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The Impact of Solid Organ Transplant History on Inpatient Complications, Mortality, Length of Stay, and Cost for Primary Total Hip Arthroplasty Admissions in the United States

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Abstract

Background—As the prevalence of and life expectancy after solid organ transplantation increases, some of these patients will require total hip arthroplasty (THA). Immunosuppressive therapy, metabolic disorders, and post-transplant medications may place transplant patients at higher risk of adverse events following surgery. The objective of this study was to compare inpatient complications, mortality, length of stay (LOS), and costs for THA patients with and without solid organ transplant history.

Methods—A retrospective cross-sectional analysis was conducted using 1998–2011 Nationwide Inpatient Sample. Primary THA patients were queried ($n=3,175,456$). After exclusions, remaining patients were assigned to transplant ($n=7,558$) or non-transplant groups ($n=2,772,943$). After propensity score matching, adjusted for patient and hospital characteristics, logistic regression and paired t-tests examined the effect of transplant history on outcomes.

Results—Between 1998 and 2011, THA volume among transplant patients grew approximately 48%. The overall prevalence of one or more complications following THA was greater in the transplant group than in the non-transplant group (32.0% vs. 22.1%; $p<0.001$). In-hospital mortality was minimal, with comparable rates (0.1%) in both groups ($p=0.93$). Unadjusted trends show that transplant patients have greater annual and overall mean LOS (4.47 days) and mean admission costs (\$18,402) than non-transplant patients (3.73 days; \$16,899; $p<0.001$). After propensity score matching, transplant history was associated with increased complication risk (odds ratio, 1.56;) after THA, longer hospital LOS (+0.64 days; $p<0.001$), and increased admission costs (+\$887; $p=0.005$).

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Conclusions—Transplant patients exhibited increased odds of inpatient complications, longer LOS, and greater admission costs after THA compared with non-transplant patients.

Keywords

total hip arthroplasty; solid organ transplant; complication; length of stay; Nationwide Inpatient Sample

INTRODUCTION

The rate of solid organ transplant (kidney, liver, heart, lung, pancreas – in order of prevalence) in the United States (US) has doubled since 1990 [1]. In 2010, there were approximately 30,000 solid organ transplant procedures [1]. Not only is solid organ transplant becoming more common, but life expectancy of its patients and organ allograft survival are also increasing.[1-6] Improved organ allocation, donor selection, surgical technique, and technology, refined corticosteroid and immunosuppressive regimens, and better diagnosis and treatment of complications have contributed to the greater success of these transplants [2, 7].

As these post-transplant patients grow older, some of them present to clinic requiring total hip arthroplasty (THA) to treat bone disease and enhance quality of life and activity. Additionally, transplant medications have some potentially serious side effects, which can manifest as avascular necrosis (AVN) in multiple joints including the hip and femoral head [8-10]. Intensive immunosuppressive therapy, metabolic disorders, and post-transplant medications may place transplant patients at higher risk of adverse events after THA [8, 11-13]. Due to the infrequency of THA among transplant patients, current studies in the literature have small sample sizes and examine mainly renal transplant patients [8, 12, 14-20].

The objective of this study was to analyze the perioperative outcomes of THA in solid organ transplant recipients in the US, comparing comorbidities, acute hospital complications, mortality, length of stay (LOS), and admission costs for THA patients with and without a history of solid organ transplant. A large national administrative database over fourteen years was used to provide sufficient statistical power.

MATERIALS AND METHODS

The present study was deemed exempt from approval by our hospital's institutional review board as it used non-identifiable information obtained from a publicly available national database.

Data Source

This study represents a retrospective cross-sectional secondary data analysis of the 1998-2011 Nationwide Inpatient Sample (NIS) files. Developed as a part of the Healthcare Cost and Utilization Project (HCUP) and sponsored by the Agency for Healthcare Research and Quality (AHRQ), the NIS represents the largest all-payer inpatient care database in the US [21]. Each annual sample contains patient-level data for approximately 7 to 8 million

inpatient stays from over 1,000 hospitals, representing a 20% stratified random sample of hospitals within each characteristic stratum. Numerical weights are included to provide national estimates of the data. Over 100 clinical and nonclinical data elements are available, including demographics, hospital characteristic, primary and secondary diagnoses, inpatient procedures, insurance type, discharge status, LOS, and total charges.

