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## REVIEW ARTICLE

# Preventing infection in shoulder surgery

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Although rare, infection after shoulder surgery can represent a devastating complication. Infection can negatively affect clinical outcomes, and eradication often requires a protracted treatment course. *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Propionibacterium acnes* are among the most frequently isolated pathogens. Perioperative measures can be implemented to reduce infection risk. Here we review various perioperative practices and their efficacy at reducing infection after shoulder surgery.

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Although a recent study indicated periprosthetic joint infection (PJI) rates after primary total shoulder arthroplasty remained relatively constant between 2002 and 2011 at 0.80% to 1.46%, the number of infections will likely increase as shoulder arthroplasty becomes more commonplace in an aging active population.<sup>37</sup> To mitigate associated health care costs and patient morbidity associated with PJI, it is important for surgeons to analyze methods of shoulder PJI prevention.

At the forefront of this issue is how to lessen the role of *Propionibacterium acnes* (PA) in postoperative shoulder infections. Although the typical *Staphylococcus*, *Streptococcus*, and *Corynebacterium* species that reside on the skin surface are the primary targets of most surgical infection prophylaxis regimens, PA has emerged as a problematic and elusive

bacterium. Thus, PA will occupy a special focus in this review of PJI prevention.

## Epidemiology and characteristics of PA

PA resides within sebum-rich hair follicles. Therefore, it is a unique bacterium when taken in the context of creating a sterile operative field for any surgeon who cuts into skin containing sebaceous glands. Because sebaceous glands are more common around the head, neck, groin, back, and shoulders, PA is not a common pathogen of PJI in hip and knee arthroplasty.<sup>38</sup> In regard to the shoulder, PA bacterial burden is greatest at the anterior and posterior acromion compared with the axilla.<sup>22</sup> Men have a greater burden of PA at the shoulder than women, which corresponds to studies of postoperative PA infections being more common in men.<sup>22,30,38,41</sup> Particular attention to an increased risk of PA contamination needs to be paid to men undergoing shoulder surgery.

Once thought to be a commensal organism of low virulence that was a contaminant of shoulder cultures during

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revision arthroplasty surgery, PA has been established as one of the more common causes of PJI, loosening and pain after shoulder arthroplasty.<sup>41</sup> Rotator cuff repairs are also susceptible to PA infections, with Athwal et al<sup>4</sup> demonstrating PA in 51% of infections after open rotator cuff repair.

Arthroscopic procedures are not immune to PA.<sup>21</sup> Horneff et al<sup>21</sup> recently published the culture findings in 68 patients undergoing revision shoulder arthroscopy for refractory pain and stiffness. Intra-articular tissue cultures were positive for 20 patients. PA was the organism in 16 of these 20 patients. None of the patients exhibited overt signs of infection. The confirmation of PJI diagnosis due to PA can be frustratingly difficult because of its indolent nature, atypical clinical presentation, routinely normal inflammatory markers, and difficulty with culture isolation.<sup>30</sup>

Whether PA is already present within the joint of arthritic shoulders undergoing arthroplasty remains unclear. Levy et al<sup>25</sup> demonstrated in 23 of 55 consecutive patients undergoing primary shoulder joint replacement for arthritis that PA was present in the articular fluid and tissues taken before prosthesis implantation. A possible causal role of PA in the development of arthritis was suggested.

Hudek et al<sup>22</sup> followed with a similar study in 118 patients undergoing first-time open rotator cuff repair, open anterior stabilization, or shoulder arthroplasty. Samples were taken from each level of dissection from superficial to deep. Cultures for 53 patients (45%) were positive for PA.

Mook et al<sup>31</sup> reviewed the culture results taken during an open deltopectoral approach of patients undergoing primary shoulder surgery with no overt signs of infection. In the 82 patients meeting this criteria, 14 (17.1%) had at least 1 positive PA culture.

These studies emphasize the existence of PA in the surgical field during arthroplasty as a major concern, especially given its ability to form biofilms.<sup>8</sup> The methods to reduce the bacterial burden of PA during surgical exposure, prosthesis implantation, and wound closure of shoulder procedures are still unknown; however, recent studies may shed light on how we can approach this complex problem.

## Preoperative measures

### Patient home skin preparation

It is commonplace to recommend that patients about to undergo surgery take a standard soap-and-water shower before they arrive at the hospital or surgery center. Murray et al<sup>32</sup> noted a 3-fold lower colony count for coagulase-negative *Staphylococcus* (CNS), a significant decrease in the rate of positive culture for CNS and *Corynebacterium*, and a significant decrease in overall bacterial burden with combination of a standard soap-and-water shower and chlorhexidine gluconate cloths preoperatively compared with soap-and-water shower alone.<sup>32</sup> Although a significant reduction in PA was not observed between the groups, these

cloths can be recommended for reducing other superficial resident bacteria on the skin.

### Axillary hair

Axillary hair removal has long been proposed as a method for decreasing infection risk in shoulder surgery; however, this practice is not supported by definitive data. In a recent study of 85 healthy male volunteers, cultures were taken from a clipped and a contralateral unclipped axilla in the same volunteer before and after a 2% chlorhexidine gluconate and 70% isopropyl alcohol preparation. There was an increased total bacterial burden of all species in the clipped axilla compared with the unclipped axilla before preparation, which was then negated by the preparation itself.<sup>29,30</sup> Although bacterial burden is not necessarily a reliable predictor of infection, the results led the authors to not recommend routine removal of axillary hair before surgery. In regard to PA, there was no difference in the burden of PA between the axillae after surgical skin preparation. On the basis of this limited data, shaving the axilla of patients undergoing shoulder surgery does not seem necessary, unless the surgeon feels that any hair will interfere with visualization during the procedure.

### Surgical skin preparation

The goal of any skin preparation in the operating theater is to eliminate as much skin surface bacteria as possible that could serve as an inoculum for infection and seeding of deeper tissues. Saltzman et al<sup>43</sup> tested the effectiveness of the three most commonly used surgical skin-preparation agents—ChloraPrep (Becton, Dickinson and Company, Franklin Lakes, NJ, USA), DuraPrep (3M, St. Paul, MN, USA), and povidone-iodine scrub and paint—and their effectiveness in eliminating the major skin surface bacteria of the shoulder. Patients were instructed to shower the day before surgery but not perform any further home preparation.

Skin surface cultures were taken from the first 20 patients before skin preparation to determine the most common native shoulder bacteria. The 3 most isolated organisms in descending order were CNS, *Corynebacterium* spp, and PA. Skin cultures in the next 130 patients were taken only after skin preparation with a randomized agent. The overall positive culture rate in the ChloraPrep group was lower than that in the povidone-iodine group ( $P < .0001$ ) and the DuraPrep group ( $P = .01$ ). DuraPrep and ChloraPrep were equally effective at eliminating CNS and both were more effective than povidone-iodine ( $P < .001$  for both). PA grew from 15% of shoulders after povidone-iodine, 12% of those after DuraPrep, and 7% of those after ChloraPrep. No significant difference was found in the positive PA culture rate for any of the solutions, indicating none of them were significantly more effective at eliminating PA.

We recommend the use of ChloraPrep or a chlorhexidine-based solution for surgical skin preparation. A typical

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