

Bacterial, Fungal and Viral Infections in Surgical Site: Clinical, Diagnostic and Epidemiological Aspects

Infecções Bacterianas, Fúngicas e Virais em Sítio Cirúrgico: Aspectos Clínicos, Diagnósticos e Epidemiológicos

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Abstract

Surgical Site Infections (SSI) are infections related to surgical procedures in inpatients and outpatients, indicated with high prevalence in relation to infections linked to preventable health care. Thus, the objective of the study is to perform a review on bacterial, fungal and viral infections in surgical site in relation to clinical, diagnostic and epidemiological aspects. A bibliographic and exploratory research was carried out and the Virtual Health Library (VHL), Capes Periodicals and the Pubmed to search the articles were consulted. As for the clinical aspects, the phlogistic signs that allow to identify an inflammatory picture, being a response of the organism to some aggressive agent. Among the bacterial diagnostic methods, the most used ones are the color smear examination, cultural and biochemical characteristics, ELISA, PCR and SAR. As for the detection of fungi and yeasts are the production of the germ tube, micro-culture in agar-tween 80 agar, assimilation of carbohydrates or nitrogen and fermentation of carbohydrates. For viruses, virus isolation, cell culture, laboratory animals and embryonated eggs may be used. Although bacterial infections account for most surgical infections, fungal and viral infections can also be seen in hospital settings and their diagnosis needs to be performed as soon as possible for proper treatment, reducing costs for medical services and length of stay of the patient in the hospital environment, also reducing other risks of infection.

Keywords: Surgical Wound Infection. Bacterial Infections. Mycoses. Virus Diseases.

Resumo

As Infecções do Sítio Cirúrgico (ISC) são infecções relacionadas a procedimentos cirúrgicos em pacientes internados e ambulatoriais, indicadas com alta prevalência em relação às infecções ligadas aos cuidados em saúde evitáveis. Neste sentido, o objetivo do estudo é realizar uma revisão sobre as infecções bacterianas, fúngicas e virais em sítio cirúrgico em relação aos aspectos clínicos, diagnósticos e epidemiológicos. Foi realizada uma pesquisa bibliográfica e exploratória e consultada a Biblioteca Virtual em Saúde (BVS), os Periódicos Capes e o Pubmed para busca dos artigos. Quanto aos aspectos clínicos, os sinais flogísticos que permitem identificar um quadro inflamatório, sendo uma resposta do organismo frente a algum agente agressor. Dentre os métodos diagnósticos bacterianos, os mais utilizados são o Exame de esfregaços corados, Características culturais e bioquímicas, ELISA, PCR e o SAR. Quanto à detecção de fungos e leveduras estão a produção do tubo germinativo, micro cultivo em ágar fubá-tween 80, assimilação de carboidratos ou de nitrogênio e fermentação dos carboidratos. Em relação aos vírus, podem ser utilizadas o isolamento dos vírus, a cultura de células, os animais de laboratório e os ovos embrionados. Apesar das infecções bacterianas representarem a maior parte das infecções cirúrgicas, as infecções fúngicas e virais também podem ser vistas em ambientes hospitalares e seu diagnóstico precisa ser realizado o mais rápido possível para um tratamento adequado, reduzindo os custos com serviços médicos e o tempo de permanência do paciente no ambiente hospitalar, diminuindo também outros riscos de infecção.

Palavras-chave: Infecção da Ferida Cirúrgica. Infecções Bacterianas. Micoses. Víruses.

1 Introduction

According to the National Agency of Sanitary Surveillance¹, the surgical site infections (SSI) are infections related to surgical procedures, with or without placing implants, in inpatients and outpatients, and are indicated with a high prevalence in relation to infections related to avoidable health care², being the second or third most affected worldwide infection in patients undergoing any type of surgery³⁻⁴.

In Brazil, this reality is also checked and occupies the third position among all the infections in health services, which corresponds to 14% to 16% of infections found in hospitalized patients¹⁻⁵. The degree of contamination of every surgical procedure has a direct link in the risk of infection and

the surgeries can be classified according to their potential for infection, such as the clean surgeries, potentially contaminated surgeries, contaminated surgeries and infected surgeries⁶.

In clean surgeries, the surgical site has no signs of inflammation and there is no contact with the respiratory tract, food, genital and urinary tract, being that its closure should be primary with closed drainage, if necessary. In potentially contaminated surgeries, the site enters the respiratory tracts, gastrointestinal or urinary tract in controlled conditions and not an accidental contamination. Whereas in contaminated surgeries, the wounds have a high contamination of the gastrointestinal tract, as traumatic lesions with devitalized tissue, foreign body and when there are unexpected

perforation of viscera. Finally, the infected surgeries are surgeries that enters the urinary tract with infectious urine or biliary tract with infected bile or surgeries where purulent acute inflammatory tissue is found⁶.

