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Complication rates of bilateral total hip versus unilateral total hip arthroplasty are similar

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ABSTRACT

Objective: Utilize a nationwide database to identify and compare the differences between patient demographics and clinical outcomes for patients undergoing simultaneous bilateral total hip arthroplasty (THA) and unilateral THA.

Methods: A nationwide administrative claims database was utilized; In-hospital, 90-day, and 1-year post-discharge rates of local and systemic complications were collected and compared with multivariate logistic regression.

Results: Incidence of prosthetic joint infection was significantly lower in the bilateral cohort. Length of stay was significantly shorter in the unilateral THA cohort.

Conclusion: Surgeons should consider simultaneous bilateral THA a safe and effective procedure for low risk patients with appropriate comorbidities.

1. Introduction

With the incidence of end-stage osteoarthritis expected to increase with the ageing population, total hip arthroplasty (THA) continues to improve the quality of life and help maintain independence in this patient population.[1–4] While THA remains one of the most successful orthopedic surgeries currently performed with a greater than 95% survival at 10 years postoperatively, there remains hesitancy amongst providers when considering a simultaneous bilateral THA (SimBTHA).[2–5] With the growing number of candidates for THA, the incidence of the procedure is predicted to increase to 635,000 procedures annually by 2030.[5] This increase should directly translate into an increase in the number of candidates for bilateral THA.

A large proportion of patients who receive unilateral THA eventually require contralateral treatment as forty-two percent of patients with arthritis of the hip have bilateral disease.[6–8] Earlier studies on SimBTHA demonstrated an association with increased blood loss, thromboembolic events, and cardiopulmonary issues.[9] However, recent studies suggest SimBTHA can lead to overall reduced length of hospital stay, improved cost effectiveness, less anesthetic, and shorter total surgical time compared to staged procedures.[10–12]

With the increase in volume of THA expected and contrasting results regarding safety and outcomes of bilateral verses single THA, this study aimed to utilize a nationwide cohort to compare the differences in rates of local and systemic complications between patients receiving primary unilateral THA and primary SimBTHA. This data can assist physicians on deciding who is an appropriate candidate for SimBTHA and highlight which patients pose an increased odds risk for complications.

2. Methods

Patient records were queried from PearlDiver (PearlDiver Inc, Fort Wayne, IN, USA), a commercially available administrative claims database, using International Classification of Diseases, Ninth Revision and Tenth Revision (ICD-9/ICD-10). This study used the MHip dataset which contains the medical records of two million THAs from 2010 through Q2 of 2018. It is inclusive of all payors. Institutional review board exemption was granted for this study due to the provided data being deidentified and compliant with the Health Insurance Portability and Accountability Act.

A retrospective cohort design was used to compare patients who received primary bilateral THA versus patients with a single primary THA. Patients were identified by ICD-10 codes rather than Current Procedural Technology (CPT) codes due to the former including

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temporal data detailing a patient's hospital course and allowing isolation of laterality while the latter does not. Exclusion criteria included patients with a pathologic or traumatic fracture, and those who had revision THA miscoded as a primary THA. Patients were placed into the "SimBTHA" cohort if they received a primary right and left THA simultaneously. "Unilateral THA" cohort patients were identified as having either a primary left or right THA, but not both simultaneously (Fig. 1). The ICD codes defining the study groups are provided in Appendix Table A1.

Each cohort was queried for basic demographic information, clinical characteristics, and hospital course data such as age, sex, hospital region, body mass index (BMI), length of stay (LOS), 90-day readmission rate, and Charlson comorbidity index (CCI). Regional data were categorized based on the United States Census Bureau classification of Northeast, Midwest, South, and West. Specific comorbidities queried from the database included the presence of a history of diabetes, anemia, chronic kidney disease, chronic obstructive pulmonary disease, congestive heart failure, other cardiac disease, immunocompromised status, liver disease, rheumatoid arthritis, depression, and tobacco use. An immunocompromised status was defined as a patient who had received an antineoplastic drug or immunologic agent in the year before their index procedure. A patient was classified as having "other cardiac disease" if they had a previous diagnosis of ischemic heart disease or coronary heart disease.

