Demographics, Outcomes, and Risk Factors for Adverse Events Associated With Primary and Revision Total Hip Arthroplasties in the United States

Stavros G. Memtsoudis, MD, PhD, Yan Ma, PhD, Alejandro González Della Valle, MD, Melanie C. Besculides, MPH, DrPH, Licia K. Gaber, BA, Panagiotis Koulouvaris, MD, and Spencer S. Liu, MD

Abstract

We conducted a study to analyze nationally representative data on patient and health care system characteristics and in-hospital outcomes associated with primary and revision total hip arthroplasties in the United States. Between 1990 and 2004, there were an estimated 2,748,187 hospital discharges after total hip arthroplasty. The risk factors we identified for procedure-related complications and in-hospital mortality included revision procedures, increased age, and male sex. Compared with smaller hospital capacity (number of beds), large hospital capacity was associated with a decreased odds ratio for complications but an increased risk for in-hospital mortality. Additional studies are warranted to determine causal relationships.

The number of primary total hip arthroplasties (PTHAs) and revision THAs (RTHAs) has been increasing exponentially over the past 2 decades.[1] Despite this trend, there is limited nationally representative information on patient demographics, in-hospital outcomes, and risk factors for adverse perioperative events associated with these procedures. Previous studies were limited, as they included only selected patient populations (Medicare participants[2]) or patients from single high-volume institutions.[3] Moreover, these studies were subject to regional exclusivity and temporal restrictions.[4]

To overcome these limitations, we analyzed data that had been collected over a span of 15 years for the National Hospital Discharge Survey (NHDS) so that we could provide nationally representative estimates regarding patient and health care system characteristics and in-hospital outcomes associated with PTHA and RTHA. In addition, we compared PTHA and RTHA data to identify risk factors for adverse events associated with this type of surgery.

Materials and Methods

National Hospital Discharge Survey

The NHDS database was acquired from the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention (CDC). Details of the plan and the operation of the NHDS have been published.[5] In summary, NHDS medical data have been collected annually since 1965 and include nationally representative information on inpatient use of short-stay hospitals. Hospitals included were Medicare participating, noninstitutional hospitals of various capacities, exclusive of military, Department of Veterans Affairs, and federal facilities throughout the United States. To be considered short-stay, hospitals included in the survey are required to have a mean length of stay of less than 30 days or to be a general medical or surgical hospital, regardless of length of stay. Facilities are also required to have at least 6 patient beds.

Among the data collected in the survey are diagnosis and procedure codes *(ICD–9–CM; International Classification of Diseases, Ninth Revision, Clinical Modification),* patient and hospital demographics, and information on length of stay, discharge disposition, geographic location, and primary source of payment. The NHDS uses a 3-stage probability design, introduced

Dr. Memtsoudis is Clinical Associate Professor, Department of Anesthesiology, Dr. Ma is Assistant Professor of Biostatistics, Department of Public Health, and Dr. González Della Valle is Associate Professor, Department of Orthopedics, Hospital for Special Surgery–Weill Medical College of Cornell University, New York, New York.
Dr. Besculides is Senior Public Health Researcher, Division of Public Health, Mathematica Policy Research, Princeton, New Jersey.
Ms. Gaber is Statistical Data Analyst, LKG Consulting, Plainsboro, New Jersey.
Dr. Koulouvaris is Fellow, Department of Orthopedics, and Dr. Liu is Clinical Professor, Department of Anesthesiology, Hospital for Special Surgery–Weill Medical College of Cornell University, New York, New York.

Address correspondence to: Stavros G. Memtsoudis, MD, PhD, Hospital for Special Surgery, 535 E 70th St, New York, NY 10021 (tel, 212-606-1206; fax, 212-517-4481; e-mail, memtsoudiss@hss.edu).

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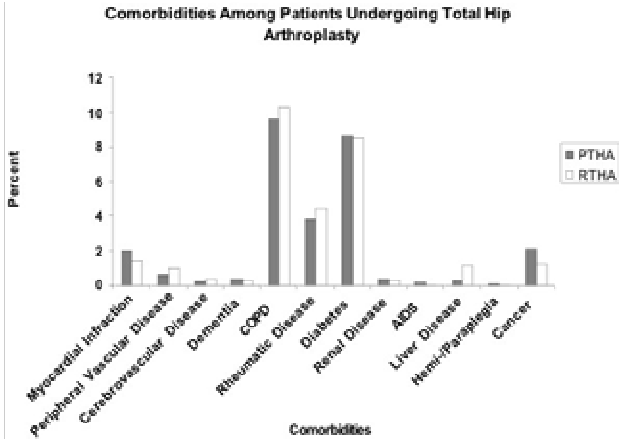

Figure 1. Incidence of comorbidities in patients hospitalized for primary total hip arthroplasty and revision total hip arthroplasty. *P*<.001 between all comorbidities, except diabetes mellitus (*P* = .352). Abbreviations: AIDS, acquired immune deficiency syndrome; COPD, chronic obstructive pulmonary disease; PTHA, primary total hip arthroplasty; RTHA, revision total hip arthroplasty.

