Arthroplasty Today 25 (2024) 101294

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original Research

In-Hospital Complications and Costs of Simultaneous Bilateral Total Hip Arthroplasty: The Case for Selection and Potential Cost Savings

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ARTICLE INFO

Article history:
Received 2 May 2023
Received in revised form
19 October 2023
Accepted 3 November 2023
Available online xxx

Keywords:
Bilateral hip arthroplasty
Simultaneous
Staged
National inpatient sample
Outcome

ABSTRACT

Background: Published comparisons between bilateral and unilateral total hip arthroplasty (THA) remain controversial regarding the potential risks and benefits. Our objectives were to compare (1) postoperative complications and (2) resource utilization of patients having simultaneous bilateral THA with patients having unilateral procedures.

Methods: The Nationwide Inpatient Sample was used to identify patients undergoing primary elective THA from January 2016 to December 2019. Complications and costs were compared between unilateral and simultaneous bilateral patients. Binary logistic regression analysis controlling demographics, comorbidities, and the primary diagnosis was performed to compare the cohorts of unilateral and bilateral patients.

Results: Nine thousand nine hundred fifty-five Bilateral procedures and 785,609 unilateral procedures were identified. Patients with bilateral procedures were at increased risk for many medical complications including gastrointestinal complications (OR: 4.1; 95% CI: 2.4-6.9, $P < .01$), postoperative blood transfusions (OR: 3.6; 95% CI: 3.3-3.9, $P < .01$), and pulmonary embolisms (OR: 3.2; 95% CI: 2.0-5.1, $P < .01$). Patients with bilateral procedures were also at increased risk for joint complications, including periprosthetic fractures (OR: 7.4; 95% CI: 5.2-10.5, $P < .01$) and other mechanical complications (OR: 27.0; 95% CI: 23-30, $P < .01$). These patients also incurred higher index hospitalization costs ($25,347 vs $16,757, $P < .001$) and were discharged more commonly to a rehabilitation facility (17.8% vs 13.4%, $P < .001$).

Conclusions: Bilateral THA are at increased risk of developing postoperative complications despite being younger and having fewer comorbidities on average when compared with unilateral patients. While bilateral patients had a higher index hospitalization cost, the overall cost of one episode of care is lower than two separate hospitalizations.

Introduction

Hip osteoarthritis is one of the most common orthopaedic disorders worldwide and affects millions of adults [1]. As many as 42% of individuals with hip osteoarthritis have bilateral disease [1]. Total hip arthroplasty (THA) is reported to be one of the most beneficial procedures for improving both function and quality of life in the aging population [2,3]. Estimates have determined that within 10 years, 16%-24% of individuals undergoing a unilateral THA will eventually require the procedure on the contralateral side [2,4]. Of those individuals, 10% will undergo the procedure on the contralateral side the very next year [3,5].

Although simultaneous bilateral THAs are increasing in popularity, there is still controversy regarding the safety of the procedure [1,4]. Arguments in favor of simultaneous bilateral THA include decreased health-care costs, shorter rehabilitation times, and benefits of a single anesthesia event [4,6–8]. Additionally, studies have reported that simultaneous bilateral THA is more effective than staged THA because it allows for improvement in bilateral hip motion concurrently and an overall improved recovery [4,9]. However, complications include increased intraoperative blood loss as well as increased rates of perioperative blood transfusion, thromboembolic disease, cardiopulmonary complications, infections, and mortality [1,4,10,11].

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https://doi.org/10.1016/j.artd.2023.101294

Literature comparisons between bilateral and unilateral THAs are limited and not widely generalizable, as many of the studies have been limited to single centers, one database, or included a relatively small sample size. There are currently no clear guidelines regarding patient selection for bilateral simultaneous THAs, though some recommendations exist based on the available evidence [12–15]. The purpose of this study is to utilize a large national database to compare postoperative complications and resource utilization in patients having simultaneous THA compared with a cohort of patients having unilateral procedures. We hypothesize that patients undergoing simultaneous bilateral THA will incur less overall hospital costs but result in greater surgical complications.