The incidences of postoperative joint and systemic complications between the two cohorts were then queried. Postoperative joint complications included prosthetic joint infection (PJI), periprosthetic fracture, hip dislocation, aseptic loosening, and other revision. PJI was defined by procedural codes that indicated a surgical intervention for a deep joint infection to exclude superficial wound complications that would have been included in diagnosis codes for PJI. Other revision was defined as aseptic revisions excluding those performed after periprosthetic fracture or hip dislocations. Each joint complication was examined at 90-days and 1-year postoperatively. The codes used to define postoperative joint complications are provided in Appendix Table A2.

Systemic complications investigated included lower extremity deep vein thrombosis, pulmonary embolism, anemia (post hemorrhagic, iron deficiency from blood loss), acute renal failure, myocardial infarction, cerebrovascular event (stroke, nontraumatic hemorrhage, occlusion of cerebral arteries), respiratory failure, pneumonia, acute mental status change, and urinary tract infection. Incidences of systemic complications were examined during the surgical encounter before discharge, and at 90-days postoperatively. Because the diagnosis of in-hospital anemia could not be specified as preoperative or postoperative, in-hospital transfusion rates were all queried. The codes used to define systemic complications are provided in Appendix Table A3.

Morphine milligram equivalents (MME) (USC-02211, USC-02212, USC-02214, USC-02221, USC-02222, USC-02231, USC-02232) were also queried for both cohorts in order to compare opiate consumption for pain management load between the two cohorts. Patients who received general anesthesia within the 1-year follow-up were excluded to account for opioid use due to additional procedures. The evaluation captured patients who had an opioid claim (a) between discharge and 90-days and (b) a subsequent claim between 90-days and 6-months (c) and a subsequent claim between 6-months and 1-year. Average MME was calculated directly in PearlDiver for each period.

All data analyses were performed using the R statistical software (R Project for Statistical Computing, Vienna, Austria) integrated into PearlDiver with an α level set to 0.05. Demographic and clinical characteristics were compared using chi-square analysis for categorical variables and Welch's *t*-test for continuous variables. Multivariate logistic regression adjusting for patient sex, age, CCI, BMI, and the presence of the comorbidities tobacco use and diabetes mellitus were used to calculate odds ratios (ORs) with corresponding 95% confidence intervals (CIs) for comparing rates of postoperative complications between the bilateral and unilateral THA cohorts.

3. Results

Between 2010 and Q2 of 2018 in the PearlDiver database, 185,123 primary total hip arthroplasty procedures were identified using ICD-10 procedural codes. After adjusting for exclusion criteria and dates for adequate follow up, this number decreased to 107,589, of which 106,859 (99.3%) patients received a primary unilateral THA and 730 (0.7%) patients received a SimBTHA (Fig. 1). Table 1 highlights SimBTHA had a greater proportion of males (Male: 53.3% vs 43.4%, $p < .001$), in the age range of <65 (75.3% vs 44.0%, $p < .001$), have a BMI