Regarding the classification of these infections, they follow some criteria to be defined and receive a correct diagnosis, namely: (a) Infections of Surgical Superficial Incisional site (ISC-S); b) incisional surgical site infections (ISC-IP); and c) surgical wound infections Organ/Cavity (ISC-OC)^{1-5,7}.

In the superficial wound infection (ISC-S), it occurs in the first 30 days after the surgery and involves only the layer of skin and subcutaneous tissue. Whereas the Deep Wound Infection (ISC-IP) happens within the first 30 days after surgery or up to one year, in case their prosthesis installation, involving soft and deep tissues, such as the fascia and muscles. In relation to the Organ/Cavity infection it also occurs in the period of 30 days or until one year after the surgery, if there is installation of prosthesis, and affects any organ or cavity that has been opened or manipulated during the surgical process^{1,5,7}.

Taking into consideration the surgical site infections, and these may occur in the intraoperative period or immediately peri-operative period, being that the source of bacteria and other micro-organisms can include own sites colonized of patients, the medical and nursing team or even the hospital environment itself, being that several factors may influence the acquisition of an infection, such as for example the immune status, age, abusive use of antibiotics, medical procedures (in particular, the invasive), immunosuppression or failures in infection control procedures⁸.

Among the surgical site infections, bacterial, fungal and viral infections can affect the person who is subjected to a surgical procedure, being addressed in this study regarding their clinical, epidemiological and laboratory diagnosis. Thus, the objective of the study is to perform a review on bacterial, fungal and viral infections in surgical site in relation to clinical, diagnostic and epidemiological aspects. Therefore, it will be possible to promote reflection on professionals who are directly and indirectly related to surgical procedures, as well as the people who undergo this process, in a way that it may prevent or reduce the risk of nosocomial infection.

2 Development

2.1 Methodology

For conducting this study, a bibliographic and exploratory research was performed in scientific articles, books, periodicals and documents that deal with the bacterial, fungal and viral infections in surgical site in relation to the clinical aspects, diagnosis and epidemiological data, so that it was possible to achieve the objective of the present study.

According to Gil⁹, the bibliographical research is developed based on material already prepared, consisting primarily of books and scientific articles, while the exploratory, the aim is to provide greater familiarity with the problem, in order to

clarify it, and may involve bibliographic survey.

The articles used in this research were consulted in the Virtual Health Library (VHL), using the databases SciELO (*Scientific Electronic Library Online*), MEDLINE (*Medical Literature Analysis and Retrieval System Online*) and the Lilacs (Latin American and Caribbean Literature in Health Sciences), the Capes and the Pubmed journals. For the realization of the searches, the following descriptors were used of the Health Sciences (DeCS) and combinations in Portuguese and English languages: *Infecção da Ferida Cirúrgica* (Surgical Wound Infection), *Infecções Bacterianas* (Bacterial Infections), *Infecções Fúngicas* (Fungal Infections) and *Infecções Virais* (Viral Infections). As inclusion criteria for the selection of the studies the indexing of articles in their respective databases, published in Portuguese or English were used, direct relationship with the descriptors and the period from 1990 to 2018.

2.2 Bacteria, fungi and viruses: characterization

Bacteria are single celled organisms, found in an isolated manner, or in colonies, consisting of a cell (unicellular) that do not have defined nucleus (prokaryotes) nor membranous organelles, being variable regarding the size and shapes. They can be grouped into three types regarding their morphology in general: cocci, bacilli and coiled¹⁰.

In the form of cocci, they have spherical characteristics and is the most homogeneous group as to size, being named according to their arrangement: a) Micrococci - isolated cocci; b) Lancet - cocci grouped in pairs; c) Tetrads - a group of four cocci; d) Sarcina - cluster of eight cocci in cubic form; d) Streptococci - group of cocci in chains; e) Staphylococci - irregular groups of cocci, seeming bunches of grapes¹⁰.

Regarding the bacilli or sticks, the bacteria have cylindrical cells or in the form of rods, varying in shape and size between species and genera, being some portions square, rounded, sharp or thin terminals. Whereas the spiral shapes bacteria are the cells in spiral, being divided into spirillaceae- they resemble a corkscrew and have a rigid body and move at the expense of external scourges - and Spirochetes - have a flexible body and move through contractions of the cytoplasm^{10,11}.

