HK 48: What patients are candidates for Debridement, implant retention, and antibiotic administration (DAIR)?

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Response/Recommendation: In general, all patients with acute onset of infection and with a stable prosthesis are candidates for DAIR. However, the expected infection eradication rate greatly depends on several patient and infection characteristics. The following patients are considered good candidates for DAIR:

- Infection within six weeks of the index arthroplasty
- Infection with an onset symptom of < seven days
- Well-fixed and stable implants.
- Exceptions may apply

Level of Evidence: Strong

Delegate Vote:

Rationale:

Debridement, implant retention, and antibiotic administration (DAIR) have shown favorable outcomes in selected patient populations, and their efficacy is limited by several factors, including the timing of intervention, patient comorbidities, microbiological burden, and surgical complexity. Recent advances, such as predictive scoring systems and machine learning algorithms, have provided new tools to improve risk stratification and guide decision-making. Despite these developments, the criteria for selecting appropriate candidates for DAIR remain complex and require a nuanced understanding of the interplay between host-, procedural-, and pathogen-specific variables.

Timing Relative to Symptom Duration

A shorter symptom duration before intervention was associated with improved DAIR outcomes. Patients treated within two days of symptom onset achieved an infection control rate of 89%, whereas those treated between three and seven days had a success rate of 59.5% [1]. When the mean duration from symptom onset to debridement was < seven days, the pooled success rate was 71.6%. Conversely, when this interval was extended beyond three weeks, the success rate dropped to 35%, a statistically significant decline ($P < 0.05$) [2]. This is echoed in multiple studies using different cut-off points; the duration of symptoms (> 10 days) was identified as an independent risk factor for failure, with an 8.5-fold increase in the hazard of failure compared to patients treated earlier ($P = 0.016$) [3-6]. Additionally, logistic regression revealed that each additional day of symptoms decreased the odds of success by 7.5%[7]. If symptoms persisted for > four weeks, patients were 2.35 times more likely to fail than those who had a symptom duration of < one week [8-11].

Timing Relative to Index Arthroplasty

The interval between index surgery and DAIR also plays a major role in success rates. Infections managed within 14 days of surgery showed lower reinfection rates (24.3%) than those treated between 46 and 90 days (45.8%)[12,13]. While there was no significant difference in outcomes when DAIR was performed within 28 versus 42 days postoperatively (85 versus

88%), delays beyond 90 days led to a marked decline in success rates (60%)[14]. Failures peaked in week seven (23%), but remained significantly high from week one to six. However, delaying DAIR beyond six weeks from the index procedure increased the failure rates [15]. When comparing early and late infections, success rates were significantly higher for early interventions. DAIR conducted within four weeks of the primary surgery had an 8% revision rate compared with 13% for procedures performed between four and 12 weeks [16]. Chronic infections (> three months from surgery) were associated with poorer outcomes, with success rates dropping to 45% regardless of symptom duration[17,18,6]. When combined The median time from the index surgery to DAIR was shorter in successful cases than in failures. However, the median interval from symptom onset to surgery remained similar between groups, emphasizing the importance of both parameters in determining outcomes [19,20]

Demographic Factors

Age was a significant factor in DAIR outcomes. Patients aged ≥ 85 years have a 391% increased risk of reinfection compared to those aged 65 to 69 years ($P < 0.001$) [13,12]. However, in some studies, age was not found to be a statistically significant factor for DAIR success [21,22]. Men have also been identified as a predictor of failure in several analyses[23-25]. The heterogeneity of the different comorbidity scoring indices used makes comparisons among these studies difficult. Patients who have higher CCI scores (≥ four) had similar failure rates (64%) to those who have scores of 1 to 3 (67%) [22]. Rheumatoid arthritis (RA) is a significant independent risk factor for failure, with hazard ratios ranging from 2.20 to 45.1 in various studies [23,26-28]. Conditions such as ischemic heart disease, chronic obstructive pulmonary disease (COPD), and chronic kidney disease (CKD) also predict poor outcomes[23,29,25,30-32]. Obesity, particularly morbid obesity, is an important predictor of treatment failure. Morbidly obese patients experienced significantly higher failure rates (57.9%) compared to non-obese patients (36.8%), with a hazard ratio (HR) of 2.77 ($P = 0.035$) [33]. Smoking is also associated with increased failure rates, particularly in early acute infections.[34]. Psychiatric conditions, such as major depressive disorder (MDD) and generalized anxiety disorder (GAD), have been identified as contributors to failure [34,24]. The use of immunosuppressive medications is a strong independent predictor of DAIR failure (odds ratio [OR], 0.13) [35,36]. Patients who underwent arthroplasty for non-osteoarthritis indications (e.g., inflammatory arthritis or hip fractures) had significantly higher failure rates[23,37,38].