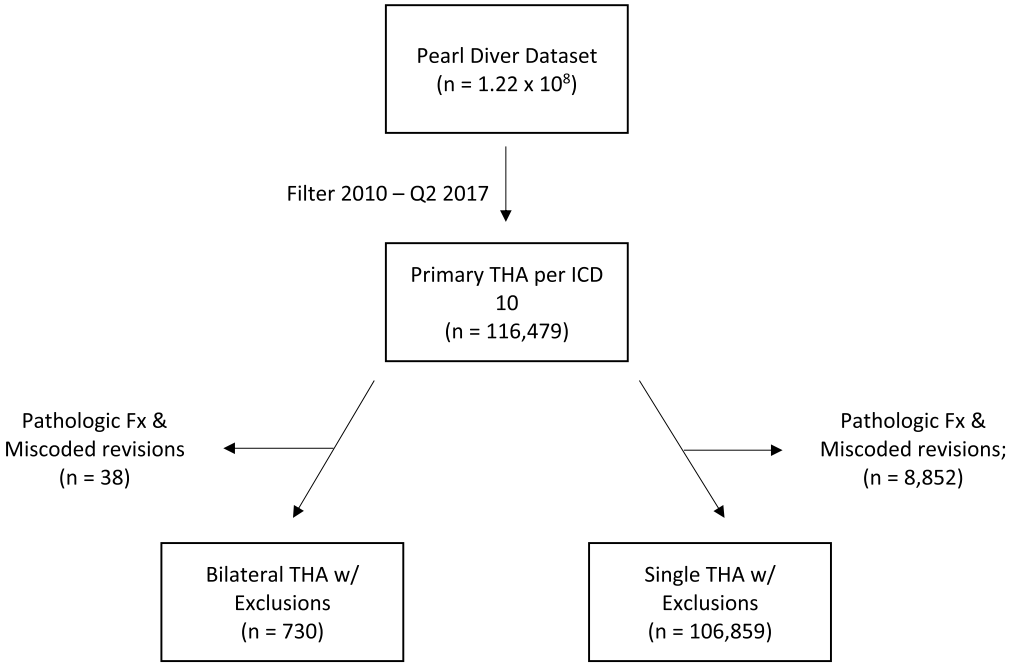

Fig. 1. Flow diagram of patients included in study. THA, total hip arthroplasty; Fx, fracture.

Table 1
Comparison of demographics and clinical characteristics of patients receiving THA.

Demographic Variable	Bilateral Primary THA (n = 730)	Unilateral Primary THA (n = 106,859)	p
Sex, n (%)			
Female	341 (46.7)	60,531 (56.7)	<.001
Male	389 (53.3)	46,328 (43.4)	<.001
Age, n (%)			
<65	550 (75.3)	47,011 (44.0)	<.001
65–79	180 (24.7)	59,940 (56.1)	<.001
≥80	0 (0.0)	0 (0.0)	<.001
BMI[a], n (%)			
<30	21 (16.9)	1643 (8.9)	0.003
30–40	87 (70.2)	10,200 (55.2)	<.001
≥40	16 (12.9)	6620 (35.9)	<.001
CCI, mean ± SD	0.64 ± 1.36	1.01 ± 1.72	<.001
Specific Comorbidities, n (%)			
Tobacco use	142 (19.5)	27,807 (26.0)	0.002
Rheumatoid Arthritis	39 (5.3)	5262 (4.9)	0.694
Liver Disease	61 (8.4)	11,178 (10.5)	0.105
Congestive Heart Failure	16 (2.2)	8201 (7.7)	<.001
Cardiac Disease	107 (14.7)	29,969 (28.1)	<.001
COPD	152 (20.8)	28,446 (26.6)	0.007
Chronic Kidney Disease	32 (4.4)	11,207 (10.5)	<.001
Diabetes	161 (22.1)	36,240 (33.9)	<.001
Pre-operative Anemia	150 (20.5)	30,300 (28.4)	<.001
Immunocompromised	34 (4.7)	4062 (3.8)	0.290
Depression	154 (21.1)	26,775 (25.1)	0.058

THA, Total Hip Arthroplasty; BMI, Body Mass Index; CCI, Charlson co-morbidity Index.
[a] BMI data were available for 17.0% of bilateral cases and 17.3% of unilateral cases.

less than 30 (16.9% vs 8.9%, p = .003), as well as a BMI between 30 and 40 (BMI 30–40: 70.2% vs 55.2%, p < .001) (Fig. 2.), and had a lower average burden of comorbidities (CCI: 0.64 vs 1.01, p < .001). Patients in the unilateral cohort had a shorter hospital length-of-stay (LOS: 2.61 vs 6.11, p < .001) and had higher rates of the following comorbidities: *Diabetes* 33.9% vs 22.1%, p < .001, *Tobacco Use* 26.0% vs 19.5%, p = .002, *Congested Heart Failure* 7.7% vs 2.2%, p < .001, *Cardiac Disease* 28.1% vs 14.7%, p < .001, *COPD* 26.6% vs 20.8%, p = .007, *CKD* 10.5% vs 4.4%, p < .001, *Pre-operative anemia* 28.4% vs 20.5%, p < .001.

