| REVIEW ARTICLE |

SURGICAL WOUNDS INFECTIVE MICROBIOTA: NATIONAL AND INTERNATIONAL ANALYSIS OF SCIENTIFIC PRODUCTION

Microbiota infectante de feridas cirúrgicas: análise da produção científica nacional e internacional

Microbiota infeccioso de las heridas quirúrgicas: análisis de la producción científica nacional e internacional

Wanderlei Barbosa dos Santos[1], Maria Gabriella Silva Araujo[2], Jeferson Caetano da Silva[1], Thaís Honório Lins Bernardo[3], Maria Lysete de Assis Bastos[4], Regina Célia Sales Santos Veríssimo[3]

ABSTRACT: Objective: to identify the microbial flora of infected surgical wounds described in scientific literature. **Method:** integrative review conducted in the following databases: *Literatura Latino-Americana e do Caribe em Ciências da Saúde*, Medical Literature Analysis and Retrieval System Online, Scientific Electronic Library Online, Cochrane, and SciFinder Scholar. Five keywords from the Health Sciences Descriptors and boolean operators "OR" and "AND" were used for the selection of articles. A form with the information was completed: article identification, purpose, type of study, and results. **Results:** A total of 56 papers were selected, published between 1960 and 2013. The main infectious microorganisms were bacteria, followed by fungi. Infections were primarily caused by *Staphylococcus aureus* (39.3%), *Escherichia coli* (30.4%), *Pseudomonas aeruginosa* (19.6%), *Staphylococcus epidermidis* (17.8%), *Klesbsiella* spp (12.5%) and *Enterobacter* spp (10.7%). **Conclusion:** Gram-negative bacteria are the most common infectious microorganisms in surgical wounds. However, *Staphylococcus aureus* is the most frequent microorganism.

Keywords: Bacteria. Protozoan infections. Viruses. Fungi. Surgical wound infection.

RESUMO: Objetivo: Identificar a microbiota de feridas operatórias infectadas descritas em produções científicas. **Método:** Revisão integrativa realizada em bases de dados: Literatura Latino-Americana e do Caribe em Ciências da Saúde, *Medical Literature Analysis and Retrieval System Online*, *Scientific Electronic Library Online*, *Cochrane* e *SciFinder Scholar*. Para a seleção dos artigos foram utilizadas cinco palavras-chaves contempladas nos Descritores em Ciências da Saúde e os operadores booleanos OR e AND. Utilizou-se formulário com informações: identificação dos artigos, objetivo, tipo de estudo e resultados. **Resultados:** Foram selecionados 56 artigos, publicados entre 1960 e 2013. Os principais microrganismos infectantes foram as bactérias, seguidas pelos fungos. Infecções foram causadas principalmente por: *Staphylococcus aureus* (39,3%), *Escherichia coli* (30,4%), *Pseudomonas aeruginosa* (19,6%), *Staphylococcus epidermidis* (17,8%), *Klesbsiella* spp (12,5%) e *Enterobacter* spp (10,7%). **Conclusão:** Bactérias Gram-negativas são os mais frequentes microrganismos infectantes de feridas cirúrgicas. Contudo, *Staphylococcus aureus* é o microrganismo de maior frequência.

Palavras-chave: Bactérias. Infecções por protozoários. Vírus. Fungos. Infecção da ferida operatória.

RESUMEN: Objetivo: Identificar flora microbiana de heridas quirúrgicas infectadas descritas en producción científica. **Método:** Revisión integradora realizada en las bases de datos: Literatura Latino-Americana e do Caribe Ciências da Saúde, *Medical Literature Análise e Retrieval System on-line*, *Scientific Electronic Library Online*, Cochrane e *SciFinder Scholar*. La selección se utilizó cinco palabras clave que se contemplan en Ciencias de la Salud y operadores booleanos "OR" y "AND". Utilizó formulario con información: la identificación del papel, propósito, tipo de estudio y resultados. **Resultados:** 56 documentos fue seleccionado con la publicación entre 1960 y 2013. Principales microorganismos infecciosos era bacterias, seguidos por hongos. Infecciones fueron causadas principalmente por *Staphylococcus aureus* (39,3%), *Escherichia coli* (30,4%), *Pseudemonas aeruginosa* (19,6%), *Staphylococcus epidermidis* (17,8%), *Klesbsiella* spp (12,5%), *Enterobacter* spp (10,7%). **Conclusión:** bacterias Gram-negativas son microorganismos infecciosos más comunes de heridas quirúrgicas. Staphylococcus aureus es el microorganismo más frecuente.

