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Original Research

Hospital Financial Burden of Surgical Procedures for Periprosthetic Total Hip Arthroplasty Infection

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ABSTRACT

Background: For reimbursement purposes, current coding fails to reflect the true complexity and resource utilization of hospital encounters for surgeries performed to treat periprosthetic total hip arthroplasty (THA) infection. Therefore, when compared to aseptic revisions, we sought to determine (1) Is length of stay (LOS) longer for septic surgeries? (2) Are septic procedures more expensive? and (3) How do different surgical procedures for infection compare with aseptic revisions on hospital LOS and charges?

Methods: Retrospective chart review of 596 unilateral THA reoperations (473 patients) performed at a single institution (January 2015 to November 2020). Demographics, professional (ie, physicians), and technical (ie, room, implants) hospital charges per case were compared between 6 different surgery types: (1) aseptic revision (control; n = 364); (2) debridement, antibiotics, and implant retention (n = 11); (3) explantation (n = 145); (4) spacer exchange (n = 7); (5) 2-stage reimplantation (n = 59); and (6) 1-stage reimplantation (n = 10).

Results: Overall, septic surgeries (n = 232) had longer LOS (mean 6.3 vs 3.3 days, $P < .001$) and 43% higher total charges ($P < .001$), vs aseptic revisions. Particularly, explantations had longer LOS (7.1 vs 3.3 days) and 56% higher total charges (both $P < .001$). When compared to aseptic revisions, proportional total charges for septic procedures were debridement, antibiotics, and implant retention +29%, $P = .4$; explantation +56%, $P < .001$; spacer exchange +69%, $P = .008$; 2-stage reimplantation +11%, $P = .659$; and 1-stage reimplantation +46%, $P = .06$.

Conclusions: Some surgical procedures performed to treat periprosthetic THA infection are associated with longer LOS and significantly higher hospital charges when compared to aseptic revisions. Reimbursement adjustment is needed as current coding for septic reoperations does not reflect actual hospital resource consumption and this situation may limit access to patient care.

Introduction

There is a growing demand for primary total hip arthroplasty (THA) in the United States driven in part by aging of “baby boomers” and the excellent long-term results of this procedure related to pain reduction, improved mobility, and quality of life, to the point that the volume of annual procedures for THA is expected to keep growing [1]. Nevertheless, the volume of revisions has not decreased over time and periprosthetic joint infection (PJI) remains one of the most common etiologies for reoperation [2]. In a series of 4555 primary cementless THAs, acute PJI accounted for 26% of all indications for revisions with isolated exchange of at least 1 modular component [2]. As the demand for primary THA is projected to increase, so too will be the financial burden of surgical procedures for PJI treatment [3]. Unfortunately, the economic impact of periprosthetic infection after THA is substantial [4]. In a Markov analysis that included direct and indirect costs, the global lifetime treatment cost of periprosthetic infection following THA has been estimated to be $390,806 per patient aged 65 years at the time of the initial revision for infection. Lost wages (indirect costs) represented a substantial portion of the costs which increase

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noticeably as age at the time of infection decreases. This model also accounted for incidence and cost estimates for common medical complications such as pulmonary embolism, myocardial infarction, and deep venous thrombosis in addition to other variables such as use of skilled nurse facilities, home healthcare, home with outpatient physical therapy, inpatient rehabilitation, and failure rates of various septic procedures during and after the first year, among many others [5].

Septic procedures and aseptic revisions after THA are reimbursed based on similar Current Procedural Terminology codes [6] and Multiple Severity-Diagnostic Related Groups [7]. However, in our academic suburban tertiary care referral center, we have observed that various surgical procedures for periprosthetic infection after THA usually use more inpatient resources than others. Current reimbursement coding fails to reflect the true complexity of hospital encounters for some types of septic surgeries. As a result, hospitals may have substantial negative financial margins when treating such patients. A major problem derived from this situation is that patients with deep infection following THA may have limited access to care as hospitals might reduce the number of such procedures.

