SH75: What are the recommendations for the route (IV versus PO) and duration of postoperative antibiotic treatment when a one-stage revision arthroplasty is performed for subacute or chronic shoulder PJI caused by an indolent organism (e.g., *C. acnes* or Coagulase Negative Staphylococcus)?

Liaison: Surena Namdari
Lead Delegate: Jessica Seidelman
Supportive Delegates: Joideep Phadnis; Jay D. Keener

Response: There is data to support both the use of intravenous or oral antibiotics in the treatment of one-stage revision arthroplasty for subacute/chronic PJI caused by an indolent organism. Selection of antibiotic type and route should be dictated by infection characteristics in consultation with Infectious Disease specialists when available.

Strength of Recommendation: Limited

Delegate Vote: 50 (98%) agree; 0 disagree; 1 (2%) abstain

Rationale

Background

Periprosthetic joint infections (PJIs) represent a significant complication following shoulder arthroplasty. The incidence of shoulder PJIs varies depending on the type of procedure, with rates reported at approximately 0.4% to 4% for primary shoulder arthroplasty, increasing to 4% to 15.4% in revision cases.[1-3] Despite the lower overall prevalence compared to hip and knee PJIs, shoulder PJIs pose unique diagnostic and therapeutic challenges due to the predominance of indolent pathogens. Specifically, *C. acnes* is identified as the primary pathogen in about 64% to 86% of shoulder PJI cases, while coagulase-negative staphylococci account for approximately 24% of cases.[4,5]

The clinical presentation of shoulder PJIs often differs from that of hip and knee PJIs. While hip and knee PJIs typically manifest with overt signs of infection, including pain, swelling, erythema, and fever, shoulder PJIs frequently present with more subtle symptoms.[6] These may include low-grade pain, stiffness, and delayed recovery of function, which can complicate diagnosis. The predominance of indolent organisms like *C. acnes* and coagulase-negative staphylococci is a significant factor in this atypical presentation. These organisms are less virulent, resulting in fewer systemic signs of infection, but their presence can lead to persistent inflammation and joint dysfunction.[7]

The treatment of shoulder PJIs has traditionally relied on a two-stage revision procedure, which involves removal of the infected prosthesis, placement of an antibiotic spacer, and subsequent reimplantation of a new prosthesis after infection eradication. This approach has been associated with high rates of infection control but carries the drawback of increased morbidity due to the need for multiple surgeries. Recently, a one-stage revision procedure, where the infected prosthesis is removed and a new prosthesis is implanted in a single surgery, has gained favor.[8] Rodrigues-Lopes et al. (2024) conducted a comprehensive study comparing one-stage and two-stage revision procedures for shoulder PJIs.[9] They found that one-stage revision provided infection control rates equivalent to the two-stage approach, with significantly reduced surgical morbidity and faster recovery times. These findings have contributed to the growing

acceptance of one-stage procedures as a viable option for managing shoulder PJIs caused by indolent organisms. The relative benefits of and indications for one-stage and two-stage revision procedures for shoulder PJI remains debated given the significant heterogeneity of subject populations in the existing literature.

In addition to surgical management, there has been increasing interest in optimizing the antibiotic treatment of bone and joint infections, including PJIs. Recent studies have explored the efficacy of oral antibiotics as an alternative to intravenous therapy, as well as the possibility of shortening the overall duration of antibiotic treatment without compromising infection outcomes.[10,11] However, there remains a lack of consensus regarding the optimal type and duration of postoperative antibiotics for shoulder PJIs, particularly in the context of one-stage revision procedures.

To address this knowledge gap, we reviewed and summarized the limited evidence surrounding antibiotic therapy following one-stage revision arthroplasty for shoulder PJIs caused by indolent organisms. By consolidating current findings, this review aims to provide insights into the management of these challenging infections and highlight areas for future research.

Methodology

A PubMed search with "shoulder (mesh)," "arthroplasty," "revision," and "antibiotic" yielded 72 articles. Abstracts of the papers were reviewed to identify appears reporting one-stage revision for indolent prosthetic joint infections. Thirteen relevant studies were selected for this review.

