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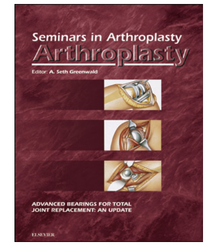

Preventing infection in shoulder arthroplasty: Navigating the minefields

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ABSTRACT

Periprosthetic infection after shoulder arthroplasty represents a devastating complication that often requires extensive revision surgery with substantial economic and patient burden, and ultimately leads to reduced patient function. Preoperative, intraoperative, and postoperative measures can be taken to decrease infection rates by both the surgeon and the patient. While many are not modifiable, several factors are within the surgeon's control and optimization of these factors can reduce the incidence of infection. We review these challenges as well as emphasize certain preoperative, intraoperative, and postoperative protocols to better reinforce a successful outcome for the patient.

1. Introduction

The incidence of periprosthetic joint infection (PJI) after primary shoulder arthroplasty has been reported to be 0.7–3.9% and the rate is higher in revision cases ranging from 4% to 15.4% [1–4]. Infection after shoulder arthroplasty is a devastating complication that often requires extensive revision surgery with substantial economic and patient burden, and ultimately leads to reduced patient function.

The management of PJI almost always requires surgical intervention and extended antimicrobial therapy. This creates a heavy economic burden on the patient and healthcare system. In an analysis of the Nationwide Inpatient Sample (NIS) database, Padegimas et al., reviewed the economic burden of infection following total shoulder arthroplasty (TSA). The authors concluded that not enough studies have been done to fully comprehend the economic impact of PJI in TSA; however, findings can be extrapolated from hip and knee arthroplasty infection. Their results showed that at an institutional level, patients with PJI after knee arthroplasty had longer hospital courses (5.3 vs. 3.0 days), more readmissions (3.6 vs. 0.1), and more expensive mean annual cost ($116,383 with a range of $44,416–$269,914 vs. $28,249 with a range of $20,454–$47,957) compared to a matched group of arthroplasty patients [5,6].

Functional outcomes for infected arthroplasty show significantly lower outcome measures than uninfected shoulder arthroplasty. While we are not aware of direct comparative studies, the literature suggests that functional outcomes are much lower following PJI. Given the substantial burden, prevention of PJI following TSA is vital. This review summarizes the evidence for methods for prevention of PJI following TSA.

2. Preoperative

Numerous preoperative factors have been associated with shoulder PJI, some of which are modifiable and others which

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are not. Richards et al., [7] identified younger age, male sex, reverse shoulder arthroplasty (RSA), and post-traumatic arthritis as risk factors . More recently, Morris et al., [8] noted that the greatest risk factors after reverse arthroplasty include age under 65 years old and revision arthroplasty. Other nonmodifiable factors that have been associated with infection include, lupus and RA, although the latter has had conflicting evidence [9,10]. Furthermore, a study conducted by Mollon et al., [11] showed that patients with a history of depression had a 2.1 times greater risk of acquiring an infection in-hospital after TSA. They noted depression in 12.4% of patients underoing TSA and it was more common in female patients and those of lower socio-economic status. Bozic et al., [12] found similar findings in that depression is an independent predictor or PJI following total hip and knee arthroplasty .

Potentially modifiable patient risk factors include diabetes, smoking, excessive alcohol intake, anemia, nutritional deficiency, and obesity. It is crucial that orthopedic surgeons identify risk factors prior to TSA so that they can minimize the risk of postoperative infections. Han and Kang [13] has shown that HbA1C $\leq$ 8% provides a significantly lower risk of early postoperative deep infection. Similarly, Lübbeke et al., [14] concluded that patients with a body mass index of $\geq$ 35 and in those weighing $\geq$100 kg had double the rate of PJI after primary total joint arthroplasty. One factor that can be controlled by the surgeon is injection prior to surgery. Werner et al., [15] demonstrated that there is a significant increase in postoperative infections in patients who receive intra-articular ipsilateral shoulder injection within 3 months before shoulder arthroscopy and arthroplasty.

