and to avoid massive postoperative edema, which could lead to secondary healing.
- Wound suturing must avoid tissue ischemia or strangulation of the approximated edges, ensuring sufficient vascularization so the wound can heal primarily.
- Avoid dead space within the wound – sutures should be placed in individual layers, not as a single block.

- Edge approximation is mandatory to ensure contact between wound edges, but suturing under tension should be avoided, as postoperative edema may promote unsightly scarring.

VII.2.3.10. Suturing Techniques

The sutures most visible to patients, and which also serve as the calling card of the treating physician, are the skin sutures. Therefore, in skin suturing, eversion of the wound edges and proper alignment of the epidermal layer on both sides, as well as the dermal layer to restore cutaneous continuity, are essential elements for minimizing postoperative scarring. To achieve this, interrupted (simple) or continuous suturing methods can be used. The chosen suture pattern is the surgeon's preference, who has the responsibility to select the simplest suturing method to achieve optimal results.

VII.2.3.10.1. Simple (Interrupted) Suture

It consists of sutures placed and tied individually, independently of each other. An advantage of this technique is that, in the case of more pronounced postoperative edema along the wound, within a well-defined segment of the wound, it requires only the removal of the individual simple sutures corresponding to that segment, the others not being affected or compromised by this aspect (16). On the other hand, we have the disadvantage of a longer time spent performing the suture, as well as decreased patient comfort due to the presence of a large number of suture knots (17).

Common indications for its use:

- Lacerations
- Alignment of wound edges
- Skin incisions
- Repair of tendons and nerves (18).

Simple surgical suture technique:

1. The needle is inserted perpendicular to the epidermis, through one edge of the wound, approximately 3–5 mm from it.
2. Ensure that the needle passes through **both edges of the wound** at a **symmetric level** and a **uniform depth** (19).
3. The suture thread should be passed completely through the tissue, **without causing traumatic injury** or excessive tension (20).
4. Avoid grasping the tip of the needle, which can be **damaged by repeated friction with the needle holder** (21).

5. After passing the thread through both edges of the wound, tie a **surgical knot**, taking care to **minimize tension on the epidermis** and avoid **over-tightening the wound edges** (22).
6. Hold the needle and thread carefully, **avoiding injury**, in the non-dominant hand while holding the needle holder in the dominant hand. Wrap the suture material **twice around the needle holder clockwise**. Using the tip of the holder, grasp the end of the thread and pass it through the two loops created on the needle holder (23).
7. Pull the needle holder toward you while simultaneously pulling the non-dominant hand in the opposite direction, forming the **initial knot** (24).
8. Repeat the previous step, but this time **wrap the thread around the needle holder once counterclockwise**. Tighten the knot, and repeat a third time, **wrapping the thread once clockwise** around the needle holder (25). Tightening the knot should bring the wound edges **sufficiently together** without compromising tissue vascularization.
9. After completing the knots, cut the suture ends **approximately 3 mm from the knot**. Ensure the knot is **not placed on the wound**, but always to one side or the other (26, 27).
10. Sutures are placed **successively at regular intervals of 5–10 mm**, depending on the size of the wound, to ensure a **uniform and stable suture**. At the end, check the **integrity of the suture**, **alignment of wound edges**, and **presence of tension** to prevent complications.
11. Suture removal is performed according to the anatomical area: **10–14 days postoperatively** for the posterior thorax, abdominal region, and upper and lower limbs; **7–10 days** for the anterior cervical region; and **5–7 days** for the face.

Tips and tricks (27-34):

1. **Carefully apply aseptic and antiseptic measures to properly prepare the surgical field and the wound.**
2. **Place the patient in a comfortable position with the surgical wound well exposed.**
3. **Choose the appropriate suture material and instruments for the anatomical area where the suture will be performed.**
4. **Perform the technique correctly: needle inserted perpendicular to the skin surface, at similar distances from the wound edges and at the same depth.**
5. **Tie 3–4 surgical knots to ensure the security of the suture.**

6. **Check the tension of the suture to avoid marginal ischemia.**
7. **Cut the suture ends 3–5 mm from the knot.**
8. **Take into account the skin relaxation lines (Langer's lines).**

VII.2.3.10.2. Continuous Suture (Surgeon's Stitch / Running Suture)

It is performed with the same thread along the entire length of the wound. This method has the advantage of being fast, saving material, and less traumatic. Tightening of the loops is done uniformly. In general, it is recommended only for deep tissues (35).

Continuous suture technique:

1. The needle is placed in the needle holder and will be inserted perpendicular to the surface of the skin, at approximately 3-5 mm from the wound edge (36).
2. By rotational movements of the radiocarpal joint, the needle is passed through both edges of the wound, at equal distances from them, then the surgical knots are performed (37).
3. The needle is introduced again on the initial side of the wound, at a distance of approximately 3–5 mm from the previous loop (38).
4. The above step will be repeated, maintaining a similar distance between loops (5-10 mm) until completion of the wound suture.
5. At the end, the ends of the thread are cut at a distance of approximately 3 mm from the knot.

Tips and tricks

1. **Respect the asepsis and antisepsis measures in preparing the operative field and the wound (debridement and lavage to remove debris or necrotic tissues).**
2. **Properly approximate the wound edges for the best possible aesthetic result.**
3. **Insert the needle perpendicular to the wound edge at 3-5 mm from it, then pass it through the opposite side at the same distance from the edge.**
4. **Perform 3-4 surgical knots to secure the thread at the beginning of the continuous suture.**
5. **To avoid an unaesthetic result or loosening of the suture, the loops must be parallel to each other.**
6. **Tighten the thread enough to approximate the wound edges, without overlapping them or compressing them excessively.**
7. **Maintain an equal distance between suture steps (ideally between 5 - 10 mm).**

8. **Ensure an adequate depth of the suture (2/3 of the wound thickness for proper healing).**
9. **Practice is the key, start by performing simple sutures and then move to complex ones.**

The main disadvantage of this method is that the integrity of the entire suture line relies only on two knots. Moreover, if there is any compromise of the suture material at any point, this can lead to a complete loss of integrity of the suture line. Because each suture loop is placed successively, this technique does not allow the same level of fine adjustment of epidermal approximation as a simple surgical suture. In addition, since each loop of the continuous suture thread is designed to support an equal amount of tension, areas of the wounds subjected to greater tension, such as their central portion, may tend to open. Similarly, especially if the knot is under tension, it may lead to the occurrence of marginal necrosis – due to the compromise of local vascularization.

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Chapter VIII
Clinical standards in the care of acute wounds: surgical toilet, instrumentation and ensuring sterility

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VIII.1. Emergency wound toilet

VIII.1.1. History

The vision of ancient Egyptian physicians for treating open wounds is documented in papyri dating from 1400 BC. They applied a paste made of honey, fat and gauze on open wounds to remove skin and pus and to encourage their healing (1). The Hippocratic collection describes the ancient Greek practice (400 BC) of surgical drainage of pus with a thin piece of pipe placed in the abscess cavity - a practice lost along with the ancient Greek civilization.

(2). The syringe was invented by a Greek barber in 280 BC and was considered good for injecting liquids and for aspirating pus from wounds. Napoleon's surgeon, Dominique Jean Larrey (1766 - 1842), wrote extensively about the necessity of early amputation for any injured limb that cannot be saved. Germ theory and infection were understood only in 1865, when Joseph Lister (1827–1912) first demonstrated the use of an antiseptic in surgery and the treatment of wounds with dressings soaked in carbolic acid. Wound care manuals from the 1880s emphasized the importance of wound toilet, removal of foreign materials, possible splinters and lavage with carbolic acid (3). Carl Reyher (1846 -1890), a Russian military surgeon, added further instructions. He recommended adding a more extensive mechanical toilet of the lesion, which he called "debridement" (3). Many authors attribute the modern concept of debridement to French surgeons of the 18th and early 19th centuries, especially the French surgeon Pierre Joseph Desault (1744 -1795) (3). Reyher should be credited with the first description of the modern notion of debridement. However, full credit for the modern practice of debridement belongs to the Belgian army surgeon Antoine Depage (1862-1925) (3). Ancient physicians did not understand the concept of hemostasis. Minor bleedings were controlled by applying a kind of "material" in the wound and bandaging it, and those that caused major bleeding ended with the death of the affected person due to hemorrhage (2).

VIII.1.2. Introductory concepts

A wound represents a disruption of the epithelial integrity of the skin, with possible involvement of deeper tissues, including the dermis, fascia, muscles, and bones (4).

Traumatic wounds frequently present to the emergency department. Although most minor traumatic wounds and lacerations will heal well, proper treatment is necessary to preserve function and aesthetics, as well as to prevent infection and other complications (5).

Classification of traumatic wounds in the emergency department (6-10):

- Traumatic wound: a wound or laceration of traumatic origin without evidence of macroscopic contamination or signs of active infection (low probability of infection).
- Heavily contaminated traumatic wound: a wound or laceration of traumatic origin with macroscopic contamination. These include wounds with simultaneous perforation of a viscus, presence of devitalized tissues, foreign bodies, those occurring in a contaminated environment (manure, swamps), animal bites, puncture wounds, etc.
- Infected traumatic wound: a wound or laceration of traumatic origin with clear signs of infection (pathological secretions, edema, erythema).

Traumatic wounds are among the most common conditions treated in the emergency department. Approximately 7 million patients in the United States require treatment for traumatic wounds each year, which represents a rate of 1 wound every 4.5 seconds. These injuries account for >5% of total annual visits to the emergency department (2). The most frequent location of wounds is the upper extremity (35%), followed by facial wounds (28%), trunk (14.5%), lower extremity (12.5%), and head and neck (10%) (11,12).

The emergency department is often the first point of presentation for acute wounds, which is expected given the convenience, resources, and expertise available. Acute wounds are frequently caused by trauma, such as burns, lacerations, or abrasions (13). Because the historical and clinical characteristics of the skin injury differ, wounds must be evaluated and treated individually.

Without proper debridement and care, these acute wounds can lead to complications such as impaired healing and infection. Optimizing wound healing through proper management involves the removal of devitalized/necrotic tissue, exploration of underlying injuries, control of bacterial load, and appropriate closure. A comprehensive, evidence-based approach to acute wound management is an essential set of skills for any emergency physician or acute care practitioner (14).

Typical acute wounds usually progress through an orderly sequential process of hemostasis, proliferation, maturation, and remodeling (15). To ensure normal healing physiology, wounds must have adequate blood supply. Inflammation, infection, or residual debris can delay or prevent proper healing. As healing occurs, the tensile strength of the wound will reach approximately 20% at 3 weeks and 60% at 4 months (15). As with all emergencies, patient resuscitation and stabilization are of critical importance. Except for wounds requiring immediate intervention due to significant

hemorrhage, most wounds are inspected during secondary assessment. Wound lavage and exploration in a well-lit area can help identify bleeding sites, allow immediate intervention, and identify any urgent surgical issues.

In addition to volume loss caused by hemorrhage, wounds involving more than 10% of body surface area are associated with excessive extracellular fluid loss. These can be life-threatening and often require continuous hospitalization and operative intervention (16).

The main goals of wound care are to achieve functional closure, reduce potential infection risk, and minimize pathological scarring (16). Therefore, a complete patient history is necessary to determine possible risks, potential contamination type, activity at the time of injury, functional changes, and any comorbidities that may impede or delay normal healing. Injuries through the epidermis can allow bacterial migration, inflammation, and subsequent infection if not treated properly.

Risk factors associated with infection include advanced age, diabetes, larger wound size, wound contamination, or presence of foreign bodies (17). In addition, before initiating wound treatment, tetanus vaccination history, medications, and allergies must be obtained.

The time elapsed from injury to management of acute wounds is a critical factor for their proper closure. Studies by Berk, Chisholm, and Lammers provided the framework for establishing the optimal time period for wound closure (18-20). In general, 6–10 hours is an appropriate time frame for extremity laceration repair, extending to 10–12 hours for facial and scalp wounds, which are better vascularized.

Wound debris can act both as an infectious medium and as a toxic contaminant (21). Wounds contaminated with soil or dirt are considered contaminated at the time of injury and may need to remain open if proper debridement is uncertain, or may require more aggressive operative lavage. A deeply contaminated wound that is not fully aseptized carries an increased risk of developing anaerobic infection if closed (16).

Physical examination of a wound requires assessment of location, length, width, depth, type of tissue in the wound bed, neurovascular and functional status of adjacent structures, and associated contaminants. If there is neurovascular risk or involvement of deep structures such as tendons, muscles, or bones, specialist consultation may be necessary (14). It is imperative to assess all wounds through a full range of motion, paying special attention to position at the time of injury. If the patient presents late, infection may occur in the form of secondary abscess, purulent drainage, or skin with a “peau d’orange” appearance around 1 cm of the wound. Wounds that appear

dry, necrotic, or with demarcated gangrene are not amenable to healing due to ischemia and other secondary factors (14).

Proper evaluation and debridement of wounds can be a painful process, which can cause less physical and emotional harm if anesthetics are used. Current options include topical, local, and regional anesthetics (14). Although numerous commercially available topical anesthetic agents exist, most take 10–30 minutes to take effect. For a faster anesthetic response, injectable lidocaine (1%), bupivacaine (0.25%), or procaine (1%) is commonly used. While these medications remain the foundation of anesthesia for skin injuries, injection-associated pain remains a major drawback. The anesthetic should be injected through the edges of uncontaminated wounds. Bupivacaine provides a duration of action of 4–8 hours, compared to 1–2 hours with lidocaine (14). When epinephrine is added, the duration of action is prolonged, but it should only be used in areas with adequate vascular supply (14).

VIII.1.3. Non-surgical debridement techniques

Proper wound preparation improves healing and outcomes (22). Although evidence-based recommendations exist for wound care, many practitioners continue to treat wounds based on personal preference—some using unnecessary or potentially harmful techniques (22). Non-surgical debridement of acute wounds includes three different techniques: dressings, irrigation, and soaking. The technique used and the degree of debridement depend on the type of injury, environmental factors, and the condition of the wound at presentation.

a. Dressings

Cleaning with dressings is performed by gently pressing a moistened gauze on the wound to remove coarse surface debris while simultaneously improving the wound's moisture balance (22). In wounds with dried debris or dehydrated tissue, brief soaking will hydrate the wound, soften the underlying tissue, and enhance the irrigation process (23).

b. Pressure irrigation

Wound irrigation is undoubtedly the most important step for optimizing wound healing, as long as adequate pressure and volume are applied. Recommendations regarding irrigation pressure, often cited in the literature, mainly come from studies on chronic wounds (14).

Classically, the equipment used for irrigation has included syringes with needles or attached catheters, saline solution, other antiseptics in special containers, etc. (24).

- Irrigation volume

Irrigation volumes of 50 to 100 ml per cm of wound have been reported (20,25). The irrigation volume should be adapted to the characteristics of the wound and the degree of contamination. All wound surfaces must be irrigated, and it may be necessary to open the wound edges and flaps for proper exposure (20). Repeat irrigation has been recommended after any wound re-examination (26).

- Irrigation solution

Decontamination, including the removal of any dried chemicals before copious irrigation, is an essential part of initial wound treatment. It is important to consider toxicological exposure when irrigating wounds. Antiseptic solutions, such as povidone-iodine, chlorhexidine, and hydrogen peroxide, can be toxic to tissues and may impede the healing of acute wounds (24). A study on chemical burns recommended copious amounts of tap water or saline solution for irrigation and decontamination (27).

VIII.1.4. Surgical debridement

Debridement may be necessary to remove any devitalized tissue or to facilitate better wound closure. Generally, devitalized tissue is removed using a scalpel or surgical scissors (28). In addition, surgical debridement produces regular wound edges. Sometimes, surgical debridement of the wound may be required in the operating room (28).

Acute wounds without intrinsic, extrinsic, or mechanical injuries can be debrided and closed immediately. Wounds allowed to heal by secondary intention will require follow-up for further evaluation and possible secondary debridement to ensure proper healing (14).

VIII.1.5. Antibiotic therapy/Tetanus vaccination

Current guidelines from the Centers for Disease Control and Prevention recommend tetanus vaccination for wound management based on vaccination history and wound severity. All patients with an unknown vaccination history or who have received fewer than three doses should be administered a diphtheria-tetanus vaccine. Patients who are inadequately vaccinated and present with any wound other than a clean, minor wound should also receive tetanus immunoglobulin. Patients who have received three or more tetanus vaccines prior to the injury need tetanus vaccination only if the previous dose was administered more than 10 years ago for clean, minor wounds, or more than 5 years ago for other types of wounds (29).

The need for antibiotic therapy should be based on wound characteristics as well as the method of closure. Wounds more likely to

become infected include bites to the hand or face, deep puncture wounds, and lacerations with pus or contamination by saliva, feces, or vaginal secretions (30). Patients who are immunocompromised, have prosthetic joints, are at risk for endocarditis, or are receiving corticosteroids should be considered for antibiotic therapy (30,31). Although 6 hours is considered the "golden period" between injury and infection risk, 3 hours is a more prudent recommendation for deciding on initiating antibiotic therapy when indicated (32).

The most predictive factors for wound infection are wound location, wound age, depth, configuration, contamination, and patient age (20). Infection rates are also well correlated with the clinician's perceived risk (20). Antibiotic selection should be based on local resistance patterns and microbial risks according to the type of injury.

VIII.1.6. Considerations for wound closure

Primary wound closure includes suturing, use of tissue adhesive, staples, and strips, either individually or in combination. Sutures remain the most commonly used closure technique, supported by years of refinement and safety. Low- to medium-tension wounds are closed with percutaneous sutures using low-reactivity materials, including monofilament threads such as nylon or polypropylene. Surgical strips, suitable only for low-tension wounds, have low reactivity and are often used in conjunction with another closure method. Wounds that are stapled or glued appear to have similar outcomes; however, gluing is less painful and performed more quickly (33).

Tissue adhesives are associated with significantly higher dehiscence than sutures and are best suited for non-mucosal facial wounds and low-tension extremity wounds (33). Complex wounds should be closed in two layers using absorbable sutures such as polydioxanone (PDS), polyglycolic acid (Dexon-Plus), or polyglactin 910 (Vicryl).

Staples are faster to place and less costly than sutures. When wounds are properly prepared and the site is correctly selected, staples tend to have lower wound infection rates and fewer complications (34). When used on the scalp, staples are not associated with increased scar formation compared to sutures. However, if left in place too long, staples can lead to a higher rate of pathological scarring (34). Staples are commonly used on the scalp, trunk, and extremities—areas less prone to aesthetic concerns.

VIII.1.7. Healing of heavily contaminated wounds

Heavily contaminated wounds may require delayed primary closure to minimize the risk of infection. These wounds are debrided and dressed with a moist dressing to prevent further contamination. The moist dressing is

usually changed daily, and the wound is re-evaluated after 3–4 days. If no signs of infection are present at re-examination, secondary closure can be performed. Heavily contaminated wounds may benefit from daily debridement and dressing changes during the first 3 to 5 days before closure (14).

If secondary closure cannot be performed, healing by secondary intention is generally employed. No attempt at assisted wound closure is planned (14).

VIII.1.8. Follow-up care

Several factors directly impact wound outcomes. A moist wound-healing environment has been shown to help prevent dehydration and cell death, promote angiogenesis, and improve phagocytosis and growth factor release. Moisture also enhances the rate of re-epithelialization, reduces pain, and improves aesthetic outcomes (35). It is essential to discuss proper wound dressing, patient education regarding wound care, and clinical follow-up.

Current literature, primarily from plastic surgery and dermatology, recommends the use of sunscreen on a scar for 3–6 months postoperatively (14).

In conclusion, the variety of acute wounds presenting to the emergency department requires the clinician to select the most appropriate treatment to facilitate healing. A complete wound history, along with knowledge of the wound's healing potential in relation to the patient's specific medical and environmental considerations, forms the basis for decision-making in wound management. It is essential to consider each wound individually to create optimal conditions for healing (14).

VIII.2. Basic surgical instruments

Basic surgical instruments represent an essential set of tools used by surgeons during surgical procedures. They are designed to facilitate precise tissue handling while ensuring efficiency and safety during operations. Knowledge of and correct use of these instruments is essential for practitioners in the surgical field (36).

VIII.2.1. Cutting instruments

Instruments used for cutting tissues are divided into three groups: scalpels, scissors, and other cutting instruments (36).

VIII.2.1.1. Scalpel (Figure 1)

For centuries, the scalpel has been considered the surgeon's traditional instrument. In recent years, the two-piece version (handle and disposable blade) has

become the standard instrument. The blade is always sharp, and a variety of blades and handles are available for use. Scalpels can be used to cut skin, connective tissues, muscles, cartilage, and viscera. They should not be used on metal or bone (36–38).

The entire length of the blade, not just the tip, should be used for cutting, and it should always be held at a 90-degree angle to the skin surface. For a long skin incision, such as a laparotomy, a large handle and blade are used. The handle is placed horizontally "under the hand" between the thumb and middle finger, with the ring and little fingers wrapped around the back end. The index finger is placed on the back of the blade itself, toward its base. The depth of the incision is controlled by a combination of a smooth pull of the blade across tissues and steady, firm downward pressure applied to the blade by the forearm.

For smaller incisions or fine dissection work, a small handle and blade should be used. In these cases, the scalpel is held more like a pen, and most of the movement comes from the hand and fingers. With this grip, the surgeon's wrist can be placed on the patient to stabilize the blade during cutting (36,37).

Figure 6. Scalpel blade holder – left, and correct scalpel positioning in the hand – right

Scalpel handle – the numbers on the handle indicate the blade attachment size as well as the handle dimensions. Standard handles are straight and flat.

Scalpel blades – come in various sizes and shapes (from 10 to 26).

VIII.2.1.2. Surgical scissors (Figure 2)

Scissors are used to cut tissues during many stages of the dissection process and come in both sharp-tipped and blunt/rounded-tip models. The most commonly used in general surgery are the sharp-tipped scissors. Scissors cut

by bringing the two blades together in apposition, thereby incising the tissue. This action will not occur if the blades do not overlap. Blades may fail to meet if the scissors are damaged, too fine for the tissue, or improperly positioned due to incorrect handling (36,38).

The curved scissor variant has blades that follow the natural direction of a slightly flexed index finger, acting as an extension of it. This type of scissor is mainly used in tissue dissection. Generally, straight scissors are not recommended for cutting living tissues but are usually used for cutting sutures or dressings (36).

Scissors can also be used for dissection by inserting the blunt tips along a plane and separating tissues either by opening the blades or sliding slightly opened blades along the line of tissue fibers. Longer or shorter models can be used for dissection of fine superficial structures or deep body cavities. Sharp-tipped or right-angle scissors are often used for precision work, such as opening small blood vessels or fine dissection.

To properly hold a pair of scissors, the thumb is inserted into the upper ring and the fourth finger (ring finger) into the lower ring. The middle finger can then wrap around the instrument's shaft, with the index finger placed on the scissors' joint for stability (36).

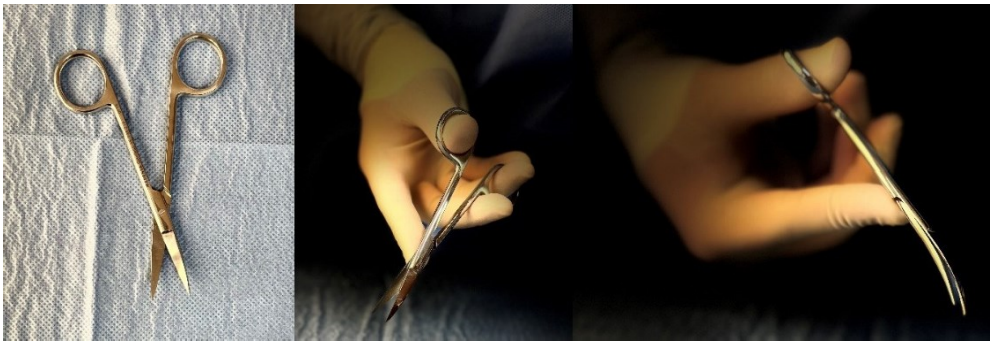

Figure 7. Surgical scissors

VIII.2.1.3. Other cutting instruments

Although not used for dissection or incision in the same way as the scalpel or scissors, there are several cutting instruments that should be considered.

a. Skin graft knife (dermatome)
   This instrument has several variations in size, shape, and complexity, ranging from a small knife carrying a single-edged blade to a large electric skin graft dermatome (36).

b. Bone cutter
   Traditionally used by orthopedic surgeons, these instruments are also used in neurosurgery, thoracic surgery, vascular surgery, plastic surgery, and any other specialty whose activity involves bone resection. These instruments are scissor-shaped and have either heavy, scissor-like blades (cutters) or a pair of notched cups (36).
c. Curette
   This cup-shaped instrument is used for debriding cavities by scraping their contents. Abscesses, infected, friable bone segments, and the uterus are just a few of the situations in which this instrument is used. The spoon-shaped tip has a sharp edge that cuts tissue. A curette is used by holding the handle in one hand, with the index finger extended along the instrument shaft, then gently scraping with the sharp edge the area containing the tissue to be removed. The sharp edge of the curette debrides tissue while scraping the cavity margins (36).

VIII.2.2. Grasping instruments

Forceps is the generic name given to any instrument used to grasp or hold. They can be hand-held (such as tweezers) or scissor-shaped, with or without a locking mechanism. Forceps can be used to grasp tissues, needles, sutures, or even other instruments. Grasping instruments are classified as follows: tissue forceps, vascular forceps, needle holders, and other grasping forceps (36–38).

VIII.2.2.1. Tissue forceps

The basic purpose of the forceps is to grasp tissue in a minimally traumatic manner, for stabilization or retraction, while performing another action such as suturing or dissection. Hand-held forceps consist of two blades made of elastic metal joined at the base and ending at the same length with grooves or teeth at the tips. These grooves meet and grasp when the two blades are squeezed between the second and third fingers and the thumb (36).

Forceps are generally used in the non-dominant hand to hold and expose tissues, apply counterpressure, or provide tension against which to dissect. Forceps with grooved tips are called anatomical forceps (Figure 3), while forceps ending with 2–3 teeth at the tip are called surgical forceps (Figure 4).

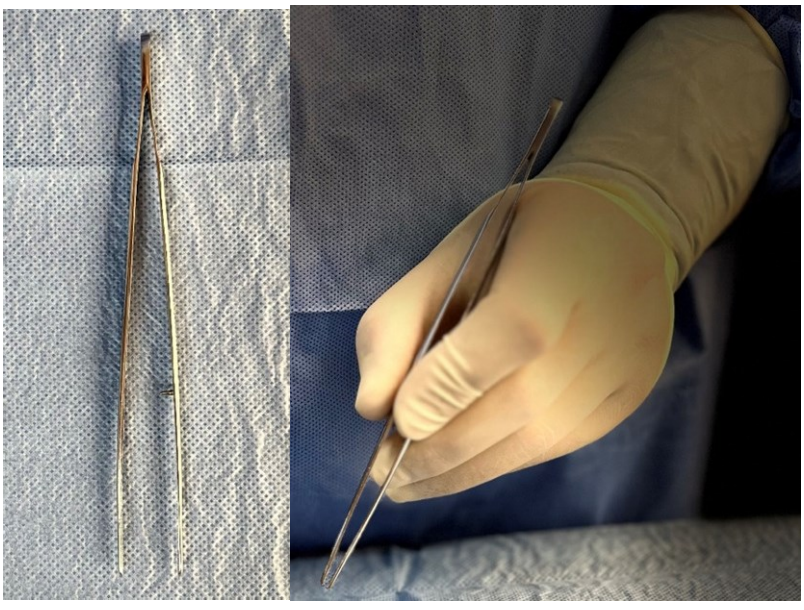

Figure 8. Anatomical forceps

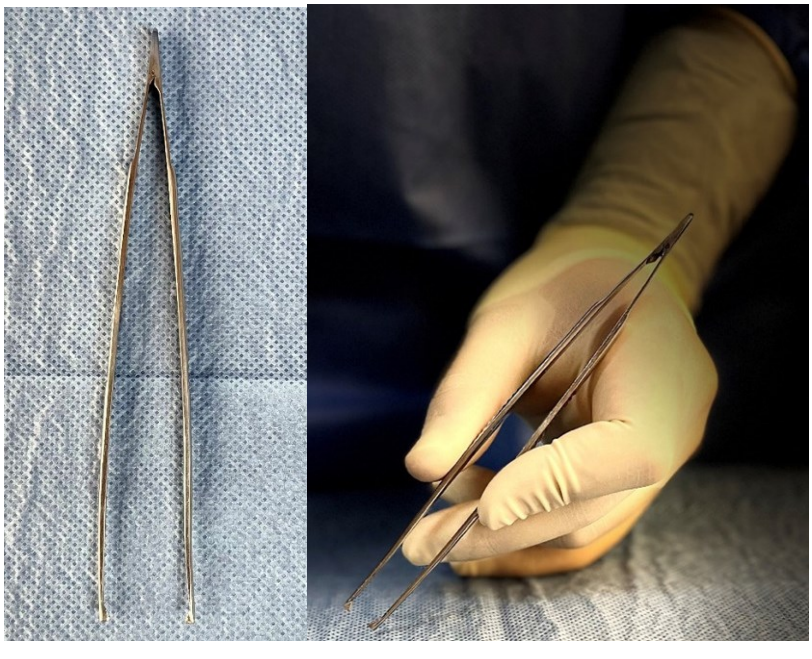

Figure 9. Surgical forceps

The second type of tissue forceps has a scissor-like shape and a pair of gripping tips with either grooves or teeth. The one with grooves is called

Pean forceps (Figure 5), and the one with toothed tips is called a Kocher forceps (Figure 6) (37).