Palabras clave: Bacterias. Infecciones por protozoos. Virus. Hongos. Infección de herida operatoria.

[1]Nursing Undergraduate Student at Universidade Federal de Alagoas (UFAL). E-mail: wanderley89@live.com; jefer_caetano@hotmail.com
[2]Nurse from UFAL. E-mail: gabriellaaraujo2@hotmail.com
[3]PhD in Biotechnology from Rede Nordeste de Biotecnologia (RENORBIO). Assistant Professor in the Nursing Undergraduate Course of the UFAL. E-mail: thais.bernardo@esenfar.ufal.br; salesregina@hotmail.com
Escola de Enfermagem e Farmácia da Universidade Federal de Alagoas – Avenida Lourival Melo Mota, s/n – Tabuleiro dos Martins – CEP: 57072-900 – Maceió (AL), Brazil.
[4]PhD in Chemistry and Biotechnology. Assistant Professor III in UFAL. E-mail: lysetebastos@gmail.com
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INTRODUCTION

Hospital infection, according to Decree No. 2616/98 of the Brazilian Ministry of Health, is defined as an infection acquired after the patient's admission and manifested during hospitalization or after discharge, when related to hospitalization or hospital/outpatient procedures or manifested during the 72 hours before admission, but associated with diagnostic and/or therapeutic procedures performed during this period[1].

Currently, due to the high rate of morbidity and mortality, wound infection is a major concern in hospitals and can also cause physical and emotional harm, often keeping the client away from work and social life. This also increases the cost of treatment, which results in a longer hospital stay and in the increase of medical expenses[2].

Surgical site infection (SSI) can be understood as the entry, establishment, and growth of the pathogen in the surgical incision. The person presents decline in general condition, anorexia, fever, and purulent drainage, exposing the condition of infection by a microorganism. Despite its nonspecific nature, fever is the most common initial clinical sign of infection[3].

Generally, infection of the surgical wound can occur between 4 and 6 days after the procedure. However, according to the US Centers for Disease Control and Prevention (CDC), 98% of the SSIs can manifest up to 30 days after surgery, or even 1 year later, when prosthesis is implanted[4].

Some factors favor the establishment and the severity of infection, which may be intrinsic — when related to the patient's condition, such as: diabetes mellitus, obesity, malnutrition, chronic vascular disease, extremes of age, protein depletion, and smoking[5] — and extrinsic, which must be identified preoperatively and are related to surgery and hospital environment, such for example, the duration of the surgical washing, prolonged hospitalization, scraping, duration of surgery, skin antisepsis, prophylactic antibiotics, and sterilization[6].

The CDC classifies SSI as superficial or deep incisional SSI, or as organ/space SSI. In superficial infection, the skin and subcutaneous tissue are affected, and, in deep, deeper layers, such as the fascial and muscle layers are affected. On the other hand, organ/space SSI involves any part of the anatomy beyond the incision that has been manipulated or opened by the surgeon[4].

In Brazil, SSI ranks third among all infections present in health services and covers 14 to 16% of infections in hospitalized patients; 93% of these are severe, invading organs or spaces accessed during surgery, thus having an incidence rate of 11%[3]. Estimates of SSIs present an incidence of 2.3% and depend on the type of surveillance conducted, the characteristics of the hospital, the patient, and the surgical procedure[7].

It is evident that the SSI can be related to the presence of microorganisms, with bacteria being what most affect surgical incisions. Some of these pathogens are part of the skin flora itself in normal conditions; however, they become pathogenic under conditions favorable for their proliferation, thereby causing SSI[8].

As a strategy to prevent SSI, prophylactic antibiotic therapy is performed. However, many bacteria in the hospital environment have become resistant to most antibiotics used perioperatively due to exposure to these drugs, increasing hospital costs, as well as harming the recovery of the patient[9].