Contemporary literature comparing the hospital financial burden of surgical procedures performed to treat THA infection with aseptic revisions is particularly scarce [8-12]. Yao et al. [8] observed that the direct medical costs of surgical treatment for PJI after THA are twice the ones of similar aseptic revisions. Treatment of PJI following THA is associated with higher hospital and physician resource utilization when compared to revisions for aseptic loosening or primary THA [9]. Assman et al. [10] showed that the mean direct cost difference between aseptic and septic procedures was \$8892.5 ($P < .001$). When compared to aseptic revision, septic revision THA is not adequately compensated by work relative value units [11]. Data from a large health system have shown that septic revisions cost more than aseptic revisions (\$17,696 vs \$11,204, $P < .0001$) [12]. However, to the best of our knowledge, no previous report has compared hospital financial data between aseptic revisions and 5 different surgical procedures for deep infection. As a result, we sought to answer the following research questions: (1) Is length of stay (LOS) longer for septic THA reoperations when compared to aseptic revisions? (2) Are septic surgeries more expensive? and (3) How do different surgical procedures for infection compare with aseptic revisions on hospital LOS, professional, technical, and total charges (professional plus technical)? We hypothesize that some types of septic reoperations would have longer inpatient stay and would have significantly higher hospital charges when compared to aseptic revisions.

Material and methods

Institutional review board approval was obtained for this investigation. Inpatient charges for a consecutive series of 623 hip reoperations with Current Procedural Terminology codes 27090, 27091, 27134, 27137, and 27138 performed by 7 surgeons at a single institution (academic suburban tertiary care referral center) from January 1, 2015 to November 10, 2020 were obtained from Enterprise Analytics which is part of our institution's division of finance and information technology. A retrospective review of the electronic medical records was performed in all cases. After chart review, hemiarthroplasties, open reduction and internal fixations, conversions, procedures superficial to the deep fascia, seromas, hematomas, cases with other joint procedures performed during the same admission, and heterotopic ossification excisions were excluded. The selection process is illustrated in Figure 1. As a result, 596 unilateral THA reoperations (473 patients) were analyzed. It is important to note that cases, instead of patients, represent the unit of analyses.

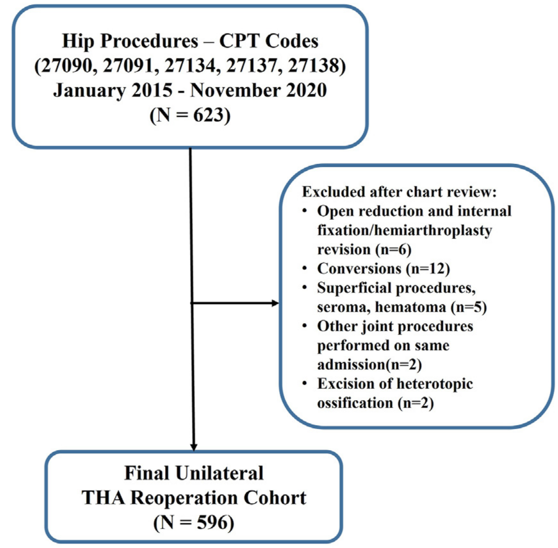

Figure 1. Flowchart illustrating the case selection process.

