Original Article

Risk factors for surgical site infection in neurosurgery

Fatores de risco de infecção da ferida operatória em neurocirurgia

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Abstract

Objective: To analyze risk factors for surgery site infection in neurosurgery.
Methods: A prospective cross-sectional study conducted in a tertiary hospital analyzing 85 elective and clean neurosurgeries with an outcome of infection within 30 days after surgery.
Results: Surgical site infection occurred in 9.4% (n=8) of cases. Bivariate analysis revealed that the following risk factors were associated with the presence of infection: total length of hospital stay, Body Mass Index, surgical size and blood transfusion. After running binary logistic regression adjustments, only the total length of hospital stay was significantly related to the presence of infection.
Conclusion: The occurrence of surgical site infection in neurosurgery in the studied institution was higher than recommended by the scientific literature. The results show that outpatient follow up of patients who undergo surgery after hospital discharge may reduce the underreporting of infection cases.

Resumo

Objetivo: Analisar os fatores de risco de infecção da ferida operatória em neurocirurgia.
Métodos: Estudo transversal, prospectivo, conduzido em hospital de nível terciário com 85 neurocirurgias eletivas e limpas, tendo como desfecho a infecção até 30 dias após o procedimento cirúrgico.
Resultados: A ocorrência de infecção de sítio cirúrgico foi de 9,4% (n=8). Na análise bivariada observou-se que os fatores de risco: tempo total de internação, Índice de Massa Corporal, porte cirúrgico e transfusão sanguínea foram associados com a presença de infecção. Após ajuste no modelo de regressão logística binária, apenas o tempo total de internação mostrou relação estatisticamente significativa com a presença de infecção.
Conclusão: A ocorrência de infecção de sítio cirúrgico em neurocirurgia na instituição estudada foi maior do que o preconizado na literatura científica. Os resultados apontaram que o acompanhamento ambulatorial do paciente cirúrgico após a alta hospitalar pode reduzir a subnotificação dos casos de infecção.

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Introduction

Surgical site infection (SSI) is the most common complication among surgery patients and, in essence, can be classified as hospital-acquired, as it is a consequence of surgery or of intrahospital invasive procedures. It can be associated with different levels of severity, from an infection limited to the surgical site to organ/space infection and prosthesis-related infections, which present an increased risk of sepsis and reopening. This type of infection presents a significant morbidity rate that increases the length of hospital stay, risk of hospital readmission, intensive care unit admission and death.(1)

A neurosurgery study assessing 390 craniectomy, cranioplasty and craniotomy cases throughout a follow-up period of two years revealed that 30 patients developed SSI, with a mean incidence of 7.7%. The results showed a statistically significant association between this type of infection and risk factors such as an American Society of Anesthesiology (ASA) II score and potentially contaminated surgery classification. Other factors such as size and duration of operation and the surgeon's experience were not associated with this complication. The mean length of time between surgery and onset of infection was 11.8 to 21.8 days.(2)

The incidence of SSI related to spinal surgery can reach 15%, depending on the diagnosis, surgical approach, area being operated on, number of intervertebral levels involved in the procedure, and the use of instrumentation (orthosis/prosthesis).(3) According to the Centers for Disease Control and Prevention, infection rates following laminectomies or other spinal fusion procedures range from 0.72 to 4.1%.(4)

The following risk factors for spinal surgery stand out: prolonged preoperative hospitalization, large incision size, prolonged duration of operation, tumor resection, high number of people involved in the surgical procedure, stage of the procedure and review of the surgical procedure.(5) Morbidity associated with SSI in this type of surgery includes prolonged use of intravenous antibiotics, multiple hospital readmissions and reopenings, surgical debridement, increased length of hospital stay, increased rate of pseudarthrosis and instrumentation failure.(6)

In light of this information, studies on the occurrence and risk factors of SSI in neurosurgery are important, especially in Brazil, as there are scarce data available on the issue in the national literature. The present study was developed with the aim to contribute with evidence that can aid reflections on current practices, the implementation of prevention and control measures, and also broaden knowledge on the theme. Thus, the general objective of the research was to analyze risk factors for surgical site infection in neurosurgery.