Hand-held forceps are used for manipulating local soft tissues or viscera during the active phases of a procedure, such as dissection or suturing. They may be short, medium, or long in size, and their tips can be toothed or non-toothed, depending on the tissue being handled. Non-toothed forceps are mainly used for grasping viscera and serosal or adventitial surfaces, as the absence of teeth greatly reduces the likelihood of puncture. Toothed hand-held forceps are commonly used for stabilizing skin or manipulating fascia and muscles during suturing. The number of teeth on each tip (1 × 2 or 2 × 3, etc.) is determined by the width of the tip. The numbers indicate the number of teeth that fit on the opposing tips (36,38).

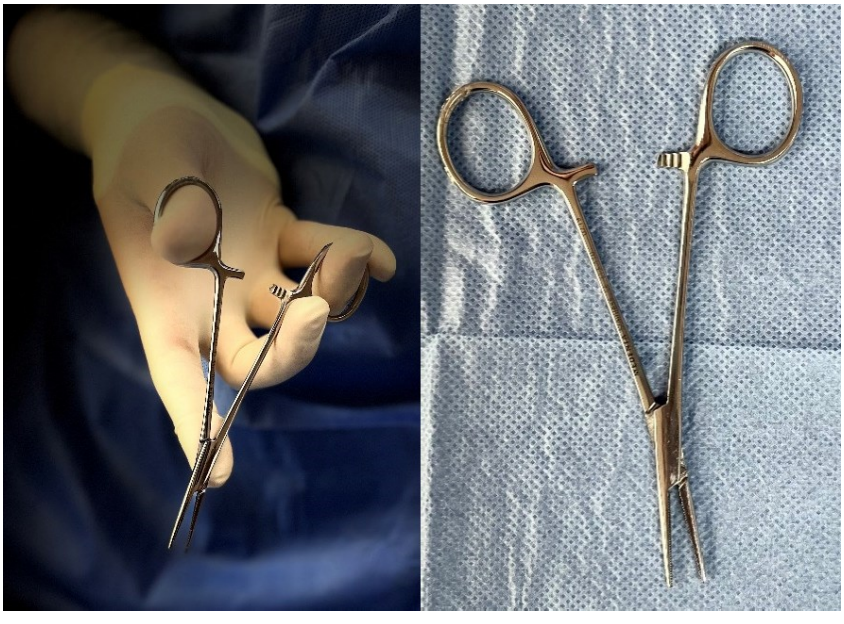

Figure 10. Pean forceps

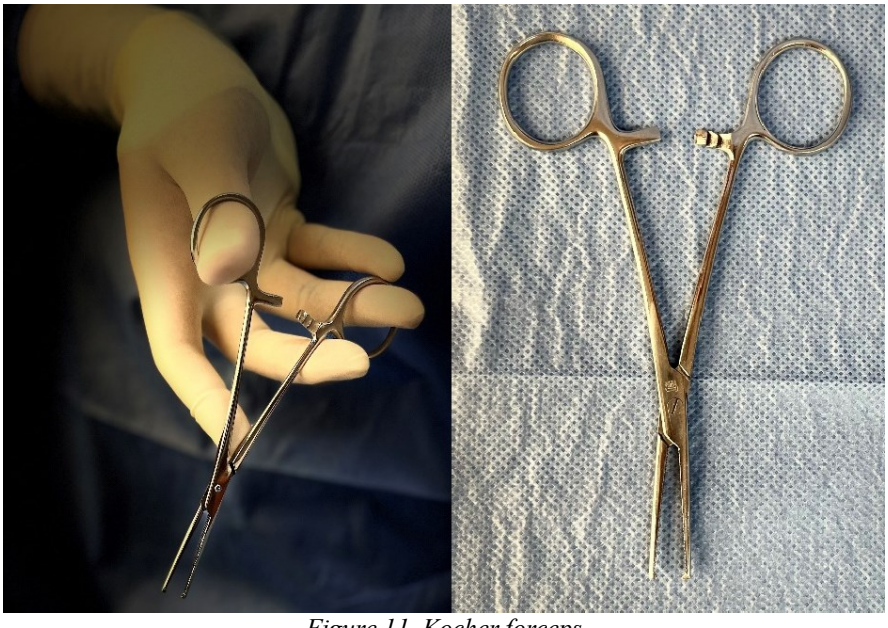

Figure 11. Kocher forceps

VIII.2.2.2. Needle holder (Figure 7)

Needle holders are used to insert (or guide) a needle attached to a suture through tissues. These forceps may have a locking mechanism or not. If a locking system is present, the holder can be designed in a classic scissor model or may have long curved shafts without finger rings.

The needle holder must be held in a specific way to be effective. The instrument should be held with its long axis in line with the forearm, the thumb placed in the upper ring, and the fourth finger in the lower ring, with the second and third fingers positioned on the instrument's joint and around the lower ring. An alternative position is to place the needle holder in the palm of the hand, with the upper ring on the thenar eminence, the length of the holder along the index finger, and the other three fingers wrapped around the lower ring (36).

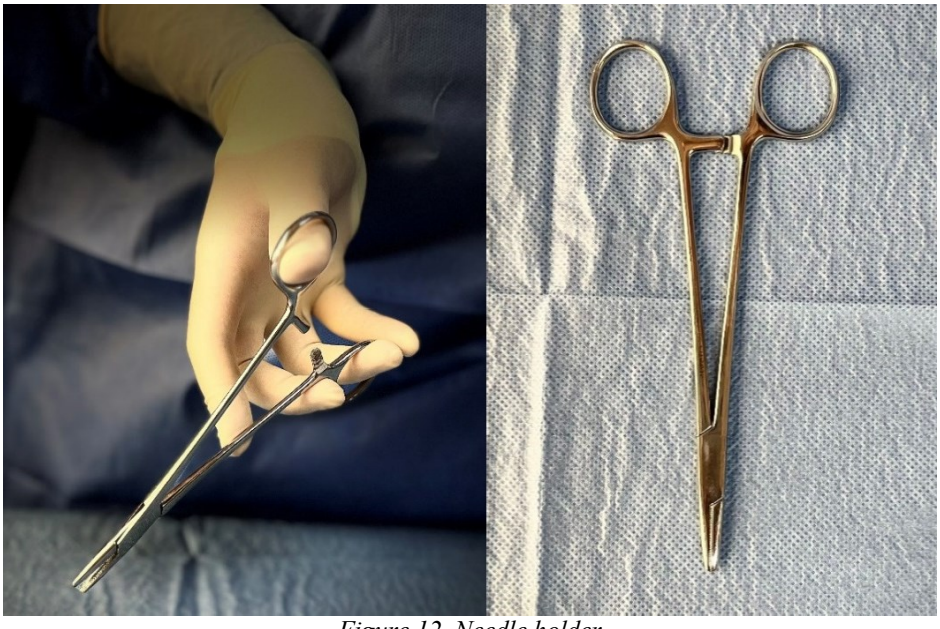

Figure 12. Needle holder

VIII.2.3. Retraction instruments

Retractors are essential instruments for exposing deep tissues by the assistant during a surgical procedure. They can be hand-held or designed as self-retaining models that lock in position with a spring, ratchet, or screw mechanism.

The fundamental principle of retraction is placing a blade in front of tissue that would otherwise obscure visibility in the surgical field. The blade can be used passively to prevent tissue from falling into the wound or for active (and sometimes forcibly required) retraction of tissues from the wound. In this situation, great care must be taken to avoid damaging the retracted structures. They are held in position by one of the assistants to move or prevent tissues from entering the operative field. When handled properly, these instruments cause minimal tissue trauma. All retractors have a "blade" of a specific size, set at approximately a right angle to a long, sometimes slender, handle (36).

VIII.2.4. Other types of instruments

VIII.2.4.1. Bowls

Each sterile set requires bowls and kidney trays of various sizes. Their uses include maintaining washing or irrigation solutions in aseptic conditions, holding specimens collected for paraffin histopathological examination, collecting wound drainage, etc. (36).

VIII.2.4.2. Surgical electrocautery

The cautery is an electrical device that can be used to coagulate blood in small-caliber blood vessels and to cut tissues. The basic principle of diathermy is that the heat generated by the current passing through tissues will coagulate blood or vaporize tissue (36).

Diathermy has two modes of operation – monopolar and bipolar. In monopolar mode, an electrosurgical generator is connected to the patient via a broad flat electrode, and a diathermy instrument is applied to the area where coagulation is required. The patient's body conducts the current between these two points to complete an electrical circuit. In bipolar mode, the active points are the two tips of an insulated pair of diathermy forceps, and the current passes between them. In bipolar mode, only the tissue between the tips and immediately adjacent is heated. Due to this localized effect, bipolar diathermy cannot be used for cutting tissues (36).

- Monopolar diathermy

Monopolar mode allows the current to flow along the paths of least electrical resistance to the plate electrode on the patient's skin. Within monopolar mode, two types of current can be generated. Cutting current is a continuous waveform that produces very high temperatures and vaporizes tissue. Coagulation waveform is delivered as intermittent bursts of energy and, although it will also vaporize tissue, it flows along vessels to coagulate blood and stop bleeding. Both can be used on almost any tissue, except bone (36).

- Bipolar diathermy

Bipolar mode is based on the flow of alternating current between the two tips of an insulated instrument as they close on a piece of tissue. This is an excellent method for sealing small vessels with minimal damage to surrounding tissue, as no current flows through these tissues. This makes bipolar diathermy the method of choice for microsurgery, neurosurgery, ophthalmology, and when operating on fingers and the penis (36).

VIII.3. Preparing the sterile surgical table for the procedure

VIII.3.1. Introduction

One of the greatest advances in surgical science came with Lister's introduction of an aseptic environment for surgery (36).

Four principles are essential in the practice of sterile technique (36). These are most strictly observed in the operating room but also apply to procedures performed outside this setting.

The first principle is the reduction of environmental contamination. Easily achieved in the operating room, this becomes progressively more difficult in emergency rooms, wards, and clinics where sterile technique is also practiced.

The second principle, adherence to asepsis and antisepsis rules in the surgical suite, is a universal practice.

The third principle, isolation of the surgical site, is maintained by ensuring barriers between the patient, surgeon, assistant, and environment. These barriers prevent direct contamination of the patient from the outside and contamination of the outside environment by the patient.

Sterilization of instruments is the fourth principle.

VIII.3.2. Reduction of environmental contamination (36)

When engaged in activities in the operating room, it is essential that all staff actively monitor the maintenance of an adequately sterile environment.

To maintain a sterile environment in the operating room, contamination is minimized. For this purpose, medical personnel must change into appropriate attire upon entering the operating room (male/female filter). Wearing a face mask and a cap is mandatory (the mask must cover the nasal and oral cavities, and the cap must fully cover the scalp). Special footwear is required to prevent contamination from outside (36).

Preparation of the sterile surgical table is carried out by the scrub nurse/operating room assistant. They must be properly equipped with a sterile gown and gloves. A helper at the side (nurse/orderly) will open the sterile packs containing the instruments required for the upcoming procedure, following asepsis and antisepsis rules.

The surgical instruments are arranged on the surgical table, which has been previously covered with a sterile drape, in the following order: from left to right, cutting instruments (scalpel, scissors) are placed first, followed by grasping instruments (forceps) and retractors. In the upper right corner, the needle holder and suture threads are usually placed. On the sterile table, there should also be a bowl for disinfectant solution, gauze/pads, and a hemostatic forceps, placed in the upper left corner (figure 8). The table is subsequently completed according to the specifics of the surgical procedure to be performed.

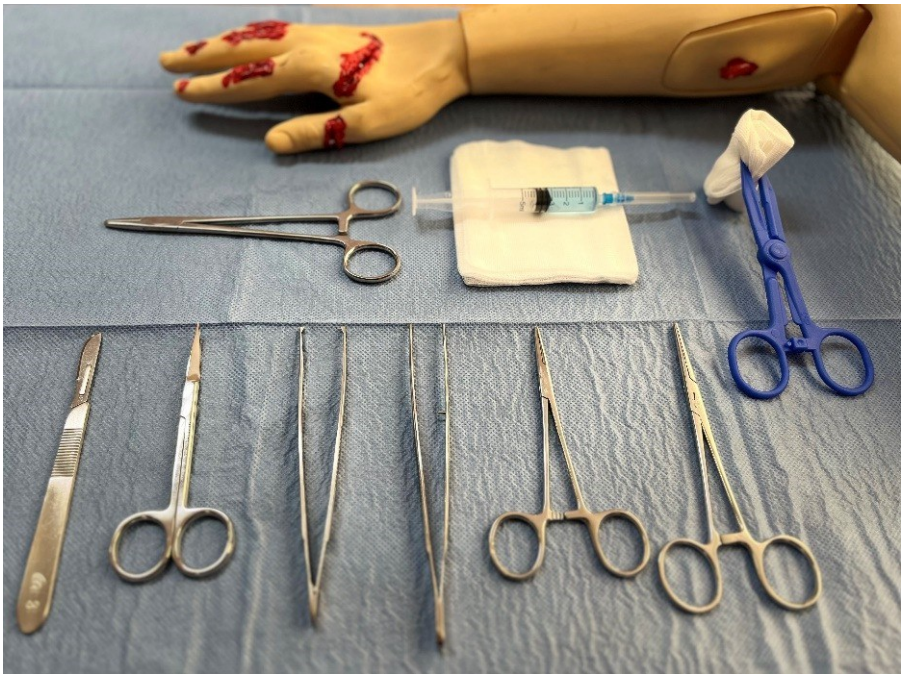

Figure 13. Positioning of instruments on the sterile table

VIII.3.3. Disinfection of the surgical site

This refers to the process of disinfecting, shaving, and decontaminating the area to be operated on. The scrub nurses or medical staff usually perform the first two tasks. If the wound is heavily contaminated with foreign bodies, it may first be cleaned in a "clean" rather than sterile manner to remove macroscopic contamination before the actual skin preparation (36).

Once dressed in a sterile gown and gloves, a team member in the operating room will isolate the surgical site with an antibacterial solution. Preparation begins at the edge of the incision site and proceeds outward in progressively larger circular motions. Preparation swabs must be discarded once dry, and new swabs must be used. The used swab must not be reintroduced into the solution. A larger area than strictly necessary should be prepared to allow for potential extension of the wound under unforeseen circumstances.

Antiseptic solutions used for preparing the surgical site include: chlorhexidine (0.5%) in alcohol (70%), chlorhexidine (0.5%) with cetrimide (2%), povidone-iodine solution (Betadine) 10%, alcoholic iodine solution, and aqueous chlorhexidine (0.5%) (36).

VIII.3.4. Isolation of the anatomical area to be operated on

The isolation of the anatomical area to be operated on using sterile drapes is called draping. It is one of the barrier methods that protect the patient from contamination by the surrounding environment. Sterile drapes can be made of cotton, paper, or plastic. Some disposable drapes have an adhesive layer for fixation.

Once the patient and the surgical field are prepared, the actual surgical procedure can begin.

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Chapter IX
Basic Clinical Skills in Local and Regional Anesthesia, Microsurgery, and Laparoscopic Surgery.

Pițˌ Daniel, Manta Bogdan, Hoinoiu Teodora

IX.1. Types of Local and Loco-Regional Anesthesia

IX.1.1. Introduction Concepts

Nerve cells (neurons) are responsible for the transmission of electrical impulses. Motor nerves carry impulses generated in the brain to an effector cell (usually a muscle) to perform a function. Sensory nerves conduct impulses in the opposite direction, from a peripheral receptor to the brain, thus allowing perception of a stimulus. The basis of local anesthesia is the prevention of perception of a harmful stimulus in the periphery (e.g., wound repair or lesion excision) by blocking the conduction of impulses along sensory nerves (1).

The conductivity of nerve cells relies on a process of depolarization and repolarization across the cell membrane, which progresses from the point of stimulus origin to the next synapse. Depolarization is caused by the rapid influx of sodium ions from the exterior into the cell, and repolarization is caused by the efflux of potassium ions from the cell. Equilibrium is restored by specialized membrane pumps that return translocated ions to their original positions (inside or outside the cell) (1).

Local anesthetics are a heterogeneous group of substances that prevent electrical conduction along neurons. Since they are poorly soluble in water and bases, the active anesthetic is in the form of a hydrochloride salt. They act by transiently "blocking" sodium transport channels in the cell membrane. This prevents the initial depolarization of the cell at that site, a process called membrane stabilization. The result is the inability of the neuron to reach its threshold potential and depolarize in the region where the local anesthetic was administered. Consequently, electrical impulse conduction is interrupted, and the function of the neuron is temporarily impaired or halted. Sensory neurons are more sensitive to this process than motor neurons. The general goal of local anesthesia is to block local or regional sensory neurons with minimal effect on motor function (1).

Many procedures, from cesarean section to craniotomy, can be performed under local anesthesia. Administration methods also vary: from infiltration of tissues and nerves to injections around spinal nerve roots or the

spinal cord. Generally, however, most practitioners use local anesthetics only for minor wound repairs or local excisions (1).

There are many techniques by which local anesthetics can be used to achieve anesthesia (see Table 1). The most commonly used method is local infiltration.

Table 1. Types of Local and Loco-Regional Anesthesia (36)

Method	**Mechanism**	**Site of action and extent**	**Advantages / Disadvantages**	**Example**
Topical administration	A liposoluble cream containing local anesthetic is applied to the skin. It is absorbed and blocks the dermal neurons.	Local tissues. Up to a few millimeters in depth	Advantage: simple and effective. Disadvantage: superficial penetration.	Topical local anesthetic cream applied to the skin prior to injection in pediatric patients.
Local infiltration	The local anesthetic is infiltrated into the tissues and blocks all small nerves in the region.	Minor branches of sensory nerves and receptors. Complete extent of infiltration and subsequent diffusion.	Advantage: simple and effective. Adrenaline helps with hemostasis and prolongs the effect of the anesthetic; allows hydro dissection. Disadvantage: risk of injection into a vessel, so aspiration is mandatory before injection; short duration of effect without the use of adrenaline.	Injected locally around a skin lesion prior to excision.
Nerve block / plexus block	Injection of local anesthetic around a major nerve or nerve plexus – it	Neurons of the major nerves The entire distribution of all infiltrated	Advantage: very effective, long-acting, does not require additional anesthesia. Disadvantage: may fail and require	Blocks of the median and ulnar nerves for hand anesthesia. Brachial plexus, axillary plexus

	diffuses around and into the nerve to block all fibers.	nerves: also has a motor effect.	general anesthesia; risk of toxicity from accidental intravenous injection.	block for arm anesthesia.
Intravenous block (Bier block)	Intravenous injection of local anesthetic into a limb that is exsanguinated and with an arterial tourniquet applied.	All nerve tissue in the respective limb. The entire limb below the tourniquet. Motor and sensory effect.	Advantage: rapid and effective, simple technique. Disadvantage: potential toxicity if administered intravenously, exsanguination and ischemia, special equipment required, performed by two physicians.	Injection of local anesthetic into the veins of the upper limbs, after tourniquet application and exsanguination, for anesthesia prior to reduction of a Colles fracture.
Central neural block	Injection of local anesthetic into the vertebral column to achieve central anesthesia. Epidural – outside the dura, diffuses into the nerve roots within the dural sheath. Spinal – into the subarachnoid space to diffuse into the spinal cord and the nerve branches within their sheath.	Epidural: into the spinal nerve roots. Spinal: directly into the spinal cord and nerve branches.	Advantage: rapid and very effective, simple to administer. Disadvantage: risk of failure and patient discomfort, risk of injury to the spinal cord/nerve roots. For dural puncture: bacterial inoculation/abscess, sympathetic block, respiratory effect if administered in the upper part of the vertebral column.	Single administration of anesthetic into the subarachnoid space for anesthesia of the lower abdomen for an inguinal hernia. Placement of an epidural catheter to extend anesthesia during the procedure and to provide analgesia after a major abdominal surgery.

IX.1.2. Local Anesthetics and Recommended Dosages

There are two distinct families of local anesthetics – esters (derived from various substances) and amides. The latter are used more frequently in daily practice. The main difference between the two lies in their metabolic degradation. Esters are hydrolyzed in plasma by pseudocholinesterases, while amides are metabolized by the liver. Both types act to block sodium channels in the neuronal cell membrane (1).

The most commonly used local anesthetics in general anesthetic practice are lidocaine (Figure 1), bupivacaine, and prilocaine. Each of these substances has specific properties that make them suitable for certain circumstances, and all are available in a variety of concentrations, from 0.25% to 2%. Combinations with adrenaline are also available in concentrations ranging from 1:100,000 to 1:400,000. A newer local anesthetic, ropivacaine, has recently been introduced and is now finding its place in clinical practice (1).

Figure 7. Local anesthesia (lidocaine)

The safe dose of any local anesthetic can be influenced by many factors and, therefore, can vary considerably between individuals. It is usually expressed in terms of "milligrams per kilogram of body weight." The exact volume available for administration can be calculated by knowing the concentration of the anesthetic solution. The main factor in deciding dosing regimens is the known toxicity profile of a drug. The administered dose usually has a fixed maximum value that should only be exceeded by experienced medical personnel. Other considerations for dose adjustment

include the area and method of administration, concomitant administration of adrenaline or other vasoconstrictors, and the rate of administration (1).

The speed required for onset and the duration of action are factors that can affect the choice of anesthetic (Table 2). These parameters also depend on the site of administration, tissue pH, and concomitant use of vasoconstrictors. Faster-acting amide anesthetics, such as prilocaine and lidocaine, begin to work within a few minutes, whereas esters, such as procaine and tetracaine, may take up to 18 minutes to take effect. Similarly, the duration of action varies greatly (1).

Table 2. Common Local Anesthetics and Their Properties (1)

Drug	Dose (alone)	Dose (in combi-nation with adrenaline)	Onset (minutes)	Duration (hours)	Comments
LIDOCAINE	2-4 mg/kg	7-9 mg/kg	5-10 minutes	1–2 h (alone) 2–3 h (with adrenaline)	Commonly used because it has a rapid onset and a duration long enough for short procedures.
BUPIVACAINE	2,5 mg/kg	2,5 mg/kg	10-15 minutes	3–4 h (alone) 3–5 h (with adrenaline)	Slower onset with less motor block. More cardiotoxic than lidocaine and may precipitate arrhythmias.
PRILOCAINE	5 mg/kg (400 mg maximum/ day)	5 mg/kg (400 mg maximum/ day)	5-10 minutes	1–2 h (alone) 2-3 h (with adrenaline)	Rapid onset, but significantly lower toxicity. Can be used intravenously (Bier block). May cause methemoglobine mia at high doses.

ROPIVACAINE	200 mg total	-	1-15 min	2-6 h	Not more effective or longer-acting when combined with adrenaline. Less cardiotoxic than bupivacaine.

IX.1.2.1. Local Anesthetic Toxicity

As with all medications, local anesthetics have the potential to harm the patient, both through known adverse effects (side effects) and through unexpected reactions (allergies). Non-allergic effects are usually dose-related, and an overdose is generally (but not always) required for them to manifest. Rapid absorption and accidental intravenous administration of the anesthetic are other major causes of adverse events (Table 3) (1).

Table 3. Reactions to Local Anesthetic Agents

Classification	Signs and Symptoms
Early Neurologic	Numbness of the mouth and tongue, tinnitus, anxiety, tremor and spasms, dizziness, confusion, drowsiness.
Late Neurologic	Incoordination, coma, respiratory arrest, death.
Cardiovascular	Hypotension, myocardial depression, cardiac arrest, cardiac arrhythmias with bupivacaine.
Respiratory	Tachypnea or respiratory depression
Allergic	Nausea and vomiting, hives, and anaphylaxis

- Contraindications and precautions

There are some special contraindications for the administration of local anesthetics. These include known hypersensitivity to the anesthetic, the use of prilocaine in anemia or methemoglobinemia, and the administration of bupivacaine for intravenous regional anesthesia. The use of solutions that contain adrenaline at the level of terminal arteries (fingers, toes, and penis) is not recommended, as it may lead to significant vasospasm and ischemic necrosis of the respective area (1).

Other situations in which local anesthesia must be administered with caution include: patients with shock, hypotension, or hypoxia, as these potentiate toxic effects. Patients with cardiac blocks or pre-existing arrhythmias, liver disease, epilepsy, and respiratory failure are also at higher risk of adverse reactions, especially those caused by bupivacaine (1).

- Management of toxicity

The earliest signs of toxicity will usually be those of central nervous origin. But sometimes even cardiac arrest may be the first indicator of a problem. Although prophylaxis is better than treatment, the physician administering the anesthetic should be able to perform emergency support and have rapid access to assistance, if necessary (1).

In situations where toxicity is suspected, the first step is administration of oxygen by mask, ensuring an adequate airway, and immediate postponement of the proposed procedure. Intubation and ventilation are rarely required. If a seizure occurs and persists for more than 20 seconds, it should be controlled with an appropriate agent, such as diazepam 5–10 mg, by slow intravenous injection. Hypotension may require administration of a vasopressor (1).

IX.1.2.2. Local anesthesia by infiltration (1)

This section describes some basic principles of administering local anesthetics by infiltration.

- Timing

Injection of the local anesthetic before the surgeon scrubs provides adequate time for it to act before making the first incision. The longer this interval, the more likely adequate anesthesia will be achieved. Bupivacaine, one of the slowest-onset anesthetic agents, always requires this pause. The skin must first be prepared with an alcohol swab or antiseptic solution.

- Dilution

If a large area is to be infiltrated, the anesthetic is diluted in normal saline to increase the volume without risking toxicity. A bicarbonate solution is sometimes used, as it also reduces stinging and accelerates the onset of anesthesia, since both are aggravated by solution acidity and tissue acidity.

- Needle

Unless otherwise indicated, a #25 (orange) or #23 (blue) needle should be used for infiltration. These are fine enough to minimize discomfort, yet long enough to reach an adequate distance.

- Aspiration

Before injecting any substance, aspiration should be performed to ensure that a blood vessel has not been accidentally punctured. This is a cause of toxicity, and therefore aspiration should be a routine procedure for all practitioners administering local anesthetic.

- Infiltration technique

A sufficient width of infiltration must be ensured for debridement and excision of devitalized tissue. Both the dermis and the underlying tissues must

be infiltrated. Marking both the lesion and the extent of infiltration will facilitate the surgical procedure. If there is a clean open wound, inject the anesthetic through the subcutaneous fat, which is practically insensitive, thereby reducing patient discomfort.

- Pressure

Firm pressure on the infiltration site will stop bleeding and will also help the anesthetic to diffuse over a distance through the local tissues. This maneuver will reduce the problem of hidden lesions under local anesthetic papules and increases the width of infiltration through diffusion.

IX.2. Microsurgery / Laparoscopic Surgery

IX.2.1. Microsurgery

Although relatively new as a surgical discipline, microsurgery has become an essential part of the plastic surgeon's toolkit over the past century. Microsurgery dates back to early 1921, when Nylen used a microscope for ear surgery. Microvascular surgery did not truly begin until technological advances in equipment allowed the anastomosis of small vessels, first performed by Jacobsen and Suarez in the early 1960s (2,3). This era of research and development culminated with the first free tissue transfer performed by McClean and Buncke in 1972 (4), when they transferred omentum to cover a scalp defect. By 1980, microvascular surgery had become an essential tool in plastic surgery at many major medical centers. In fact, reconstructive microsurgery is now a requirement and an integral part of plastic surgery training.

Mastery of these skills requires proficiency in the use of the operating microscope, along with competency in essential microsurgical instruments, including the micro-needle holder, fine forceps, and microdissection scissors, which are employed in the performance of microvascular anastomosis.

Another important tool that facilitates microvascular anastomosis is a simple or double microclip (micro-approximator) (Figure 2) (5). The micro-approximator can be used to align and approximate vessels to facilitate easier suture placement, while maintaining hemostasis, stability, and uniform, tension-free orientation of the vessels (5).

Figure 8. Microsurgical clip and micro-approximator

The main instruments used in microsurgery include: needle holder, forceps, microsurgical scissors, vessel irrigator, hemostatic clips, and clip applicator (Figure 3).

