In conclusion, DAIR is a viable option and a reasonable first therapeutic approach for patients with early postoperative and acute hematogenous infections. However, some studies have reported a high failure rate of this surgical treatment and a relatively high early mortality rates after DAIR for acute hematogenous infections compared to acute postoperative infections. These differences might be related to differences in the pathoetiology of these infections and the influence of the intrinsic host factors on the outcome. Therefore, studies focusing on improving treatment outcomes after acute hematogenous infections are desperately needed.

REFERENCES

[1] Parvizi J, Gehrke T, International Consensus Group on Periprosthetic Joint Infection. Definition of periprosthetic joint infection. J Arthroplasty. 2014;29:1331. doi:10.1016/j.arth.2014.03.009.

[2] Cook JL, Scott RD, Long WJ. Late hematogenous infections after total knee arthroplasty: experience with 3013 consecutive total knees. J Knee Surg. 2007;20:27–33.

[3] Haasper C, Buttaro M, Hozack W, Aboltins CA, Borens O, Callaghan JJ, et al. Irrigation and debridement. J Arthroplasty. 2014;29:100–103. doi:10.1016/j.arth.2013.09.043.

[4] 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 America. Clin Infect Dis. 2013;56:e1–e25. doi:10.1093/cid/cis803.

[5] Son WS, Shon OJ, Lee DC, Park SJ, Yang HS. Efficacy of open debridement and polyethylene exchange in strictly selected patients with infection after total knee arthroplasty. Knee Surg Relat Res. 2017;29:172–179. doi:10.5792/ksrr.16.040.

[6] Rodríguez D, Pigrau C, Euba G, Cobo J, García-Lechuz J, Palomino J, et al. Acute hematogenous prosthetic joint infection: prospective evaluation of medical and surgical management. Clin Microbiol Infect. 2010;16:1789–1795. doi:10.1111/j.1469-0691.2010.03157.x.

[7] Fink B, Schuster P, Schwenninger C, Frommelt L, Oremek D. A standardized regimen for the treatment of acute postoperative infections and acute hematogenous infections associated Wwth hip and knee arthroplasties. J Arthroplasty. 2017;32:1255–1261. doi:10.1016/j.arth.2016.10.011.

[8] Bryan AJ, Abdel MP, Sanders TL, Fitzgerald SF, Hanssen AD, Berry DJ. Irrigation and debridement with component retention for acute infection after hip arthroplasty: improved results with contemporary management. J Bone Joint Surg Am. 2017;99:2011–2018. doi:10.2106/JBJS.16.01103.

[9] Triantafyllopoulos GK, Soranoglou V, Memtsoudis SG, Poultsides LA. Implant retention after acute and hematogenous periprosthetic hip and knee infections: whom, when and how? World J Orthop. 2016;7:546–552. doi:10.5312/wjo.v7.i9.546.

[10] Buller LT, Sabry FY, Easton RW, Klika AK, Barsoum WK. The preoperative prediction of success following irrigation and debridement with polyethylene exchange for hip and knee prosthetic joint infections. J Arthroplasty. 2012;27:857-864.e1-4. doi:10.1016/j.arth.2012.01.003.

[11] Volpin A, Sukeik M, Alazzawi S, Haddad FS. Aggressive early debridement in treatment of acute periprosthetic joint infections after hip and knee replacements. Open Orthop J. 2016;10:669–678. doi:10.2174/1874325001610010669.

[12] Tsang S-TJ, Ting J, Simpson AHRW, Gaston P. Outcomes following debridement, antibiotics and implant retention in the management of periprosthetic infections of the hip: a review of cohort studies. Bone Joint J. 2017;99-B:1458–66. doi:10.1302/0301-620X.99B11.BJJ-2017-0088.R1.

[13] Martínez-Pastor JC, Maculé-Beneyto F, Suso-Vergara S. Acute infection in total knee arthroplasty: diagnosis and treatment. Open Orthop J. 2013;7:197–204. doi:10.2174/1874325001307010197.

[14] Sendi P, Banderet F, Graber P, Zimmerli W. Clinical comparison between exogenous and hematogenous periprosthetic joint infections caused by Staphylococcus aureus. Clin Microbiol Infect. 2011;17:1098–1100. doi:10.1111/j.1469-0691.2011.03510.x.

[15] Konigsberg BS, Della Valle CJ, Ting NT, Qiu F, Sporer SM. Acute hematogenous infection following total hip and knee arthroplasty. J Arthroplasty. 2014;29:469–472. doi:10.1016/j.arth.2013.07.021.

Authors: Antony Rapisarda, Tae-Kyun Kim, Salvador Rivero-Boschert

QUESTION 2: Should operative treatment differ in patients with systemic sepsis in the setting of periprosthetic joint infection (PJI)?

