Revista Visa em debate sociedade, ciência & tecnologia

ARTICLE
https://doi.org/10.22239/2317-269x.01472

Characterization of surgical site infections in patients undergoing neurosurgery in a public hospital between 2017 and 2019

Caracterização das infecções de sítio cirúrgico em pacientes submetidos à neurocirurgia em um hospital público entre 2017 a 2019

Josni Tauffer*

Débora Cristina Ignácio Alves

Ariana Rodrigues da Silva Carvalho

Fabiana Gonçalves de Oliveira Azevedo Matos

Universidade Estadual do Oeste do Paraná, Cascavel, PR, Brasil

* **E-mail:** josnitauffer@hotmail.com

Received: Feb 27 2020
Approved: Sep 09 2020

ABSTRACT

Introduction: Surgical site infections in patients undergoing neurological procedures contribute to the development of complications, as they constitute a serious threat to patient safety. **Objective:** To characterize the profile of surgical site infections in patients undergoing neurosurgery at a teaching hospital in Paraná. **Method:** Retrospective study, from a documentary, quantitative source, carried out from January 2017 to December 2019. Data were collected and organized in tables and analyzed using descriptive statistics. **Results:** 100.0% (n = 439) infections were reported and, of these, 10.0% (n = 44) were part of the sample. There was a predominance of males 72.7% (n = 32) and the average age of the participants was 31.2 years. The average hospital stay was 82.5 days. The implantation of peritoneal or external ventricular bypass was the surgical procedure performed in 40.9% (n = 18) of the patients and according to the potential for contamination, 100.0% of the surgeries were classified as clean. There were 68.1% (n = 30) infections clinically defined as infection of the surgical organ cavity site, with a prevalence of 33 75.0% (n = 33) cases. The prevalent microorganism was *Pseudomonas* spp. with 42.9% (n = 6). For the outcome of the cases, 29.5% (n = 13) of the patients developed other infections, 93.1% (n = 41) were discharged from the hospital and 6.8% (n = 3) patients died. **Conclusions:** SSIs directly influence the health of neurological patients, requiring the implementation of strategies aimed at reducing statistics and promoting patient safety.

KEYWORDS: Infection Control; Epidemiology; Nursing; Surgical Wound Infection; Neurology

RESUMO

Introdução: As infecções de sítio cirúrgico em pacientes submetidos a procedimentos neurológicos contribuem para o desenvolvimento de complicações, pois constituem séria ameaça à segurança do paciente. **Objetivo:** Caracterizar o perfil das infecções de sítio cirúrgico em pacientes submetidos a neurocirurgias em um hospital-escola do Paraná. **Método:** Estudo retrospectivo, de fonte documental, quantitativo, realizado no período de janeiro de 2017 a dezembro de 2019. Os dados foram coletados e organizados em tabelas e analisados por meio de estatística descritiva. **Resultados:** Foram notificadas 439 infecções de sítio cirúrgico e, destas, 10,0% (n = 44) fizeram parte da amostra. Houve predomínio do sexo masculino, 72,7% (n = 32), e a média de idade dos participantes foi de 31,2 anos. O tempo médio de internação foi de 82,5 dias. O implante de derivação ventricular peritoneal ou externa foi o procedimento cirúrgico realizado em 40,9% (n = 18) dos pacientes e, segundo o potencial de contaminação, 100,0% das cirurgias foram classificadas como limpas. Foram 68,1% (n = 30) de infecções clinicamente definidas como infecção de sítio cirúrgico de órgão cavidade, prevalecendo em 33 (75,0%) casos. O microrganismo prevalente foi *Pseudomonas* spp., com 42,9% (n = 6). Para o desfecho dos casos, 29,5% (n = 13) dos pacientes desenvolveram outras infecções, 93,1% (n = 41) tiveram alta hospitalar e 6,8% (n = 3) dos pacientes evoluíram a óbito. **Conclusões:** As infecções de sítio cirúrgico influenciam diretamente a saúde do paciente neurológico, sendo necessária a implementação de estratégias que visem reduzir as estatísticas e promovam a segurança do paciente.