Material and methods

The Nationwide Inpatient Sample (NIS) database was used to identify patients undergoing primary hip arthroplasty from January 2016 to December 2019. The study performed was institutional review board-exempt. The NIS is a stratified survey of hospitals conducted by the Federal Healthcare Cost and Utilization Project, for which hospitals are selected to approximate a 20% stratified sample of United States community hospitals with discharge summaries to develop national estimates. The large size of the database makes the NIS especially useful for epidemiological studies related to specific procedures or diseases at the national level [16,17]. We selected this as our database to ensure that our results would be widely generalizable on a large scale.

Using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) procedure codes, 795,645 patients were identified who underwent elective primary hip arthroplasty. Of these, 785,690 (98.7%) underwent a unilateral THA during the study period. Additionally, 9955 (1.3%) had a secondary primary hip arthroplasty procedure on day 1 and were considered to have had same-day simultaneous, bilateral surgeries. Patients with secondary primary hip arthroplasty on days other than day 1 were considered staged bilateral THA and were excluded. The unilateral and simultaneous THA groups were compared to one another using basic demographic variables including age, sex, race, ethnicity, Charlson comorbidity scores [18], and primary diagnoses. Postoperative complications and resource utilization were then compared between these groups for the length of their hospital stay.

To measure resource consumption, the cost of inpatient care for each discharge was estimated by multiplying total hospital charges by the cost-to-charge ratios (CCRs) available in the NIS. Hospital-specific all-payer inpatient CCRs were used when available. Per the user guide for NIS CCRs, group average all-payer inpatient CCRs were used when all-payer inpatient CCR values were unavailable. Group average all-payer inpatient CCR is a weighted average for the hospitals in peer groups (defined by 4 dimensions: state, urbanicity, ownership, and bed size), using the proportion of each hospital's beds relative to its peer group as the weight for each hospital. Costs were adjusted for inflation to 2019 USD based on consumer price index. Costs and length of stay (LOS) (days) were used as measures of resource utilization following THA. Discharge disposition (home vs rehabilitation facility) was used as an indirect measure of post-discharge resource consumption. To identify in-hospital post-operative complications, ICD-10-CM and ICD-10-PCS codes were used in any of the 40 secondary diagnosis fields. Postoperative complications included myocardial infarction (I21.XX), respiratory complications (J95.XX, J96.XX, J98.XX), gastrointestinal complications (K91.XX, K56.0, K59.00), renal failure (N99.0, N17.XX, N19), postoperative urinary tract infection (N39.0), postoperative urinary retention (R338, R339), postoperative anemia (D62), postoperative blood transfusion (30233N1), pulmonary embolism [19], deep vein thrombosis [19], postoperative infection (T814, T8140, T8140XA, T8141, T8141XA, T8142, T8142XA, T8143, T8143XA, T8144, T8144XA, T8149, T8149XA, T845, T8450, T8450XA, T8451, T8451XA, T8452, T8452XA, T8453, T8453XA, T8454, T8454XA, T8459, T8459XA), and in-hospital mortality (coded within the NIS). Orthopaedic-specific postoperative complications were also evaluated and included hip dislocations (T84020, T84020A, T84021, T84021A), intraoperative fractures (M9665, M96661, M96662, M96669), periprosthetic fractures (M970, M9701, M9701XA, M9702, M9702XA, M971, M9711, M9711XA, M9712, M9712XA), and other mechanical complications (T84090, T84090A, T84091, T84091A, T84092, T84092A, T84093, T84093A).