LOS was significantly shorter in the unilateral THA cohort (LOS 2.61 vs. 6.11, p < .001). For the SimBTHA cohort, MME data was available for 409 (56.0%), 92 (12.6%), and 65 (9.9%) patients out of the original 730 patients at the 90-day, 6-month, and 1-year MME evaluation, respectively. For the unilateral THA cohort MME data was available for 56,341 (52.7%), 17,168 (16.1%), and 12,765 (12.0%) patients out of the original 106,859 patients at the 90-day, 6-month, and 1-year MME evaluation, respectively. There was not a statistically significant difference in MME at the 90-day, 6-month, or 1 year between the two cohorts.

For joint complications, incidence of PJI at 90-days and 1-year post-discharge was significantly lower in the SimBTHA cohort (PJI 90-day: OR 0.12, 95% CI 0.01–0.52; 1-year: OR 0.18, 95% CI 0.03–0.54). No other significant differences were found between the two cohorts at 90-days postoperatively and 1-year postoperatively Table 2. Rates of systemic complications during the inpatient hospital stay and at 90-days

Table 2
Ninety-day and 1-year comparison of joint complications.

Joint Complication	Bilateral Primary THA (n = 730)	Primary Unilateral THA (n = 106,859)	OR[a] (95% CI)
Prosthetic Dislocation			
90-day	1 (0.1)	157 (0.2)	1.11 (0.06–4.99)
1 yr	1 (0.1)	196 (0.2)	0.84 (0.05–3.74)
Prosthetic Joint Infection			
90-day	1 (0.1)	1363 (1.3)	0.12 (0.01–0.52)
1 yr	2 (0.3)	1781 (1.7)	0.18 (0.03–0.54)
Periprosthetic Fracture			
90-day	2 (0.3)	424 (0.4)	0.85 (0.14–2.65)
1 yr	2 (0.3)	587 (0.6)	0.62 (0.10–1.93)
Aseptic Loosening			
90-day	1 (0.1)	272 (0.3)	0.59 (0.03–2.64)
1 yr	1 (0.1)	609 (0.6)	0.24 (0.01–1.07)
Prosthetic Revision			
90-day	2 (0.3)	328 (0.3)	1.12 (0.18–3.50)
1 yr	2 (0.3)	443 (0.4)	0.79 (0.13–2.47)

THA, Total Hip Arthroplasty; OR, Odds ratio; CI, confidence interval.
[a] Adjusting for sex, age, BMI, diabetes, tobacco use, and CCI.