PALAVRAS-CHAVE: Controle de Infecção; Epidemiologia; Enfermagem; Infecção da Ferida Cirúrgica; Neurologia

INTRODUCTION

Healthcare-associated infections (HAIs) are a major problem in public health. They are mainly associated with invasive procedures and result in an increase in direct, indirect and intangible costs, length of hospitalization, clinical complications and, oftentimes, the spread of multiresistant microorganisms.[1]

According to data from the World Health Organization (WHO), in Brazil, surgical site infections (SSIs) account for about 15% of all HAIs and lead to an average increase of 60% in patients' length of stay[2].

The incidence of SSIs is much lower in developed countries, however, it is the second most common cause of HAIs in Europe and the United States. The mortality rate in patients affected by SSIs is about 77%. Although most patients recover from this condition, SSIs can cause long-term damage, often with irreversible sequelae.[3,4]

SSIs in patients undergoing neurological procedures contribute to the appearance of complications, considering these patients' long hospital stay, their morbidities, the need for other surgical interventions, the occurrence of other HAIs, among other complications. A study done at a university hospital in Italy observed that infection rates ranged from 1.0% to 8.0% in cranial procedures and from 0.5% to 18.0% in spinal surgeries.[5]

The quality of hospital epidemiological surveillance services in the prevention and control of HAIs is still an unmet challenge, as these infections continue to pose serious threats to patient safety.[1,2,3] Improving monitoring initiatives in Hospital Infection Control Services (HICS) is essential, since the data and information acquired through this monitoring can support the planning of individual and collective actions to prevent HAIs.[6]

The search for quality in healthcare services has encouraged more robust systems to monitor adverse events, including HAIs. To address that, the Brazilian government has some hospital-oriented initiatives in place, including programs like the Patient Safety Center (NSP), which supports the adoption of measures aimed at preventing and reducing the incidence of adverse events in patient care. These initiatives are guided by international patient safety goals, namely: 1. identify patients correctly; 2. improve effective communication; 3. improve the safety of high-alert medications; 4. ensure safe surgery; 5. reduce the risk of healthcare-associated infections; 6. reduce the risk of patient harm resulting from falls. These goals were established by the WHO and recommended by the Joint Commission International (JCI).[1,7]

The importance of goals 4 and 5 stands out when it comes to the implementation of the safe surgery protocol and the reduction of HAIs, respectively. These goals are directly related to the object of this study due to the high rates of SSI in patients undergoing neurosurgery at the institution as per data from recent years.

Thus, this study aimed to characterize the profile of SSIs in patients undergoing neurosurgery at a teaching hospital in the Brazilian state of Paraná, providing the institution's HICS with tools to support measures aimed at preventing these infections, contributing to the reduction of complications associated with them and improving the quality of the hospital's patient care.

METHOD

Descriptive, retrospective study with a quantitative approach, performed through passive search in electronic health records (EHR), from January 2017 to December 2019, in a teaching hospital in the state of Paraná. Data were collected at the HICS after approval of the study by the Research Ethics Committee (CEP), under CAEE n. 50066815.8.0000.0107 and Opinion n. 3.062.301, according to the ethical and legal precepts of Resolution n. 466, of December 12, 2012, of the National Health Council (CNS).[8]

The study investigated all the health records that, in the period determined for data collection, indicated the appearance of SSI resulting from neurological surgical procedures. This included patients of both sexes and different ages, all followed up on with reporting forms prepared by the HICS until the outcome of the case.

Therefore, the study variables were: a) sex; b) age; c) length of stay; d) surgical procedure; e) surgery potential for contamination; f) diagnostic criteria for identifying the SSI; g) specific site of the SSI; h) isolated microorganisms; i) antimicrobial therapy administered and j) outcome of the cases.