Baseline demographics such as age, sex (male/female), body mass index (BMI) (kg/m^2) [13], race (Black/White/Other), ethnicity (Hispanic/Non-Hispanic), American Society of Anesthesiologists physical status classification system [14] as well as hospital LOS, professional charges (ie, surgeon, anesthesiologist, consulting physicians services), technical charges (ie, room and bed, implants, imaging, nursing), and total charges (professional plus technical) per case were collected. It is also important to highlight that charges for the hospital encounter associated with a particular reoperation are the main outcome of interest. Hospital financial data analyzed goes far beyond charges for component(s) used in any particular procedure as it encompasses the whole inpatient episode of care. After review of all operative reports, reoperations were set apart as septic surgeries (n = 232) or aseptic revisions (n = 364). These cases were also categorized into the following 6 groups: (1) aseptic revision (control group; n = 364); (2) debridement, antibiotics, and implant retention (DAIR) (n = 11); (3) explantation (n = 145); (4) spacer exchange (n = 7); (5) reimplantation as part of a 2-stage exchange arthroplasty (n = 59); and (6) 1-stage reimplantation (n = 10). All outcomes of interest (including LOS and charges) were compared between groups using aseptic revisions as a reference. Charges for all septic surgery groups are presented relative to charges for aseptic revisions (control group, reference value is 1). The percentage change of charges for septic reoperations will be positive when charges are higher than those for the aseptic revision group. Conversely, the percentage change of charges for septic surgeries will be negative when charges are lower than those for aseptic revisions. It is important to note that of the 145 explantations, 139 (95.9%) received articulating spacers, 4 (2.7%) received static spacers, and 2 (1.4%) had no spacer. On the other hand, 6 (85.7%) of the 7 spacer exchanges were performed with articulating spacers and 1 (14.3%) was done with a static spacer. Of the 11 DAIRs, 7 were performed with head and insert exchange, while 4 were done without it.

Overall, BMI was significantly higher in the septic group (all types, n = 232) when compared to the aseptic cohort (mean 30.1 [range, 16.6-49.1] vs 28.2 [range, 15-48] kg/m^2, respectively, $P < .001$). Additionally, a higher proportion of males was found in the septic cohort (61.6%) vs the aseptic group (43.7%) ($P < .001$). Other baseline demographics were not found significantly different between septic surgeries and aseptic revisions (Table 1). Demographics for the 5 different surgical procedures for infection and aseptic revisions are shown in Table 2.

Statistical analysis

Continuous variables are presented as means and ranges, while categorical variables are summarized with counts and percentages. Continuous and categorical variables of the aggregate of all septic surgeries and aseptic revisions were compared with independent *t*-test and Fisher's exact test, respectively. Continuous and categorical data for the aseptic group (control) and the different surgical procedures for infection were compared using analysis of variance with post-hoc analyses and Chi-square tests, respectively. All statistical analyses were performed using Statistical Package for Social Sciences, version 28 (IBM Corporation, Armonk, New York). Statistical significance was set at 0.05.

Results

Septic THA reoperations (all types) had longer hospital LOS when compared to aseptic revisions (mean 6.3 [range, 1-33 days] vs 3.3 days [range, 0-28 days], respectively, $P < .001$). These septic procedures (all types) also had 43% (range, +40 to +78) higher total hospital charges than revisions performed for aseptic indications ($P < .001$). Table 3 shows hospital LOS and professional, technical, and total inpatient charges for septic surgeries (all types) and aseptic revisions. Concerning the different surgical procedures for infection, DAIR (8.1 days, range 5-15, $P < .001$), explantation (7.1 days, range 2-26, $P < .001$), spacer exchange (10.9 days, range 3-33, $P < .001$), and 1-stage reimplantation (7.0 days, range 3-13, $P = .018$) groups had significantly longer LOS when compared to aseptic revisions (3.3 days, range 0-28). Total hospital charges for explantations (+56%, range +49 to +78, $P < .001$) and spacer exchanges (+69, range +44 to −20, $P = .008$) were significantly higher than the ones for aseptic revisions. Hospital LOS and percentage changes (professional, technical, and total charges) after comparisons between the 5 septic surgery groups and aseptic revisions are shown in Table 4.

Table 1
Baseline demographics and characteristics of the aseptic group (control) and all surgical procedures for infection.

