J Shoulder Elbow Surg (2014) 23, 528-535

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Incidence and risk factors for acute infection after proximal humeral fractures: a multicenter study

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Background: The rate of acute infection after surgery for proximal humeral fractures is not known. The aims of this study were to report the incidence and to analyze the risk factors for infection after proximal humeral fracture treatment.
Materials and methods: We report a retrospective multicenter study of 452 proximal humeral fractures. Data were modeled by use of univariate and/or linear regression analyses to determine the odds ratio (OR). A logistic regression analysis was used to check for demographic and other characteristics with the potential to confound a true association between risk factors and infection.
Results: The mean age was 62.1 years, and 314 patients were female patients. Of the patients, 18 (4%) had an acute infection. The factors that correlated with infection were length of surgery (OR, 1.009; $P = .05$), preoperative skin preparation with chlorhexidine gluconate (OR, 0.13; $P = .008$), and prophylactic antibiotic (OR, 10.73; $P = .03$). The delay to surgery was close to achieving significance (OR, 1.71; $P = .06$).
Conclusion: This study suggests that washing the shoulder with chlorhexidine gluconate and avoiding the use of first-generation cephalosporin in favor of more effective prophylactic therapy are effective at reducing the risk of infection after treatment for proximal humeral fractures.
Level of evidence: Level III, Retrospective Cohort Study, Treatment Study.

Keywords: Proximal humeral fracture; osteosynthesis; infection; logistic regression analysis; plate fixation; percutaneous fixation; delay of surgery

Institutional review board approval or ethical committee approval: not applicable. In light of the Italian law, we are not required to ask for approval for this type of study. However, each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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1058-2746/$ - see front matter © 2014 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2013.07.058

The correct treatment of proximal humeral fractures is still debatable. Although different treatments have been discussed, recent attention in this area has focused on complication rates.[1,30,31]

The ideal treatment for a proximal humeral fracture should allow healing of the fracture with a low incidence of complications such as malunion, nonunion, avascular necrosis, and infection. Unfortunately, none of the techniques now available have proven to be free of complications.[5,7,11,13,15,34,36]

Among the previously mentioned complications, infection is likely the most feared by surgeons. This is because postoperative infections may lead to high rates of revision surgery, long and frustrating months of treatment with antibiotics, and ultimately, unsatisfied patients.[3]

Surprisingly, very few articles have been published regarding infection after surgical treatment for proximal humeral fractures. The rate of infection reported ranges from 0% to 8% depending on the techniques and criteria used to define infection.[23,29,34] However, the actual incidence rate in a wide cohort of patients is still not known. Even less information is available on the potential risk factors for the development of an acute infection. It has been suggested in studies of other joints that several variables such as comorbidities,[10,20,27] patient age,[9,27] and delay to treatment[16,28] play a role in the rate of infection, but no data are available for the proximal humerus.

The aims of this study were to determine in a multicenter study the incidence of acute infections after surgical treatment of proximal humeral fractures and to analyze preoperative and intraoperative factors that might affect the rate of infection.

Materials and methods

A multicenter retrospective study was carried out at the 3 university hospitals in our region. The data were collected from the database at each hospital using 3 different information-reporting applications. The database contained clinical records as well as surgical and outpatient information. The records were available starting in 2004 for one hospital and from 2006 and 2010 for the second and third hospitals, respectively. Data collection was performed independently by 3 different researchers (E.B., S.M., and N.B.) not involved in the care of the patients. After being instructed by the principal investigator (D.B.), the researchers screened and collected data from the patients treated surgically for proximal humeral fractures (*International Classification of Diseases, Ninth Revision* treatment codes 78.12, 78.42, 78.52, 79.31, and 79.91). A cohort of 616 patients was initially selected. The exclusion criteria reduced this cohort to 452 patients.

The exclusion criteria were as follows: (1) patients who underwent hemiarthroplasty or reverse shoulder replacement (93 patients), (2) polytrauma cases (defined as Abbreviated Injury Scale [AIS] >2 in ≥ 2 body regions)[6] (11 patients), (3) patients with open fractures (2 patients), and (4) patients with less than 3 months' follow-up (58 patients). Of the 58 patients with less than 3 months' follow-up, 5 had died and 53 could not be traced (most frequently because of an incorrect phone number).

For the study group of 452 patients, the following variables were recorded: age; gender; delay from trauma to surgery; antibiotic prophylaxis; type of surgery; type of reduction (open vs closed); length of surgery; type of skin preparation; comorbidities (rheumatoid arthritis, liver failure, heart failure, human immunodeficiency virus, hepatitis C, and diabetes mellitus); and concomitant fractures that needed surgical treatment.

The clinical records were reviewed to identify any incidence of acute deep infection, defined as occurring within 3 months after the index fracture surgery. For this study, a deep infection was defined by the presence of positive laboratory markers for infection (increased C-reactive protein level and/or increased leucocyte count) and one of the following conditions: (1) clinical signs and symptoms of infection, such as extensive swelling, fever, and positive laboratory markers for infection, plus a positive joint fluid culture, a positive culture from a specimen deep to the deltoid muscle, or fluid draining from a wound communicating with the humerus and (2) clinical signs and symptoms of infection without a positive culture but with a documented operative finding of purulent joint fluid. Despite the potential for this to lead to an overestimation of the rate of infection, this second criterion was chosen to avoid missing those cases of infection that might have presented with negative culture results because of inadequate culture time for the identification of *Propionibacterium acnes*[24] or false-negative results because of antibiotic therapy before the culture tests were performed.

Infections that were limited to the skin and subcutaneous tissue without any extension beyond the fascial planes were categorized as superficial infections and were excluded. The extent of the involvement of the shoulder was established by use of either ultrasound or magnetic resonance imaging.

A persistent serous drainage from the skin incision or persistent drainage from a pin tract, without significant erythema and wound dehiscence, was not considered an infection. In some of these cases, antibiotics were prescribed but for less than 30 days. These patients were excluded from this study.

Antibiotic prophylaxis

All the patients received prophylactic antibiotics immediately before surgery. At 2 hospitals, a first-generation cephalosporin antibiotic (2-g dose of cefazolin) was the standard of care. At the third hospital, a third-generation cephalosporin antibiotic (2-g dose of ceftriaxone) was used in all cases. Exceptions to this approach occurred when patients were allergic to cephalosporin; these patients were instead treated with 1 g of vancomycin or fluoroquinolone antibiotics. For the statistical analysis, ''antibiotic prophylaxis'' was categorized as follows: (1) first-generation cephalosporin, (2) third-generation cephalosporin, or (3) other prophylaxis.

Skin preparation

A standard skin preparation with 1% povidone-iodine and 50% isopropyl alcohol was performed in all the patients. However, in 1 hospital the preparation was changed after May 2008. In this hospital, the skin of the entire upper limb was prewashed, with the patient under anesthesia, using 4% chlorhexidine gluconate (Neoxidina Mani; Farmec, Settimo di Pescantina, Italy), followed by a standard disinfection with 1% povidone-iodine and 50%