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Periprosthetic joint infection following hip hemiarthroplasty

FACTORS ASSOCIATED WITH INFECTION AND TREATMENT OUTCOME

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Aims

The aims of this study were to determine the incidence and factors for developing periprosthetic joint infection (PJI) following hemiarthroplasty (HA) for hip fracture, and to evaluate treatment outcome and identify factors associated with treatment outcome.

Methods

A retrospective review was performed of consecutive patients treated for HA PJI at a tertiary referral centre with a mean 4.5 years' follow-up (1.6 weeks to 12.9 years). Surgeries performed included debridement, antibiotics, and implant retention (DAIR) and single-stage revision. The effect of different factors on developing infection and treatment outcome was determined.

Results

A total of 1,984 HAs were performed during the study period, and 44 sustained a PJI (2.2%). Multiple logistic regression analysis revealed that a higher CCI score (odds ratio (OR) 1.56 (95% confidence interval (CI) 1.117 to 2.187); p = 0.003), peripheral vascular disease (OR 11.34 (95% CI 1.897 to 67.810); p = 0.008), cerebrovascular disease (OR 65.32 (95% CI 22.783 to 187.278); p < 0.001), diabetes (OR 4.82 (95% CI 1.903 to 12.218); p < 0.001), moderate-to-severe renal disease (OR 5.84 (95% CI 1.116 to 30.589); p = 0.037), cancer without metastasis (OR 6.42 (95% CI 1.643 to 25.006); p = 0.007), and metastatic solid tumour (OR 15.64 (95% CI 1.499 to 163.087); p = 0.022) were associated with increasing PJI risk. Upon final follow-up, 17 patients (38.6%) failed initial treatment and required further surgery for HA PJI. One-year mortality was 22.7%. Factors associated with treatment outcome included lower preoperative Hgb level (97.9 g/l (SD 11.4) vs 107.0 g/l (SD 16.1); p = 0.009), elevated CRP level (99.1 mg/l (SD 63.4) vs 56.6 mg/l (SD 47.1); p = 0.030), and type of surgery. There was lower chance of success with DAIR (42.3%) compared to revision HA (66.7%) or revision with conversion to total hip arthroplasty (100%). Early-onset PJI (≤ six weeks) was associated with a higher likelihood of treatment failure (OR 3.5 (95% CI 1.2 to 10.6); p = 0.007) along with patients treated by a non-arthroplasty surgeon (OR 2.5 (95% CI 1.2 to 5.3); p = 0.014).

Conclusion

HA PJI initially treated with DAIR is associated with poor chances of success and its value is limited. We strongly recommend consideration of a single-stage revision arthroplasty with cemented components.

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Introduction

Hip fracture is a growing socioeconomic problem putting an increasing burden on healthcare systems.[1] In frail, low-demand patients, the majority of intracapsular fractures are treated with hemiarthroplasty (HA).[2] Despite advances in hip fracture care pathways and rigorous infection prevention

Table I. Baseline patient characteristics at time of hip fracture.

Variable	Entire cohort (n = 1,984)	No PJI (n = 1,940)	PJI (n = 44)	p-value
Mean age, yrs (SD)	82.06 (9.6)	82.1 (9.6)	78.5 (8.6)	0.003*
Sex, n (%)				0.901†
Female	1,290 (65)	1,261 (65)	29 (65.9)	
Male	694 (35)	679 (35)	15 (34.1)	
Mean BMI, kg/m² (SD)	25.6 (5.4)	25.1 (4.89)	27.3 (6.59)	0.099*
Mean CCI (SD)	1.29 (1.93)	1.28 (1.93)	1.86 (1.90)	0.006*
Myocardial infarction, n (%)	27 (1.3)	26 (1.0)	1 (2.2)	0.598†
Congestive heart failure, n (%)	85 (4.2)	83 (4.2)	2 (4.5)	0.931†
Peripheral vascular disease, n (%)	18 (0.9)	15 (0.7)	3 (6.8)	< 0.001†
Cerebrovascular disease	39 (2.0)	24 (1.2)	15 (34)	< 0.001†
Dementia, n (%)	264 (13.3)	259 (13.3)	5 (11.3)	0.701†
Chronic obstructive pulmonary disease, n (%)	81 (4.0)	77 (3.9)	4 (9.1)	0.090†
Rheumatic disease, n (%)	8 (0.4)	8 (0.4)	0 (0)	0.670†
Peptic ulcer disease, n (%)	9 (0.4)	8 (0.4)	1 (2.2)	0.069†
Mild liver disease, n (%)	16 (0.8)	15 (0.7)	1 (2.2)	0.271†
Diabetes, n (%)	192 (9.6)	182 (9.3)	10 (22.7)	0.003†
Hemiplegia or paraplegia, n (%)	8 (0.4)	8 (0.4)	0 (0)	0.670†
Moderate to severe renal disease, n (%)	83 (4.1)	77 (3.9)	5 (11.3)	0.015†
Diabetes with chronic complications, n (%)	213 (10.7)	208 (10.7)	5 (11.3)	0.892†
Cancer without metastasis, n (%)	100 (5.0)	95 (4.8)	5 (11.3)	0.053†
Moderate-to-severe liver disease, n (%)	5 (0.2)	4 (0.2)	1 (2.2)	0.007†
Metastatic solid tumour, n (%)	44 (2.2)	39 (2.0)	5 (11.3)	< 0.001†
AIDS, n (%)	3 (0.1)	3 (0.1)	0 (0)	0.794†
ASA grade, n (%)				0.947†
≤ 2	174 (8.8)	170 (8.8)	4 (9.1)	
>2	1,801 (90.8)	1,761 (90.7)	40 (90.9)	
Mean pre-Hgb, g/l (SD)	122.4 (16.8)	122.5 (16.8)	117.9 (17.4)	0.087*

