Original Article

Survey of shoulder arthroplasty surgeons' methods for infection avoidance of *Propionibacterium*

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ABSTRACT

Introduction: *Propionibacterium acnes* infection after shoulder arthroplasty remains a source of morbidity. Determining practices amongst shoulder surgeons is the first step in developing infection-prevention best-practices.

Methods: A survey was sent to a shoulder fellowship alumni group to determine their arthroplasty infection prevention methods

Results: 74% completed the survey. Cefazolin (90%), vancomycin (50%) and clindamycin (18%) were the most commonly used antibiotics, 61% utilized more than one antibiotic. Most (76%) reported using an experience-based protocol learned during residency/fellowship.

Discussion and conclusion: There are no clear standards for prevention of *Propionibacterium acnes* infections in shoulder arthroplasty. There is a general non-scientific approach to the prevention of shoulder arthroplasty infection.

1. Introduction

Post-operative infection following shoulder arthroplasty is a rare, but potentially devastating complication.¹ *Propionibacterium acnes* is a gram-positive anaerobic bacillus, once thought to be a contaminant, but now known to be a pathogen frequently responsible for prosthetic shoulder infections.² Despite the common use of preoperative antibiotics and skin preparation, deep contamination with *P. acnes* has been reported.³

The most effective antibiotic for both infection prophylaxis and treatment of active *P. acnes* infections has not been elucidated as previous analysis of *P. acnes* isolates reveal varying degrees of sensitivity to various antibiotics. Koh et al. evaluated intra-operative cultures of *P. acnes* and found that cefazolin minimum inhibitory concentration (MIC) varied from 0.12 µg/mL to 0.32 µg/mL (st dev 0.125).⁴ Alternatively, analysis by Crane et al. found *P. acnes* isolates retrieved from shoulder surgery demonstrated the greatest antimicrobial susceptibility testing to penicillin G, cephalothin and ceftriaxone in terms of lowest MIC value, while several specimens demonstrated active resistance to

clindamycin.⁵ Furthermore, the antimicrobial effect of vancomycin against *P. acnes* in this study was noted as only 'fair'. Overall, the results of this study indicate that penicillins and first-generation cephalosporins (cefazolin and cephalothin) are the most effective perioperative antibiotics against *P. acnes*. The resultant lack of clear antibiotic indications in shoulder arthroplasty results in variable and non-uniform antibiotic *P. acnes* prophylaxis and infection treatment. The purpose of this cross-sectional study was to determine what current antibiotic prophylaxis protocols are employed by fellowship trained shoulder arthroplasty surgeons. Along with questioning these surgeons about their preferred antibiotic use, we also sought to determine other surgical preparation protocols related to shoulder arthroplasty. Given a lack of clear existing standards, we hypothesized that marked variation in *P. acnes* prophylaxis practice exists amongst a cohort of similarly fellowship trained shoulder surgeons.

2. Materials and methods

An on-line survey (Appendix A) was distributed via e-mail invitation

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to all members of a fellowship alumni group, The Codman Shoulder Society which consists of members of Shoulder and Elbow as well as sports medicine fellowships. The survey queried practice demographic descriptive information about the respondents such as years of experience and annual shoulder arthroplasty volume. Questions on their current practice of pre-, post- and intra-operative antibiotic use as well as other factors currently utilized in an effort to decrease post-operative infections after shoulder arthroplasty were included. Lastly, they were questioned regarding factors influencing their current practice regimen. Institutional Review Board protocol was obtained. Mean and mode comparative data with standard deviation was calculated to determine the variance and frequency of selected techniques and antibiotic choices.

3. Results

62 of 84 (74%) members completed the survey. Fifty-three members completed a Shoulder & Elbow fellowship, 19 completed a Sports Medicine fellowship and two completed a Hand fellowship (ten respondents had completed more than one fellowship).

These 62 members demonstrated a similar distribution regarding the number of years in practice (Fig. 1) with the largest group being in their first 1 to 3 years of practice (29%). The distribution regarding number of primary shoulder arthroplasties performed annually (Fig. 2) was also similar amongst groups, with the largest group performing 26 to 50 cases yearly.

