SH76: What are the recommendations regarding the route (IV versus PO) and length of postoperative antibiotic treatment when a one-stage revision arthroplasty is performed for subacute/chronic shoulder PJI caused by a virulent organism (e.g. MRSA, MSSA, E. coli)?

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Response: There is data to support both the use of intravenous or oral antibiotics to treat PJI caused by traditionally high-virulent organism surgically managed with one-stage revision. Antibiotic type, route, and duration should be selected in consultation with Infectious Disease specialists, when available.

Strength of Recommendation: Limited

Delegate Vote: 49 (100%) agree; 0 disagree; 0 abstain

Rationale

Periprosthetic joint infections (PJIs) are a significant complication following shoulder arthroplasty. The incidence of shoulder PJIs varies depending on the type of procedure, with rates ranging from approximately 0.4% to 4% for primary shoulder arthroplasty, increasing to 4% to 15.4% in revision cases.[1-3] However, the incidence of subacute or chronic shoulder periprosthetic joint infections (PJIs) caused by virulent organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA), methicillin-sensitive *Staphylococcus aureus* (MSSA), and *Escherichia coli* (E. coli) is relatively low compared to infections caused by indolent organisms like *Cutibacterium acnes* and coagulase-negative staphylococci. While specific incidence rates for these virulent pathogens in subacute or chronic shoulder PJIs are not extensively documented, available studies provide some insights. A multicenter retrospective study by Coste et al. reported that among 44 cases of periprosthetic shoulder infections, 9 (20.5%) were caused by MSSA and 7 (15.9%) by MRSA.[4] Additionally, the 2018 International Consensus Meeting on Orthopedic Infections noted that shoulder PJIs caused by virulent organisms such as MRSA, MSSA, and *E. coli* are less common but present significant treatment challenges.[5,6]
Traditionally, the treatment of shoulder PJIs has relied on a two-stage revision procedure, which involves removing the infected prosthesis, placing an antibiotic spacer, and subsequently reimplanting a new prosthesis after eradicating the infection. While this approach achieves high infection control rates, it is associated with increased morbidity due to multiple surgeries.
More recently, one-stage revision procedures have gained traction.[7] In this approach, the infected prosthesis is removed, and a new prosthesis is implanted in a single surgery. Rodrigues-Lopes et al. (2024) conducted a comprehensive study comparing one-stage and two-stage revision procedures for shoulder PJIs.[8] Their findings demonstrated that one-stage revision achieved infection control rates equivalent to the two-stage approach while significantly reducing surgical morbidity and enabling faster recovery times. These results have contributed to the growing acceptance of one-stage procedures as a viable option for managing shoulder PJIs caused by virulent organisms.
Alongside surgical advancements, there has been growing interest in optimizing antibiotic therapy for bone and joint infections, including PJIs. Recent studies have investigated the

effectiveness of oral antibiotics as an alternative to intravenous therapy and the potential to shorten overall antibiotic treatment durations without compromising infection outcomes.[9,10] However, consensus on the optimal type and duration of postoperative antibiotics for shoulder PJIs, particularly in the context of one-stage revision procedures, remains lacking.
To address this gap, we reviewed and synthesized the limited evidence surrounding antibiotic therapy following one-stage revision arthroplasty for shoulder PJIs caused by virlent organisms. This review aims to provide insights into managing these complex infections and identify areas for future research.

Methodology

A PubMed search was performed using the terms "shoulder (MeSH)," "arthroplasty," "revision," and "antibiotic," yielding 72 results. Abstracts were screened to identify studies reporting on one-stage revision procedures for virulent periprosthetic shoulder infections, resulting in 8 relevant articles included in this review.

Study Summary

Sperling et al. conducted a retrospective study of 25 patients with deep periprosthetic infections involving 26 shoulders (19 primary and 7 revision arthroplasties).[11] Only two patients underwent single-stage exchange. In one case, *Coagulase-negative Staphylococcus* and *Acinetobacter calcoaceticus* were cultured during direct exchange, with subsequent reinfection by *Corynebacterium species*, necessitating resection arthroplasty nine months later. This patient experienced a humerus fracture during resection and was lost to follow-up. The second patient had infections caused by *Pseudomonas aeruginosa* and *Alcaligenes species*, treated with a Neer total shoulder arthroplasty reimplanted with gentamicin-impregnated cement. At 10 years, this patient had no pain, good strength, satisfactory functional outcomes, and was able to perform all activities of daily living. While detailed antibiotic data for these two cases was unavailable, among the broader cohort, IV antibiotics averaged 31 days, followed by oral antibiotics in 13 cases for a mean of 27 days. Outcomes showed one reinfection and one successful recovery in the single-stage group.

Cuff et al. retrospectively reviewed 21 patients (22 shoulders) with deep infections following shoulder surgery, treated with extensive debridement, intravenous antibiotics, and conversion to a reverse shoulder prosthesis using either a single-stage (10 shoulders) or two-stage (12 shoulders) approach.[12] Infections included cases caused by *MRSA/MSSA (1)*, *MRSA (3)*, *Enterobacter cloacae (1)*, *Enterococcus faecalis* (1) and *Serratia (1)*. Postoperative antibiotic duration varied: patients with draining sinuses or intraoperative evidence of pus, as well as those with positive histology or cultures, received six weeks of antibiotics, while those with positive intraoperative cultures but negative histology were treated for two weeks to account for potential contamination. Unfortunately, the authors did not specify the antibiotic treatment plans for the virulent bacteria above. They also do not specify if the patients received intravenous or oral antibiotics. At a mean follow-up of 43 months (range: 25-66 months), there was no evidence of recurrent infection, and outcomes were comparable between single- and two-stage procedures.

