HK51: What is the optimal surgical protocol for performing debridement, antibiotics, and implant retention **in patients who have an acute periprosthetic joint infection?**

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Response/Recommendation:

Debridement, antibiotics, and implant retention involves meticulous mechanical debridement and chemical debridement with the use of multiple antiseptic agents. Local delivery of antibiotics, whenever possible, combined with extended systemic antibiotics (for 12 weeks) is recommended.

Level of Evidence: Moderate

Delegate Vote:

Rationale:

Debridement, antibiotics, and implant retention (DAIR) represents a viable surgical strategy for treating periprosthetic joint infections (PJI). Addressing the infection while retaining the implants avoids the morbidity associated with revision arthroplasty and is characterized, when successful, by a markedly lower economic burden (1). This surgical approach yields improved outcomes when the patient selection, timing of surgery, pathogen identification, and surgical techniques are optimized (2). DAIR encompasses a variety of surgical options, including radical debridement aimed at achieving a cure and DAIR-like non-radical treatments that focus on suppressing or controlling the infection. The true DAIR procedure involves radical surgical debridement, exchange of modular implant parts, and administration of appropriate antimicrobial therapy, aiming for a microbiological cure. The reported success rate for DAIR has varied markedly, ranging from 33 to 100% (2) (3).

Numerous factors influence the outcome of DAIR, with the correct indications for the procedure being perhaps the most important. However, the indications for DAIR are the subject of another inquiry

(HK48), so we will not delve into this issue further. To answer the above question (HK51), we conducted a comprehensive literature review across two databases (PubMed and Cochrane Library) using the MeSH terms developed by our librarians. After screening the potentially eligible studies, 332 were included for full review and data extraction; ultimately, 97 were selected.

The optimal surgical protocol for performing DAIR was previously discussed and published in the prior compendium of the International Consensus Meeting 2018 (4). The latter emphasizes the importance of thorough and aggressive mechanical debridement of infected tissues, followed by chemical debridement using various antiseptic irrigation solutions (4).
Several authors have suggested creating distinct “clean” and “dirty” operating room setups.
All drapes, surgical instruments, gowns, and gloves should be replaced with clean ones after the debridement and irrigation phases and before the reimplantation of the modular components (5). Multiple authors have also advocated using disclosing agents to guide the debridement of biofilms; in particular, diluted methylene blue has been included in some DAIR protocols (6) (7). A radical synovectomy is strongly recommended, especially when the knee joint is involved. This surgical step should entail the removal of all infected tissue as well as the excision of all hypertrophic intra-articular synovium from the suprapatellar pouch, lateral gutters, and the posterior aspect of the knee (2)(3) (6) (5) (8).
After completing the mechanical debridement, it is recommended to use sterile saline irrigation along with various antiseptic solutions. So far, no consensus has been reached regarding the use of low- or high-pressure lavage systems for delivering irrigation solutions during DAIR procedures (5).
Several antiseptic irrigation solutions have been recommended during DAIR, including povidone-iodine (PI), chlorhexidine gluconate (CHG), acetic acid, hydrogen peroxide, sodium hypochlorite, and many preformulated commercially available combination solutions (9).
Different PI concentrations have been tested against various organisms to determine bactericidal activity in relation to host cells; however, the studies are too varied to conclude on an optimal antiseptic or formulation. A dilute (0.5%) PI sterile formulation is commercially available and was approved by the Food and Drug Administration in 2020 for clinical use. This product has been tested against a range of organisms and has demonstrated a broad spectrum of activity against gram-positive organisms, including MSSA, MRSA, and coagulase-negative *Staphylococcus*, as well as gram-negative bacteria, fungi, and mycobacteria (10).
Also, CHG, at higher concentrations of 2 to 4%, has exhibited broad-spectrum activity (11) (9)(12).
Due to potential cytotoxicity concerns with CHG, further studies are necessary to establish the optimal, non-toxic concentration of CHG. Andriollo et al. (13) suggested using a commercially available acetic acid (AA) solution to treat acute PJIs, as AA has been shown to be effective against both Gram-positive and Gram-negative organisms (14). Hydrogen peroxide at a 3% concentration has demonstrated effectiveness against viruses, bacteria, yeasts, and bacterial spores, exhibiting greater activity against Gram-positive bacteria (15); however, most literature regarding its use pertains to *in vitro* studies. Despite sodium hypochlorite being proposed as an antiseptic, limited *in vitro* and *in vivo* studies focus on its effectiveness against biofilm and in PJI management; this may be due to its short half-life and rapid degradation (16). Commercially available combination solutions, such as propyl-betaine and polyhexanide (PHMB), have previously shown microbicidal activity in chronic wounds and burns. However, their use in the DAIR procedure has not yet been explored (31).
To effectively perform mechanical debridement, the exchange of modular components has been shown to be necessary (5) (11). The role of modular component exchange in DAIR has been addressed in another question (HK52) and will not be discussed here.
Another important issue related to DAIR is the local delivery of antibiotics. A workgroup from the 2018 ICM concluded that there was no evidence to support the beneficial effects of local antimicrobial therapy at that time (17). Recently, multiple authors (18) have provided evidence supporting the local delivery of antibiotics to enhance the efficacy of DAIR as an adjuvant to surgical treatment,