The criteria used to classify the SSIs were established by the Centers for Disease Control and Prevention (CDC)[9] and the Diagnostic Criteria for Healthcare-associated Infections of Brazil's National Health Surveillance Agency (Anvisa).[6]

Antibiotic therapy is administered from the moment the SSI is confirmed until hospital discharge, considering the diagnostic criteria of HAIs already described, which were organized into classes according to Anatomical Therapeutic Chemical (ATC), WHO.[10]

The passive search for HAIs at the study institution is part of the in-service training carried out by residents of the Nursing Residency Program—Specialization in Health Surveillance and Infection Control. This program started in 2017, which justifies the period addressed in this study. The data available in the EHR were collected through the HAI reporting form, prepared by the HICS, with data inherent in the daily monitoring of patients, including clinical signs and symptoms, clinical analysis and imaging tests, antimicrobial therapy used before, during and at the end of the treatment of the HAI, and data about any invasive procedures.

The collected data were compiled and processed in Microsoft Office Excel 2007 electronic spreadsheets. The data were then submitted to descriptive statistical analysis and presented as absolute and relative frequency.

RESULTS

A total of 439 cases of SSI were observed during the study period and, after applying the inclusion criteria established for the study, we could identify 10.0% (n = 44) of SSIs in patients undergoing neurosurgery. Table 1 shows the variables analyzed in the total sample.

The average length of stay was 82.5 days (range, 10-379), with a median of 50 days, standard deviation of 83.7 (95% confidence interval [CI], 57.7-107.2).

According to the Diagnostic Criteria for Healthcare-associated Infections,[6] we analyzed the relationship between the surgical procedure to which the patient was submitted and the site affected by the infection. This classification can be seen in Table 2.

The criteria and diagnoses of infection, which determine how to confirm an infection, can be defined as clinical-only or criteria with laboratory support (which may confirm a microorganism as the causative agent of the infection). Regarding the clinical criteria, the patient's symptoms are observed: fever, signs of inflammation or purulent drainage at the insertion of the surgical wound, decrease or increase in heartbeat or complaints of pain in the surgical wound.

For laboratory criteria, microbiological analysis is required to evidence the presence of a causative agent, that is, to find the microorganisms that are directly linked to the infection of the surgical site wound. This investigation takes place by collecting material from the wound, researching the pathogen and determining its susceptibility to antimicrobials in order to inform the treatment.

Of the 14 SSIs defined by microbiological criteria, the following could be identified: *Pseudomonas aeruginosa* in 42.9% (n = 6) of the infections, *Staphylococcus aureus* in 28.6% (n = 4), *Escherichia coli* in 14.3% (n = 2), and *Klebsiella pneumoniae* and *Neisseria meningitidis* in 7.1% (n = 1).

During the investigation period, there were 108 antibiotic prescriptions for the total sample, including situations with concomitant use of two or more antibiotics by the same patient. For cases in which a microorganism was identified by laboratory means, the antibiotic class and the resistance profile of the microorganism were determined.

Resistance to ß-lactams was identified in 66.6% (n = 4) of the *P. aeruginosa* strains, 25.0% (n = 1) of the *S. aureus* strains and in 100.0% of the *E. coli* , *K. pneumoniae* and *N. meningitidis* strains. For these last two microorganisms, resistance to quinolones was also identified. Half of the *S. aureus* strains (50.0%; n = 2) were resistant to aminoglycosides. All patients who had identified microorganisms were receiving some type of antibiotic from the therapeutic classes in which resistance was identified.

Regarding the outcome of the cases, the prevalence was of hospital discharge, which totaled 93.1% (n = 41) of the patients, whereas 6.8% (n = 3) of the cases evolved to death, with a fatality rate of 6.8%.

Table 1. Distribution of the characterization of patients undergoing neurosurgeries who presented with surgical site infection from January 2017 to December 2019. Paraná, 2020.