Methods

This was a prospective cross-sectional study conducted in a tertiary hospital in the state of São Paulo, Brazil. A convenience sample was used, which consisted of 85 adult patients undergoing elective and clean neurosurgery (with a potential for surgical site contamination), including patients submitted to neurosurgical procedures with instrumentation (orthosis/prosthesis), between June 2012 and April 2013. It is important to highlight that the study only analyzed the outcome of infection within 30 days of the surgical procedure, even though implant cases may manifest infection within a year of the procedure.(7)

Data were obtained through an instrument created by experts on the theme and submitted to face and content validation. This instrument consisted of two parts. The first contained data regarding patient characteristics and identified risk factors for developing infection (factors related to the patient, the surgical procedure and the environment). The second part included data related to diagnostic criteria for SSI, according to the Centers for Disease Control and Prevention, based on in-patient and postdischarge surveillance.

The data were analyzed with the Statistical Package for the Social Sciences *(*SPSS), version 20.0, and the results were presented according to frequency distribution and descriptive statistical measures, such as: arithmetic mean, standard deviation, median, and minimum and maximum values for quantitative variables.

Bivariate analysis was adopted to analyze the association between categorical variables (blood transfusion, presence of a chronic illness, ASA classification, surgical size, antibiotic prophylaxis) and infection, by using Fisher's exact test. The Mann-Whitney test was employed for continuous variables (age, BMI, duration of operation, duration of anesthesia, total length of hospital stay).

Subsequently, variables that presented *p*-values less than 0.05 in association or comparison tests with the SSI response variable were included in the binary logistic regression model, which was then adjusted with a confidence interval of 95%.

The level of significance used was $\alpha = 0.05$.

The development of this study complied with national and international ethical guidelines for research involving human subjects.

Results

Of the 85 participants in the study (N=85), 77 did not present SSI (90.6%) and eight developed the infection, an occurrence rate of 9.4%. The mean age of the sample was 53.3 years (SD=14.16), with ages ranging from 21 to 86 years, and the most frequent age group being from 60 to 70 years, with 21 subjects (24.7%). Most patients were male, representing 57.6% of the sample. Of the eight patients who developed SSI, four (50%) were between the ages of 60 to 70, six (75%) were female and two (25%) male.

Regarding the ASA classification, the results showed that 33 (38.8%) patients of the sample were classified as ASA I (patient in normal health), however, of these participants, three developed SSI. Most of the sample, i.e., 51 (60%) patients were classified as ASA II (patient with mild or moderate systemic disease resulting in no functional limitations) and of these, five (9.8%) presented infection. Only one individual (1.2%) was classified as ASA III (patient with severe systemic disease that limits activity but is not incapacitating) and did not develop this type of infection (Table 1).

Of the 85 studied patients, 40 (47.1%) did not have chronic diseases, however, three (3.5%) developed SSI. Of the 45 (52.9%) patients with chronic diseases, four (8.9%) had diabetes, three (6.75%) presented diabetes and obesity (one patient developed an infection), 36 (80%) presented diabetes and arterial hypertension (four patients developed infection) and two (4.4%), other comorbidities.

The mean BMI of the sample was 26.18 kg/m^2 (SD=4.7), which varied between 18.37 and 47.03 kg/m^2. Of the 85 patients, 40 (47%) presented normal weight, composing the category with the most number of individuals. However, a similar number of patients were overweight and obese, a total of 44 (51.8%). Of the eight patients with SSI, four (50%) were overweight and three (37.5%) obese.

Regarding procedure-related variables, mean duration of anesthesia was 185.81 minutes, ranging from 10 to 440 minutes. Mean duration of operation was 154.35 minutes, ranging from 15 to 400 minutes.