particularly in cases where the pathogen has been identified (6) (19). Despite the lack of randomized trials to define local antibiotics' type and delivery method in DAIR cases, emerging evidence supports its value. A notable improvement in the DAIR success rate was observed in patients who received both local and systemic antibiotics compared to those who received only systemic antibiotics (20) (21). However, there is no consensus on the efficacy of local antibiotics compared to standard therapy.
Another fundamental aspect of managing patients undergoing DAIR relates to postoperative antibiotic therapy. The critical element of antimicrobial treatment relates to isolating the infective organism(s), which may not be known at the time of DAIR, particularly when performed as an emergency procedure.

Systemic antimicrobials are crucial to treating patients undergoing DAIR (22). For culture-negative patients, administration of broad-spectrum antibiotics has been recommended (23). In general, particularly while awaiting culture results, administering broad antibiotic coverage, including vancomycin-based combinations, appears protective against future failures (24). The optimal length of antibiotic therapy following DAIR is also a topic of discussion: 12 weeks have been recommended by several authors as part of the DATIPO trial (25). Antibiotic administration should be parenteral at least during the initial periods (OVIVA trial) (26). Less data are available on the efficacy of shorter durations of postoperative antibiotic therapy: few authors recommend a minimum of six weeks of postoperative antibiotic therapy (27) (28).

In conclusion, based on our experience, the success rate of DAIR is substantially improved when meticulous mechanical and chemical debridement is employed during surgery. The administration of systemic, and whenever possible, local antibiotics is also a crucial part of managing patients undergoing DAIR.

References:

1. Premkumar A, Kolin DA, Farley KX, Wilson JM, McLawhorn AS, Cross MB, et al. Projected Economic Burden of Periprosthetic Joint Infection of the Hip and Knee in the United States. J Arthroplasty. 2021 May;36(5):1484-1489.e3.
2. Longo UG, De Salvatore S, Bandini B, Lalli A, Barillà B, Budhiparama NC, et al. Debridement, antibiotics, and implant retention (DAIR) for the early prosthetic joint infection of total knee and hip arthroplasties: a systematic review. Vol. 9, Journal of ISAKOS. International Society of Arthroscopy Knee Surgery and Orthopaedic Sports Medicine; 2024. p. 62–70.
3. Fontalis A, Yasen AT, Giebaly DE, Luo TD, Magan A, Haddad FS. Cite this article. Bone Joint J. 2024;106(12):1377–84.
4. Argenson JN, Arndt M, Babis G, Battenberg A, Budhiparama N, Catani F, et al. Hip and Knee Section, Treatment, Debridement and Retention of Implant: Proceedings of International Consensus on Orthopedic Infections. J Arthroplasty. 2019 Feb;34(2):S399–419.
5. Deckey DG, Christopher ZK, Bingham JS, Spangehl MJ. Principles of mechanical and chemical debridement with implant retention. Arthroplasty. 2023 Apr 6;5(1):16.
6. Indelli P, Ghirardelli S, Valpiana P, Bini L, Festini M, Iannotti F. Debridement, Antibiotic Pearls, and Retention of the Implant (DAPRI) in the Treatment of Early Periprosthetic Joint Infections: A Consecutive Series. Pathogens. 2023 Apr 16;12(4):605.
7. Shaw JD, Miller S, Plourde A, Shaw DL, Wustrack R, Hansen EN. Methylene Blue–Guided Debridement as an Intraoperative Adjunct for the Surgical Treatment of Periprosthetic Joint Infection. J Arthroplasty. 2017 Dec;32(12):3718–23.