Study Population

All primary THA procedures performed from 1998 to 2011 were queried from the NIS using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure code 81.51 (n=3,175,456; weighted frequency) (Fig. 1). Elective primary adult cases were identified by sequentially excluding the following patient types: “non-elective” (i.e., emergency, urgent, newborn, trauma center, other) admission types, primary diagnosis of femoral neck fracture, primary diagnosis suggestive of previous and/or bilateral lower extremity arthroplasty, primary or secondary diagnoses indicating lower extremity malignancies and/or metastatic cancer, primary or secondary diagnoses indicating lower extremity pathologic fracture, and age less than 18 years (totaling n=387,708 excluded) (Fig. 1). The remaining 2,787,748 THA patients were classified by transplant history status. THA patients with a history of previous kidney, heart, lung, liver, and/or pancreas solid organ transplant (ICD-9-CM diagnosis codes V42.0, V42.1, V42.6, V42.7, V42.83, respectively) were identified. A control group of non-transplant THA patients was formed by excluding discharge records with any diagnosis suggestive of transplant, including that of the solid organs as well as tissue, bone, cornea, marrow, stem cells (Fig. 1).

Outcomes

The goal of this analysis was to examine the relative rates, resources used, and immediate risk associated with THA among patients with and without a history of solid organ transplant. First, the total prevalence of and annual trends in primary THA status post solid organ transplant were estimated. Overall comorbidity status between the two patient cohorts was summarized using the van Walraven modified Elixhauser composite score [22]. Additionally, the unadjusted and adjusted association between history of transplant and acute hospital complications, mortality, LOS, and admission costs were examined. A variety of hospital complications, modified from those published by Lin et al [23], D’Apuzzo et al [24], and Memtsoudis et al [25], were identified using specific definitions. Appendix 1 outlines the list of complications included and their respective diagnosis codes, procedure codes, or column value. “Any complication” was defined as one or more of these complications. Admission costs were calculated by multiplying the total charges by a hospital-specific cost-to-charge ratio provided by HCUP, and were inflation-adjusted to 2014 dollars [26].

Covariates

Covariates for statistical models included patient demographics (i.e., age group, sex, race, insurance), hospital characteristics (i.e., geographic region, urban/rural, size, and teaching status), and patient comorbidities. The covariates were defined as recorded by HCUP with a few category modifications to facilitate model formation [21]. Age was categorized into: 18-40 years, 41-50 years, 51-60 years, 61-70 years, 71-80 years, 81-90 years, and 91 years.

Race was categorized as White, Black, Hispanic, and other. Since approximately 25% of the discharge records did not have a race value, we created an additional race category and captured it as “Unknown Race.” Insurance status was categorized as Medicare, Medicaid, private, self-pay, and other. Comorbidities were identified and classified using the most recent revision of the AHRQ Elixhauser ICD-9-CM coding algorithm (Version 3.7) [27], an expansion of the original Elixhauser coding [28]. Cardiac arrhythmias was also calculated (omitted from Version 3.7) in order to include in the van Walraven modified Elixhauser composite score outcome. Three comorbidities were excluded from multivariable regression model analyses. Metastatic cancer was an exclusion criterion, and thus was not present in our cohort. Liver disease and renal failure categories were excluded from multivariable data analysis because their coding definitions include the respective transplant codes (V42.0, V42.7), and would present collinearity issues if included. Hospital urban/rural designation was based on Metropolitan Statistical Area designation prior to 2004, and based on Core Based Statistical Area designation from 2004 onward. The cut points for hospital bed size vary by geographic location, urban-rural designation, and teaching status [21].

Statistical Analysis

All analyses were performed using SAS System for Windows, Version 9.3 (SAS Institute Inc., Cary, NC). The distribution of data and descriptive statistics were calculated for all baseline variables included in the analyses. National frequency estimates were obtained using the discharge weights, accounting for the NIS stratified sampling scheme and clustering by hospital. Association between each baseline variable and transplant history was tested. Overall unadjusted complication rates, mortality, LOS, and admission costs were compared between transplant and non-transplant THA groups. Additionally, annual trends in LOS and admission costs were examined. Costs were adjusted for inflation based on real GDP chained to 2014 dollars. Univariate comparisons were made using Pearson’s chi-squared test for categorical variables and Student’s t-test for continuous variables.