*Mann-Whitney U test.
†Chi-squared test.
ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index; PJI, periprosthetic joint infection; SD, standard deviation.

protocols, incidence rates of periprosthetic joint infection (PJI) following HA vary between 1.7% and 7.3%.[3] For these patients, who have a reduced physiological reserve and are already in a catabolic state following injury and surgery,[4] a PJI is a devastating complication with an associated one-year mortality rate of up to 50%.[5]

There currently exists no evidence-based treatment algorithm for managing HA PJI. Current standards of treatment share principles outlined by the International Consensus Meeting[6] that relate to PJI following elective total hip arthroplasty (THA). With evidence suggesting differences in epidemiology, clinical features, and outcome exist between patients who undergo elective THA and HA for hip fracture,[7,8] these may in part explain why debridement, antibiotic therapy, and implant retention (DAIR) has much lower chances of success with a HA (21% to 82%),[7-11] compared to elective THA (72.2%).[12]

The aims of this study were to determine the incidence and risk factors for developing PJI among patients who had a HA for hip fracture at our centre, evaluate the treatment outcome of HA PJI, and identify factors associated with treatment outcome.

Methods

Study design. This is an institutional review board-approved retrospective consecutive case series of patients who underwent a primary HA for hip fracture at an academic, tertiary referral hospital between January 2010 and June 2021. The hospital's database served to identify patients with a minimum of one-year follow-up. Any HA performed for the treatment of failed osteosynthesis was excluded.

Study participants and data collection. A total of 1,984 patients received a HA for hip fracture during the study period. Of these, 44 were diagnosed with a PJI using established criteria,[6] and formed the sub-cohort of interest. Index patient demographic characteristics were collected and are presented in Table I. These include age, sex, BMI, medical comorbidities and pre-injury physical status as recorded according to the Charlson Comorbidity Index (CCI)[13] and American Society of Anesthesiologists (ASA) grade,[14] respectively, and preoperative haemoglobin

Table II. Perioperative characteristics and surgical strategy used for the initial treatment of patients with a hemiarthroplasty periprosthetic joint infection.

Variable	Value
Mean preoperative serology, value (SD)	
Hgb, g/l	103.45 (15.0)
WBC, g/l	9.84 (4.12)
Creatinine, umol/l	112.07 (91.4)
ESR, mm/hr	73.42 (57.4)
CRP, mg/l	55.63 (29.7)
Time to infection, n (%)	
≤ 6 wks	25 (56.8)
> 6 wks	19 (43.2)
Type of surgery, n (%)	
DAIR	26 (59.1)
Revision arthroplasty	18 (40.9)
Single-stage revision hemiarthroplasty	6 (13.6)
Single-stage revision to THA	12 (27.3)
Surgery performed by arthroplasty surgeon, n (%)	28 (63.6)
Microbiology, n (%)	
Gram-positive	22 (50.0)
Gram-negative	3 (6.8)
Polymicrobial	11 (25.0)
No growth	8 (18.2)

ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index; SD, standard deviation; THA, total hip arthroplasty.

Table III. Multivariate analysis results for risk factors for developing periprosthetic joint infection following hip hemiarthroplasty.