RECOMMENDATION: Yes. Patients with systemic sepsis in the setting of PJI should have surgical bioburden reduction, either with implant retention or resection of components (if indicated and safe), along with concurrent anti-microbial therapy. Reimplantation should be delayed until sepsis is resolved.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 79%, Disagree: 19%, Abstain: 2% (Super Majority, Strong Consensus)

RATIONALE

Infection of total joint arthroplasty is a known and devastating complication all surgeons seek to avoid. Despite best efforts, prosthetic joints can be seeded from local and systemic sources [1–9]. Although PJI usually presents without systemic signs of pyrexia, chills and other symptoms, occasional PJI may result in systemic sepsis when the blood culture may also be positive for infection. In the context of systemic sepsis, hematogenous spread is the definitive mechanism by which PJI develops in previously well patients. Orthopaedic infections appear to be caused by the same common group of bacterial pathogens. In this group, the majority are gram-positive cocci, namely, *Staphylococcus aureus* and *Staphylococcus epidermidis*. There is the ever-present threat of methicillin-resistant *Staphylococcus aureus* (MRSA) as a difficult PJI infection to remove. Moreover, the growing number of vancomycin-resistant enterococcus and other serious gram-negative bacteria are also a concern. Gram-negative bacteria are associated with more severe episodes of sepsis due to the production and release of lipopolysaccharides (endotoxin).

Highlighted across several studies is the concept of the arthroplasty surface acting as a unique microbial substratum [10]. Gallo et al. reported the affinity of *S. epidermidis* to attach to polyethylene surfaces as opposed to *S. aureus* preference for bare metal. In each of the papers examined by Gallo et al. the presence of biofilm on the wearing or corroded surfaces of the implants was a key factor in the bacterial resistance to host and antimicrobial attack. A paper referenced in the Gallo et al. review by Gristina [11], characterised the colonization of the prosthesis as a "race for the surface" [10]. This concept is apt at highlighting the need for pathogens to colonize, undeterred by local and host factors.

These concepts are of pivotal importance when examining the published material reviewed here in the context of the original question, "to evaluate whether operative treatment should differ in patients with systemic sepsis in the setting of prosthetic joint infection." As demonstrated in this review and supported by the significant cohort size, PJI can occur as a consequence of local or hematogenous colonization. Overall, severity of infection is higher with hematogenous spread [12–14], as is the difficulty in clearing the infection for subsequent implant revision. Osteomyelitis prior to implantation of prosthetic joints indicates increased risk as

reported by Jerry et al. [4]. The nearly 5-fold increase in recurrence rates seen in patients with prior bone infection serves as a significant warning to surgeons to adequately debride as much contaminated surface as is feasible to allow for control of infection and subsequent implantation.

Based on the articles included in this review, there is no evidence to suggest that the implantation of prosthetic joints during an episode of sepsis is advisable. Often, however, joint arthroplasty procedures will need to be performed to alleviate the tremendous pain associated with infective destruction of a joint surface. Each of the included studies recommended a staged approach to surgical management of PJI with the most common approach being two-staged revision. There is very limited evidence to support retention of implants if a curative outcome is the main objective of the treatment. Also, there is a lack of evidence to suggest initiating antibiotic therapy to counter the systemic sepsis before the first-stage revision surgery. Though, identification and eradication of clinically obvious secondary foci, like indwelling catheters and skin, soft tissue, respiratory and genito-urinary infections, could be of vital importance for controlling the PJIs and preventing subsequent relapse. Therefore, like PJIs without systemic sepsis, a combination of effective debridement and concurrent intravenous antimicrobial therapy is the current best practice standard of care. The main limitation associated with the effective execution of this thorough and proven care strategy seems to be the accurate diagnosis of the complete clearance of infection to restore *aseptic* status to the patient.

It must be noted, as of the completion of this review, there are no studies that directly evaluate whether operative treatment should differ in patients with systemic sepsis in the setting of PJI. There are a number of closely related papers quoted above, but that is the limit of current knowledge. It is, however, our opinion that patients with systemic sepsis exhibiting constitutional symptoms are at serious risk and should be treated urgently. The best option of treatment is bioburden reduction which involves extensive soft tissue debridement and removal of infected prostheses.

