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Original Article

The incidence and microbiological profile of surgical site infections following internal fixation of closed and open fractures☆

Priscila Rosalba Oliveira, Vladimir Cordeiro Carvalho, Cassia da Silva Felix, Adriana Pereira de Paula, Jorge Santos-Silva, Ana Lucia Lei Munhoz Lima*

Universidade de São Paulo, Hospital das Clínicas, Instituto de Ortopedia e Traumatologia, São Paulo, SP, Brazil

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ABSTRACT

Objective: To evaluate the incidence and microbiological profile of surgical site infections (SSIs) associated with internal fixation of fractures and to compare differences in the SSIs observed among patients with closed and open fractures.
Methods: Retrospective study. Analyzed data included information from all patients who underwent surgery for fixation of closed or open fractures from January 2005 to December 2012 and remained outpatients for at least one year following surgery. Incidence of surgical site infection (SSI) was compared between patients with closed and open infection, as well as polymicrobial infection and infection related to Gram-negative bacilli (GNB). Cumulative antibiograms were performed to describe microbiological profiles.
Results: Overall incidence of SSI was 6%. This incidence was significantly higher among patients with open fractures (14.7%) than among patients with closed fractures (4.2%). The proportions of patients with polymicrobial infections and infections due to GNB were also significantly higher among patients with open fractures. *Staphylococcus aureus* and coagulase-negative *Staphylococcus* (CoNS) species were the primary infectious agents isolated from both groups. The overall incidence of MRSA (methicillin-resistant *S. aureus*) was 72%. *A. baumannii* was the predominant GNB isolate recovered from patients with open fractures and *P. aeruginosa* was the most frequent isolate recovered from patients with closed fractures, both exhibited low rates of susceptibility to carbapenems.
Conclusions: Incidence of SSIs related to the internal fixation of fractures was significantly higher among patients with open fractures, indicating that an open fracture can be a risk factor for infection. Among the bacterial isolates, *S. aureus* (with a high prevalence of MRSA) and CoNS species were most prevalent. *A. baumannii* and *P. aeruginosa* isolates underscored the low rate of susceptibility to carbapenems that was observed in the present study.

☆ Work developed at the Universidade de São Paulo, Hospital das Clínicas, Instituto de Ortopedia e Traumatologia, São Paulo, SP, Brazil.

* *Corresponding author.*
E-mail: priscila.rosalba@hc.fm.usp.br (P.R. Oliveira).

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Infecção de sítio cirúrgico após fixação de fraturas fechadas e expostas – Incidência e perfil microbiológico

Palavras-chave:
Infecção da ferida operatória
Fixação interna de fraturas
Fraturas expostas
Fraturas fechadas

RESUMO

Objetivo: Avaliar a incidência e o perfil microbiológico das ISC relacionadas a procedimentos de fixação de fraturas num hospital acadêmico ortopédico terciário em São Paulo, Brasil, e comparar as diferenças observadas entre os pacientes com fraturas fechadas e expostas.
Métodos: Estudo retrospectivo. Foram incluídos na análise os dados relativos a todos os pacientes que passaram por procedimento cirúrgico para fixação de fraturas fechadas ou expostas de janeiro de 2005 a dezembro de 2012 e que mantiveram seguimento por pelo menos um ano. Foi verificada a presença de associação entre o tipo de fratura, a incidência de ISC e as incidências de infecções polimicrobianas e por bacilos Gram-negativos. O perfil microbiológico foi estabelecido por meio da elaboração de antibiogramas cumulativos.
Resultados: A incidência geral de infecção de 6%. Essa incidência foi maior no grupo de pacientes com fraturas expostas (14,7%) do que naqueles com fraturas fechadas (4,2%), com diferença estatisticamente significante. O número de pacientes com infecções polimicrobianas e com infecções relacionadas a BGN também foi significativamente maior no grupo de casos relacionados a fraturas expostas. *Staphylococcus aureus* e espécies de *Staphylococcus* coagulase-negativo (CoNS) foram os principais agentes isolados nos dois grupos. A incidência de MRSA (*S. aureus* resistente a meticilina) dentre todos os isolados de *S. aureus* foi de 72%. *A. baumannii* foi o principal BGN isolado entre os pacientes com fraturas expostas e *P. aeruginosa* entre os pacientes com fraturas fechadas. Em ambos os casos, observaram-se baixos índices de sensibilidade a carbapenêmicos.
Conclusões: A incidência de ISC relacionada à fixação interna de fraturas foi significantemente maior nos pacientes com fraturas expostas, o que indica que esse tipo de fratura pode ser um fator de risco para a ocorrência desse tipo de infecção. Dentre os isolados bacterianos, predominaram no geral *S. aureus* (com elevada prevalência de MRSA) e S. coagulase-negativo. Dentre os BGN, houve predomínio de *A. baumanni* também entre os isolados de pacientes com fraturas expostas e *P. aeruginosa* entre os isolados daqueles com fraturas fechadas.