The bacteria are part of our life on earth and are found anywhere, either on the skin, mucous membranes or intestinal tract of man and animals. Some of them are harmless, other beneficial to host and provide nutrients or assume the role of protection against pathogens and diseases that respond quickly to changes in the environment^{12,13}.

When addressing the issue of bacterial infections at surgical site, several pathogens can be seen and able to affect hospitalized individuals, among them are *Escherichia coli*, *Pseudomonas sp*, *Klebsiella sp*, *Proteus sp*, *Enterobacter sp*, *Serratia sp*, *Streptococcus sp*, *Staphylococcus aureus*, *Staphylococcus epidermitis*, being that some sites that seem to be infected may not have pathogens in culture and others will have a growth of multiple species^{8,14}.

In relation to fungi, they are heterotrophic eukaryotes, and usually multicellular organisms, taken as ubiquitous microorganisms and found in the most diverse environments. The most known are the molds, mushrooms, pycnoporus sanguineus and the yeasts and their dispersion is made by several ways or tracks, either animals, insects, water and atmospheric air through the winds¹⁰.

Molds are multicellular fungi that produce filamentous structures, while the yeasts are unicellular fungi that have varied forms¹⁵. These forms are the result of the way of reproduction, the conditions of cultivation and age of culture, and may present round, oval, cylindrical, triangular, apical and warhead shapes¹⁰.

The fungi dispersed by atmospheric air (airborne fungi) are allergenic and if inhaled, some species may become pathogenic on account of natural break the mechanism of host defense, may cause various mild or severe clinical signs, and, in the case of hospital environment, may represent a problem^{16,17}.

Among the most well-known species of fungi are *Candida spp.* (found in the oral, vaginal and intestinal mucosa), *Aspergillus spp.*, *Cryptococcus spp.*, *Histoplasma capsulatum*, and other opportunist filamentous fungi^{12,18}.

Regarding the viruses, they are not considered living organisms and they differ from other beings by depending on a host for their multiplication, using induction of synthesis of specialized structures which transfer the nucleic acid to other cells. They have a single type of nucleic acid (DNA or RNA) and protein coverage that involves this nucleic acid¹⁰.

A complete viral particle is called virion, composed by a nucleic acid surrounded by a cover that protects the environment and serves as a means of transmission from one host to another, being classified as to the differences in the structure of these coverings: the enveloped ones, in which there is a layer of lipids, proteins and carbohydrates that cover the capsid (head of the virus); and the non-enveloped, whose capsids are not covered by an envelope¹⁰.

Regarding their morphology, they take as a basis the architecture of the capsid, and may be classified as helical virus, where the capsid is cylindrical, hollow and helical; polyhedral virus; and, in the majority of the capsids they have the shape of an icosahedron; enveloped viruses, whose capsid is covered by an envelope; and complex viruses, which have complicated structures and for this reason they receive this designation (viruses that attack bacteria, for example)^{10,11}.

Closing this topic, Amabis and Martho¹⁵ present a table, commenting briefly the characteristics of each microorganism cited:

Table 1 - Characteristics of bacteria, fungi and viruses

| Microorganism | Characteristics |
|---------------|---|
| Bacteria | Prokaryotes; do not have nuclear membrane (karyotheca) and organized intracellular membranous structures. |
| Fungi | Eukaryotes with rigid cell wall; uni or multicellular; devoid of chlorophyll. Known as molds, yeasts and mushrooms. |
| Viruses | Acellular; smaller and simpler than the bacteria; usually contains only one type of nucleic acid (DNA or RNA), protected by a cover; protein can multiply only within living cells. |

Source: Adapted from Amabis and Martho¹⁵.

2.3 Bacterial, fungal and viral infections in surgical site: clinical and laboratory diagnosis

Regarding the clinical aspects, we can see signs of inflammation (signs and symptoms) that allow to identify inflammatory signals, being a response of the body forward to any aggressor agent, such as heat, redness (reddish), tumor (wound, edema) and pain, known as the tetrad of Celsius¹⁹.

With the increase of blood flow, the first signal occurs, the redness, characterized by reddish color on site. Consequently, the occurrence of this increased blood flow, the local temperature is also increased, causing the second signal, the heat. Subsequently, there is the output of plasma to the interstitium, due to the increase in permeability and blood flow, generating an edema. Finally, this edema can compress the nerve endings and irritate them, causing pain. The inflammation if not treated in time, may cause a loss of the physiological function of the injured site and the aggressor agent must be detected through the laboratory diagnosis¹⁹.