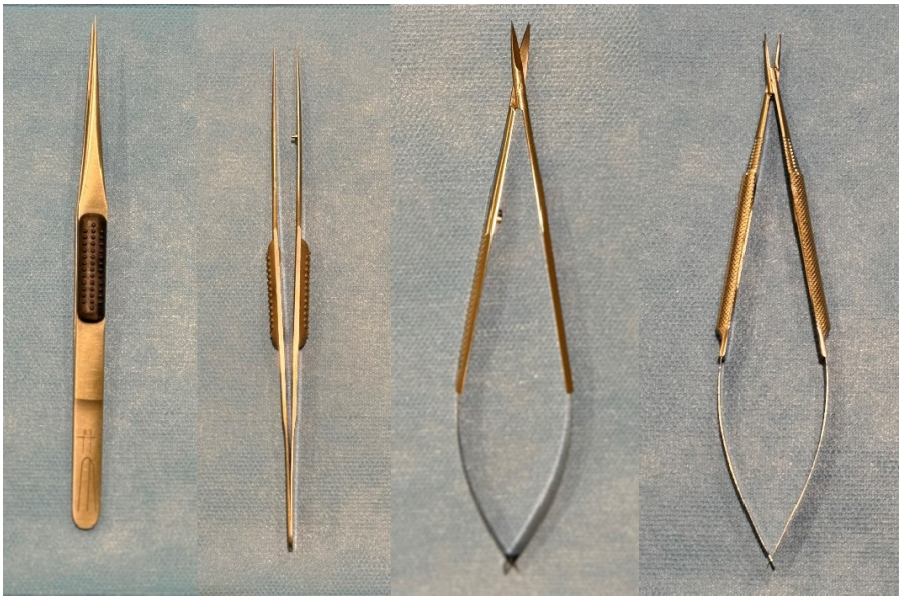

Figure 9. Basic microsurgical instruments (forceps, needle holder, scissors)

When using the operating microscope, choosing the appropriate level of magnification is essential. Magnification can be divided into three basic levels. Low magnification (6×–12×) can be used for vessel preparation and knot tying; medium (10×–15×) can be used for suture placement; and higher magnifications are used for performing anastomoses of small-caliber vessels and inspecting the anastomoses at the end of the procedure. In certain cases, magnifying loupes have also been used (Figure 4) (5×–6×), which have been successfully employed for microvascular anastomosis of vessels larger than 1 mm in diameter (6).

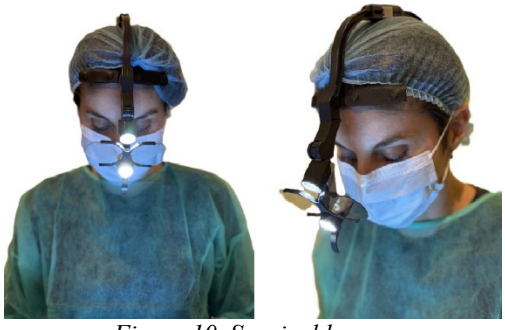

Figure 10. Surgical loupes

Understanding the use of suture material and the appropriate needle for different vessel sizes is essential for achieving a perfect anastomosis. Most commonly, free flaps have vessel diameters ranging from 1 to 3 mm. Vessels around 1 mm are sutured with 9-0 or 10-0 sutures, while 3 mm vessels can be sutured with 8-0 or 9-0 sutures (Figure 5). Proper needle selection is important to avoid unnecessary vessel injury during anastomosis (7).

Figure 11. 9-0 suture thread

In preparing to perform a microsurgical anastomosis, both the surgeon and the assistant must be positioned comfortably, either seated or standing. Most importantly, the surgeon's hands and the radiocarpal and elbow joints must be supported near the operative field (7).

Before placing sutures, the surgical field must be arranged to optimize conditions for a successful anastomosis. Placement of a background (e.g., a plastic sheet, usually colored – blue/green) will keep the vessels free from surrounding tissues and easily visible during suture placement. The suture is then performed according to standard rules (7).

IX.2.2. Laparoscopy

Endoscopy comes from the Greek language and means "visualization of the interior spaces of the human body" ("endo" and "skopein") (8). It can be used both for diagnostic purposes (exploratory laparotomy) and therapeutic purposes (laparoscopic surgery).

Laparoscopic surgery has experienced remarkable development over the last decade; it was initially introduced at the beginning of this century by Dimitri Ott, Georg Kelling, and Hans Christian Jacobeus (9). Von Ott performed an examination of the abdominal depression of a pregnant woman in 1901, and later Georg Kelling carried out a procedure called "koelioscopy," similar to the description of modern laparoscopic techniques. At the same time, Jacobeus published his first report on what he called "Laparothorakoskopie" (9). Major advances in endoscopy occurred between 1960 and 1980, accompanied by the transition from diagnostic to surgical laparoscopy. These advances are inseparably linked to the names Raoul Palmer in Paris and Kurt Semm in Kiel (10).

It was only with the introduction of the rod-lens optical system and cold fiber-optic illumination that laparoscopy became more popular, especially in gynecology departments. At that time, laparoscopy in general surgery was mainly performed to investigate liver diseases and abdominal trauma. The first laparoscopic appendectomy was performed by Semm on September 13, 1980, in the Department of Obstetrics and Gynecology at the University of Kiel (10). Lukichev in 1983 and Muhe in 1985 performed their own versions of laparoscopic cholecystectomy in humans (11).

Their initial approaches did not attract the attention they deserved, and interest in laparoscopy among general surgeons grew only after the French gynecologist Mouret performed the first recognized laparoscopic cholecystectomy using four trocars in 1987 (12).

Laparoscopic surgery can be considered one of the greatest advances in the field of surgery. It has brought a revolution in the use of digital and robotic technology in surgical practice, radically reduced patient recovery time compared to "open" surgeries, and, remarkably, these advances were achieved while improving the quality of surgical interventions (13). Many surgical procedures have since been performed using this new approach.

During a laparoscopic procedure, special instruments are used (Figure 6), such as:

- The laparoscope is a thin, flexible tube equipped with a video camera and a light at the tip, allowing visualization of internal organs on a screen.

- Trocars are tubes inserted through the skin to create access to the abdominal cavity, allowing insertion of the laparoscope and other surgical instruments (14).
- The surgical instruments used during laparoscopy are usually smaller and thinner than those used in open surgery, allowing precise manipulation of tissues and organs.
- Other specialized surgical instruments include scissors, forceps, and coagulation devices.

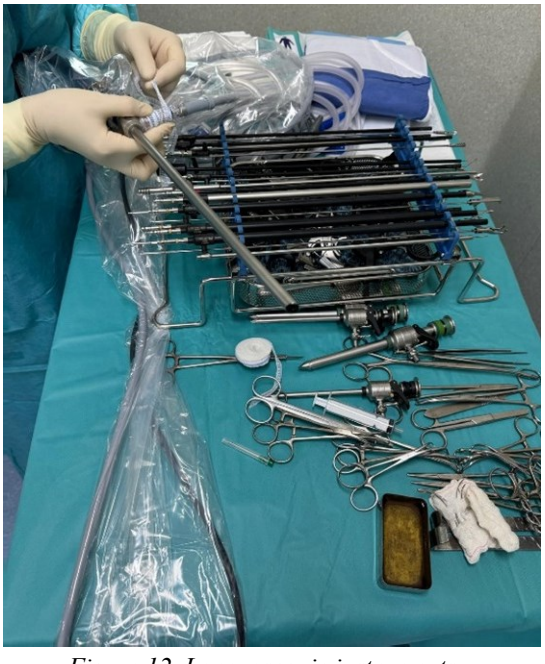

Figure 12. Laparoscopic instruments

Laparoscopy is used for a wide range of surgical procedures, including (15,16):

- Cholecystectomy (removal of the gallbladder) – for gallstones or inflammation.
- Appendectomy (removal of the appendix) – for appendicitis.
- Hysterectomy (removal of the uterus) for gynecological conditions such as uterine fibroids or endometriosis.
- Hernia repairs and other abdominal and pelvic surgeries.
- It is also used for diagnosing and treating endometriosis, ovarian cysts, infertility, abdominal bleeding, and other conditions.

Laparoscopy is expanding into other medical specialties, including orthopedics, urology, and neurosurgery, with procedures such as arthroscopy, laparoscopic prostatectomy, and endoscopic approaches for brain tumors.

Laparoscopic surgery is associated with less pain, fewer wound infections, shorter hospital stays, reduced morbidity and mortality, as well as faster return to work and overall improved quality of life (16,17).

Limitations and contraindications: laparoscopy may be difficult or impossible in certain situations, such as the presence of extensive abdominal scars or other anatomical anomalies. There are also contraindications for laparoscopy, including severe heart or lung disease, blood clotting disorders, or morbid obesity, which can increase the risk of complications (18,19).

The development of robotic surgical systems, such as the Da Vinci Surgical System, allows surgeons to perform laparoscopic procedures with improved precision and control. The use of virtual reality and computer simulation aids in surgeon training and enhances their skills in laparoscopic surgery (10).

Intraoperative imaging guidance, such as magnetic resonance imaging or intraoperative computed tomography, helps to precisely locate tumors and other anatomical structures, reducing the risk of complications. The use of contrast agents and fluorescent markers in laparoscopy assists in more accurate tissue identification and enables more precise and efficient surgical interventions.

Further development of imaging and instrumentation technologies is anticipated, allowing greater precision and efficiency in laparoscopic procedures. The increasing integration of artificial intelligence in laparoscopy, such as assistance and data analysis systems, could optimize surgical procedures and reduce the risk of human error (10,19).

In conclusion, laparoscopy represents a revolution in surgery, offering significant benefits in terms of rapid patient recovery, reduced risk of complications, and improved surgical outcomes. Since its initial introduction into clinical practice, laparoscopy has undergone continuous development, driven by significant technological advancements and an expanding range of applications across multiple surgical disciplines. However, it is important to continue critically evaluating this technology and ensure that laparoscopic procedures are used responsibly and effectively. With ongoing innovations and a rigorous approach to quality and safety, laparoscopy will continue to redefine standards in modern surgery and provide significant benefits to patients worldwide.

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Chapter X
Dressings and Bandages

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X.1. History

The concept of keeping a wound clean and bandaged has been known for a very long time. Wound care was recorded as early as 2100 BC, when the "three gestures of healing" were inscribed on the famous Sumerian clay tablet: washing the wound with beer and hot water, preparing plasters (mixtures of herbs, ointments, and oils), and bandaging the wound (1,2).

Physicians in ancient Greece covered patients' wounds with a variety of ointments diluted in wine and made from combinations of salts (copper acetate, copper oxide, lead oxide), vinegar, nuts, flowers, fat, and perfume (myrrh or frankincense – both bactericidal and aromatic). During the time of Christ, Roman doctors used antiseptics similar to the Greek ones. Cornelius Celsus, a Roman physician and author of the treatise De Medicina, an eight-volume work, listed 34 plasters and ointments (1).

In 1891, Johnson & Johnson was the first company to mass-produce sterile surgical dressings by sterilizing cotton and gauze with dry heat and then with steam and pressure. The company's founder, Robert Wood Johnson, had heard Dr. (Sir) Joseph Lister speak in 1876 about his antiseptic methods (operating in a carbolic acid mist) and antiseptic dressings. Lister is credited with developing the first antiseptic dressing in 1867 by soaking lint and gauze in carbolic acid (phenol).

Tulle gras, a non-adherent wound dressing, was composed of loosely woven curtain mesh cut into squares and impregnated with soft paraffin (98%), Peru balsam (1%), and olive oil (1%). It was developed and primarily used in France but gained worldwide popularity during World War I (3).

As late as the 19th century, aseptic surgery was not yet routine. Sterilization of instruments began in the 1880s, as did wearing gowns, masks, and gloves. Routine use of surgical gloves was introduced by Halsted's student, Joseph Bloodgood. Halsted also advocated the use of silver-foil dressings for wound care. The antibacterial properties of silver were reappraised in the mid to late nineteenth century (Romans used silver nitrate and other metal filaments on wounds) (4).

In 1944, fine-mesh gauze was introduced, offering modest absorption but minimal adherence surface. In 1954, Telfa, a non-adherent dressing, was introduced (5).

Today, dozens of dressings are available, impregnated with everything from petroleum jelly to genetically engineered growth factors (5).

X.2. Introductory Concepts

All surgical specialties rely on a detailed understanding of wound healing mechanisms and frequently face the challenge of treating chronic injuries. Wound healing involves a wide range of overlapping cellular and metabolic processes that are orchestrated as a fundamental homeostatic response to injury. Understanding these concepts is essential for wound care in all surgical disciplines (6).

Classically, wound healing is divided into three distinct phases (Table 1): inflammatory, proliferative, and remodeling. Although each phase is described as a separate event, there is a high degree of temporal overlap and variability among these phases. Factors influencing the timing and duration of these events include ischemia, host age, nutrition, radiation, smoking, systemic diseases such as diabetes, contamination or infection, and the amount of devitalized or necrotic tissue in the wound (7,8).

A. Inflammatory Phase (immediately after wound formation up to days 4–6).

When an injury occurs, blood vessels are damaged, leading to activation of the endothelium and adjacent platelets, followed by vasoconstriction and activation of the coagulation cascade. A fibrin clot forms, consisting of fibronectin, thrombin, platelets, and collagen. The clot has a dual significance. First, it is a rich source of cytokines and growth factors, which are released as the activated platelets degranulate (9). Second, it serves as a scaffold for invading cells, such as neutrophils, monocytes, macrophages, and endothelial cells, which are chemotactically attracted through cellular signaling immediately after clot formation (10). Degranulation of platelet alpha and dense granules releases various substances, including platelet-derived growth factor (PDGF) and transforming growth factor-β (TGF-β), which trigger chemotaxis and proliferation of inflammatory cells that characterize this phase of wound healing. After the vasoconstriction period, cell migration to the injury site is facilitated by vasodilation and increased endothelial permeability (mediated by histamine, prostacyclin, and other substances) (8). The first cells to arrive are polymorphonuclear leukocytes (PMNs), which increase in number within the first 24 hours. These cells help clear the wound of debris and bacteria. Over the next 2–3 days, macrophages replace PMNs as the predominant cell type. Macrophages play several critical roles in wound healing, including phagocytosis, releasing additional growth factors and cytokines, and recruiting more inflammatory cells. Finally, lymphocytes populate the wound, although their direct role in wound healing requires further investigation (8).

B. Proliferative Phase

The clot formed during the inflammatory phase provides the provisional matrix and scaffold for the proliferation of the dominant cell type in this phase – the fibroblast. In addition, growth factors stimulate angiogenesis and capillary growth by endothelial cells. The capillaries and fibroblasts form a substrate clinically and histologically recognized as granulation tissue.

Fibroblasts produce collagen, which is the main structural molecule in the final scar. Initially, type III collagen is produced in relatively high amounts in the healing wound; the normal adult ratio of 4:1 between type I and type III collagen is gradually restored during the remodeling phase. Collagen formation is a dynamic, multi-step process with intracellular and extracellular components. Procollagen is synthesized and organized into a triple-helix structure. After procollagen is secreted into the extracellular space, peptidases cleave residues from the terminal ends, allowing the collagen molecule to associate with other secreted fibrils. Finally, hydroxylation and crosslinking of collagen are required for the strength and stability of this protein (7,8).

C. Remodeling Phase

Approximately 2–3 weeks after the initial injury, collagen accumulation reaches a steady state, in which there is no change in total collagen content. During this time, random collagen fibers are replaced with organized, cross-linked fibers. This remodeling process persists for up to one year. Scars continue to gain strength during this phase; however, the tensile strength of scars never reaches that of intact skin, approaching approximately 70% of normal strength (8).

Table 4. Phases of Wound Healing (8)

Phase	Cellular Response	Vascular Response	Time Period
Inflammatory	PMNs, macrophages, lymphocytes	Vasoconstriction followed by vasodilation	From injury up to 7 days
Proliferative	Fibroblasts, endothelium	Angiogenesis, collagen deposition	5 days to 3 weeks
Remodeling	Fibroblasts	Collagen cross-linking and increased fiber strength	3 weeks to 1 year

D. Epithelialization

The skin consists of two primary layers: the epidermis and the dermis. One of the key functions of the epidermis is to serve as a protective barrier against bacteria and other pathogens, while also maintaining cutaneous moisture. When the skin is injured, epithelialization begins to restore the wound surface shortly after the initial injury. In partial-thickness wounds, the epithelium originates from dermal appendages, hair follicles, and sweat glands. In contrast, in full-thickness wounds, the epithelium migrates from the wound edges at a rate of 1 to 2 millimeters per day. Delayed epithelialization leads to a prolonged inflammatory phase, compromising the body's ability to restore skin structure and function (8).

The goal of a surgeon in achieving successful wound healing is based on two fundamental principles: optimizing conditions for the body's natural wound healing mechanisms to occur and minimizing the multiple injuries that interfere with this process (8). Although current wound healing products are increasingly varied and sophisticated, their primary function remains to support the intrinsic wound healing process.

X.3. Dressings

Dressings encompass all techniques and methods used to protect a tissue or organ from pathogens in the external environment. A surgical dressing involves the medical act of maintaining the asepsis of a wound with the aim of achieving optimal healing. The purpose of dressings is to control local factors and create an environment that will optimize the wound bed for healing (11). An ideal dressing that can achieve these objectives should have the following properties (8):

- Maintains a moist wound healing environment
- High absorbency
- Provides a barrier against bacteria
- Debrides – both macroscopic and microscopic material
- Reduces edema
- Eliminates dead space
- Protects against further injury caused by trauma, pressure, and shear
- Keeps the wound warm
- Promotes the skin integrity of surrounding tissue and does not damage the wound

X.3.1. Types of Dressings

There are hundreds of commercially available wound dressings. A practical approach is to classify dressings based on the material they are made of (traditional and modern) (12) and according to their role (protective – for dry wounds, absorbent – for exudative wounds, compressive – for bleeding lesions, and occlusive – for wounds involving bone injuries) (12).

X.3.1.1. Traditional Dressings

Gauze, plasters, bandages/cloths (natural or synthetic), and cotton are common dry items used as primary or secondary dressings in wound treatment to prevent contamination (13).

A. Gauze

Gauze dressings (Figure 1), composed of woven and non-woven fibers of cotton, rayon, and polyester, provide a certain level of defense against bacterial infections. With their fibers, some sterile gauze pads can be used to absorb fluids and exudates from an open wound. Frequent replacement of these dressings is necessary to prevent maceration of healthy tissues. Gauze bandages are less economical. Excessive wound drainage causes the dressings to become wet and stick to the wound, making their removal uncomfortable. Wet gauze dressings are frequently used in maintaining remission of atopic eczema and dry skin conditions (12,13).

Figure 13. Sewn Gauze Dressings

B. Bandage/Cloth

Bandages are made from natural cotton, cellulose, or synthetic bandages made from polyamide materials and serve different purposes. For example, short-stretch compression bandages provide light to moderate compression, while high-compression bandages ensure prolonged compression in the case of venous ulcers, whereas cotton bandages are used to secure simple dressings (12,13).

Each dressing technique consists of different methods of applying the bandage. The following basic patterns can be used for most techniques:

a. Circular Bandage – the cloth is applied in an overlapping manner. Almost all bandaging techniques begin and end with a few turns of circular bandage.
b. Spiral Bandage – hold the gauze cloth in the right hand, with the free end in the left hand; apply the bandage from left to right (clockwise) and from bottom to top, without moving the gauze through the air. Begin with 2–3 turns of circular bandage, then continue obliquely from bottom to top, each new turn covering 2/3 of the previous turn (11).
c. Figure-of-8 Bandage – used for joint regions (elbow, ankle, knee). Start with a circular bandage below the joint, then continue with the first oblique layer upwards, followed by the second layer downwards, crossing to form the figure 8. Finish with 2–3 turns of circular bandage.

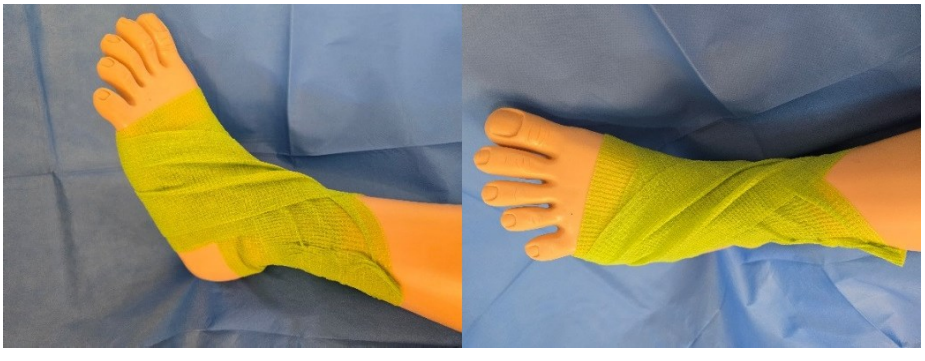

Figure 14. Figure-of-8 Bandage

d. Dessault Bandage – this technique is used for clavicle and shoulder injuries, as well as a method of immobilization for arm fractures. The Dessault bandage is designed to fix the upper limb flexed at a right angle (90 degrees) at the elbow joint. The patient's upper limb is supported so that the arm and forearm form a 90-degree angle. If the patient's condition allows, they are asked to support the forearm of the injured limb with the healthy hand. The thorax is wrapped with circular turns of the cloth. The fixing turn starts at the base of the thorax, and the bandage is continued in a spiral up to the axilla. This step isolates the skin of the thorax from the skin of the forearm and arm to prevent irritation caused by local perspiration. The arm and forearm are fixed to the thorax with the elbow flexed at 90 degrees.

The upper limb is secured to the thorax with circular turns of the cloth, which must include the arm, elbow, and forearm. From the back, the cloth passes over the injured shoulder, descends anteriorly over the arm, under the elbow, rises back parallel to the arm, then returns forward over the injured shoulder, passes obliquely under the healthy axilla, and returns anteriorly over the injured shoulder, descending laterally along the arm, under the elbow, then supporting the forearm, passes toward the opposite thorax, and performs a circular turn to fix the elbow. After this fixing turn, the cloth passes again over the injured shoulder, descends anteriorly, and supports the forearm. After immobilizing the upper limb with 2–3 circular turns, the entire assembly is reinforced with adhesive tape. The hand and fingers must remain free.

e. Capeline Bandage (Figure 3) – this is the classic head bandage, made with a cloth. A gauze strip of approximately 1 m is applied over the head so that its ends pass in front of the auricles and must be held suspended by the patient (if possible) or by an assistant. With another gauze, 2–3 circular fronto-occipital fixing turns are made. Maintaining tension, a turn is made around the gauze strip and directed toward the opposite region (temporo-temporal) until the entire head is evenly covered. The end of the cloth is secured to the gauze strip with adhesive tape or tied to one of the ends held downward, which is later tied under the chin.

f.

Figure 15. Capeline Bandage

g. Bandaging of the Hand and Fingers – for the hand, the most suitable technique is the spiral bandage. For finger injuries, the dressing is applied over the wound and covered with gauze/elastic bandage as follows: begin with 2–3 circular fixing turns at the radiocarpal joint, then continue with the gauze over the dorsal side of the hand toward the affected finger (to avoid blocking finger flexion), continuing on the finger with spiral turns. At the end, return back to the radiocarpal joint along the dorsal side of the hand. If multiple fingers are affected, each finger is dressed separately in the same manner to allow finger movement and maintain a functional hand (Figure 4).

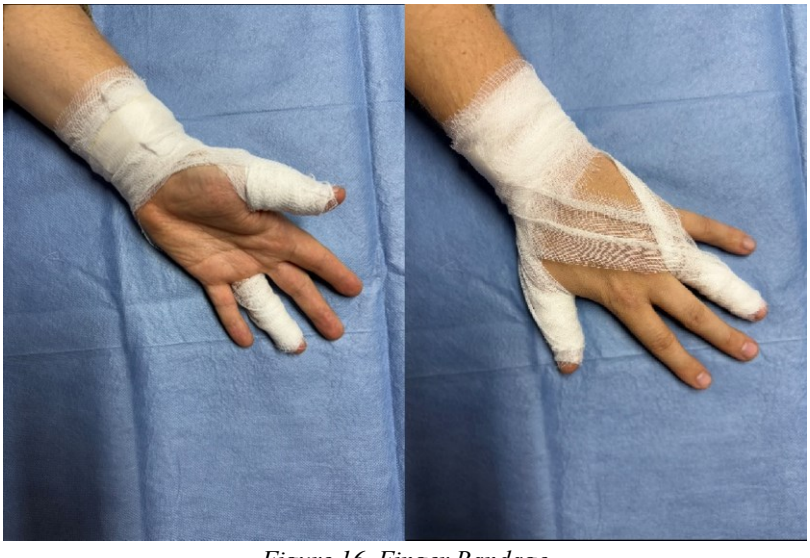

Figure 16. Finger Bandage

C. Tulle Dressings

Tulle dressings are ideal for clean, superficial wounds (Figure 5). Traditional dressings should usually be used as secondary dressings or for clean, dry wounds with low levels of exudate. Modern dressings with more sophisticated formulations have replaced conventional dressings, as the latter cannot provide a moist environment for the wound (13).

Figure 17. Paraffin gauze dressing

X.3.1.2. Modern Dressings

Modern dressings have been developed to support the wound's function rather than merely cover it. These dressings are designed to protect the wound from dehydration and to promote healing. Based on the cause and type of wound, numerous products are available on the market, making selection a challenging task. Modern dressings are usually based on synthetic polymers and are classified as passive, interactive, and bioactive products. Passive products are non-occlusive, such as gauze and tulle dressings, used to cover the wound and restore its function. Interactive dressings are semi-occlusive or occlusive, available as films, foam, hydrogel, and hydrocolloids. These dressings act as a barrier against bacterial penetration into the wound environment (14–17).

A. Semi-Permeable Film Dressings

These dressings are made of transparent, adhesive polyurethane that allows the transmission of water vapor, O_2 , and CO_2 from the wound and also enables autolytic debridement of eschars while being impermeable to bacteria (18). Initially, the films were made from nylon derivatives with a polyethylene adhesive backing that made them occlusive. At first, nylon-derived film dressings were not used for wounds with heavy exudate due to their limited absorption capacity, which caused maceration of the wound and surrounding healthy tissues (19). However, these dressings are highly elastic and flexible, conforming to any shape without additional taping. Inspection and closure of the wound are possible without removing the dressing thanks to the transparent films. Therefore, these dressings are recommended for epithelializing, superficial wounds and those with low exudate. Commercially available film dressings vary in vapor permeability, adhesive properties, conformability, and extensibility (20).

B. Semi-Permeable Foam Dressings

Foam dressings are made of hydrophobic and hydrophilic foam, sometimes with adhesive edges (21). The hydrophobic properties of the outer layer protect against liquids while allowing gas and water vapor exchange. Silicone-based rubber foam conforms and shapes to the wound. The foam can absorb varying amounts of exudate depending on the thickness of the dressing. Adhesive and non-adhesive foam dressings are available. Foam dressings are suitable for leg ulcers and wounds with moderate to heavy exudate and are also indicated for granulating wounds. Generally, they are used as primary dressings for absorption, and secondary dressings are not required due to their high absorption capacity and moisture vapor permeability (22,23). The disadvantage of foam dressings is that they require

frequent changes and are not suitable for wounds with low exudate (dry wounds and scars), as they rely on exudate for healing (24).

C. *Hydrogel-Based Dressings*

Hydrogels are insoluble hydrophilic materials made from synthetic polymers, such as poly(methacrylates) and polyvinylpyrrolidone. The high-water content of hydrogels (70–90%) helps granulation tissue and epithelium maintain a moist environment. Their soft and elastic structure allows hydrogels to be applied and removed easily after wound healing, without causing any damage. Hydrogels lower the temperature of skin wounds, providing a soothing and cooling effect. They are used for dry chronic wounds, necrotic wounds, pressure ulcers, and burn wounds. Morgan (22) reported that, except for infected wounds with heavy exudate, hydrogel dressings are suitable for all four stages of wound healing. Hydrogel dressings are non-irritating, do not react with biological tissue, and are permeable to metabolites. Many researchers have reported that hydrogel dressings are used for the treatment of chronic leg ulcers. Challenges of hydrogel dressings include exudate accumulation, which can lead to maceration, and bacterial proliferation, which can produce an unpleasant odor. Additionally, the low mechanical strength of hydrogels makes them difficult to handle (24). Some examples of hydrogels are Intrasite™, Nu-gel™, Aquaform™ polymers, impregnated gauze, and water-based gels.

D. Hydrocolloid Dressings

Hydrocolloid dressings (Figure 6) are among the most commonly used interactive dressings and consist of two layers: an inner colloidal layer and an outer water-impermeable layer. These dressings are made from a combination of gel-forming agents (carboxymethylcellulose, gelatin, and pectin) with other materials such as elastomers and adhesives (25). Hydrocolloids are permeable to water vapor but impermeable to bacteria, and they also have debridement properties and absorb wound exudate (26). They are used on wounds with light to moderate exudate, such as pressure ulcers, minor burns, minor wounds, and traumatic wounds. These dressings are also recommended for pediatric wound care, as they do not cause pain upon removal (27). When these dressings come into contact with wound exudate, they form gels and provide a moist environment that helps protect granulation tissue by absorption and retention of exudate. Granuflex™, Comfeel™, Tegasorb™ are available as sheets or thin films. The disadvantages of hydrocolloids are that they are not indicated for neuropathic ulcers or heavily exudative wounds and are mainly used as secondary dressings (25).