Introduction

Surgical site infections (SSIs) associated with internal fixation of fractures are regarded as serious complications. An SSI constitutes a challenge for the entire staff involved in patient's care because it significantly increases recovery time and treatment costs and negatively impacts both functional results and long-term rehabilitation.[1,2] Although incidence of SSIs is expected to be higher in patients with open fractures than in patients with closed fractures, few studies have confirmed this hypothesis.[3,4] Regarding the microbiological profiles of SSIs, Gram-negative bacilli (GNB), most notably *Acinetobacter baumannii* and *Pseudomonas aeruginosa*, have been described as having increasingly important roles in these infections, particularly in cases involving high-energy trauma.[5–8]

The current study sought to evaluate the incidence and microbiological profile of SSIs associated with internal fixation of fractures and to compare differences in the SSIs observed among patients with closed and open fractures.

Methods

A retrospective study was conducted at the *Instituto de Ortopedia e Traumatologia*, a tertiary orthopedic academic hospital in São Paulo, Brazil. Analyzed data included information from all patients who underwent surgery for fixation of closed or open fractures from January 2005 to December 2012 and remained outpatients for at least one year following surgery. These data were collected from the database maintained by the institution's Infection Control Board.

In accordance with the institution's protocol, patients with closed fractures who underwent surgery for the internal fixation of their fractures received 24 h of antimicrobial prophylaxis with cefazolin. Patients with type I open fractures according to the Gustilo classification received antimicrobial therapy with cefazolin for 14 days, beginning at their admission. Patients with open fractures of Gustilo types II and III received combination therapy with clindamycin and gentamicin for 14 days, beginning at admission. In addition, patients with open fractures initially had their fractures stabilized by external fixation; internal fixation was subsequently performed after improvement in the soft tissue adjacent to fracture.

Determinations of the incidence of SSIs only included patients who presented with an SSI within 1 year following surgery and were diagnosed based on the criteria established by the Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC-NHSN).[9] To determine the microbiological profile of infections, cumulative antibiogram reports were prepared using established Clinical and

Table 1 – Patient population of the study.

	Total	Closed fractures	Open fractures	Comparison between the groups with closed and open fractures
Patients	11,030	9143	1887	–
Patients with SSIs	664 (6%)	386 (4.2%)	278 (14.7%)	$p < 0.001$
Patients with polymicrobial infections	199 (1.8%)	90 (1%)	109 (5.8%)	$p < 0.001$
Patients with GNB infections	293 (2.65%)	130 (1.42%)	163 (8.64%)	$p < 0.001$

Laboratory Standard Institute (CLSI) standards.[10] Only isolates from cultures of bone, deep soft tissue or exudate collected in the operating room after the debridement of devitalized tissues were considered.

Chi-square tests were used to determine how fracture type was associated with the incidences of SSI, polymicrobial infections and GNB infections. These associations were estimated by utilizing bivariate logistic regressions to calculate odds ratios (ORs) and the corresponding 95% confidence intervals. Microbiological findings were only assessed by descriptive analysis.

Results

During the analyzed period, 11,030 patients underwent internal fixation of fractures, including 9143 patients (82.9%) with closed fractures and 1887 patients (17.1%) with open fractures. A total of 664 patients presented with SSIs related to fixation procedures; thus, the overall incidence of infection was 6%. This incidence was significantly higher among patients with open fractures (14.7%) than among patients with closed fractures (4.2%). The proportions of patients with polymicrobial infections and infections due to GNB were also significantly higher among patients with open fractures (Table 1).

The microbiological findings indicated that a total of 529 infection-associated bacterial isolates were recovered, including 357 isolates from patients with open fractures and 172 isolates from patients with closed fractures. In both groups, the predominant isolates were Gram-positive cocci, which accounted for 53% of the observed infections. GNB accounted for 45% of the isolates; both patient groups exhibited a similar incidence of GNB, although a greater absolute number of isolates were recovered from patients with open fractures than from patients with closed fractures.

Staphylococcus aureus and coagulase-negative *Staphylococcus* (CoNS) species were the primary infectious agents isolated from both groups. The overall incidence of MRSA (methicillin-resistant *S. aureus*) was 72%; this incidence was 75% among patients with open fractures and 66% among patients with closed fractures. For the group of patients with open fractures, in addition to CoNS species, *Enterococcus* spp. were the second most agent that was isolated; 76% of the *Enterococcus* isolates exhibited susceptibility to vancomycin.

A. baumannii was the predominant GNB isolate recovered from patients with open fractures. *P. aeruginosa* was the most frequent isolate recovered from patients with closed fractures. Both *A. baumannii* and *P. aeruginosa* exhibited low rates of susceptibility to carbapenems (susceptibilities to imipenem of 57% and 47%, respectively). Anaerobic bacteria and fungi accounted for 2% of the isolates. Table 2 summarizes the microbiological findings described in this study.

Table 2 – Comparison of the main microbiological findings in the groups of patients with closed and open fractures.