Cefazolin (90%), vancomycin (50%) and clindamycin (18%) are the most commonly used parenteral antibiotics given preoperatively, while 61% of respondents utilize more than one preoperative antibiotic. Cefazolin (82%), vancomycin (27%) and clindamycin (16%) are the most common postoperative parenteral antibiotics given with 35% of surgeons utilizing more than one postoperative antibiotic. Intraoperative local antibiotic powder is not used by 59% of surgeons, while 39% apply topical vancomycin powder, and a single surgeon adds gentamycin powder intraoperatively (Fig. 3). Eighty-five percent of surgeons utilize Chloraprep® (BD, Franklin Lakes, NJ) for surgical skin prep, while 8% use DuraPrep™ (3M™St Paul, MN)] and 6% use an Iodine based scrub. Ioban™ (3M™St Paul, MN), an antimicrobial-impregnated adhesive drape, is employed by 81% of surgeons.

When questioned on post-operative infections, 52% of surgeons reported no known infections, while 37% experienced infections with *P. acnes* and 31% *Staphylococcus* species (*S. aureus* or coagulase-negative staphylococcus[CNS]) (Fig. 4). Most surgeons (76%) reported protocol choices are based on recommendations learned from residency and/or fellowship while 56% used an interpretation of available literature and 56% reported personal experience as the rationale for their treatment protocol (Fig. 5).

4. Discussion

Deep periprosthetic infection following shoulder arthroplasty is a

Fig. 1. Graph depicting the years in practice of the survey respondents.

Fig. 2. Graph depicting the number of primary shoulder arthroplasties performed annually by the survey respondents.

Fig. 3. Graph depicting the intra-operative local antibiotic powder use of the survey respondents.

Fig. 4. Graph demonstrating the organisms responsible for the known post-operative infections by the survey respondents.

devastating yet potentially preventable problem.⁶ Patients with periprosthetic infections are typically treated with irrigation and debridement, removal of implants, placement of an antibiotic spacer, implant exchange or even resection arthroplasty¹ as antibiotic treatment alone has an unacceptably high failure rate.⁷

Over the past three decades, shoulder arthroplasty registries indicate an epidemiological shift in the most common pathogen in post-operative infection from *Staphylococcus* species to near equal incidence of *Staphylococcus* and *P. acnes*.⁸ *P. acnes* is part of the normal skin flora and as such is found frequently in the epidermal layer of planned surgical sites in primary shoulder arthroplasty cases, with higher rates in male patients.⁹ Differences in patient factors can also lead to an increase in the likelihood of a post-operative infection due to *P. acnes*. There is also a 2.5 times increase in relative risk in male patients compared to women, also due to the presence of sebaceous follicular glands.^{2,10}

P. acnes is a gram-positive, facultative, anaerobic rod that colonizes human skin, the oral cavity and genitourinary and gastrointestinal

Fig. 5. Graph demonstrating the reasons that the survey respondents utilized to adopt their current perioperative infection prevention protocol.

tracts.¹¹ First isolated in acne vulgaris, it is now recognized as a pathogen due to its virulence factors that allow for tissue degradation, cell adhesion and polysaccharide biofilm formation. The location of the bacteria accounts for the difficulty in typical surgical preparation to eliminate it from the surgical field. *P. acnes* resides in the sebaceous glands and hair bulbs of the dermis, making it out of reach to a topical surgical preparation.¹² This explains why even ChloraPrep® (2% chlorhexidine gluconate and 70% isopropyl alcohol) does not eradicate the bacteria and propionibacteria can have a 70% persistence rate after skin preparation with this solution.¹² Despite this, and due to the effectiveness of ChloraPrep® versus *Staphylococcus*, our respondents showed the highest utilization of ChloraPrep® for their preoperative surgical preparation.

The results to this survey indicate that in a large group of shoulder specialists who perform shoulder arthroplasty, there remains no clear consensus on best practices for avoiding a surgical site infection. Despite current literature available on the treatment of known *P. acnes* infections there remains no clear guidelines on infection prophylaxis. Therefore, our survey participants responded with a wide variety of practices performed to decrease surgical site infections and no consistency was found.

Even in the case of a known active *P. acnes* infection, there remains a clear lack of consensus for the optimal treatment. Some authors recommend 3–6 months of total treatment with at least 2–6 weeks of intravenous beta lactams.¹¹

Penicillin and first-generation cephalosporins (cefazolin and cephalothin) show promise as perioperative antibiotics. Although clindamycin is often utilized as a prophylactic as well as a treatment antibiotic, reports of resistance to this medication have been noted.^{5,13} Despite the evidence of penicillin having strong activity versus *P. acnes*,⁵ our study demonstrated that it is not widely utilized as a perioperative antibiotic. Indeed, none of the respondents recorded utilizing penicillin as a pre- or post-operative antibiotic.