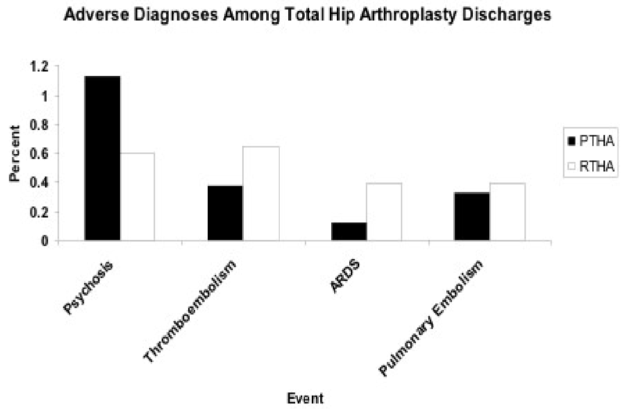

Figure 2. Incidence of selected in-hospital adverse events associated with primary total hip arthroplasty (PTHA) and revision total hip arthroplasty (RTHA). *P*<.001 between all groups for all adverse events. Abbreviations: ARDS, acute respiratory distress syndrome; PTHA, primary total hip arthroplasty; RTHA, revision total hip arthroplasty.

in 1988. Primary sampling units (PSUs) include counties, groups of counties, county equivalents or towns and townships, hospitals within PSUs, and discharges within hospitals. A multistage estimation procedure—inflation by reciprocals of probabilities of selection, adjustment for nonresponse, and population weighting ratio adjustments—was implemented to derive unbiased national estimates from this complex survey.[5] The actual NHDS sample represents approximately 1% of all hospital discharges in the United States. To ensure accurate, nationally representative sampling, the NHDS takes multiple steps to ensure validity and accuracy of coding and data entry.

The NHDS has been used extensively to analyze data associated with a wide range of procedures across a variety of medical specialties. More than 400 selected medical publications have used data from the NHDS or the National Survey of Ambulatory Surgery (NSAS) since 1980. These publications are listed on the CDC Web site.[6]

Patient Selection and Analysis

Data collected for each year between 1990 and 2004 were obtained, read into statistical software (SAS version 9.1; SAS Institute, Cary, NC), and analyzed. Discharges with an *ICD–9–CM* procedure code for PTHA (81.51) or RTHA (81.53) were identified and included in the sample. The incidence of procedure subtypes and the respective demographics—age, sex, race, disposition status, distribution of procedures by hospital capacity (number of beds) and US region, primary source of payment, and length of care—were determined. Frequencies of procedure-related complications were analyzed by determining cases that listed *ICD–9–CM* diagnosis codes specifying complications of surgical and medical care (996.X–999.X). The code for RTHA device-related complications (996.X) most likely represented the primary preoperative indication for surgery and thus was excluded from comparative analysis. In addition, we determined the incidence of selected adverse diagnoses, including pulmonary embolism and venous thrombosis, as described by Stein and colleagues.[7] Respiratory insufficiency after trauma or surgery/adult respiratory distress syndrome (ARDS) and psychosis were identified using appropriate *ICD–9–CM* diagnosis codes. Comorbidities were defined with the Charlson Comorbidity Index (CCI), developed by Charlson and colleagues[8] and adjusted for use with administrative data by Deyo and colleagues.[9] The Deyo modification takes into account chronic comorbidities as well as acute comorbidities that may have occurred during hospital admission. Differences in in-hospital mortality between procedure subtypes were also assessed.

Subsequently, multivariate regression analysis was performed, and odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated, to determine if surgery type, age, sex, and hospital capacity were independent predictors for in-hospital mortality and procedure-related complications.