Given the above, this review has the following guiding question: what is the infectious microflora of surgical wounds described in scientific publications?

OBJECTIVE

This study aimed at identifying the microbiota present in surgical wound infections described by national and international scientific productions.

METHOD

This is an integrative review, which is an important tool for clinical practice, gathering results on a given topic and providing a deepening of the research theme.

The search was conducted in the following databases: *Literatura Latino-Americana e do Caribe em Ciências da Saúde* (LILACS), Medical Literature Analysis and Retrieval System Online (MEDLINE), Cochrane, and virtual libraries Scientific Electronic Library Online (SciELO) and SciFinder Scholar. The guiding question was the infecting microbiota in surgical wounds.

The study was conducted between September and December 2013, with no time frame. For the selection of the articles, the following Portuguese keywords were used: *bactérias; protozoários, vírus, fungos e infecção de ferida operatória*; in

English: bacteria, protozoan, viruses, fungi, surgical wound infection; and Spanish: *bacterias, protozoos, virus, hongos, infección de herida operatória*; all of which were included in DeCS (Health Sciences Descriptors).

Boolean operators OR and AND were used, and the crossing of descriptors in Portuguese, English, and Spanish was used as a research strategy, such as (*bactérias* OR *protozoários* OR *vírus* OR *fungos*) AND (*infecção de ferimento pós-operatório* OR *infecção da ferida operatória* OR *infecção de ferida pós-operatória*).

Inclusion criteria for selection were: articles published in Portuguese, English, or Spanish that portrayed in full the theme of the study. Items that do not relate to surgical wound infection and duplicates were excluded. Studies found in more than one database were considered only once.

For the analysis of the articles, the following variables were selected: title of the articles, authors, country, journal, database, publication year, qualification of the authors, language, professional area, approach, study type, classification of the surgeries, and types of surgeries infected.

The articles that met the inclusion criteria were analyzed using a form that included identification information for each article, in order to consolidate all the results presented in scientific production.

RESULTS

A total of 278 articles were found with the search in the databases, among which 56 articles met the search criteria. The bibliometric profile of the 56 studies included in the review was plotted and is shown in Table 1.

Most of the studies had a quantitative approach (94.6%), among which the exploratory descriptive studies were predominant (85.7%), and 71.4% were published in journals with international distribution.

Regarding the general theme, all articles dealt with different surgeries that presented SSI. Surgeries were classified and identified according to their site as shown in Table 2.

The microbiota responsible for the infection in these surgeries has also been identified and analyzed, and the main infectious microorganisms from surgical wounds described in the scientific productions were bacteria, followed by fungi (Tables 3 and 4).

The infections most cited in scientific publications were mainly caused by: *Staphylococcus aureus* (39.28%), *Escherichia coli* (30.35%), *Pseudomonas aeruginosa* (19.64%), *Staphylococcus epidermidis* (17.85%), *Klesbsiella* spp (12.50%), *Enterobacter* spp (10.71%), *Morganela morganii* (8.92%), and *Bacteroides* spp (7.14%). It is observed that the main microorganism in surgical wound infections were Gram-negative bacteria, which have a tendency to resist to the therapy used.

Table 1. Bibliometric profile of the studies analyzed.

Variable	n (%)
Database	
Cochrane	29 (51.8)
LILACS	25 (44.6)
SciELO	2 (3.6)
Continents	
North America	13 (23.21)
Central America	5 (8.92)
South America	20 (35.71)
Europe	11 (19.64)
Asia	7 (12.5)
Decades	
1960 – 1969	1 (1.80)
1970 – 1979	2 (3.60)
1980 – 1989	11 (19.6)
1990 – 1999	8 (14.3)
2000 – 2009	22 (39.3)
2010 – 2013	12 (21.43)
References	
International	40 (71.4)
National	16 (28.6)
Academic education	
Doctor	153 (62.4)
Nurse	8 (3.3)
Dentist	8 (3.3)
Chemist	3 (1.2)
Unspecified	73 (29.8)
Approach	
Quantitative	53 (94.6)
Qualitative	3 (5.4)
Study design	
Descriptive exploratory	48 (85.7)
Review study	4 (7.1)
Experimental	2 (3.6)
Experience report	1 (1.8)
Observational	1 (1.8)

Table 2. Classification and identification of the types of surgeries found in the studies analyzed.