Study Summaries

A study by Yao et al included 92 patients who underwent revision shoulder arthroplasty excluding patients with obvious infection defined as positive ICM definitive infection classification (sinus present, gross purulence, and 2 or positive cultures of the same virulent organism). The perioperative antibiotic regimens were chosen based on the surgeon's preoperative suspicion of infection.[12] Patients with a high PJI suspicion (red group) received IV antibiotics initially, completing six weeks of IV therapy followed by a minimum of three months of oral antibiotics if cultures were positive. Those with low PJI suspicion (yellow group) started on oral antibiotics, switched to IV antibiotics if cultures turned positive, and completed at least three months of therapy. Surgeons correctly predicted infection (red vs yellow group) defined as positive multiple cultures in 72% of cases. Among 17 patients who required additional revision surgery, infection was the indication in eight cases: five from the red group (three Cutibacterium, one Coagulase-negative Staphylococcus, one Corynebacterium) and three from the yellow group (one each of Cutibacterium, Coagulase-negative Staphylococcus, and Staphylococcus aureus). Patients who received IV antibiotics compared to oral antibiotics had a similar rate of infection-free and revision-free survivorship. Ceftriaxone was used for Cutibacterium, vancomycin for Coagulase-negative Staphylococcus, and oral rifampin was added where appropriate. Oral regimens included doxycycline or amoxicillin-clavulanate. At two years, infection-free survivorship was 85% for the red group and 93% for the yellow group.

Hsu et al evaluated 55 shoulders undergoing single-stage revision arthroplasty without obvious clinical evidence of infection where intraoperative cultures were obtained.[13] Twenty-seven of 55 had ≥2 positive cultures for Propionibacterium acnes. Initial perioperative antibiotic regimens varied by clinical suspicion of infection: patients with high suspicion received IV ceftriaxone via a PICC line, with vancomycin discontinued unless cultures confirmed mecA-

positive Coagulase-negative Staphylococcus. If cultures were negative at three weeks, antibiotics were discontinued. Patients with low suspicion were treated with oral amoxicillin-clavulanate until cultures were negative at 21 days or until two cultures identified the same bacterial species, prompting a 6-week IV course followed by oral antibiotics for at least six months. Among 33 patients surveyed, 42% reported side effects, including gastrointestinal and dermatologic complications, with adverse events more common in those receiving IV antibiotics. In the culture-positive group, 11% required further procedures for pain or stiffness, but no positive cultures were identified during subsequent revisions.

Padegimas et al. retrospectively reviewed 117 one-stage revision shoulder arthroplasties performed without preoperative suspicion of infection and followed patients for over four years.[14] Postoperatively, 28 patients (23.9%) had unexpected positive cultures (UPCs), with C. acnes identified in 57.1% of cases. Among these, 13 patients had C. acnes, five had Coagulase-negative Staphylococcus, and two had both organisms. Antibiotic regimens varied: 64.3% received six weeks of IV antibiotics, while 35.7% received only two weeks of oral antibiotics. Overall, 10 patients received no additional antibiotics beyond the initial two weeks, three were treated with six weeks of oral doxycycline, and seven received six weeks of IV vancomycin or penicillin. Patients with UPCs had a lower reoperation rate (7.1%) compared to those without UPCs (19.1%), and only one patient experienced a late recurrent infection (2.2 years), which was attributed to C. acnes contamination and not treated with prolonged antibiotics. Positive UPC's were not correlated with the need for further revision surgery.

Another retrospective study reviewed 35 patients with periprosthetic shoulder infections treated with a one-stage exchange procedure.[15] Of these, 26 patients were available for clinical follow-up, with a mean follow-up of 4.7 years (range: 1.1 to 13.25 years). In all cases, preoperative aspirations revealed the infected organism species and all revisions were performed with placement of antibiotic laden cement. The majority of intraoperative cultures yielded Staphylococcus epidermidis, C. acnes, or Staphylococcus capitis. Postoperatively, IV antibiotics were initiated based on preoperative aspirates and bacterial sensitivities and continued for an average of 10.6 days until CRP levels normalized, white cell counts stabilized, and the wound healed. Tailored oral antibiotics were prescribed post-discharge for 5 to 24 days in selected cases. The infection-free survival rate was 94%, though two patients (5.7%) developed recurrent infections requiring resection arthroplasty at two months and 3.9 years postoperatively due to poor bone stock.

