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Master's Thesis

MANAGEMENT AND TREATMENT OF VARIOUS SURGICAL WOUNDS
(WOUND MANAGEMENT AND SURGICAL WOUND TREATMENT)

Master of Science in Nursing

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ABSTRACT

The problem of management and treatment of wounds and the occurrence of purulent wound infection and its treatment and prevention continues to be one of the most relevant problems in modern surgery and remains in the spotlight of surgical community's attention. The purulent and infectious complications are also a major problem in the post-injury period. Purulent wounds require long-term treatment and are associated with high treatment costs; all these call for new ways of improving the already existing ways of treatment. The aim of the study is to investigate the specific aspects of nursing process in surgery, to study the classification of wounds, the mechanisms of wound healing, the specific aspects of different types of wounds, to study the types of infected wounds and their causative agents, to determine the proper treatment of wounds in surgery and the associated roles of nursing personnel; to obtain samples from wounds and perform bacteriological testing, to determine the prevailing colony of microbial pathogens in the wound and to determine their sensitivity to antimicrobial agents. status. The data for this project was collected through general clinical assessment, general surgical assessments and microbiological tests, including microbiological testing of wound biomaterial and microbial sensitivity to antibiotics, history of present disease and health history; patient observation, physical examination, general health assessment; data comparison, laboratory and imaging tests; analytic method; and statistical research methods. When studying the mechanisms of wound healing in surgical patients, we have detected key points of care for patients with wounds; we have assessed the course of the wound process in surgical patients; we have identified the main methods of postoperative wound treatment and the ways to prevent their microbial contamination; we have studied the types of infected wounds and the methods of their treatment; in the study, we have determined the causative agents most frequently found in the wounds and leading to chronization of the wound healing process; we also assessed the sensitivity of microorganisms to

antimicrobial treatment with antibiotics for determination and use of optimal wound treatment approaches. These findings indicate the need for differentiated schemes of treatment of wounds in order to choose optimal wound treatment approaches.

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INTRODUCTION

The relevance of the study. The problem of management and treatment of wounds and the occurrence of purulent wound infection and its treatment and prevention continues to be one of the most relevant problems in modern surgery and remains in the spotlight of surgical community's attention. The purulent and infectious complications are also a major problem in the post-injury period [5, 11]. Purulent wounds require long-term treatment and are associated with high treatment costs; all these call for new ways of improving the already existing ways of treatment [3, 6, 12].

The significant relevance of care-associated problems is due to the fact that the number of patients with these problems is steadily increasing, reaching 35 to 40% of the entire patient population of surgical clinics and in-patient facilities [7, 10]. The need for basic patient care depends not only on the severity of the patient's condition, but also on the location of the wound. The patients with extensive wounds of the face, hands and feet are often incapable of movement or self-care and, despite satisfactory physical well-being, may require constant supervision and care of health care personnel [2, 13].

A crucially important aspect of wound care is its adequate treatment. Since purulent infection is caused by pathogenic microorganisms entering the wound, the cause of the condition should be primarily addressed [22, 30].

Therefore, lack of a definitive solution for the problem of care in purulent wounds and frequently unsatisfactory therapeutic outcomes stimulate global surgical community to develop new methods of treatment and care [4, 9].

The aim of the study: to investigate the specific aspects of nursing process in surgery, to study the classification of wounds, the mechanisms of wound healing, the specific aspects of different types of wounds, to study the types of infected wounds and their causative agents, to determine the proper treatment of wounds in surgery and the associated roles of nursing personnel; to obtain samples from wounds and perform bacteriological testing, to determine the prevailing colony of microbial pathogens in the wound and to determine their sensitivity to antimicrobial agents.

Study objectives.

1. To investigate the specific aspects, the classification and the mechanisms of wound healing.
2. To investigate the wound management roles of surgical health care personnel.
3. To define the principles of care for patients with postoperative surgical wounds.
4. To investigate the specific aspects of postoperative wounds in various patients.
5. To study the types of microbial pathogens isolated from the wounds of patients in the surgical practice of a nurse.
6. To study potential methods of treatment of infected wounds and the methods to prevent microbial contamination of wounds.
7. To compare the number of pathogenic colonies isolated from infected wounds.
8. To compare the sensitivity of pathogenic wound bacteria to various antibiotics.

The object of the study. Surgical patients with infected wounds who had a culture and sensitivity test in order to type the causative agents and to determine their sensitivity to antibiotics.

The subject of research. Nursing process as applied to surgical practice; wounds, wound process, infected wounds, identification of causative agents of wound infections and assessment of sensitivity to various types of antimicrobial drugs.

The methods of study included the following: general clinical assessment, general surgical assessments and microbiological tests, including microbiological testing of wound biomaterial and microbial sensitivity to antibiotics, history of present disease and health history; patient observation, physical examination, general health assessment; data comparison, laboratory and imaging tests; analytic method; and statistical research methods.

The scientific and practical value of the study. When studying the mechanisms of wound healing in surgical patients, we have detected key points of care for patients with wounds; we have assessed the course of the wound process in surgical patients; we have identified the main methods of postoperative wound treatment and the ways to prevent their microbial contamination; we have studied the types of infected wounds and the methods of their treatment; in the study, we have determined the causative agents most frequently found in the wounds and leading to chronization of the wound healing process; we also assessed the sensitivity of microorganisms to antimicrobial treatment with antibiotics for determination and use of optimal wound treatment approaches.

CHAPTER 1

THE PRINCIPLES OF SURGICAL TREATMENT OF WOUNDS IN NURSING PRACTICE (REVIEW OF LITERATURE)

The science of wound treatment has a long history. Back in the ancient times, humans sustained wounds and faced the need to heal them. Wounds are a type of injuries very common both in time of peace and in time of war. In all wars, wounds are the main cause of incapacitation, disability and mortality of combatants [1, 8]. The problem of inflammation attracted attention of scholars even in the ancient times. The description of external signs of inflammation, which allowed its isolation from a number of other abnormal processes, has been provided by Celsus (in I-II century CE). In part, Celsus has pointed out four signs of inflammation, i.e. redness, swelling, feeling hot and pain [6, 18]. In the age of Renaissance, wound treatment was dominated by the same methods as those used in the Middle Ages, such as cauterization with red-hot iron tools and boiling oil, treatment with various ointments and widespread "miraculous" remedies. The development of the doctrine of wounds was greatly contributed by the numerous wars in the XVII-XVIII centuries. The decisive boost to the doctrine of wounds has been given by the concept of antiseptics and asepsis, which has emerged in the XIX century [23].

As the knowledge area of wound care develops and is becoming relevant as a distinctive healthcare specialty, it becomes necessary to define practical competencies for all of the appropriate professionals in this field. Therefore, it should be borne in mind that the incalculable number of nurses practicing wound care in various institutions worldwide is making a unique contribution to the global wound care team [14, 20]. In addition, we may clarify the hierarchy of wound care nurses with different levels of licensing, certification and scope of practice, in order to distinguish between leadership and reimbursement issues for solving current health problems [15].

The variety of wound types and the multifacetedness of the wound process have become the reason for forming a large number of various understandings concerning classifications, pathogenesis, differential diagnosis and treatment approaches to this population of surgical patients, which supports the need for a detailed consideration of wound management issues during training and staff development of nursing professionals [1, 16].

A widespread encyclopedic definition of a wound is a full-thickness impairment of anatomical integrity of integumentary or internal tissues, often involving internal organs.

The traditional medical definition of wounds was primarily based on etiology, where the cause of the wound (currently referred to as acute wound) was the application of external force (knife, bullet etc.), while the abnormal process on the skin caused by “internal disease” (such as venous stasis with hypertension, diabetes, etc.) has been referred to as ulcer (this lesion type is currently referred to as chronic wound) [21, 24].

Presently, the majority of skin injuries are referred to as wounds; these are divided into acute and chronic depending on how long the patient has been experiencing them, and on a tendency to heal (or a lack of healing). Consequently, the etiological factor does not play a decisive role in this case.

According to modern understanding, all skin injuries are referred to as wounds (including diabetic wounds and radiation-induced wounds) [17, 33]. Whether external cause or internal cause was the primary factor, is not taken into account.

The current understanding of a chronic wound is a wound existing for more than 3 weeks or a wound incapable of proceeding through a consecutive process of restoring anatomical integrity and maintaining a functional outcome.

There is, nevertheless, a number of reasons, which do not allow discarding the previously existing classifications, since these older classifications accommodated the etiology of the process, the type of the damaging agent, the anatomical location, as well as the required therapeutic interventions and the therapeutic outcomes [9, 12]. In this connection, the research community decided to stop upon the following terminology.

The wound is an impaired integrity of tissues and organs, which occurs simultaneously with impaired integrity of skin and mucous membranes due to a number of reasons [25, 27].

The classic signs which allow for establishing the existence of a wound, include the following:

1. pain;
2. dehiscence;
3. bleeding.

Classification of wounds.

By etiology (depending on the type of the injuring agent) [10, 19,28]:

1. Surgical wounds (sustained in an operating room setting; these wounds are aseptic).

2. Accidental wounds.

Depending on the type of the injuring agent.

- Cut wounds (inflicted with a sharp object (knife, broken glass, razor); there is little damage to surrounding tissue, the edges of the wound are even and exposed, the bleeding is intense, the pain is moderate. As a rule, these wounds heal by primary intention;

- Stab wounds (inflicted with a sharp and long object (a narrow knife, bayonet, awl, nail, etc.), the inlet is small and the wound channel is deep; the pain is relatively weak, external bleeding is usually absent, but the bleeding may be internal; there is a high risk for anaerobic infection and damage to internal organs).