Propensity score matching was used to adjust for any potential confounding due to baseline covariates predicting likelihood of a solid organ transplant [29-32]. First, we calculated a propensity score using a logistic regression model with solid organ transplant as the outcome, and all 57 baseline covariates (30 demographic/hospital characteristics, 27 comorbidities) listed in Figure 2 as the predictors. The log-transformed predicted probability of solid organ transplant was used as the propensity score. We then performed a 1:1 greedy match without replacement of solid organ transplant THA patients and control THA patients based on propensity score and a caliper of 0.1 times the standard deviation using the %GMATCH macro for SAS [33]. This process matched 1,310 unweighted cases in each group with similar propensity scores. Absolute standardized differences between transplant and non-transplant groups for all covariates were calculated before and after matching to assess covariate balance, and presented as a Love plot (Fig. 2) [34]. All post-match standardized differences were less than 10%, demonstrating substantial reduction of bias.

After propensity score matching, logistic regression models examined the effect of transplant history on the various acute hospital complications and the “any complication” outcome. The difference in outcome means for LOS and admission costs between the

matched transplant and non-transplant cohorts were evaluated using a paired t-test. Survey weights were not used in propensity score analysis because our goal here was not to provide national estimates, but to estimate the average effect of transplant on complication outcomes, costs, and LOS in our study sample. We also performed a stratified analysis of our outcomes by high (>100 per year) and low (<100 per year) hospital THA volume. A p-value of <0.05 was considered significant for all analyses.

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RESULTS

Between 1998 and 2011, a total of 2,787,748 elective adult primary THA cases meeting inclusion/exclusion criteria were estimated to have been performed in the US. Of these, 7,558 (0.27%) cases had a previous history of one or more solid organ transplant procedures. There was an increase in the annual number of transplant patients undergoing elective primary THA during the study period (48% increase; 444 to 658 cases/year), which was primarily driven by an increase in the total number of primary THA cases (non-transplant, 119% increase) (Table 1).

The distribution and descriptive statistics of the demographics and hospital characteristics for transplant and non-transplant THA groups are presented in Table 2. THA patients with a history of solid organ transplant were significantly younger than their non-transplant peers (53.2 years vs. 65.1 years; $p<0.001$). Also, THA status post-transplant was elevated among the following categories: males, Blacks and Hispanics, and Medicaid and private insurance. Furthermore, the majority of THA cases with a prior history of transplant occurred in urban (94.8%), large-sized (73.4%), and academic (70.3%) institutions, significantly higher rates than those for non-transplant THA cases (Table 2).

Transplant THA patients were significantly sicker than their non-transplant peers, with an elevated mean van Walraven modified Elixhauser composite score (7.43 vs. 1.22; $p<0.001$). The increased comorbidity score was significantly affected by the presence of liver disease and renal failure comorbidities among the transplant group. When these 2 comorbidities were excluded, the difference in mean composite scores between the two study cohorts decreased (transplant, 1.58; non-transplant, 1.03; $p<0.001$). The prevalence of hypertension, deficiency anemias, uncomplicated diabetes, fluid and electrolyte disorders, coagulopathy, and diabetes with chronic complications were substantially greater in the transplant THA cohort ($p<0.001$) (Figure 3). Conversely, chronic pulmonary disease, obesity, hypothyroidism, and depression were more common in the non-transplant THA group ($p<0.001$).

A summary of unadjusted rates for select inpatient complications and adverse events after THA, stratified by transplant history, is presented in Table 3. The overall unadjusted prevalence of 1 or more acute inpatient complications (i.e., any complication) following THA was greater in the transplant group (32.0%) than in the non-transplant group (22.1%; $p<0.001$). Due to the high frequency of allogenic blood transfusion relative to other complications, “any complication” was also evaluated excluding transfusion. Without transfusions, transplant patients still had significantly higher prevalence of a hospital complication after THA than their non-transplant peers (13.9% vs. 8.7%; $p<0.001$). In-hospital mortality was minimal, with similar rates (0.1%) in both study groups ($p=0.93$). The unadjusted annual trends for LOS and admission costs are illustrated in Figure 4. Mean LOS decreased and mean admission costs increased for both groups over the study period. Overall unadjusted calculations revealed that transplant patients had a greater mean LOS (4.47 days $\pm$ standard error [SE], 0.09) and mean costs (\$16,127 $\pm$ SE, 297) per THA admission than non-transplant patients (3.73 days $\pm$ SE, 0.01; \$14,860 $\pm$ SE, 81; $p<0.001$ for both).