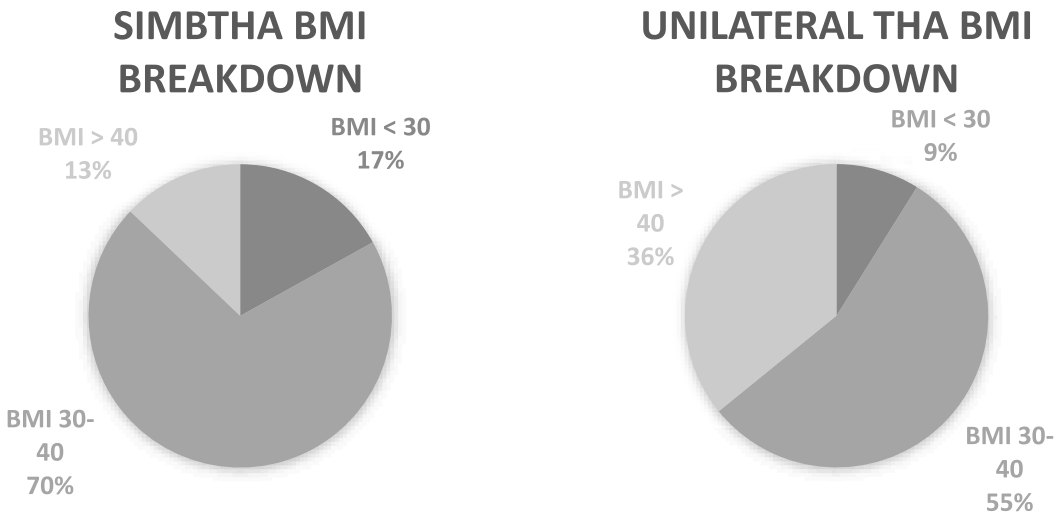

Fig. 2. BMI breakdown of SimBTHA and unilateral cohorts.
BMI, body mass index; THA, total hip arthroplasty.

post-discharge were all insignificant between the two cohorts Table 3.

4. Discussion

The increasing demand for THA along with the predicted shortage of over 5000 orthopedic surgeons by 2025 in the United States is driving surgeons to be as efficient as possible.[13] This present study suggests healthy, younger patients with bilateral osteoarthritis can undergo SimBTHA without significantly increasing their odds risk of systemic and joint complications relative to patients undergoing primary unilateral THA. Bilateral procedures in this study demonstrated a lower incidence of PJI at both 90-days and 1-year (PJI: 90-day OR 0.12; 1-year OR 0.18). At 90-days and 1-year, rates of all other joint complications were comparable for the two cohorts. Furthermore, rates of all systemic complications assessed during the in-hospital stay and at 90-days post-discharge were similar for both patient populations. However, patients in the SimBTHA cohort experienced a significantly longer average length of hospital stay (LOS: 2.61 vs. 6.11, p < .001). Additionally, SimBTHA patients were significantly younger (Age <65: 75.3% vs 44.0%, p = .003), had a lower CCI (CCI: 0.64 vs 1.01, p < .001), and were less likely to be classified as overweight or obese (BMI <30: 16.9% vs 8.9%, p < .001; BMI 30–40: 70.2% vs 55.2%, p < .001).

Table 3
In-hospital and ninety-day comparison of systemic complications.

Systemic Complication	Bilateral Primary THA (n = 730)	Unilateral Primary THA (n = 106,859)	OR[a] (95% CI)
Deep Vein Thrombosis			
In-hospital	1 (0.1)	270 (0.3)	0.59 (0.04–2.65)
90-day	9 (1.2)	1781 (1.7)	0.86 (0.41–1.57)
Altered Mental Status			
In-hospital	3 (0.4)	326 (0.3)	2.61 (0.80–6.17)
90-day	3 (0.4)	1026 (1.0)	0.56 (0.14–1.45)
Pulmonary Embolism			
In-hospital	2 (0.3)	239 (0.2)	1.42 (0.23–4.46)
90-day	5 (0.7)	1005 (0.9)	0.87 (0.31–1.88)
Anemia			
In-hospital	235 (32.2)	22,583 (21.1)	1.96 (1.67–2.29)
90-day	84 (11.5)	7866 (7.4)	1.99 (1.57–2.49)
Acute Renal Failure			
In-hospital	11 (1.5)	2370 (2.2)	0.96 (0.49–1.65)
90-day	12 (1.6)	2323 (2.2)	1.11 (0.59–1.88)
Myocardial Infarction			
In-hospital	0 (0.0)	231 (0.2)	NA
90-day	5 (0.7)	540 (0.5)	1.93 (0.69–4.21)
Cerebrovascular Event			
In-hospital	1 (0.1)	895 (0.8)	0.23 (0.01–1.02)
90-day	2 (0.3)	1778 (1.7)	0.23 (0.04–0.72)
Pneumonia			
In-hospital	0 (0.0)	442 (0.4)	0.82 (0.14–2.57)
90-day	4 (0.6)	1465 (1.4)	0.78 (0.31–1.60)
Respiratory Failure			
In-hospital	2 (0.3)	1021 (1.0)	0.65 (0.16–1.71)
90-day	3 (0.4)	1367 (1.3)	0.64 (0.20–1.51)
Urinary Tract Infection			
In-hospital	11 (1.5)	1393 (1.3)	1.68 (0.86–2.92)
90-day	21 (2.9)	4574 (4.3)	0.96 (0.60–1.45)

THA, Total Hip Arthroplasty; OR, Odds ratio; CI, confidence interval.
[a] Adjusting for sex, age, BMI, diabetes, tobacco use, and CCI.