Variable	n (%)
Classification of surgeries	
Deep	32 (37.6)
Superficial	32 (37.6)
Organ/space	21 (24.8)
Types of surgeries infected	
Digestive tract	27 (31.73)
Cardiothoracic	15 (17.64)
Orthopedic	15 (17.64)
Head and neck	9 (10.6)
Abdominal	9 (10.6)
Urologic	1 (1.17)
Unspecified	9 (10.58)

Table 3. Percentage of surgical site infection by Gram-positive bacteria identified in the scientific publications.

Microorganisms	%
Staphylococcus aureus	39.28
Staphylococcus epidermidis	17.85
Staphylococcus coagulase-negativa	10.71
Staphylococcus spp	12.50
Staphylococcus haemolyticus	3.57
Staphylococcus saprophyticus	1.78
Staphylococcus capitis	1.78
Streptococcus pyogenes	1.78
Staphylococcus hominis	1.78
Streptococcus viridans	3.57
Streptococos pneumoniae	1.78
Streptococcus pyogenes	1.78
Streptococos spp	5.35
Corynebacterium minutissimum	1.78
Corynebacterium bovis	1.78
Corinebactérias	1.78
Clostridium innocuum	1.78
Enterococcus spp	10.71
Enterococus faecalis	7.14
Peptococcus spp	3.57
Peptostreptococci	7.14
Propionibacterium spp	1.78
Propionibacterium acnes	3.57
Pneumococus spp	1.78
Eubacterium lentum	1.78

Table 4. Percentage of surgical site infection by Gram-positive bacteria, identified in the scientific publications.

Microorganisms	%
Acinetobacter baumanii complex	3.57
Acinetobacter baumannii	1.78
Acinetobacter spp	3.57
Acinetobacter calcoaceticus	5.35
Bacteroides fragilis	7.14
Bacteroides spp	7.14
Bacillus spp	1.78
Cedecea lapagei	1.78
Escherichia coli	30.35
Enterobacter spp	10.71
Enterobacter cloacae	7.14
Enterobacter aerogenes	1.78
Klebsiella spp	12.5
Klebsiella pneumoniae	5.35
Klebsiella ornithinolytica	1.78
Klebsiella oxytoca	1.78
Morganella morganii	8.92
Mycobacterium massiliense	1.78
Mycobacterium abscessus	1.78
Mycobacterium chelonae	1.78
Mycobacterium fortuitum	1.78
Melaninogenicus bacillus	1.78
Micrococcus luteus	1.78
Pseudomonas aeruginosa	19.64
Pseudomonas epiderme	1.78
Pseudomonas spp	5.35
Proteus spp	3.57
Proteus mirabilis	7.14
Proteus vulgaris	3.57
Serratia marcescens	3.57
Serratia spp	3.57
Sphingomonas paucimobilis	1.78
Salmonella spp	1.78
Veillonella	3.57
Haemophilus influenzae	3.57
Fusobacterium	1.78
Moraxella	1.78
Thetaiotaomicron bacteroides	1.78

DISCUSSION

Although there has been progress with the development of antibiotic therapy in the treatment of nosocomial infections, it is observed that surgical incision infections are still a concern, especially when the dehiscence of the wound occurs[10].

Infection with microorganisms at the surgical site is increasingly becoming a health problem, particularly infections caused by *E. coli*, *S. aureus,* and *P. aeruginosa*, which can cause complete surgical dehiscence without evisceration, abscess, retarding of the healing process, and death by septic shock and/or pneumonia[11].

Destitution and bacterial growth are the main prerequisite for the development of infection as well as the kind of microorganisms and toxins synthesized by them. Many pathogens have specific components that increase its virulence, such as *Klebsiella* spp and *Streptococcus pneumoniae* capsules, the endotoxins of gram-negative bacteria *Pseudomonas sp*, *Acinetobacter baumannii,* and *Bacillus* spp, exotoxins of streptococci, biofilms of *S. aureus* and *S. epidermidis*, contributing to antibiotic resistance[12].

