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Surgical Site Infection (SSI)

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Abstract

Surgical Site Infections (SSIs) are a significant complication of invasive surgical procedures, contributing to increased morbidity, mortality, and healthcare costs globally. Despite advancements in surgical techniques, hygiene practices, and the implementation of infection control protocols, SSIs remain a critical issue in postoperative care. This document provides a comprehensive overview of SSIs, including their definition, causes, risk factors, and microbiology. The primary pathogens responsible for SSIs are Gram-positive bacteria and fungi, with specific concern for immunosuppressed patients who are at increased risk for opportunistic infections. The classification of SSIs based on wound cleanliness and depth is essential for determining the appropriate treatment strategy, which may include drainage, surgical debridement, and the use of local or systemic antibiotic therapy. The document also highlights the importance of preventive measures, including rigorous perioperative antibiotic prophylaxis and adherence to established surgical protocols, to reduce the incidence of SSIs. The discussion is supported by data from various studies and clinical guidelines, emphasizing the need for ongoing vigilance in infection control practices to mitigate the impact of SSIs on patient outcomes.

Key words: surgical site infection, inflammation, surgical wounds, postoperative mortality, routes of infection, gram-positive bacteria, aerobic bacteria, anaerobic bacteria, pathogenic fungi, SSI risk indices, surgical drainage, local antibiotic therapy, VAC technique

Introduction

A surgical site infection (SSI) should be defined as an inflammatory condition within the wound resulting from invasive surgical procedures. Despite significant advancements in maintaining proper hygiene during surgical procedures and an increased awareness among medical personnel regarding microbiological risks in recent years, and the implementation of many infection prevention protocols, surgical site infections remain a serious issue. They contribute to significant morbidity and mortality among patients, leading to increased healthcare costs. This type of infection doubles the risk of postoperative mortality. It is estimated that surgical site infections affect approximately 2-6% of surgical patients, which, given the approximately 30 million surgeries performed globally each year, represents a substantial healthcare problem (Cianciara et al. 2007, Kasper et al. 2012, Olson et al. 1984). All surgical wounds are characterized by the presence of microbial colonies; however, in most cases, infection does not develop due to the effective functioning of defense mechanisms manifested through the actions of elements of the nonspecific immune response. The occurrence of an infection in a surgical patient is influenced by a number of factors that create a specific network of interactions between the pathogen, perioperative factors, and the efficiency of the patient's immune system (Townsend et al. 2004).

The most common routes of infection include contiguous spread, which typically presents macroscopically as necrosis, cellulitis, or abscess formation, and hematogenous spread. The most common cause of surgical site infections is Gram-positive bacteria and fungi. Aerobic bacteria (e.g., Streptococcus, Klebsiella, Escherichia coli), anaerobic bacteria (e.g., Bacteroides, Clostridium), and fungi (e.g., Histoplasma, Coccidioides, Candida, Nocardia, Actinomyces) play a significant role in surgical infections. Special attention should

be given to patients who are immunosuppressed, as they are additionally at risk of developing infections caused by pathogens such as Pseudomonas aeruginosa and Serratia, which are typically nonpathogenic in patients with a normally functioning immune system. In such cases, the infection is classified as opportunistic, meaning it is caused by endogenous flora in immunosuppressed patients (Montewka et al. 2012, Managram et al. 1999, Olson et al. 1984). Surgical wound infection can occur via primary or secondary mechanisms. In the case of a primary wound, direct infection occurs with endogenous or exogenous bacterial flora, leading to abscess formation. When a hematoma, serous fluid collection, retained foreign body, or necrotic tissue becomes infected, it is referred to as a secondary infection (Townsend et al. 2004).

The location of the infection significantly influences the treatment techniques employed; hence, surgical wounds that have become infected are classified primarily based on their depth and cleanliness, making it crucial to accurately determine the etiology of its formation. (Table 1; Figure 1) (Olson et al. 1984).

	% of infections with prophylaxis use*
Clean wounds (there is no disruption of the continuity of systems colonized by endogenous microorganisms, such as the respiratory, urinary, genital, and gastrointestinal systems).	0,8
Clean-contaminated wounds (non-traumatic wounds; controlled disruption of the gastrointestinal tract, respiratory tract, or urinary tract, without contact with their contents; no significant contamination of the surgical field).	1,3
Contaminated and dirty-contaminated wounds (entry of contents from the gastrointestinal, genitourinary, or respiratory systems into the wound; significant violation of the sterility of the surgical field,	10,2

traumatic wounds, e.g., those caused by a dirty instrument).	

Tab. 1. *Based on data from: Olson M, O'Connor M, Schwartz ML. Surgical wound infections. A 5-year prospective study of 20,193 wounds at the Minneapolis VA Medical Center. Ann Surg. 1984 Mar;199(3):253259.