Variable	n	%
Sex		
Male	32	72.7
Female	12	27.2
Age		
0 to 9	13	29.5
10 to 19	4	9.1
20 to 29	6	13.6
30 to 39	4	9.1
40 to 49	3	6.8
50 to 59	5	11.3
60 to 69	5	11.3
69 to 79	4	9.1
Surgical procedure		
Peritoneal or external ventricular shunt	18	40.9
Decompressive craniectomy	10	22.7
Lumbar arthrodesis	6	13.6
Brain surgery for tumor removal	6	13.6
Surgery for removal of brain aneurysm	2	4.5
Spinal cord surgery for tumor removal	1	2.3
Surgical treatment to correct dysraphism	1	2.3
Contamination potential		
Clean	44	100.0
SSI diagnostic criteria		
Clinical	30	68.1
Microbiological	14	31.8
SSI specific site		
Organ Space Surgical Site Infection (SSI-OS)	33	75.0
Deep Incisional Infection (SSI-DI)	8	18.1
Superficial Incisional Infection (SSI-SI)	3	6.8
Outcome		
Hospital discharge	41	93.1
Death	3	6.8
Other healthcare-associated infections		
Other	13	29.5

SSI: surgical site infection
Source: Data from the survey of electronic health records, 2020.

Moreover, as for deaths, we can observe that there was no trend pointing to a specific period of life in relation to age, and among the three cases, the ages were, respectively, eight months, 34 years and 75 years. These three cases were patients who developed organ/space surgical site infection (SSI-OS) after

Table 2. Distribution of surgical site infections in neurosurgeries according to the specific site of involvement according to the criteria[6] used. Paraná, 2020.

Variable	n	%
Organ/space infection (SSI-OS)	33	100.0
Peritoneal or external ventricular shunt	17	51.5
Decompressive craniectomy	6	18.1
Brain surgery for tumor removal	6	18.1
Lumbar arthrodesis	3	9.0
Surgery for removal of brain aneurysm	1	3.0
Deep Incisional Infection (SSI-DI)	8	100.0
Decompressive craniectomy	3	37.5
Lumbar arthrodesis	2	25.0
Peritoneal or external ventricular shunt	1	12.5
Spinal cord surgery for tumor removal	1	12.5
Surgical treatment to correct dysraphism	1	12.5
Superficial Incisional Infection (SSI-SI)	3	100.0
Decompressive craniectomy	1	33.3
Lumbar arthrodesis	1	33.3
Surgery for removal of brain aneurysm	1	33.3

Source: Data from the survey of electronic health records, 2020.

peritoneal shunt surgery, microsurgery for intracranial tumor, and arthrodesis, respectively. Among the diagnostic criteria for the identification of a SSI, 75.0% (n = 2) were clinically defined and 25.0% (n = 1) of the cases had a microbiological definition, with a predominance of *Pseudomonas* spp.

Among the cases that developed other HAIs, the prevalence of these infections was 46.1% (n = 6) in ventilator-associated pneumonia (VAP), 38.4% (n = 5) in urinary tract infection (UTI), 30.7% (n = 4) pneumonia, 23.0% (n = 3) in peripheral intravenous catheter (PIVC), 15.3% (n = 2) in primary bloodstream infection (BSI), and 7.6% (n = 1) in tracheobronchitis. It is noteworthy that, in some cases, patients developed more than one HAI during the study period.

DISCUSSION

As defined by the CDC and the Diagnostic Criteria for Healthcare-associated Infections by Anvisa, SSIs must occur within the first 30 days of the surgical procedure, or 90 days if any implant is placed.[6,9]

Once the possibility of SSI is identified, the criteria and diagnoses help confirm it by determining the insertion site affected by the infection, that is, the location and depth where this infection is located. For this, the criteria follow some specific definitions to identify the origin of the infection, such as superficial incisional infections (SSI-SI) that involve only subcutaneous tissue, deep incisional infections (SSI-DI) that affect soft and deep tissues in the incision, and SSI-OS involving any organ or cavity that was manipulated during the surgery.[6]

In this study, data have shown an occurrence of 72.7% among males. These data differ from other studies that found between 46.3% and 58.9% of occurrence for males[11,12,13,14,15,16,17,18,19] and suggest that sex is not a risk factor for the development of SSIs after neurosurgery. Our research shows that most cases occurred in males. We can correlate this with the fact that one of the main causes of admission was trauma, since males tend to be more involved in risky situations, and also because the state of Paraná is one of the Brazilian states with the highest rates of traffic accidents, especially in the West Region, where the study was conducted.[11]

Concerning age, the mean ranged between 46.6 and 61.0 years of age for most studies.[5,12,13,14,15,16,17,18] The data obtained in our study, 31.2 years on average, are corroborated by the results presented above. We emphasize that few studies were found whose target population was under 18 years of age and, in the study presented here, 38.6% of the patients were aged between 0 and 19 years. This is significant data, since the hospital studied here is a state reference center for the treatment of congenital neurological anomalies, and that is why this age group is present in this study.