- Slash wounds (inflicted with a heavy sharp object (e.g. ax, saber); the pain is intense, there is a large area of necrosis around the wound with deep tissue damage; the bleeding is moderate).

- Compound, lacerated, crushed wounds (inflicted with a blunt object, such as a hammer, stone or log; the pain is intense, with damage and hemorrhage in the surrounding tissues. Crushed tissue is a favorable environment for the development of infection).

- Bites (these wounds occur as a result of an animal or human bite; their distinctive feature is heavy contamination by the microbial flora of animal or human oral cavity; these wounds have uneven edges, the healing is occurring slowly, there is a risk for rabies).

- Ballistic wounds (inflicted by shrapnel, bullets, shots; blunt, penetrating or tangential wounds; these wounds are characterized by a small inlet and large outlet, damage to internal organs, blood vessels and nerves; ballistic wound is a favorable environment for the development of anaerobic infection).

- Poisoned wounds (caused by chemical or biological toxic substances that enter the wound, i.e. bites of snakes, insects, etc.).

Depending on the presence and the quantity of microbial flora in the wound, the wounds are classified into [31, 37]:

1. Aseptic (clean) wounds are sustained under sterile conditions (that is, with adherence to aseptic precautions); according to modern understanding, surgical wounds are referred to as “conventionally sterile”, and require prophylactic antibiotics in the postoperative period.
2. Contaminated wounds (i.e. those with microbial contamination) include all accidental wounds, as well as the cases when due to conditionally clean surgeries the wound is populated by pathogenic microorganisms from the disease focus (i.e. from acute appendicitis, peritonitis etc); the decisive factor for conversion of a contaminated wound into an infected wound is an insufficient antibacterial therapy.
3. Infected wounds (including purulent ones) are the wounds characterized by the development of active inflammation with an immune component as a response to contamination by microbial pathogens in the absence of adequate antibacterial therapy.

In relation to body cavities, the wounds can be:

1. Penetrating.

2. Non-penetrating.

Depending on the presence of complications, the wounds can be:

1. Complicated.

2. Noncomplicated.

In terms of duration, the wounds can be:

1. acute
2. chronic

The factors that contribute to complications include the nature and the degree of tissue damage, and the presence of blood clots, areas of necrotic tissue and foreign bodies in the wound, as well as the counts and the virulence of microbial flora [26, 29].

The types of wound healing:

1. Healing by primary intention is the perfect type of healing, since it occurs rapidly and with a thin scar. This is the way aseptic surgical wounds or small superficial wounds are healing [3, 7]. The edges of the wound are tightly in contact and glued together due to fibrin. There is simultaneous growth of epithelium from the edges of the wound.

2. Healing by secondary intention occurs when the sides of the wound are not opposed, and in the presence of suppuration and excessive granulation tissue. Granulation tissue is a special type of connective tissue, a delicate fine-grained structure that bleeds at the slightest damage. The principal function of granulation tissue is to protect the wound from penetration by microbial pathogens. The granulations may be excessive (hypergranulations), in which case they are excised, or insufficient (hypogranulations), in which case they are stimulated (for example, by solcoseryl, a biologically active deproteinized derivate of bovine blood) [14, 20]. Normal granulations fill the entire wound more or less evenly.

3. Healing under scab occurs in insignificant superficial damage (abrasions, excoriations, attritions, etc.). The poured blood, lymph and tissue fluid clot on the wound surface. A dense crust (scab) is forming, which is playing a role of a

protective dressing [32]. The epidermis is rapidly forming under this crust, and the scab is detached. The type of wound healing is extremely important because it determines the clinical course of the wound process, as well as the entire therapeutic strategy. Virtually any wound may heal with or without suppuration. It all depends on a number of conditions. The conditions for healing by primary intention include the following:

1. Absence of high-grade microbial contamination of the wound.
2. Absence of foreign bodies, blood clots and non-viable tissues in the wound.
3. Sufficient blood supply.
4. Precisely opposed wound edges; no tension of wound edges or pockets.
5. Preserved nerve supply of wound edges.
6. Absence of metabolic disturbances (e.g. in poorly controlled diabetes). Any wound should be actively brought into compliance with these conditions, because in that case the treatment is going to take much less time.

The wound process occurs in phases, and surgeons have noticed that long ago. There have been different attempts at classification of the phases of the wound process. In part, according to the teaching of the wound process by N. Pirogov, the wound passes through the three phases of edema, wound cleansing and granulation [2, 11].

The modern classification of the phases of the wound process includes the following phases:

1) inflammation;

2) proliferation;

3) regeneration (cicatrization or scar formation).

The inflammation phase. This is the first stage on the way to wound healing. The process of wound healing begins from the moment when bleeding stops in the wound due to plasmatic clotting factors and the thrombocytic link of hemostasis [34]. Acidosis is formed in the wound and in the surrounding tissues due to impaired blood supply of damaged areas and due to accumulation of organic acids. While the normal pH of the body's internal environment is 7.3, the pH in the wound may be as low as 5 or even lower.

The excessive acidification in the wound may disrupt immunological responses. However, the wound acidosis is playing by and large a protective role since it prevents microbial organisms from reproduction. The increased acidity of tissues leads to their hydrophilic transformation, paralleled by the increased permeability of capillaries [13, 18]. Hyperkalemia occurs in parallel to development of acidosis. There is active exudation into the wound, which promotes its cleansing. Simultaneous edema and swelling of wound edges facilitate approximation and proper juxtaposition of wound edges, which ensures delimitation of the inflammation zone from the outer environment. Provided the wound edges are precisely opposed, there is simultaneous gluing of the wound edges due to sedimentation of fibrin on the wound walls. There is a profound metabolic change in the wound; the metabolic processes are shifted towards catabolism. There is a simultaneous migration of inflammatory cells (macrophages, polymorphonuclear white blood cells, lymphocytes) into the wound [32, 35]. These cells, being triggered by mediators of inflammation, release enzymes and other biologically active substances into the wound. Proteases promote the lysis of non-viable tissues. Oxidase prevents excessive accumulation of toxins. Superoxide dismutase (SOD) leads to the accumulation of reactive oxygen species, which have a toxic effect on microorganisms. Lipase destroys the protective membranes of microbial cells and makes them vulnerable to other protective factors of the host.

There is also a concomitant increase in serum protection factors in the wound. At the end of the inflammation phase, the wound is cleansed from the products of decay (if previously present), with a gradual and smooth transition to the next phase. When the wound is healing by primary intention, this phase is short and takes 2-3 days; however, when the wound is healing by secondary intention and/or suppurated, this phase may take over a week [16, 24].

Proliferation phase. This phase lasts up to 14-28 days after sustaining an injury. It is characterized by predomination of granulation processes. Granulations are a "young" connective tissue, which contains large numbers of proliferation-capable cellular elements. There is improved tissue nutrition, ingrowth of new capillaries into the newly formed tissues, improved microcirculatory processes and reduced tissue edema. The metabolic processes are shifted back towards anabolism.

Regeneration phase. Depending on how the wound healing was occurring (by primary or by secondary intention), there is either epithelization of the wound by epithelium "creeping over" from the edges of the wound (i.e. healing under scab or by primary intention) [17, 29], or a coarse connective tissue scar is formed (i.e. healing by secondary intention).

The treatment of accidentally sustained wounds should aim at wound healing by primary intention [38]. The chances for such favorable scenario are greatly increased by performing primary surgical debridement of the wound.

At the first aid step, the health professional should stop the bleeding and close the wound with an aseptic dressing. If there is any damage to the bone apparatus, shunting is performed. The stage of qualified physician's intervention includes final arrest of the bleeding and wound debridement. Wound debridement includes the following:

1) Arrest of the bleeding;
2) Revision of the wound cavity, removal of foreign bodies and non-viable tissues;
3) Excision of wound edges, processing with antiseptics;
4) Opposition of wound edges (suturing the wound).

Depending on the timing of debridement, the classification includes the following:

1. Primary debridement (up to 6 hours after sustaining an injury);

2. Delayed debridement (6-24 hours after sustaining an injury);
3. Late debridement (more than 24 hours after sustaining an injury).

In primary debridement, the objective is to create the conditions under which the wound will heal by primary intention. However, this is not always feasible and/or expedient [28, 36]. In some cases, it is more reasonable to leave the wound healing by secondary intention. When dissecting the wound edges, the surgeon should not aim at dissecting as much tissue as possible. Only non-viable tissue should be removed, in order to allow for subsequent adequate opposition of wound edges without strong tension (since in strong tension, there is ischemia of wound edges, which makes healing more difficult).

The final stage of initial debridement includes applying sutures to the wound [26, 33]. Depending on the timing and the conditions of suture application, the following sutures are distinguished:

1) Primary sutures. These are applied and tied immediately after debridement. The wound is sutured tightly. The precondition to apply primary sutures is than not more than 6 hours should have elapsed after sustaining an injury. In a setting of prophylactic antibiotic therapy, this time period may be extended up to 24 hours;

2) Delayed primary sutures After primary debridement of the wound, a thread is led through all the layers of the wound without tying it. An aseptic dressing is applied to the wound [15]. As a next step, in the absence of signs of inflammation and/or purulent effusion, the dressing should be removed and the wound should be closed, tying the sutures;

3) Secondary early sutures. These sutures are applied to a purulent wound after it has cleansed and granulations have begun to form. The edges of the wound are pulled together, which reduces the size of the wound and accelerates its healing;

4) Secondary late sutures. These sutures are applied after scar formation, which is dissected. The edges of the wound are opposed.