An inherent limitation in any administrative claims database study is the accuracy of the findings depends on the accuracy of codes in the database, which are subject to human error. Additionally, clinical data such as duration of surgery, blood loss, implant information, radiographic images, functional outcomes scores, and patient satisfaction could not be queried from the database such that this is limited to the identification of comorbidities and complications to the binary presence or absence of the factor. The use of ICD-10 codes drastically reduced the number of THAs in this study compared to the total amount of THAs performed during the time period studied; however, limiting the definition of THA to only ICD-10 codes allowed for greater precision as it details laterality and allowed for assessment of LOS. While confounders were reduced with the use of multivariate logistic regression, it is possible other confounders influenced the data.

It is important to note SimBTHA patient's demographics tended to be young males with a low CCI which aligns with recent studies.[7,12,14] After adjusting for these factors, the present study found SimBTHA still had fewer PJIs at 90-days and at 1-year post-discharge. In 2015, Stavrakis et al. performed a 15-year review of 202,986 patients receiving THA of which 1.1% were SimBTHA and compared the outcomes versus unilateral; they reported no significant difference in PJIs.[15] The results of both studies support the notion patients without notable preexisting conditions can undergo bilateral THA if indicated without an increased risk of PJI.

The present study does not, however, indicate SimBTHA is comparably as safe to unilateral THA across all ranges of patient demographics. Fewer patients in the SimBTHA cohort had a BMI >40 and a large majority were <65 years old when compared to the unilateral THA cohort. In a study analyzing outcomes of SimBTHA, Weinstein et al. demonstrated a higher risk of postoperative complications in patients >75 years old when compared younger patients.[16] Moreover, this study emphasizes the importance of optimizing preoperative management and coordination between the surgeon and the patients primary care provider to reduce patient preoperative comorbidities and refine patient selection for bilateral versus unilateral THA accordingly.[17,18]

Furthermore, the present study found the LOS for SimBTHA was significantly longer than the unilateral cohort. Numerous studies align with this, showing SimBTHA having an extended LOS, however, recent reports have shown no association with increased LOS.[14,15,19] While not evaluated in the current study, a common argument in support of SimBTHA is a shorter LOS when compared to a two-stage procedure. Parvizi demonstrated SimBTHA length of stay was significantly shorter than the two-staged THA.[11] This improved efficiency can reduce the time patients spend in hospitals, which could reduce medical complications and healthcare spending.

The United States has a significant portion of patients using opioids and it has been documented opioid use can impact patient outcomes and morbidity following orthopedic procedures.[20–24] Pivec et al. evaluated an opioid naïve cohort compared to patients on opioids prior to THA and reported the patients in the opiate cohort received significantly higher total daily opioid doses as inpatients and had longer hospital stays.[21] Weick et al. demonstrated opioid naïve patients had significantly lower revision rates at 1 year and readmissions at 30-days postoperatively.[24] With a majority of staged THAs occurring between 3 and 6 months apart,[10,11] this could place patients at an increased risk of prolonged opiate use which has also been shown to increase dependence and abuse.[21–23]

5. Conclusion

Surgeons should consider simultaneous bilateral total hip arthroplasty a safe and effective procedure for low risk patients with

appropriate comorbidities. The identification of these patients and optimizing preoperative management could improve efficiencies and reduce recovery to one surgical event.