Mean total length of hospital stay (perioperative period) was 11.48 days (SD=13.15), varying between two and 80 days. Surgical site infection occurred with greater frequency among patients who remained in hospital seven to nine days (2 cases; 25%) and among those who remained in hospital for a period ≥ 22 days (2 cases; 25%).

All individuals in the study were given a prophylactic antibiotic (cefuroxime). In relation to the moment of application, medication was administered intravenously before surgical incision in 100% of patients.

Of the 85 studied individuals, 47 (55.3%) underwent surgery of size I, 25 patients (29.4%) of size II, 11 patients (12.9%) surgery of size III and only two patients (2.4%) underwent a surgery of size IV. Of the eight patients who developed SSI, four (50%) were submitted to surgery of size I, three patients (37.5%) to surgery of size III and only one patient (12.5%) underwent surgery of size IV.

Regarding blood transfusion, of the total sample, (N=85), 15 patients (17.6%) received transfusions and four (26.7%) developed SSI.

Statistical analysis revealed that total length of hospital stay (p=0.001), BMI (p=0.022), surgical

Table 1. Distribution of patients undergoing neurosurgery (n=85), according to the investigated variables

Variables	Infection						p-value*
	Yes n(%)			No n(%)			
ASA							1.000
I	3(37.5)			30(39.0)			
II	5(62.5)			46(59.7)			
III	-			1(1.3)			
Blood transfusion							0.030
Yes	4(50.0)			11(14.3)			
No	4(50.0)			66(85.7)			
Surgical size (hours)							0.016
I (up to2)	4(50.0)			43(55.8)			
II (> 2 to 4)	0			25(32.5)			
III (> 4 to 6)	3(37.5)			8(10.4)			
IV (> 6)	1(12.5)			1(1.3)			
Chronic disease							0.520
Diabetes *mellitus* (DM)	0			4(5.2)			
DM + obesity	1(12.5)			2(2.6)			
DM + HA	4(50.0)			32(41.6)			
Others	0			2(2.6)			
None	3(37.5)			37(48.1)			
Variables	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**	**p-value****
Duration of operation (minutes)	196.88	120.88	180.00	149.94	88.56	150.00	0.262
Duration of anesthesia (minutes)	228.13	123.92	215.00	179.08	95.03	170.00	0.313
Total length of hospital stay (days)	30.57	24.66	28.50	9.74	10.20	7.00	0.001
Age (years)	57.88	10.80	59.50	52.86	14.44	54.00	0.302
BMI (kg/m^2)	29.12	3.58	29.23	25.87	4.72	24.76	0.022

*Fisher's exact test; AH – arterial hypertension; SD – standard deviation; **Mann-Whitney U Test

size (p=0.016) and blood transfusion (p=0.030) were associated with the presence of SSI (statistically significant difference) (Table 1).

As mentioned above, binary logistic regression was applied to variables with *p*-value less than 0.05 (total length of hospital stay, BMI, surgical size and blood transfusion); thus, according to the model, only the total length of hospital stay was associated with the presence of SSI (p<0.001).

Discussion

Cross-sectional studies present limitations when investigating conditions of low occurrence (SSI in clean surgery), requiring a larger sample. The outcome of SSI was assessed within 30 days after surgery, despite the researchers' knowledge that in implant cases, this type of infection can manifest up to a year after the surgical procedure. Another aspect to be considered was the conduct of health professionals, who intensified their precautions towards reducing infection rates in the operating room due to the presence of one of the researchers who was also member of the institution's hospital infection control committee.

The results of this study provide a basis for understanding the issue within the Brazilian context. Outpatient follow-up of surgical patients can reduce underreporting of infection cases. Furthermore, the study presents evidence that can direct further research on interventions for clinical practice that can minimize the occurrence of SSI in neurosurgery and consequently improve the quality of care provided to surgical patients.