The treatment of a purulent wound is different from the treatment of a wound without signs of inflammation. The principles of active surgical treatment of purulent wounds and acute purulent surgical disease.

1. Debridement of the wound or a purulent focus.

2. Draining of the wound with a polyvinyl chloride drain and prolonged washing with antiseptic solutions.

3. Early wound closure using delayed primary sutures, early secondary sutures and skin grafting.

4. Systemic and local antibacterial therapy.

5. Boosting specific and non-specific host defenses.

Cut wound (provided there is no infection) will normally heal by primary intention, because all the necessary conditions are met [4, 19, 31]. Slash wounds, compound wounds, and most certainly lacerated wounds heal by secondary intention. This is why all of these wound types are essentially converted into cut (incised) wounds via primary debridement.

Bites (bite wounds). The characteristic feature of bite wounds inflicted by animals is their profuse contamination with saliva. Animal saliva contains large numbers of pyogenic flora; however, the purulent process in this setting is not much different from a "conventional" purulent wound process. Cat bites may have an additional allergic component, since cat proteins are strongly allergenic [25, 37]. A combination of feline bites and excoriations may lead to a specific inflammatory disease, i.e. felinosis. If untreated, human bites have a very aggravated course. Human saliva contains large numbers of anaerobic microorganisms; therefore, if inflammation develops, it is usually of a putrefactive nature. In addition to that, the microorganisms isolated from humans possess resistance to multiple antibiotics.

Ballistic (gunshot) wounds. The severity of the wound depends on the type of missile and on its kinetic energy [23, 32]. A ballistic wound is characterized by the fact that several zones of tissue damage are distinguished in that wound.

1. The wound tract, which is formed by a missile. It contains the missile per se, gunpowder particles, combustion gases, fragments of clothing and blood clots.

2. The zone of primary tissue necrosis around the wound tract. This zone is formed due to the crushing effect of the missile.

3. The zone of molecular concussion. This is the zone of tissue damage, where microcirculation is impaired and necrobiotic processes are developing. This condition is potentially reversible, but the events are most frequently moving in an unfavorable direction, and the zone of necrosis is expanded [22, 30].

A characteristic feature of gunshot wound management is a broad dissection along the entire wound tract and removal of necrotic tissue. In peacetime, primary sutures can be applied. In combat conditions, delayed primary sutures are applied.

Purulent wounds. The treatment is conducted according to the stages of the wound process.

1. During the inflammation phase, local treatments are used, such as daily dressing changes using the entire range of mechanical, physical and chemical methods of antisepsis. When indicated (e.g. in profuse exudation), more frequent dressing changes are performed. The injured body segment is immobilized and detoxification and antibacterial therapy is carried out. The antibiotics are prescribed with allowances made for sensitivity of the isolated microbial flora; the duration of the course is up to 3 days of normal body temperature.

2. During the proliferation phase, when there no longer is any exudate and the wound is filled with granulations, local treatment is made more sparing. Dressing changes are done in such a way as to avoid damage to granulation tissue; no wound irrigation is used. Ointments and creams that contribute to tissue regeneration (Methyluracil, Actovegin). Active electrotherapy is used (ultrahigh frequency therapy, laser therapy, magnet therapy, etc.) [5, 21].

3. No active treatment is indicated during the regeneration phase.

In order to ensure successful wound healing by primary intention, the nurse shall provide for the following interventions:

1. Pain control: selection of patient's position in the bed taking into consideration the location of the wound and administration of analgesics as prescribed by the physician.

2. Prevention of secondary infection: monitoring the status of the dressing, helping the physician with dressing change, ensuring compliance with aseptic precautions during instrument-assisted dressing change, and administration of antibiotics as prescribed by the physician.

3. Monitoring the patient's general condition: observation of the patient's appearance, measuring blood pressure, heart rate (HR) and body temperature, and monitoring hematologic parameters as prescribed by the physician.

5. Removal of cutaneous sutures: preparation of instruments, ensuring compliance with aseptic precautions when performing the interventions [27, 34].

On a global scale, the physicians and nurses who are conducting high-priority research studies in the area of diagnosis and treatment of patients with wounds and purulent infection, including those in a setting of other disease (e.g. diabetes or varicose veins of the lower extremities and atherosclerosis) have a common goal of reducing patient mortality and disability [35, 38], and mitigating the risk for recurrent inflammation in the wound. Modern highly specialized doctors and nurses are developing new active surgical tactics, as well as unique methods of surgical interventions and intensive care, which allow achieving excellent therapeutic outcomes in anaerobic infection, extensive purulent wounds, post-traumatic and hematogenous osteomyelitis, trophic ulcers, purulent-necrotic forms of diabetic foot and various postoperative purulent complications.

CHAPTER 2

THE OBJECT OF RESEARCH AND METHODS OF STUDY

The object of our research included surgical patients with infected wounds who had a culture and sensitivity test in order to type the causative agents and to determine their sensitivity to antibiotics.

During analysis of nursing process in surgery during treatment of wounds, as well as during comparison of bacterial colonies isolated from the wounds and testing sensitivity to antibiotics, we used the following methods:

- general clinical assessment,
- general surgical methods,
- microbiological testing methods,
- collected history of present disease and health history: anamnesis vitae, anamnesis morbi, observation, information about the patient's mental health, physical examination data, general health assessment and collecting information on major complaints,
- comparison,
- analytical methods,
- statistical methods,
- laboratory and imaging tests.

This study consisted of patient observation and data analysis.

In the first part of the research project, we carried out a bacteriological study (microbial culture) of the biological material isolated from the wounds of surgical patients. We also compared the species of the detected microorganisms and their numbers using microbiological methods of wound contents inoculation.

The study enrolled a total of 86 surgical patients who had inoculations of material from the wounds with failure to heal for more than a week (i.e. from chronic wounds).

In the second part of the research project (that is, when detecting antibiotic sensitivity) we isolated microbial cultures. After this, we put a small disk soaked with the antibiotic into a Petri dish with the culture and then performed the applicable measurements to assess the growth of microbial colonies.

As a next step, we have conducted data analysis, comparisons and data summarization with inferencing.

CHAPTER 3

TREATMENT OF POSTOPERATIVE WOUNDS

Postoperative wound is a skin incision, which is usually made with a scalpel during a surgical procedure. Surgical wounds are closed by suturing or by using surgical staples or surgical glue. Wound process is a complex set of local and systemic biological responses of tissues and systems in the body, directed at delimitation and rejection of necrotic masses, infection control, and restoration and replacement of damaged structures.

The majority of surgical wounds are classified as acute wounds, which heal uneventfully within expected time frames. However, as with all wounds, the healing is affected by internal and external factors, which may lead to complications.

Preoperative skin preparation has been the subject of some debate, especially regarding the potential impact on postoperative wound infection.

In some cases, shaving is necessary to gain access to the surgical site and to prevent the hair from tangling in the suture line. Shaving has become a routine part of preoperative care and remained intact until the 1970s, when it has been suggested that shaving was potentially associated with infection of the postoperative wound, causing superficial skin damage and contributing to bacterial colonization. There are, however, no definitive studies in that regard.

Preoperative bath or shower: in the past, patients were advised to wash with aseptic solutions before the procedure. At least three showers with chlorhexidine would be required to effectively reduce the number of bacteria on the skin; although no statistically significant results have been provided regarding the incidence of wound infection.

Taking a shower is generally preferred over bathing as it is less likely to transfer organisms from highly colonized areas such as the perineum to less colonized areas. In the same way, the likelihood of transferring microorganisms from one patient to another is higher if the baths are not properly cleaned between patients.

Other bacteria-containing lesions, such as pressure ulcers, increase the risk of infecting a postoperative wound. Whenever possible, the surgery should be postponed until they are healed. Orthopedic surgery can be disastrous if the patient develops a deep wound or bone infection; therefore, it is rarely performed if the patient has any infection elsewhere.

In cases where a surgical intervention cannot be avoided, covering existing lesions with hydrocolloid at least one day preoperatively and leaving it for 24-48 hours afterwards may ensure the best protection since it is completely occlusive. There is no scientific evidence to support this claim, but, from the author's own experience, it can be used in some areas to reduce bacterial dissemination in the immediate postoperative period.

All wounds pass through a certain cellular and biochemical healing sequence. Immediately after the injury, mast cells are degranulated and release mediators of inflammation, which allows for dilation of local blood vessels. Neutrophils enter the wound area to digest bacteria, followed by macrophages, which fill the wound bed and release growth factors and prostaglandins that impact the healing process. This inflammatory phase is often characterized by redness and edema around the wound, which are accompanied by fever and pain. In clean postoperative wounds, this phase may last from three to seven days.

During the reconstructive or proliferative stage, there is growth of new vessels and tissues. Fibroblasts migrate into the wounds, and, in addition to the growth of new vessels, there is collagen synthesis and filling the wound with granulation tissue. As the defect is filled, the wound is pulled together and epithelial tissue is formed along the edges. This stage is finished when the wound is completely closed.

At the final stage of healing, i.e. maturation, the wound is regaining its tensile strength. As collagen fibers are reorganized, the scar is losing a part of its red pigment and becomes more flat on the surface of the skin. This phase may take up to 18 months.

Postoperative wound care includes aseptic processing of the wound, protection from external irritating stimuli and routine wound inspection. The care is performed in order to prevent complications and to accelerate wound healing.