All statistical analyses were performed using SPSS version 28 for Windows (IBM Corp, Armonk, NY). Binary logistic regression analysis controlling for age, gender, race, ethnicity, comorbidities, and primary diagnosis was performed. Descriptive statistics were obtained for all variables used in the study. Missing values were excluded for the purpose of the analyses. Independent sample t-tests and Pearson's chi-squared analyses were used for bivariate comparisons. A multivariate modeling logarithmic transformation was used to examine the risk-adjusted patients. Odds ratios (ORs) were calculated with their respective 95% confidence intervals (CIs). Statistical significance was set at $P < .05$.

Results

A total of 9955 (1.3%) simultaneous bilateral procedures were compared with 785,609 (98.7%) unilateral procedures for this analysis. A comparison of the patient demographics was performed to evaluate the patients' baseline characteristics prior to the procedure (Table 1). Bilateral patients were more often younger, male, non-White, had lower Charlson scores, and were more likely to undergo surgery for secondary causes of osteoarthritis (Table 1).

Patients undergoing bilateral procedures were at a statistically increased risk for many in-hospital medical complications including respiratory (OR: 1.8; 95% CI: 1.5-2.2, $P < .01$), gastrointestinal (OR: 4.1; 95% CI: 2.4-6.9, $P < .01$), renal (OR: 1.3; 95% CI: 1.1-1.6, $P < .01$), urinary tract infection (OR: 1.2; 95% CI: 1.0-1.5, $P < .04$), urinary retention (OR: 1.2; 95% CI: 1.1-1.4, $P < .01$), postoperative anemia (OR: 1.5; 95% CI: 1.4-1.6, $P < .01$), postoperative blood transfusion (OR: 3.6; 95% CI: 3.3-3.9, $P < .01$) and pulmonary

Table 1
Patient demographics among unilateral and bilateral total hip arthroplasty in the National Inpatient Sample (NIS 2016-2019).

Characteristic	Unilateral n = 730,630 % (n)	Bilateral n = 9955 % (n)	*P*-value
Age (years ± SD)	66 ± 10	61 ± 11	<.01
Gender			<.01
Male	44.9 (353,080)	52.6 (5235)	
Female	55.1 (432,495)	47.4 (4720)	
Race			<.01
White	83.5 (655,715)	81.8 (8140)	
African American	6.7 (52,490)	7.4 (740)	
Ethnicity			<.01
Hispanic	3.1 (24,580)	3.9 (390)	
Charlson score			<.01
No comorbidities	67.0 (526,170)	74.0 (7365)	
1 or more	33.0 (259,520)	26.0 (2590)	
Primary diagnosis			
Primary OA	91.9 (722,045)	86.2 (8585)	<.01
DDH	0.7 (5715)	2.0 (200)	<.01
Secondary OA	2.0 (15,690)	3.4 (340)	<.01
Osteonecrosis	4.9 (38,590)	7.2 (720)	<.01
Inflammatory	0.5 (3650)	1.1 (110)	<.01

OA, osteoarthritis.

embolism (OR: 3.2; 95% CI: 2.0-5.1, $P < .01$). Patients with bilateral procedures were also at a statistically increased risk for many orthopaedic-specific complications including intraoperative fractures (OR: 2.1; 95% CI: 1.6-2.6), periprosthetic fractures (OR: 7.4; 95% CI: 5.2-10.5) and other mechanical complications (OR: 71; 95% CI: 23-30) (Table 2). All $P < .01$.

Patients undergoing bilateral procedures accumulated greater hospital costs (USD 25,347 vs USD 16,757, $P < .001$) with an absolute difference of USD 8590. In the bilateral group, the LOS was higher on average (2.28 days vs 1.84 days, $P < .001$) along with a discharge rate to a rehabilitation facility (17.8% or 1775 individuals vs 13.4% or 105, 560 individuals, $P < .001$) (Table 3).

Table 3
Mean and relative cost associated with bilateral compared to unilateral patients undergoing THA.