Variables	Aseptic rTHA (n = 364)	All surgical procedures for infection (n = 232)	*P* value
Age, mean in years (range)	68.4 (28-94)	66.6 (25-93)	.07
Sex			<.001
Female	205 (56.3%)	89 (38.4%)	
Male	159 (43.7%)	143 (61.6%)	
BMI, mean in kg/m^2 (range)	28.2 (15.0-48.0)	30.1 (16.6-49.1)	<.001
Race[a]			.8
Black	36 (9.9%)	24 (10.4%)	
White	318 (87.8%)	200 (86.6%)	
Other	8 (2.2%)	7 (3.0%)	
Ethnicity			.2
Hispanic	30 (8.2%)	26 (11.2%)	
Non-Hispanic	334 (91.8%)	206 (88.8%)	
ASA			.2
1	8 (2.2%)	3 (1.3%)	
2	177 (48.6%)	105 (45.3%)	
3	174 (47.8%)	116 (50.0%)	
4	5 (1.4%)	8 (3.4%)	

ASA, American Society of Anesthesiologists; BMI, body mass index; rTHA, revision total hip arthroplasty.
[a] Available data.

Discussion

We have observed that some types of septic THA surgeries clearly use more inpatient resources than others, and current reimbursement coding usually fails to reflect the true complexity and inpatient resource consumption of many septic procedures. There is a scarcity of contemporary reports evaluating the inpatient financial burden of the most common types of surgeries performed to treat PJI after THA, above all, in contrast to revision THAs performed for aseptic indications [8-12]. As a result, when compared to aseptic revisions, the current investigation addressed the following 3 questions: (1) Is hospital LOS longer for septic reoperations? (2) Are septic surgeries more expensive? and (3) How do different surgical procedures for infection compare with aseptic revisions on inpatient LOS, professional, technical, and total charges (professional plus technical)?

Concerning hospital LOS, we observed that septic THA reoperations (all types) had significantly longer stay when compared to aseptic revisions, probably because of the wait for cultures and/or placement of the peripherally inserted central catheter for antibiotics. Our findings are in line with the ones of Bozic et al. [9] who compared resource utilization per patient during the episode of care (defined as 12-month period following the index procedure) for revision THA for infection, revision THA for aseptic loosening, and primary THA, and showed that the mean total number of days in the hospital for the 3 groups were 28.2, 8.1, and 6.2 days, respectively ($P < .001$). Duwelius et al. [12] showed that septic cases had significantly longer LOS when compared to aseptic ones (4.3 vs 2.4 days, respectively, $P < .0001$). Assman et al. [10], comparing aseptic and 2-stage septic revisions, observed that hospital stay was significantly longer in the septic cohort (40.2 vs 15.6 days, $P < .001$). Arguably, because all septic cases were associated with at least 2 separate procedures.

Regarding hospital financial burden of septic surgeries when compared to aseptic revisions, we found that septic procedures (all types) had 43% higher total charges than revisions performed for aseptic indications ($P < .001$). Our results agree with the ones of Bozic et al. [9], who in comparisons among revision THA for infection, revision THA for aseptic loosening, and primary THA, showed that total hospital costs were $96,166, $34,866, and $21,654, respectively ($P < .001$). Assman et al. [10] showed that the average cost difference between aseptic procedures (mean was $5,487; range, $3080-$17,345) and septic procedures (mean was $14,380; range, $7813-$29,051) was $8892 ($P < .001$). Duwelius et al. [12] demonstrated that, overall, septic revisions cost more than aseptic revisions ($17,696 vs $11,204, $P < .0001$).