Closed fractures	Open fractures
Total number of isolates	
357	172
Primary agents	
S. aureus (56 isolates – 33%) 66% MRSA	*S. aureus* (83 isolates – 23%) 75% MRSA
CoNS species (24 isolates – 14%)	CoNS species (51 isolates – 14%)
	Enterococcus spp. (51 isolates – 14%) 76% sensitivity to vancomycin
P. aeruginosa (18 isolates – 10%) 47% sensitivity to carbapenems	*A. baumannii* (44 isolates – 12%) 57% sensitivity to imipenem

Discussion

The incidence of SSI was significantly higher in patients with open fractures. Although this finding is to be expected due to the high degree of contamination observed in these high-energy injuries,[2] few studies have proven the higher incidence of SSI in this population, and none of them featured a sample as large as that of the present study. There was a predominance of GNB infections and polymicrobial infections in the group of patients with open fractures. Other studies, conducted mainly in soldiers stationed in the Middle East, corroborate these findings.[1,5–7]

Among all agents that were isolated, *S. aureus* and CoNS species were the primary causative agents of infection; MRSA was highly prevalent. Among patients with open fractures, *Enterococcus* spp. were also important causative agents of SSIs; only 76% of these *Enterococcus* isolates were susceptible to vancomycin. *A. baumannii* and *P. aeruginosa* were the main GNB isolated from SSIs in the group of patients with open fractures and in the group with closed fractures, respectively. Both of these species exhibited low rates of susceptibility to antimicrobial agents, including carbapenems. These findings are consistent with the results of Torbert et al.,[1] who previously analyzed 214 cases of SSIs related to fracture fixation. Other studies that analyzed severe open fractures in combat environments have also found that *A. baumannii* was highly prevalent.[5–7] A high prevalence of *P. aeruginosa* has also been reported by a study that evaluated the infectious complications of traumatic amputations.[8]

Conclusion

The incidence of SSIs related to the internal fixation of fractures was significantly higher among patients with open fractures, indicating that an open fracture can be a risk factor for infection. The current study also indicated that there were a significantly elevated number of polymicrobial and GNB infections among patients with prior open fractures. Further studies are needed to evaluate potential variables that could be relevant to these findings.

Among the bacterial isolates, *S. aureus* (with a high prevalence of MRSA) and CoNS species were most prevalent. *Enterococcus* spp. (with a low rate of sensitivity to vancomycin) and *A. baumannii* were also prevalent among the isolates recovered from patients with open fractures. In addition, *P. aeruginosa* was one of the more significant isolates recovered from patients with closed fractures. The *A. baumannii* and *P. aeruginosa* isolates underscored the low rate of susceptibility to carbapenems that was observed in the present study.

Conflicts of interest

The authors declare no conflicts of interest.

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REFERENCES

1. Torbert JT, Joshi M, Moraff A, Matuszewski PE, Holmes A, Pollak AN, et al. Current bacterial speciation and antibiotic resistance in deep infections after operative fixation of fractures. J Orthop Trauma. 2015;29(1):7–17.
2. Hannigan GD, Pulos N, Grice EA, Mehta S. Current concepts and ongoing research in the prevention and treatment of open fracture infections. Adv Wound Care (New Rochelle). 2015;4(1):59–74.
3. Gaebler C, Berger U, Schandelmaier P, Greitbauer M, Schauwecker HH, Applegate B, et al. Rates and odds ratios for complications in closed and open tibial fractures treated with unreamed, small diameter tibial nails: a multicenter analysis of 467 cases. J Orthop Trauma. 2001;15(6):415–23.
4. Court-Brown CM. Reamed intramedullary tibial nailing: an overview and analysis of 1106 cases. J Orthop Trauma. 2004;18(2):96–101.
5. Burns TC, Stinner DJ, Mack AW, Potter BK, Beer R, Eckel TT, et al. Microbiology and injury characteristics in severe open tibia fractures from combat. J Trauma Acute Care Surg. 2012;72(4):1062–7.
6. Johnson EN, Burns TC, Hayda RA, Hospenthal DR, Murray CK. Infectious complications of open type III tibial fractures among combat casualties. Clin Infect Dis. 2007;45(4): 409–15.
7. Mody RM, Zapor M, Hartzell JD, Robben PM, Waterman P, Wood-Morris R, et al. Infectious complications of damage control orthopedics in war trauma. J Trauma. 2009;67(4):758–61.
8. Giesecke MT, Schwabe P, Wichlas F, Trampuz A, Kleber C. Impact of high prevalence of pseudomonas and polymicrobial gram-negative infections in major sub-/total traumatic amputations on empiric antimicrobial therapy: a retrospective study. World J Emerg Surg. 2014;9(1):55.
9. Maragakis LL, Perl TM. Basics of surgical site infection surveillance and prevention. In: Lautenbach E, Woeltje KF, Malani PN, editors. Practical healthcare epidemiology. 3rd ed. Chicago, IL: The University of Chicago Press; 2010. p. 173–85.
10. Clinical and Laboratory Standards Institute. Analysis and presentation of cumulative antimicrobial susceptibility test data. Approved guideline M39-A2. 2nd ed. Wayne, PA: CLSI; 2006.