Optimal treatment of postoperative wounds in an outpatient setting is important for prevention of potential complications, such as surgical site infections and suture line disruption/wound dehiscence. Therefore, general practitioners who are playing an important role in the treatment of subacute postoperative wounds, should understand the physiology of wound healing and the principles of care for postoperative wounds.

Key elements of postoperative wound care include timely wound inspection, adequate wound cleaning and dressing changes, as well as early recognition and active treatment of wound complications.

There are two principal types of wound healing: healing by primary intention and healing by secondary intention. The vast majority of surgical wounds are subject to primary closure, where the loss of tissue is minimal and the wound edges can be satisfactorily approximated. This ensures healing by primary intention, with rapid wound epithelization and minimal cicatrization.

Healing by secondary intention involves the process where the full thickness of the wound is deliberately left exposed. This may be associated with the presence of infection or with inability to achieve satisfactory rapprochement of the wound edges. When healing by secondary intention, the wound is healing in a natural way via granulation, possible reduction and slow epithelization. The wounds that are subject to healing by secondary intention often result in larger scars.

Regardless of the wound healing mechanism, the goals of postoperative wound care remain the same: to provide for a rapid and uneventful wound healing, with the best possible functional and esthetic outcomes.

In particular, the wounds to be healed by primary intention should have well-approximated wound edges. At the initial stage of healing, the wound has but a minimal tensile strength, since no remodeling of collagen fibers occurs. Therefore, there is a need for additional support (available as sutures, staples or bands) until full remodeling and epithelization occurs.

The main function of wound dressings is to promote healing by creating a moist environment and by protecting the wound from potentially hazardous agents and damage. In closed surgical wounds, the main function of the dressing is to absorb blood or hemoserous fluid in the immediate postoperative period. There are many types of surgical wound dressings, and the choice often depends on cost considerations and on personal preferences.

The most commonly used types of dressings include simple, low-adhesion islet-type dressings. However, care should be taken since some adhesives may cause adverse cutaneous reactions in patients with sensitive skin. Blisters may occur if dressings are applied with tension or on a joint whose movements lead to friction between the skin and the dressing. The choice of dressing should also be informed by the patient’s needs. For example, if the patient is treated in a day hospital, waterproof dressing may be the most suitable option if the dressing must be in place for more than 24 hours.

The decision how often and for how long the dressing on the surgical wound shall be changed also depends on personal preferences. Some surgical units prefer to leave the wounds open from the moment of closure, others open them in 24 hours, and the third ones keep them dressed until complete healing and removal of sutures/clamps/staples.

There is no conclusive evidence in favor of a specific approach to management of incision sites. When dressings are applied in the operating room, it is recommended to avoid disturbing them unless when they are stained with discharge/blood, when there are clinical signs of infection or when the patient has signs of a systemic infection. There is no need to change the dressing of a closed surgical wound in 48 hours. However, some patients may prefer to have the dressing on their wound changed.

Open surgical wounds that heal by secondary intention should be appropriately dressed in accordance with their size, depth and position. Unfortunately, many surgeons opt for gauze dressings to be used in the operating room, which cause excessive pain when removed and may completely fuse with the healing tissue. A study of hydro-fiber dressings vs the traditional gauze dressings in excision surgery (a type of surgical intervention when an entire lesion or organ is removed) has demonstrated smaller duration of hospitalization, reduced pain, increased confidence of patients and accelerated healing; in addition to those, these dressings are easier to apply and remove.

The following principles are advice should be used for changing dressing and for cleaning the wound:

- Use aseptic non-contact method for changing or removing dressings.
- Strive to leave the wound intact for 48 hours after the surgery, using sterile normal saline for wound irrigation during this period only if necessary.
- Tell the patients that it is safe to take a shower in 48 hours after the operation.
- Use tap water to wash the wound in 48 hours if the wound burst open or was opened surgically to allow the outflow of pus.
- Use an interactive wound dressing for the surgical wounds that are healing by secondary intention.

Antibiotic treatment should be performed according to the following rules:

- If a microbial contamination is suspected (either primary or due to lack of treatment efficacy), administer antibiotic in the patient.
- Select the antibiotic, which is known to be effective in the likeliest causative agents. Take into account the local resistance models and the results of microbiological tests.

Specialized wound care services:

- In order to improve the management of surgical wounds, use a structured approach to care and provide extended training.

Do not use the following agents to reduce the risk for infection:

- local antimicrobial agents for surgical wounds healing by primary intention,
- gauze or mercury-containing antiseptic solutions for surgical wounds healing by secondary intention

Dressings are another important component of postoperative wound care. A good dressing should maintain an optimally moist wound environment and thus promote wound healing. It should also be able to remove excessive exudate that may lead to wound maceration, and provide for a good barrier against bacterial or fluid contamination. This material should adhere to the skin, but be nevertheless non-traumatic when removed.

Since no two wounds are the same, dressing change routines shall be customized according to the needs of each patient with a wound. The factors that shall be taken into consideration when selecting a proper dressing, include the position, size and depth of the wound, as well as the level of exudate/effusion. A detailed discussion of all types of dressings goes well beyond the scope of this work, but general recommendations on selection of suitable dressings have been provided. The dressings applied intraoperatively have been applied under sterile conditions and ideally they should remain in place for the time period established by the surgical team.

It is permissible to remove the initial dressings prematurely when there is a need to inspect the wound, and, in some situations, to apply a new dressing. Such situations include the cases when the dressing no longer serves its purpose (e.g. when the dressing falls off or when excessive amount of exudate seeps through the dressing, which leads to suboptimal conditions for wound healing), or when a wound complication is suspected.

Two main potential complications may occur in surgical wounds: suture line disruption and microbial contamination. Suture line disruption may vary from splitting of skin layers to complete dehiscence of muscles and fascia, exposing internal organs. Sometimes, skin layers are intact, but deeper layers are destroyed, which leads to postoperative herniation.

Many factors are associated with suture line disruption in a surgical setting. It is believed that age, malnutrition, being male and long-term steroid use affect the incidence of suture line disruption in abdominal cavity, while such factors as smoking, diabetes and rheumatoid arthritis may adversely affect the healing by impacting microcirculation. While malnutrition adversely affects healing, obesity may contribute to destruction of wounds due to reduced tissue oxygenation and increase in subcutaneous "dead space", making the patient more susceptible to hematomas and seromas and increasing the incidence of infections.

Applying tight sutures may lead to skin rupture and impaired blood supply of the wound edges, which in turn may lead to necrosis and splitting of the wound (dehiscence). Insufficient use of electrocoagulation in surgery may lead to excessive bleeding and hematoma formation. The "dead space" left in place of a hematoma may weaken the suture line and become a focus of infection. In most cases, blood is absorbed within a few days; alternatively, one or two stitches may be removed in order to provide for drainage. In severe cases, the sutures must be re-opened, and the hematoma must be surgically evacuated. After the cleansing, the wound may be re-sutured or allowed to heal by secondary intention.

Wound infection is characterized by redness, pain, local/systemic hyperthermia and edema of the wound and the wound site. These signs are also found in a normal inflammatory response, but usually they subside after a few initial days. Persistent inflammation or the presence of pus or purulent discharge may suggest an infection. The factors that influence the incidence of wound infection are identical to the factors that influence suture line disruption, although any drains and sutures in place are effectively acting as foreign bodies and thereby increase the risk of microbial contamination.

Timely removal of sutures, staples or clamps is beneficial for the prevention of infection. When infection is diagnosed or suspected, it is recommended to start appropriate systemic antibiotic treatment and remove the drains, sutures and staples at the infection site. Infection often leads to incision line disruption. In situations where the wound has obvious signs of destruction, attempts at preserving its integrity often make no sense. Removal of sutures and staples will allow for a better wound assessment and contribute to healing by secondary intention or by delayed primary intention.

CHAPTER 4

INFECTED WOUNDS AND METHODS OF THEIR TREATMENT

Infected wound is a local defect or splitting of the skin or the underlying soft tissue, where microbial pathogens invade the viable tissues surrounding the wound. Wound infection triggers a host immune response, causing inflammation and tissue damage, as well as slowing down the healing process. Many infections will remain limited and will disappear spontaneously (such as an excoriation or an infected hair follicle). Other infections may become more serious if untreated and may require medical intervention.

The skin is the body's first line of defense; the surface of the skin is protected by a thin acidic film produced by sebaceous glands (this film is referred to as the acid mantle). This acid mantle is a dynamic barrier that regulates skin pH and supports normal cutaneous microbiome, the latter preventing pathogens from entering the body. However, pathogens may often out-compete some part of the normal microbiome and colonize certain areas, but in most cases, this does not lead to infection and does not stimulate immune responses. However, if skin integrity is compromised or the immune system is weakened, virtually any microorganism that colonizes the skin or enters the wound may become capable of causing an infection. The microbial species, which may infect a wound, mainly depend on the microorganisms present on the skin, as well as on the depth and location of the wound.

Some people are more susceptible to wound infections due to underlying respiratory or cardiovascular disease, which affect the delivery of oxygenated blood to the tissues. Elderly people are especially vulnerable to infection.

Pressure ulcers consist of ischemic tissues, which makes them more susceptible to infection. This is attributable to the fact that ischemic tissue is not receiving enough nutrients, oxygen, immune cells, antibodies and antibiotics.

Diabetes is known to weaken the immune system because it is associated with nerve dysfunction and peripheral arterial disease.

In addition to that, human immune capacity is adversely affected by renal insufficiency, malignancies, rheumatoid arthritis, obesity and malnutrition.

Medications such as steroids and cytotoxic drugs may also adversely affect the patient’s immune system and their subsequent capacity to fight infection.