When comparing the average length of stay of studies that addressed the same characteristic, results vary between 2 and 28 days of hospitalization,[2,12,14,16] while for the present study, the average of days of hospitalization was 82.5 days (range 10-379), with a median of 50 days, standard deviation of 83.7 (95% confidence interval [CI], 57.7-107.2). These data predominate in relation to the characteristics of the patients, and it has been described that 38.6% are children between 0 and 19 years old with congenital neurological anomalies, often with suppression of the immune system and severe conditions, which led to more complex and longer treatments.

Surveillance prior to surgery has the objective of collecting data about the patient and about the conditions that led to the need for a surgical procedure. This surveillance is extremely important to define cases of SSI, as it supports the identification of this type of infection and whether it meets the criteria for being an HAI. It has been analyzed in some studies and the data found can help determine the situations that favor the onset of SSIs, like chronic diseases, length of hospital stay, history of underlying lung disease, surgical emergencies, confinement to bed, increase in the perioperative period, anatomy of the surgical site and the potential for dirty or infected contamination. All these variables tend to increase the risks for the development of SSIs.[2,5,12,13,14,15,17]

According to the classification of surgical contamination potential, surgeries can be classified as clean, potentially contaminated, contaminated and infected. Clean surgeries are those performed on sterile or decontaminated tissues, in the absence of a local infectious process on areas like epidermis, subcutaneous tissue, musculoskeletal, nervous and cardiovascular systems.[9]

This classification is described in the guidelines[6,9] and in the criteria adopted by the institution and depends on a thorough assessment of various factors, which is to be done by the surgeon. Some studies reported a variation between 1% to 10% for the development of SSI in clean surgeries.[8] Surgical preparation and the number of professionals in the operating room are considered predictors and should be analyzed so that SSI prevention measures can be effectively adopted.[4,12,14]

The relationship between SSI and contamination potential can be observed in a study involving 185 neurological surgeries defined as clean. Of these, 3.8% (n = 7) developed SSI. When compared to other cases of different specialties and contamination potentials, these data were prevalent in neurosurgery.[20]

Regarding the type of surgical procedure, in the present study, considering patients who underwent shunt implantation, whether peritoneal or external, the prevalence of SSI was 40.9%. This prevalence was also observed in a study in which 333 cranial procedures were analyzed. Of this total, 7.2% (n = 24) of the procedures developed SSI, and in 91.6% (n = 22) of these procedures, an external ventricular bypass was implanted.[13]

This incidence was also described in a university hospital in Germany, where 218 patients underwent external ventricular bypass procedures, with an infection incidence rate of 10.4 per 1,000 procedures. Additionally, 95% of these HAIs developed between 6.2-16.5 days after catheter placement. Among these procedures, 88 implanted catheters were of the conventional type and 122 of them were silver-impregnated. The use of the latter did not show any differences in terms of post-surgical non-contamination.[16]

In this study, the SSI-DI and SSI-OS were the most prevalent among the surgical procedures performed. Other studies have shown that these surgical sites are predominant for this classification due to their anatomical location, mainly due to the type of surgery, which, in most cases, involves deeper planes.[13,14,15] These numbers were also significant in a study of 30 cases of SSI after neurosurgery, in which 70% (n = 21) of the cases were SSI-OS, 17% (n = 5) SSI-SI and 13% (n = 4) SSI-DI.[14]

In most cases, infection by pathogens is strongly related to the patient's natural microbiota and the microbiological profile of the institution. Some prospective studies on positive cultures show that most pathogen infections were caused by *Staphylococcus* spp.[14,17,21]