Preoperative C-Reactive Protein (CRP)

CRP is a well-established marker of inflammation and infection, and its levels are consistently correlated with DAIR outcomes. Patients who have failed DAIR had significantly higher CRP levels at presentation than those who had successful outcomes. In one study, the mean CRP was 162.5 mg/L in the failure group and 105.5 mg/L in the success group ($P < 0.001$) [39,40]. Another study identified a CRP cut-off of 65 mg/L, where 68.9% of patients who have CRP > 65 mg/L failed treatment compared to 43.6% with CRP ≤ 65 mg/L ($P < 0.0002$) [39,40]. Higher CRP thresholds further exacerbated the risk of failure. A preoperative CRP level >100 mg/L was independently associated with failure ($P = 0.001$), and logistic regression showed that each unit increase in CRP level increased the odds of failure (OR 1.01, $P < 001$) [41,42,10,32,43]. However, some evidence suggests variability in the predictive value of CRP. In certain cases, preoperative CRP levels did not significantly correlate with DAIR success, suggesting that CRP alone may not always predict outcomes[44,19].

Erythrocyte Sedimentation Rate (ESR)

The role of ESR in predicting DAIR outcomes was less consistent than that of CRP level. In some studies, a higher preoperative ESR was associated with failure. Patients who have an ESR > 40 mm/hour were 4.7 times more likely to fail DAIR than those who have an ESR < 40 mm/hour [45]. Similarly, mean ESR levels were significantly higher in the failure groups (103.5 mm/hr) than in the success groups (69.1 mm/hour) [46]. However, in other analyses, ESR was not significantly associated with the DAIR outcomes [39,40,19]. The variability in findings may stem from differences in the study populations and ESR thresholds used for the analysis. Bacteremia at the time of DAIR was associated with a significantly lower success rate (31%) compared to those who did not have bacteremia (65%)[47,36]. Late acute and hematogenous infections were also associated with worse outcomes than early postoperative infections. Late acute PJI had an OR of 4.52 for failure, with bacteremia further worsening the success rates in these cases [36,26]. In patients who have acute hematogenous PJI, treatment success rates were significantly lower in those who have positive blood cultures (36.3%) than in those who have negative cultures (66.7%, $P = 0.047$) [48,49]. Bacteremia was particularly detrimental in late acute infections, where it was associated with worse outcomes compared to early acute infections (31% success versus 65%, OR 4.1) [5]. Furthermore, patients who have sepsis had lower treatment success rates (51%) than those who do not have sepsis (67%)[50].

Combined Consideration of Markers

Combining inflammatory markers with blood culture results provides a comprehensive assessment. Elevated CRP, ESR, and bacteremia collectively increase the likelihood of DAIR failure. For instance, in one study, patients who have a CRP > 22 mg/dL and positive blood cultures exhibited significantly higher failure rates.[51]. The use of CRP and ESR ratios has also been explored to differentiate between types of infections. For chronic postoperative reinfections, ESR demonstrated a sensitivity of 75% and a specificity of 84% at a cutoff of 1.31 [52]. The efficacy here is mild to moderate discrimination at best based on the AUC; these parameters are useful adjuncts, but no single variable is perfect in predicting the outcome.