Psychosocial factors, including poor personal hygiene and unhealthy lifestyles (e.g., smoking) will further hinder the body's attempts to remain infection-free.

Diagnosis of wound infection is essentially a clinical skill. The classic signs of infectious inflammation include pain, redness, hyperthermia, and swelling around the wound, and are mostly associated with acute infections.

The World Union of Wound Healing Societies (WUWHS) has proposed additional signs and symptoms of localized and expanding wound infection, which include the following: new, increased, or changed pain; near-wound edema; change in the color of the wound bed, etc.

Infected wounds are more painful than uninfected ones. As a result of an inflammatory response caused by bacterial enzymes, the tissue releases free radicals, which cause damage and pain. Consequently, the presence of, change of or an increase in wound pain are important indicators of wound infection.

Diabetes-associated neuropathy may mask the presence of pain and other signs of inflammation. Redness of the foot in diabetic patients can be caused by other inflammatory processes, such as Charcot arthropathy, which makes it particularly difficult to diagnose wound infection in this patient population.

Although microbiological tests may provide information to assess wound infection, it is important to emphasize that wound smears are not routinely recommended in clinical practice.

Clinicians may often erroneously assume that the wound smear culture will diagnose wound infection. It is the clinical presentation that leads to the diagnosis of wound infection, while the result of a wound swab confirms exactly which bacteria are present in the wound bed.

This is why a wound swab should only be obtained if the clinical presentation suggests wound infection. In some cases, the wound swab results may read “no growth detected”, which is reportedly suggesting the absence of infection. This negative result may be a false negative due to poor wound swab technique.

The wound swab technique should be reliable and comply with local wound care protocols. Prior to obtaining the swab, the wound bed should be cleansed from the dressing debris and superficial contamination. If the wound bed is dry and clean, moisten the tip of the swab with sterile saline before rubbing the wound. Wetting the swab increases the chance of extracting bacteria from a dry wound.

If the wound is large, obtain the swab from an area of a least 1 cm^2, including the bottom and the edges of the wound. If pus is present, obtain a sample for analysis.

The swab shall be returned into the container immediately after the procedure and delivered to the laboratory as soon as possible, preferably within four hours. It is important to label the swab correctly and to provide the information, which will help interpret the results.

The information required by the laboratory will include any underlying disease, age of the patient, current antibiotic or antimicrobial therapy, wound location, as well as the clinical signs and symptoms of wound infection.

It is important to maximize the host's potential to fight wound infection. This will include improved control of underlying disease, e.g. reducing and/or stabilizing blood sugar levels, correction of malnutrition and pain management.

Wound care will include wound cleaning with every dressing change, as well as removal of non-viable tissues (i.e. those with desquamation and necrosis), which effectively are a source of nutrients for bacteria and promote bacterial growth.

Topical antimicrobials play an important role in the prevention and treatment of wound infection. Antimicrobial is the terminology used for antiseptics and antibiotics, which kill or inhibit the growth of bacteria.

Antimicrobial dressings contain antiseptics possessing a wide spectrum of nonselective antibacterial effect. Such dressings will differ in terms of type and amount of the antiseptic they contain, as well as in terms of duration of effective action and cost efficiency.

Antimicrobial dressings may be used as an independent modality to prevent wound infection in a patient or for treatment of localized wound infection. The management of local expanding or systemic infection will require a combination of systemic antibiotic therapy and antimicrobial dressings.

The antiseptic components found in wound dressings include polyhexamethylene biguanide (PHMB), chlorhexidine, iodine- and silver-containing preparations, ionic silver, nanocrystalline silver, etc.

When selecting an antimicrobial agent, the nurse should find out whether the proposed dressing will be effective against known or suspected microorganisms. In addition to that, the nurse should make sure that the dressing is capable of dealing with problems of the wound, such as moistening of the wound bed, exudate absorption and elimination of the wound odor.

The clinical presentation of infected wounds includes fever, erythema, swelling, induration, increased pain and change of the nature of secretions to purulent. However, the symptoms of infection are more difficult to discern in chronic wounds or in debilitated patients. In such cases, the diagnosis may be based on non-specific symptoms, such as loss of appetite, malaise or less effective glycemic control in diabetic patients.

The treatment of skin wounds is a key study area in connection with the important functional and esthetic role of this tissue. When the skin is damaged, bacteria may soon penetrate the underlying tissues, which may lead to life-threatening infections.

Consequently, the management of such abnormal conditions calls for effective treatment methods. More recently, the wound dressings that contain antimicrobial agents have become an effective modality to reduce bacterial colonization of the wound and to arrest microbial contamination in order to improve the healing process.

The wound may present as a simple or severe organ damage (e.g. skin) or tissue damage, and may involve other tissue and anatomical structures (e.g. subcutaneous tissue, muscles, tendons, nerves, blood vessels and even bones). Among all organs in the human body, the skin is undoubtedly the most susceptible to damage and injuries, excoriations and burns. The damage to epithelium and connective tissue structures weakens the capacity of the skin to provide protection from environmental factors. Therefore, it is extremely important to reconstruct the functional epidermis and even other layers of the skin. This occurs as a result of intertwining phases known as wound healing or wound regeneration. Regeneration is achieved as a result of the skin’s ability to replace the lost skin structure with viable structure and as a result of scar formation.

After diagnosing an infected wound, an important first step in wound healing is wound debridement. This procedure includes a thorough cleaning of the wound area and removal of all calluses, infected and dead tissue, as well as foreign particles and dressing debris covering the surface of the wound. After wound debridement, the cells in this area are stimulated to release cytokines and healing factors, which allow the body to heal the wound properly.

An effective treatment plan accommodates multiple factors, including elimination of major problems, such as poor blood flow and reduced oxygen supply due to diabetes and nutrient deficiency, as well as the duration and the type of existing infection.

Incorrect recovery process can cause serious damage, such as loss of skin and the onset of infection with subsequent damage of underlying tissue and even systemic infection. The most frequent and inevitable obstacle to wound healing is mechanical transmission of infection, more frequently in case of chronic wound. Although bacteria are a regular part of microbiome of both intact skin and wounds, the critical threshold of existing bacteria and biofilm formation may interfere with wound healing. In this respect, despite the recent progress in wound management, bacterial and fungal infections are still among the most prevalent and painful conditions leading to significant mortality and morbidity. Methicillin-resistant *S. aureus* and *Pseudomonas aeruginosa* are the predominant strains of microbial organisms found in patients with infected wounds.

Due to the characteristic non-sterile biological environment of the wound and the extremely complex wound healing system, effective and targeted therapies are still required. Consequently, current research is directed towards finding more effective therapeutic agents for both chronic and acute wound infections. In the case of chronic wounds, where patients are often subjected to intensive treatment and regular dressing changes, a fully soluble, non-adherent wound dressing that accurately distributes treatment to the wound site may improve therapeutic outcomes and wound response to drugs.

Wound dressings are typically used only for protecting the wound from external contamination, but they can also be functionalized by using various therapeutic devices for delivery to the wound sites. Unlike traditional dressings (such as cotton bandages), which play no active part in the healing process, the improved wound dressings may participate in wound healing due to the presence of active ingredients. Integrated complexes should be playing a dynamic role in the wound healing process by removing necrotic tissue, preventing/treating established infections or by a combination of these actions. In this respect, the dressings may be improved by many antibiotic classes (such as quinolones, tetracyclines, aminoglycosides, cephalosporins, etc.) or other substances possessing antibacterial properties (e.g., essential oils). Wound dressings with antibiotics are useful in treating local infections when high concentrations of antibiotics are required.

However, in some cases, large amounts of antibiotics may lead to systemic toxicity. In recent years, there has been a decline in the development of new antibiotics and but a small number of companies are still working actively in this field. In addition to that, there has been a significant increase in antibiotic-resistant microorganisms, in part due to excessive use and misuse of antibiotics. This antibiotic crisis is still going on and impacts the treatment with antibiotics used for both systemic and local infections. For example, the treatment of chronic wounds (in diabetic foot, venous ulcers and pressure ulcers) usually involves long-term therapy.

As soon as the skin is damaged, typical microorganisms of normal cutaneous flora, as well as exogenous bacteria and fungi may soon get access to underlying tissue, which provides a moist, warm and nutrient-rich environment for their development. However, when healing is delayed, normal wound microbiome is changed and more aggressive microbial types emerge. Consequently, an open wound may be a favorable place for microbial proliferation and colonization. In the initial phases of chronic wound formation, Gram-positive microorganisms are most frequently found, mainly *Staphylococcus aureus*. In the late phases, the predominant microorganisms include Gram-negative species (such as *Escherichia coli* and *Pseudomonas sp.*). These pathogens are likely penetrating into deeper skin layers with significant tissue involvement. In addition to that, types of cocci are present in approximately 50% of chronic wounds. Wound site infection begins with contamination and continues as (acute) colonization and microbial contamination of the wound.

Neither infecting, nor colonization of the wound causes an immune response in these patients. In addition to reproduction of microbial cells, acute colonization is usually associated with an increase in local pain and with an onset of inflammatory response. When healthy tissues are invaded by microorganisms, this creates a cascade of local and systemic host reactions, such as purulent expulsion, expanding erythema, or symptomatic cellulitis.

As was already mentioned, unrestricted development of microorganisms may delay wound closure due to exacerbation and a prolonged inflammation stage. Problem-causing pathogenic microbial agents are summarized in Table 4.1.