8. Xu Y, Wang L, Xu W. Risk factors affect success rate of debridement, antibiotics and implant retention (DAIR) in periprosthetic joint infection. Arthroplasty. 2020 Dec 7;2(1):37.
9. Siddiqi A, Abdo ZE, Rossman SR, Kelly MA, Piuzzi NS, Higuera CA, et al. What Is the Optimal Irrigation Solution in the Management of Periprosthetic Hip and Knee Joint Infections? J Arthroplasty. 2021 Oct;36(10):3570–83.
10. Goswami K, Austin MS. Intraoperative povidone-iodine irrigation for infection prevention. Arthroplast Today. 2019 Sep;5(3):306–8.
11. Abouljoud MM, Alvand A, Boscainos P, Chen AF, Garcia GA, Gehrke T, et al. Hip and Knee Section, Prevention, Operating Room Environment: Proceedings of International Consensus on Orthopedic Infections. J Arthroplasty. 2019 Feb;34(2):S293–300.
12. George J, Klika AK, Higuera CA. Use of Chlorhexidine Preparations in Total Joint Arthroplasty. J Bone Jt Infect. 2017 Jan 1;2(1):15–22.
13. Andriollo L, Sangaletti R, Velluto C, Perticarini L, Benazzo F, Rossi SMP. Impact of a Novel Antiseptic Lavage Solution on Acute Periprosthetic Joint Infection in Hip and Knee Arthroplasty. J Clin Med. 2024 May 24;13(11):3092.
14. Tsang STJ, Gwynne PJ, Gallagher MP, Simpson AHRW. The biofilm eradication activity of acetic acid in the management of periprosthetic joint infection. Bone Joint Res. 2018 Aug;7(8):517–23.
15. Glynn AA, O'Donnell ST, Molony DC, Sheehan E, McCormack DJ, O'Gara JP. Hydrogen peroxide induced repression of *icaADBC* transcription and biofilm development in *Staphylococcus epidermidis*. Journal of Orthopaedic Research. 2009 May 22;27(5):627–30.
16. Ernest EP, Machi AS, Karolcik BA, LaSala PR, Dietz MJ. Topical adjuvants incompletely remove adherent *Staphylococcus aureus* from implant materials. Journal of Orthopaedic Research. 2018 Jun 30;36(6):1599–604.
17. Aswathanarayan JB, Rao P, HM S, GS S, Rai RV. Biofilm-Associated Infections in Chronic Wounds and Their Management. In 2022. p. 55–75.
18. Steadman W, Chapman PR, Schuetz M, Schmutz B, Trampuz A, Tetsworth K. Local Antibiotic Delivery Options in Prosthetic Joint Infection. Antibiotics. 2023 Apr 14;12(4):752.
19. Vicenti G, Pesare E, Colasuonno G, Buono C, Albano F, Ladogana T, et al. Debridement, Antibiotic Pearls, and Retention of the Implant (DAPRI) in the Treatment of Early Periprosthetic Knee Joint Infections: A Literature Review. Healthcare. 2024 Apr 16;12(8):843.
20. Reinisch K, Schläppi M, Meier C, Wahl P. Local antibiotic treatment with calcium sulfate as carrier material improves the outcome of debridement, antibiotics, and implant retention procedures for periprosthetic joint infections after hip arthroplasty – a retrospective study. J Bone Jt Infect. 2022 Jan 20;7(1):11–21.
21. Jarusriwanna A, Mu W, Parvizi J. Local Antibiotic Infusion in Periprosthetic Joint Infection Following Total Hip Arthroplasty. J Clin Med. 2024 Aug 16;13(16):4848.
22. Tai DBG, Berbari EF, Suh GA, Lahr BD, Abdel MP, Tande AJ. Truth in DAIR: Duration of Therapy and the Use of Quinolone/Rifampin-Based Regimens After Debridement and Implant Retention for Periprosthetic Joint Infections. Open Forum Infect Dis. 2022 Sep 2;9(9).
23. Le Vavasseur B, Zeller V. Antibiotic Therapy for Prosthetic Joint Infections: An Overview. Antibiotics. 2022 Apr 5;11(4):486.
24. Baghdadi JD, Goodman KE, Magder LS, Claeys KC, Sutherland ME, Harris AD. Association between Delayed Broad-Spectrum Gram-negative Antibiotics and Clinical Outcomes: How Much Does Getting It Right with Empiric Antibiotics Matter? Clinical Infectious Diseases. 2025 Jan 28;
25. Bernard L, Arvieux C, Brunschweiler B, Touchais S, Ansart S, Bru JP, et al. Antibiotic Therapy for 6 or 12 Weeks for Prosthetic Joint Infection. New England Journal of Medicine. 2021 May 27;384(21):1991–2001.

26. Li HK, Rombach I, Zambellas R, Walker AS, McNally MA, Atkins BL, et al. Oral versus Intravenous Antibiotics for Bone and Joint Infection. New England Journal of Medicine. 2019 Jan 31;380(5):425–36.
27. Lora-Tamayo J, Mancheño-Losa M, Meléndez-Carmona MÁ, Hernández-Jiménez P, Benito N, Murillo O. Appropriate Duration of Antimicrobial Treatment for Prosthetic Joint Infections: A Narrative Review. Antibiotics. 2024 Mar 23;13(4):293.
28. Osmon DR, Berbari EF, Berendt AR, Lew D, Zimmerli W, Steckelberg JM, et al. Diagnosis and Management of Prosthetic Joint Infection: Clinical Practice Guidelines by the Infectious Diseases Society of Americaa. Clinical Infectious Diseases. 2013 Jan 1;56(1):e1–25.