arthroplasty over cefazolin alone, although two studies suggest a trend towards reduced infection [14,15]. Combination therapy may be associated with higher rates of nephrotoxicity than vancomycin alone [14]. However, the value of preventing prosthetic joint infections may still justify its use. Additional study to clarify risks and benefits of these strategies is warranted.

One of the most common causes for use of an alternative perioperative antibiotic other than cefazolin is beta-lactam allergy or intolerance. Most of these patients are not actually allergic and will be able to safely receive cefazolin after evaluation by an allergist [16]. Patients with a true hypersensitivity reaction or adverse reaction that prohibits cefazolin should receive vancomycin or clindamycin in agreement with the Clinical Practice Guidelines for Antimicrobial Prophylaxis in Surgery [4].

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QUESTION 2: What are the optimal perioperative antibiotics for patients undergoing revision shoulder arthroplasty?

RECOMMENDATION: Patients undergoing revision shoulder arthroplasty should receive prophylactic antibiotics as discussed in Question 1. As addressed in Question 5, if there is suspicion for preexisting infection during surgery, consider oral amoxicillin or first-generation cephalosporin (or oral doxycycline if beta-lactam allergic) until cultures are finalized.

LEVEL OF EVIDENCE: Consensus

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

RATIONALE

After a thorough search of the PubMed database for studies evaluating the optimal perioperative antibiotic for patients undergoing revision shoulder arthroplasty, there are no prospective controlled studies comparing surgical antibiotic prophylaxis strategies for revision shoulder arthroplasty that adequately assess clinical outcomes.

Prophylaxis should target organisms most likely to cause prosthetic shoulder infection. The most common organisms to cause shoulder surgical site infection and PJI are coagulase-negative Staphylococcus species, *Cutibacterium acnes* (formerly known as *Proprionibacterium acnes*) and *Staphylococcus aureus* [1–3]. In the setting of revision surgery without an obvious reason for joint failure such as trauma, there may be a question of whether the patient's pain and/or stiffness may be caused by an occult perioperative joint infection (PJI) acquired during a prior case or joint injection. *C. acnes*, in particular, has emerged as a pathogen often cultivated from deep operative specimens in patients undergoing revision for pain and/or stiffness [4].

Unfortunately, inflammatory markers are often normal in these patients, and intraoperative evaluation is often benign-appearing, making it difficult to predict who will ultimately have substantially positive cultures after 14 days of incubation. Thus, surgeons may consider postoperative oral antibiotics to cover the most likely pathogen that may be detected after discharge—*C. acnes*—until cultures are finalized as negative [5]. This is distinctly different from the antibiotic prophylactic strategy for primary shoulder arthroplasty cases, which usually stops when the case concludes, certainly within 24

TABLE 1. Recommended antimicrobial prophylaxis for patients undergoing revision shoulder arthroplasty

Clinical Situation	Antimicrobial Recommended at Surgery (Note: Administer on time as usual, even if concerned about occult infection.)	Postoperative Antimicrobials to Consider if High Intraoperative Suspicion of Infection
No beta-lactam allergy	Cefazolin 2 gm IV (3 gm if patient weighs > 120 kg) starting within 30 minutes prior to incision; re-dose Q 4 hours; postoperative doses not required and should not be given beyond 24 hours.	Amoxicillin 500 mg PO Q 8 H or cefadroxil 500 mg PO BID x 14 days until operative cultures are reported negative. (Adjust for renal insufficiency.)
Personal history of MRSA infection or colonization	In **addition** to cefazolin above, add vancomycin 15 mg/kg (max dose 2 gm) starting within 1 hour prior to incision; postoperative doses are not required and should not be given beyond 24 hours.	Same as above, unless positive intraoperative gram stain or culture positive for MRSA (in which case, convert to treatment program with ID consultation).
Proven, serious beta-lactam allergy	Vancomycin 15 mg/kg (max dose 2 gm) starting within 1 hour prior to incision; postoperative doses are not required and should not be given beyond 24 hours.	Doxycycline 100 mg PO Q 12 H x 14 days until operative cultures are reported negative.

BID, twice daily; MRSA, methicillin-resistant *Staphylococcus aureus*; PO, orally; Q H., every hour

hours post-operatively [6]. Continuing antibiotics postoperatively carries risk of adverse events such as diarrhea, *C. difficile* infection, other side effects, toxicities, development of resistance and drug interactions.

In addition to antimicrobial spectrum, agents selected for prophylaxis should also achieve bactericidal tissue concentration at the time of incision. In the absence of shoulder-specific literature and recognizing the microbiology and other factors, we believe it is reasonable to extrapolate from the non-shoulder arthroplasty literature. The agent most likely to provide optimal tissue concentrations for prophylaxis against these organisms is cefazolin; with dosing based on patient body weight. Vancomycin can be added when patients have a personal history of MRSA colonization or infection, but, ideally, vancomycin should not be given alone. Studies have identified an increased risk of periprosthetic joint infection and surgical site infection, when prophylaxis with an agent other than cefazolin is used [7,8]. One of the most common causes for use of an alternative perioperative antibiotic other than cefazolin is a beta-lactam allergy or intolerance. Most of these patients are not actually allergic and will be able to safely receive cefazolin after evaluation by an allergist or the administration of a test-dose if the prior reaction was felt to be mild. Patients with a true hypersensitivity reaction or adverse reaction that prohibits cefazolin should receive vancomycin or clindamycin in agreement with the Clinical Practice Guidelines for Antimicrobial Prophylaxis in Surgery [9].

Of note, timely administration of intravenous prophylactic antibiotics immediately before incision is unlikely to negatively impact the yield of deep cultures, if they are obtained [10].

Studies measuring microbial burden (primarily *C. acnes*) at the time of incision after surgical antimicrobial prophylaxis in the setting of shoulder surgery have been disappointing [11,12]. One small randomized controlled study comparing preoperative doxycycline administration to placebo did not demonstrate a reduction in *C. acnes* colonization [13]. The relevance of these findings with respect to surgical prophylaxis in the shoulder is not known. Surgical prophylaxis in total joint arthroplasty does reduce the burden of other cutaneous microorganisms and is recommended for all orthopaedic implant surgery [14].

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