Table 4.1. The types of microorganisms most commonly found in acute and chronic wounds

Variant	**Form**	**Metabolism**	**Incidence**
Staphylococcus aureus	Cocci	Facultative anaerobic	Chronic wounds
Staphylococcus epidermidis			Acute wounds
Streptococcus pyogenes		Aerobic	Chronic wounds
Pseudomonas aeruginosa	Bacilli	Aerobic	Chronic wounds
Stenotrophomonas maltophilia			
Escherichia coli		Facultative anaerobic	
Proteus sp.			
Klebsiella sp.			
Propionibacterium acnes		Aerotolerant anaerobic	Acute wounds
Acinetobacter baumannii	Coccobacilli	Aerobic	Chronic wounds

The infection in chronic wounds is often polymicrobial, which enhances the synergistic effect (both aerobic and anaerobic microorganisms mutually support their persistence and reproduction). This collective effect may be usually supported by oxygen consumption. Aerobic bacteria may contribute to tissue hypoxia by creating favorable conditions for anaerobic reproduction. Once anaerobic species are established, they can interfere with the phagocytosis of other microorganisms by producing short-chain fatty acids. Moreover, the flow of nutrients from one bacterium can support the evolution and reproduction of another one. In many types of chronic wounds, usual findings include S. aureus and P. aeruginosa, which are growing simultaneously in co-cultures.

Complications of purulent wounds may include the following:

- lymphadenitis,
- lymphangitis, - thrombophlebitis,
- osteomyelitis,
- pyarthrosis,
- cellulitis,
- abscess,
- sepsis.

The development of putrefactive infection is also possible. Putrefactive infection is caused by the following pathogens:

- Proteus,
- E. coli,
- fusiform bacillus,
- sporogenic bacteria.

Manifestations of putrefactive infection: foul smell appears in the wound, necrotic tissue changes are increasing; the purulent exudate acquires a dirty gray color, akin to meat slops in appearance. The zone of tissue necrosis is progressively increasing and expanded; however, unlike clostridial (gaseous) gangrene, there is no gas formation in the tissues.

Anaerobic infection is an infection caused by clostridial spore-forming anaerobes.

Paravulnar cellulitis. As a result of diffuse active purulent infiltrative inflammation of the tissues around the wound tract, a phlegmonous inflammation develops, which does not have any distinctive borders and passes into intact tissue structures.

Fistulas are the narrow channels through which the suppuration focus in the depth of the gunshot wound communicates with the external environment or with a hollow organ. They are formed when wound holes are filled with granulations, and suppuration in the depth has not been complete yet.

Thrombophlebitis. Purulent thrombophlebitis is one of the frequent complications of wound suppuration, especially gunshot osteomyelitis. It usually develops 2-3 months after the ballistic injury.

Lymphadenitis and lymphangitis. Purulent lymphangitis and regional lymphadenitis are usually diagnosed only in the presence of poorly debrided extensive festering wounds and gunshot fractures of extremities treated without immobilization.

Toxic resorptive fever. The most important feature of toxic resorptive fever is its constant dependence on the primary purulent focus: when the purulent focus is eliminated, the toxic resorptive fever usually disappears. If the infectious complication of the ballistic injury does not recede after elimination of the primary focus, sepsis should be considered.

Sepsis is characterized by significant changes in host defenses and in special adverse immunobiological conditions, often with development of purulent metastases in various areas of the body.

Abscesses along or in direct proximity to the wound tract are formed when a specific portion of the festering wound is isolated, which makes discharge of pus impossible or substantially impeded. The developing abscesses may evacuate into body cavities or produce leakages and fistulas.

Leakages. The term “purulent leakage” refers to the channels communicating with the festering wound, which are formed along the layers of loose adipose tissue and along aponeuroses, fascias and neurovascular bundles. Local and systemic host responses are observed in leakages. The causes of leakages include impeded outflow and prolonged retention of discharge in the wound.

Tetanus. This wound infection is caused by a spore-forming bacillus (*Clostridium tetani*), an anaerobe. The spores of the causative agent enter the wound with earth and with foreign bodies. Wounds are quite often contaminated with the causative agent of tetanus, but the disease develops relatively rarely, only when strictly anaerobic conditions are created in the wound. The introduction of specific seroprophylaxis has been of great importance in the prevention of tetanus. As a result, the incidence of tetanus in the wounded soldiers during the Second World War decreased by 10-12 times compared with World War I, and amounted to 0.07%. The incubation period in tetanus may be of different duration - from 3 to 20 days and longer. In this regard, several forms of tetanus are distinguished:

- fulminant: it develops 2-3 days after the injury,
- early: within 2 weeks,
- late: in 15-20 days,
- latent: later than 20 days.

The development of tetanus requires a number of contributing conditions:

- the presence of dead or non-viable tissue in the wound,
- late debridement, i.e. impaired circulation in the tissues (prolonged tourniquet time, vascular damage, anemia),
- sufficient virulence and quantity of the microorganisms that have entered the wound.

The shorter the incubation period, the more severe is the course of tetanus. The causative agent releases a potent tetanus toxin (tetanospasmin), which causes seizures, and tetanolysin, which lyses red blood cells. Early symptoms of tetanus include the following:

- twitching in the wound,
- increased pain,
- increased muscle tone near the wound.

Tetanus prevention. Of great significance is the prevention of tetanus, which is routinely conducted with tetanus toxoid (0.5 ml twice in a month with re-vaccination in a year). Children are immunized with a DPT vaccine (diphtheria-pertussis-tetanus vaccine). Acute prophylaxis is performed in all wounded and burned persons: previously vaccinated individuals receive only 0.5 ml of tetanus toxoid and previously non-vaccinated individuals receive 1.0 ml of toxoid and 3,000 units of anti-tetanus serum.

Numerous pathogens can stick together to form biofilms, i.e. microbial masses surrounded by a polymeric environment, thus avoiding the destructive activity of antibiotics and host effectors. Biofilms can be seen as a physical barrier to wound healing, where the normal process of the inflammatory phase may be prolonged. Bacterial byproducts in the form of fatty acids may impede chemotaxis of neutrophils and phagocytosis of *E. coli* and *S. aureus* bacterial cells. Infections make the host susceptible to other forms of bacterial and fungal infections and, over time, lead to multi-species wound infections that are difficult to eliminate. For example, methicillin-resistant *Staphylococcus aureus* accounts for 40% of wound isolates and infects 14–17% of patients with burn wounds.

In persons with weak immunity, bacteria may penetrate to deeper tissues. With the purpose of accelerating wound healing, topical antimicrobials may contribute to the treatment of severely infected wounds. Both in vitro tests and patient data demonstrate that antimicrobial wound dressings may be useful in the wounds, which may be affected by biofilms.

Although antibiotics have greatly improved human health by treating infections, many of the above infectious strains continue to cause serious problems worldwide (both in the hospital setting and in the community setting) due to resistance to antimicrobial drugs.

Many studies have shown that various bacteriostatic or bactericidal antibiotics may contribute to wound closure. However, their positive impact on wound healing usually goes unnoticed. In spite of the fact that there are countless known antibiotics, which are effective against infection-causing microorganisms, only quinolones, tetracyclines, aminoglycosides and cephalosporins have been used for the manufacture of antimicrobial wound dressings.

However, prolonged use of antimicrobial dressings is usually not recommended; they should be discontinued after successful treatment of wound infection.

It should also be taken into account that it is important to avoid excessive use of topical antibiotics in management of infected wounds in order to minimize the risk of allergy and emergence of bacterial resistance.

In addition to physical treatment of an individual with wound infection, it is important to provide psychological support. The patient should be involved into development of the treatment plan for wound infection; in this way, the nurse will be contributing to improved well-being and faster recovery of the patient.

The nurse should keep in mind that there are factors, which may slow down the wound healing process. The effect of these factors on the patient should be minimized or prevented. For example, the patient should be receiving adequate nutrition. During assessment, the nurse may find out various causes for alimentary disorders in the patient, such as loss of appetite, indigestion, inability to take food independently, etc.

The desk nurse and the patient (if applicable) should assess the status of wound dressing: correct position, cleanliness, soaking (with pus, blood or exudate) and the presence of discomfort (pain, compression, drying, etc.).

Wound assessment is performed during dressing change:

- the presence and the status of sutures on the wound (for clean wounds),
- wound size: length, width, depth (when healing by secondary intention),
- wound discharge: absent, presence, scarce, moderate, copious,

- the nature of discharge: pus, blood, exudate, serous discharge, hemorrhagic discharge, etc.,
- smell from the wound,
- the presence of necrotic tissue in the wound,
- the presence of granulation tissue in the wound,
- the presence of wound epithelization,
- the presence of signs of skin inflammation around the wound (edema, hyperemia, local hyperthermia,
- other changes of skin around the wound: maceration, ulceration, rash, etc.
- the presence of pain in wound area and when the pain occurs: permanent pain, when changing dressing, with movements, etc.

Primary debridement is conducted in compliance with the rules of asepsis, under anesthesia and includes the sequential execution of the following steps:

- dissection of the wound,

- inspection of the wound tract,

- excision of the edges, the walls and the bottom of the wound,

- hemostasis, - restoration of integrity of the damaged organs and structures,

- suturing of the wound and leaving drains in place (as indicated).

Depending on the “age” of the wound, three types of primary debridement are used:

1. Early primary debridement is conducted within up to 24 hours after the patient sustained the wound. It includes all major steps and is usually concluded with application of primary sutures. In a situation of extensive damage to subcutaneous tissue and/or inability to achieve complete arrest of capillary bleeding, a drainage tube is left in the wound for 1–2 days. Subsequently, this injury is treated as in a clean postoperative wound, delayed primary debridement is performed within 24 to 48 hours after the patient has sustained the wound. During this period, inflammation develops and edema and exudate appear. The difference from early primary debridement is performing

the procedure against the backdrop of antibiotic administration and finalizing the intervention by leaving the wound open, with subsequent use of delayed primary sutures.