Many studies suggest that screening for MRSA (methicillin-resistant Staphylococcus aureus) and treating MRSA-positive patients preoperatively reduces the risk of surgical site infections following surgery [16–18]. Furthermore, preoperative MRSA screening and decolonization is highly cost-effective [19]. However, surgeons performing arthroplasty should be aware that treatment for decolonization treatment does not ensure that the patient will remain decolonized in the future [20]. Furthermore, MRSA is not the most common cause of PJI of the shoulder.

It has been well documented that *Propionibacterium acnes* (*P. acnes*) is the most common pathogen involved in shoulder PJI [3,21]. *P. acnes* is a slow growing anaerobic gram positive bacillus which can be difficult to identify with tradition diagnostic testing [21,22]. There are specific steps the patient can undertake to decrease the bacterial load prior to surgery, such as preoperative body washing, showering instead of bathing, and the use of chlorhexidine instead of soap [23,24].

Further measures can also be taken to decrease the risk of PJI. In total knee arthroplasty, Kapadia et al., demonstrated that a prehospital chlorhexidine skin wipe is associated with a reduced relative risk of PJI after total knee arthroplasty. Preoperative chlorhexidine skin preparation had an infection rate of only 0.3% compared to a control group of 1.9% [25]. Murray et al., instructed patients to shower with soap and water the evening before their operation and to wipe their operative site with a 2% chlorhexidine gluconate impregnated cloth 1 hour after showering. The morning of surgery, patients in the treatment group were instructed to avoid showering and to apply a second 2% chlorhexidine gluconate impregnated cloth in the same manner as the first within 2 hours of departing for the hospital. The positive culture rate for the coagulase-negative Staphylococcus was 30% in the treatment group compared with the control group of 70% (P = .0001) Unfortunately, the positive culture rate for *P. acnes* remained high at 46% in the treatment group and 58% in the control group (P = 0.32) [26]. Saltzman et al., compared ChloraPrep, Betadine, and DuraPrep surgical site preparation prior to shoulder surgery. They found ChloraPrep to be the most effective in eliminating bacteria in the shoulder region preoperatively. However, none of the preps reduced the incidence of *P. acnes*.[27]. Sabetta et al., found that topical 5% benzoyl peroxide applied 48 hours before surgery decreases *P. acnes* on the skin before, during, after surgery. They found that only 6% of patients treated with benzoyl peroxide had positive skin cultures at initiation of surgery compared to 29% in historical reports [28].

3. Intraoperative

3.1. *Antibiotics*

It is believed that preoperative antibiotics play an important role in preventing PJI. A revolutionary study conducted by Fogelberg et al., [29] concluded that the incidence of infection was 1.7% in a group receiving prophylactic antibiotics vs. 8.9% in a group that did not receive antibiotics. Currently, preoperative antibiotics are the standard of care prior to shoulder surgery. There is no consensus on the type of antibiotic to be administered. At our institutions we use a first-generation cephalosporin (cefazolin) in the majority of cases. In the presence of allergy then clindamycin is recommended. Vancomycin is considered in at risk patients.

3.2. *Barriers*

One key to reducing the transmission of disease and subsequent infection is maintaining a barrier between the patient and operating room personnel. Glove perforation has been shown to increase the likelihood of infection for both the patient and surgical team [30–33]. Carter et al., [34] revealed that there was a 3.7% glove perforation during primary surgery and 8.9% during revision surgery. In a randomized controlled trial conducted by Makema et al., results showed that there was a 15% glove perforation in single gloving and a 1.2% in double gloving. Furthermore, they showed that the use of double gloving has more than a 90% protection to both the patient and surgeon [35]; thus, wearing double gloves during surgery is likely beneficial to both parties.

The use of surgical helmet or hood systems are frequently used to create a barrier, but Tayton et al. [36] have shown these to lead to a possible increase in risk of PJI. Der Tavitian et al., [37] concluded that body-exhaust suits have no effect on PJI rates, although these suits may potentially decrease bacterial air count when compared to occlusive clothing. Studies regarding laminar flow systems show either a potential increased risk of PJI [36,38–40] or no difference in infection rates [41].