EI Amiri et al conducted a retrospective monocentric study evaluated 40 patients (14 women and 26 men) diagnosed with periprosthetic joint infection (PJI) following shoulder arthroplasty, all of whom underwent one-stage prosthesis revision for infections persisting beyond three weeks.[16] In 45% of cases, the causative organism was not identified at the time of revision, but Cutibacterium acnes was the most common pathogen, present in 67.5% of patients. Probabilistic antibiotic therapy was initiated intraoperatively and adjusted based on final culture results, with treatment durations ranging from six to 12 weeks under infectious disease specialist guidance. At a minimum two-year follow-up, 90% of patients (36/40) were infection-free, with only one recurrence involving a patient whose cultures grew C. acnes and Staphylococcus epidermidis.

Sevelda et al. reviewed 14 patients who underwent one-stage exchange for shoulder periprosthetic joint infection (PJI).[17] Inclusion required identification of an isolated microorganism from synovial fluid aspiration or biopsy with a defined antibiotic susceptibility profile before revision surgery. Twelve patients with rotator cuff insufficiency received reverse

shoulder arthroplasty, while two with intact rotator cuffs underwent anatomic total shoulder arthroplasty. The most frequently detected pathogens were Cutibacterium acnes and Staphylococcus epidermidis, with all infections caused by either C. acnes or Coagulase-negative Staphylococcus (CoNS) and preoperative organisms matching in 12 of 14 cases. Patients were treated with local and systemic antibiotics tailored to the microorganism's susceptibility profile. Infection-free survival rates were 100% at one year and 93% at five years, with only one recurrence occurring 22 months postoperatively.

Between 2004 and 2012, 79 patients underwent surgical management for shoulder periprosthetic joint infection (PJI) using either a component exchange (n=15), a complete revision with reimplantation (CRR; n=45), or a two-stage revision (n=19) in a study by Stone et al.[18] Of the 60 patients treated with one-stage procedures, 18 had infections caused by Coagulase-negative Staphylococcus (CoNS) and 19 by Cutibacterium acnes. All patients received six weeks of postoperative intravenous antibiotics directed by intraoperative cultures, although the use of chronic suppressive therapy was not reported. At an average follow-up of 45 months (range: 12-105 months), the overall recurrence rate was 13% (10 of 79 patients). Among one-stage procedures, reoperation rates varied: 26.7% for component exchanges, 4.3% for CRR, and 33% for two-stage revisions. Of the 23 patients with positive cultures for CoNS, 13% experienced reinfection, including one patient treated with component exchange and two treated with two-stage revision.

Jacquot et al. conducted a retrospective multicenter study to evaluate the outcomes of various therapeutic approaches for infection following reversed shoulder arthroplasty.[19] Between 1996 and 2011, 32 patients (mean age 71 years, range: 55-83) underwent reoperations for infection involving 23 primary and 9 revision prostheses. The preoperative Constant score averaged 34, improving to 53 postoperatively in one-stage cases. Among 38 total procedures, treatments included debridement (n=13), one-stage revision (n=5), two-stage revision (n=14), and implant removal (n=6). Infections were most commonly caused by Coagulase-negative Staphylococcus (56%) and Propionibacterium acnes (59%). One-stage revision, performed in 5 cases as a first-line treatment for acute, subacute, and chronic infections, achieved 100% infection control at a mean follow-up of 36 months (range: 12-137 months).

In a retrospective study by Ince et al 16 patients underwent one-stage exchange for shoulder PJI with a mean follow-up of 5.8 years.[20] In all cases, antibiotic laden cement was used for humeral fixation. Eleven cases involved *C. acnes* or Coagulase-negative Staphylococcus. Systemic antibiotics averaged 8.6 days, followed by PO therapy based on clinical response. Three aseptic revisions were required. No recurrences were reported at follow-up.

Grosso et al retrospectively reviewed 17 patients with UPCs (at least one positive culture) managed with one-stage revisions and routine 24-hour postoperative IV antibiotics.[21] The most common pathogen cultured at revision surgery was Propionibacterium acnes (10 of 17 [56%]), followed by coagulase-negative Staphylococcus species (6 of 17 [35%]). Despite no extended antibiotic therapy, the recurrence rate was low (5.9%). This study suggests that intensive antimicrobial treatment strategies may not be necessary to reduce recurrent infections in patients with positive intraoperative cultures, without overt clinical signs of infection before or during the revision surgery.