Resource	Unilateral n = 730,630 mean/median (range)	Bilateral n = 9955 mean/median (range)	*P*-value
Total cost (USD)	16,757 ± 9579	25,347 ± 20,451	<.001
Length of stay (days)	1.84 ± 1.26	2.28 ± 1.42	<.001
Disposition	n (%)	n (%)	
Home	86.5 (679,435)	82.2 (8180)	<.001
Rehabilitation facility	13.4 (105,560)	17.8 (1775)	<.001

Median was used for total costs. Total costs were adjusted for inflation to 2019 US dollars.

Discussion

Indications for simultaneous bilateral THA remain a controversial topic, as the potential cost benefit may be outweighed by the risk of potential postoperative complications when compared to unilateral THA. Utilizing the NIS as a nationally representative database, this study conducted a comparison of the in-hospital complication rates between patients undergoing simultaneous bilateral THA vs unilateral THA procedures and found that patients undergoing simultaneous bilateral THA are at increased risk of developing important postoperative complications when compared to patients undergoing unilateral THA procedures.

The literature has demonstrated that patients who undergo simultaneous bilateral THA are often younger and have fewer comorbidities at baseline than those undergoing unilateral or staged THA [20]. This is the case in our study, where the patients undergoing bilateral simultaneous THA were significantly younger (66 years vs 71 years, $P < .01$) and had lower Charlson comorbidity scores (26 vs 33, $P < .01$). Other notable differences included gender, race/ethnicity, and primary diagnosis. These differences in the baseline characteristics were addressed using binary logistic regression analysis controlling for age, gender, race, ethnicity, comorbidities, and primary diagnosis. Interestingly, despite being younger in age with fewer comorbidities at baseline, the results of our analysis demonstrate that patients who undergo simultaneous bilateral THA have increased odds of developing in-hospital medical postoperative complications and orthopaedic-specific postoperative complications and have higher resource utilization when compared to patients who underwent unilateral THA. Of note, in our cohort of patients who underwent simultaneous bilateral THA, there were no reports of deep vein thromboses, postoperative infections, or death.

The safety and efficacy of simultaneous bilateral THA compared to unilateral THA are inconclusive. This may be partly due to many studies reported in the literature are single-institutional retrospective studies, thus limiting the variability of the population, surgeon, preoperative and postoperative protocols, and procedural techniques [1–5,21,22]. Our study is one of a handful that utilizes a national database registry to obtain data from multiple institutions and mitigates these concerns by minimizing selection bias. To the authors' knowledge, this is one of the largest, most recent database studies on this topic and takes into consideration both medical and orthopaedic-specific postoperative complications. In addition, this is the first study to analyze specific in-hospital complications, mortality, and cost of care after simultaneous bilateral THA in a large contemporary cohort using the NIS database.

A few studies in the literature have demonstrated no difference in complication rates in patients after simultaneous bilateral THA compared to patients with unilateral THA ([2,6,15,22–26]). Several other studies have shown increased rates of both mortality and complications after simultaneous bilateral THA ([1,6,15,20–22,27]). A study by Rasouli et al used the NIS database and analyzed an unmatched cohort from 2002-2010 of simultaneous bilateral THAs vs staged THAs in the same admission to compare the rates of medical complications and mortality [20]. They reported that simultaneous bilateral THA was associated with an increased risk of systemic complications (OR 2.1; 95% CI: 1.94-2.26, $P < .001$). Although our study compares simultaneous bilateral THA to unilateral THA, our results also show increased complications in the

Table 2
Risk of postoperative complications for bilateral patients compared to unilateral patients after THA.