Risk factor	Odds ratio (95% CI)	p-value*
Age, yrs	0.99 (0.955 to 1.026)	0.568
Preoperative haemoglobin, g/l	0.99 (0.975 to 1.016)	0.631
CCI	1.59 (1.117 to 2.187)	0.003
Peripheral vascular disease	11.34 (1.897 to 67.810)	0.008
Peptic ulcer disease	2.31 (0.076 to 70.307)	0.631
Cerebrovascular disease	65.32 (22.783 to 187.278)	< 0.001
Diabetes	4.82 (1.903 to 12.218)	< 0.001
Moderate to severe renal disease	5.84 (1.116 to 30.589)	0.037
Moderate to severe liver disease	3.92 (0.004 to 3,733.323)	0.696
Cancer without metastasis	6.41 (1.643 to 25.006)	0.007
Metastatic solid tumour	15.64 (1.499 to 163.087)	0.022

*Multiple logistic regression.
CCI, Charlson Comorbidity Index; CI, confidence interval.

level. Date of PJI surgery was recorded along with preoperative diagnostic serum test results, as well as surgery and microbiology characteristics (Table II). Patients were grouped into those who underwent surgical treatment of PJI within six weeks following HA (i.e. early-onset PJI) and those treated later. This timeframe was chosen as DAIR has previously been shown to be a valuable option in the treatment of hip PJI in the early postoperative period (≤ six weeks).[15]

Surgical strategy. Initial surgery for PJI was carried out by 17 orthopaedic surgeons, of whom eight were arthroplasty fellowship-trained. Patient and surgical details are provided in Table II. The median time interval between HA and PJI surgery was 5.5 weeks (interquartile range 3.643 to 7.357). Type of surgery employed was left to the discretion of the treating surgeon and is therefore a reflection of each surgeon's skillset and perspective while accounting for patient characteristic and infection chronicity. Type of surgery performed included DAIR or revision arthroplasty; no excision arthroplasty was performed. All HAs had modular heads (no monobloc implants). DAIR was performed in 26 cases (26/44; 59.1%). Extensive debridement without exchange of bipolar head was performed in three patients, while the femoral head was exchanged in the remaining cases. Revision arthroplasty consisted of either a single-stage revision HA (exchange of femoral implant, n = 6; 13.6%) or revision arthroplasty with conversion to THA (n = 12; 27.3%) (Figure 1). Revision to THA consisted of cementing a polyethylene liner in the acetabulum and exchange of the femoral implant unless an uncemented stem was deemed to have a sound (i.e. not compromised) interface with the proximal femur, in which case only the femoral head was exchanged (3/15; 20%).

Microbiology. Multiple tissue samples were obtained early in the operation to minimize risk of contamination. Once samples were obtained, broad spectrum intravenous antibiotics were administered, unless tailored antibiotic therapy was available based on the results of preoperative synovial fluid cultures. Choice and duration of targeted antibiotic therapy was decided in consultation with infectious disease specialists and our pharmacist upon final culture and sensitivity results. All microbiological samples were cultured for a minimum of five to seven days. However, in cases of suspected PJI due to low virulence organism(s), or negative preoperative cultures, cultures were maintained from 14 to 21 days, as per international recommendations.[16,17]

Outcome measure. Treatment success was defined as infection control at a minimum of 12 months, with or without suppressive antibiotics. Treatment failure was defined as the need for any further surgical procedure due to: persistence of infection characterized by a persistent wound drainage or infection recurrence caused by the same organism strain; implant-related problems; or PJI-related death. This multidimensional definition was used as it reflects the Delphi-based international multidisciplinary consensus definition.[18] Cause of death and infection status for deceased patients was established from hospital records at the time of death. In-hospital, postoperative medical complications were recorded. Medical complications included urinary tract infection, deep vein thromboembolism, pulmonary embolism, myocardial infarction, and pneumonia.