Table 4 presents the results for acute complications, LOS, and admission costs after propensity score adjustment for patient demographics, hospital characteristics, and comorbidities. Inpatient mortality was not adjusted because it did not reach statistical significance in the unadjusted analysis and frequency was too low. Only individual complications with a weighted frequency ≥ 25 in the transplant group were included in the separate regression model. After controlling for confounders, history of transplant was associated with a 56% greater likelihood of a complication after THA (odds ratio [OR], 1.56; 95% confidence interval [CI], 1.32-1.86; $p<0.001$). This overall complication risk decreased slightly if blood transfusion was excluded (OR, 1.51; 95% CI, 1.18-1.93; $p<0.001$). Genitourinary complications (OR, 2.29) and allogenic blood transfusion (OR, 1.56) were noted to be significantly more likely to occur ($p<0.05$) in the transplant THA patients (Table 4). Additionally, history of transplant caused an overall increase in LOS of 0.64 days (95% CI, 0.38-0.90 days; $p<0.001$) and increased admission costs of \$887 (95% CI, \$262-\$1,512, $p=0.005$).

In stratified analysis by high- and low-volume hospitals, the mean cost difference for transplant patients was higher in high-volume (\$1,111; 95% CI, \$408-1814, $p=.002$) vs low-volume hospitals (\$418; 95% CI: -\$894 – \$1730, $p=.53$). The difference in LOS (0.76 days [0.54 – 0.98] vs 0.33 days [0.02 – 0.63]) was also higher in high-volume hospitals compared to low. The odds ratios of all complications were not meaningfully different across strata.

DISCUSSION

The purpose of this study was to better understand the relative rates, resources used, and early risk associated with THA among patients with and without a history of solid organ transplant. While THA cases post-transplant represent only a small population of all THAs performed annually in the US, the annual volume of this patient population is increasing. This study represents the largest investigation of this complex population to date.

Solid organ transplantation is a proven and effective treatment for end-stage organ disease and failure [2]. The success of these procedures is due in large part to improvements in surgical techniques and donor allocation, and perhaps more importantly, the development and efficacy of the immunosuppressant and immunomodulatory medications required to prevent graft-host rejection [2]. Medications commonly used include calcineurin inhibitors, corticosteroids, antimetabolites, and biologic therapy [35].

A review of the literature suggests results and outcomes with great variability. Several reports of successful THA status post solid organ transplant have been published, however the size of these studies is frequently small [10, 14, 17-19, 36]. Moreover, complication rates have been reported to range from zero to “significant,” making risk-benefit-analyses difficult [13, 17, 37]. The findings of the present study complement those of Klatt et al [12], who found that in solid organ transplant patients undergoing total knee arthroplasty, 9 out of 23 patients (39.1 %) presented with one or more complications and 4 out of 23 patients (17.3%) presented with infections. Our results also suggest that there are differences in blood loss and LOS in transplant recipients compared to non-transplant patients. Unlike our results, Levitsky et al [38] reported that in the 12 patients in their study who underwent liver transplantation and THA, the average blood loss was 185 CC (range, 100 to 250) and average LOS was 7 days (range, 3 to 14), which was comparable to THA performed in healthy immunocompetent individuals.

There are several notable limitations to this study. The NIS database is a retrospective, secondary data source and only provides inpatient data for the present admission only. There are no primary identifiers available to be able to discern any details regarding a patient prior to or after the admission of interest. Any complications or readmissions thereafter are not accounted for and therefore not available for inclusion in these data analyses. Additionally, the NIS relies heavily on ICD-9-CM codes, which were not designed for research and surveillance purposes, which has been noted in the literature as causing miscoding and undercoding for certain variables [39, 40]. The NIS only includes total cost of a stay, and not the individual cost components. Therefore, it is not possible to separate out which costs are related to extra bed days in the hospital and which are related to other factors.

The present study hypothesized that transplant recipients undergoing THA would have increased cost and LOS. While the analysis did not reveal a significant inpatient cost difference after adjusting, it did show a significant difference in LOS and certain acute complications.

CONCLUSION

The trends from this study require monitoring as THA patients post-transplant have statistically greater odds of inpatient complications, longer LOS, and increased admission costs than their non-transplant peers. While these data support that THA in the transplant population can be performed safely and have a significant impact on quality of life, these results will better enable arthroplasty surgeons to counsel patients given the size of this study compared to those available in the literature. Surgeons should be cautious of potential elevated early complication risk in this population, particularly infection and transfusion.

Post-discharge and long-term outcomes of this patient population need to be examined further, particularly complications, to examine if early outcomes translate to increased rate of revision of THA. Lastly, the results of this study are useful in informing guidelines for increases in cost and resources, especially levels of reimbursement and bundled payments for high-risk patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1.