2. Late primary debridement is performed later than 48 hours, when the inflammation is approaching its peak intensity and when the development of infectious process begins. Even after primary debridement, suppuration remains highly likely. In this situation, it is necessary to leave the wound open (without suturing) and conduct a course of antibiotic therapy. It is possible to apply early secondary sutures on Day 7-20, when the wound is completely covered with granulations and acquires relative resistance to infection. In most cases, debridement of a festering wound, which includes dissection, opening of pockets and purulent leakages, excision of necrotic and pus-soaked tissues allows achieving a reduction in microbial counts in the wound. In this way, owing to primary debridement, an accidental infected wound becomes an aseptic incision wound, which allows for its rapid healing by primary intention.

The treatment of wounds uses the principal types of soft dressings, such as dry antiseptic dressings, antiseptic (bactericidal) hypertonic dressings, oil and balm dressings and protective hemostatic dressings. Dry antiseptic dressings are applied to dry a wound, which is achieved by absorption of wound secretion by highly capillary material. In wounds that heal by primary intention, drying contributes to the rapid formation of a dry scab. In infected wounds, along with the pus absorbed into the dressing, a significant fraction of microorganisms and toxic substances are removed from the wound. Antiseptic (bactericidal) dressing is designed for antibacterial (bactericidal or bacteriostatic) action of the active substances it contains. The classification differs between dry and moist drying bactericidal dressings.

The design of dry bactericidal dressing is not different from that of dry aseptic dressings; however, it is prepared from the dressing materials impregnated with antiseptic agents. Alternatively, it can be a dry aseptic bandage, where the gauze layer is sprinkled with powdered antiseptic (streptocide).

Moist drying hypertonic dressing. In terms of design, it is not different from moist drying bactericidal dressing, the only difference being that its is soaked with hypertonic (5-10%) sodium chloride solution instead of an antiseptic solution. A solution of magnesium sulfate, which has analgesic properties, can also be used.

Oil and balm dressings are the dressings with balm (as a 20% solution in oils). These dressings are used for the treatment of wounds, ulcers and certain inflammatory conditions (infected wounds, abscesses and cellulitis after being opened, paraproctitis, mastitis, etc.). The algorithm of dressing change in a purulent wound:

- don gloves;
- carefully remove the old dressing (cut with scissors). In case the dressing has dried on the wound, pre-soak with antiseptic solution;
- process the skin around the wound with antiseptic;
- wash the wound with antiseptic using cotton swabs and remove pus (with blotting motions);
- dry the wound with a dry sterile swab;
- apply antibacterial agent to the wound using a spatula or apply a napkin soaked in an antiseptic solution;
- cover the wound with gauze (at least 3 layers);
- fix the dressing with adhesive plaster, bandage or adhesive bandage.

Any dressing change by a nurse should occur in sterile conditions. It is forbidden to touch the wound or dressing without wearing gloves. The nurse performing the dressing change should take special precautions for protection from infection: the nurse will need latex gloves, eye protection and a mask covering the mouth and the nose. Prior to the dressing change, moist mopping with disinfectants is performed and the room is ventilated. The need for basic patient care depends not only on the severity of the patient’s condition, but also on the location of the wound. The patients with extensive wounds of the face, hands and feet are often incapable of movement or self-care and may require constant supervision and care.

Thus, a properly applied bandage must necessarily cover the affected area completely, while not disturbing blood circulation and not restricting the patient's movements.

When caring for a draining system, the nurse should perform a daily change of the dressing around the drain. Once a day, the nurse shall rinse all connecting tubes and aspiration devices with running water, removing pus, bile and other contents from the lumen. Then the nurse shall immerse the drains for 2-3 hours into a solution consisting of 1% hydrogen peroxide and 0.5% synthetic detergent. After a repeated rinsing with running water, the tubing and other appliances shall be boiled for 30 minutes. In conclusion, it should be emphasized that draining of the wound and drain care require that the nurse carefully observe aseptic precautions.

CHAPTER 5

COMPARISON OF CAUSATIVE AGENTS OF PURULENT AND INFLAMMATORY WOUNDS IN SURGICAL PATIENTS

Purulent infection is one of the most severe complications of various forms of diseases that affect the skin and the subcutaneous adipose tissue. In this work, we view purulent infection as the most important surgical problem in wound management. Purulent wounds are one of the complications, extremely common both in peacetime and in wartime. Purulent infection is sometimes referred to as a “never-old problem”.

The high relevance of care-associated problems is due to the fact that the number of patients with these problems is steadily increasing, reaching 35 to 40% of the entire patient population of surgical clinics and in-patient facilities. The need for basic patient care depends not only on the severity of the patient’s condition, but also on the location of the wound.

In our study, we conducted inoculations of wound material in surgical patients. We also compared the counts of various microorganisms from wound cultures.

The study enrolled a total of 86 surgical patients who had bacteriological culture of contents from the wounds with failure to heal for more than a week (i.e. from chronic wounds).

Bacteriological testing is a test intended for isolation of bacteria and assessment of their properties in order to make a microbiological diagnosis.

During the bacteriological testing, we inoculated growth media with the material collected from the patient, in order to obtain the growth and reproduction of the causative agent of the disease. In course of the bacteriological testing, we could detect not only the very fact of presence, but also the concentration of pathogenic microorganisms in a biomaterial (in particular, in our study, this was biological material from the wound).

Bacteriological testing (inoculations) is of great importance not only for identification of a specific type of microorganism, but also for establishing the microorganism's sensitivity to a particular antibiotic. In this way, maximum efficiency of a particular type of antibiotic therapy is determined.

When conducting the analysis, it is important to remember that certain microorganisms perish fairly quickly, since they have an increased tendency towards self-destruction. Therefore, inoculations should be done promptly.

After the study material has been obtained and placed into the growth medium, identification of microbial species is the task for specialist microbiologists.

The time required for microbial flora culture to form is from 3 to 10 days. Recognition/identification of microbial organisms is conducted by studying their individual biochemical and cultural traits inherent in a particular species.

Based on the results of our study (Diagram 5.1.), *Staphylococcus* was the most frequent bacterial genus present in polymicrobial communities in the test samples from chronic wounds.

It is noteworthy that almost half of the wound samples tested contained traditional commensal microorganisms, including coagulase-negative Staphylococci, Corynebacteria and Propionibacteria species (*Propionibacterium*).

With respect to coagulase-negative Staphylococci, one of the key signs of the pathogenicity of all staphylococci is the ability (or, conversely, the inability) to coagulate plasma. Depending on the aforementioned ability, these microorganisms can be either coagulase-positive, i.e.: *Staphylococcus aureus*, *Staphylococcus intermedius, Staphylococcus schleiferi subsp. coagulans, Staphylococcus hyicus, Staphylococcus lutrae, Staphylococcus delphini, Staphylococcus pseudintermedius* or coagulase-negative: *Staphylococcus saprophyticus, Staphylococcus epidermidis, Staphylococcus haemolyticus, Staphylococcus hominis, Staphylococcus warneri, Staphylococcus capitis, Staphylococcus simulans*, etc. *S. epidermidis* is a normal inhabitant on human skin and even in wounds, that is, no interventions are necessary when this organism is isolated. However, *S. epidermidis* presents a clinical problem in a surgical setting.