The present study has shown that *Pseudomonas* spp. predominated in positive cultures. This pathogen is a microorganism that is not part of the natural human microbiota. It is commonly found in soil, decaying organic matter, vegetation and water, and disseminated in hospital settings through the contamination of hospital devices and materials, especially those with liquid components, such as mechanical ventilation equipment, intravenous infusion fluids, among others.[22]

For studies in which the population was affected by SSI after neurosurgery, infections by *S. aureus* were prevalent compared to other microorganisms. This microorganism is present in most cases of HAI and is highly pathogenic. Although it is part of the microbiota of most individuals, this pathogen is frequently found in hospital settings, since its main transmission mechanism is contact. Therefore, in most cases, its main carriers are healthcare professionals, especially because *S. aureus* colonizes nasal cavities, hands and health products.[23]

Another study that included 808 cases of spinal surgery has shown that *S. aureus* was found in 58.6% (n = 17) of positive cultures. Furthermore, in 44.8% (n = 13) of these, the patient had not received any prophylactic measures, and in four (13.7%) surgeries, bacterial growth was found even after this measure. Also, in this study, the occurrence of pathogens in two different surgeries was compared. Of a total of 25 craniotomy surgeries, 24.0% (n = 6) presented *S. aureus* as the main pathogen of SSI and, for spinal surgery, this microorganism was found in 22.2% (n = 4) of SSI.[17]

In a study that analyzed 334 craniotomy procedures, 133 (40%) patients developed SSI, and 88% of post-craniotomy meningitis had Gram-negative bacteria: *Acinetobacter* spp; *Klebsiella* spp; *P. aeruginosa*; *Enterobacter*; *Proteus mirabilis*, results that are similar to those of the present study.[24]

Apparently, adopting a preoperative prophylaxis regimen can modify the organism's microbial flora by eradicating antibiotic-sensitive strains and the colonization by drug-resistant organisms.[14,25] It is noteworthy that in this study, the vast majority of microorganisms found in the cultures were resistant to the class of antibiotics chosen for their treatment.

Most microorganisms found in the study are generally present in the endogenous microbiota of human beings, especially in the hands of healthcare professionals, who often contaminate medical devices. This evidence calls into question the correct adoption of hand hygiene procedures by professionals and even the preoperative preparation of patients, among others,[26,27] considering that these measures could avoid about 60% of SSIs.[6,9]

Regarding the outcome of patients after SSI due to neurological surgery, there was no difference from the other studies listed for this research. One of these studies deals with 43 cases of SSI in neurosurgeries, in which 34.8% (n = 15) of the patients had other HAIs, such as UTI, pneumonia and other SSIs resulting from other surgeries. Additionally, it has been shown that mortality is not high among these patients, with 1.5% for every 30 days of hospitalization.[17] This lethality is largely influenced by several factors inherent in the patient, such as surgery conditions, comorbidities, prolonged hospital stay and development of other HAIs.

Patients who were hospitalized for a neurological specialty tend to be more likely to develop HAIs, according to a study that characterized the profile of these infections, in which 32.1% (n = 70) of the patients developed VAP, 10% (n = 22) SSI and 16% (n = 36) were affected by BSI.[28]

In a study carried out with 2,018 patients after external ventricular bypass, 44% had post-implant HAI, with prevalence of UTI and BSI. It showed that the ASA score was more related to the patient's death than the SSI.[18]

As limitations of this study, the lack of information in the hospital management system stands out. The data of this study were retrieved from secondary sources in which there is information fed by the multidisciplinary team and, therefore, there can be some degree of underreporting as some cases may have gone unnoticed by the surveillance service. Above all, despite having met the proposed objectives, the results of this study indicate the need for new approaches to the subject, considering the modus operandi of the SSIs with other approaches and new research scenarios.

CONCLUSIONS

In the present study, SSIs in patients undergoing neurosurgery mainly affected male individuals, aged between 0 and 79 years, with a predominance of those aged 0 to 9 years, with a mean of 31.2 years.