Regarding financial comparisons between the 5 different surgical procedures for infection and aseptic revisions, we observed that inpatient total charges for explantations and spacer exchanges were significantly higher than the ones of aseptic revisions by 56% ($P < .001$) and 69% ($P = .008$), respectively. Assman et al. [10] observed that the mean cost of septic explantations was $5508 vs $8872 for septic implantations, which is in addition 61.7% more than the cost of aseptic procedures. Duwelius et al. [12] showed that direct costs were highest for a 2-stage exchange arthroplasty ($37,642) and lowest for a liner revision ($8979). Yao et al. [8] found in a retrospective study that mean direct hospitalization costs of 2-stage THA revisions performed for PJI and aseptic THA revisions were $58,369 and $22,846, respectively ($P < .001$). Even when accounting for 2 procedures instead of 1 in the case of 2-stage THA revision, costs were about 28% higher than twice the costs of aseptic THA revision ($P < .001$). Moreover, mean overall direct

Table 2
Baseline demographics and characteristics of the aseptic group (control) and the 5 surgical procedures for infection.

Variables	Aseptic rTHA (n = 364)	DAIR (n = 11)	Explantation (n = 145)	Spacer exchange (n = 7)	Reimplantation as part of a 2-stage (n = 59)	1-stage reimplantation (n = 10)	*P* value
Age, mean in years (range)	68.4 (28 to 94)	69.7 (60 to 81)	67.9 (32 to 93)	59.9 (50 to 81)	63.5 (25 to 90)	69.0 (53 to 81)	.019[a]
Sex							<.001
Female	205 (56.3%)	3 (27.3%)	62 (42.8%)	4 (57.1%)	19 (32.2%)	1 (10%)	
Male	159 (43.7%)	8 (72.7%)	83 (57.2%)	3 (42.9%)	40 (67.8%)	9 (90%)	
BMI, mean in kg/m^2 (range)	28.2 (15.0 to 48.0)	29.4 (22.8 to 43.0)	29.8 (16.6 to 49.1)	28 (24.2 to 38.5)	30.8 (19.5 to 48.2)	31.6 (18.4 to 44.5)	.006[a]
Race[b]							.395
Black	36 (9.9%)	2 (18.2%)	11 (7.6%)	0 (0%)	10 (16.9%)	1 (10%)	
White	318 (87.8%)	9 (81.8%)	128 (88.9%)	6 (85.7%)	48 (81.4%)	9 (90%)	
Other	8 (2.2%)	0 (0%)	5 (3.5%)	1 (14.3%)	1 (1.7%)	0 (0%)	
Ethnicity							.294
Hispanic	30 (8.2%)	3 (27.3%)	13 (9%)	1 (14.3%)	8 (13.6%)	1 (10%)	
Non-Hispanic	334 (91.8%)	8 (72.7%)	132 (91%)	6 (85.7%)	51 (86.4%)	9 (90%)	
ASA							.314
1	8 (2.2%)	0 (0%)	2 (1.4%)	0 (0%)	1 (1.7%)	0 (0%)	
2	177 (48.6%)	5 (45.5%)	63 (43.4%)	2 (28.6%)	32 (54.2%)	3 (30%)	
3	174 (47.8%)	5 (45.5%)	74 (51.0%)	4 (57.1%)	26 (44.1%)	7 (70%)	
4	5 (1.4%)	1 (9.1%)	6 (4.1%)	1 (14.3%)	0 (0%)	0 (0%)	

ASA, American Society of Anesthesiologists; BMI, body mass index; DAIR, debridement, antibiotics, and implant retention; rTHA, revision total hip arthroplasty.
[a] *P* value reported is ANOVA between groups.
[b] Available data.

inpatient costs of irrigation and debridement after THA for PJI were approximately 2 times the ones of aseptic THA partial component exchange ($39,597 vs $19,297, respectively, $P < .001$). In a report from Australia that evaluated 114 patients with deep infections after THA, the average costs for DAIR were $13,187, while the costs for 1-stage revisions and 2-stage revisions were $27,006 and $42,772, respectively [15].