In the case of bacterial infections, early diagnosis is extremely important, so it is done its immediate treatment as soon as possible. Generally, the bacterial infection tends to cause more fever than viral infections (often reach 41°C) and increase the amount of white blood cells. Furthermore, blood tests can be carried out for evidence of harmful bacteria, either by means of expectoration or urine. In case there is a suspicion of pulmonary infection an X-ray can be done or a biopsy of the site to be examined or, in the case of meningitis, a lumbar puncture²⁰.

Blot²¹ recommends that the laboratory diagnosis is essential in the fungal diseases, however, it is also important for viral and bacterial infections, since not always the clinical diagnosis based on signs and symptoms of the patient are inconclusive and often are similar to each other.

Pereira and Petrechen²² developed a literature review which addresses the major bacterial diagnostic methods and list as being five the most used ones, describing their techniques and ways of implementation, such as the examination of stained smears (including Gram staining and acid-fast bacilli staining), cultural and biochemical characteristics, ELISA (*Enzyme-linked Immunosorbent Assay*), PCR (*Polymerase Chain Reaction*) and the rapid agglutination (SAR).

Regarding laboratory tests that are used and taken as the

gold standard for checking the presence of fungi and yeasts are the production of germ tube, micro cultivation on agar-tween 80, assimilation of carbohydrates or nitrogen (auxanogram) and fermentation of carbohydrates (zymogram)¹⁶.

Other tests are also used to provide a clinical report in situations of fungal infections, as the chromogenic culture media that differentiate the colonies according to the color produced²³, direct mycological and histopathological examinations²⁴, as well as serologic methods in case of suspicion of *Candida*, in which it is evaluated the presence of antigens or anti-*Candida* antibodies in the serum²⁵.

For viruses, to perform their diagnosis, some laboratory techniques may be used, such as the virus isolation, cell culture, laboratory animals and embryonated eggs using a live host. It is worth noting that the method with use of laboratory animals is not much used currently by the difficulty of adopting the use by the Ethics of Laboratory Animals, biosecurity and by the time demanded for the development of the disease in animals²⁶.

Still, it is possible to perform the direct and indirect identification of viruses or part of them, such as proteins and nucleic acid, using electronic microscopy, immunological tests and molecular assays like PCR and hybridization²⁶.

However, observing the clinical aspects and conducted the appropriate laboratory diagnosis it is possible to begin the process of treatment of the respective disease, either in bacterial infections (most common), fungal or viral infections.

2.4 Bacterial, fungal and viral infections in surgical site: epidemiological aspects

The surgical site infections collaborate significantly to increase the rates of morbidity and mortality of patients subjected to some surgical procedure, as well as raise the costs of hospitals due to the time of permanence of these patients in the hospital²⁷⁻²⁸.

According to data from the National Agency of Sanitary Surveillance, the surgical site infections correspond to approximately 14% to 16% of infections in health services in general^{1,5}.

Among these procedures for preventing surgical site infections are the pre-operative measures, such as the preoperative bath, decolonization with mupirocin ointment, tracking of colonization by bacteria, removal of the preparation of the surgical site with antiseptics, preparation of hands for surgery, maintaining normal body temperature and others; Intraoperative measures as nutritional support advanced and the perioperative oxygenation; and the measures of postoperative complications such as advanced dressings and the extension of the surgical antibiotic prophylaxis²⁹. However, even though, several studies have reported epidemiological data related to surgical site infections.

In 2011, a study published by Mu and collaborators³⁰ gathered data reported to the *National Healthcare Safety Network* (NHSN) for all operating procedures performed

from January 1st, 2006 to December 31st 2008 and raised information of 847 hospitals in 43 states that have reported a total of 849,659 procedures and, among them, 16,147 cases of surgical site infections, representing a value of 1.9% of risk.

In Brazil, as previously mentioned, the surgical site infections represent from 14% to 16% of infections in health services in general¹. A study done by Gomes and 31 collaborators at Teaching Hospital of Medicine School of Botucatu evaluated 3,427 patients who underwent surgical procedures in six specialties (General Surgery, gastric/intestinal tract, Vascular, Neurological, Gynecology and Obstetrics, in the period from July 2010 to May 2012, and reached the result of 222 (6.4%) patients who acquire an infection, being that 138 patients had the onset of infection after hospital discharge.

Another study conducted in Brazil in Hospital Geral of Belo Horizonte in the period from January 2008 to December 2011 managed to gather data from 16,882 surgical procedures, of which 568 patients (3.3%) presented infections³².

Corroborating these data and also to factors that influence the risk of contracting some surgical site infection, Lofti and collaborators³³ performed a prospective cohort study in São Paulo and analyzed surgical procedures of the head and neck in 258 patients with cancer and found a rate of 38.8% of infection, showing that the state immune status has a direct relationship to increase the risk of infection.

