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Quantifying the Burden of Revision Total Joint Arthroplasty for Periprosthetic Infection

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ABSTRACT

Periprosthetic joint infection (PJI) represents substantial clinical and economic burdens. This study evaluated patient and procedure characteristics and resource utilization associated with revision arthroplasty for PJI. The Nationwide Inpatient Sample (Q4 2005–2010) was analyzed for 235,857 revision THA (RTHA) and 301,718 revision TKA (RTKA) procedures. PJI was the most common indication for RTKA, and the third most common reason for RTHA. PJI was most commonly associated with major severity of illness (SOI) in RTHA, and with moderate SOI in RTKA. RTHA and RTKA for PJI had the longest length of stay. Costs were higher for RTHA/RTKA for PJI than for any other diagnosis except periprosthetic fracture. Epidemiologic differences exist in the rank, severity and populations for RTHA and RTKA for PJI.

Periprosthetic infection is a rare but serious complication after hip and knee arthroplasty. The incidence of periprosthetic joint infection (PJI), ranging between 2.0–2.4% in one recent study [1], may be on the rise in the United States based on epidemiologic analysis [1]. Furthermore, the absolute numbers of revision total hip arthroplasty (RTHA) [2,3] and revision total knee arthroplasty (RTKA) procedures [3–6] have increased over time, and the burden of revision hip and knee procedures per orthopedic surgeon has also grown [7].

Periprosthetic joint infection and associated revision surgery represent a substantial clinical and economic burden for surgeons, hospitals, and most importantly, patients [8,1,9,2]. Hospitalization charges are significantly greater for management of PJI than for aseptic causes of revision TJA [10]. This places significant strain on the surgeon, patient, and health system in the United States [11–13] and in other countries [14–16].

Prosthetic joint infection may be a persistent problem even after index treatment. At ninety days postoperatively, revision TJA for PJI carries the highest readmission rate (antibiotic-spacer staged RTHA 18%; revision of infected TKA 18%) when compared to aseptic revision TJA (RTHA 10%; RTKA 13%) and primary TJA (primary THA 5%; primary TKA 6%) [12,13]. The risk of developing SSI after RTHA is higher than after primary THA (odds ratio 2.2, 95% confidence interval 1.3–3.7, in a prior study [17]), which may skew PJI rates at those institutions performing a large volume of revisions. Outcomes, including functional scoring, morbidity, and survival free of re-operation, after RTKA for PJI are worse than for aseptic knee revision [18–22]. For reasons associated with this clinical care burden and potential reimbursement forces, the management of PJI may be clustering to referral centers [23].

The etiology of the increase in the number of revision procedures, including those for PJI, is multi-factorial. The growing number of primary TJA [6,24–26] and certain patient factors such as obesity [27,28] certainly contribute to the increase in revision rates. Advances in surgical technique and implant design have not sufficiently offset these rates [3], and projections based on population studies point to continued future growth in the incidence of revision procedures [29,1,30]. According to latest projections by our group, the number of RTHAs is expected to increase from 48,200 in 2010 to 55,600 in 2015 to 66,000 in 2020,

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while RTKAs are projected to increase from 64,100 in 2010 to 88,300 in 2010 to 127,500 in 2020 [31].

Evaluation of the burden of PJI in RTKA and RTHA will help guide treatment algorithms and resource allocation for this challenging population. While qualitative differences exist between RTKA and RTHA procedures associated with PJI, such as intra-operative characteristics, surgical techniques, soft tissue envelopes, and types of fixation, there remains a clear lack of information regarding the comparative epidemiology of RTKA and RTHA for PJI. Moreover, there exists a paucity of information regarding the epidemiology of revision TJA for PJI as compared to other indications for revision. The purpose of this study was to evaluate and compare patient and procedure characteristics and resource utilization associated with revision TJA for PJI. As epidemiology is a dynamic process, this analysis sought to define the changing patterns of PJI management in populations undergoing RTKA and RTHA over a five-year period.

Patients and Methods

The National Inpatient Sample (NIS) database was used to identify revision procedures for PJI that occurred between Q4 2005 and 2010. We identified 235,857 RTHA and 301,718 RTKA procedures from hospital discharge records. The International Classification of Disease, 9th Revision (ICD-9-CM), was used to record diagnoses and procedures performed in the hospital discharge summary, from which the NIS data are derived. The ICD-9-CM procedure codes 81.53, 00.70, 00.71, 00.72, 00.73 were used to identify RTHAs; whereas the codes 81.55, 00.80, 00.81, 00.82, 00.83, 00.84 were used to identify RTKAs associated with a principal diagnosis of PJI based on ICD-9-CM diagnosis code 996.66.

The NIS is the largest and nationally representative (designed to sample 20% of all hospital discharges in the United States) data available, compiled under the Healthcare Cost and Utilization Project (HCUP). In 2011, the NIS received discharge data from 1049 hospitals from 46 states covering 97% of the total United States population. Each discharge record includes patient demographics, a set of diagnosis and procedure performed at the hospital, diagnosis related group (DRG) information, various risk metrics (e.g., APRDRG), payer information, hospital charges, length of stay, and various hospital characteristics.