Catheter implant surgeries for peritoneal ventricular bypass and/or external ventricular bypass were the most frequent and all procedures were classified as clean surgeries. The most prevalent topography of the SSI was defined as SSI-OS and, in general, the clinical criterion was the only criterion used to define the cases. Of the SSIs defined by the microbiological criterion, it was possible to evidence *Pseudomonas* spp. as the main pathogen causing the infections. Most patients progressed to hospital discharge, with only three cases of death, and only 29.5% of cases with more than one HAI.

The conducts for the prevention and control of HAIs must be based on scientific evidence, including the assessment of the patient's history and screening based on surveys and laboratory research, so as to support the measures to improve quality of care and patient safety.

REFERENCES

1. Nogueira Junior C, Padoveze MC, Lacerda RA. Governmental surveillance system of healthcare-associated infection in Brazil. Rev Esc Enferm USP. 2014;48(4):657-62. https://doi.org/10.1590/s0080-623420140000400012
2. Karhade AV, Cote DJ, Larsen AMG, Smith TR. Neurosurgical infection rates and risk factors: a national surgical quality improvement program analysis of 132,000 patients, 2006-2014. World Neurosurg. 2017;97(1):205-12. https://doi.org/10.1016/j.wneu.2016.09.056
3. Allegranzi B, Bischoff P, Jonge S, Kubilay NZ, Zayed B, Gomes SM et al. New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. Lancet Infect Dis. 2016;16(12):276-87. https://doi.org/10.1016/s1473-3099(16)30398-x
4. Ban KA, Minei JP, Laronga C, Harbrecht BG, Jensen EH, Fry DE et al. American college of surgeons and surgical infection society: surgical site infection guidelines, 2016 update. J Am Coll Surg. 2017;224(1):59-74. https://doi.org/10.1016/j.jamcollsurg.2016.10.029
5. Dobran M, Marini A, Nasi D, Gladi M, Liverotti V, Costanza MD et al. Risk factors of surgical site infections in instrumented spine surgery. Surg Neurol Int. 2017;8(1):212-24. https://doi.org/10.4103/sni.sni_222_17
6. Agência Nacional de Vigilância Sanitária – Anvisa. Critérios diagnósticos de infecção relacionada à assistência à saúde. Brasília: Agência Nacional de Vigilância Sanitária; 2017.
7. Representação no Brasil da Organização Pan-Americana da Saúde. Aliança mundial para segurança: cirurgias seguras salvam vidas. Brasília: Representação no Brasil da Organização Pan-Americana da Saúde; 2009[acesso 23 fev 2020]. Disponível em: http://www.into.saude.gov.br/upload/arquivos/pacientes/cirurgias_seguras/Seguran%C3%A7a_do_Paciente_guia.pdf
8. Conselho Nacional de Saúde – CNS. Resolução Nº 466, de 12 de dezembro de 2012. Aprova as diretrizes e normas regulamentadoras de pesquisas envolvendo seres humanos. Diário Oficial União. 13 dez 2012.
9. Berrios-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR et al. Centers for Diseases Control and Prevention guideline for the prevention os surgical site infections, 2017. JAMA Surg. 2017;152(8):784-91. https://doi.org/10.1001/jamasurg.2017.0904
10. World Health Organization – WHO. Guidelines for ATC classification and DDD assignment 2013. Geneva: World Health Organization; 2012[acesso 23 fev 2020]. Disponível em: http://www.whocc.no/filearchive/publications/1_2013guidelines.pdf
11. Carvalho CHR. Desafios da mobilidade urbana. Brasília: Instituto de Pesquisa Econômica Aplicada; 2016.
12. Amirjamshidi A. The incidence and risk factors for surgical site infection after clean spinal operations: a prospective cohort study and review of the literature. Surg Neurol Int. 2015;6(1):154-62. https://doi.org/10.4103/2152-7806.166194
13. Strahm C, Albrich WC, Zdravkovic V, Schöbi B, Hildebrandt G, Schlege M. Infection rate after cranial neurosurgical procedures: a prospective single-center study. World Neurosurg. 2018;111:277-85. https://doi.org/10.1016/j.wneu.2017.12.062.
14. Jeong TS, Yee GT. Prospective multicenter surveillance study of surgical site infection after intracranial procedures in Korea: a preliminary study. J Korean Neurosurg Soc. 2018;5(61):645-52. https://doi.org/10.3340/jkns.2018.0021
15. Chiang H. Risk factors and outcomes associated with surgical site infections after craniotomy or craniectomy. J Neurosurg. 2014;120(2):509-21. https://doi.org/10.3171/2013.9.jns13843
16. Rolston JD, Han SJ, Lau CY, Berger MS, Parsa AT. Frequency and predictors of complications in neurological surgery: national trends from 2006 to 2011. J Neurosurg. 2014;120(3):736-45. https://doi.org/10.3171/2013.10.jns122419