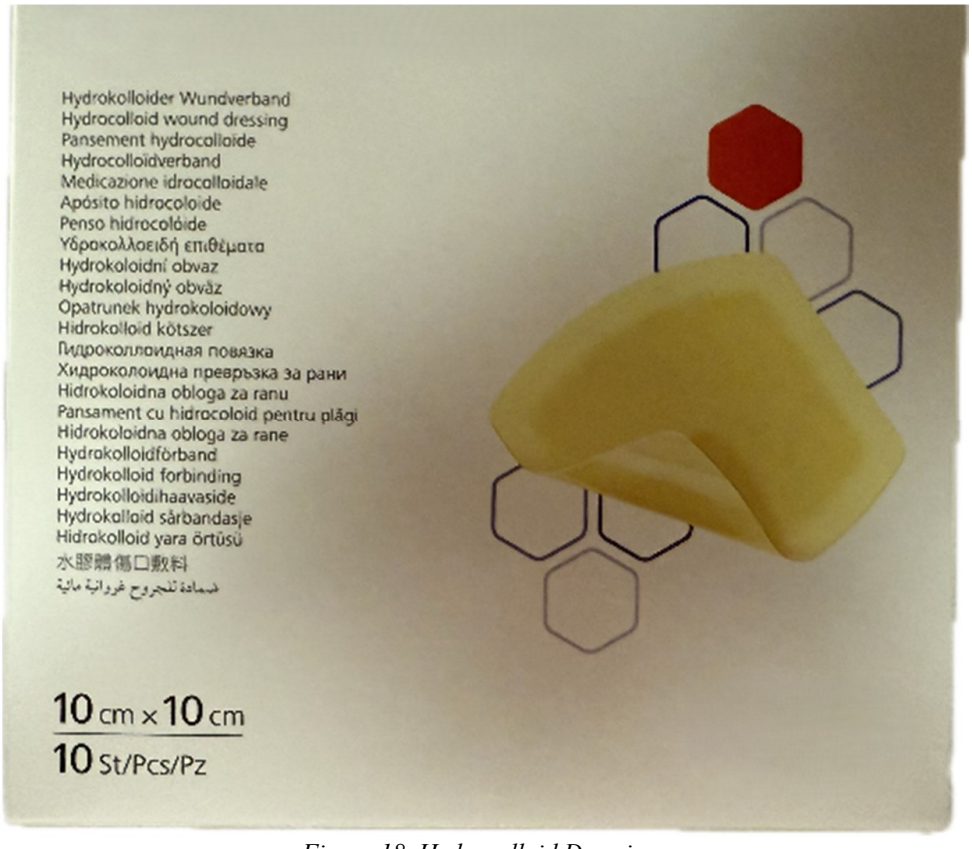

Figure 18. Hydrocolloid Dressings

E. Alginat Dressings

Alginat dressings (Figure 7) are made from sodium and calcium salts containing mannuronic acid and guluronic acid units. Absorbent and biodegradable alginates are derived from seaweed. The absorption capacity is achieved by forming a strong hydrophilic gel, which limits wound exudate and minimizes bacterial contamination.

Although some studies have reported that alginate inhibits keratinocyte migration, Thomas et al. (28) reported that alginates accelerate the healing process by activating macrophages to produce TNF-α, which initiates inflammatory signaling. Once alginate dressings are applied to the wound, the ions present in the alginate exchange with blood to form a protective film. Alginates are suitable for wounds with moderate to heavy drainage and are not recommended for dry wounds, third-degree burn wounds, or severe wounds with exposed bone. These dressings also require secondary dressings, as they may dehydrate the wound, delaying healing. Sorbsan™, Kaltostat™, Algisite™ are some commercially available alginate dressings.

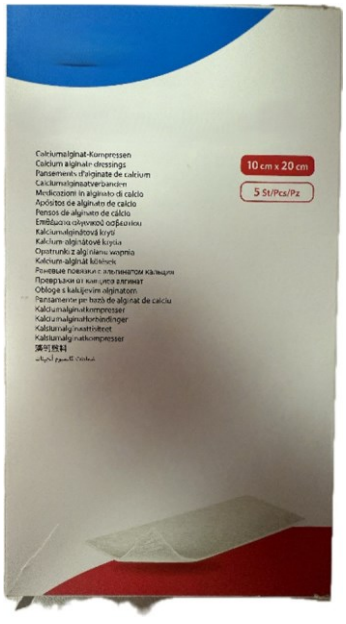

Figure 19. Calcium Algininate Dressings

F. Bioactive Dressings

The last type of modern wound dressings are bioactive dressings, which are made from biomaterials that play an important role in the healing process. These dressings are known for their biocompatibility, biodegradability, and non-toxic nature and are generally derived from natural tissues or artificial sources, such as collagen (23), hyaluronic acid (29), chitosan (30), alginate, and elastin. Polymers from these materials are used alone or in combination, depending on the nature and type of the wound. Biological dressings are sometimes incorporated with growth factors and antimicrobials to enhance the wound healing process. Collagen, a major structural protein, has been discussed by many researchers for its active role in the natural healing process (31–33). Collagen initiates fibroblast formation and accelerates endothelial migration upon contact with the wound tissue (34). Hyaluronic acid (HA) is a glycosaminoglycan component of the extracellular matrix (ECM) with unique biological and physicochemical characteristics. Similar to collagen, HA is also biocompatible, biodegradable, and naturally non-immunogenic (35). Chitosan promotes granulation tissue formation during the proliferative stage of wound healing (36). Compared to other dressings, biological dressings are reported to be superior to other types of dressings.

X.3.1.3. Tissue-engineered skin substitutes

Human skin or dermal equivalent (HSE) has two types of tissue-engineered substitutes available: one mimics the skin layer composed of keratinocytes and fibroblasts on a collagen matrix (cell-containing matrix). The second contains only dermal elements with fibroblasts on a collagen matrix (cellular matrix) (31). The main mechanism of the dermal equivalent is to secrete and stimulate wound growth factor through which epithelialization occurs. Bioengineered dressings are capable of adapting to their environment so that they can release growth factors and cytokines incorporated into the dressings. Bioengineered dressings are suitable for diabetic foot ulcers and venous leg ulcers. Apligraf is an FDA-approved skin equivalent substitute, composed of keratinocytes and collagen seeded with fibroblasts for venous ulcers. Among commercially available skin substitutes are Alloderm™, composed of normal human fibroblasts with all cellular materials removed, and the artificial skin Integra™, consisting of a collagen/chondroitin-6-sulfate matrix overlaid with a thin silicone sheet. A few other substitutes include Laserskin™, Biobrane™, Bioseed™, and Hyalograft3-DTM (37).

X.3.1.4. Medicated Dressings

Medicated dressings containing active substances are essential in the healing process, contributing directly or indirectly to the removal of necrotic tissues (38). This is achieved through the use of agents for cleansing or debridement of necrotic tissues, as well as antimicrobial agents that prevent infections and stimulate tissue regeneration. Frequently incorporated substances in these dressings include antimicrobial agents, growth factors, and enzymes. A wide range of commercially available antimicrobial dressings exists on the market. Additionally, dressings impregnated with silver (Figure 8) are used, such as fibrous hydrocolloids, polyurethane foam films, and silicone gels (39). The primary purpose of antimicrobial agents in these dressings is to prevent or treat infections, especially in cases of diabetic foot ulcers (40).

Figure 20. Silver-impregnated dressings

Another crucial aspect of promoting normal healing is the enzymatic debridement of necrotic tissue without affecting healthy tissue. Currently, papain- and collagenase-based ointments are used to debride necrotic tissue. Collagenase acts on native collagen, gradually breaking down the tissue while preserving viable collagen, whereas papain targets cysteine residues and is associated with an inflammatory response. Debridace™ is a commercially available dressing that enhances proteolytic activity (41).

X.3.1.5. 3D Customized Dressings for Wounds

The application of external dressings on wounds is crucial for protecting the affected areas and supporting the healing process. It is essential to cover as much of the wounded surface as possible to shield the wound from external factors. However, certain areas of the body, such as the ears, nose, and anterior cervical region, require adapted dressings specifically designed to provide an optimal healing environment.

3D scanning technology allows the creation of precise three-dimensional models of these areas, facilitating the production of customized dressings for each individual patient (42).

To achieve this goal, several 3D printing methods are available, including:

- Electrohydrodynamic jet (E-jet) printing,
- Fused Deposition Modelling (FDM),
- Pneumatic FDM,
- Piston-based FDM,
- Modified FDM, and
- Stereolithography (SLA) (43).

X.3.1.6. Wearable smart dressings

Recent advances in biosensors can be classified based on the sensing target, such as biophysical and biochemical inputs, or according to system functionality, such as passive and active sensors (44). This classification is based on the types of properties that sensors are designed to detect. For example, biophysical sensors monitor physical properties, such as temperature, pressure, or mechanical stress. These sensors typically use physical mechanisms to detect changes and require a thin, adhesive substrate to ensure optimal data quality (45).

In contrast, biochemical sensors are designed to measure chemical properties, such as pH and glucose levels or the presence of specific molecules. These devices often use biological components, such as enzymes or antibodies, to detect certain chemicals, and require an absorbent interface between the sensor and the skin surface (46).

Both physical and chemical sensors are considered passive, collecting information from the epidermis and transmitting it either to a personal device, the cloud, or directly to a healthcare provider. The distinction between passive and active sensors is based on the complexity of the sensor function, which includes both data collection and delivery, imposing additional requirements on the type of dressings used.

For both sensor types, there are basic substrate requirements in addition to sensor-specific needs, all of which can be met by specialized dressings. The distinct advantages of these products, which are approved and commercially available, such as permeability and biocompatibility, allow for extended periods of sensor wear on the epidermis. Additionally, improved skin adhesion reduces noise caused by motion artifacts (45).

Current smart dressing technologies have shown promise in detecting various physiological conditions, including pH, temperature, oxygenation,

impedance, motion, and enzymatic activity (47). Electrical stimulation has also been shown to be effective in reducing bacterial colonization and biofilm infections while promoting normal wound healing. Moreover, it can improve tissue perfusion, stimulate immune cell function, and accelerate keratinocyte migration through galvanotaxis. However, current electrical stimulation devices are often bulky, wired, and uncomfortable, limiting patient comfort. Recent efforts to develop nanogenerator devices that harness mechanical movements to generate electric fields for wound healing have had limited success. Furthermore, integrating sensing and electrical stimulation technologies into a single device for active wound care has encountered challenges. Mechanical movements are unpredictable, and metal electrodes often lack sufficient tissue adhesion to function effectively in the complex wound environment. Therefore, there is an urgent need for portable, autonomous, and cost-effective devices to improve wound care (47).

For optimal therapeutic outcomes, an ideal smart dressing must meet several criteria. It should be flexible and wireless, eliminating the discomfort of conventional rigid devices, and must integrate both sensing and stimulation capabilities for closed-loop autonomous wound management. In addition, it should provide strong but reversible adhesion to the skin for efficient signal and energy transfer, while allowing easy removal to prevent secondary skin damage. In response to these needs, a flexible, battery-free bioelectronic system has been developed, incorporating wireless-powered sensing and stimulation circuits with hydrogel electrodes designed for intimate tissue contact, using a biocompatible conductive polymer. This smart dressing is anticipated to improve therapeutic outcomes and advance understanding of wound care (47).

The design of this smart dressing includes a miniaturized flexible printed circuit board (FPCB) containing an energy-harvesting antenna, a microcontroller, a crystal oscillator, and filtering circuits for continuous two-channel monitoring of wound impedance and temperature. Additionally, a parallel stimulation circuit delivers programmed electrical pulses to accelerate wound healing. To ensure efficient energy delivery and signal transfer between the circuits and the skin's soft tissue, a low-impedance adhesive hydrogel electrode was developed using poly (3,4-ethylenedioxythiophene):polystyrene sulfonate (PEDOT:PSS). This hydrogel, which is both electrically and ionically conductive, provides lower impedance across the frequency spectrum than traditional ionic conductive hydrogels, allowing more efficient charge injection during stimulation. To reduce the risk of secondary skin damage upon electrode removal, a thermally controlled reversible phase transition mechanism was introduced, reducing

adhesion by two orders of magnitude at elevated temperatures compared to normal skin temperature (47).

Preclinical studies using multiple animal models have demonstrated that this type of smart dressing can continuously monitor physiological skin signals and provide targeted electrical stimulation, leading to accelerated wound closure, increased neovascularization, and improved dermal recovery. The wireless nature of the device also allowed for the use of complex animal models, such as parabiosis, to explore potential mechanisms behind the beneficial effects of electrical stimulation. Recorded data suggest that the positive outcomes in wound healing may be due to the activation of pro-regenerative genes in monocyte and macrophage populations (47).

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Chapter XI
Post-Traumatic Immobilizations

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XI.1. History

The first documented evidence of a traumatic injury treated medically dates back approximately 3,605 years (1). Primary sources providing information about early Egyptian medicine include the Smith, Ebers, Hearst, and Brugsch papyri, which serve as reference medical documents for this period (1,2). The Smith Papyrus, dated around 1600 BCE (Before Common Era), was intended to train military surgeons in managing various traumatic accidents (1,3). It details 48 cases of injuries, including aspects of examination, diagnosis, classification of injuries, and therapeutic options (1,4).

Additionally, paintings discovered in ancient tombs, dating around 2500 BCE, suggest surgical and medical practices predating the papyri (2). Archaeological evidence and historical texts indicate that surgical interventions were rare and limited in Ancient Egypt, with emphasis placed on fracture treatment and performing incisions in specific parts of the body. Analysis of the skeletons of workers involved in pyramid construction shows the use of fracture immobilization techniques comparable to current standards. Furthermore, treatments for cranial trauma, burns, and the primitive use of prosthetics are also documented (3).

Imhotep, considered the first known physician of antiquity and later revered as a god, symbolizes the remarkable progress of Egyptian medicine. He represents an emblematic figure both for his innovative contributions in the medical field and for his lasting impact on the development of medical science in Egyptian civilization (2). The relationship between Egyptian and Greek medicine is highlighted by Homer, who mentions the Egyptians' expertise in preparing medicines, suggesting that they possessed advanced knowledge in anatomy and therapy, superior to that of the Greeks at that time (2).

XI.2. Definition

Post-traumatic immobilizations are medical procedures used to fix a part of the human body that has suffered a specific trauma. Their role is to limit movement in the affected area, thereby facilitating healing and simultaneously reducing the risk of complications (5).

XI.3. Types of immobilizations

Stabilization of a body area is performed by using splints, casts, compression bandages, or other immobilization devices to maintain bones and tissues in the proper position during the recovery process (5). The most common methods are:

- The splint is used to protect bones and joints affected by trauma. It can be made of various materials, for example plastic, metal, or wood, and is predominantly used for fractures and sprains.
- The compression bandage is used to reduce edema and provide support to the affected area. Compression bandages can be elastic or non-elastic and are often used for soft tissue injuries, such as sprains.
- Functional immobilizations provide protection to the affected area while allowing the maintenance of a certain degree of mobility for the traumatized patient. These devices are frequently used in cases of sports injuries, contributing to accelerating the recovery process and facilitating rapid reintegration into physical activity. Thus, functional immobilizations ensure an optimal balance between injury stabilization and preserving the functionality of the affected segment, promoting efficient rehabilitation and minimizing the risk of secondary complications caused by prolonged immobilization (6,7).

XI.4. Principles of good immobilization

For correct immobilization, certain principles must be respected, thus ensuring optimal recovery and preventing potential complications that may affect the victim (8):

- Immobilization may be performed only after the stabilization of the patient's vital functions.
- Immobilization methods must ensure correct alignment and relative stabilization of the affected segment, thus facilitate adequate anatomical positioning and contribute to an efficient healing process.
- A good immobilization will include both the joints located proximal and distal to the fracture site.
- Immobilization must be adapted to the affected segment.
- The immobilization method will be simple and non-compressive.
- Immobilization must be performed in the physiological position of the affected limb.
- Immobilization must not cause pain.
- Immobilization involves visualizing the segment distal to the fracture.

XI.5. Types of trauma

Immobilizations are essential and have special importance in cases of certain injuries and traumatic conditions.

A sprain represents a lesion of the ligaments that have the role of stabilizing a joint.

This traumatic condition occurs following the forcing or excessive twisting of these ligamentous structures, being caused by direct trauma or extreme movements that exceed the physiological resistance capacity of the ligaments. It is a soft tissue, tendon, and ligament lesion that suffers a stretching or even a rupture. A sprain can affect any joint, but is more frequent at the ankle joint (9). Lesions occurring at the level of a ligament can vary from simple stretches to partial or even complete ruptures. The specialist doctor in this case will perform a staging of the trauma. Sprains can have three grades of severity:

Grade I: involves a mild stretching or incomplete rupture of the ligaments, with minimal pain, mild tenderness, stiffness, and local edema. Grade II: involves a partial lesion of the ligaments, with moderate edema and ecchymosis. The affected area is tender to palpation, and the patient presents moderate pain while walking.

Grade III: is represented by a complete rupture of the ligaments, with severe edema and ecchymosis. In most cases walking is impossible, but the initial pain may decrease in intensity.

When this type of ligamentous trauma affects the victim, first aid involves both provisional immobilization which will determine the reduction of severe pain, as well as the application of cold compresses on the joint and a compression bandage.

Depending on the grade of the sprain, the treatment will consist of: either rest for the patient, immobilization of the affected limb for a period of 14 days, or sometimes surgical treatment will be recommended. An elastic bandage will be used for Grade I sprains and a cast for a duration between 14-21 days for Grade II and III sprains. To help the patient, in the first 24-72 hours or until the edema disappears, ice packs can be applied in intervals of 20-30 minutes 3-4 times a day, but never in direct contact with the skin (10,11).

Dislocation is a trauma represented by the stretching or tearing of ligaments associated with the displacement of bone heads outside the joint cavity. The contact between the articular surfaces of the bones forming a joint is no longer present in this case, thus partially or totally disrupting articular congruence. Depending on the way in which they are produced, dislocations

can be complete or incomplete. Dislocation can affect any joint, but the most frequent types of dislocations are those of the shoulder or ankle (12).

Clinical signs for this condition include: severe pain (which can visibly decrease at rest, can intensify at the slightest movement), edema, joint swelling, and sensation of bone displacement. A deformation of the region is visible. In this circumstance, first aid consists of provisional immobilization of the affected limb, but without attempting to reduce the dislocation, followed by transporting the victim to the hospital (12,13).

Fracture represents an interruption of bone continuity. This condition takes place following a traumatic action that reflects directly or indirectly upon the bone segment. Fractures can be closed, when the bone segment does not penetrate the skin, these being also the most numerous, as well as open in cases where the overlying soft tissue has been destroyed, the fracture site coming into contact with the surrounding environment (12,14,15).

The clinical diagnosis of a fracture is based on anamnesis, examination, and investigations. In this case, pain is a very important symptom and an indicator of this condition, therefore it must not be ignored. The diagnosis of a fracture is established based on the following signs (16):

Signs of probability are common to all osteoarticular lesions (for example in fractures, dislocations, and sprains). In this case, an X-ray examination is necessary. The signs of probability are:

- Spontaneous pain: located in a fixed point, it intensifies upon palpation or when attempting to move the affected area.
- Ecchymoses: violaceous coloration of the skin overlying the fractured area, due to the lesion of blood vessels and neighboring tissues, which leads to swelling of the area and increased local temperature.
- Deformation: appearance of a prominence under the skin due to the displacement of bone heads.
- Functional impotence: the patient's inability to move the limb affected by trauma.
- Shortening of the limb: the fractured limb may appear shorter due to the upward displacement of the lower end of the bone, as a result of reflex muscle contracture. The affected limb is positioned in external rotation and adduction.

Signs of certainty: the presence of any of these signs confirms the diagnosis of fracture, with the radiographic image showing only the fracture line. The signs of certainty are (17):

- Abnormal mobility: upon palpation, movement of the bone at the fracture site can be observed.
- Interruption of bone continuity: by palpating the edge of the bone, a discontinuity can be detected and, sometimes, a small depression at the skin level.
- Non-transmission of movement: when attempting to mobilize the limb from the proximal level, the distal portion remains dropped.
- Bone crepitations: certain specific sounds produced upon palpation of the fracture are notable, caused by the rubbing of the fractured bone heads against each other, similar to the sound produced by the noise of footsteps on snow.

X.6. Complications of trauma

Following a trauma of the locomotor system, the clinical examination must identify potential complications as well:

- vascular complications: the peripheral pulse will be checked depending on the case at the humeral, radial, femoral, popliteal, pedal, posterior tibial artery, and the skin color and temperature will be evaluated.
- nervous complications.

Complications of fractures can be divided into:

a. *Immediate complications:*

- General: these include cardiorespiratory arrest, internal or external hemorrhage in cases of open fractures, traumatic shock, and fat embolism.
- Local: these involve opening of the fracture site, lesions of blood vessels and nerves, as well as interposition of soft tissues.

b. *Late complications:*

- General: refer to thromboembolism and complications caused by prolonged immobilization.
- Local: include the formation of a vicious callus, delayed union or pseudoarthrosis, osteitis and chronic osteomyelitis, joint stiffness, muscular hypotrophy, hydrarthrosis, hemarthrosis and septic arthritis, compartment syndrome, algoneurodystrophy, and post-immobilization osteoporosis.

Provisional immobilization of the affected area helps maintain the axial reduction of the fractured fragments. At the accident scene, an anatomical reduction is not attempted. If a person presents a fracture, they must remain

calm and seek help as soon as possible. Any movement of the fractured bone can aggravate the situation. Severe fractures require rapid intervention and emergency medical treatment (8,18). The basic rules that must be respected when providing first aid in case of a fracture are the following (19):

- a fractured bone must never be moved, especially if it is unstable or involves critical areas such as the cervical region, head, spine, hip. If it is necessary to move the injured person, this must be done with care, lifting them by the upper part of the clothes (the top of the shirt, belt, and trousers).
- applying cold compresses to the fracture site can help reduce inflammation.
- preventing the onset of shock in the victim by covering them with a blanket and raising the lower limbs a few centimeters above the head level, except in cases where there are suspicions of injuries to the head, cervical region, spine, or pelvic girdle.
- in the case of open fractures, it is important to perform disinfection of the wound, to apply a sterile dressing, and to keep the bleeding under control by applying light pressure to the affected area.

XI.7. Immobilization at the accident scene

Splints used for immobilizing a fracture, whether specially designed or improvised from various objects such as canes, umbrellas, pieces of wood, broom handles, or other materials, must meet three essential criteria to be effective (17-19):

- Ease of use: Splints must be lightweight so they can be applied without causing additional discomfort to the patient. This means that the materials used must be easy to carry and apply, even by a person with limited first-aid knowledge. Quick and effective immobilization is crucial to reduce the risk of complications and for the patient's comfort.
- Rigidity: Splints must be rigid enough to provide effective immobilization of the affected area. Rigidity is essential to prevent unwanted movements that could worsen the fracture or cause additional damage to surrounding tissues. Materials used for improvisation, such as wood or metal, must be strong enough not to deform during patient handling.
- Adequate length: Splints must be long enough to stabilize both the lower and upper joints of the fractured area. This means that the splints must cover both the fractured bone and the adjacent joints, to

prevent movement at the fracture site and provide complete stabilization.

XI.7.1. Principles of Temporary Fracture Immobilization

Temporary immobilization of a fracture must follow a few basic principles to be effective and safe (18-19):

- Immobilization of joints adjacent to the fracture site: It is important to immobilize not only the fracture itself but also the joints located proximal and distal to it. This prevents chain movements of the limb, which could worsen the injury and cause additional pain to the patient.
- Protection of bony prominences: It is recommended to use soft materials, such as cotton, clothing, or sheets, to cover and protect bony prominences and prevent additional injuries or pressure sores. Protective materials should be applied evenly, avoiding any irregularities (knots, folds, buttons, etc.) to prevent pressure points that could damage the patient's skin.
- Constant supervision: During immobilization, vital functions must be monitored, and the fingers and toes should remain exposed to allow observation of any changes in circulation, sensation, or movement. Continuous monitoring can prevent complications such as compartment syndrome or ischemia.

XI.7.2. Special Immobilization Devices

- Inflatable splints: These are effective tools frequently used in prehospital settings. They come in various sets and can be used for different parts of the body that may sustain injuries. The advantages of these splints include rapid application and the ability to provide firm limb stabilization. However, the disadvantages include sustained circumferential compression, which can lead to ischemia or compartment syndrome, difficulty controlling inflation pressure, and limited access to the distal parts of the affected limb. (19)
- Vacuum splints (figure 1): These are similar to vacuum mattresses and are ideal for stabilizing distal limbs. They are frequently used in cases where firm and adaptable limb fixation is required, providing a higher degree of stability and patient comfort.

Figure 14. Immobilization of the lower limb with a vacuum splint

- Traction splints: Traction splints are unique in that they are used for the reduction and stabilization of fractures outside the hospital, unlike other splints that only immobilize fractures. Their use requires specspecialized medical training, and once applied, continued stabilization and fixation are achieved using other extension methods. There are contraindications for using these splints, such as fractures of the ankle, tibia, knee, or pelvis (18-19).

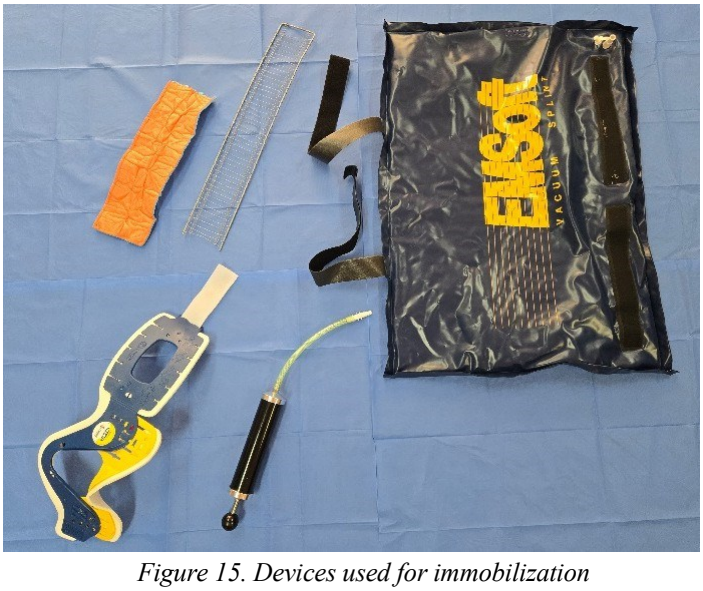

Figure 15. Devices used for immobilization

XI.8. Principles of Immobilization by Anatomical Regions

XI.8.1. Thoracic Immobilization

Thoracic trauma represents a challenge in emergency medicine and in the care of trauma patients, encompassing a wide range of injuries, from minor rib fractures to severe thoracic organ conditions that can be life-threatening. Accidents, falls, assaults, and road traffic collisions are common causes of thoracic trauma. Life-threatening injuries require immediate intervention. The most frequent injuries caused by thoracic trauma are pneumothorax and hemothorax, which can be definitively managed in 80% of cases through tube thoracostomy. Specific life-threatening thoracic injuries must be suspected, as they require diagnosis and treatment during the initial examination (20,21).

A. Tension Pneumothorax

Tension pneumothorax is a medical emergency characterized by the progressive accumulation of air in the pleural space, which cannot escape due to a one-way valve at the site of the pleural or pulmonary injury. This air buildup increases intrathoracic pressure, causing collapse of the lung on the affected side, mediastinal shift toward the opposite side, and compression of mediastinal structures (including the vena cava). This process impairs blood flow to the heart and reduces cardiac output, leading to cardiovascular collapse if not treated urgently (22,23).

The diagnosis of tension pneumothorax should be suspected based on clinical examination: patients present with dyspnea, hypoperfusion, distension of the cervical veins, decreased or absent breath sounds on the affected side, hyperresonance to percussion over the lesion, and tracheal deviation to the opposite side. If tension pneumothorax is suspected, the next step involves inserting a large-bore needle (usually a 14G IV catheter) into the pleural space, typically in the second intercostal space at the midclavicular line or the fifth intercostal space at the anterior axillary line. Once decompression of the tension pneumothorax is achieved (sometimes indicated by the sound of air escaping from the pleural space), the patient's circulation will improve. The initial assessment should be completed with the placement of a tube thoracostomy on the side of the pneumothorax as soon as possible, before performing a chest X-ray (24).

B. Pericardial Tamponade (Cardiac Tamponade)

Cardiac tamponade is a critical condition in which the accumulation of fluid (usually blood) in the pericardial sac increases intrapericardial

pressure, decreasing diastolic filling of the heart and reducing cardiac output.

This phenomenon leads to a series of clinical signs known as Beck's triad: arterial hypotension, distended jugular veins, and muffled heart sounds. The increased pressure exerted by the pericardial fluid can rapidly cause circulatory collapse and even death without prompt intervention (25,26).

Cardiac tamponade requires urgent treatment, starting with pericardiocentesis to remove the accumulated fluid from the pericardial sac. In cases of active bleeding, surgical intervention is necessary. Intravenous fluid administration can temporarily increase cardiac output, and performing an ultrasound quickly confirms the presence of pericardial fluid and helps establish the diagnosis. Chest X-rays cannot rule out tamponade, as even a small amount of blood (150–200 ml) can cause the condition. If immediate surgery is not possible, a cannula can be placed for serial aspiration, temporarily improving cardiac function (25,26).

C. Massive Hemothorax

Massive hemothorax is a medical emergency caused by the rapid accumulation of a large amount of blood (over 1,500 ml or more than one-third of the circulating blood volume) in the pleural space, usually as a result of major thoracic trauma. This blood accumulation causes collapse of the lung on the affected side, hypoxia, and compression of mediastinal structures, which can lead to hypovolemic shock. Initial treatment of massive hemothorax involves emergency thoracostomy followed by immediate surgical intervention to control the bleeding, which may be caused by injuries to the pulmonary parenchyma or the intercostal and internal mammary arteries. If, after initial drainage of blood (more than 600 ml in 6 hours), bleeding continues, the diagnosis of "massive hemothorax" is made, usually requiring thoracotomy (27,28).

Autotransfusion of the drained blood can be considered, provided that the blood is not contaminated. The decision depends on the patient's condition and the risk of infection that may result from possible intestinal injuries.