Statistical Methods

Significant differences between procedure types were assessed first using χ^2 tests and then using Z scores for categorical variables when appropriate. The significance of differences between procedure types for continuous variables was evaluated with *t* test. $P = .001$ was used to define significance. For multivariate logistic regression analysis, control variables were procedure type, age, sex, race, hospital capacity, primary source of payment, US region, and comorbidities. The analysis was performed for dependent variables to include the occurrence of any procedure-related

Table I. Characteristics of Patients Discharged After Primary and Revision Total Hip Arthroplasties

Characteristic	Total Hip Arthroplasty: Primary	Total Hip Arthroplasty: Revision
N, weighted/unweighted	2,288,579/19,795	459,608/4103
Age, y (range)[a]	66.68 (6-99)	66.70 (4-99)
Age groups, y, % of total[b]		
<45[c]	7.12	10.36
46-64[c]	29.50	26.37
65-84[c]	57.78	54.41
>85[c]	5.60	8.85
Sex, % of total[b]		
Male[c]	41.74	41.60
Female[c]	58.25	58.39
Race, % of total[b]		
White[c]	69.16	71.73
Black[c]	4.93	5.89
Other[c]	1.62	1.65
Not stated[c]	24.28	20.73
Discharge status, % of total[b]		
Routine discharged home[c]	50.16	47.05
Left against medical advice[c]	0.08	0.03
Discharge to short-term facility[c]	8.93	9.31
Discharge to long-term facility[c]	22.44	23.48
Alive, disposition not stated[c]	16.18	17.77
Dead[c]	0.32	1
Not stated or reported[c]	1.88	1.37
Hospital capacity, no. beds, % of total[b]		
6-99[c]	18.88	15.25
100-199[c]	25.40	21.61
200-299[c]	20.80	21.91
300-499[c]	23.88	29.06
500+[c]	11.04	12.17
US region, % of total[b]		
Northeast[c]	22.96	25.88
Midwest[c]	27.57	23.55
South[c]	29.75	32.21
West[c]	19.72	18.36
Primary source of payment, % of total[b,d]		
Medicare[c]	53.38	56.57
Medicaid[c]	3.07	4.11
Private[c]	30.79	26.09
Other[c,e]	11.73	12.36
Not stated[c]	1.03	0.88
Length of care, d (range)[a]	5.81 (1-315)	7.02 (1-89)

[a]$P<.001$ by t tests between groups.
[b]$P<.001$ by χ^2 tests between groups.
[c]$P<.001$ by Z scores between groups.
[d]$P<.001$ between payment sources and procedure types.
[e]Includes *Workmen's Comp., Title V, Other Government, No Charge,* and *Other,* as listed in National Hospital Discharge Survey.

complication and in-hospital mortality. All statistical analyses were performed with SAS version 9.1, and the SAS procedures Surveyfreq and Surveylogistic were used to adjust for the sampling methods used in the NHDS.

Results

We estimated there were 2,748,187 discharges after THA between 1990 and 2004. Of those, approximately 83% were PTHA and 17% RTHA. Patient characteristics associated with PTHA and RTHA are listed in Table I. Most THAs (~58%) were performed on females (minimal differences between PTHA and RTHA). The mean age of patients who underwent these procedures was similar (PTHA, 66.68 years; RTHA, 66.70 years), and most patients were between 65 and 84. In patients older than 85 and younger than 45, however, the proportion of RTHAs was larger than that of PTHAs. Racial differences between procedures were small but have to be interpreted in the context of a large number of discharges for whom race was not stated.

Figure 1 depicts the incidence of comorbid diseases for PTHA and RTHA patients. Patients who underwent RTHA had a higher overall incidence of peripheral vascular and cerebrovascular disease, chronic obstructive pulmonary disease, rheumatic disease, and liver disease. However, there was no difference (P = .91) in overall CCI between the PTHA group (0.38; 95% CI, 0.36-0.39) and the RTHA group (0.38; 95% CI, 0.34-0.42). A larger proportion of RTHAs (63.14%) than of PTHAs (55.72%) was performed at hospitals with a capacity of more than 200 beds (Table I). Regional discrepancies between the proportional use of RTHAs versus PTHAs was found, with the RTHA–PTHA ratio higher than 1 in the Northeast (1.13) and the South (1.08). Revision burden was 18.33% in the Northeast, 14.65% in the Midwest, 17.79% in the South, and 16.02% in the West.

Table II. Procedure-Related Complications (ICD–9–CM 997-999) After Total Hip Arthroplasties

Complications	Total Hip Arthroplasty (% of Total) Primary	Revision
Complications affecting specific body systems (*ICD–9–CM* 997)		
Central nervous system[a]	0.17	0.13
Cardiac[a]	0.93	1.79
Peripheral vascular[a]	0.16	0.51
Respiratory[a]	1.17	1.47
Gastrointestinal[a]	0.95	0.97
Genitourinary[a]	1.09	0.69
Other (organ-specific)[a]	0.2	0.48
Other complications of procedure (*ICD–9–CM* 998)		
Postoperative shock[a]	0	0.12
Hematoma/seroma[a]	1.51	2.76
Accidental puncture/laceration[a]	0.1	0.12
Disruption of operative wound[a]	0	0.14
Postoperative infection[a]	0.47	0.48
Other complications of procedure[a]	2.31	2.7
Complications of medical care (*ICD–9–CM 999*)		
Complications of medical care[a]	0.22	0.51
Any procedure-related complication (*ICD–9–CM* 997-999)[a]	8.33	11.5

Abbreviation: ICD–9–CM, International Classification of Diseases, Ninth Revision, Clinical Modification.
[a]*P*<.001 between groups within complication group.