The respondents reported a high rate of additional infection prevention practices. They were questioned specifically about their use of a pre-scrub prior to the surgical preparation, their use of a surgical prep solution, intra-operative use of topical benzoyl peroxide, the use of iodine-impregnated self-adhesive drapes (Ioban™), the use of body-exhaust suits (sterile hoods) and the use of laminar air flow in the operating room. Respondents were also encouraged to write in any other perioperative techniques utilized and a multitude of additional techniques were reported. These additional techniques included the use of

silver-impregnated dressings, changing knife blades after the skin incision, changing gloves multiple times, use of surgical prep again prior to skin closure, use of a wound sleeve so the dermis does not have contact with the surgical field and different types of irrigation throughout the case. This variety of responses again highlights the lack of a clear consensus on surgical site infection prevention amongst shoulder arthroplasty surgeons.

Saltzman et al. performed a prospective study examining the efficacy of three different surgical skin preparation methods in eradicating bacteria from the shoulder.¹⁴ They cultured the skin prior to and following skin preparation and found that ChloraPrep® had the lowest positive culture rates compared to DuraPrep™ and povidone-iodine. They also reported that ChloraPrep® and DuraPrep™ were more effective at eliminating CNS, however there was no difference in eliminating *P. acnes* between the three methods. Matsen et al. also looked at surgical prep for primary shoulder arthroplasty and examined the effects of preoperative antibiotics.³ Specimens were taken from various levels of tissue depth during arthroplasty after preoperative antibiotics consisting of IV ceftriaxone and vancomycin as well as double skin preparation of ChloraPrep®. They found that, despite this regimen, 7/50 specimens were still positive for *P. acnes*. They concluded that skin preparation and preoperative antibiotics cannot reliably eliminate *P. acnes* from the surgical field.

Intra-operative administration of antibiotics was evaluated retrospectively between two groups of patients undergoing shoulder arthroplasty. One group received systemic prophylactic antibiotics and one group received systemic prophylactic antibiotics as well as an intra-articular injection of 160 mg of gentamicin. Deep infection rates were found to be statistically decreased in the group of patients receiving the additional intra-articular antibiotics.¹⁵ Scalpel blades have been studied to determine if it is a safe method to only use one blade during orthopaedic procedures. Three blades each (skin, deep tissue and control) were cultured from 203 procedures. Skin blades were culture-positive 15.3%, deep tissue blades 10.8% and control blades 6.4% of the time despite skin prep with chlorhexidine gluconate 0.5% and industrial methylated spirit 70%. The most commonly isolated organisms were CNS and *Propionibacterium* species.¹⁶ Other authors, however, report a low rate of positive *Propionibacterium* cultures despite a rigorous protocol to collect deep tissue specimens from patients undergoing shoulder arthroplasty. Maccioni et al. demonstrated only 3/32 positive cultures in their series and suggested that different studies with higher rates might represent varying rates of contamination as opposed to true infection. In their series, all patients were administered 2 gm of cefazolin and the surgical site was disinfected with 10% povidone-iodine solution and the use of Ioban™ adhesive drapes.¹⁷ Our participants also routinely used Ioban™ drapes, although povidone-iodine was not widely utilized in those surveyed.

The pathogenesis of deep *P. acnes* infections is thought to be due to the biofilm formation that occurs and deep infections are believed to be underestimated due to the lengthy culture times needed to isolate this organism. Future directions of implants may include antimicrobial coating to decrease the biofilm formation and limit colonization, possibly preventing *P. acnes* infections.¹⁸

4.1. Limitations of study

The primary limitation of this study is its small sample size of those surveyed. By sending our survey to only members of a specific fellowship alumni group, our number of potential surgeons was limited, although we received a high response rate not commonly reached with surveys. We believe this response rate will limit the response bias typically experienced with cross-sectional studies consisting of surveys. Our members were also all trained in-part by the senior author, producing biases in the training they received. Curiously, although the results differed with respect to other techniques used to decrease infection rate, most participants (76%) cited their experiences learned in

residency/fellowship as the reason they chose their perioperative protocol. This likely takes into account the evolving techniques utilized by the senior author.

5. Conclusions

In summary, there are marked variations in practice, consisted with a non-scientific approach to the prevention of shoulder arthroplasty infection, notably with *P. acnes* among shoulder surgeons. This lack of consensus is demonstrated by the variety of infection prevention techniques by a group of shoulder arthroplasty surgeons. Future research is needed to create best practice guidelines that can be adopted to limit post-operative infection after shoulder arthroplasty.

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Ethical approval

All authors were responsible for the original thought and development of this study and/or the production of the manuscript and/or the final editing of the manuscript.

Conflict of interest

None.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jor.2018.01.052>.

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