D. Flail Chest

Flail chest is a severe thoracic injury in which two or more adjacent ribs are fractured in at least two places, creating a free segment of the chest wall. This free segment moves paradoxically relative to the rest of the thorax during respiration—it moves inward during inspiration and outward during

expiration—causing respiratory difficulties and hypoxia. Flail chest is often associated with underlying pulmonary contusion, which worsens respiratory insufficiency and increases the risk of severe complications (29,30).

Immediately after trauma, a small flail segment may appear. Over time, as fluid shifts toward the area of pulmonary contusion, lung compliance decreases, requiring greater pressure to expand the lungs. The increasing pressure gradient between intrathoracic and atmospheric pressure can exceed the strength of the muscles near the rib fractures, causing more pronounced paradoxical movement of the chest wall. The patient's overall condition can deteriorate rapidly due to decreased ventilation efficiency and increased respiratory muscle effort. This creates a vicious cycle of reduced ventilation efficiency, muscle fatigue, and hypoxemia. In some cases, the increased respiratory workload can lead to sudden respiratory arrest. In the past, straps and adhesive bands were applied to fix and stabilize the chest. These methods inhibited thoracic expansion, worsening pulmonary atelectasis. The therapeutic approach in this situation focuses on providing adequate analgesia to allow full lung expansion, with the ultimate goal of improving ventilation and clearing bronchial secretions (31).

Patients with small to moderate flail segments, associated pulmonary contusion, and no other significant injuries—or only minor injuries—can be managed without ventilatory support through a conservative approach, which includes the following interventions:

- Pain control – achieved through the administration of systemic analgesics or intercostal nerve blocks, with the goal of enabling effective breathing and minimizing pulmonary complications.
- Cough stimulation and respiratory physiotherapy – essential measures for maintaining adequate respiratory function and preventing accumulation of secretions in the lungs.
- Restriction of intravenous fluid administration – aimed at preventing fluid overload, which could worsen pulmonary edema and compromise respiratory function

However, in situations where, despite these therapeutic measures, the arterial partial pressure of oxygen (PaO_2) remains below 80 mm Hg even with supplemental oxygen, ventilatory support becomes necessary to maintain adequate oxygenation and prevent severe hypoxemia.

A controversial topic in the management of flail chest is the indication for surgical stabilization of fractured ribs or the sternum. The primary goal of surgical intervention is to reduce the need for mechanical ventilation and promote faster recovery of pulmonary function. While some surgeons in

Europe and Asia have reported a significant reduction in mortality and morbidity through the use of surgical fixation of flail segments, this practice is still rare in the United States, where non-surgical approaches are frequently preferred due to their effectiveness and the risks associated with surgical intervention (32).

E. Rib Fractures

Rib fractures occur when one or more ribs are broken or cracked, usually as a result of direct trauma to the chest. Patients presenting with pain and localized tenderness over the ribs after thoracic trauma should be evaluated for a possible rib fracture. Approximately 50% of rib fractures, particularly those of the first five ribs, may not be detectable on conventional radiography, especially in the first few days after the injury (33).

The primary goal of diagnostic evaluation of rib fractures is to identify associated complications, such as hemopneumothorax, pulmonary contusion, or major vascular injuries. If a pneumothorax is suspected but not confirmed on the initial X-ray, a follow-up X-ray taken during expiration may more clearly reveal its presence. In cases of severe trauma or when sharp bone fragments are present from a fracture, serial chest X-rays are recommended for monitoring.

Pain associated with rib fractures can significantly impair the patient's ventilation. The use of adhesive bands or chest binders to immobilize the ribs is not recommended, as this may increase the risk of developing atelectasis and pneumonia. In some circumstances, when the patient is hospitalized, intercostal nerve blocks with agents such as bupivacaine can relieve pain and improve ventilation for 6–12 hours. The use of intrapleural catheters to administer local anesthetics can also provide effective pain relief. Epidural analgesia is often the most effective method of pain control but requires intensive care unit admission for monitoring (33).

Fractures of ribs 1 and 2 require significant force to occur, except in cases of direct trauma, such as a blow from a hammer. These fractures are frequently associated with severe injuries, including myocardial injuries (previously termed myocardial contusions), bronchial ruptures, or major vascular injuries. There are conflicting opinions in the literature regarding the association of these fractures with increased mortality; however, it is estimated that 15–30% of patients with fractures of ribs 1 and 2 have an unfavorable prognosis (34).

If a patient with fractures of ribs 9, 10, and 11 presents with hypotension without massive hemothorax or tension pneumothorax, intra-abdominal hemorrhage from the liver or spleen should be suspected. In cases of major

trauma, abdominal CT scanning is recommended when multiple rib fractures are present to rule out associated injuries.

Patients with rib fractures should be hospitalized for at least 24–48 hours if they are unable to cough and clear respiratory secretions adequately, particularly if they are elderly or have pre-existing pulmonary conditions. Hospitalization allows careful monitoring and early identification of potential complications that may not be immediately apparent.

XI.8.2. Upper Limb Immobilization

- Immobilization Position: The upper limb should be immobilized in an intermediate position. The arm must be aligned alongside the trunk, and the forearm flexed at a 90-degree angle at the elbow, positioned on the ventral side of the trunk. This position helps reduce pain and prevent complications caused by unwanted movements.
- Splints and Fixation: A Krammer splint (figure 2) is used, properly adjusted to fit the size and immobilization position of the arm, supported at the distal third of the forearm, forming a right angle. The splints are secured using a sling that passes around the cervical region, ensuring adequate stabilization without compromising circulation. The hand must remain free and unimmobilized to allow assessment of circulation and neurological function, except in fractures at this level.
- For Diaphyseal Fractures: Inability to transmit movements, presence of abnormal mobility in the affected segment, pain and bony crepitus, and loss of function of the segment.
- In Cases of Major Vascular Axis Injury: Peripheral pulse is absent, extremity is cold and pale, hypoesthesia or anesthesia, functional impairment, and sometimes shock. If the radial nerve is also affected, finger extension cannot be performed, and anesthesia may appear on the dorsal side of the hand.
- Subjective Signs: Pain and loss of function, accompanied by abnormal movements of the arm. Radial nerve injury prevents active extension of the fingers.
- For Radial Head Fractures: Pronation-supination becomes painful, especially on palpation of the radial head. In olecranon fractures, active extension of the elbow cannot be performed.
- Distal Epiphyseal Fractures: Manifest as radiocarpal swelling, pain, functional impairment, and specific deformity depending on the type of displacement.

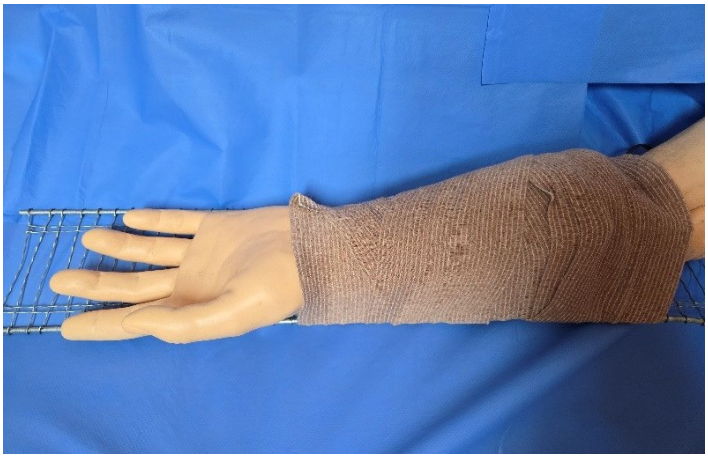

Figure 16. Immobilization of the upper limb on the Krammer splint

XI.8.3. Lower Limb Immobilization

- Immobilization Position: For temporary stabilization of an injured lower limb, the unaffected lower limb may be used as support, functioning as a natural splint. This method is especially effective in emergency situations where resources are limited.
- Krammer Splints and Other Devices: Immobilization is performed with the thigh in extension on the pelvis, the leg in extension on the thigh, and the foot in dorsal flexion at 90° from the tibiotalar joint. Krammer splints or vacuum splints adjusted to the required length and position of the lower limb may be used, which can be shaped in the form of a trough. Other options include plastic troughs or plaster splints made on site and secured with a gauze bandage wrapped in a spiral. The splints must be well padded to prevent any complications.

XI.8.4. Spinal Immobilization

In the case of a fracture or suspicion of a fracture of the spinal column, the victim must be placed on a hard, horizontal surface, in the supine position, until definitive immobilization is applied. This helps prevent unwanted movements that could aggravate a spinal injury and cause permanent neurological damage.

The vertebral fractures that occur most frequently are those at the level of the cervical spine, which can be extremely dangerous for victims, having the potential to cause instant death. In many cases, the signs of a fracture are not immediately visible after an accident, but it is crucial to suspect a cervical fracture, especially following road traffic accidents.

XI.8.5. Immobilization of the cephalic extremity and the cervical region

The cervical region is often exposed to simple fractures and those associated with dislocation of the vertebral bodies. Such an injury can be critical, because displacement of a vertebra may compress the spinal cord, which could lead to death. Therefore, if the victim shows symptoms such as intense pain in the posterior cervical region caused by the slightest head movement, numbness in the hands or feet, or even paralysis, rapid and adequate immobilization of the region is essential (35).

Immobilization can be achieved using a special cervical collar to support the cervical spine or by fixing the head and neck with two thick rolled blankets or by creating an improvised collar from a generous amount of cotton wrapped in gauze.

Proper cervical immobilization at the site of an accident is crucial to prevent worsening of stable or unstable injuries at the level of the cervical spine. The immobilization process can be performed in four essential steps:

- Alignment of the head in a neutral position: Provided that this maneuver is not contraindicated by emergency protocols.
- Measuring the patient: To determine the distance between the shoulder and the chin; this aspect will guide the selection of the collar size.
- Selection of the collar size:
    - A size will be selected from the four available.
    - Identification of the appropriate size on the collar.
    - Adjustment and locking of the collar:
        - Adjustment of the chin support to the selected size.
        - Locking the sides of the collar by pressing the two fastening clips.
- Preforming and applying the collar
    - Shaping the collar into a circular form to fit around the neck.
    - Applying the collar while the head is maintained in a neutral position by: properly placing the chin support under the victim's chin; pulling the end of the collar while the front part is firmly secured under the chin, then closing the collar.
    - For patients placed in the supine position, the back part of the collar is fixed first, then the chin support is adjusted.
    - If a different size is needed, the collar is removed to avoid stretching or injury, resized, and can be reapplied.

It is important that these steps are carefully followed to ensure effective and safe immobilization of the cervical spine (35).

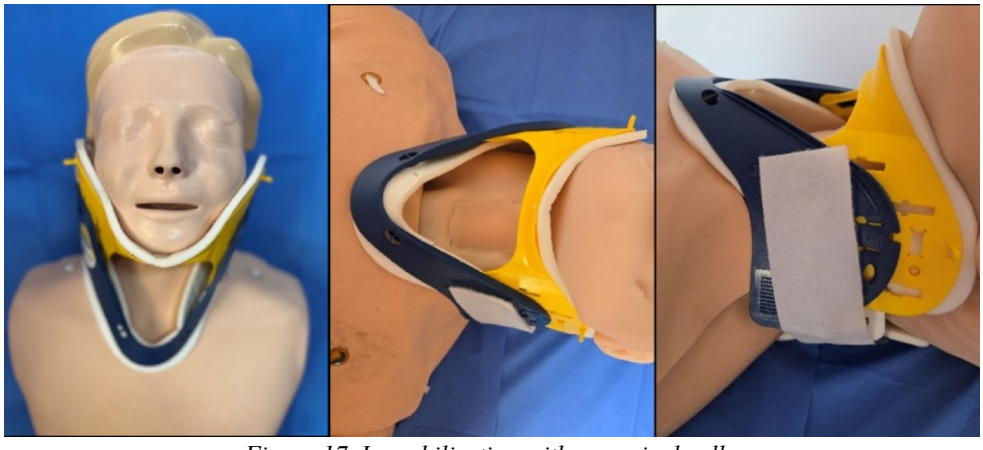

Figure 17. Immobilization with a cervical collar

XI.8.6. Pelvic Belt

The pelvic belt is an important tool in the management of patients with pelvic trauma, serving to provide temporary stabilization and to prevent movements that could worsen existing injuries. It is important to correctly understand the indications and contraindications for using this device, in order to minimize associated risks and ensure proper patient management (36).

Steps for Applying the Pelvic Belt:

- Positioning the patient in a neutral position: The patient should be placed in the supine position, in a neutral posture, to allow proper application of the pelvic belt. Position the patient on a firm surface, ensuring the body is symmetrical.
- Placing the pelvic belt: The belt is positioned under the lumbar region and pelvis, aligned evenly on both sides with the help of two rescuers. The material must be properly adjusted and cover the entire pelvis to allow adequate fixation.
- Tightening the belt: The belt should be secured firmly but not excessively, so as to stabilize the pelvis without restricting blood circulation. Tighten until compression is effective, avoiding severe pain or major discomfort for the patient.
- Monitoring the patient's condition: It is essential to monitor the patient's condition, including vital signs and any changes in blood circulation in the extremities. Observe for any changes in pain, sensation, or mobility. The patient should be maintained in this position until transfer to a proper medical facility for definitive evaluation and treatment (37).

Tips and tricks

A. First Aid for Musculoskeletal Injuries:

- **Immobilization of injuries is essential for any type of musculoskeletal trauma (fractures, sprains, dislocations). Splints are used to limit movement and prevent worsening of the injuries.**
- **Supporting the joints and limiting movement is crucial in cases of dislocations. It is recommended to keep the affected limb in the position in which it was found and to apply a bandage or support device to prevent displacement.**
- **Applying ice can reduce swelling and inflammation. It should be applied for short periods (20–30 minutes) every 3–4 hours, without direct contact with the skin to avoid frostbite**

B. Management of Sprains

- **Immobilization and compression: In the case of a sprain, it is important to apply an elastic compression bandage, which will reduce swelling and support the affected area.**
- **Rest: The affected area should be immobilized and kept at rest for several days to prevent ligament damage and accelerate the healing process.**
- **Elevation of the affected limb: It is recommended to raise the affected limb above heart level to reduce swelling.**

C. Interventions for Dislocations

- **Immediate immobilization: Dislocations require immobilization without attempting reduction at the accident site. The victim must be transported to a medical facility for intervention.**
- **Dressing and protection: If a dislocation is accompanied by an open wound, it should be dressed to prevent infection.**

D. Treatment for Thoracic Injuries

- **Monitoring vital signs: In cases of thoracic trauma, such as rib fractures or pneumothorax, it is essential to monitor vital signs, including breathing and pulse.**
- **Chest immobilization: The use of elastic chest bandages can provide stability to the affected ribs; however, it is important not to apply them too tightly so as not to restrict breathing.**

- **Respiratory support: If the victim has difficulty breathing, supplemental ventilation should be provided, and they must be transported urgently to a hospital.**

E. Interventions for Spinal Injuries:

- **Cervical region immobilization: In cases of suspected cervical spine injuries, it is essential to use a cervical collar. The victim's head and neck must be kept in a neutral position to prevent any further spinal cord damage.**
- **Placement on a rigid stretcher: Victims who have suffered spinal injuries must be placed on a rigid stretcher and transported with great care to prevent vertebral displacement.**

F. Management of Head Injuries:

- **Monitoring neurological signs: Any head injury requires careful monitoring for symptoms such as loss of consciousness, nausea, or vomiting, which may indicate a brain injury.**
- **Maintaining a lying position: The victim should be kept lying down, with the head slightly elevated, if possible, to reduce the risk of cerebral edema.**

G. Do Not:

- **Avoid improper handling:**
  - **Any forceful maneuver or attempt to reposition a dislocated joint or fracture must be avoided. Such uncontrolled actions can worsen the situation and cause additional injuries to blood vessels or nerves.**
- **Do not administer oral fluids:**
  - **A victim of major trauma should not consume liquids or food, as they may require emergency surgical intervention. Giving fluids can lead to intraoperative complications.**
- **Avoid attempting to lift the victim:**
  - **In cases of spinal or head trauma, the victim should not be lifted or moved except in an absolute emergency. Uncontrolled movements can cause irreversible injury to the spinal cord or brain.**
- **Do not use non-sterile substances:**

- **Wound dressing or immobilization must be done with the cleanest materials possible. Using non-sterile items can lead to severe infections, complicating the healing process.**

- **Avoid hot compresses:**
  - **In cases of acute trauma, hot compresses should be avoided, as they can increase inflammation and swelling. Cold compresses are preferred during the first 24–48 hours to reduce pain and inflammation.**

H. Additional Considerations for Trauma Management:

- **Immobilization in the Physiological Position: Affected limbs should be immobilized in the physiological position or as close to it as possible, to limit discomfort and prevent additional muscle contractures.**
- **Protection of Joints and Soft Tissues: During immobilization, soft materials (cotton, towels) should be used to protect the skin and prevent pressure points that could cause pressure ulcers.**
- **Monitoring for Signs of Shock: Victims of severe trauma are at high risk of going into shock. It is essential to monitor for symptoms of shock (pallor, sweating, rapid and shallow breathing, weak pulse) and take measures to maintain blood pressure (such as elevating the lower limbs).**

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Chapter XII
Basic Clinical Skills in Cardiopulmonary Resuscitation

Goje Greta, Miloicov Vlad, Ciorcan Mircea

List of Abbreviations and Symbols

- AED – Automated External Defibrillator
- AHA – American Heart Association
- CPR – Cardiopulmonary Resuscitation
- EES – External Electric Shock
- EMS – Emergency Medical System
- ERC – European Resuscitation Council
- PALS – Pediatric Life Support
- ROSC – Return of Spontaneous Circulation
- RP – Recovery Position
- UAO – Upper Airway Obstruction
- VF – Ventricular Fibrillation
- VT – Ventricular Tachycardia

XII.1. History

Cardiopulmonary resuscitation (CPR) is a life-saving method used in cases of cardiac arrest, combining chest compressions and artificial ventilations to maintain oxygenated blood circulation to vital organs until the return of spontaneous circulation (ROSC). The history of CPR is marked by significant discoveries and improvements over the centuries. In 1740, the French Academy of Sciences recommended mouth-to-mouth resuscitation for drowning victims, marking the first official recognition of artificial ventilation (1). In 1891, Dr. Friedrich Maass performed the first documented external cardiac massage (2). Later, in 1903, Dr. George Crile demonstrated successful cardiopulmonary resuscitation on a dog using external cardiac massage and artificial ventilation (3).

The pioneers of resuscitation, Drs. Kouwenhoven, Safar, and Jude, combined mouth-to-mouth ventilation with chest compressions to create the cardiopulmonary resuscitation protocol. In the same year, the American Heart Association (AHA) began promoting CPR techniques to the general public. In the 1970s, CPR courses were introduced to train medical personnel and the general population, leading to the widespread dissemination of CPR knowledge and skills (4).

American and European guidelines, periodically updated by organizations such as the AHA and the European Resuscitation Council (ERC), reflect the latest scientific discoveries and best practices to improve survival rates in cardiac arrest.

XII.2. Chain of Survival

The chain of survival for victims of out-of-hospital cardiac arrest was initially described by Friedrich Wilhelm Ahnefeld in 1968, aiming to emphasize the importance of timely interventions (represented as links) in maximizing survival chances. The concept was further developed in 1988 by Mary M. Newman from the Sudden Cardiac Arrest Foundation in the United States, and later modified and adapted by the American Heart Association (AHA) in 1991 (5). The design representing the chain of survival has been frequently updated, but the message conveyed by each link has remained unchanged. The chain of survival, in its current format, summarizes the vital links necessary for successful resuscitation:

- **Early recognition and activation of the emergency medical services (EMS)**

The first link highlights the importance of recognizing victims at risk of cardiac arrest and activating emergency medical services (EMS). Prompt recognition of chest pain as cardiac in origin and alerting emergency services before the victim loses consciousness allows rapid intervention by trained medical personnel, leading to better survival outcomes.

Once cardiac arrest occurs, recognition can be challenging. Both bystanders and EMS dispatchers must establish the diagnosis immediately to activate the chain of survival. Early recognition is crucial for the prompt initiation of CPR by bystanders. European Resuscitation Council guidelines emphasize that key observations for diagnosing cardiac arrest are unresponsiveness to stimuli and absence of breathing or abnormal breathing (6,7).

- **Early cardiopulmonary resuscitation (CPR) by bystanders**

Immediate initiation of CPR can double or quadruple survival after a cardiac arrest. Bystanders who have attended first aid courses can perform both chest compressions and rescue ventilations. If a bystander is untrained in CPR, the emergency medical dispatcher can guide them in performing chest compressions until the medical team arrives (8).

- **Early defibrillation**

The benefits of early defibrillation on survival and functional outcome are indisputable. Defibrillation within 3–5 minutes of collapse can achieve survival rates of up to 50–70%. This can only be accomplished through public access automated external defibrillator (AED) programs. Studies show that each minute of delay in defibrillating a shockable rhythm reduces the likelihood of survival by up to 10–12% (9).

- **Early advanced life support and standardized post-resuscitation care**

In situations where initial resuscitation efforts are unsuccessful, advanced medical intervention may be required, including airway management, administration of emergency medications, and treatment of reversible causes of cardiac arrest. Optimal treatment during the post-resuscitation phase, including emergency coronary angiography in patients with acute myocardial infarction, optimization of circulation and ventilation, temperature management, multimodal prognostication, and subsequent rehabilitation, improves outcomes (10).

XII.3. Basic life support in adults

Basic life support (BLS) is a set of essential measures aimed at maintaining the vital functions of a victim in cardiac arrest until the arrival of the medical team or the restoration of spontaneous circulation.

Prompt initiation of CPR is likely the most important intervention for improving survival and neurological outcome. Ideally, emergency system activation and CPR initiation occur simultaneously. In the current context of widespread mobile device use, a single rescuer can activate the emergency system while beginning CPR by calling the emergency service and placing the phone on speaker mode to continue communication. Existing evidence suggests that the potential harm caused by CPR to a patient incorrectly identified as being in cardiac arrest is low. Overall, the benefit of initiating resuscitation in cardiac arrest outweighs the relatively low risk of injury to patients who are not in cardiac arrest (11).

Sequence of actions in basic life support for adults

a) Ensure the safety of the rescuer and the victim. Check responsiveness to verbal and tactile stimuli. Ask bystanders for help.

b) If the victim does not respond, open the airway and assess breathing for no more than 10 seconds using the Look, Listen, and Feel (LLF) method:

- Technique: place one hand on the victim's forehead and two fingers under the chin, gently tilt the head back while lifting the chin (head hyperextension);
- If there is more than one rescuer, the second rescuer should immediately call emergency services upon recognizing unconsciousness;
- Request an AED as soon as possible.

c) If the victim is unconscious and breathing is absent or abnormal, begin resuscitation maneuvers, starting with chest compressions:

- Rescuer positioning: kneel beside the victim at chest level; place the heel of one hand in the center of the sternum, overlay the other hand, interlock the fingers; fully extend the arms, keeping elbows locked and shoulders positioned perpendicular over the victim's sternum.

Characteristics of chest compressions:

- Rate: 100–120 per minute; maintain a steady and regular rhythm;
- Depth: press the sternum firmly and consistently, compressing it to a depth of 5–6 cm;
- Recoil: avoid leaning on the chest; release all pressure between compressions and allow the chest to fully recoil to let the heart refill with blood;
- Minimize interruptions: stop compressions only to deliver ventilations (if applicable) or to use the AED;
- Rescuer rotation: if possible, switch the rescuer performing compressions every 2 minutes to prevent fatigue and maintain compression quality;

d) After performing 30 chest compressions, give 2 rescue breaths as follows:

- Keep the airway open by tilting the head back and lifting the chin;

e) Pinch the victim's nose and deliver air over approximately 1 second for each ventilation, until chest rise is observed;Continue alternating compressions and ventilations at a ratio of 30:2 (Figure 1) until the AED or specialized medical team arrives. As soon as the AED is available, turn it on and follow the voice prompts: attach the pads as indicated, allow the device to analyze the heart rhythm, and follow the instructions for delivering the external electric shock.

Continuation of resuscitation after a shock: after each shock, immediately resume chest compressions for 2 minutes and continue resuscitation according to the basic life support (BLS) algorithm.

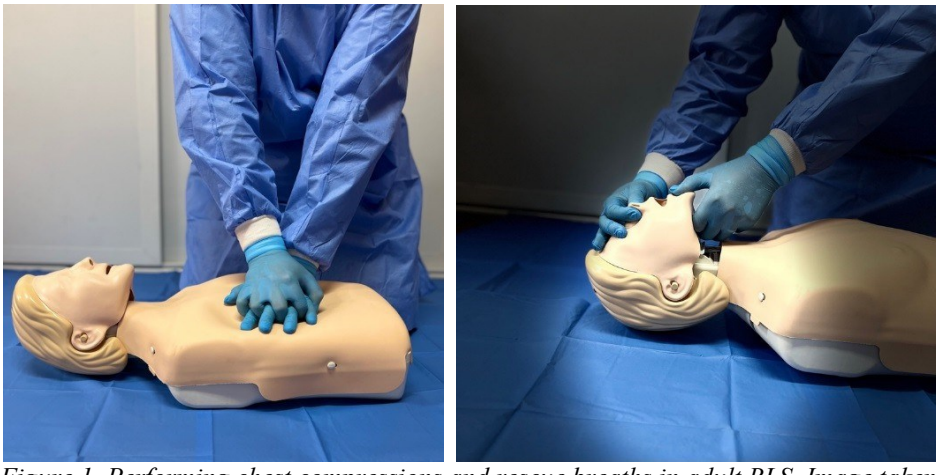

Figure 1. Performing chest compressions and rescue breaths in adult BLS. Image taken from the department's archive.

Cardiopulmonary resuscitation should be stopped in the following situations:

- Return of spontaneous circulation: when the victim begins to breathe normally, move, or show signs of life. Continuous monitoring of the victim is important, and the BLS algorithm should be resumed if necessary.
- Arrival of the specialized medical team and handover of responsibility for victim care. The medical team will assess the patient's condition and continue with advanced life support.
- Rescuer exhaustion: if the rescuer is completely exhausted and can no longer perform chest compressions effectively, BLS may be temporarily stopped until another rescuer or the medical team arrives (12).

XII.4. Use of an automated external defibrillator (AED)

An AED is a portable, battery-powered device equipped with adhesive pads that are attached to the victim's chest to detect the heart rhythm in the event of cardiac arrest. If the detected rhythm is ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT), the operator receives an audible signal and the AED delivers an external electric shock (EES). In the case of cardiac arrest due to asystole, no EES is delivered. The European Resuscitation Council recommends performing chest compressions and rescue breaths until an AED arrives, is turned on, and connected to the victim, with EES delivery if the rhythm is shockable (VF/VT without pulse) (13).

AED pad placement is performed in the anterolateral position, which is the standard and most commonly used position. One pad is placed below the right clavicle, and the other pad is placed lateral to the left nipple along the anterior axillary line (Figure 2) (14).

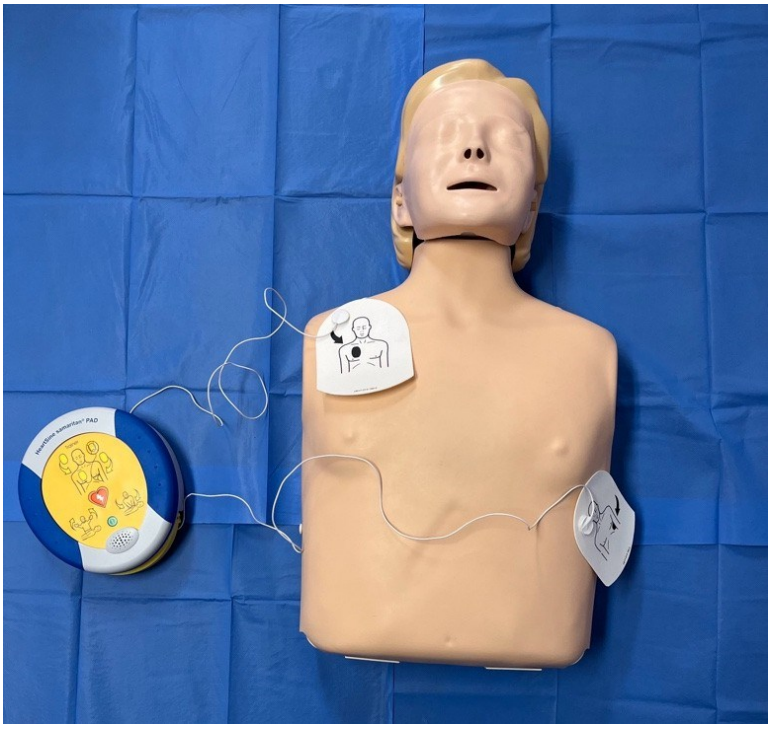

Figure 2. AED pad placement. Image taken from the department's archive.

XII.5. Safe lateral position in adults

The recovery position (lateral safe position) is an essential maneuver in basic life support (BLS), used to maintain airway patency and prevent obstruction in unconscious patients who are breathing spontaneously. This position facilitates secretion drainage and prevents aspiration of gastric contents in the event of vomiting.