Characteristics of Factors Increasing SSI Risk

Extensive antibiotic prophylaxis and strict sanitary control have led to a noticeable reduction in the incidence of surgical site infections in recent years. Despite the high standards of services offered by surgical departments and the established awareness among medical staff regarding the maintenance of proper surgical room sterility, surgical site infection remains one of the main postoperative complications. Most causes are exogenous. Several groups of factors significantly increase the risk of surgical site infection (Managram et al. 1999).

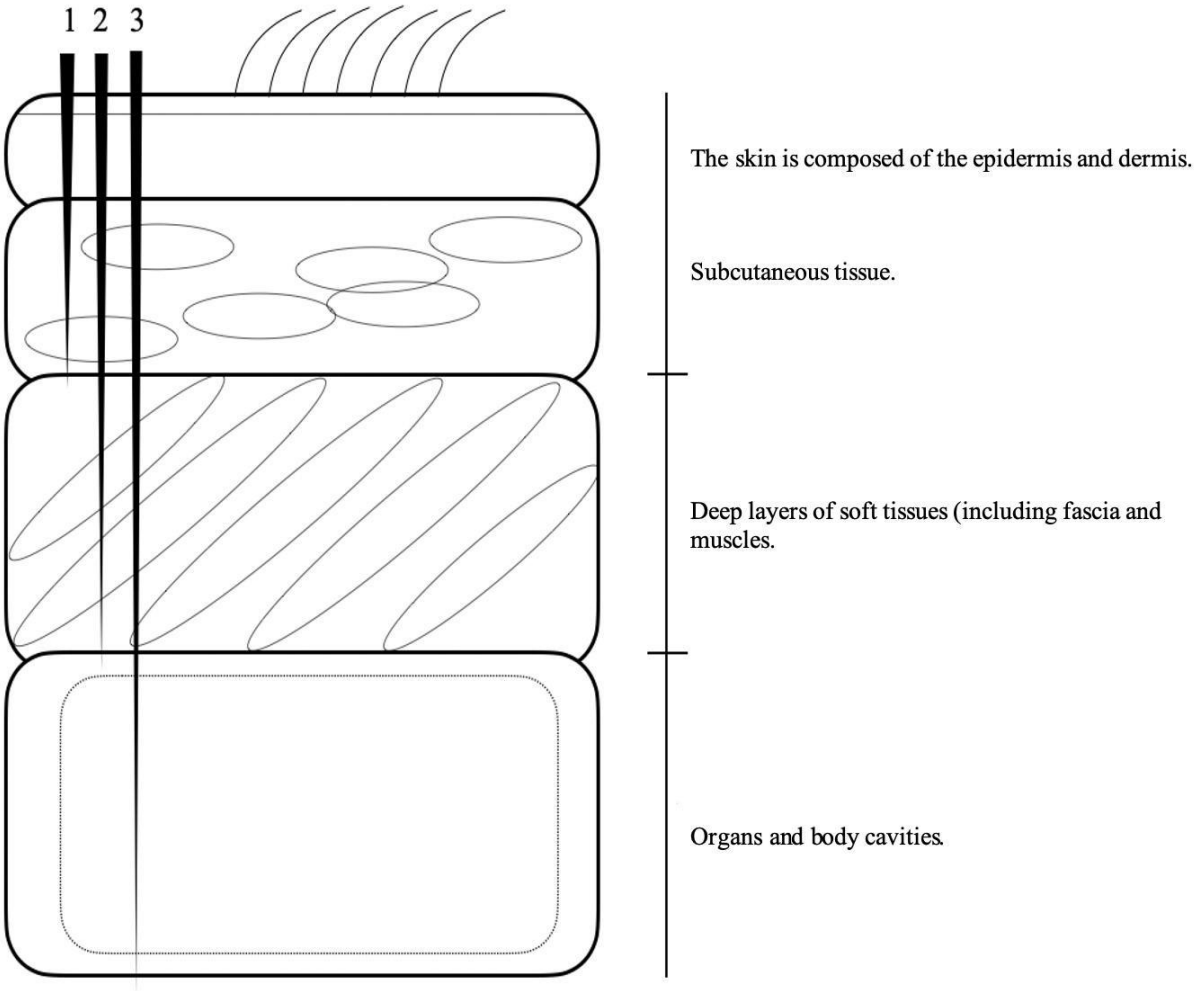

Fig. 1 The black arrow indicates the depth of the wound.
1 - Superficial surgical site infection (skin and subcutaneous tissue).
2 - Deep infection resulting from incisions, for example (fascia and muscle).
3 - Organ or body cavity infection.

The largest group consists of factors directly related to the patient:

- The patient's overall condition, classified using assessment scales such as ASA.
- The patient's nutritional status; particularly vulnerable are emaciated and malnourished patients.
- The presence of diagnosed chronic diseases, such as liver cirrhosis, diabetes, cardiopulmonary failure, and renal failure.

- Oncology patients; the use of invasive cancer treatment techniques such as chemotherapy and radiotherapy.
- Significant anemia.
- Impaired immune system function; drug-induced immunosuppression, e.g., due to steroid treatment; lymphopenia, HIV infections.
- Patient addictions, such as smoking.
- Metabolic disorders such as hypoalbuminemia, uncontrolled hyperglycemia, and hypocholesterolemia.
- Blood product transfusions.