Statistical analysis. Data were summarized using descriptive statistics including count and percentages for categorical variables. Non-parametric tests were used

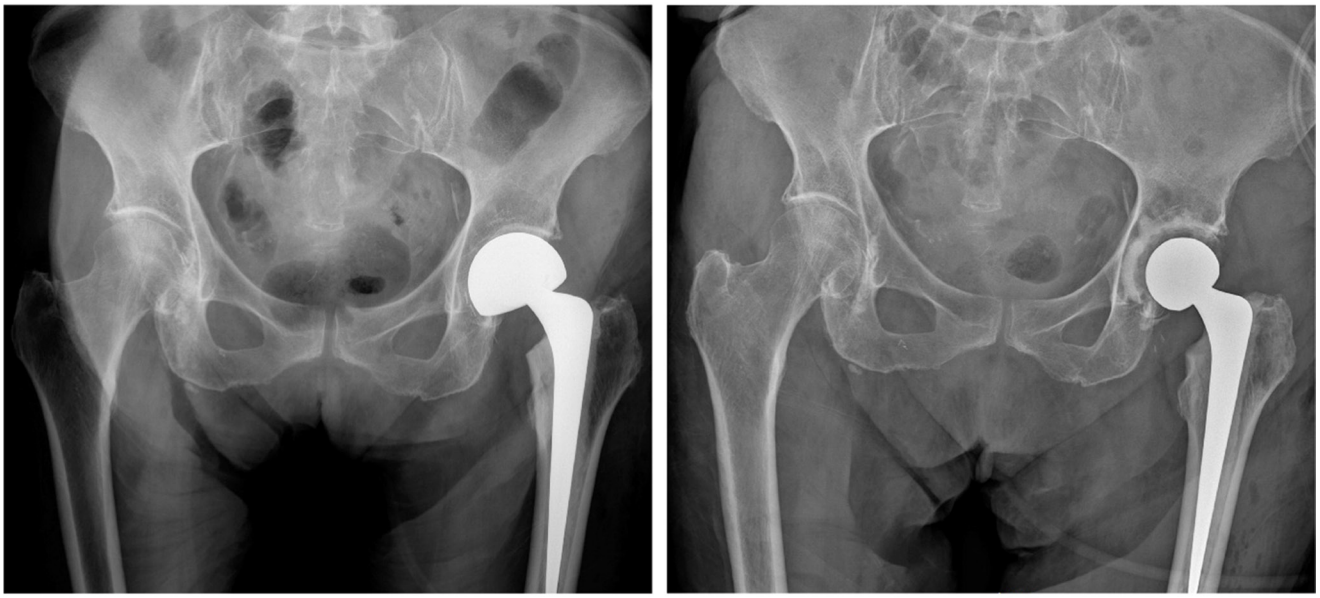

Fig. 1

Preoperative (left) and postoperative (right) anteroposterior radiographs of a 76-year-old female patient who underwent a single-stage revision arthroplasty with conversion to total hip arthroplsaty for a left early-onset hemiarthroplasty periprosthetic joint infection. Postoperative radiograph demonstrates a cemented acetabular polyethylene liner and revised cement femoral implant.

