The Incremental Hospital Cost and Length-of-Stay Associated With Treating Adverse Events Among Medicare Beneficiaries Undergoing TKA

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ABSTRACT

This paper estimates the incremental hospital resource consumption associated with treating selected adverse events experienced by Medicare beneficiaries undergoing TKA. This retrospective study, using the Medicare Provider Analysis and Review file, identified 353,650 Medicare beneficiaries who underwent a primary TKA during 2011. Overall, 11.82% of Medicare beneficiaries (MBs) undergoing TKA experienced at least one of the study's adverse events. MBs experiencing any adverse event consumed significantly more unadjusted hospital resources ($3110 cost) and had longer stays (1.3 days). The risk-adjusting incremental cost of treating adverse events ranged between $30,902 (pneumonia) and $2167 (hemorrhage or post-operative shock requiring transfusion). Most major adverse events occur infrequently; however when an adverse event occurs following TKA, it adds substantially to hospital costs.

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Osteoarthritis (OA) of the knee is responsible for a large and increasing burden of care and cost within the U.S. healthcare delivery system [1,2]. The prevalence of symptomatic knee OA in patients 45 and older has been estimated between 5.9% and 13.5% in men and 7.2% and 18.7% in women and approximately 10 million adults had symptomatic knee OA in 2010 [3]. Although there are a number of conservative evidence-based alternatives for the treatment of knee OA [3] (including but not limited to arthritis self-management, weight loss and pharmacologic treatments), many patients do not receive significant improvement and opt for total knee arthroplasty (TKA). TKA is highly successful, with clinically significant improvement in patient-reported pain and functional outcome in over 90% of the patients [4–9]. The high success rate may account for the increasing total expenditures associated with TKA. During fiscal year 2011, the Medicare program reimbursed US hospitals $3.5 billion for TKA, making this procedure the largest CMS expenditure for a single procedure [10]. In comparison, total Medicare program expenditures for Heart Failure was $3.4 billion, $2.0 billion for Percutaneous Coronary Intervention with Drug Eluting Stents and $3.2 billion for spinal fusion [10].

Despite the high level of success reported for TKA, a number of articles have reported on mortality and other adverse events for patients undergoing TKA [11–15]. Other than mortality, the clinical impact of venous thromboembolism (VTE) and periprosthetic joint infection has received the most attention in the clinical literature [16–20]. While clear national focus has been applied to VTE and periprosthetic joint infection, there has been relatively little reporting on acute, inpatient adverse events and their associated cost during the TKA admission.

The primary objective of this analysis is to estimate the incremental hospital resources consumed (dollar value of direct medical care provided and length-of-stay [LOS]) while treating adverse events experienced by Medicare beneficiaries who underwent primary TKA in a US hospital during fiscal year 2011. This retrospective study estimates both the observed and risk-adjusted incremental hospital resources consumed (cost and LOS) in treating Medicare beneficiaries experiencing each event. To the extent that evidence-based practice guidelines and quality improvement initiatives decrease adverse event rates, the estimated incremental cost of treating adverse events presented in this paper can be used to evaluate the business case for quality improvement initiatives. Further, the relative size of the incremental resources consumed to treat these events provides both administrators and the medical staff with a means for prioritizing quality improvement efforts.

Methods

Data Source

The Medicare Provider Analysis and Review (MedPAR) file for fiscal year 2011 (October 1, 2010 through September 30, 2011) was the data

source for this retrospective analysis. The MedPAR file is an administrative database that is maintained by the Centers for Medicare and Medicaid services and contains all claims that are submitted by hospitals for services provided to Medicare beneficiaries. For each hospitalization, a MedPAR record includes patient information on age, gender, race, date of admission, date of discharge, the principal diagnosis code, up to 24 secondary diagnosis codes, a flag indication if each diagnosis code was present on admission, primary procedure code, up to 24 additional procedure codes, discharge status, total charges, and total reimbursement.

Study Population: Inclusion/Exclusion

The population in this study consisted of all US hospitalizations in which a Medicare beneficiary underwent a primary TKA during fiscal year 2011. There were a total of 358,922 hospital admissions for Medicare beneficiaries with a primary International Classification of Diseases-9-Clinical Modification (ICD-9-CM) procedure code indicating that the patient underwent TKA (81.54) during that admission in a U.S. hospital. A total of 5272 hospitalizations were deleted because of low estimated use of hospital resources (total estimated cost between $0 and $5000) for the entire hospitalization for TKA. The final study data set consists of 353,650 hospital admissions in 3348 hospitals (mean volume = 105.6 TKA and median volume of 61 per hospital).