Scoring Systems

The KLIC scoring system integrates factors such as CRP level, time from arthroplasty to debridement, and comorbidities to predict DAIR outcomes. A one-point increase in the KLIC score corresponds to a 1.32 to 1.45 times higher risk of failure[10,11]. Patients who have scores < 3.5 had high success probabilities, while scores > 6 were associated with significant failure rates (e.g., >85% failure for scores > 7)[32,11,53]. For example, a KLIC score of 3.5 had an AUC of 0.762, with a sensitivity of 77% and a specificity of 57% [54,53]. Patients who have scores of > 7 had a 100% failure rate [53]. Adjusting thresholds for clinical applicability revealed that scores < 4 had failure rates of 27.9%, while scores > 7 had failure rates exceeding 85%[32]. Similarly, the CRIME80 scoring system, which incorporates variables such as CRP, comorbidities, and infection chronicity, demonstrated a failure rate of 67.9% for scores ≥ 3 compared with 35.8% for scores < 3 ($P < 0.0001$) [54]. However, as with the KLIC score, its predictive accuracy diminishes in intermediate-risk categories, highlighting the need for further refinement of these models. Patients who have low scores (e.g., KLIC < 3.5 or CRIME80 < 3) are likely to achieve success with DAIR, allowing for more confident recommendations for conservative management. High-risk scores (for example, KLIC > 6 or CRIME80 ≥ 3) highlight the need for alternative strategies, such as staged revisions, particularly when comorbidities or elevated inflammatory markers are present.

Machine Learning Predictive Algorithms for DAIR Outcomes

In a cohort of 556 patients, the algorithm predicted failure risk with varying degrees of success. Among patients categorized as low risk (< 30% failure probability), only 21.8% failed DAIR.

For those in the intermediate-risk category (30 to 50% failure probability), 37.6% experienced failure. However, patients classified as high risk (> 50% failure probability) had a failure rate of 62.5%, underscoring the model's capacity to stratify patients effectively [23]. In a cohort of 64 patients, the overall success rate was 60.9%; most cases exhibited success probabilities between 40 and 80%, suggesting the moderate utility of the model in predicting outcomes [55]. The application of Shohat's scoring system to the same cohort yielded an AUC of 0.69, indicating moderate predictive ability. Using a 50% cut-off value, the score achieved a sensitivity of 82%, a specificity of 44%, and a negative predictive value of 0.611. This result supports Shohat's system as an adjunct for predicting DAIR success [55]. However, the limitations of these systems must be acknowledged. In some cohorts, AUCs for these models ranged from 0.6 to 0.8, reflecting moderate discrimination [56,53]. Furthermore, sensitivity and specificity are often suboptimal in intermediate categories, which reduces their clinical precision in such cases [11,53].

Revision TKA

Recent advancements in machine learning have enhanced the ability to predict outcomes following revision total knee arthroplasty (TKA) for PJI. Neural network models demonstrated the highest predictive accuracy, with AUC values ranging from 0.81 to 0.84, indicating excellent discrimination[57]. Previous irrigation and debridement with or without modular component exchange and > four open surgeries were the strongest predictors of failure[6,58]. Comorbidities, such as obesity, renal failure, diabetes, metastatic disease, and depression, significantly increase the risk of recurrent infection. The success of revision TKA in the context of PJI is influenced by the surgical approach chosen. For patients who have extensive instrumentation, success rates were similar between irrigation and debridement with chronic suppression (62.5%) and two-stage revision (67.7%)[59]. However, long-term infection-free survival favored two-stage revision, with a 5-year infection-free survival rate of 75% compared with 16% for DAIR or extended DAIR (P = 0.006). [60]. Megaprostheses, pose additional challenges in the management of PJI. There was one study focusing on DAIR in non-oncological femoral megaprostheses that reported a success rate of 64.3% with a minimum follow-up of five years[61]. However, these results must be interpreted cautiously as the study did not account for other patient or procedural factors. Extended DAIR procedures in megaprostheses, which involve removing all components except the stems, have been explored as an alternative to complete revision. While these approaches preserve some structural integrity, their long-term efficacy remains limited, with Kaplan-Meier analysis showing a 5-year infection-free survival rate of 16%[60]. This highlights the critical need for improved strategies to manage infections in patients who have megaprostheses.

Debridement, antibiotics, and implant retention (DAIR) remain valuable limb- and implant-preserving options for managing periprosthetic joint infections (PJI) in appropriately selected patients. Critical factors influencing DAIR success include the timing of intervention relative to symptom onset and index surgery, patient demographics, comorbidities, inflammatory markers, bacteremia, and the use of predictive scoring systems. These factors should be considered when evaluating which patients are candidates for DAIR.

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