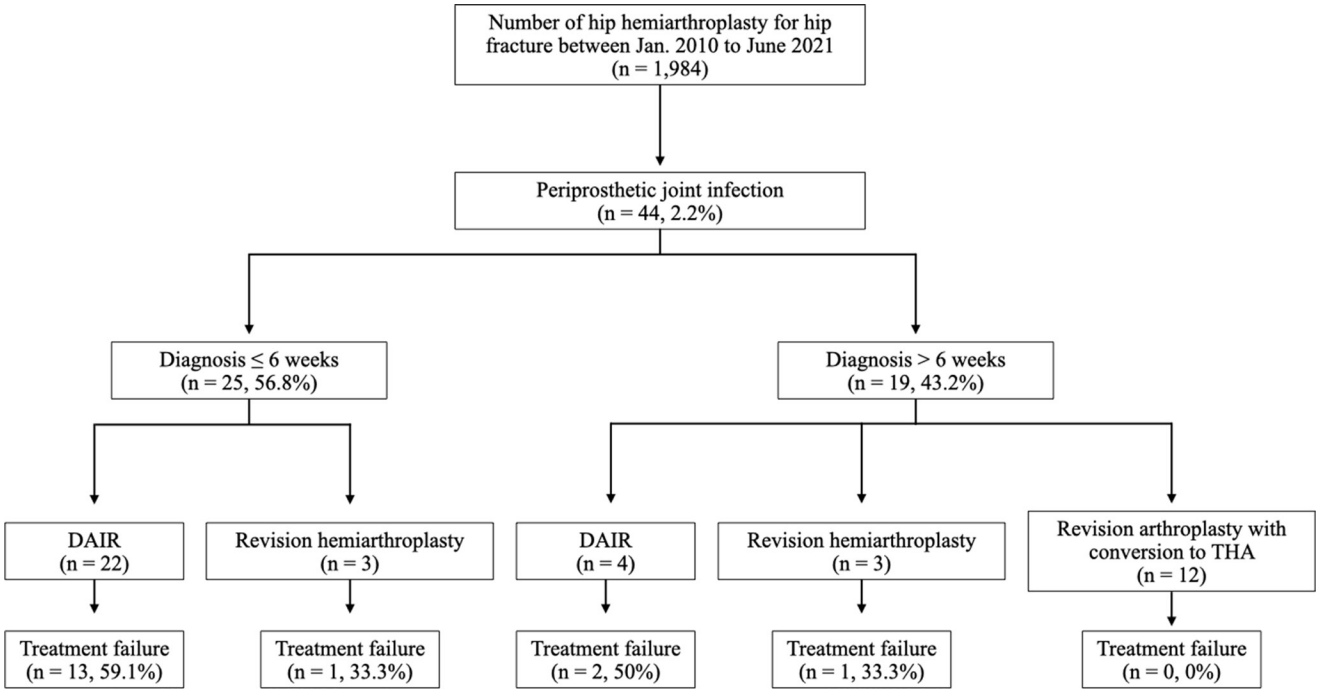

Fig. 2

Flow diagram illustrating the management of primary hip hemiarthroplasty periprosthetic joint infection relative to time of presentation and the associated treatment outcomes thereafter. DAIR, debridement, antibiotics, and implant retention; THA, total hip arthroplasty.

for analyses. Mann-Whitney U test was used for scale data. Chi-squared and Fisher's exact tests were used for categorical variable analysis. Univariate analysis was performed to identify factors associated with PJI. Factors with a trend to significance ($p \leq 0.100$) were entered in the multivariable (binary logistic) regression model to identify factors associated with risk of developing a PJI. Univariate analyses were performed to identify factors associated with improved chances of success following treatment. A p-value of < 0.05 was considered significant.

Table IV. Differences in perioperative outcomes between surgical strategies used for initial treatment of hemiarthroplasty periprosthetic joint injection.

Type of surgery	n	Treatment failure, n (%)	Perioperative complications, n (%)	Death within one year, n (%)
DAIR	26	15 (57.7)	2 (7.7)	6 (23.1)
Single-stage revision hemiarthroplasty	6	2 (33.3)	2 (33.3)	3 (50)
Single-stage revision to THA	12	0 (0)	2 (16.7)	1 (8.3)

DAIR, debridement, antibiotics, and implant retention; THA, total hip arthroplasty.

All analysis was performed using SPSS for Mac 9 v. 27 (IBM, USA).

Results

Incidence and factors associated with HA PJI. The cumulative incidence of HA PJI was 2.2% (Figure 2). Factors entered into the multivariate regression analysis and complete results are presented in Table III. Multiple logistic regression analysis revealed that a higher CCI aggregated score, peripheral vascular disease, cerebrovascular disease, diabetes, moderate to severe renal disease, cancer without metastasis, and metastatic solid tumour were associated with increasing PJI risk following HA for hip fracture.

Outcome for treatment of HA PJI. At a mean follow-up of 4.5 years (standard deviation (SD) 4.2; range 1.6 weeks to 12.9 years), 17 patients (17/44; 38.6%) failed initial PJI treatment and required further surgery (Table IV). The mean time between the first and second PJI surgery was 3.6 weeks (SD 3.4). Six patients (6/44; 13.6%) required ≥ three surgeries. Upon final follow-up, 16 patients (16/44; 36.4%) had died; of these patients, 22.2% (10/44) died within the year that followed their PJI, at a mean 14.7 weeks. One patient died from postoperative respiratory-related complications during hospitalization. Treatment failure was not found to be associated with mortality (odds ratio (OR) 0.767 (95% CI 0.325 to 1.808); p = 0.534, chi-squared test).

The causative microorganism(s) was retrieved for all cases, and in most cases were single gram-positive microorganisms (22/44; 50%). Coagulase-negative *Staphylococcus* (CoNS) was the most prevalent causative microorganism (11/44; 25%), followed by *Staphylococcus aureus* (7/44; 15.9%). Only three patients (6.8%) grew a single gram-negative microorganism; five patients (11.4%) had polymicrobial infections; 13 patients (13/44; 29.5%) received lifelong suppressive antibiotics. There was no significant difference in use of suppressive antibiotic relative to type of initial surgery (p = 0.914, chi-squared test).