Definitions of Adverse Events, Demographics, and Co-Morbidities

Eleven adverse events of interest were defined for this study. These events included: in-hospital death; acute myocardial infarction; hemorrhage or post-operative shock requiring transfusion; hematoma; post-operative adult respiratory distress syndrome; infection; venous thromboembolism; acute renal failure; pneumonia; pulmonary edema or congestive heart failure; and ventricular tachycardia or fibrillation. These adverse events were selected after an extensive literature review. All adverse events, except for in-hospital mortality, were identified from specific ICD-9-CM codes. Appendix A lists the ICD-9-CM procedure and/or diagnosis codes used to identify each adverse event reported in this study. In addition, adverse events were only considered adverse events if the present on admission flag associated with the specific ICD-9-CM diagnostic code indicated that the condition did not exist prior to the TKA hospitalization. Demographic variables of interest include age, gender, and race. Co-morbidities of interest included obesity, body mass index greater than 30, malnutrition, diabetes mellitus, current smoker, history of smoker, congestive heart failure, previous myocardial infarction, atrial fibrillation, peripheral vascular disease, hypertension, inflammatory bowel disease, rheumatoid arthritis, osteoporosis, sickle cell disease, coagulopathies, anemia, psoriasis, chronic obstructive pulmonary disease, chronic liver disease, any cancer, chronic kidney disease, nephrotic syndrome, history of hemodialysis, knee fracture present on admission, mechanical complication of prior TKA present on admission, prior TKA, prior total hip arthroplasty, prior joint arthroplasty nonspecific, prior pathologic fracture, prior traumatic fracture, prior CVA, prior cardiac revascularization procedure, prior liver transplant, prior kidney transplant, prior VTE, long-term use of aspirin, long-term use of anticoagulation, long-term use of antiplatelet, long-term use of NSAIDs, and long-term use of steroids. All co-morbidities were defined based on ICD-9-CM diagnosis codes contained in the MedPAR file. In addition, when appropriate present on admission codes were used to assure that the co-morbidity was present on hospital admission.

Hospital Resource Utilization

This study examined two alternative measures of the hospital resources consumed in treating the selected complication of interest:

LOS and total hospital cost. This study measures resources consumed from the perspective of the entire hospital admission. LOS was defined as the number of days from admission to discharge. Post surgery LOS was not calculated because privacy issues associated with the public use version of the MedPAR file prohibit the use of any actual dates associated with a patient's hospitalization. Hospital resource costs (2011 U.S. dollars) were estimated by multiplying the total billed charges that were in the MedPAR file by the appropriate hospital's overall cost-to-charge ratio, obtained from the most recent audited Medicare Cost Report for each hospital. This method of estimating total hospital cost has been discussed and used previously in the literature [21,22]. The required cost-to-charge ratios needed to estimate a hospital costs were missing for 4492 hospitalizations (1.25% of study population). For the hospitals with missing cost-to-charges ratios, the expected cost of each hospitalization was estimated by multiplying the average hospital cost per day among all Medicare beneficiaries undergoing TKR in the hospital's state by the reported hospital length-of-stay for each of the 4492 hospitalizations.

Statistical Analysis

Univariate differences in baseline demographic data and co-morbidities between patients who experienced any adverse event and those who did not were assessed with chi-square analysis or Fisher's exact test for discrete variables and Student's t test for continuous variables. Observed rates for all adverse events are reported as the proportion of hospitalizations with a selected adverse event out of all study hospitalizations. Mean hospital cost and mean hospital LOS for all patients experiencing selected adverse events are presented as mean ± SD. Multivariate regression models, controlling for demographic characteristics and patient co-morbidities, were estimated using the linear and log-linear forms of the estimated resource equation. However, this study only reports the results from the linear regression models. In this study differences between study groups were considered statistically different if the *P* value was less than or equal to 0.01. All analyses were performed with SAS 9.3 (SAS Institute, Cary, North Carolina).

Strategy for Estimating for Adjusted Resource Use

Adjusted resources (cost and LOS) consumed in treating each adverse event of interest were estimated using multivariate linear regression models, controlling for differences in patient demographic characteristics and co-morbidities as defined previously. This approach defined the incremental resources consumed by Medicare beneficiaries experiencing a specific study event as the estimated coefficient on the dichotomous variable that was set equal to 1 if the patient developed the adverse event of interest and to 0 for all Medicare beneficiaries in the sample not experiencing any adverse event defined in the study. In each risk-adjusted model those patients only experiencing any of the other study adverse events were deleted from the data set used to estimate resource use for that model. For comparison, we also report the observed, average incremental resources consumed in treating a selected adverse event, which was defined as the difference between the average hospital resources consumed by all patients who experience a selected adverse event versus those who did not experience that specific event within the study population.

Results

Table 1 presents baseline demographic and clinical characteristics for all Medicare beneficiaries in the study population and by study cohort according to whether the Medicare beneficiary experienced any adverse events during their hospitalization for primary TKA. In addition, for 31 of the 43 co-morbid conditions listed in Table 1, a significantly higher proportion of Medicare beneficiaries who experienced