Table III. Risk Factors for Adverse In-Hospital Events: Multivariate Regression (Odds Ratios, 95% Confidence Intervals)[a]

	Risk Factor	Any Procedure-Related Complication Odds Ratio	95% Confidence Interval		Mortality Odds Ratio	95% Confidence Interval	
Procedure type (referent, primary THA)	Revision THA	1.41	1.14	1.73	2.81	1.19	6.59
Age group (referent, 45-64 y)	<45 y	1.11	0.76	1.63	0.84	0.13	5.30
	65-84 y	1.17	0.91	1.49	3.21	1.04	9.90
	85+ y	1.53	1.03	2.27	9.37	3.24	27.08
Sex (referent, female)	Male	1.39	1.19	1.64	1.31	0.64	2.67
Hospital capacity (referent, 200-299 beds)	<99 beds	1.01	0.78	1.31	1.37	0.34	5.51
	100-199 beds	0.79	0.62	1.00	1.98	0.51	7.68
	300-499 beds	0.94	0.76	1.17	4.95	1.69	14.48
	500+ beds	0.75	0.59	0.95	2.16	0.70	6.64

Abbreviation: THA, total hip arthroplasty.
[a]Odds ratios with 95% confidence intervals that do not overlap with 1 represent significantly different values when compared with referents.

Discharge to long- and short-term care facilities was only marginally higher for RTHAs (32.79%) than for PTHAs (31.37%) (Table I). The primary source of payment was more often Medicare or Medicaid for RTHAs (60.68%) than for PTHAs (56.45%) (Table I).

Significant differences were found in outcome measures between the PTHA and RTHA groups. Mean length of hospital stay was 5.81 days for PTHAs and 7.02 days for RTHAs. Procedure-related complications occurred approximately 30% more often in the RTHA group (11.60%) than in the PTHA group (8.33%). Table II details the incidence of specific procedure-related complications. The incidence of in-hospital pulmonary embolism, thrombotic events, and lung injury after trauma or surgery/ARDS was increased after RTHA compared with PTHA; the rate of psychosis (postoperative confusion) was decreased (Figure 2). In-hospital mortality was 3 times higher for RTHA patients (0.98%) than for PTHA patients (0.32%).

In the multivariate regression analysis, independent risk factors for a procedure-related complication were RTHA, advanced age, and male sex (Table III). The ORs for in-hospital mortality were highest for RTHA, advanced age, and procedures performed at larger hospitals (300-499 beds) versus smaller hospitals.

There was no significant impact of CCI on procedure-related complications (OR, 0.91; 95% CI, 0.81-1.006) or in-hospital mortality (OR, 1.31; 95% CI, 0.891-1.897).

Discussion

In our study of 2,748,187 estimated hospital discharges after THA between 1990 and 2004, we detected differences in demographics and in-hospital outcomes between patients who had undergone PTHAs and patients who had undergone RTHAs. In a multivariate analysis, RTHA, increased age, and hospital capacity of 300 to 499 beds were risk factors for increased incidence of in-hospital mortality after surgery.

These findings are important, as both mean age of US population and THA use are increasing. During the study period, the US population rose 18%[10] while the elderly population (older than 65 years) rose approximately 30%.[11] Thus, it is expected that the number of patients who undergo THA will increase, as multiple studies have documented significant quantitative and qualitative improvement in physical function and health-related quality of life after THA.[12] It was recently projected that PTHAs would see an estimated 174% increase in demand through the year 2030.[13] Increased awareness of risk factors for adverse events after surgery may help in directing resources, strategies for care, and research objectives.

In our study, RTHAs were associated with increased risk for complications, prolonged hospital stay, and in-hospital mortality. These findings are important, because the age group with the largest increase in PTHA use during the study period was 45 to 64 years. As this group should continue to enjoy increasing longevity,[14] and as prostheses exceed their engineered life spans, the RTHA burden is expected to grow.