Technique:

To place an unconscious but breathing adult in the recovery (lateral safe) position, first ensure the surrounding area is clear. Remove glasses, if applicable. Position the patient's arm closest to you at a right angle to the body, with the elbow bent and the palm facing upward. Bring the other arm across the victim's chest, with the back of the hand lightly touching the cheek on your side. Ensure both legs are extended, then bend the knee of the leg farthest from you. Next, grasp the shoulder and gently roll the victim toward you, keeping the hand under the cheek to support the head. Make sure the victim is stable in the lateral position, with the head slightly extended to maintain airway patency, adjusting the bent lower limb for stability.

Monitoring:

- Periodically check the patient's breathing and pulse;
- If the patient's condition changes, seek emergency medical assistance (15);

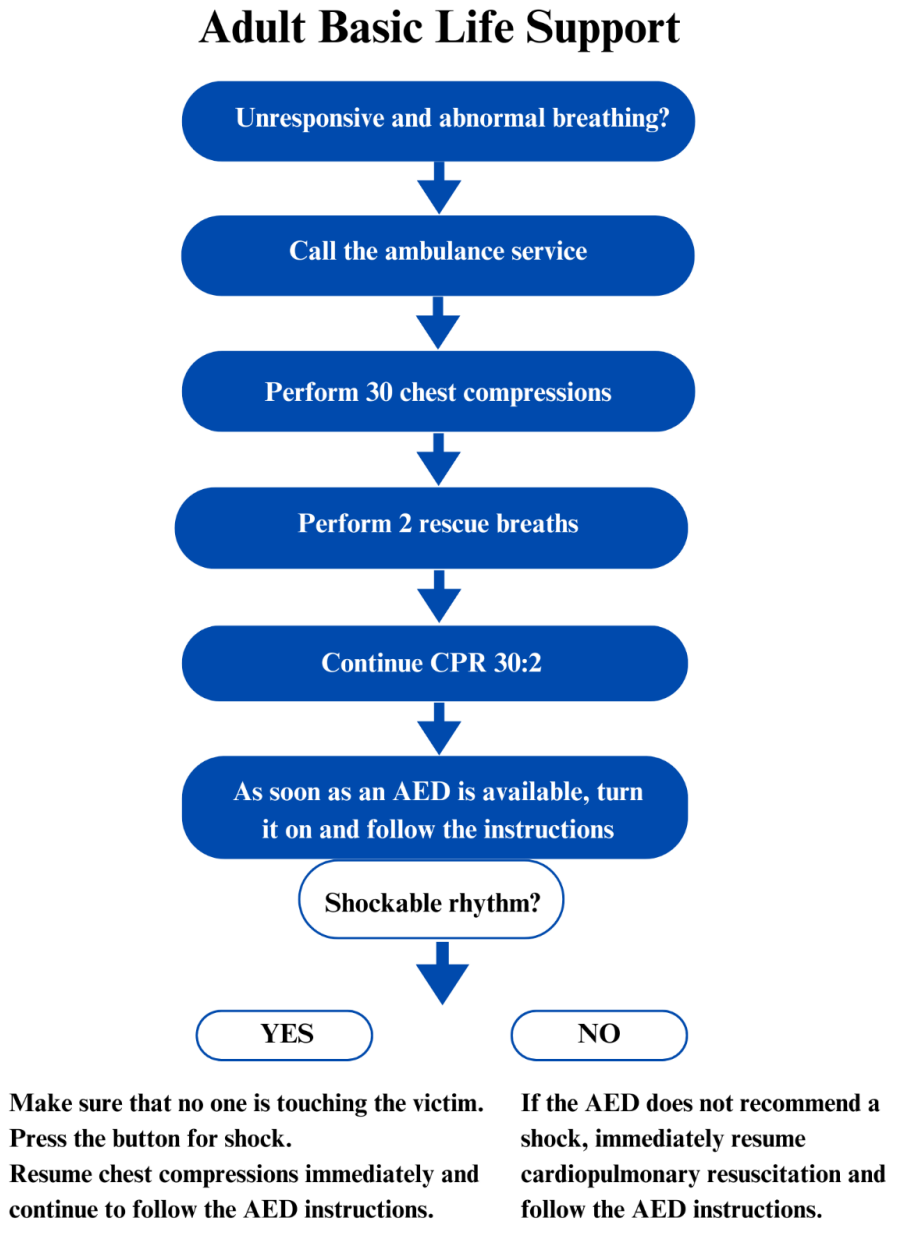

Figure 3. Adult basic life support (BLS) algorithm.
Adapted from the 2021 European Resuscitation Council Guidelines (12).

XII.6. Upper airway obstruction (UAO) by foreign body in adults

Upper airway obstruction (UAO) by a foreign body is a common problem, with many cases being resolved easily without medical personnel involvement. However, UAO is an important cause of accidental death, affecting all age groups but occurring more frequently in older adults (16).

Recognition of UAO:

Recognizing airway obstruction is key to a favorable outcome. It is important not to confuse this emergency with syncope, myocardial infarction, seizures, or other conditions that may cause sudden respiratory distress, cyanosis, or loss of consciousness. Factors predisposing to UAO include psychotropic medication, alcohol intoxication, neurological conditions that reduce swallowing reflexes, dementia, poor dentition, and advanced age (16).

Airway obstruction can be partial or complete. In partial obstruction, air can pass around the obstruction, allowing partial ventilation or coughing. In this case, encouraging coughing is recommended, as it generates high and sustained airway pressures that may expel the foreign body. Complete obstruction occurs when air cannot pass the blockage. If untreated, complete airway obstruction will rapidly lead to hypoxia, loss of consciousness, and cardiac arrest within minutes. In such cases, prompt treatment is essential (17).

First Aid:

a) Back blows: Position yourself slightly behind and to the side of the victim; support the victim's chest with one hand; deliver five firm back blows with the heel of your hand between the victim's shoulder blades; check after each blow whether the foreign body has been expelled.
b) Heimlich maneuver (abdominal thrusts): Stand behind the victim and encircle them with your arms; locate the victim's navel and place a fist just above it; grasp the fist with your other hand and deliver five quick, forceful abdominal thrusts, directed upward and inward; check after each thrust whether the foreign body has been expelled.

Alternate five back blows with five abdominal thrusts until the obstruction is cleared. If the victim becomes unconscious, place them in the supine position and begin cardiopulmonary resuscitation (CPR).

Note: In pregnant women or obese individuals, abdominal thrusts should be performed at the lower chest, similar to chest compressions in CPR (12,18).

XII.7. Pediatric basic life support

Many of the underlying etiologies and pathophysiological processes involved in the care of critically ill children differ from those seen in adults. Critical conditions are less common in children, and evidence-based management is often limited and/or extrapolated from adult literature. The Pediatric Life Support (PLS) working group of the European Resuscitation Council (ERC) recognizes this and strives to develop clear, evidence-based guidelines. ERC pediatric life support guidelines apply to infants (up to one year of age) and children (from 1 to 18 years of age) (19).

Sequence of actions in pediatric basic life support

a) Ensure the safety of the rescuer and the child. Check responsiveness to verbal and tactile stimuli. Ask bystanders for help.

b) If the child does not respond, open the airway and assess breathing for no more than 10 seconds.

- If you encounter difficulty opening the airway using the head tilt–chin lift method, or in cases of trauma, use the jaw-thrust technique;
- In the first minutes after cardiac arrest, a child may have slow or irregular breathing; if in doubt about normal breathing, act as if it is abnormal;
- If more than one rescuer is present, the second rescuer should immediately call emergency services upon recognizing unconsciousness.

c) In an unconscious child, if breathing is absent or abnormal, give five initial rescue breaths.

- For infants, maintain a neutral head position; in older children, slight head extension may be required;
- Blow steadily into the infant's mouth (or both mouth and nose for infants) for approximately 1 second, enough to produce visible chest rise;
- If there is a single rescuer with a mobile phone, call 112 immediately after giving the initial rescue breaths (using speaker mode), and continue to the next step while awaiting a response; if no phone is immediately available, perform 1 minute of CPR before leaving the child.

d) Immediately continue with 15 chest compressions, unless there are clear signs of circulation (such as movement or coughing).

Characteristics of chest compressions:

- Rate: 100–120 per minute, for both infants and children;
- Depth: compress the lower half of the sternum by at least one-third of the anteroposterior chest dimension. Compressions should never exceed the adult limit of 6 cm;
- Recoil: avoid leaning on the chest; release all pressure between compressions and allow full chest recoil;
- Whenever possible, perform compressions on a firm surface; move the child only if it provides significantly better CPR conditions;
- Perform compressions with two fingers for infants, taking care to allow complete recoil;
- In children over 1 year, use either the one-hand (Figure 4) or two-hand technique.

e) After 15 chest compressions, give 2 rescue breaths and then continue alternating at a 15:2 ratio. Do not interrupt CPR unless there are clear signs of circulation (such as movement or coughing) or if the rescuer becomes exhausted. When multiple rescuers are present, they should frequently rotate the person performing compressions to prevent fatigue (20).

Figure 4. Performing chest compressions in pediatric BLS.
Image taken from the department's archive.

Chest compression technique for infants (Figure 5):

- Two-finger technique: The rescuer places two fingers of one hand on the lower third of the sternum; during the relaxation phase, the fingers remain on the chest wall; at the end of each set of 15 compressions, the fingers are lifted to allow effective airway opening and delivery of two rescue breaths.
- Two-thumb encircling technique: One rescuer positions at the infant's head to open the airway and provide ventilation, while a second rescuer performs chest compressions using both thumbs on the lower third of the sternum; the rescuer's hands encircle the infant's chest to support the back (20).

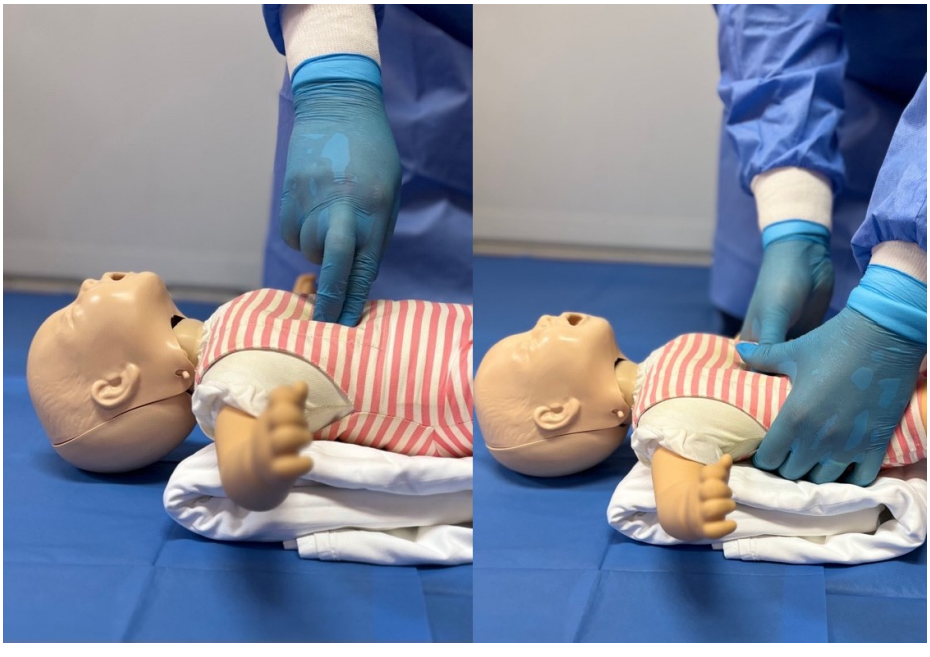

Figure 5. Performing chest compressions in infant BLS.
Image taken from the department's archive.

Use of an automated external defibrillator (AED):

In the event of cardiac arrest in a child, a lone rescuer should promptly initiate cardiopulmonary resuscitation as outlined above. When the likelihood of a shockable rhythm (ventricular fibrillation or pulseless ventricular tachycardia) is high, such as in sudden collapse, the lone rescuer may quickly retrieve an AED (if readily accessible) and deliver an external electric shock (EES) while simultaneously calling emergency services (112). If multiple rescuers are present, a second rescuer should call emergency services and then retrieve the AED, if possible.

The use of an AED with a pediatric attenuator is recommended for infants and children under 8 years of age, if available. If such a device is not available, a standard AED for all ages may be used (20).

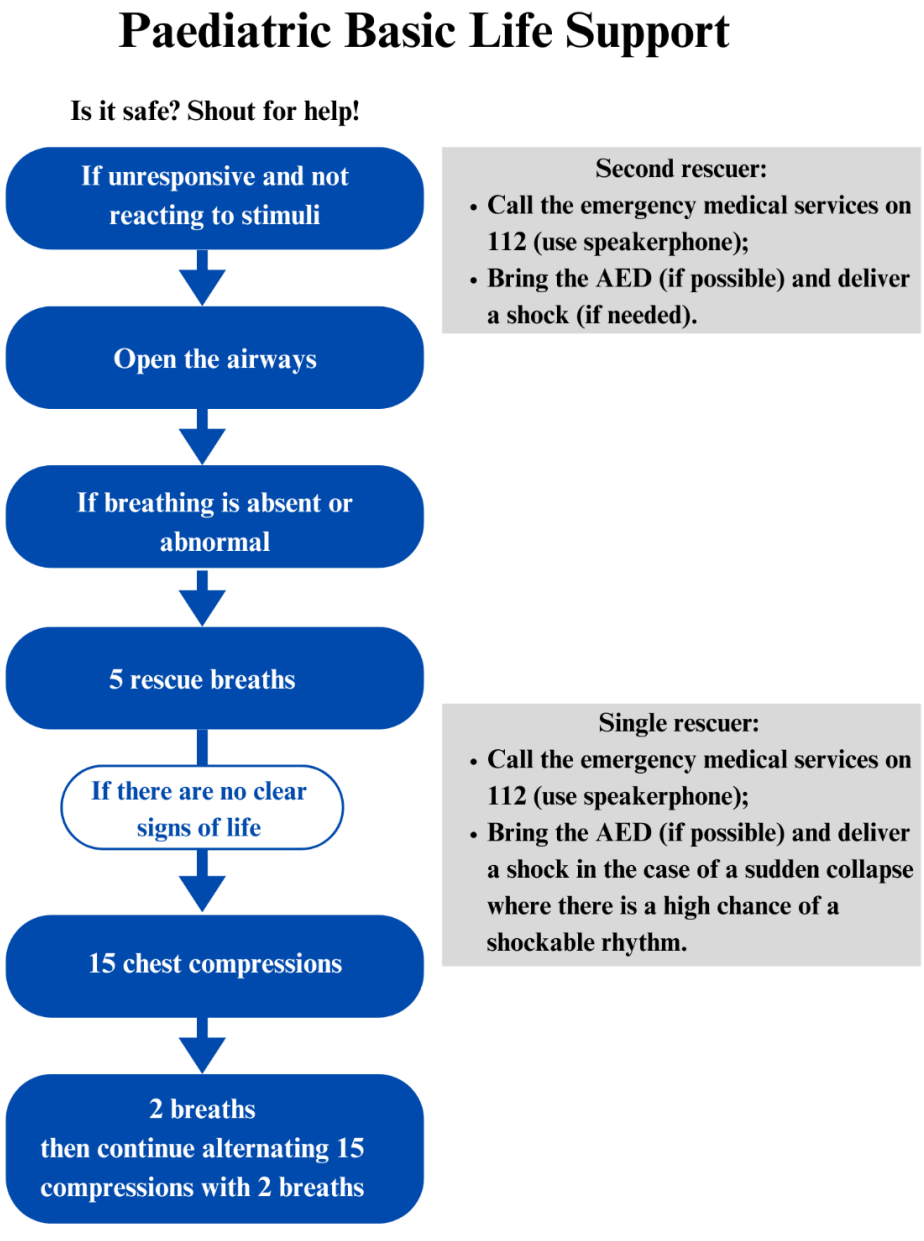

Figure 6. Pediatric basic life support (BLS) algorithm.
Adapted from the 2021 European Resuscitation Council Guidelines (20).

XII.8. Pediatric recovery (lateral safe) position

In the case of an unconscious child with a detactable pulse and spontaneous respiration, the airway should be kept open by continuous head tilt, chin lift, and placement in the recovery (lateral safe) position, especially when there is an increased risk of vomiting. After positioning in the lateral safe position, breathing should be reassessed every minute to detect cardiac arrest immediately if it occurs (untrained rescuers may require dispatcher guidance to do this) (20).

XII.9. Foreign body airway obstruction in children

In cases of foreign body airway obstruction, the onset of respiratory symptoms (coughing, dyspnea, stridor) is sudden; a history of playing with small objects or recent ingestion of food immediately before symptom onset may further alert the rescuer.

a) If the child is coughing effectively (conscious, coughing forcefully, breathing before coughing, crying, or speaking), no intervention is needed. Encourage the child to continue coughing and maintain monitoring.
b) If the child's cough becomes ineffective (characterized by decreased consciousness, weak or silent cough, inability to breathe or speak, cyanosis), the rescuer should check the child's level of consciousness. A second rescuer should call emergency services (112), preferably using a mobile phone on speaker mode. A single trained rescuer should begin rescue maneuvers immediately (unless they can simultaneously call using speaker mode).

If the child is still conscious but coughing ineffectively, deliver 5 back blows. If the back blows do not relieve the obstruction, perform 5 chest compressions for infants or abdominal thrusts for children. If the foreign body has not been expelled and the victim remains conscious, continue the sequence of 5 back blows followed by 5 chest compressions (infants) or abdominal thrusts (children). If the object is successfully expelled, assess the child's clinical condition (Figure 7).

c) If a child with airway obstruction is or becomes unconscious, continue according to the pediatric basic life support (BLS) algorithm (20).

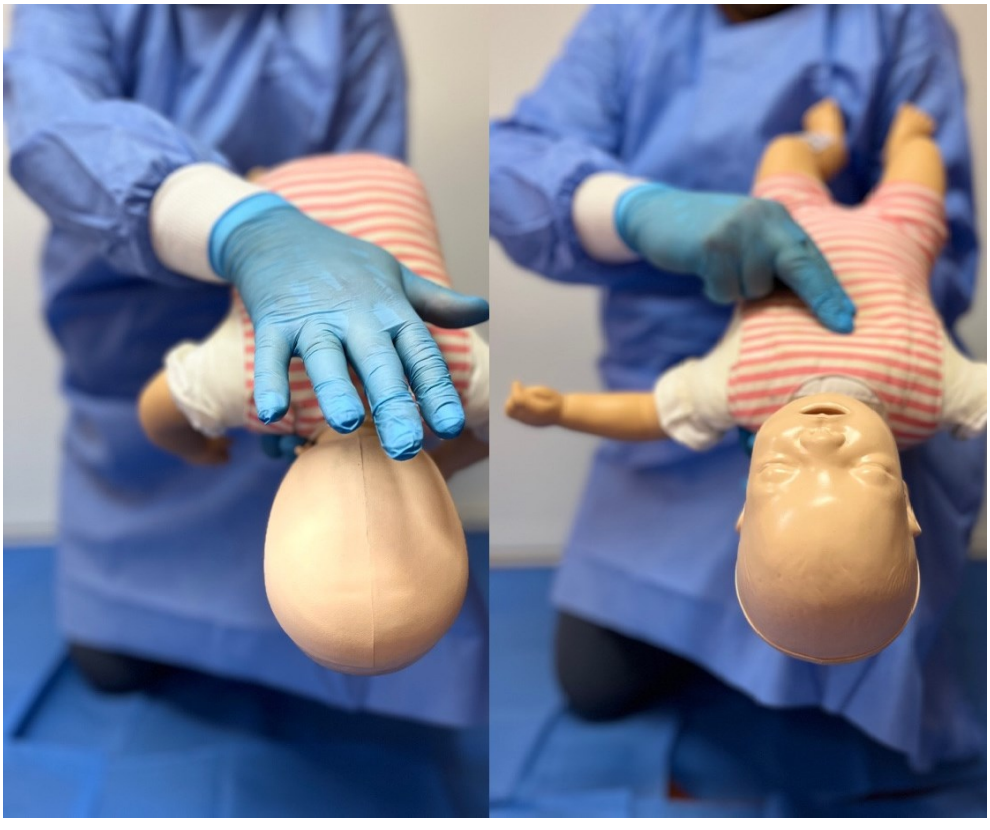

Figure 7. First aid for foreign body airway obstruction in an infant.
Image taken from the department's archive.

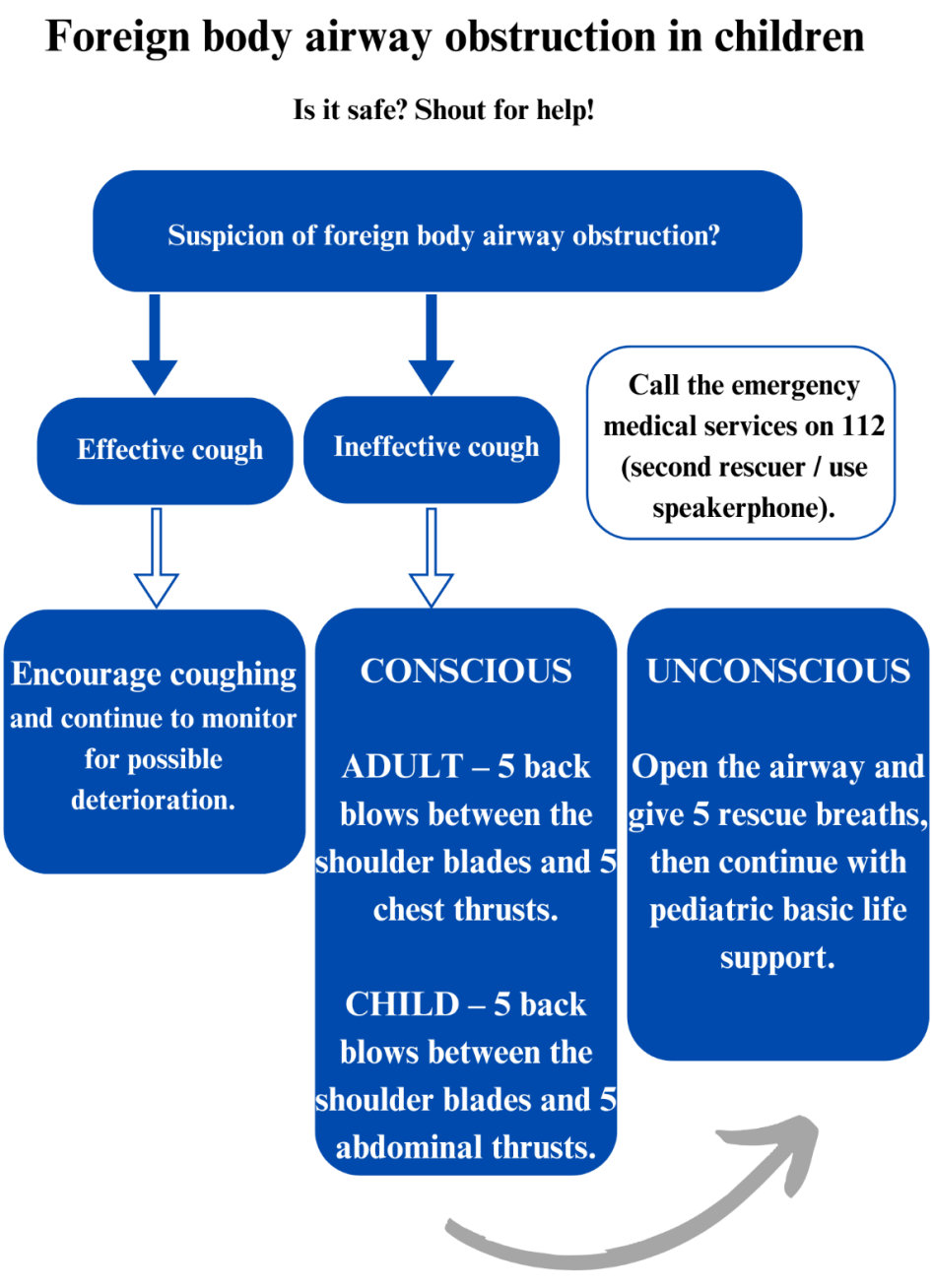

Figure 8. First aid algorithm for foreign body airway obstruction in the pediatric population. Adapted from the 2021 European Resuscitation Council Guidelines (20).

Tips and tricks

- **The key components of cardiopulmonary resuscitation (CPR) are: delivering chest compressions at an appropriate rate and depth, minimizing interruptions in CPR, allowing full chest recoil between compressions, and avoiding excessive ventilation.**
- **Early defibrillation combined with high-quality CPR is crucial for survival when cardiac arrest is caused by ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT).**
- **Resuscitation does not end with the return of spontaneous circulation (ROSC); post-resuscitation care is extremely important to achieve the best outcomes and requires a multidisciplinary system.**

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Chapter XIII
Practical clinical skills in the management of the burn patient

Hoinoiu Teodora, Piț Daniel, Caizer - Găitan Isabela

Abbreviations

ABSI – Abbreviated Burn Severity Index
ARDS – Acute Respiratory Distress Syndrome
B.S.A. – Body Surface Area
TBSA – Total Body Surface Area

Burn injuries represent one of the most devastating forms of trauma, having a profound impact on patients physically, physiologically, and psychologically (1). Despite advances in medical treatments over the centuries, burns continue to be a major cause of death and disability worldwide. In the past, many treatments offered limited benefits due to a lack of understanding of the pathophysiological impact of burn injuries (1). The 18th century and the early 20th century witnessed a substantial increase in biomedical research and knowledge in burn care, including the recognition of the importance of burn surface area and the introduction of skin grafts by Reverdin (2). However, these advances were initially not reflected in improved survival rates, as many patients died from shock and infections. It is only in the last 50 years that burn-related mortality has decreased significantly, thanks to a deeper understanding of the pathophysiology of burn injuries

XIII.1. History

Understanding and treating burns has a long history, traceable to rock paintings over 3,500 years old, suggesting early recognition of this condition. Ancient Egyptian documents, such as the Smith Papyrus from 1500 B.C. recommended the use of a resin- and honey-based ointment for treating burns (3,4). Chinese practices around 600 B.C. included applying tinctures and extracts from tea leaves (3). Around 400 B.C. Hippocrates proposed using melted pork fat and dressings soaked in resin, alternating with soaking in warm vinegar and tanning solutions prepared from oak bark (3). Celsus, in the first century A.D., referred to wine and myrrh as burn treatments, likely due to their bacteriostatic properties (5).

Galen (130–210 A.D.) used vinegar and air exposure to treat burns, while Rhazes, an Arab physician, prescribed cold water to relieve pain. Ambroise Paré (1510–1590 A.D.) effectively treated burns with onions and was among the first to describe early excision procedures for burn injuries. In 1607, German surgeon Guilhelmus Fabricius Hildanus published De Combustionibus, detailing the pathophysiology of burns and offering insights into managing contractures (6,7).

Edward Kentish's 1797 essay introduced pressure dressings as a means to relieve pain and blistering from burns. Around the same period, Marjolin identified squamous cell carcinomas in chronic burn wounds. In the early 19th century, Guillaume Dupuytren reviewed the treatment of 50 burn patients, using occlusive dressings and developing a burn depth classification system still in use today (7,8). Dupuytren was also among the first to observe gastric and duodenal ulceration as complications of severe burns, a phenomenon later discussed by Curling in London in 1842. The first hospital for severe burns was established on the Royal Infirmary grounds in Edinburgh in 1843, using a small property building (8).

Truman G. Blocker Jr. was likely the first to demonstrate the benefits of a multidisciplinary approach in burn care, particularly following the explosion of two ammonium nitrate–fertilizer–loaded cargo ships at the Texas City dock on April 16, 1947 (9). This explosion caused 560 deaths and over 3,000 injuries. Blocker mobilized the University of Texas Medical Branch in Galveston, Texas, to treat the numerous victims arriving by trucks. This "Texas City Disaster" remains the deadliest industrial accident in American history (9).

Over the following nine years, Truman and Virginia Blocker monitored the outcomes of over 800 burn patients from this incident and published numerous papers and government reports on their findings. The Blockers became renowned for their contributions to burn care and were both honored with the Harvey Allen Distinguished Service Award by the American Burn Association (9,10).

Truman Blocker Jr. was also recognized for pioneering research in burn treatment through debridement, air exposure, and proper nutritional support. In 1962, his dedication to pediatric burn care led the Shriners of North America to build the first Shriners Burn Institute for Children in Galveston, Texas (10).

Between 1942 and 1952, shock, sepsis, and multiple organ failure resulted in a 50% mortality rate among children with burns covering 50% of the total body surface area (TBSA). More recently, pediatric burn care has improved so that burns covering over 95% of TBSA now have a survival rate

exceeding 50%. In the 1970s, Andrew M. Munster focused on measuring quality of life, as excisional surgery and other improvements had significantly reduced mortality. First published in 1982, his Burn Specific Health Scale became the foundation for most modern studies on burn treatment outcomes and has been updated and expanded to include children (11).

XIII.2. Burn surface area assessment

By the late nineteenth century, a correlation between burn extent and mortality had first been identified. An early attempt to correlate burn size with prognosis was made by Smart CB in 1876, who studied 12 victims of a ship explosion and concluded that burn severity was determined by both the size and depth of the burns, as well as involvement of other systems such as the airways (12). Schjerning further developed this idea in 1884, finding that death was inevitable if two-thirds of the body surface was burned and likely when 50% of the body surface area (BSA) was affected (13).