Beekman et al. conducted a retrospective review of 11 patients with infected reverse shoulder arthroplasties who underwent single-stage revision arthroplasty.[13] Two patients had monobacterial infections caused by virulent organisms (*Staphylococcus aureus* and *Escherichia coli*). Both received at least three days of IV antibiotics before being transitioned to oral

antibiotics for at least three months. At a median follow-up of 24 months (range: 12 to 36 months), both patients were free of infection and fistula and had been off antibiotic therapy for a minimum of six months.

Klatte et al. retrospectively reviewed 35 patients (19 men and 16 women) with periprosthetic shoulder infections treated with one-stage exchange arthroplasty.[14] At a mean follow-up of 4.7 years (range: 1.1 to 13.25 years), infection-free survival was 94%. Among the cases, one preoperative culture grew *Enterococcus faecalis* and another grew *Morganella morganii.* In another patient, one intraoperative culture grew *Staphylococcus aureus*. Postoperatively, IV antibiotics tailored to intraoperative cultures and clinical markers, such as CRP and white cell count, were administered for an average of 10.6 days (range: 5-29 days). Oral antibiotics were prescribed after discharge for selected patients, lasting 5 to 24 days based on bacterial sensitivity and CRP trends. Two patients (5.7%) experienced reinfections at two months and 3.9 years postoperatively, requiring resection arthroplasty due to poor bone stock. However, from the manuscript we do not know which patients had recurrent infections and what their specific antibiotic treatment courses were.

Stone et al. reviewed 79 patients with periprosthetic shoulder infections treated between 2004 and 2012 with either component exchange (n=15), complete revision with reimplantation (CRR; n=45), or two-stage revision (n=19).[15] Sixty patients underwent one-stage debridement with modular component exchange or complete removal and reinsertion of a prosthesis with antibiotic cement. Among these, 10 patients had infections caused by MSSA and 1 by MRSA. All patients received six weeks of IV antibiotics tailored to intraoperative cultures under infectious disease guidance. At an average follow-up of 45 months (range: 12-105 months), the overall recurrence rate was 13% (10 of 79 patients). Reinfection rates varied by procedure: 26.7% for component exchange, 4.3% for CRR, and 33% for two-stage revisions. Among 12 patients with infections due to *Staphylococcus aureus*, 33% experienced reinfections, including all patients in the two-stage group and one in the one-stage group.

Padegimas et al. analyzed 117 revision shoulder arthroplasties performed without preoperative suspicion of infection, identifying unexpected positive cultures (UPCs) in 28 cases (23.9%).[16] Among these, four patients had virulent organisms: one with *Enterococcus faecalis* treated with six weeks of IV ampicillin, one with MRSA treated with six weeks of oral Bactrim, and one with vancomycin-resistant *Enterococcus* treated with six weeks of IV daptomycin. Notably, no recurrent infections were reported in this group.

Yao et al performed a retrospective review of 175 revision shoulder arthroplasties classified patients into high suspicion (n=62) and low suspicion (n=113) groups based on clinical assessment.[17] High suspicion patients began IV antibiotics, discontinued at 21 days if cultures were negative but extended to six weeks if cultures were positive. Low suspicion patients received oral antibiotics for 21 days, transitioning to six weeks of IV antibiotics followed by three months of oral therapy if cultures were positive. Among the 30 low-suspicion patients with positive cultures (Yellow-Positive group), 27 grew low-virulence organisms (*Cutibacterium* or Coagulase-negative *Staphylococcus*), while two grew virulent species (*Pseudomonas* and *Staphylococcus lugdunensis*). No patients in the high suspicion group with positive cultures grew virulent organisms. Specific antibiotic regimens and outcomes for the groups were not detailed. El Amiri et al. conducted a retrospective monocentric study of 40 patients (14 women and 26 men) diagnosed with periprosthetic joint infection (PJI) following shoulder arthroplasty, all treated with one-stage prosthesis revision for infections persisting more than three weeks.[18] Pathogens included *Staphylococcus aureus* (n=5), *Escherichia coli* (n=1), *Enterobacter cloacae*

(n=2), and *Pseudomonas aeruginosa* (n=1), with many cases being polymicrobial. Probabilistic antibiotic therapy was initiated intraoperatively and subsequently tailored to final culture results, with total treatment durations of six to twelve weeks per infectious disease specialist recommendations. At a minimum two-year follow-up, 36 of 40 patients (90%) had no recurrence of infection. Two of the four poor outcomes involved patients with *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Unfortunately, the authors do not detail the antibiotic regimens for these patients.

The management of subacute or chronic shoulder periprosthetic joint infections (PJIs) caused by virulent organisms remains a complex clinical challenge. This review highlights the limited but growing body of evidence surrounding antibiotic regimens following one-stage revision arthroplasty for shoulder PJIs. Existing studies report varied approaches to the route (IV versus oral) and duration of postoperative antibiotic treatment, reflecting significant variability in clinical practice. While certain studies demonstrate success with short durations of IV antibiotics followed by oral therapy, others employ extended IV regimens or a combination of both. Overall, the data indicate that individualized antibiotic strategies tailored to culture results and clinical markers, such as inflammatory indices, may yield acceptable infection control rates. However, the heterogeneity of study designs, antibiotic protocols, and outcome measures complicates direct comparisons and the establishment of standardized recommendations.

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