In RTHA surgery, mechanisms for increased risk include both the procedure and the underlying patient characteristics. RTHA is associated with increased technical difficulty resulting in prolonged operating room time, extensive surgical exposure, blood loss, and complications.[15] Our data indicate that patient characteristics also differed between RTHA and PTHA groups. RTHA was more often performed in very elderly patients (older than 85 years). In previous smaller studies conducted in the United States and Europe, age was associated with worse outcomes and quality of life after both PTHA and RTHA.[4,16] Results from our much larger, longitudinal study seem to confirm this association. Multiple other studies involving nonorthopedic surgical procedures have also identified increased age as a risk factor for postoperative complications, likely caused by decreased physiologic reserve to withstand the stresses of surgery.[17] Thus, a combination of operative and patient factors may explain the increased risk for worse outcomes and prolonged length of stay with RTHA. More studies are needed to examine specifically whether improvements in surgical techniques, implant devices, perioperative care, or increased monitoring can decrease risk after RTHA. For the present, surgeons should consider whether RTHA warrants additional perioperative monitoring.

Patient characteristics were independently associated with increased risk for complications and in-hospital mortality after PTHA and RTHA. Increased age slightly increased the risk for complications but markedly increased the risk for in-hospital mortality. This increased risk was particularly striking in the very elderly group (older than 85 years), with a 9-fold increased likelihood of in-hospital mortality. Although women underwent most of the THAs (primary and revision), male sex carried an increased risk for complications. Several other studies that have examined perioperative risk factors have also identified male sex as an independent risk factor for complications after nonorthopedic procedures.[18,19] Although hormonal differences may play a role, it remains unclear why male sex would carry an independent risk for worse outcomes after THA. More work is needed to identify potential mechanisms and strategies to reduce risk.

We observed that larger hospital capacity was associated with decreased risk for complications but increased risk for in-hospital mortality. Associations between hospital characteristics and outcomes have been controversial. Although some studies have identified large surgical volume and performance in a teaching center as independent positive factors that decrease mortality, postoperative complications, and length of stay after THA in the United States, England, and Europe,[20-22] other studies have not confirmed this finding.[23] Recent evidence suggests that a more important characteristic for outcomes after hip and knee replacement may be whether the hospital is a specialty-care orthopedics hospital, as opposed to a general-care hospital.[23] Unfortunately, the NHDS does not allow for further definition of procedural volume or specialty care and does not include any additional hospital information. Thus, we could not separate relative contributions from hospital capacity, procedural volume, and specialty focus of hospitals. We can speculate, however, that the increased mortality at larger hospitals may reflect more complex cases being treated with more complex procedures at larger tertiary-care facilities. This speculation is partially supported by our finding that a larger proportion of RTHAs was performed at larger hospitals (more than 200 beds). Causal relationships, however, remain purely speculative. More studies are needed to identify the exact hospital characteristics and processes that may reduce risk for complications after THA.

Our study is limited because of several factors inherent to the analysis of large databases designed for administrative purposes. As the NHDS lacks detailed clinical information, its data should be interpreted with caution. Data on anesthesia type or procedure specifics are not available. Well-recognized limitations include bias potential and underreporting in assigning complication codes (there are no defined clinical criteria).[24] Thus, we elected to examine only in-hospital mortality and any postoperative complications as adverse outcomes, as these will be more robust in comparison with individual complications. As comorbidity codes also suffer from the same recognized limitations, undercoding of diagnosis, particularly of chronic conditions, is likely to influence analysis of individual comorbidities as risk factors. This problem has been described before.[24,25] Iezzoni and colleagues[24] found that many comorbidities that, on a clinical basis, should be associated with increased risk for adverse outcomes were associated with lower risk for in-hospital death. However, undercoding affects the reported incidence of comorbidities for each procedure type equally within the NHDS and thus allows for comparative data analysis. Identifying certain comorbidities as risk factors, particularly when low-incidence outcomes are analyzed, may yield misleading results, so we did not attempt this. Further, with use of the Deyo modification of the CCI in this analysis, the erroneous impact of individual comorbidity codes may be minimized.

Another limitation is that we did not examine relationships between outcomes and some potential risk factors, such as race and payment source, as data collection for both of these characteristics was incomplete. Finally, as NHDS data are generated only from hospital stays, the incidence of complications after hospital discharge is not captured.

In conclusion, in analyzing hospital discharges after THA surgery between 1990 and 2004, we determined that the risk factors for increased incidence of complications and/or in-hospital mortality were RTHA, increased age, and male sex. Large hospital capacity was associated with decreased risk for perioperative complications and increased risk for in-hospital mortality. More studies are needed to identify causal relationships.

Authors' Disclosure Statement

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