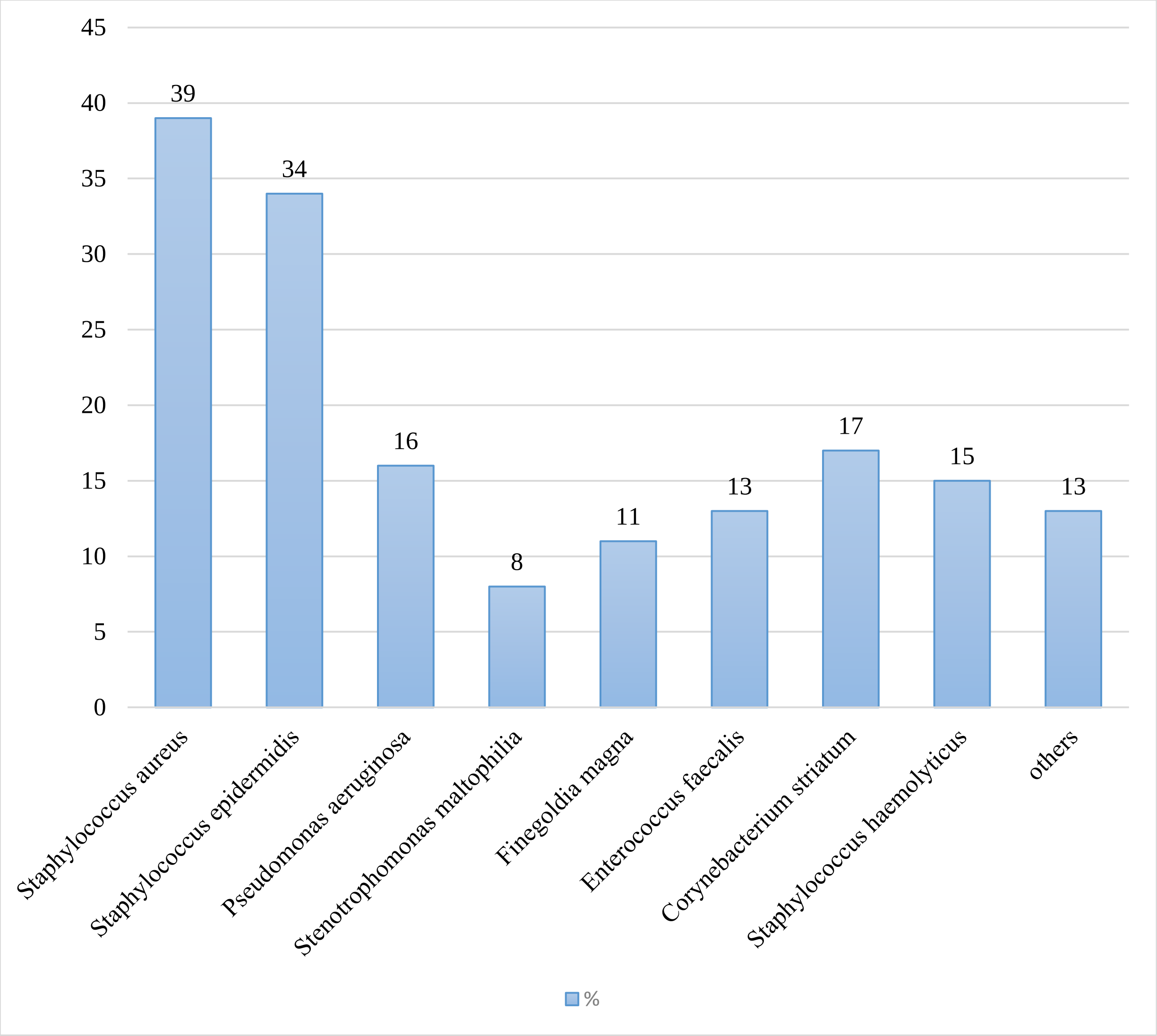

Diagram 5.1. Comparing the amount of flora (relative microbial count) detected using bacteriological culture from chronic wounds, depending on the causative agent

In addition to that, in spite of the fact that chronic skin wounds are exposed to relatively high levels of oxygenation, large amounts of anaerobic bacteria have been detected in wound samples. For example, obligate anaerobes detected in samples from chronic wounds, in particular, Finegoldia magna (this is a genus of Gram-positive bacteria; these are anaerobic cocci of the Clostridia class, with Finegoldia magna being the typical species. F. magna was previously known, along with several other Gram-positive anaerobic cocci, as Peptostreptococcus magnus, but was transferred to its own genus in 1999) were present in 11% of the wounds, indicating that anaerobes make up a significant portion of the chronic wound microbiome.

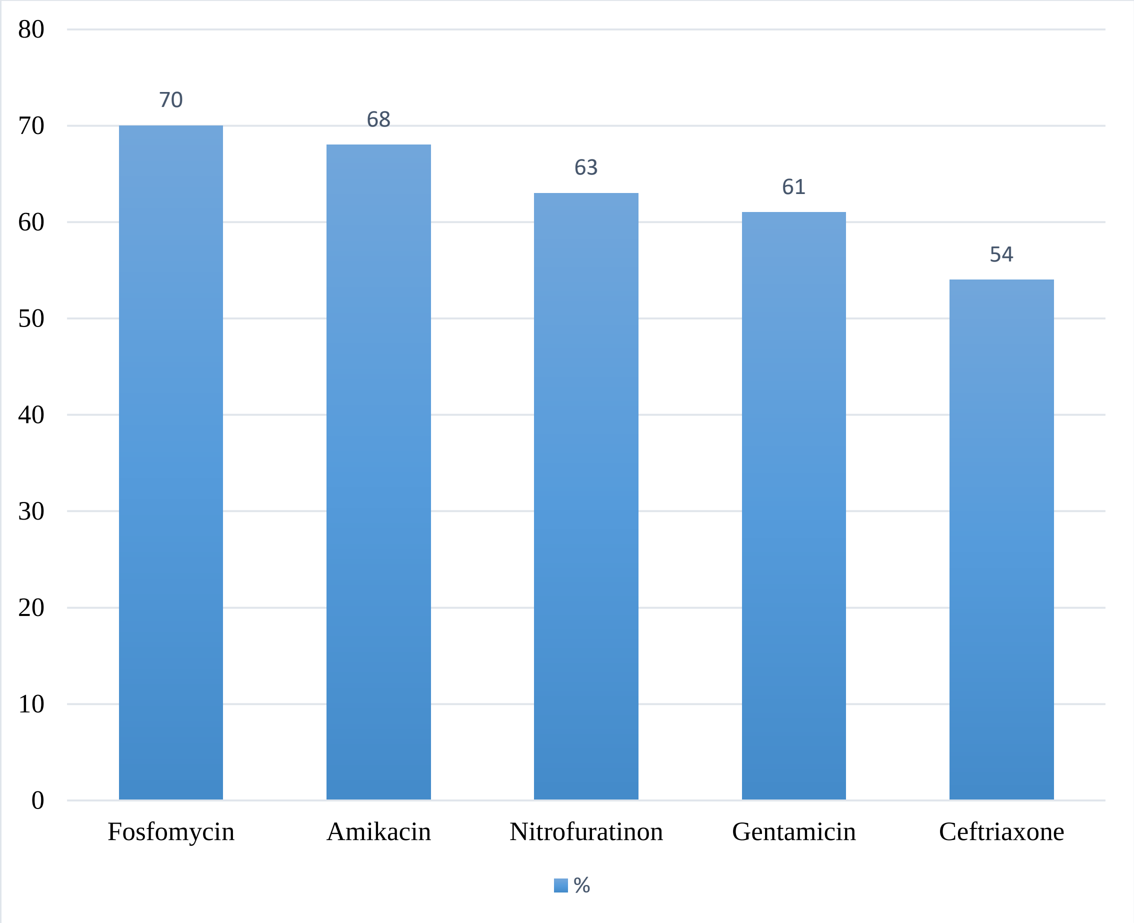

Diagram 5.2. Comparison of antibiotic sensitivity of the bacteria isolated from wounds

In order to determine antibiotic sensitivity of bacteria, we selected various types of antibiotics:

- Fosfomycin
- Amikacin
- Nitrofuratinon

- Gentamicin
- Ceftriaxone

When detecting sensitivity, we used isolation of microbial culture, after which a small disk soaked in antibiotic was placed into a Petri dish, and measurements of colonial growth were made after a certain time has elapsed.

After the antibiotic sensitivity test, the patients had dressing changes and the management of their wounds was adjusted based on the antibiotic sensitivity of bacteria isolated from the wounds.

From a practical perspective, monitoring of microbial burden in the wounds is a vitally important factor for mitigation of infection, and this goal can be achieved in several ways.

Antimicrobial agents (antibiotics) are mostly used either prophylactically in the management of wounds, which may be heavily contaminated postoperatively, or for medical management purposes in management of clinically infected wounds.

Since both aerobic and anaerobic pathogens may contribute to microbial contamination of polymicrobial wounds (often due to synergistic interaction), the most successful treatment is ensured by broad spectrum antibiotics.

Heavily contaminated "dirty" wounds (e.g., chronic wounds or acute traumatic wounds), which fail to heal and are possibly deteriorating, but which have only local signs of microbial contamination or lack clinical signs of generalized infection, can be subject to a higher-quality treatment that combines topical antibiotic therapy and antiseptic therapy. Although topical antibiotics are selectively toxic to bacteria and not to human tissue, they are likely to cause bacterial resistance, and for this reason antiseptics are the preferred agents for local use. However, prolonged use of antiseptics can compromise the viability of human tissue, and, consequently, hamper the accelerated healing caused by the antimicrobial effect.

Debridement of damaged (non-viable) tissue not only exposes the healthy perfused tissue required to start wound healing, but also effectively removes the majority of microbial contaminations and any associated foul odor, thereby reducing the risk of infection, which has a proven efficacy in the management of both infected and necrotic tissues.

Reluctantly healing wounds are also managed by the methods of physical antisepsis; these are the methods that create such conditions in the wound, which are unfavorable for bacterial growth and absorption of toxins and tissue degradation products. In addition to the use of hygroscopic dressings (cotton wool, gauze, gauze sponges, napkins) and hypertonic solutions, the physical methods also include sorbents (carbonaceous substances in the form of powder or fibers); drainage (passive drainage and active drainage, i.e. drain with a pump); instrumental modalities: laser irradiation with high directivity and energy density, which results in a sterile coagulation film, ultrasound therapy with cavitation bubbles and H^+/OH^-, UV (ultraviolet radiation) for decontamination of rooms and wounds, hyperbaric oxygenation therapy and radiation therapy for the treatment of deeply located purulent foci in osteomyelitis and bony panaris).

All of these methods are actively used by physicians and nurses in the management of reluctantly healing wounds in surgical patients.

CONCLUSIONS

1. The authors have investigated the specific aspects, the classification and the mechanisms of wound healing.
2. The authors have identified the wound management roles of surgical health care personnel.
3. The authors have defined the principles of care for postoperative wounds in surgical patients.
4. The authors have investigated the specific aspects of postoperative wounds in various patients.
5. The authors have studied the types of microbial pathogens isolated from the wounds in the surgical practice of a nurse.
6. The authors have studied the potential methods of treatment of infected wounds and the methods to prevent microbial contamination of wounds.
7. The authors have conducted a comparative analysis of the number of pathogenic colonies isolated from infected wounds.
8. The authors have conducted a comparative analysis of the sensitivity of pathogenic wound bacteria to various antibiotics.

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