However, it was not until the late 18th and early 19th centuries that real efforts were made to measure burn size accurately. In 1879, Meeh described the first method using graph paper to measure the burned surface area of the body (BSA) (14). Weidenfeld considered this technique too complicated and uncomfortable for patients. Using both his own calculations and those of Meeh, Weidenfeld discovered a consistent relationship between the surface areas of well-defined body regions, such as the head or arm, and the total body surface area. This knowledge allowed for more precise estimation of burn extent and later correlation with early mortality. He also identified other important factors, such as age, burn depth, and overall patient health (14).

Berkow calculated the surface areas of different body parts in relation to total body surface area, using body surface calculations based on height and weight by Du Bois D and Du Bois EF (14). Berkow recognized that his formula needed adjustment for use in children. In 1944, Lund and Browder modified Berkow's method, precisely defining anatomical regions and dividing the BSA into 12 regions, introducing an age correction factor for children based on Boyd's calculations from 1935, which in turn were adapted from Du Bois D and Du Bois EF. The Lund and Browder chart remains a fundamental tool in burn assessment. In 1982, Chinese scientist Chu used a wet paper modeling method to estimate body proportions in the Chinese population; however, the differences between his findings and those of Lund and Browder were minimal, confirming the accuracy of these parallel methods (15).

Berkow's method led to the development of the Lund and Browder chart, but it also inspired a simplified method for estimating BSA known as the "Rule of Nines." Wallace published the details of this simplified method in 1951 to measure BSA (Figure 1) (16). This method is sometimes also attributed to Pulaski and Tennison (particularly in the USA), who presented a similar idea at a 1950 symposium and later combined it with Wallace's concept. The Rule of Nines estimates the patient's hand surface area (defined as the area outlined by a line around the patient's hand with fingers extended) as 1% of BSA, although it has been shown to be less precise (17,18,19). Nonetheless, this method remains useful for the rapid assessment of minor burns.

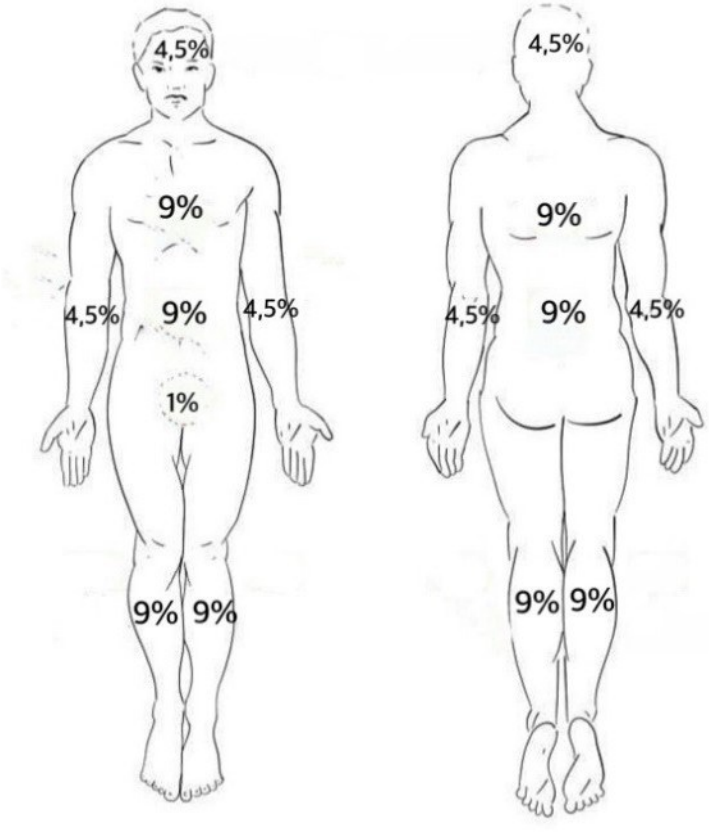

Figure 21. Wallace's Rule ("Rule of Nines")

Assessment of burn size is now an essential part of the diagnostic and treatment process, particularly for fluid replacement therapy, and plays an important role as a prognostic indicator (20).

XIII.3. Burn classification

Assessment of burn depth began as early as the 16th century. Guilhelmus Fabricus Hildanus, considered the father of surgery in Germany, observed in 1634 the relationship between the duration of heat exposure and the extent of resulting damage (21). Hildanus divided burns into three stages: the first stage manifested as erythema and blisters with colorless fluid; the second stage was characterized by erythema and blisters with yellow fluid; and the third stage, the most severe, was marked by the absence of blisters, leathery and dry skin, blue or black coloration, and lack of pain. Hildanus published De Combustionibus in 1670, discussing the pathophysiology of burns and contributing to the treatment of contractures. The three-stage description method was later used by Van Alberding in 1681, who classified burns as mild with blisters, skin contraction, and separation of the skin from underlying tissue, leading to crust and ulcer formation (21).

The classification of burns by "degree" was first introduced in the eighteenth century by German surgeons Heister (1724) and Richter (1788), who distinguished four degrees of burn severity:

- First-degree: pain, heat sensation, and the presence of small vesicles.
- Second-degree: intense pain accompanied by the formation of large vesicles.
- Third-degree: destruction of the skin and underlying tissues, with subsequent crust formation.
- Fourth-degree: full-thickness tissue destruction extending to the bone.

In the nineteenth century, Guillaume Dupuytren proposed a more detailed classification based on the analysis of 50 clinical cases. His system defined six degrees of burn depth:

- First-degree: erythema.
- Second-degree: cutaneous inflammation with detachment of the epidermis.
- Third-degree: partial involvement of the papillary dermis and subpapillary vascular network.
- Fourth-degree: complete destruction of the skin extending to the subcutaneous tissue.
- Fifth-degree: formation of a necrotic crust involving skin and muscle.
- Sixth-degree: extension of the burn to the bone.

Although Dupuytren's classification is still referenced by some authors, modern practice more commonly employs a simplified three-degree system introduced by the French surgeon Boyer in the early nineteenth century (1814):

- First-degree: erythema.
- Second-degree: vesicle formation with superficial ulceration.
- Third-degree: tissue destruction with formation of a dry, yellow necrotic crust.

Currently, burn classification is primarily based on depth, using the terms superficial, mixed depth, and full thickness. New techniques are being developed to help clinicians determine burn depth more accurately and objectively, including thermal imaging (24), laser-based techniques such as laser Doppler imaging and laser speckle perfusion imaging (25), as well as computer-assisted photographic methods like intracutaneous spectrophotometry (26).

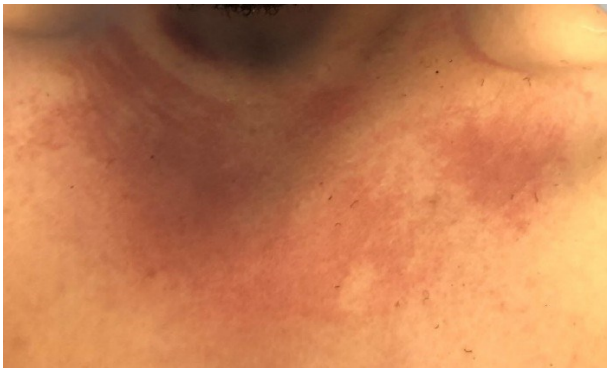

Figure 22. First-degree (superficial) thermal burn

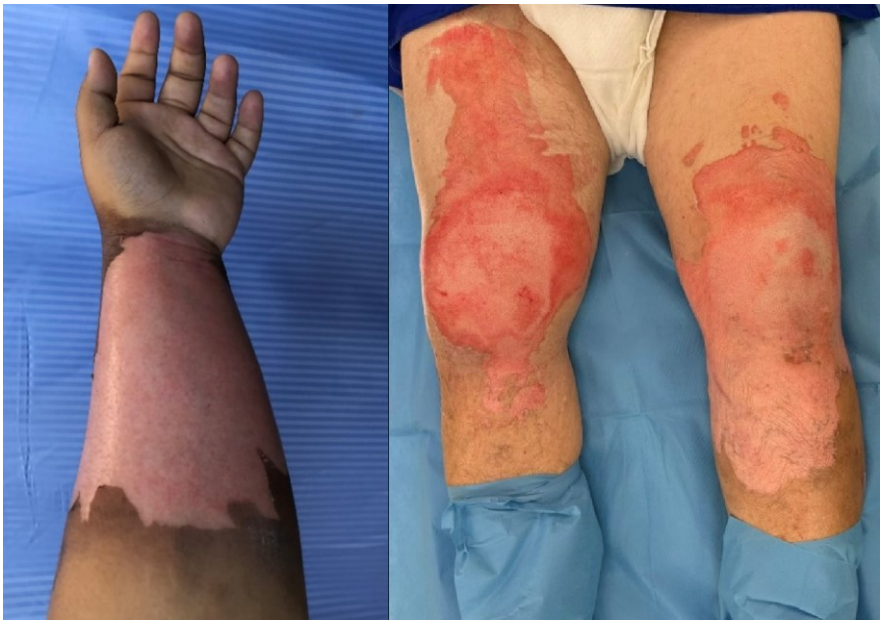

Figure 23. Second-degree (partial-thickness) thermal burn (IIA on the left and IIB on the right

)

Figure 24. Third-degree (full-thickness) thermal burn

Table 5. Characteristics of burns by depth [27]

Depth	Affected tissue	Color	Vascularization	Skin texture	Blisters
Superficial (First Degree)	Epidermis only	Red	Normal or increased	Dry	Absent
Partial-thickness burns (Second Degree)					
Partial superficial (IIA)	Epidermis and papillary dermis	Pink	Rapid capillary refill	Very moist, edematous	Present
Partial intermediate (IIB)	Epidermis and mid-dermis	Pale pink	Delayed capillary refill	Moist, edematous	Present
Deep partial-thickness (IIB)	Epidermis and papillary and reticular dermis	White or mottled red	Capillary refill very reduced to absent	Less moist, without edema	Present, but usually ruptured
Full-thickness burns (Third Degree)	Epidermis and entire dermis	Leathery, white or brown	Capillary refill absent	Dry, contracted	Absent

XIII.4. ABSI (Abbreviated Burn Severity Index) Score and Burn Mortality

The Abbreviated Burn Severity Index (ABSI), developed in 1982 by Tobiasen (28) and his collaborators, is a simple and effective assessment system designed to estimate the probability of survival of a patient following a burn. This index consists of five variables: sex, age, presence of inhalation injuries, extent of full-thickness burns (third-degree burns), and total body surface area burned (TBSA). Each variable contributes to the Total Burn Score, which is correlated with the probability of survival and mortality rate (Table 2 and Table 3) (29).

ABSI is recognized as one of the most popular and widely used assessment systems worldwide for predicting burn-related mortality (29,30,31). A predictive mortality score that is accurate and reliable is essential, considering that burns are the fourth most common cause of death globally (32,33). Since the introduction of ABSI in 1982, significant advances in the treatment of thermal burns, especially in intensive care and therapy, have led to a considerable reduction in mortality (34,35).

The total ABSI score for burns, which ranges from 2 to 13, is obtained by summing the individual scores of each variable. This score allows the determination of the probability of survival and the level of life threat for each patient. ABSI was developed and validated in Virginia in 1982 (29).

Transfer of the patient to a specialized burn center should be considered in the following situations: - ABSI score greater than or equal to 6, - High-voltage electrical burns, - Burns associated with other major injuries, - Full-thickness (Third Degree) burns affecting the face, axillae, joints, hands, feet, or genitalia

Estimation of the percentage of total body surface area burned is most easily done using the well-known "Rule of Nines – Wallace" (Figure 1)

Table 6. ABSI Score Parameters and Their Grading

Variable	Patient characteristic	SCORE
1. SEX	MALE	0
	FEMALE	1
2. Age (years)	0-20	1
	21-40	2
	41-60	3
	61-80	4
	81-100	5
3. Third-degree burn	YES	1
	NO	0
4. Upper airway injuries	YES	1
	NO	0
5. Total body surface area burned (%)	1-10 %	1
	11-20 %	2
	21-30 %	3
	31-40 %	4
	41-50 %	5
	51-60 %	6
	61-70 %	7
	71-80 %	8
	81-90 %	9
	>90%	10

Table 7. ABSI SCORE AND MORTALITY RATE

TOTAL BURN SCORE	MORTALITY RATE (%)	DEGREE OF THREAT TO THE PATIENT'S LIFE
2-3	< 1	Very low
4-5	2	Low
6-7	10-20	Moderate
8-9	30-50	Moderately severe
10-11	60-80	Severe
12-13	> 90	Maximum

XIII.5. Initial Management. At the Accident Scene.

The initial assessment is performed at the accident scene by the emergency crew. Assessment and initial treatment are carried out simultaneously with the trauma resuscitation protocol (36,37). This algorithm is based on the ABCs of trauma care, namely: **A**irway, **B**reathing, and **C**irculation.

The rescuer first evaluates the situation to ensure their own safety while providing first aid (Safety First). Emergency services (112) are called, and if possible, the victim is removed from the danger area (extrication, removal of high-voltage cables, fire extinguishing, etc.). Burned clothing remnants and accessories that could act like a tourniquet (watches, bracelets, etc.) are removed.

The primary assessment includes: the degree of respiratory insufficiency, determination of smoke inhalation injury, airway burns (burns on the face with destruction of hair follicles), evaluation of cardiovascular risk, checking for other injuries, and determining the depth and extent of the burn injuries.

Also at the accident scene, if possible, the emergency crew, with the help of family members, tries to obtain a history of how the accident occurred: whether there was an explosion in an enclosed or open space, whether the victim was thrown or propelled, the cause and mechanism of the fire, and whether the victim had consumed alcohol or drugs; all this information is useful for the subsequent management of the victim.

A. *Airway Assessment*

Airway injuries caused by inhalation burns remain one of the most frequent causes of mortality among burn victims, despite advances in respiratory management (38,39,40). When airway burns are involved, they

also increase the total body surface area burned. In two-thirds of cases where the burned body surface exceeds 70%, airway injuries are also present (41). The rescuer should immobilize the cervical spine to maintain airway patency (especially if a cervical spine injury is suspected) and provide supplemental oxygen to burn victims so that O_2 saturation remains between 90–96% (42). Glottic edema in burn victims can develop suddenly; therefore, if an airway burn is suspected, intubation during transport to the nearest hospital is mandatory, followed by transfer to a specialized burn center (43). A significant portion of these patients will develop acute respiratory distress syndrome (ARDS).

Common Signs of Smoke Inhalation Injuries:

- Persistent cough, stridor, wheezing
- Hoarseness
- Deep burns on the face or circumferential burns around the neck
- Inflamed or hairless nostrils
- Black-colored sputum / presence of soot in the oral cavity
- Blisters on the buccal mucosa / inflammation and edema in the oropharynx
- Depressed mental status, including evidence of alcohol or drug use
- Respiratory failure
- Hypoxia / hypercapnia
- Elevated carbon dioxide levels

These signs may indicate the need for victim intubation.

B. Fluid resuscitation

The shock that characterizes the first 24–48 hours in cases of major burns manifests as myocardial depression and increased capillary permeability, resulting in a significant depletion of intravascular volume (44–46). Inadequate fluid resuscitation is associated with a considerable increase in mortality (47–49).

It is imperative to establish at least one peripheral intravenous line at the accident scene and to begin fluid resuscitation as soon as possible after the injury (later in this chapter, we will discuss the calculation method and the fact that every hour counts in managing a major burn victim). Correct resuscitation is monitored by tracking the patient's urine output over 24 hours.

It is important to note that over-resuscitation (excessive fluid administration) is also a problem. It can lead to acute respiratory distress, pulmonary edema, pneumonia, multiple organ failure, and even compartment syndrome (50–52). This issue is most common in non-specialized centers where clinicians tend to overestimate the total body surface area burned.

According to the American Burn Association protocol guidelines, any burn that is not superficial and exceeds 20% of total body surface area requires fluid and electrolyte resuscitation (46). For patients with intact skin, it is recommended to insert two peripheral intravenous lines or even a central line for resuscitation. If necessary, lines can also be placed through burned areas to avoid delaying fluid resuscitation.

Principles of Fluid and Electrolyte Resuscitation:

- Resuscitation is initiated with crystalloid solutions (Ringer's lactate). It is preferred over 0.9% NaCl (normal saline) because it contains a higher concentration of electrolytes, and the lactate component helps reduce the incidence of hyperchloremic acidosis caused by large volumes of isotonic saline.
- The use of colloid solutions or hypertonic saline in initial resuscitation is controversial. Review studies including meta-analyses show no difference in mortality when comparing various crystalloids (53).
- To monitor the effectiveness of proper resuscitation, urine output should be at least 0.5 ml/kg/h (54).

Estimation of Initial Resuscitation Needs:

Currently, there are several calculation formulas that can be used to determine the volume required for resuscitation in major burn cases. It should be noted that all these formulas are approximate and serve as a starting point for initial fluid resuscitation (55). Factors such as patient age, associated injuries, comorbidities, and airway burns influence the resuscitation process (56,57).

The most commonly used initial formulas for resuscitation according to the American Burn Association are the modified Brooke formula and the Parkland formula, which will be presented in detail (44).

According to the modified Brooke formula for fluid resuscitation, the initial 24-hour fluid requirement is 2 ml/kg of body weight for each percent of total body surface area (TBSA) burned. Note that superficial burns involving only the epidermis are not included in the total TBSA burned. Of this total, half is administered during the first 8 hours, and the remainder over the next 16 hours, calculated from the time of injury. Administration should be as continuous as possible, as any decrease in infusion rate can lead to vascular collapse and increased edema (58).

According to the Parkland formula (also known as Baxter), the 24-hour fluid requirement is 4 ml/kg of body weight for each percent of TBSA burned.

We also mention the "Rule of 10" as a simplified option to calculate fluid requirements for hydro-electrolytic resuscitation (59,60). This involves the following steps:

1. Estimate the total body surface area (TBSA) burned to the nearest multiple of 10.
2. Burned TBSA (%) × 10 – for adults weighing between 40–80 kg.
3. For patients weighing over 80 kg, increase the infusion rate by 100 ml/h for every additional 10 kg.

For children, the most commonly used formula in practice is the Galveston formula.

It is very important to monitor urine output to assess the effectiveness of fluid resuscitation. For this purpose, a urinary catheter (Foley catheter) must be inserted. In adults, urine output is measured hourly and should be at least 0.5 ml/kg of body weight. Typically, patients with extensive burns who develop oliguria or anuria do not survive.

Monitoring of a severely burned patient is continuous, including vital signs, cardiac and respiratory parameters, and checking for peripheral pulses.

Blood transfusions may be necessary if hemoglobin (Hb) drops below 8 g/dL. For major burn patients, families are often informed in advance to have potential donors available if transfusions become necessary. It should be noted that blood transfusions must be performed with caution, as studies have shown increased mortality in patients requiring multiple blood product transfusions (61–63).

C. Primary Wound Care

For any burn injury, copious irrigation with saline solution is necessary to remove biological debris.

At the accident scene, clothing remnants, jewelry, and anything that could contaminate the burn wounds should be removed.

Burned areas are cooled using either water or saline solution. For small to moderate burns, this is a very important step. Studies show that early, copious irrigation—ideally within the first 15–30 minutes—reduces pain and limits burn progression by decreasing the histiocytic reaction (64–66). Irrigation is performed with large volumes of saline solution (commonly 2,000–3,000 ml), depending on the burned surface area.

Ice should be avoided, as it can worsen the burn injury, cause frostbite, or even systemic hypothermia.

For burns exceeding 10% of total body surface area (TBSA), vital signs, including temperature, must be monitored to prevent hypovolemic or

hypothermic shock. Core body temperature should be maintained above 35°C to avoid additional physiological imbalances (67,68).

If necessary, warm intravenous fluids can be administered to help maintain normal body temperature.

D. Pain Management

Burn injuries tend to be very painful, which is why most patients require opioid treatment—such as morphine—in addition to standard analgesics. Benzodiazepines may also be used in combination to manage anxiety associated with these injuries.

It is important to note that the deeper a burn injury is, the more the nerve endings in the reticular dermis are affected, which can result in a reduction or absence of the sensation of burning and pain.

XIII.6. Hospital Management of the Burn Patient

Upon presentation of a burn patient in the emergency department, the following procedures are performed (which continue in the Burn Unit if the patient requires admission):

1. If the patient has not had blood tests performed at another facility, an emergency panel is collected, including: complete blood count, biochemistry including inflammatory markers (D-dimers, fibrinogen, C-reactive protein, procalcitonin), and coagulation times. Obligatory, in the case of major burns, blood group and Rh factor are also collected, and if the patient requires transfusions, a request must be made to the Transfusion Unit to have blood units on standby.
2. Vital signs are monitored – cardiac and respiratory function, ECG, chest X-ray, or even trauma CT if multiple injuries are suspected (for example: the victim was involved in an explosion and was projected). The hydro-electrolytic resuscitation rate, urine output, and presence or absence of peripheral pulses are monitored.
3. Tetanus prophylaxis – performed routinely as part of the emergency presentation protocol for any burn injury that is not superficial.
4. Antibiotic prophylaxis – for superficial lesions it is not necessary; in the case of partial-thickness burns, local topicals containing antibiotics are applied (e.g., Silver Sulfadiazine, Bacitracin). In the case of deep and extensive burns, bacteriological screening is performed upon admission to the Burn Unit, and due to the destruction of the skin barrier function by the burn injury and the fact that dermal eschar (third-degree burn) is prone to bacterial colonization, together

with the ICU and the hospital's infectious disease team, the antibiotic prophylaxis protocol is decided until the results of wound cultures are available (69-71).

5. Wound management: primary wound care is performed using surgical soap (based on Povidone-Iodine or Chlorhexidine) and irrigation with non-irritant antiseptic solutions (Dermobacter, Prontosan, etc.). Debris and devitalized tissue are removed by excisional debridement (performed under anesthesia if the lesion requires it). If the patient does not have a partial- or deep-thickness lesion over a significant body surface area, a sterile dressing with a local epithelializing topical agent containing antibiotics is applied (e.g., Hyalo4, Dermazin, Cicatrol, Kadermin). The dressing must be soft, non-compressive (due to dynamic edema in the first 72 hours), thick enough to protect the wound and absorb exudate. It is changed every 2 days or more frequently if necessary, depending on the degree of exudate.
6. Wound dressings: in burn injuries, dressings must meet the following criteria: sterile, absorbent, impermeable, non-adherent to the wound (to avoid pain during removal and to prevent trauma to epithelial buds forming in the remaining dermis), soft and non-compressive to preserve local vascularization (72). Examples of dressings used in burns: Biotitus, Atrauman Ag, Cuticell, Epicite.
7. Escharotomies: in the case of deep second-degree (IIB) / third-degree burn injuries, enzymatic debridement with Nexobrid (bromelain-based proteolytic enzyme concentrate) can be used. In the presence of respiratory dysfunction in a patient with deep thoracic burns, or absence of peripheral pulses in the case of circumferential deep burns of the upper or lower limbs, escharotomies are required (73,74). These are preplanned incisions in anatomical regions performed by a specialized surgeon, aimed at restoring or maintaining local tissue viability (75). They are performed under maximum sterile conditions in the operating room, protecting the critical structures present at these levels (Fig.1,2,3). These are called decompression incisions. If, after performing these, the tissues are still compromised with doubtful viability, the clinician decides whether further incisions – fasciotomies – are necessary (in addition to the eschar and superficial fascial incision) to prevent compartment syndrome, which could permanently compromise tissues underlying the burn lesion.

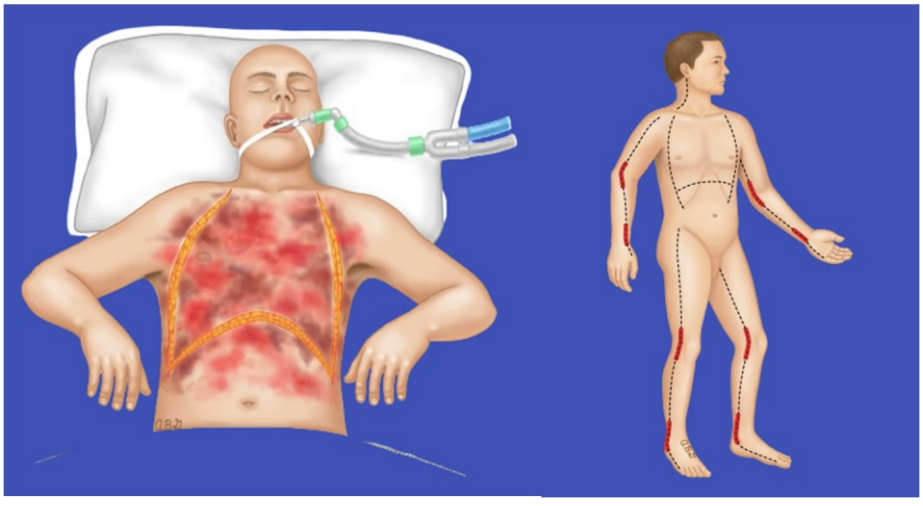

Figure 25. Decompression Incisions on the Thorax and Limbs

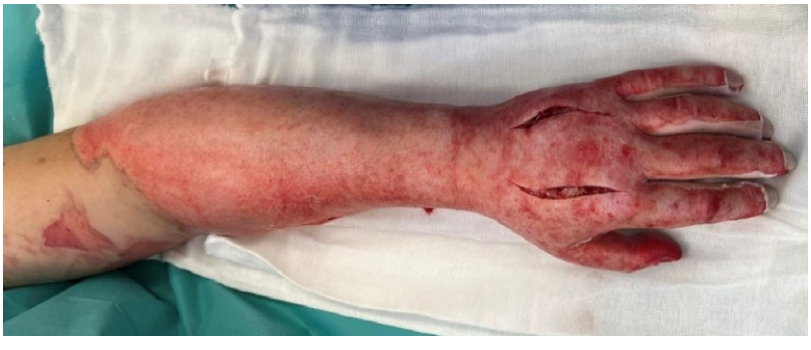

Figure 26. Decompression Incision on the Hand

Escharotomies can be performed using either an electric or a conventional scalpel. It is preferable to use electrocautery to avoid unnecessary blood loss. If compartment syndrome is suspected, the clinician performs fasciotomies (in addition to incising the skin and subcutaneous tissue, the fascia is also cut). The correctness of the incisions is verified by the presence of peripheral pulses, measurement of SaO_2 (oxygen saturation) using a pulse oximeter, and the clinical presence of capillary refill.

8. Criteria for Admission to a Burn Unit – American Burn Association

1. Second- and third-degree burns covering more than 10% of TBSA in patients under 10 years or over 50 years of age.
2. Second- and third-degree burns covering more than 20% of TBSA in any age group.
3. Second- and third-degree burns involving the face, hands, feet, genital region, perineum, or major joints.
4. Third-degree burns covering more than 5% of TBSA at any age.
5. Electrical burns.
6. Chemical burns.
7. Inhalation burns.
8. Burns in patients with multiple comorbidities.
9. Burns in patients with associated traumatic injuries (e.g., fractures).
10. Hospitals lacking personnel or equipment adequate for the treatment of burns in children.
11. Burns in children with suspected abuse or illicit substance use.

9. Avoiding Complications

Shock resulting from burn injuries can cause vasoconstriction in the mesenteric circulation, which may lead to gastric distension and ulcers (stress ulcer – Curling's ulcer). For this reason, a nasogastric tube is necessary in patients with partial- and full-thickness burns exceeding 20% of TBSA (43).

Efforts to mitigate the body's catabolic response can be made by initiating enteral feeding as early as possible (76,77).

Major burns induce a hypermetabolic state, which can lead to immunosuppression, delayed wound healing, muscle atrophy, and organ dysfunction. Management of these complications is overseen by the ICU team in conjunction with the Burn Unit.

In conclusion, major burns represent a challenge both for the surgeon and the ICU team, with a burn patient being considered comparable in complexity to a polytrauma patient.

The patient's course is dynamic over time and requires the involvement of the entire team—surgical, medical, physiotherapy, and psychological—to ensure survival and support reintegration into social and professional life.

XIII.7. Chemical Burns

Chemical burns differ from thermal burns in that the lesions evolve dynamically, with the potential to deepen during the first 72 hours. They can be caused by either acids or bases. It is very important to remember that these types of injuries should not be neutralized; the correct approach is copious irrigation with water or saline solution and rapid removal of any soaked clothing, if applicable.

Another characteristic of these injuries is the need to monitor systemic toxic effects, in which case blood gas analysis and electrolyte measurements are performed and repeated during the first 24–36 hours after the incident.

The burned wound is classified and treated according to the same principles described above (78).

XIII.8. Electrical Burns

Electrical burns are a type of complex trauma divided into two main categories: injuries below 1000 V and injuries above 1000 V. Burns caused by voltages below 1000 V typically present as burn lesions, whereas those above 1000 V often present as polytrauma, with hidden injuries that can affect multiple organs.

A characteristic finding on local examination of this type of burn is the presence of an entry wound ± an exit wound.

Initial evaluation of an electrocution patient includes blood tests to assess renal and hepatic function, a cardiology consultation with ECG, and a neurological consultation. These evaluations are repeated 48–72 hours after the incident, as these parameters may worsen dynamically, with the potential development of cardiac arrhythmias or even seizures (78).