We would like to emphasize that charges for components are not the outcome of interest in the current report. Instead, charges for the whole hospital episode of care associated with each type of surgery, septic or aseptic, are the main outcome of interest. We consider that the main problem with the different surgical procedures for infection is that current coding places a lot of emphasis on the components exchanged. For the most part, aseptic and septic procedures are both treated from the standpoint of components, when many more resources beyond components (ie, more laboratories including cultures and/or serum monitoring of antibiotic levels and/or renal function, additional expenses associated with peripherally inserted central catheter lines, imaging, infectious disease interconsultations, extended hospital stay) are consumed during the hospital encounter for septic procedures. In our series, DAIRs, which are the simplest type of reoperation when it comes to components exchanged (some cases even did not have any), had higher inpatient professional (by +33%), technical (by +27%), and total charges (by +29%) when compared to the average aseptic revision group containing cases in which more components were exchanged. Although not significantly different from the statistical perspective, probably because of the small sample size of the DAIR group (n = 11). The paradigm of reimbursement and components needs to change, to potentially change the reimbursement for septic procedures, and therefore limit the financial burden to hospitals.

Table 3
Hospital length of stay and inpatient charges for the aseptic group (control) and all surgical procedures for infection.

Variables	Aseptic rTHA (n = 364)	All surgical procedures for infection (n = 232)	*P* value
Length of stay, mean in days (range)	3.3 (0 to 28)	6.3 (1 to 33)	<.001
Charges in USD[a]	Control	%	
Professional, mean (range)	1 (1 to 1)	+24 (−23 to +32)	<.001
Technical, mean (range)	1 (1 to 1)	+48 (+57 to +72)	<.001
Total, mean (range)	1 (1 to 1)	+43 (+40 to +78)	<.001

rTHA, revision total hip arthroplasty; USD, United States dollars.
[a] Data reported as mean charges and ranges. Percentage change with respect to aseptic revisions (control group, reference value is 1).

As hospital charges and hospital expenditures/resource consumption have a direct or proportional relationship, which is a reflection of the fee-for-service payment system, and in view that our data showed that hospital encounters related to septic surgeries like explantations and spacer exchanges have significantly increased charges when compared to aseptic revisions, our results highlight the need for changes of the value for reimbursement codes as these do not adequately account for the increased resource consumption associated with many hospital encounters to perform septic reoperations, particularly those involving spacers. We speculate on possible answers to this problem. A plausible solution is the establishment of referral centers for PJI after THA with a particular reimbursement structure for these institutions. Another solution might be to create new codes that fairly account for the hospital expenses associated with certain types of septic reoperations, namely, staged revisions. Finally, an additional answer could be a wider adoption by surgeons of single-stage reimplantation instead of staged procedures granted these procedures are reimbursed appropriately. For the treatment of PJI, 2-stage exchange arthroplasty has been considered the standard of care [16]. However, Kurtz et al. [17] in a recent report showed that although 2-stage exchange arthroplasty is the preferred surgical treatment for PJI following THA in the United States, for many Medicare patients who underwent this treatment modality, the likelihood of completing within 12 months of explantation a second-stage revision was only 43.1%. Furthermore, the 90-day post-explantation mortality rate was 7.1% while the median additional cost for hospitalizations between stages was $23,582. An ongoing randomized controlled trial (NCT02734134) comparing 1-stage to 2-stage revision for hip and knee PJI might bring to light the real value of single-stage reimplantation [18]. In case of a favorable outcome for 1-stage revisions, this new information might encourage surgeons to avoid staged revisions in selected patients, and with it, many of the problems associated with that treatment modality.

Table 4
Length of stay and inpatient charges of the aseptic group (control) and the 5 surgical procedures for infection.