Schematic representation of study cohort development, including inclusion and exclusion definitions and codes. Note: Numbers in the figure are adjusted to the weighted national frequencies. Three- and four-digit diagnosis and procedure codes include all respective four- and five-digit codes, unless otherwise specified. Abbreviations: ASOURCE – admission source; ATYPE – admission type; CM_METS – metastatic cancer comorbidity; DX – ICD-9-CM diagnosis codes, principal (DX1) and secondary (DX2-DX25); PR – ICD-9-CM procedure codes, principal (PR1) and secondary (PR2-PR15).

Fig. 2.

Love plot illustrating absolute standardized differences for all patient and hospital characteristics before and after propensity score matching between subjects with and without a history of solid organ transplant. Note: Value for the pre-match linear propensity score (150%) falls outside the scale of the graph.

Fig. 3.

Prevalence of comorbidities in transplant and non-transplant THA patient cohorts (1998-2011). Note: Comorbidities with prevalence < 1% are omitted from figure. *Denotes statistically significant (<0.001) univariate comparison.

Fig. 4.

Unadjusted annual trends of (a) mean length of stay and (b) mean cost per admission in transplant and non-transplant THA patient cohorts (1998-2011). Note: Cost-to-charge ratio is not available 1998-2000. Standard error bars for non-transplant cohorts are plotted, but may be too small to be visible for some years.

Table 1

Annual Frequency of Primary THA Status Post Solid Organ Transplant vs. Non-Transplant (1998-2011)

	Solid Organ Transplant		Non-Transplant	
Year	Frequency	Weighted Frequency ^a	Frequency	Weighted Frequency ^a
1998	81	444	24,694	125,359
1999	89	443	26,398	129,338
2000	103	510	28,383	138,769
2001	91	461	32,081	160,670
2002	110	517	36,764	175,250
2003	94	451	35,723	172,643
2004	115	558	40,603	197,356
2005	110	550	42,158	206,388
2006	123	592	41,444	201,275
2007	123	604	46,457	224,406
2008	116	569	50,345	246,766
2009	124	620	50,254	253,225
2010	116	581	53,821	267,428
2011	138	658	57,064	274,070
Overall (all years)	1,533	7,558	566,189	2,772,943

^aWeighted frequencies provide national estimates derived from the Nationwide Inpatient Sample.

Table 2

Patient Demographics and Hospital Characteristics of Primary THA Status Post Solid Organ Transplant vs. Non-Transplant

	Solid Organ Transplant N = 7,558		Non-Transplant N = 2,772,943		
Variable	Frequency ^a	% of Transplant	Frequency ^a	% of Non- Transplant	P Value
Age (mean, SD), yr	53.2, 12.8	-	65.1, 12.7	-	<0.001
Age Group ^b					<0.001
18-40 yr	1,313	17.4%	97,132	3.5%	
41-50 yr	1,648	21.8%	270,129	9.7%	
51-60 yr	2,269	30.0%	584,915	21.1%	
61-70 yr	1,820	24.1%	769,628	27.8%	
71-80 yr	468	6.2%	761,538	27.5%	
81 yr	40	0.5%	289,600	10.4%	
Sex					<0.001
Male	4,698	62.2%	1,210,485	43.7%	
Female	2,860	37.8%	1,556,351	56.1%	
Missing	0	0%	6,107	0.2%	
Race					<0.001
White	4,117	54.5%	1,847,967	66.6%	
Black	892	11.8%	134,790	4.9%	
Hispanic	402	5.3%	62,808	2.3%	
Other ^c	284	3.8%	60,368	2.2%	
Unknown Race	1,863	24.6%	667,010	24.1%	
Insurance					0.05
Medicare	3,971	52.5%	1,478,623	53.3%	
Medicaid	288	3.8%	84,387	3.0%	
Private	3,164	41.9%	1,117,855	40.3%	
Self-Pay	24	0.3%	20,451	0.7%	
Other ^c	111	1.5%	66,054	2.4%	