Factors associated with treatment outcomes of HA PJI. Several factors were associated with PJI treatment outcome (Table V). Lower preoperative haemoglobin level (97.9 g/l (SD 11.4) vs 107.0 g/l (SD 16.1); p = 0.009, Mann-Whitney U test) and elevated preoperative CRP levels (99.1 mg/l (SD 63.4) vs 56.6 mg/l (SD 47.1)) were associated with failure of treatment (p = 0.030, Mann-Whitney U test). Early-onset PJI (≤ six weeks) was associated with a higher likelihood of treatment failure (OR 3.5 (95% CI 1.2 to 10.6); p = 0.007, chi-squared test). Patients treated by a non-arthroplasty surgeon were more likely to fail treatment (OR 2.5 (95% CI 1.2 to 5.3); p = 0.014, chi-squared test). Type of surgery was also associated with outcome; there was a lower chance of success with DAIR (11/26; 42.3%) compared to revision HA (4/6; 66.7%) or single-stage revision to THA (12/12; 100%). Most of the DAIRs were performed for early-onset PJI (22/26; 84.6%), while most single-stage revision arthroplasty surgeries were performed for PJI that presented later (15/18; 83.3%; p < 0.001, chi-squared test). Surgeon expertise was not associated with outcome of DAIR (p = 0.530, chi-squared test). There was no statistical difference between causative microorganism profile and time to infection (p = 0.164). Type of causative microorganism was not associated with risk of treatment failure (p = 0.274, chi-squared test). Use of suppressive antibiotics was not associated with outcome (p = 0.914, chi-squared test).

Discussion

PJI continues to be a feared complication following hip arthroplasty. At our institution, the incidence of PJI following primary THA is approximately 0.7%,[19] in line with national reports.[20] However, our incidence of HA PJI is 2.2%. This higher incidence is believed to reflect inherent differences in patient populations.[7,8] This study expands current knowledge by identifying patient factors associated with developing infection in the HA population. Such pertinent information may perhaps help identify risk factors that can be targeted preoperatively to mitigate PJI risk and perhaps eventually help in developing a scoring system to predict risk of PJI after hip fracture.

Current standards of treatment for HA PJI follow treatment principles developed for elective, primary THA PJI.[6] Based on these guidelines, DAIR is often the treatment of choice since it is associated with less morbidity and therefore is perhaps more appropriate for this frail patient population. However, the results of this study, and others alike,[7–11,21,22] challenge this perception given the inferior treatment success rates of DAIR for HA PJI, which range from 22% to 82% (Table VI). In our study, DAIR was the most common treatment modality used (59%). However, these patients only showed a

Table V. Outcome of surgical treatment for hemiarthroplasty periprosthetic joint infection.

	Outcome		
Factor	**Success**	**Failure**	**p-value**
Total, n	27	17	
Age, yrs	77.7 (8.2)	79.7 (9.4)	0.473*
Sex, n (%)			0.241†
Male	11	4	
Female	16	13	
Mean BMI, kg/m^2 (SD)	26.5 (5.5)	28.6 (8.0)	0.454*
Mean CCI (SD)	5.9 (2.5)	5.3 (1.7)	0.613*
Mean ASA grade (SD)	3.3 (0.8)	3.2 (0.6)	0.392*
Mean serology values (SD)			
Pre-Hgb, g/l	107.0 (16.1)	97.9 (11.4)	0.094†
Pre-WBC, g/l	9.2 (3.6)	10.8 (4.8)	0.193†
Pre-creatinine, umol/l	131.7 (109.8)	80.9 (34.8)	0.242†
Pre-ESR, mm/hr	53.9 (30.9)	58.2 (28.4)	0.471†
Pre-CRP, mg/l	56.6 (47.1)	99.1 (63.4)	0.030†
Fixation, n			0.583†
Cemented	12	9	
Uncemented	15	8	
Time to infection, n			0.007†
Within 6 wks	11	14	
More than 6 wks	16	3	
Type of surgery, n			0.003†
DAIR	11	15	
Revision hemiarthroplasty	4	2	
Conversion to THA	12	0	
Type of surgeon, n			0.014†
Nonarthroplasty	6	10	
Arthroplasty	21	7	
Organism profile, n			0.274†
Gram-positive	14	8	
Gram negative	3	0	
Polymicrobial	7	4	
Culture positive	3	5	
Suppressive antibiotics, n	8	5	0.914†

*Mann-Whitney U test.
†Chi-squared test.
ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index; DAIR, debridement, antibiotics, and implant retention; SD, standard deviation; THA, total hip arthroplasty; WBC, white blood cells.