Variables	Aseptic rTHA (n = 364)	DAIR (n = 11)	Explantation (n = 145)	Spacer exchange (n = 7)	Reimplantation as part of a 2-stage (n = 59)	1-stage reimplantation (n = 10)
Length of stay, mean in days (range)	3.3 (0 to 28)	**8.1** (5 to 15) ($P < .001$)	**7.1** (2 to 26) ($P < .001$)	**10.9** (3 to 33) ($P < .001$)	3.4 (1 to 11) ($P = 1.0$)	**7.0** (3 to 13) ($P = .018$)
Charges in USD[a]	Control	%	%	%	%	%
Professional, mean (range)	1 (1 to 1)	+33 (+39 to −41) ($P = .4$)	**+31** (+12 to +32) ($P < .001$)	+65 (−23 to −24) ($P = .056$)	−0.8 (+25 to −47) ($P = 1.0$)	+29 (+66 to −59) ($P = .679$)
Technical, mean (range)	1 (1 to 1)	+27 (+61 to −45) ($P = .5$)	**+62** (+72 to +72) ($P < .001$)	**+70** (+85 to −18) ($P = .012$)	+14 (+57 to −46) ($P = .4$)	**+51** (+154 to −33) ($P = .045$)
Total, mean (range)	1 (1 to 1)	+29 (+50 to −47) ($P = .4$)	**+56** (+49 to +78) ($P < .001$)	**+69** (+44 to −20) ($P = .008$)	+11 (+40 to −46) ($P = .6$)	+46 (+115 to −33) ($P = .06$)

DAIR, debridement, antibiotics, and implant retention; rTHA, revision total hip arthroplasty; USD, United States dollars.
[a] Data reported as mean charges and ranges. Percentage change with respect to aseptic revisions (control group, reference value is 1). Values in **bold** were found significantly different in ANOVA post hoc comparisons with the aseptic group (control).

The current report should be viewed considering certain limitations. Our data are limited to hospital charges instead of costs, and it was unknown to investigators what proportion of charges related to any particular hospital encounter for the surgery was actually reimbursed. However, we do not consider that any particular type of THA reoperation had a significantly higher reimbursement rate when compared to others as payors do not discriminate based on the categorizations set up for the present study, but on individual services provided (fee-for-service payment system). However, this circumstance remains a possibility. Another limitation is that we did not adjust for other confounders like demographics and comorbidities. However, beyond the *P* value, baseline differences between septic and aseptic groups were minimal. For example, BMI was significantly different but only by approximately 2 points and the difference in proportion of males between both groups was about 18%. These differences alone, regardless of *P* value, could not have explained the significant differences found in hospital charges between septic and aseptic reoperations. A previous report, concerning 2-stage revision THA for PJI, showed that the 3 main drivers of inpatient costs were operating room/anesthesia (29%), hospital room (24%), and implants (17%) [8]. We were unable to obtain stratified costs, and only professional and technical charges were available. Therefore, this circumstance represents another limitation. Finally, this is a retrospective study, and there is always the possibility of missing data or bias. However, we do not consider that this limitation played in favor of any group when comparisons were performed between the different types of surgeries.

Conclusions

Our data suggest that some types of septic THA reoperations have longer inpatient LOS and significantly increased hospital charges when compared to aseptic revisions. In our series, explantations and spacer exchanges were the most expensive surgical procedures for infection. Reimbursement adjustment is urgently needed as current coding associated with septic THA reoperations does not reflect actual resource consumption during the hospital encounter for these procedures, and for patients, this situation may limit access to care as increased risk is being transferred from payers to healthcare providers.

Conflicts of interest

Tejbir S. Pannu is in the medical/orthopaedic publications editorial/governing board of Journal of Orthopaedic Surgery and Research. Carlos A. Higuera is a paid consultant for KCI (3M Company) and Stryker; owns stock or stock options in PSI; received research support from Stryker, Zimmer Biomet, 3M, Osteal, and OREF; is in the medical/orthopaedic publications editorial/governing board of Journal of Hip Surgery; and is a board member of AAOS International Committee and AAHKS International Committee.

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CRediT authorship contribution statement

Jesus M. Villa: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tejbir S. Pannu:** Writing – review & editing, Visualization, Methodology, Formal analysis. **Robert B. Eysler:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation. **Vivek Singh:** Writing – review & editing, Visualization, Methodology, Investigation. **Alison K. Klika:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration. **Carlos A. Higuera:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Conceptualization.

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