Variable	Solid Organ Transplant N = 7,558		Non-Transplant N = 2,772,943		P Value
	Frequency ^a	% of Transplant	Frequency ^a	% of Non-Transplant	
Missing	0	0%	5,573	0.2%	0.42
Hospital Region					
Northeast	1,522	20.1%	578,920	20.9%	
Midwest	1,964	26.0%	742,219	26.8%	
South	2,549	33.7%	864,001	31.2%	
West	1,523	20.2%	587,803	21.2%	
Hospital Location					<0.001
Rural	386	5.1%	295,695	10.7%	
Urban	7,162	94.8%	2,469,405	89.1%	
Missing	10	0.1%	7,843	0.3%	
Hospital Bed Size					<0.001
Small	669	8.9%	412,300	14.9%	
Medium	1,334	17.7%	669,037	24.1%	
Large	5,545	73.4%	1,683,763	60.7%	
Missing	10	0.1%	7,843	0.3%	
Hospital Teaching					<0.001
Non-Teaching	2,235	29.6%	1,449,447	52.3%	
Teaching	5,313	70.3%	1,315,653	47.4%	
Missing	10	0.1%	7,843	0.3%	

^a Presented frequency values are weighted to provide national estimates, 1998-2011.

^b 81-90 years and 91 categories were collapsed to protect patient confidentiality due to small n.

^c Other Race = Asian/Pacific Islander, Native American, and Other; Other Insurance = No Charge, Other

Frequency of Select^a Acute Complications and Adverse Events Following Primary THA Status Post Solid Organ Transplant vs. Non-Transplant

Table 3

Complication	Solid Organ Transplant N = 7,558		Non-Transplant N = 2,772,943		P Value
	Frequency ^b	% of Transplant	Frequency ^b	% of Non-Transplant	
<i>Mechanical complications</i>					
Dislocation of prosthetic joint	25	0.33%	2494	0.09%	0.002
<i>Procedure-related complications</i>					
Cardiac, including acute myocardial infarction	75	0.99%	27566	0.99%	0.97
Peripheral vascular	14	0.19%	2367	0.09%	0.16
Respiratory	81	1.07%	18779	0.68%	0.07
Gastrointestinal	69	0.91%	21742	0.78%	0.58
Genitourinary, including acute renal failure and urinary tract infection	668	8.84%	105555	3.81%	<0.001
Bleeding (hemorrhage, hematoma, seroma, hemarthrosis)	144	1.90%	30061	1.08%	0.003
Postoperative infection	59	0.78%	4721	0.17%	<0.001
<i>Other adverse events</i>					
Cellulitis	44	0.58%	3720	0.13%	<0.001
Pneumonia	45	0.59%	12388	0.45%	0.41
Pulmonary embolism	16	0.21%	5337	0.19%	0.90
Pulmonary insufficiency after trauma and surgery/adult respiratory distress syndrome	25	0.33%	5994	0.22%	0.35
Lower extremity venous thrombotic events	15	0.20%	3956	0.14%	0.56
Allogeneic blood transfusion	1751	23.17%	454810	16.40%	<0.001
Incision and debridement	11	0.15%	4064	0.15%	0.99

^aIndividual complications with frequency < 11 in the transplant group are omitted from table.^bPresented frequency values are weighted to provide national estimates, 1998-2011.

Table 4Effect of Transplant History on Outcomes among Primary THA Patients, after Propensity Score Matching ^a

Variable	Difference in Means ^b	95% CI	P Value
LOS, days	+0.64	0.38 - 0.90	<0.001
Cost per admission, \$	+887	262 –1,512	0.005
	Odds Ratio^c		
Any complication	1.56	1.32 – 1.86	<0.001
Any complication, excluding allogenic blood transfusion	1.51	1.18 –1.93	<0.001
Cardiac, including acute MI	1.00	0.46 – 2.17	0.99
Respiratory	2.41	0.85 – 6.87	0.09
Gastrointestinal	1.22	0.51 - 2.96	0.65
Genitourinary, including ARF and UTI	2.29	1.62 – 3.27	<0.001
Bleeding (hemorrhage, hematoma, seroma, hemathrosis)	0.94	0.48 – 1.84	0.87
Postoperative infection	3.02	0.97– 9.38	0.06
Cellulitis	3.01	0.81 - 11.16	0.10
Pneumonia	1.60	0.52 – 4.92	0.41
Allogenic blood transfusion	1.56	1.29 – 1.89	<0.001

^a Analysis was conducted on the propensity score matched sample (n=1,310 unweighted cases).^b LOS and cost outcomes were calculated as the difference in means between transplant patients and non-transplant patients.^c Complication outcomes were measured as odds ratios comparing transplant vs. non-transplant patients, and were obtained from logistic regression. Individual complications with weighted frequency < 25 in the transplant group are omitted from table.

Abbreviations: ARF – acute renal failure; CI – confidence interval; LOS – length of stay; MI – myocardial infarction; UTI – urinary tract infection