A retrospective review of 21 patients (10 one-stage revisions) by Cuff et al describes 21 patients who presented with deep infection after surgery to the shoulder.[22] The patients were treated by an extensive debridement, intravenous antibiotics, and conversion to a reverse shoulder prosthesis in either a single- (10 shoulders) or a two-stage (12 shoulders) procedure. Six

patients had either CoNS or C. acnes on culture. 4 of them had acute inflammation. Patients with a draining sinus before the operation or evidence of pus during the operation were treated with six weeks of antibiotics post-operatively as also were those with positive frozen sections or positive permanent sections with or without positive intra-operative cultures. Those with negative frozen and permanent sections but positive intra-operative cultures were given antibiotics for two weeks, as it was felt that positive cultures with negative histology could potentially represent contamination. At a mean follow-up of 43 months (25 to 66) there was no evidence of recurrent infection. There was no statistically significant difference in any outcome between the single-stage and the two-stage group.

In a multicenter retrospective review of 42 cases by Coste et al in 2004, three patients underwent one-stage revisions.[23] They defined infection based on seven criteria including the presence of a sinus tract, elevated serum white blood cell (WBC) count, elevated erythrocyte sedimentation rate, or C-reactive protein (CRP), positive culture including preoperative aspiration, X-ray evidence of implant loosening and positive bone scan, with no further details on how these criteria were weighted in their definition. The causative organisms were Staphylococcus epidermidis (one), Staphylococcus aureus (one) and Proprionibacterium acnes (one).Antibiotic therapy was only available in 30 of the 42 patients. The duration of antibiotic treatment after surgery varied with a mean of 3.9 months (0.01 to 16.6) for the entire series. In 15 patients this treatment bore no relationship to the bacteria found in cultures nor to the bony-penetration properties of the antibiotic. In 3 patients the duration was less than 3 weeks. The infection was eradicated in all and none required further surgery.

Lastly, a retrospective study by Yao et al of 175 patients explored IV versus PO antibiotic regimens after revision arthroplasty.[24] 62 patients were placed in the high suspicion group, and 113 in the low suspicion group. High-suspicion patients were started on IV antibiotics, discontinued at 21 days if cultures were negative, but continued for 6 weeks if cultures were positive. Low-suspicion patients were given oral antibiotics for 21 days, and this was either discontinued or patients were switched to 6 weeks of IV antibiotics followed by 3 months of oral antibiotics if cultures returned positive. Twenty-seven of the 30 patients in the yellow-positive group grew Cutibacterium of coagulase-negative staphylococcus on culture. If Cutibacterium was the sole organism detected, then the drug of choice was ceftriaxone 2 g IV every 24 hours. Patients unable to take ceftriaxone were given either IV vancomycin (targeting a trough of 10 to 20 µg/mL) or IV daptomycin (dosed at 8 mg/mL). If coagulase-negative Staphylococcus was the sole organism detected, patients were usually given IV vancomycin (targeting a trough of 10 to 20 µg/mL) or IV daptomycin (dosed at 8 mg/mL). Oral rifampin (600 mg daily) was added if no major drug-drug interactions and no underlying liver disease were present. IV antibiotic treatment was followed by a minimum of 3 months of oral antibiotics (doxycycline or amoxicillin-clavulanate). Adverse events were not systematically reported. Those patients in the red protocol group and those treated with greater than 3 weeks of IV antibiotics had a significantly higher rate of adverse reactions to antibiotics. Reinfection risks were not reported Management of postoperative antibiotic therapy following one-stage revision arthroplasty for shoulder periprosthetic joint infections (PJIs) caused by indolent organisms, such as *Cutibacterium acnes* and coagulase-negative staphylococci, remains an area of evolving clinical practice. The reviewed literature demonstrates a wide variation in antibiotic regimens, ranging from short courses of oral antibiotics to extended intravenous (IV) therapy, often followed by oral antibiotics. While infection-free survival rates are generally high (ranging from 85% to 100% across studies), the optimal route and duration of antibiotic treatment are not standardized.

The evidence suggests that treatment strategies tailored to culture results and individual patient factors can achieve favorable outcomes. However, the data remain limited by heterogeneity in study design, treatment protocols, and definitions of success. Further research is essential to establish definitive guidelines that balance efficacy, patient safety, and resource utilization.

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