Tips and tricks

1. **At the accident scene, the rescuer must first ensure their own safety and then that of the victim.**
2. **Initial stabilization may include patient intubation if there are signs of inhalation injury.**
3. **Overestimation of burn injuries in terms of total body surface area is common among untrained personnel.**
4. **Inhalation injuries add approximately 10–15% TBSA to the burn assessment.**
5. **Inadequate fluid resuscitation can lead to patient death.**
6. **Vital signs must be continuously monitored under intensive care conditions.**

7. **Pain management is very important in burn patients.**
8. **In chemical burns, the substance should not be neutralized; instead, copious irrigation with running water or saline is performed.**
9. **Electrical burns can produce "invisible injuries" to internal organs**
10. **Any burn injury is a dynamic wound, evolving over 48–72 hours from the time of injury until stabilization, and must be treated as such (the patient must be closely monitored).**

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Chapter XIV
Management of the Polytrauma Patient at the Accident Scene / During Transport / Emergency Care

Heredea Rodica, Ciorcan Mircea, Hoinoiu Teodora

List of Abbreviations and Symbols

AIS – Abbreviated Injury Scale
BAS – Blood Alcohol Concentration
CPP – Cerebral Perfusion Pressure
CPR – Cardiopulmonary Resuscitation
ED – Emergency Department
FAST – Focused Assessment with Sonography for Trauma
GCS – Glasgow Coma Scale
OTI – Orotracheal Intubation
PL – Peritoneal Lavage

Polytrauma is a complex condition and continues to be a persistent health problem, particularly among younger age groups. Acute mortality in these patients has improved globally, especially in developed countries, as protective systems, preventive measures, and our understanding of trauma pathophysiology have been implemented. However, uncontrolled bleeding has been reported as the cause of 25% of all trauma-related deaths and between 40% and 80% of potentially preventable deaths, in both military and civilian settings (1).

Traumatic injuries can range from minor, isolated wounds to complex injuries involving multiple organs. All polytrauma patients require systematic evaluation to maximize outcomes and reduce the risk of missed injuries.

Every year, approximately 1.19 million lives are lost due to road traffic accidents. Between 20 and 50 million people suffer non-fatal injuries, many of whom will be left with disabilities.

Road traffic accidents cause significant economic losses at individual, family, and national levels. These losses arise both from treatment costs and from lost productivity of those who die or are disabled by injuries. Road traffic accidents consume about 3% of the gross domestic product in most countries (2).

Among the causes of road traffic accidents is increased average speed, which is directly related both to the likelihood of an accident occurring and to the severity of its consequences. For example, every 1% increase in average speed produces a 4% increase in the risk of a fatal accident and a 3% increase in the risk of a serious accident. The risk of death for pedestrians struck by a vehicle rises sharply (4.5 times from 50 km/h to 65 km/h). In side-impact car-to-car collisions, the risk of death for vehicle occupants is 85% at 65 km/h.

Driving under the influence of alcohol or any psychoactive substance or drug increases the risk of an accident leading to death or severe injury. For alcohol consumption, the risk of a road accident starts at low blood alcohol concentration (BAC) levels and increases significantly when the driver's BAC is ≥ 0.04 g/dl. For drivers under the influence of drugs, the risk of a road accident varies depending on the psychoactive substance used. For example, the risk of a fatal accident among amphetamine users is approximately five times higher than for someone who has not used the substance.

Correct use of a helmet can reduce the risk of death in an accident by more than sixfold and the risk of brain injury by up to 74%. Seat belts can reduce the risk of death among vehicle occupants by up to 50%, and using child car seats can reduce infant deaths by 71%.

Attention deficits caused by mobile phones are an increasing concern for road safety. Drivers using mobile phones are about four times more likely to be involved in an accident than those not using a phone. Using a phone while driving slows reaction time (especially braking reaction time, but also response to traffic signals) and makes it difficult to maintain lane position and proper following distance. Hands-free phones are not much safer than handheld ones, as texting significantly increases accident risk.

Patients with severe traumatic injuries have a significantly lower probability of mortality or morbidity (10.4% vs. 13.8%) when treated in trauma centers. Advanced age, obesity, and major comorbidities are associated with worse outcomes after trauma. In traumatized patients with significant hemorrhage, lower Glasgow Coma Scale (GCS) scores and advanced age are independently associated with increased mortality.

The most common causes of mortality following trauma are hemorrhage, multiple organ dysfunction syndrome, and cardiopulmonary arrest (3).

Conversely, the most common causes of morbidity are unintentional extubation, surgical technical failures, neglected injuries, and complications related to vascular catheters.

A relatively small number of patients die within the first 24 hours after trauma. Most deaths occur either at the scene of the incident or within the first four hours after arrival at a trauma center (4).

The concept of the "golden hour" (5), which emphasizes the increased risk of death and the need for rapid intervention within the first hour of care after major trauma, has been described in trauma studies and promoted in manuals and training courses. Although rapid intervention can improve outcomes in trauma patients, such as managing airway obstruction, tension pneumothorax, and severe hemorrhage, the relevance of the exact timing of intervention and its impact on mortality may be more complex than previously thought. A large study based on registries from multiple trauma centers in North America did not identify a clear association between prehospital intervention intervals (e.g., time at the scene and transport time) and trauma patient mortality (6).

XIV.1. Primary Assessment and Management

A clear, systematic, and structured approach is essential in the management of polytrauma patients. The primary survey is organized according to the identification of life-threatening conditions and is conducted in the sequence outlined below. This initial assessment serves to prioritize immediate threats to life, with any abnormalities identified requiring prompt intervention prior to progression to subsequent stages of evaluation.

The primary assessment consists of the following steps:

- Assessment and protection of the airway (while maintaining cervical spine immobilization)
- Assessment of breathing and ventilation (ensuring adequate oxygenation)
- Assessment of circulation (control of hemorrhage and maintenance of adequate organ perfusion)
- Assessment of neurological function (basic neurological evaluation)
- Exposure – control of environmental factors (undress the patient and thoroughly search for possible injuries while preventing hypothermia) (7).

Keep the following points in mind while performing the primary assessment:

- Airway obstruction is a major cause of immediate death after trauma. The airway can be blocked by the tongue, a foreign body, aspirated material, tissue edema, or an expanding hematoma (8).

- There are no definitive guidelines for tracheal intubation in trauma. In general, early intubation is indicated if the patient has sustained significant facial or neck injuries that could lead to airway edema or distortion. In cases of hemodynamic instability, it may be preferable to delay intubation until adequate physiological optimization is achieved, as medications used for rapid sequence intubation can worsen hypotension. Once the airway is secured, it is important to fix it well and ensure it does not shift during patient movement.
- It is important to continuously reassess the respiratory status of trauma patients who develop hemodynamic instability after intubation and to monitor ventilator pressure alarms closely.
- Hemorrhage is the most common preventable cause of death in trauma patients. Hypotension generally does not occur until at least 30% of blood volume is lost (6). These patients are at high risk of death. Even a single episode of hypotension significantly increases the risk of severe injury.

A. Airway Assessment

Severely injured and polytrauma patients may develop airway obstruction or inadequate ventilation, which can lead to hypoxia and death within minutes. Observational studies (8) suggest that airway obstruction is a major preventable cause of death among trauma patients. Therefore, airway assessment and management remain fundamental steps in the treatment of any critically ill patient.

In a conscious patient, the initial airway assessment can be performed as follows:

- Start by asking the patient a simple question (e.g., “What is your name?”). A clear and precise response verifies the patient’s ability to speak and temporarily protect their airway.
- Observe the face, neck, chest, and abdomen for signs of respiratory distress, including tachypnea, use of accessory or asymmetrical muscles, abnormal breathing, and stridor.
- Inspect the oropharyngeal cavity for injuries to the teeth or tongue; presence of foreign bodies, blood, vomit, or secretions. Check for obstacles that may interfere with laryngoscope or endotracheal tube placement.
- Inspect and palpate the neck for lacerations, bleeding, edema, or other signs of injury. Palpation of the cervical region also helps identify landmarks for a cricothyrotomy. In an unconscious patient, the airway must be secured immediately along with the removal of any obstructions (foreign body, vomit, displaced tongue, etc.).

For all trauma patients, a cervical spine injury should be assumed until proven otherwise. However, patients with isolated penetrating trauma, without secondary injuries and with a normal neurological exam, generally do not have an unstable spinal injury. In such cases, cervical spine immobilization is not recommended and has even been shown to be associated with increased mortality. Immobilization is also unnecessary when managing the airway in patients with penetrating neck trauma (9).

B. Respiration

Once airway patency is ensured, the next step is the proper assessment of oxygenation and ventilation. In this context, it is important to inspect the chest for signs of injury, including asymmetric or paradoxical movement, auscultate breath sounds, and palpate for crepitus and deformities.

If a pneumothorax is suspected—characterized by hypotension, dyspnea, and decreased breath sounds on the affected side—needle decompression is required. This is performed using a large-bore needle (14 gauge or larger), placed either in the second intercostal space at the midclavicular line or in the fifth intercostal space at the midaxillary line, followed by chest tube insertion (10).

A number of airway management tools and devices can be useful in the care of a polytrauma patient:

- Suction catheters
- Masks with bag-valve attachment for high-flow oxygen
- Combitube, laryngeal masks
- Videolaryngoscopes
- Cricothyrotomy kit
- Endotracheal tubes in a range of sizes
- Laryngoscopes, including blades and handles of various sizes (11)

C. Circulation Assessment:

The initial assessment of a patient's circulation begins with palpation of the central pulse at the carotid artery. If the carotid or femoral pulse is present and there is no obvious external bleeding, circulation can initially be considered intact; completing the primary assessment should not be delayed by obtaining an exact blood pressure measurement.

While circulation is being assessed, two large-bore intravenous (IV) catheters (16 gauge or larger) should be placed in the antecubital fossae of both upper extremities.

Life-threatening hemorrhage must be controlled immediately. A combination of direct manual pressure, proximal compression with a tourniquet, a manual blood pressure cuff, or elevation of the affected limb is generally sufficient to control external arterial bleeding at the scene. If these measures are ineffective, hemostatic agents may be used. Venous bleeding is controlled with direct pressure. Severe pelvic injuries may require a pelvic binder (12).

Emergency thoracotomy may be necessary for trauma patients with absent femoral or carotid pulses. This procedure is most effective in victims of penetrating chest trauma who have an initial arterial pulse or other signs of life (e.g., voluntary movement). It is rarely beneficial in blunt trauma or when performed in settings without immediate surgical capability. Notably, trauma patients requiring cardiopulmonary resuscitation (CPR) within one hour of hospital arrival have a low survival rate to discharge; according to Newgard CD et al. (6), only 13% survive to hospital discharge.

Clinical markers essential for assessing blood circulation and tissue perfusion include level of consciousness, skin temperature and color, capillary refill time, and pulse rate and quality. Identify and control external bleeding using direct pressure, including checking for posterior bleeding. Initiate cardiac and blood pressure monitoring, and collect blood for basic laboratory tests, including hematocrit and a pregnancy test for all women of childbearing age.

Treatment

Resuscitate the patient using warmed fluids and, if necessary, packs of red blood cells (13). Treat cardiac tamponade, cardiac arrest, and massive hemothorax; consider immediate emergency thoracotomy if indicated.

For pregnant patients beyond 20 weeks' gestation, the left lateral decubitus position is recommended to avoid compression of the inferior vena cava by the gravid uterus. This improves venous return and, consequently, uteroplacental and systemic perfusion.

Hemorrhagic shock should be treated with rapid infusion of warmed isotonic fluids (normal saline or Ringer's lactate). Young, healthy patients may receive up to 2 L immediately (or 20 mL/kg in children) (14). Older patients or those with congestive heart failure/renal insufficiency should receive smaller boluses (250–500 mL) to prevent fluid overload.

Monitor the response to fluid resuscitation using vital signs, clinical condition, and emergency serum lactate levels. Patients who do not improve with fluid resuscitation should receive blood along with additional fluids. In extreme cases, O-negative blood is used for women of childbearing age and

O-positive blood for men (from available emergency department stocks until hospital blood products become available) (14).

Hemorrhage Control

During the primary assessment, the physician identifies and controls major sources of bleeding. Even soft tissue and musculoskeletal injuries can involve large vessels and cause dangerous exsanguination. External bleeding is treated with direct pressure. Avoid the use of hemostatic, as blind clamping may damage adjacent vessels or nerves. The tourniquet (15) should be used only in limited circumstances (traumatic amputations).

Intra-abdominal hemorrhages are common sources and should be considered in any hypotensive patient, in cases of splenic rupture, severe liver lacerations, and major vascular injuries. Direct surgical control in the operating room is crucial for patients who do not respond to initial fluid resuscitation. Intra-abdominal bleeding is rapidly assessed with focused abdominal sonography for trauma (FAST) or peritoneal lavage (PL), if ultrasound is unavailable (16).

Fractures can cause severe bleeding. Tibial and humeral fractures can lead to blood loss up to 750 mL, femoral fractures up to 1500 mL, and pelvic fractures to several liters (17). Temporary stabilization with splints can be lifesaving. In primary assessment, bleeding from pelvic fractures should be controlled with non-invasive techniques such as a pelvic binder. Anti-shock trousers or a pneumatic anti-shock device can also be used for tamponade of bleeding from pelvic fractures (18). Bleeding from pelvic fractures is frequently retroperitoneal and must be differentiated from intraperitoneal bleeding caused by ruptured solid organs. This is usually done via FAST, but may require CT scanning, angiography, or emergency exploratory laparotomy (19).

Cardiac tamponade occurs due to the accumulation of increased fluid or blood in the pericardium, compressing the heart and preventing venous return, causing pump failure. Suspect cardiac tamponade in any patient with penetrating trauma to the left chest, upper left abdomen, or back. Even 150–200 mL of blood can cause significant cardiac compromise. Clinical signs include shock refractory to fluids and vasopressors, pulseless electrical activity, jugular vein distension, muffled heart sounds, Kussmaul sign, paradoxical pulse, and electrical alternans on ECG. Pericardial effusion is detected by transthoracic ultrasound, showing a hypoechoic fluid band between the myocardium and pericardium. Treatment consists of immediate pericardiocentesis or a pericardial window in the operating room. Aspiration

of 10–15 mL of blood can improve cardiogenic shock and buy time for definitive treatment (19).

Any patient without a pulse should be immediately assessed with defibrillator paddles, and unstable arrhythmias should be treated by electrical cardioversion to prevent their conversion to non-shockable rhythms, such as pulseless electrical activity or asystole (20). Absence of vital signs associated with penetrating thoracic trauma constitutes an indication for emergency thoracotomy. Endotracheal intubation with mechanical ventilation is performed, and intravascular volume must be simultaneously replenished. After access to the thorax, the surgeon or emergency physician can treat cardiac tamponade, directly control intrathoracic bleeding vessels, perform open cardiac massage or defibrillation, and clamp the aorta to slow blood loss and increase perfusion to the heart and brain (21). Emergency thoracotomy is not beneficial for blunt trauma.

D. Neurological Assessment

After airway, breathing, and circulation issues have been addressed, a neurological examination is performed, which should include a description of the patient's level of consciousness using the Glasgow Coma Scale (GCS). It is also important to note any signs that may suggest a spinal cord injury. The GCS is widely used and can be employed to monitor the patient's neurological status. However, it is important to remember that multiple studies suggest that the initial GCS (22) is not predictive of outcomes in patients with severe brain injuries, and intubation, sedatives, or intoxication with alcohol or other substances can interfere with its application.

Spinal immobilization must be maintained for all patients with suspected spinal cord injury until it is ruled out (23).

E. Exposure and control of body temperature:

Ensure that the trauma patient is completely undressed and examined for the presence of injuries during the primary assessment (24). Undiagnosed injuries represent a serious threat. Commonly overlooked areas include the scalp, axillary folds, perineum, and in obese patients, abdominal folds. Penetrating wounds can be present anywhere. After performing cervical spine immobilization, examine the patient's posterior thoracic region, the gluteal fold, and the scalp.

Hypothermia should be prevented and treated immediately once identified, as it can promote coagulopathy and the development of multiple organ dysfunction syndrome (25). During winter months and whenever a trauma patient presents with hypothermia, the resuscitation room should be

warmed; wet clothing should be quickly removed, warm blankets and active external warming devices used, and warmed intravenous fluids and blood administered.

Transport

Patients with polytrauma must be stabilized without delaying transfer to a higher-level medical facility, as any delay can significantly increase the risk of mortality. Transfer criteria include factors such as the patient's age and general condition, the mechanism of injury (road traffic accidents, falls from height), and initial clinical findings (vital signs, neurological status, type and severity of injuries) (26).

It is crucial to note that a complete and detailed evaluation is not required before transfer. Delaying transfer to complete laboratory tests or imaging studies only postpones definitive treatment that can be provided in the Emergency Department (ED). Furthermore, many of these investigations will need to be repeated at the receiving facility, making the initial delay unnecessary.

Therefore, the primary concern should be the patient's initial stabilization and the rapid organization of transfer, ensuring that the patient reaches a trauma center capable of providing the necessary definitive care as quickly as possible (27).

XIV.2. Evaluation and Treatment of Polytrauma Patients in the Emergency Department

The mission of emergency departments is to provide urgent medical services and ensure the survival of patients with acute health issues. Initial management and diagnosis of polytrauma patients are delivered in the emergency department.

Any patient presenting with multiple traumas, equivalent to critical injuries in different anatomical regions of the body, or who has an Abbreviated Injury Scale (AIS) >15, is considered a polytrauma patient (28). The injury severity score, also known as AIS (Abbreviated Injury Scale), is a system used to classify and describe the severity of physical injuries. The AIS score ranges from 1 to 6, where:

1. **Minor (1):** Minor injuries, such as scratches or bruises.
2. **Moderate (2):** Moderate injuries that require medical care but are not life-threatening, such as simple fractures**.**
3. **Serious (3):** Serious injuries that require intensive medical treatment and have the potential to be life-threatening, such as complex fractures or organ injuries.

4. **Severe (4):** Severe injuries with a high risk of death or disability, such as brain injuries or internal hemorrhages.
5. **Critical (5):** Critical, extremely severe injuries with a major risk of death, such as multiple organ traumas or massive hemorrhages.
6. **Maximal (6):** Maximal or fatal injuries, which are usually incompatible with survival.

Once the patient arrives at the hospital, the trauma team takes over from the ambulance crew and transfers the patient to a trauma or resuscitation room. The trauma resuscitation team for polytrauma consists of physicians, nurses, and auxiliary medical staff, all dedicated to managing the patient. Generally, trauma centers have a single trauma level, while others may have two or three levels specifically defined by policy and monitored through the trauma quality assurance process. The size and composition of the team may vary depending on the hospital's capacity, injury severity, and the corresponding level of trauma team activation. A high-level response for a critical patient consists of a multidisciplinary team of physicians: emergency physician, general surgeon, neurosurgeon, anesthesiologist, radiologist, radiology technician (where available in the emergency department), orthopedic surgeon, vascular surgeon, and plastic surgeon. The primary tasks of the trauma team are to maintain and improve vital functions, provide early diagnosis and treatment of injuries, and perform emergency procedures to save life. Major trauma affecting multiple organs and regions is certainly a condition where a multidisciplinary approach can yield significant outcomes. All levels specifically depend on the hospital resources available for the trauma patient, as well as the physiological condition of the victim(s).

Even in the prehospital setting (if indicated), sedation and general anesthesia are acceptable and desirable methods to ventilate a polytrauma patient. However, sedation as the sole means of controlling agitation is not always effective, as agitation can be caused by correctable factors such as hypoxia, hypovolemia, toxins or alcohol, primary brain injuries, pain, hypoglycemia, or hypo/hyperthermia.

In the management of neurotrauma, there are certain "gold standards" that must be adhered to:

1. Airway protection and oxygenation: orotracheal intubation (OTI) after rapid sequence induction is optimal.
2. Ventilation: maintenance of hypocapnia or normocapnia.
3. Correction of hypotension: maintaining cerebral perfusion pressure (CPP) between 80–100 mmHg.

4. Adjunctive measures: use of diuretics versus fluid restriction, administration of mannitol 0.5–1 g/kg IV (may reduce intracranial pressure short-term but can cause nonselective osmotic dehydration and hypovolemia) and corticosteroids; alkalinization (preferably THAM) rather than bicarbonate, which through dissociation increases CO_2 ; antioxidants.
5. Barbiturate coma: for control of cortical activity and seizure prevention.
6. Trauma Computed Tomography: head, neck, chest, and pelvis—when possible, to identify surgically treatable expansive lesions.
7. Neurosurgical intervention: if indicated, such as for hematomas or cerebrospinal fluid fistulas.
8. Intensive care (ICU): for overall monitoring and treatment (29).

Imaging of the polytrauma patient:

Standard radiographs performed in the polytrauma patient include:

- Skull radiography in anteroposterior (frontal) and lateral projections
- Cervical spine radiography – frontal and lateral, with mandatory visualization of all cervical vertebrae and the cervicothoracic junction, complemented by trauma CT with reconstruction, spinal MRI, chest radiography, pelviC radiography , and FAST ultrasound.

If necessary, total-body radiography and trauma CT with intravenous contrast for intra-abdominal or thoracic injuries, MRI, and angiography can be performed.

Sometimes, "Radiology can be a dangerous place," so a hemodynamically unstable patient should not be transported for long-duration imaging studies (such as CT) or those of uncertain benefit; in such cases, the patient undergoes only the minimum examinations that can quickly identify the injury site and allow admission to the operating room for definitive treatment. Laparotomy remains the gold standard for penetrating trauma, while imaging alternatives, such as cardiac and thoraco-abdominal ultrasonography and diagnostic peritoneal lavage with laboratory analysis of the fluid, should be considered (30).

In particular, for a pregnant trauma patient, ultrasonography is useful both for detecting maternal pathological findings and for fetal monitoring, given the well-known need to minimize radiologic investigations in these cases. In the multidisciplinary trauma team, it is acknowledged that no single investigation is perfect and all have limitations, especially since imaging for trauma patients is often performed in suboptimal positions (for example, supine chest radiography usually provide relatively little significant data). A negative abdominal CT or negative peritoneal lavage should not dissuade the surgeon from performing a laparotomy or laparoscopy in a polytrauma patient if clinical suspicion of internal injuries exists, supported by laboratory findings (e.g., decreasing hemoglobin) (30).

XIV.3. Death of the Polytrauma Patient

Management of polytrauma patients represents one of the major public health problems due to multiple injuries affecting several organs or systems, associated disabilities, and the increased risk of death, as well as socio-economic consequences. Worldwide, trauma is the leading cause of death for both adults and children, accounting for approximately half of all deaths in these age groups (30). It is essential to increase the survival rate and recovery of these patients. In medical practice, there are two types of autopsies: clinical and medico-legal. Clinical autopsy is performed by a pathologist within the hospital where the patient was admitted and aims to determine the cause of death. Medico-legal autopsy is performed in forensic medicine services when there is suspicion of a suspicious or violent death, or when the cause of death is unknown.

Recently, the management of polytrauma patients has been developed and standardized, improving prehospital evaluation, transport, and care methods for these patients. Mortality patterns in trauma have been introduced, and recognizing them has led to significant changes in patient management. Guidelines standardizing initial care for patients have emerged as a result of optimizing basic clinical care, monitoring physiological parameters, and applying advanced life support algorithms (31).

The criteria determining death are essential for medical practice, legislation, scientific research, and organ donation (32). Healthcare personnel must be familiar with the physiological criteria of death, know how to assess them, and determine whether medical interventions constitute treatment or mechanical support for patients in the terminal phase. At the hospital level, resource allocation is based on patient condition, and standardized protocols should be established regarding the boundary between life and death. These are particularly important in the context of organ donation from deceased individuals, where organ procurement for transplantation depends on the precise determination of death. The definition of death should apply to all individuals, in all circumstances, and regardless of age. Therefore, clarity and consistency regarding the biomedical definition of death and its determination criteria are critical for medical staff (33).

The declaration of a patient's death is based on measurable and observable biological indicators, which are outlined in the death determination criteria (34). These criteria are crucial for ensuring legal and ethical practice in organ donors, where the immediate consequence of death determination is organ retrieval (36). The initial examination of the patient follows the ABCDE system: assessment and management of Airway, Breathing, Circulation, Disability, and Exposure (35).

Death is considered to have occurred when cerebral function is lost and cannot be restored spontaneously or through intervention. It is characterized by the complete absence of any form of consciousness and the absence of brain reflexes, including the ability to breathe independently (35).

Resuscitation measures and the advent of organ-supporting technologies, which allow maintenance or restoration of vital functions in patients with absent cerebral function, have blurred the line between life and death, highlighting the need to improve existing criteria for death determination and the measures to be taken when death is confirmed (36).

Determination of death by circulatory criteria is made based on the absence of extracranial circulation, which leads to the permanent absence of intracranial circulation (35). Blood pressure, ECG, and pulse should be monitored. These parameters are observed for at least 5–10 minutes in patients who are potential organ donors.

Determination of death by neurological criteria must meet certain prerequisites: there must be a severe brain injury capable of causing death, supported by neuroimaging evidence, and potential confounding factors in the clinical assessment must be considered and excluded.

This determination of death assesses:

- the absence of consciousness, demonstrated by the lack of wakefulness and response to stimuli,
- the absence of brain function, demonstrated by testing the cranial nerves,
- the absence of the ability to breathe, demonstrated by formal apnea testing (35).

The death of a polytrauma patient is considered a violent death and has medicolegal implications, even when it occurs some time after the event.

If the injuries lead to the patient's death, it may occur at the accident site, in the ambulance, or at the hospital. Deaths that occur within the first hours after the injury account for approximately 80%, and the causative injuries are usually traumatic brain injuries or massive hemorrhages. Late deaths occur several days or weeks after the accident and are secondary to sepsis or multiple organ failure (37).

When death occurs at the accident site, the body is taken over by the forensic medicine service, and the specific documents are subsequently prepared. If the patient dies in the ambulance, the personnel must hand over the body, along with the accompanying documents, to the nearest hospital. In this case, the Pathology Department will prepare the documents for transfer to Forensic Medicine.

When death occurs at the hospital, after confirmation, the body will be kept in the room or a specially designated area for 2 hours.

After the two-hour period following confirmation of death, the attending physician or the on-call doctor is required to notify the legal relatives of the deceased patient by phone, or the social worker in their absence. The notification must be recorded in the observation chart (the time, date, and the name of the relative or social worker who was informed, as well as the signature of the person who made the call).

The physician will complete the body transfer form before transporting the deceased to the morgue.

The deceased is transported without clothing, without valuable items (rings, earrings, etc.), wrapped in a sheet or placed in an opaque dark-colored plastic bag; the presence of fixed gold dental prostheses must be noted in writing (on the deceased's transfer form).

The deceased patient must obligatorily wear an identification bracelet with: name, surname, age, ward where admitted, date and time of death, and observation chart number.

The transport of the deceased must be carried out with the deceased's transfer form.

The following documents will be sent to the hospital's Pathology Department:

- Deceased's identity card/passport/birth certificate;
- Observation chart with daily updates, including confirmation of death and death summary with signature, stamp, and date;
- ED form completed and ED report – for deaths occurring in the ED or ambulance.

The staff in the morgue/prosecture unit will perform an external examination of the deceased and record the existing injuries. Signs of death are identified by: cadaveric rigidity in all body segments, postmortem lividity, and algor mortis, dehydration of the ocular conjunctiva and lips, and skin pallor. After completing the external examination, the deceased will undergo an autopsy, with each organ examined individually.

The forensic pathologist will complete the death certificate after performing the medico-legal autopsy.

RESPONSIBILITIES:

Head Nurse / Duty Nurse

- Notifies the legal next of kin of the deceased patient after 2 hours from the time of death confirmation.
- Records the notification in the patient's medical chart.
- Hands over the personal belongings of the deceased to the family members.

Attending Physician / On-Call Physician

- Prepares the hospital discharge documents for the deceased.
- Completes and sends the transfer form for the deceased.
- Sends the medical records and the deceased's identification documents to the Pathology Department.

Head of Department

- Is responsible for the proper implementation of organizational measures in case of death by the staff under their supervision.
- Oversees and ensures that the organizational procedures in case of death are correctly applied.

Pathology Department Staff

- Registers the deceased in the Deceased Register;
- Reviews the documents accompanying the deceased;
- Prepares the documents for transfer to the Forensic Medicine Service;
- Completes all necessary paperwork for the handover of the deceased.

DON'T FORGET:

- ✓ The death of a polytraumatized patient has medicolegal implications
- ✓ The deceased patient will remain in the ward for 2 hours before transport to the morgue
- ✓ The deceased patient must always wear an identification bracelet

Tips and triks

- **Be alert to subtle signs of hemorrhagic shock, especially in elderly patients who may be on cardiovascular medications that mask such signs, and in healthy young patients who may not show obvious manifestations.**

- **For all trauma patients, assume a cervical spine injury until proven otherwise. Cervical spine immobilization is not recommended in isolated penetrating trauma without secondary injuries and with a normal neurological exam, as it may increase mortality.**
- **Use equipment such as suction catheters, bag-valve-mask devices, video laryngoscopes, and cricothyrotomy kits for airway management in polytrauma patients.**
- **Airway obstruction is a major cause of immediate death after trauma. Ensure that the airway is stabilized and that the endotracheal tube does not move during patient transfer.**
- **Hemorrhage is the most common preventable cause of death. It is important to control bleeding and maintain adequate organ perfusion.**

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