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QUESTION 4: Is there a role for preoperative joint aspiration prior to reimplantation during two-stage exchange for shoulder periprosthetic joint infection (PJI)?

RECOMMENDATION: There is a dearth of information on the role of preoperative joint aspiration prior to second stage revision after treatment of shoulder PJI. Furthermore, several studies have pointed to the high incidence of "dry taps" and false negative cultures from joint aspirates. Thus, there is little evidence in support of routine preoperative aspiration prior to second stage reimplantation.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 88%, Disagree: 4%, Abstain: 8% (Super Majority, Strong Consensus)

RATIONALE

A systematic review of the published literature was performed on PubMed using the search terms Shoulder (Title) AND [Periprosthetic OR reverse shoulder OR total shoulder OR arthroplasty OR replacement OR prosthesis (Title/ Abstract)] AND [Infection OR infected OR septic OR sepsis OR PJI OR propionibacterium OR acnes OR staphylococcal OR staphylococcus OR second stage OR OR staged OR revision OR spacer OR two-stage OR two stage OR reimplantation OR purulent OR purulence OR sinus tract (Title)]. This search yielded 255 articles. All titles were reviewed and articles with potential relevance had their abstracts reviewed. In total, with full texts reviewed, 31 articles where considered relevant to this topic in some fashion. Articles were deemed relevant if they included any aspirate information on patients with shoulder arthroplasties. These articles were used to make the recommendation. The reference lists of the included articles were further searched to identify other references that may have been omitted.

Controversy remains regarding the best surgical treatment of shoulder PJI. The literature documents interventions including open debridement with component retention or liner exchange, single stage re-implantation comprising removal of all components and immediate re-implantation after thorough debridement and lavage, resection arthroplasty after removal of all components and two-stage re-implantation. The latter involves a first stage that includes removal of all components followed by debridement, and in many cases insertion of an antibiotic impregnated polymethylmethacrylate cement spacer for local antibiotic delivery and to preserve soft tissue tension. The patient is then treated with intravenous (sometimes followed by oral) antibiotics and monitored, typically with serial serologic evaluation, prior to the second surgery (second stage revision) at which time the spacer is removed and new components are re-implanted.

In patients who undergo two-stage re-implantation for shoulder PJI, shoulder joint aspiration or arthrocentesis prior to second stage revision is one method to evaluate for persistent infection after the first stage explantation and subsequent antibiotic treatment. The aspirate can be sent for cultures, leukocyte cell count and differential, and also for analysis of biomarkers such as alpha-defensin. Shoulder aspiration is an established diagnostic tool and is commonly used (although not routinely) as part of the workup of PJI, including shoulder PJI.

However, there is little published information on the use of shoulder aspiration prior to second stage revision. In addition, there is no data documenting an advantage of shoulder aspiration over no aspiration or over any alternative diagnostic tool for shoulder PJI. Sabesan et al. reported that 12 of 17 patients had preoperative aspiration prior to the first stage. re-implantation [1]. Fluid was obtained for culture in 10 and 6 had positive cultures. Prior to the second stage the patients were ruled out for persistent infection with preoperative erythrocyte sedimentation rate, C-reactive protein (CRP), white blood cell (WBC) count and a negative preoperative aspirate. One of the 17 patients had intraoperative frozen section that was positive for acute inflammation and had repeat treatment for infection. Two small case series studies recommend preoperative aspiration prior to considering second stage revision, but only in cases with persistently elevated CRP and WBC [2,3]. Buchalter et al. have described their algorithm for two-stage re-implantation for shoulder PJI but do not mention shoulder aspiration as a factor in their timing of second-stage revision [4]. Patients were offered a second stage reimplantation if they had no clinical signs of infection and their inflammatory markers normalized.

If shoulder joint aspiration is considered in the evaluation for PJI, it is typically recommended to hold antibiotics for at least 14 days prior to aspiration [2,3,5]. It is also important to note that a negative culture of fluid aspirate or dry aspirate is not diagnostic of a resolved infection based on studies that include preoperative shoulder aspirations [5,6].

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QUESTION 5: Is there a role for pre-reimplantation open or arthroscopic tissue biopsy in the evaluation during two-stage exchange of shoulder periprosthetic joint infection (PJI)?

RECOMMENDATION: Unknown. There is one level IV study suggesting that open biopsy prior to second-stage revision for shoulder PJI can identify patients with persistent infection who may benefit from subsequent repeat irrigation and debridement (I&D) prior to second stage reimplantation.

LEVEL OF EVIDENCE: Limited

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

RATIONALE

PubMed and Embase were searched from 1980 to January 2018 to identify studies evaluating preoperative open or arthroscopic tissue biopsy prior to second stage revision shoulder arthroplasty after treatment of shoulder PJI. A secondary search of the references of included studies was also conducted. One article was selected for inclusion. Articles regarding hip and knee arthroplasty were excluded.

Zhang et al. reported a level IV case series in which they performed open biopsy prior to second stage revision for treatment of shoulder PJI [1]. Eighteen patients with shoulder PJI between 2005 and 2012 were included. Patients were treated with a standard protocol involving I&D, removal of implants, antibiotic spacer placement and antibiotic therapy based on culture results for six weeks based on infectious disease service recommendations. At a minimum four weeks after completion of antibiotics, patients were re-evaluated to ensure no clinical symptoms of infection were present and erythrocyte sedimentation rate/ C-reactive protein (ESR/CRP) had normalized. At this point, all patients underwent open biopsy via deltopectoral incision to obtain at least three soft tissue and bone cultures from tissue adjacent to the bone-antibiotic spacer interface. If cultures were negative for 7 to 14 days, patients underwent reimplantation. If cultures were positive, patients instead underwent repeat I&D with antibiotic spacer exchange and the protocol was repeated.

Zhang et al. found that 4 of 18 patients (22%) had positive cultures from the open biopsy indicative of persistent infection with a 38% persistent infection rate for individuals infected with *C. acnes*. One patient had positive cultures again on second open biopsy and underwent a second spacer exchange prior to finally obtaining a negative third biopsy and undergoing reimplantation. *C. acnes* was the most common pathogen, present in 44% of index shoulder PJIs. Among persistent infections, 3 of 4 patients (75%) had *C. acnes*, and the patient requiring two spacer exchanges had *C. acnes* on each occasion. At a mean of 24 month follow-up (range 12 to 36 months), all 18 patients were reimplanted (2 hemiarthroplasty, 1 total shoulder arthroplasty (TSA), 15 reverse total shoulder arthroplasty (RTSA)) and noted to be clinically infection-free with an average American Shoulder and Elbow Surgeons (ASES) score of 71.

This study is limited in its level IV design and small sample size. Furthermore, patients undergoing two-stage revision had variable index procedures from which they developed shoulder PJI, including one open reduction internal fixation (ORIF) proximal humerus fracture, three hemiarthroplasties, six rotator cuff repairs, five TSAs and three RTSAs. There is no comparison group of patients who did not undergo open biopsy, and no comparison to alternative methods such as shoulder aspiration or arthroscopic biopsy.

The role of open or arthroscopic biopsy prior to reimplantation during a two-stage exchange arthroplasty remains unclear.

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