In this study, the mean age of the sample was 53.3 years, a similar finding to that of a study also conducted in neurosurgery (mean age of 57.7 years).[8] Regarding the group that developed infection (n=8), four (50%) patients were between the age of 60 and 70. The literature indicates age as a risk factor for developing SSI, with extremes of age (newborns and older adults) being the main age groups.[9]

The ASA physical status classification system is one of the most commonly used methods for patients' preoperative clinical assessment and in the literature it is considered a risk factor for the occurrence of SSI. In other words, the more severe the patient's clinical status, the higher the likelihood of infection.[9,10]

Of the eight patients who developed SSI in this study, five (62.5%) were classified as ASA II. This finding is similar to the results of a study carried out between June 2007 and May 2009, in which the authors conducted a prospective assessment of 390 patients who underwent neurosurgery. On testing associations between variables, an ASA II classification and the potential for wound contamination (potentially contaminated surgery) were considered risk factors for SSI.[2]

Regarding BMI, of the eight infected patients, four (50%) were classified as overweight and three patients (37.5%), obese. The result of the bivariate analysis showed that this variable was associated with SSI (p=0.022). A retrospective study that assessed incidence of SSI among 363 adult patients submitted to spinal surgery showed that obesity was an independent risk factor for developing infection.[11] On the other hand, another retrospective study that assessed the effect of body weight on postoperative complications (n=63 patients, of whom 24 had normal weight, 25 were obese and 14 morbidly obese and who underwent lumbar spinal fusion), showed a low rate of SSI, being that only one obese patient and one morbidly obese patient presented this type of infection.[12]

In the present study, 52.9% of patients (n=45) presented some type of comorbidity. The literature indicates diabetes *mellitus* as a risk factor due to the pathophysiological complications that occur during the healing process, a consequence of an impaired defense system and of vasculopathy, common among people affected by diabetes.[7]

In this study, 100% of patients received antibiotic prophylaxis according to the institutional protocol, which consisted of cefuroxime. Despite this preventive measure, eight cases of SSI were detected, probably due to the presence of other risk factors among the studied sample. The presence of the researcher may have contributed to the proper implementation of antibiotic prophylaxis, since the surgical team was aware that this professional was a member of the institution's hospital infection control committee and, for this reason, some questions were raised regarding the drug of choice and its dose.

Correct antibiotic prophylaxis requires administering the proper antibiotic within 30 to 60 minutes before surgical incision and its discontinuation within 24 hours after the surgical procedure, as recommended by the Centers for Disease Control and Prevention.[7,13]

The literature indicates that the duration of anesthesia and of operation are associated with risk of SSI.[7] A study conducted with patients who underwent neurosurgical procedures found that the duration of operation was an independent risk factor for the occurrence of SSI, due to the prolonged exposure of the surgical wound to the environment; intraoperative complications, such as major blood loss; decline of the efficiency of patient's defense mechanisms; postoperative pain, due to prolonged time in the same surgical positions; cardiac arrhythmias and other postoperative infections, such as pneumonia.[14]

In a retrospective cohort study with 4,588 patients undergoing lumbar fusion, duration of operation was an independent risk factor for postoperative complications, including superficial surgical site infection. Surgery duration of five hours or more was associated to increased risk of reopening, organ/space infection, wound dehiscence, and deep vein thrombosis.[15]

Of the eight detected cases of SSI, four (50%) occurred after procedures of size I and the other four cases (50%), after procedures of size III and IV, being that this variable was associated with SSI (p=0.016) in the bivariate analysis. These data are similar to the results of another study, in which duration of operation longer than 150 minutes was indicated as a risk factor for developing complications after spinal surgery.[16]

In this study, total length of hospital stay was a variable of interest and bivariate analysis revealed an association with SSI (p=0.001), as did the binary logistic regression (p<0.001). In a recent study,[17] this variable also proved to be significantly related to infection.