Of the Gram-positive pathogens, *S. aureus* is responsible for many hospital infections that are usually transmitted by direct or indirect contact, from the patient's own normal skin flora, or by migration during the end of the procedures. In many cases, it can also have high resistance to antibiotics. Its severity and occurrence depend essentially on the triple relationship: host susceptibility, resistance, and quantity of microorganism[13].

Studies show that the pathogens of the SSI microbiology vary depending on the type of operation and the procedures performed. *S. aureus* was the most prevalent microorganism isolated in SSIs, followed by *K. pneumoniae*, *E. coli,* and *Klebsiella ozonae*[14].

Some authors have identified in their research a total of 343 bacterial colonies (average of 1.5 per patient), by 13 different resistant microorganisms, and the most common 5 accounted for more than 90% of cases (*A. baumannii*, 36.3%; *P. aeruginosa*, 21.9%; methicillin-resistant *S. aureus*, 14.7%; *Klebsiella pneumoniae*, 11%; and *E. coli*, 7.8%). However, this does not denote that the infections were caused by the resistant microorganisms isolated, only that the colonization were in many cases associated with the presence of these or other microorganisms in developed infections[15].

Other microorganisms that were not resistant became evident; however, they demonstrated their ability to be responsible for nosocomial infections, the most common being *Candida albicans* (18,5%), *E. coli* (15.1%), *P. aeruginosa* (8.9 %), *Enterobacter cloacae* (8.2%), and *Enterococcus faecalis* (8.2%). Among the more common resistant microorganisms that cause nosocomial infection are *A. baumannii* (35.1%), *P. aeruginosa* (21.6%), *K. pneumoniae,* and *E. coli* (10.8%)[15].

Although Gram-positive bacteria are the main causal agents, there are wide variations, and each service must know the microbiota related to health care. Other agents besides the germs are various contaminants from exogenous sources, such as instruments and prostheses[16].

With regarding to the determination of the specific site of the SSI, the sample showed that the superficial and deep categories showed the same quantity, followed by organ and space, both in-hospital and after discharge. Thus, during the hospitalization period, in the superficial and deep category, a total of 37.6% of infections was recorded, and, in the organ or space, 24.8%. These results do not support other studies, which have recorded 87.5% in superficial and 12.5% in deep SSI, with no SSI record of organ or space. The same study also shows that, in the postdischarge period, the total percentage of SSI diagnosed was 91.6% in the superficial category, 4.2% in deep and 4.2% for organ/space[17].

It is known that SSI is multifactorial; therefore, for the purpose of reducing the SSI rates, prophylactic measures should be provided, such as surgical antisepsis of the hands and forearms, justified by a rate of perforation of gloves by the end of surgery of 66.7%, as such perforations are not observed by the professionals at the end of the procedure. Other measures can also be taken, such as the appropriate time for the removal of hair, when needed; choice of antimicrobial prophylaxis related to the time of administration; nonuse of hand or forearm accessories by surgeon teams and the proper use of surgical mask, sterile coat/gown[18].

Investing in education in order to improve the assistance and the involvement of professionals in the implementation of preventive measures for SSI are essential to the full incorporation of the recommendations against SSI in the care of surgical patients[19].

CONCLUSION

In the face of the articles analyzed, it was found that surgeries with highest number of infections on the surgical site are those performed in the digestive tract, followed by cardiothoracic and orthopedic surgeries.

Gram-negative bacteria are the organisms most cited in the studied articles as responsible for infection of surgical incisions. However, *S. aureus* was the most present microorganism in infected surgical incisions that was mentioned in the scientific publications analyzed.

REFERENCES

1. Brasil. Ministério da Saúde. Portaria nº 2.616, de 12 de maio de 1998. Regulamenta as ações de controle de infecções hospitalares no Brasil. Brasília: Diário Oficial da União; 1998 [acesso em 2014 mar 14]. Disponível em: http://www.ccih.med.br/portaria2616.html

2. Silva QCG, Barbosa MH. Fatores de risco para infecção de sítio cirúrgico em cirurgia cardíaca. Acta Paul Enferm. 2012;25(Núm Especial):89-95.