Concerning micro-organisms and infectious agents that affect the surgical wound, Santos et al.³⁴ showed in their scientific review that the bacteria predominate the infection signals, followed by the fungi, in 56 selected studies in the period of 1960 and 2013. The authors also reported that the most addressed infections in publications were mainly caused by: *Staphylococcus aureus* (39.28%), *Escherichia coli* (30.35%), *Pseudomonas aeruginosa* (19.64%), *Staphylococcus epidermidis* (17.85%), *Klebsiella spp* (12.50%), *Enterobacter spp* (10.71%), *Morganela morganii* (8.92%) and *Bacteroides spp* (7.14%).

Moreover, they conclude that the surgeries performed in the digestive tract, cardiothoracic surgeries and orthopedic procedures are the ones that most have infections in their surgical site infections, being the Gram-negative microorganisms the most commonly cited in the studies articles in spite of the species *Staphylococcus aureus* being the most present organism in infected surgical incisions³⁴.

Regarding fungal infections in surgical patients, Nakamura et al.³⁵ assessed the incidence of fungal infections in patients undergoing surgical procedures at Hospital das Clínicas of Medicine School of (SP) in 64 patients who presented fungal infections after surgery in the period from 2006 to 2008, 39 of which occurred in male patients (60.94%) and 25 females (39.06%), also showing that 18.74% of the infections were observed in children, 34.38% in adults and 46.88% in the elderly. The infective agent most frequently found in this study was *Candida albicans* (51.51%), followed by *Candida*

tropicalis, *Candida parapsilosis* and other species, being the gastric surgeries (73.43%) the most frequent, followed by cardiac specialties (32.81%) and otorhinolaryngology (31.25%)³⁵. The authors showed that the data found in their research go hand in hand with the database of fungal infections documented in tertiary hospitals, being the genus *Candida* fungus nosocomial the most important, responsible for about 80% of fungal infections in this context^{3,19}.

No less important, viruses can also be associated to the infections clinical signals in surgical sites, especially when dealing with the providing of the immunological status of the patient and the environment which he or she is inserted. In a revision study done by Silva and collaborators³⁶ the authors sought to analyze the quality of the air-conditioned in hospital environments as a risk factor for hospital infection, once the air can be a potential source of infection, as well as check the exposure of professionals and patients to various pollutants in the period from 1982 to 2008 in several scientific databases. In that study, the authors found microorganisms in air conditioning equipment, and reported outbreaks of nosocomial infections associated with *Aspergillus*, *Acinetobacter*, *Legionella*, among other genres such as *Clostridium*, *Nocardia*, showing that there is a need for measures of quality control of the air conditioned these environments.

Even knowing that the main source of viruses in the internal environment is the human being himself, there is consensus that the viruses have the ability to spread by air currents or in aerosol droplets dispersed by saliva, being that the air can be a vector in the process of infection³⁶, mainly the air conditioning, contaminated by particles, dust or colonized filters³⁷.

Thus, in agreement with the literature found, the microorganisms most prevalent in these air-conditioned indoor environments were the bacteria and fungi, however, the influenza virus and respiratory syncytial appeared, proving what Pereira³⁸ and Afonso³⁹ reported, that the respiratory syncytial virus survives ten times more on surfaces than on the skin.

2.5 influences and ways of prevention of surgical site infections

There are several factors that directly influence of surgical site infections, either personal issues of hospitalized patients (age, immune status, chronic diseases, abusive use of antibiotics) and medical procedures (preparation) before, during and after Surgery^{1, 8}.

It is also known that the duration of the surgery directly influences the appearance of surgical site infections, whether by bacteria, fungi or viruses present in the microbiota of patient, the environment or due to the lack of care in handling of surgical objects, having an excessive exposure of tissues, and may generate failures²⁸.

Therefore, the World Health Organization published in the

year 2016 several global guidelines for prevention of surgical site infections, namely Infections Related to Health Care more monitored and frequent in low- and middle-income countries, affecting up to one third of patients subjected to surgeries²⁹.

3 Conclusion

At the end of this work, it was possible to realize that the surgical site infections represent a significant portion of infections related to health, either at global level or at national level and many of these infections can be avoided.

Despite bacterial infections represent the most affected infections in people who undergo any surgery, infections caused by fungi and viruses can also be seen in hospital environments and their diagnosis must be carried out as soon as possible so that an appropriate treatment occurs.

Thus, taking preventive measures, as well as performing the most efficient diagnosis to detect the type of infection, makes the costs with medical services and the time of permanence of the patient in the hospital environment be reduced, decreasing the risk of infection.

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