In the present study, of the 15 patients who needed blood transfusion, four (26.7%) developed SSI and bivariate analysis showed that it was associated with SSI (p=0.030). This result is corroborated by that of another study, in which blood transfusion was a risk factor for developing this type of infection (statistically significant difference).[18]

As previously mentioned, the occurrence of SSI in the studied sample was 9.4%. This result proves to be high, since the recommended infection rate for clean surgery is 1% to 5%, according to parameters set by the Centers for Disease Control and Prevention.[7] Therefore, the number of expected cases for this sample of 85 patients would be of one to a maximum of four; however, there were eight cases of SSI.

In the literature, some studies showed similar results to those of the present research. One study had rates ranging from 2.1% to 8.5% after spinal surgeries with instrumentation (implants)[19] and another[20] showed that the rate of infection depended on the nature of the procedure, that is, after discectomy, the rate of infection was approximately 1%, and could reach values higher than 9% in surgeries with instrumentation.

Of the eight cases of infection in the present study, four occurred after arthrodesis surgery with instrumentation (implants). This result can suffer alterations, as patients were assessed up to 30 days after surgery and, according to the Centers for Disease Control and Prevention, prosthesis implant cases can present infection within a year after the surgical procedure.

A study that analyzed the incidence of SSI following neurosurgical procedures and identified patients at a high risk for developing this infection conducted a prospective investigation on 390 patients for two years. The results showed a mean incidence rate of 7.7%,[2] a similar finding to the results of the present research.

A systematic review that compared the incidence of SSI following spinal arthrodesis using open and a minimally invasive surgical technique had the aim to determine treatment-related hospital costs. The authors also found lower incidence of infection when using minimally invasive techniques (0.6%), as opposed to open surgery (4%). This finding supports the hypothesis that the larger the surgical incision, the higher the risk of SSI.[21]

Other recent studies in the literature presented lower SSI rates than those of the present study. One retrospective descriptive study assessed the incidence and risk factors in patients submitted to spinal surgery with degenerative diseases in the period of 1993-2010. The sample consisted of 817 participants, of which 37 developed infection; an incidence rate of 4.5%.[17] In a prospective descriptive study with a sample of 1,110 patients who underwent neurosurgery (elective surgery), 41 developed SSI, an incidence of 3.47%. It is worth noting that of the 41 cases of infection, 34 were diagnosed during hospitalization and seven postdischarge.[22] In a prospective cohort study with 502 patients submitted to craniotomy, the rate of SSI was 5.6%.[23]

In order to obtain accurate indicators,[7] postdischarge surveillance is a necessary strategy, considering that 12% to 84% of SSI cases are diagnosed during this period.

In the current research, postdischarge surveillance was conducted during the patients' follow-up appointment in the wound dressing room (30 days after surgery). This was done in order to reliably determine the epidemiological profile of those who underwent neurosurgery, as up to that moment, all neurosurgical procedures conducted in the selected institution for this study had only been assessed through an active search during the patients' hospital stay. Thus, eight cases of SSI were diagnosed, one in the wound dressing room during the follow-up appointment scheduled by the researcher. This finding corroborates those in the literature, which show that infection rates increase when there is a postdischarge search strategy in place. In a recent study, also in the field of neurosurgery, the results showed that 70% of SSI cases were identified postdischarge.[24]

Conclusion

The occurrence of surgical site infection in neurosurgery in the studied institution was higher than recommended by the scientific literature. Statistical analysis revealed that the risk factors total length of hospital stay, BMI, surgical size and blood transfusion were associated with the presence of SSI (statistically significant difference). However, binary logistic regression revealed that only total length of hospital stay was significantly associated with the presence of infection.

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Belusse GC participated in the project conception, data collection, data analysis and interpretation, drafting of the article, and final version for publication. Ribeiro JC collaborated with the project conception, critical review of its important intellectual content and with the final version for publication. Campos FR collaborated with data collection, critical review of its important intellectual content and with the final version for publication. Poveda VB cooperated with data analysis and interpretation, drafting of the article and final version for publication. Galvão CM participated in the project conception, data analysis and interpretation, drafting of the article and final version for publication.

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