Complication	Unilateral % (n)	Bilateral % (n)	OR (95% CI)	*P*-value
Myocardial infarction	0.1 (645)	0.1 (10)	1.6 (0.8-3.1)	.10
Respiratory complications	0.8 (5990)	1.3 (125)	1.8 (1.5-2.2)	<.01
Gastrointestinal complications	<0.1 (330)	0.2 (15)	4.1 (2.4-6.9)	<.01
Renal failure	1.5 (11,415)	1.6 (160)	1.3 (1.1-1.6)	<.01
Postoperative UTI	0.7 (5845)	0.8 (75)	1.2 (1.0-1.5)	.04
Postoperative urinary retention	1.9 (14,770)	2.2 (220)	1.2 (1.1-1.4)	<.01
Postoperative anemia	16.8 (131,780)	22.3 (2220)	1.5 (1.4-1.6)	<.01
Postoperative blood Tx	1.9 (14,795)	5.8 (575)	3.6 (3.3-3.9)	<.01
Pulmonary embolism	0.1 (510)	20 (0.2)	3.2 (2.0-5.1)	<.01
DVT	0.1 (580)	0	N/A	N/A
Postoperative infection	<0.1 (80)	0	N/A	N/A
Hip dislocations	0	0	N/A	N/A
Intraoperative fractures	0.4 (3335)	0.9 (85)	2.1 (1.6-2.6)	<.01
Periprosthetic fractures	<0.1 (390)	35 (0.4)	7.4 (5.2-10.5)	<.01
Other mechanical complications	0.1 (940)	3.2 (320)	27 (23-30)	<.01
Mortality	0.03 (210)	0	N/A	N/A

Binary logistic regression analysis controlling by age, gender, race, ethnicity, comorbidities and primary diagnosis.
UTI, urinary tract infection.

bilateral simultaneous THA cohort, such as having an OR of 1.5 for postoperative anemia, 3.6 for postoperative blood transfusions, and 3.2 for pulmonary embolism to name a few. Other complications such as intraoperative fractures and periprosthetic fractures in the simultaneous bilateral THA cohort could be attributable to the increased surgical time and associated surgeon fatigue.

Other studies have used different administrative databases, such as the National Surgical Quality Improvement Program database, the English National Health Service Database, and the European IDES Hip Registry database, to address postoperative complications in a cohort of patients [23,27,28]. Morcos et al used the National Surgical Quality Improvement Program database to compare a medium-sized cohort of 575 simultaneous procedures to a matched cohort of 2290 unilateral total hip procedures. They matched based on age, sex, and American Society of Anesthesiologists scores [23]. They showed that there are similar odds of having a major complication after simultaneous bilateral THA compared to unilateral THA (OR 0.72; CI: 0.41-1.24, $P = .24$). Partridge et al used the English National Health Service Database to compare postoperative complications between simultaneous and staged bilateral THA in England [27]. Similar to our study, they found worse outcomes after simultaneous bilateral THA, where patients had a higher risk of pulmonary embolism, myocardial infarction, renal failure, chest infection, and in-hospital death when compared to staged procedures. In contrast to our study, they found that simultaneous THA had a significantly shorter hospital stay than unilateral THA (8.9 vs 10.4 days, $P < .001$) [27]. Aghayev et al performed a post hoc analysis of prospectively collected data between the years 1965 and 2002 to assess complications and functional outcomes between simultaneous and staged bilateral THA [28]. Unlike other studies, they found that the frequency of postoperative local and systemic complications was the lowest in simultaneous bilateral THA when compared to unilateral staged procedures and that the highest rate of complications was observed in patients with a staged procedure taking place between 6 months and 5 years [28]. It is known that different databases incorporate data from different institutions making observations that are seen across multiple large databases very valuable. Our results mostly support the results of Partridge et al, although there are certain elements that are congruent with each study [23,27,28]. The lack of consensus between these database reviews illustrates the importance of continued studies to provide insight on this controversial topic.