3. Brasil. Agencia Nacional de Vigilância Sanitária. Sítio cirúrgico: critérios nacionais de infecções relacionadas à assistência à saúde. Brasília: ANVISA; 2009.

4. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Am J Infect Control. 1999;27(2):97-132.

5. Oliveira EM, Paula JB. Fatores associados à infecção de sítio cirúrgico em pacientes idosos submetidos à cirurgia cardíaca com esternotomia. Saúde (Sta Maria). 2014;40(1):37-44.

6. Feitosa RGF, Fernandes FAM, Narciso Junior J, Araújo Junior ON, Costa FA, Cavalcante LDW. Análise da incidência de infecção de sítio cirúrgico em cirurgias oncológicas do aparelho digestivo no Hospital Geral de Fortaleza. Medicina (Ribeirão Preto). 2014;47(2):157-64.

7. Ren T, Ding L, Xue F, He Z, Xiao H. Risk factors for surgical site infection of pilon fractures. Clinics. 2015;70(6):419-22.

8. Santos GC, Baylão AFG, Borges SCF, Silva LA, Batista MHJ, Leite GR. Incidência e fatores de risco de infecção de sítio cirúrgico: revisão integrativa. IR. 2015;11(1):1-17.

9. Pereira GCB, Lima LS, Pinheiro PNQ, Dolabela MF. Perfil de uso de antimicrobianos em procedimentos de otorrinolaringologia. Rev Para Med. 2014;28(1):31-9.

10. Santana RS, Viana AC, Santiago JS, Menezes MS, Lobo IMF, Marcellini PS. Consequências do uso excessivo de antimicrobianos no pós-operatório: o contexto de um hospital público. Rev Col Bras Cir. 2014;41(3):149-54.

11. Alves ANF, Duartes CA, Paula MP, Moraes RE, Coutinho RMC. Conhecimento da enfermagem na prevenção de infecção hospitalar. Rev Inst Ciênc Saúde. 2007;25(4):365-72.

12. Lichtenfels E, Lucas ML, Webster R, d'Azevedo PA. Profilaxia antimicrobiana em cirurgia vascular periférica: cefalosporina ainda é o padrão-ouro? J Vasc Bras. 2007;6(4):378-87.

13. Vilarinho LM, Vilarinho MLCM, Silva FL, Guimaraes MSO, Leal ACAM. Isolamento de *Staphylococcus aureus* em mãos de profissionais de unidades de terapia intensiva. Rev Pre Infec e Saúde. 2015;1(1):10-18.

14. Rodrigues AL, Simoes MLPB. Incidência de infecção do sítio cirúrgico com o preparo pré-operatório utilizando iodopolividona 10% hidroalcoólica e clorexidina alcoólica 0,5%. Rev Col Bras Cir. 2013;40(6):443-8.

15. Oliveira AC, Kovner CT, Silva RS. Infecção hospitalar em unidade de tratamento intensivo de um hospital universitário brasileiro. Rev Latino-Am Enfermagem. 2010;18(2):233-9.

16. Ercole FF, Chianca TCM, Duarte D, Starling CEF, Carneiro M. Infecção de sítio cirúrgico em pacientes submetidos a cirurgias ortopédicas: o índice de risco NNIS e predição de risco. Rev Latino-Am Enfermagem. 2011;19(2):269-76.

17. Oliveira AC, Ciosak SI. Infecção de sítio cirúrgico em hospital universitário: vigilância pós-alta e fatores de risco. Rev Esc Enferm USP. 2007;41(2): 258-63.

18. Oliveira AC, Gama CS. Avaliação da adesão às medidas para a prevenção de infecções do sítio cirúrgico pela equipe cirúrgica. Rev Esc Enferm USP. 2015;49(5):767-74.

19. Pereira BRR, Mendoza IYQ, Couto BRGM, Ercole FF, Goveia VR. Artroplastia do quadril: prevenção de infecção do sítio cirúrgico. Rev SOBECC. 2014;19(4):181-7.