17. Cassir N, Rosa S, Melot A, Touta A, Troude L, Loundou A et al. Risk factors for surgical site infections after neurosurgery: a focus on the postoperative period. Am J Infect Control. 2015;43(12):1288-91. https://doi.org/10.1016/j.ajic.2015.07.005
18. Hagel S, Bruns T, Pletz MW, Engel C, Kalff R, Ewald C. External ventricular drain infections: risk factors and outcome. Interdiscip Perspect Infect Dis. 2014;2014:1-6. https://doi.org/10.1155/2014/708531
19. Davies BM, Jones A, Patel HC. Implementation of a care bundle and evaluation of risk factors for surgical site infection in cranial neurosurgery. Clin Neurol Neurosurg. 2016;144:121-5. https://doi.org/10.1016/j.clineuro.2016.03.025
20. Xue J, Ma J, Hou F, Li J, Li R, Lang H. Neurosurgical site infection prevention: single institute experience. Turk Neurosurg. 2016;26(2):234-9. https://doi.org/10.5137/1019-5149.jtn.12738-14.0.
21. Kourbeti IS, Vakis AF, Ziakas P, Karabetsos D, Potolidis E, Christou S et al. Infections in patients undergoing craniotomy: risk factors associated with post-craniotomy meningitis. J Neurosurg. 2015;122(5):1113-9. https://doi.org/10.3171/2014.8.jns132557
22. Lima MLC, Castro Junior AS, Maciel JB, Vandesmet LCS. *Pseudomonas aeruginosa*. Mostra Cient Biomed. 2016;1(1):1-7.
23. Lima MFP, Borges MA, Parente RS, Victória Júnior RC, Oliveira ME. *Staphylococcus aureus* e as infecções hospitalares: revisão de literatura. Uninga Rev. 2015;21(1):32-9.
24. Cao Y, Pu K, Li G, Yan XJ, Ma Y, Xue K et al. The role of antibiotic prophylaxis in clean neurosurgery. World Neurosurg. 2017;100:305-10. https://doi.org/10.1016/j.wneu.2016.12.108
25. Chagas MQL, Costa AMM, Mendes PHB, Gomes Junior SC. Análise das infecções de sítio cirúrgico em pacientes pediátricos após cirurgia ortopédica: um estudo caso-controle. Rev Paul Pediatr. 2017;35(1):18-24. https://doi.org/10.1590/1984-0462/;2017;35;1;00011
26. Motta NH, Bohrer CD, Oliveira JLC, Matos FGOA, Alves DCI. Prevenção da infecção de sítio cirúrgico em hospital universitário: avaliação por indicadores. Vigil Sanit Debate. 2017;5(3):92-9. https://doi.org/10.22239/2317-269x.00973
27. Tauffer J, Carmello SKM, Berticelli MC, Zack BT, Kassim MJN, Alves DCI. Caracterização das infecções relacionadas à assistência à saúde em um hospital de ensino. Rev Epidemiol Controle Infecç. 2019;9(3):248-53. https://doi.org/10.17058/reci.v9i3.12976

Authors' Contribution

Tauffer J – Conception and planning (study design), data acquisition, analysis and interpretation, and writing of the manuscript. Alves DCI – Conception and planning (study design), data acquisition, analysis and interpretation. Carvalho ARS, Matos FGO – Data acquisition, analysis and interpretation.

All authors approved the final draft of the manuscript.

Conflict of Interest

The authors report that there is no potential conflict of interest with peers and institutions, nor political or financial conflicts in this study.