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QUESTION 3: Is there a role for postoperative antibiotic treatment when a revision arthroplasty is performed with subsequent unexpected positive cultures of the shoulder caused by an indolent organism (e.g., *C. acnes* or coagulase-negative *Staphylococcus*(CNS))?

RECOMMENDATION: Postoperative antibiotic treatment beyond 24 hours after revision arthroplasty with unexpected positive cultures for an indolent organism does not appear to reduce the risk of subsequent infection.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 84%, Disagree: 4%, Abstain: 12% (Super Majority, Strong Consensus)

RATIONALE

A comprehensive literature review was performed to identify all studies on prophylactic/suppressive antibiotics after revision shoulder arthroplasty. Searches for the terms “shoulder replacement,” “indolent,” “infection,” “antibiotics,” “postoperative” and/or “joint replacement” were performed using the search engines PubMed, Google Scholar and Cochrane review, which were searched through February 2018. Inclusion criteria for our systematic review were all English studies (Level I-IV evidence) that reported on antibiotic prophylaxis, or lack thereof, in cases of revision shoulder arthroplasty. Exclusion criteria were non-English language articles, nonhuman studies, retracted papers, incomplete antibiotic records, case reports, review papers, studies without clinical follow-up/infection rates and technique papers without patient data. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria were followed.

The prevalence of subclinical infections (unexpected positive culture (UPC)) is common after shoulder arthroplasty due to anatomic and demographic factors. In fact, the rate of positive cultures in primary and revision arthroplasty settings have been reported as high as 56% [1–3]. The significance of such cultures remains unknown. There is limited data in the shoulder literature for or against the role for postoperative antibiotics after revision shoulder arthroplasty without clinical or radiographic signs of infection. While several studies described the use of prophylactic or suppressive antibiotics after revision shoulder arthroplasty, there were no prospective randomized studies and none of the studies specifically evaluated efficacy by antibiotic or organism.

Among the published studies for outcomes after revision shoulder arthroplasty with subclinical presentations and unexpected positive cultures, all were retrospective studies with differing methodologies [4–8]. All of the studies reported the majority of positive cultures (> 80%) from indolent organisms (*C. acnes* and/or CNS). None of the studies found a detrimental effect to not prescribing prolonged antibiotics postoperatively, although one study with no comparison group reported a 25% recurrence rate after UPC. One systematic review confirmed a pooled true infection rate after UPC of 10.2%, with antibiotic use not influencing the rate of occurrence of true infection after UPCs ($P = 0.498$) [9].

Grosso et al. used antibiotic-impregnated cement and 24 hours of routine postoperative antibiotics after revision shoulder arthroplasty and reported 1 superficial infection and no deep infections (91% of organisms cultured were indolent) [4]. Foruria et al. reported 10% persistent infection rate after single stage revision shoulder arthroplasty, although postoperative antibiotic use and positive cultures did not influence the rate of true infections (83% of cultures were positive for indolent organisms) [5]. Padegimas et al. reported a 23.9% UPC rate after revision shoulder arthroplasty with standardized UPC treatment of 6 weeks antibiotics or 2 weeks antibiotics at surgeon discretion. They found only 1 recurrent infection in the UPC group, 3.5% versus 3.4% in the non-UPC group [6]. Kelly et al. reported 8/28 (29%) UPC rate after revision shoulder arthroplasty and only treated one with antibiotics postoperatively for 4 weeks (due to superficial wound infection). Of 8 patients, 2 (25%) developed late clinical infection with *C. acnes* [7]. Lastly, Hsu et al. reported a 49% positive culture rate after revision shoulder arthroplasty and treated patients

based with a protocol of 6 weeks intravenous and 6 months of oral antibiotics if > 2 cultures were positive. Zero percent of patients had recurrence of infection with this protocol in both the positive culture and negative culture groups [8]. On the other hand, the risks of prolonged antibiotic use are significant. Two studies reported a 19-42% complication side-effect rate associated with prolonged antibiotic administration, which was seen in both oral and intravenous medication use [4,8].

The long-term consequences for an unexpected indolent positive culture after revision shoulder arthroplasty are unknown. However, despite lacking randomized comparative methodologies, the literature shows limited evidence that prolonged antibiotic use is not necessary in this scenario. Furthermore, there are well-reported risks of antibiotic-related side-effects and resistance with widespread use.

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3.2. TREATMENT: ANTIBIOTIC FOR PERIPROSTHETIC JOINT INFECTION

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QUESTION 1: Is there a need for antibiotic therapy following irrigation and debridement of patients with acute shoulder periprosthetic joint infection (PJI) caused by a virulent organism (e.g., methicillin-resistant *Staphylococcus aureus* (MRSA), methicillin-sensitive *Staphylococcus aureus* (MSSA) or *E. coli*)?

RECOMMENDATION: In the absence of high level data, we propose that patients with acute PJI of shoulder caused by virulent organisms, such as MRSA, MSSA or *E. coli*, receive postoperative antibiotics. The optimal antibiotic, route of administration and duration of treatment are unknown and should be individualized after consultation with infectious disease specialists.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

A systematic review was performed using PubMed and Google Scholar databases in February, 2018 to identify studies regarding the treatment outcomes after shoulder arthroplasty. The keywords included “shoulder AND (replacement OR arthroplasty) AND infection.” This search identified 46 articles with relevance to surgical treatment of shoulder prosthetic joint infection, 9 of which described treatment with irrigation and debridement with or without modular component exchange for acute infection (<3 months from surgery or acute hematogenous spread) [1-9]. These nine studies only included small numbers of patients with only 6 patients with acute PJI caused by a virulent organism [1].

There were no studies identified that directly compared irrigation and debridement versus irrigation and debridement with postoperative antibiotics for the treatment of acute PJI. The nine studies had varied definitions of “acute,” with periods ranging from four weeks to three months [1-9]. Data regarding the pathogenic organism was not clearly reported, thus making it difficult to determine whether the virulence was a factor in the treatment or outcome. The surgical management of the acute infections varied,

including arthroscopic irrigation and debridement, open irrigation and debridement, and open irrigation and debridement with modular component exchange. Given the limitations of the data, it is not possible to answer the narrow question of whether there is a role for antibiotic therapy in the management of acute shoulder PJI caused by a virulent organism (MRSA, MSSA, *E. coli*) after irrigation and debridement.

Nevertheless, postoperative antibiotics were always part of the treatment of acute PJI in the published literature. Treatment types and length varied; both intravenous and oral regimens were employed, and treatment lengths ranged from 13 days to chronic lifetime suppression [1,2]. Most studies used a four to six-week protocol of postoperative antibiotic therapy [1,3-8]. It appears to be the consensus opinion that acute shoulder PJI treated with irrigation and debridement should be followed by a course of antibiotic therapy. The type, dose and route of administration of the antibiotic should be individualized and determined after consultation with an infectious disease specialist.