Another group of factors increasing the risk of surgical site infection (SSI) are those directly related to the environment:

- Prolonged hospitalization.
- Improper preparation of surgical instruments, lack of sterility.
- Inadequate disinfection of the surgical site and surrounding skin areas.
- Unsuitable operating room conditions, such as humidity, temperature, and the number of people present.

Additionally, factors related to the work of the medical staff and the surgeon's skills also deserve attention. Patients undergoing emergency surgery are at higher risk of SSI due to inadequate preparation, as there is often insufficient time. To reduce the risk of SSI, perioperative antibiotic prophylaxis should be appropriately administered, and care should be provided in accordance with proper procedures. It is also worth noting that in the case of contaminated wounds, such as those caused by a dirty instrument, the presence of exogenous bacteria is a factor that increases the risk of SSI. In wounds of this etiology, the type of bacteria, their virulence, and their resistance to antibiotics, chemotherapeutics, and antiseptics are significant factors in the increased risk of SSI (Montewka et al. 2012, Olson et al. 1984, Townsend et al. 2004, Managram et al. 1999).

Microbiology of Surgical Site Infections

The number of factors that influence the occurrence of an infection within a surgical site is so large that infection control alone is not sufficient to prevent all infections. One of the criteria for classifying an infection as a surgical site infection is the appearance of clinical signs of infection within 30 days after surgery or within 12 months after the implantation of a foreign body (e.g., mesh, prosthesis, or implant). Clinically, surgical site infections are diagnosed based on a range of symptoms, including fever, patient malaise, swelling and tenderness, redness and increased warmth around the wound, and serous or purulent discharge from the wound, often requiring drainage (Olson et al. 1984).

As previously mentioned, the main cause of surgical site infections is the endogenous bacterial flora present on the patient's and surgeons' skin, accounting for 50% of infection cases. About 25% of SSIs are caused by Staphylococcus aureus and coagulase-negative staphylococci, particularly dangerous in the context of central nervous system infections. Other microorganisms significant in the etiology of surgical site infections include Escherichia coli, Enterococcus species, Pseudomonas aeruginosa, Enterobacter species, Streptococcus species, and Klebsiella species, among others (Cianciara et al. 2007, Kasper et al. 2012).

Indices have been developed to assess the risk of developing SSIs. Among the most well-known are the SENIC (Study of the Efficacy of Nosocomial Infection Control) index and the NNISS (National Nosocomial Infection Surveillance System) index. According to SENIC, risk factors include abdominal surgeries, surgeries lasting more than 2 hours, and contaminated or dirty surgical fields. According to NNISS, there are three main risk factors for SSI development: surgery in a contaminated or dirty field, surgery duration exceeding 2 hours or more than 75% of the expected time for the procedure, and a patient’s general condition according to the ASA (American Society of Anesthesiologists) scale scoring above 3 points (Olson et al. 1984, Managram et al. 1999, Montewka et al. 2012).

Treatment of Surgical Site Infections

Depending on the classification of the infection, different therapeutic techniques are applied to achieve satisfactory treatment outcomes. In cases where serous fluid or pus

accumulates within the wound, drainage and appropriate surgical debridement by incision and opening of the wound must be performed. Typically, microbiological testing is not indicated for SSIs. Antibiotic therapy is initiated only when symptoms of sepsis are present, such as fever, leukocytosis, or infection of body cavities. In uncomplicated SSIs, only local antibiotic therapy is used. To accelerate wound healing, techniques such as VAC (Vacuum-Assisted Closure) or hydrocolloid dressings with silver can be applied (Cianciara et al. 2007, Kasper et al. 2012, Montewka et al. 2012).

Disclosure:

Author's contribution:

Conceptualization: Jakub Buczkowski, Weronika Biaduń, Jakub Maciej Pieniążek; Methodology: Aleksandra Ciuła, Klaudia Arciszewska; Software: Aleksandra Padkowska, Kinga Rogowska, Michał Borawski, Aleksandra Ciuła; Check: Jakub Buczkowski, Weronika Biaduń, Jakub Maciej Pieniążek, Aleksandra Padkowska; Formal analysis: Jakub Buczkowski, Weronika Biaduń, Jakub Maciej Pieniążek, Mateusz Dobosz; Investigation: Michał Borawski, Aleksandra Ciuła, Jakub Maciej Pieniążek; Resources: Jakub Buczkowski;

Data curation: Kinga Rogowska, Jakub Buczkowski; Writing - rough preparation: Jakub Maciej Pieniążek, Kinga Rogowska, Aleksandra Padkowska; Writing - review and editing: Jakub Buczkowski, Mateusz Dobosz, Michał Borawski, Aleksandra Ciuła, Aleksandra Romanowska; Visualization: Klaudia Arciszewska,

Aleksandra Romanowska; Supervision: Jakub Maciej Pieniążek, Aleksandra Padkowska; Project administration: Michał Borawski, Kinga Rogowska.

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