In addition to releasing the NIS data annually, the HCUP also releases an annual cost-to-charge file. This supplemental data provide a ratio between the hospital cost and the total all-payer submitted charges, which allows the hospital charges to be converted into approximate costs. This ratio is derived from the hospital cost report compiled by the Center for Medicare and Medicaid Services (CMS). There is a hospital-specific ratio for most facilities in the NIS sample. For a small number of hospitals without a specific ratio, a regional or group ratio is available as an approximation. For the present analysis, in addition to converting the reported total charges into the corresponding cost, the dollar values have also been adjusted for inflation using the consumer price index for medical care services published by the Bureau of Labor Statistics. All cost values reported have been adjusted to the January 2013 level.

The calculation of severity of illness (SOI) was developed by 3M Health Information Systems and is a part of the APR-DRG incorporated into the NIS data [32]. The SOI quantifies the extent of physiologic decomposition or organ system loss of function, and is used as a measure of the patient's underlying characteristics. There are four SOI subclasses (minor, moderate, major, and extreme). The determination of the SOI is disease-specific: for example, certain types of infections are considered a more significant problem in a patient who is immunosuppressed when compared to those in a patient with a fractured arm. The process of determining the SOI subclass of a patient consists of three phases. In the first phase, the level of each secondary diagnosis is determined. Once the level of each secondary diagnosis is established, the second phase determines a base sub-class for the patient based on the patient's secondary diagnoses. In phase three, the final subclass for the patient is determined by incorporating the impact of principal diagnosis, age, operating room procedures, non-operating room procedures, and combinations of categories of secondary diagnoses.

Based on this NIS database framework, this study compared patient characteristics, procedure information, and resource utilization across patients receiving RTHA and RTKA for a principal diagnosis of PJI.

Results

Periprosthetic joint infection (25%) was the most common reason for RTKA (Fig. 1), and the third most common for RTHA (15.4%) (Fig. 2). The average age for patients who underwent RTHA and RTKA for PJI was similar (65.4 years for RTHA and 65.7 years for RTKA). The age group with the most revisions for PJI was in the 65–69 year old age groups for both RTHA and RTKA. In RTKA for PJI, the gender distribution was equal; for RTHA there were slightly more females (51.5%) who underwent revision for PJI (Table 1). For both RTHA and RTKA, white patients accounted for more than 80% of all revisions in each year. Black and Hispanic patients followed, but accounted for less than 15% of the total revisions. A high proportion (>50%) of RTKAs for PJI was managed in urban non-teaching hospitals. Likewise, RTHA for PJI was more commonly performed in urban non-teaching hospitals. Medicare insurance represented the largest payer group for patients undergoing both RTHA and RTKA.

With regard to SOI scoring, PJI was commonly associated with major SOI in RTHA. The RTHA diagnoses most commonly associated with a major SOI were implant-related problems, followed by infection. Although only 33.2% of RTKA patients had a major SOI (RTKA patients most commonly had moderate SOI), RTKA for PJI and fracture was the diagnoses most commonly associated with a major (and/or extreme) SOI. For both revision TKA and THA, PJI was the only principal diagnosis for which the lowest SOI was moderate (i.e. no patients exhibited scores of minor/none) (Table 2).

The three most common revision procedures for PJI were arthrotomy/removal of prosthesis (46.7% of RTHA procedures and 45.5% of RTKA procedures), all-component revision (25.3% for RTHA; 19.4% for RTKA), and modular component exchange (11.0% for RTHA; 16.5% for RTKA) (Figs. 3A and B).

Revisions for PJI were associated with the longest average length of stay (ALOS) for both RTHA (9.9 days) and RTKA (7.5 days). For all RTHA patients, the highest overall stay was for "arthrotomy or removal" for infection (>10 days). As with RTHA, the average LOS was greatest for RTKA management of PJI (requiring >7 days average LOS). Across all years, the average LOS for "arthrotomy or removal" for RTKA infection was >8 days. Average hospitalization costs for RTKA ($25,692) and RTHA ($31,753) associated with PJI were lower than costs for periprosthetic fracture ($35,562 for RTKA and $32,167 for RTHA) (Table 2). "Arthrotomy or removal" RTHA procedures in our analysis accounted for the highest hospitalization costs (>$30,000 in 2010), while all-component revision and "other" accounted for the highest RTKA costs (~$27,000 in 2010).

Discussion

Periprosthetic joint infection represents a major challenge in TJA, and this epidemiologic and population health problem consumes significant resources for prevention, diagnosis, and management [23,33]. This study sought to characterize the comparative epidemiology of RTHA and RTKA associated with PJI in the United States. Particular focus was made to differences in the rank, severity and characteristics of patients in revision hip and knee populations over this five-year period.

Our demographic findings may reflect an increasing proportion of primary TKAs [25] and THAs [34,26] that are being performed in younger patients. A study of Medicare population data showed that the rates of THA increased with age, up to the age of 75–79 years [35]. In a study in the California Patient Discharge Database from 2005 to 2009, the one-year risk of PJI was 1.8 times higher in patients younger than 50 years of