treatment success rate of 42.3%. Whether a DAIR was performed by an arthroplasty surgeon did not influence outcome. These results are disappointing since DAIR was performed largely for PJIs that developed within six weeks of index HA, a timeframe shown to favour DAIR outcome.[15] While studies have attributed these inferior outcomes to this population's reduced physiological reserve and differences in causative microorganisms,[7,8] this study emphasizes the influence of surgical factors. The factor that showed the greatest association with treatment success was initial surgical strategy employed. The success rate of revision arthroplasty was noticeably better than DAIR (88.9%), despite being performed for more chronic and established infections. Moreover, no treatment failure was reported in patients who underwent revision arthroplasty with conversion to THA. These more comprehensive single-stage revisions were invariably performed by arthroplasty surgeons, but these patients also had higher preoperative haemoglobin level and less of an elevated inflammatory response.[7,8] Perhaps HA PJI should be managed by surgeons skilled in arthroplasty as they would be more likely to employ the optimal surgical strategy: single-stage revision arthroplasty with conversion to THA.

Craxford et al[9] reported on patients who underwent surgical treatment (43 DAIR, seven excision arthroplasty) for surgical site infection following HA. They showed that stem exchange was not associated with improved treatment success. The authors recommended that for frail patients who fail initial DAIR, or are infected by an unfavorable microorganism, an excision arthroplasty should be performed. Despite being an established surgical strategy for PJI, an excision arthroplasty in frail elderly patients is not without significant implications. These patients are often compromised hosts and may not have the physical or psychological capacity to tolerate the functional disadvantage from excision arthroplasty or the surgical burden of a staged revision arthroplasty. In fact, Vincenten et al[24] compared patients following an excision arthroplasty for hip PJI to a normative population with respect to health status and quality of life. They showed that patents with excision arthroplasty have significantly lower health status and quality of life, even lower than patients with a lower limb amputation or a myocardial infarction. While there will always be reluctance to entertain a single-stage revision arthroplasty in frail patients, this study did not show increased postoperative morbidity or mortality at a minimum of one-year follow-up.

The findings of this study suggest that performing a revision arthroplasty with conversion to THA should be strongly considered as the initial treatment for HA PJI. The premise behind this approach is to thoroughly debride additional nidus of infection that cannot be appropriately addressed with DAIR.[25] Reaming the acetabular cartilage allows surgeons to curette any subchondral cysts and debride any infection that may have seeded itself deep to the cartilage or into the subchondral bone. Without a complete eradication, an infection will persist and gradually cause permanent joint damage, chronic osteomyelitis, and risk bacterial dissemination.[26] Following bacterial seeding, bacterial products initiate the inflammatory cascade.[27] The subsequent influx of cytokines induces a cascade of events that is responsible for the pathogenesis thought to contribute to destruction of cartilage and joint erosion,[28] a process shown to occur within three days of infection.[27] In addition, recent studies have discovered bacterial colonization of the osteocyte-lacuno canalicular network, a reservoir for bacteria which unquestionably plays an important

Table VI. Comparison of current literature examining outcomes following debridement, antibiotic, and implant retention in hip hemiarthroplasty.