From a monetary perspective, our results show that total hospital costs, LOS, and indirect measures of resource consumption were higher in the simultaneous bilateral THA cohort for that individual hospitalization. A study by Lorenze et al performed an analysis of total hospital charges submitted to the insurance companies comparing unilateral and bilateral simultaneous THA [24]. They found that there was a significant 24% reduction ($P < .05$) in charges for each case if simultaneous bilateral THA was done [24]. Our results support these findings and show that bilateral simultaneous THA likely offers cost savings when compared to unilateral THA. The cost of a single hospitalization for simultaneous bilateral THA was USD 25,347, whereas 2 separate hospitalizations would result in a total cost of USD 33,514, a cost savings of USD 8167. These findings are supported by Rasouli et al, who found that hospital costs are significantly higher in cases of staged bilateral THA when compared to unilateral and simultaneous procedures ($P < .001$) [20]. This evidence becomes useful when considering the prevalence of bilateral disease; up to 24% of patients are reported to have bilateral disease and will likely need a hip replacement on the contralateral side at some point in their lifespan [3,4]. Other studies have demonstrated that a simultaneous procedure can be considered cost-effective and functionally efficacious due to the aggregate shorter recovery time as well as shorter overall rehabilitation time and need for only a single anesthesia event [7,8,15,21]. However, our analysis differs due to the longer LOS and higher proportion of nonhome discharges that were observed.

Many of the limitations of our study are inherent to the analysis of large administrative databases such as the NIS. Incomplete data collection, uncertain compliance and accuracy of coding related to diagnosis and procedure performed, and a lack of detailed clinical information are all valid concerns. Due to the properties of the NIS, our analyzed complications may only reflect those incurred during the index hospitalization and fail to capture the entire postoperative period. We are also limited to what data are available for analysis; for example, we are unable to determine the duration of the surgical procedure, if the surgery was performed truly simultaneously (by 2 surgeon teams), or staggered within the same anesthesia event (by single surgeon team). Staged bilateral procedures were also excluded from this analysis due to the inherent in-hospital perspective of the NIS. Since the NIS does not have the capability to track patients across multiple hospitalizations, a true comparison of staged vs simultaneous bilateral procedures is not possible. While the NIS can identify staged procedures during an index hospitalization, these are declining in popularity and would not provide a meaningful comparison. In Rasouli et al, staged procedures during the index hospitalization historically only comprised about 10% of their bilateral cohort and saw year-over-year decreases from 2006 to 2010. Additionally, since this is a large national database study, there is no data on variables related to arthroplasty procedures: type of prosthesis, surgical approach, functional outcomes, anticoagulation protocols, or postoperative rehabilitation and physical therapy protocols. Future studies may want to adjust for these factors to see, ultimately, how they affect outcomes. Another consideration is that patients with bilateral osteoarthritis who require bilateral surgery but are too sick or at high risk for the simultaneous procedure demonstrate a clinical limitation of this study, as the NIS database does not provide information regarding the indication for bilateral vs unilateral procedures.

Conclusions

Patients undergoing simultaneous bilateral THA are at increased risk of developing important postoperative complications despite being younger and having fewer comorbidities on average when compared with patients undergoing unilateral THA. Although patients who undergo a simultaneous bilateral THA have higher hospitalization costs, the amount is less than 2 separate hospitalizations considering that many unilateral procedures require the contralateral side. This data highlights the importance of careful and diligent patient selection, optimization for bilateral THA, and the potential risks and benefits of the procedure.

Conflicts of interest

M. D'Apuzzo is a paid consultant for Zimmer Biomet; receives research support from Orthopaedic Research and Education Foundation; and is a board/committee member of American Academy of Orthopaedic Surgeons, Florida Orthopaedic Society, and Miami Orthopaedic Society. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101294.

Author contributions

Gireesh Reddy contributed to writing – review and editing, writing – original draft, validation, supervision, methodology,

investigation, and conceptualization. Michele D'Apuzzo contributed to writing – review and editing, writing – original draft, supervision, methodology, investigation, formal analysis, data curation, and conceptualization. Ramakanth Yakkanti contributed to writing – review and editing, writing – original draft, validation, methodology, investigation, and conceptualization. Alina Syros contributed to writing – review and editing and writing – original draft.

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