REFERENCES

[1] Wigren A, Karlstrom G, Kaufer H. Hematogenous infection of total joint implants: a report of multiple joint infections in three patients. Clin Orthop Relat Res. 1980:288–291.
[2] Cherney DL, Amstutz HC. Total hip replacement in the previously septic hip. J Bone Joint Surg Am. 1983;65:1256–1265.
[3] Southwood RT, Rice JL, McDonald PJ, Hakendorf PH, Rozenbilds MA. Infection in experimental hip arthroplasties. J Bone Joint Surg Br. 1985;67:229–231.
[4] Jerry GJ, Rand JA, Ilstrup D. Old sepsis prior to total knee arthroplasty. Clin Orthop Relat Res. 1988;236:135-140.
[5] Luessenhop CP, Higgins LD, Brause BD, Ranawat CS. Multiple prosthetic infections after total joint arthroplasty. Risk factor analysis. J Arthroplasty. 1996;11:862–868.
[6] Takwale VJ, Wright ED, Bates J, Edge AJ. Pasteurella multocida infection of a total hip arthroplasty following cat scratch. J Infect. 1997;34:263–264.
[7] David TS, Vrahas MS. Perioperative lower urinary tract infections and deep sepsis in patients undergoing total joint arthroplasty. J Am Acad Orthop Surg. 2000;8:66–74.
[8] Murdoch DR, Roberts SA, Fowler VG, Shah MA, Taylor SL, Morris AJ, et al. Infection of orthopedic prostheses after Staphylococcus aureus bacteremia. Clin Infect Dis. 2001;32:647–649. doi:10.1086/318704.
[9] Lee GC, Pagnano MW, Hanssen AD. Total knee arthroplasty after prior bone or joint sepsis about the knee. Clin Orthop Relat Res. 2002;404:226-231.
[10] Gallo J, Kolár M, Novotný R, Riháková P, Tichá V. Pathogenesis of prosthesis-related infection. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2003;147:27–35.
[11] Gristina AG, Naylor PT, Myrvik QN. Musculoskeletal infection, microbial adhesion, and antibiotic resistance. Infect Dis Clin North Am. 1990;4:391–408.
[12] Sendi P, Banderet F, Graber P, Zimmerli W. Periprosthetic joint infection following Staphylococcus aureus bacteremia. J Infect. 2011;63:17–22. doi:10.1016/j.jinf.2011.05.005.
[13] Vilchez F, Martínez-Pastor JC, García-Ramiro S, Bori G, Tornero E, García E, et al. Efficacy of debridement in hematogenous and early post-surgical prosthetic joint infections. Int J Artif Organs. 2011;34:863–869. doi:10.5301/ijao.5000029.
[14] Tande AJ, Palraj BR, Osmon DR, Berbari EF, Baddour LM, Lohse CM, et al. Clinical presentation, risk factors, and outcomes of hematogenous prosthetic joint infection in patients with Staphylococcus aureus Bacteremia. Am J Med. 2016;129:221.e11-e20. doi:10.1016/j.amjmed.2015.09.006.

Authors: Ali Oliashirazi, James J. Purtill, Brianna Fram

QUESTION 3: What should be done for patients with persistent wound drainage (PWD) after total joint arthroplasty? What are the indications for surgical intervention?

RECOMMENDATION: Management of draining wounds after total hip arthroplasty (THA) or total knee arthroplasty (TKA) consists of two main steps; nonoperative and operative. The nonoperative measures include: modification of venous thromboembolism (VTE) prophylaxis, nutritional supplementation, dressing measures (such as negative pressure wound therapy (NPWT)) and restriction of range of motion. If draining continues for more than seven days after implementing the nonoperative measures, operative interventions may be indicated – including irrigation and debridement, synovectomy and single-stage exchange. In certain situations, superficial wound washout may be indicated (Fig. 1).

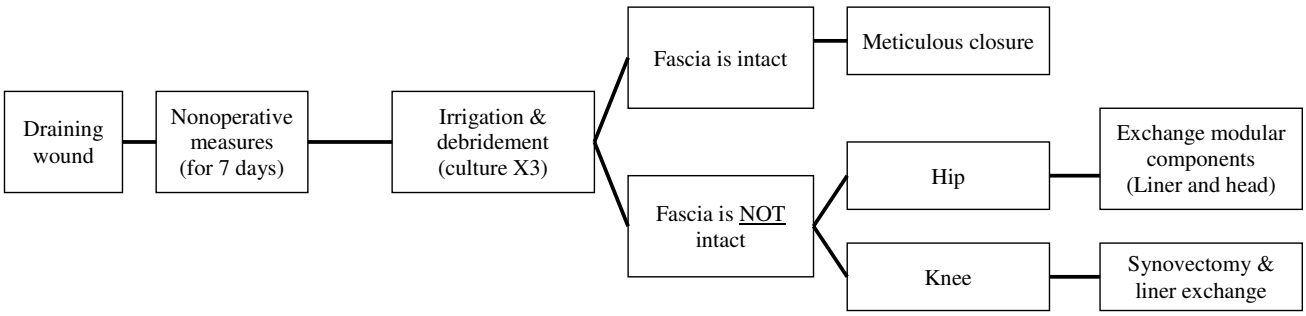

Figure 1. Management of draining wounds after total joint arthroplasty.