Studies	Patients	Surgical strategies	Outcomes	Risk factors
Craxford et al, 2021[9]	51 patients were diagnosed with a deep SSI and 18 were treated for a superficial SSI	43 with DAIR with or without stem exchange, and 7 with excision arthroplasty	DAIR had a success rate of 20.93%; the all-cause mortality at one year after deep SSI was 55.87% vs 24.9% without deep infection	Gram-negative organism reduced success rates to 12.5%; MRSA and *Pseudomonas* had a poor outcome, with 100% mortality at one year despite implant removal; no DAIR was successful if performed over 32 days from the index procedure
Yassin et al, 2020[10]	26 patients with early PJI after HA for hip fracture	23 patients underwent DAIR and 3 proceeded directly to excision arthroplasty	DAIR was successful in 3 patients (13%) after a single procedure, with success in 2 additional patients after a second procedure; overall success rate of 22%	Not studied
de Vries et al, 2018[21]	23 out of 1,457 patients (1.6%) after hip fracture surgery (HA or THA)	DAIR was performed in 20 (87.0%) patients and exchange arthroplasty performed in 3 (13%) patients	Revision surgery was performed in 34.8% of patients after hip fracture surgery (HA and THA) within 1 year after PJI	Not studied
Mellner et al, 2017[22]	33 out of 736 patients (4.5%) developed an early (< 6 weeks) PJI following hip arthroplasty (THA or HA) for neck of femur fracture	28 patients were treated with DAIR	DAIR eradicated the PJI in 82% (23/28) of patients; there were no systematic differences between those who sustained a PJI and those who did not regarding type of arthroplasty	≥ 2 dressing changes due to wound bleeding was associated with an increase risk of developing PJI (OR 4.9 (95% CI 1.5 to 16.1))
Bergkvist et al, 2016[11]	35 patients who developed early-onset postoperative PJI	All patients treated with DAIR; 8 patients had a HA	DAIR treatment success rate of 25% for HA	Hip fracture patients had an increased risk of failure compared to osteoarthritis patients (OR 8.3)
Kazimoglu et al, 2015[23]	49 of 1,082 patients (4.5%) with acute onset PJI (diagnosed < 3 months after implantation)	39 patients were treated with DAIR with prosthesis retention	Overall success rate was 41%	Sedimentation rate over 60 mm/h and the longer duration (2 weeks) after prosthesis implantation were found as factors negatively influencing the success rate
del Toro et al, 2014[8]	127 patients with periprosthetic hip infection were included (43 hip HA, 84 THA)	31 (72.1%) of patients with a hip HA were treated debridement with prosthesis retention	Failure of initial treatment and crude mortality were more frequent among hip HA patients (44% vs 23%, and 28% vs 7%, respectively)	Inadequate surgical management, prosthesis retention, and higher CRP level
Lora-Tamayo et al, 2013[7]	210 patients with periprosthetic hip infection: 62 (39%) hip HA and 148 (61%) THA	51 patients (82%) with a HA were managed with a DAIR	Overall failure was 37%, with no significant differences among groups; a higher mortality was observed in patients managed with a HA (21% vs 4%, particularly in cemented-HA	Not studied

CI, confidence interval; DAIR, debridement, antibiotic, and implant retention; HA, hemiarthroplasty; MRSA, methicillin-resistant *Staphylococcus aureus*; OR, odds ratio; PJI, periprosthetic joint infection; SSI, surgical site infection; THA, total hip arthroplasty.

role in development of osteomyelitis.[26,29] For these reasons, a single-stage revision arthroplasty with conversion to THA is now the preferred practice at our institution for HA PJI. Cementing a polyethylene liner and femoral stem using antibiotic-loaded bone cement (ABLC) may provide the best opportunity to eradicate the sequestered infection at the bone-implant interface, while lowering the risk of reoperation.[30] The authors believe that resection arthroplasty should be reserved as a salvage procedure for persistent PJI and not considered before all other options are exhausted. We acknowledge that further studies are necessary to better understand the phenomena contributing to the pathophysiology governing treatment success. The recent development of a clinically representative in vivo rat model of a cemented hip HA PJI may provide an opportunity to investigate the pathogenesis of biofilm invasion and evolving concepts of bone infection.[31] Conceivably, such a model can improve our understanding of PJI and help elucidate the most effective surgery to eradicate infection. Furthermore, level I data are required to determine if there are any short- and long-term functional advantages to single-stage revision arthroplasty as an initial treatment option for HA PJI.

This study is not without limitations. First, this study is a retrospective review of prospectively collected data with relatively small numbers and suffers from all associated biases, including selection bias. Accordingly, the small cohort size may have likely prevented us from identifying additional factors associated with developing infection and treatment outcome. However, given the low incidence of HA PJI, retrospective observational studies serve as the best evidence currently available. Second, the institutional approach described in this study no longer reflects current practice at our hospital. We now have a dedicated PJI service with a multidisciplinary team, serviced by four arthroplasty surgeons with an interest in PJI. Despite this, the current study reflects pragmatic circumstances that portray current practice for many centres. Whether this paradigm shift to managing PJI by a dedicated multidisciplinary team with arthroplasty surgeons improves outcomes is a subject for future study. Third, the concept of treatment success in this patient population is not clearly defined, and perhaps

should differ from what otherwise constitutes treatment success and may not always equate to being infection-free.

The incidence of HA PJI at our institution was 2.2% during the study period. HA PJI is a feared complication associated with considerably morbidity and mortality. DAIR is associated with poor chances of success and its value is limited. We strongly recommend single-stage revision arthroplasty with cemented components. Further prospective multicentre studies are required to provide high-level evidence.

Take home message

- There currently exists no evidence-based treatment algorithm for managing hemiarthroplasty periprosthetic joint infection.
- Debridement, antibiotics, and implant retention with exchange of modular components is associated with poor chances of success and its value is limited.
- This study shows that single-stage revision arthroplasty with conversion to total hip arthroplasty with cemented components may provide the best opportunity to eradicate the infection.

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