Author contributions

Travis Flick: writing, data curation, formal analysis, investigation. Sione Ofa: Data curation, formal analysis. Akshar Patel: writing, investigation. Bailey Ross: writing. Fernando L. Sanchez: Writing, validation. William Sherman: Supervision, writing, validation, formal anlaysis.

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Declaration of competing interest

The Authors declare that there is no conflict of interest.

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Appendix A

Table A1Codes used to evaluate for total hip arthroplasty

Primary THA Codes			
ICD-10-P-0SR9019	ICD-10-P-0SRA039	ICD-10-P-0SRB0JZ	ICD-10-P-0SRR0JZ
ICD-10-P-0SR901A	ICD-10-P-0SRA03A	ICD-10-P-0SRB0KZ	ICD-10-P-0SRR0KZ
ICD-10-P-0SR901Z	ICD-10-P-0SRA03Z	ICD-10-P-0SRE009	ICD-10-P-0SRS019
ICD-10-P-0SR9029	ICD-10-P-0SRA07Z	ICD-10-P-0SRE00A	ICD-10-P-0SRS01A
ICD-10-P-0SR902A	ICD-10-P-0SRA0J9	ICD-10-P-0SRE00Z	ICD-10-P-0SRS01Z
ICD-10-P-0SR902Z	ICD-10-P-0SRA0JA	ICD-10-P-0SRE019	ICD-10-P-0SRS039
ICD-10-P-0SR9039	ICD-10-P-0SRA0JZ	ICD-10-P-0SRE01A	ICD-10-P-0SRS03A
ICD-10-P-0SR903A	ICD-10-P-0SRA0KZ	ICD-10-P-0SRE01Z	ICD-10-P-0SRS03Z
ICD-10-P-0SR903Z	ICD-10-P-0SRB019	ICD-10-P-0SRE039	ICD-10-P-0SRS0J9
ICD-10-P-0SR9049	ICD-10-P-0SRB01A	ICD-10-P-0SRE03A	ICD-10-P-0SRS0JA
ICD-10-P-0SR904A	ICD-10-P-0SRB01Z	ICD-10-P-0SRE03Z	ICD-10-P-0SRS0JZ
ICD-10-P-0SR904Z	ICD-10-P-0SRB029	ICD-10-P-0SRE0J9	ICD-10-P-0SRS0KZ
ICD-10-P-0SR907Z	ICD-10-P-0SRB02A	ICD-10-P-0SRE0JA	
ICD-10-P-0SR90J9	ICD-10-P-0SRB02Z	ICD-10-P-0SRE0JZ	
ICD-10-P-0SR90JA	ICD-10-P-0SRB039	ICD-10-P-0SRR019	
ICD-10-P-0SR90JZ	ICD-10-P-0SRB03A	ICD-10-P-0SRR01A	
ICD-10-P-0SR90KZ	ICD-10-P-0SRB03Z	ICD-10-P-0SRR01Z	
ICD-10-P-0SRA009	ICD-10-P-0SRB049	ICD-10-P-0SRR039	
ICD-10-P-0SRA00A	ICD-10-P-0SRB04A	ICD-10-P-0SRR03A	
ICD-10-P-0SRA00Z	ICD-10-P-0SRB04Z	ICD-10-P-0SRR03Z	
ICD-10-P-0SRA019	ICD-10-P-0SRB07Z	ICD-10-P-0SRR07Z	
ICD-10-P-0SRA01A	ICD-10-P-0SRB0J9	ICD-10-P-0SRR0J9	
ICD-10-P-0SRA01Z	ICD-10-P-0SRB0JA	ICD-10-P-0SRR0JA	
Exclusion Codes for Hip			
ICD-9-D-82021	ICD-10-D-S72141C	ICD-10-D-S72001B	ICD-10-D-M84559A
ICD-9-D-82011	ICD-10-D-S72064A	ICD-10-D-S72146B	ICD-10-D-M84559D
ICD-9-D-82020	ICD-10-D-S72043C	ICD-10-D-S72012B	ICD-10-D-M84559G
ICD-9-D-8209	ICD-10-D-S72142B	ICD-10-D-S72002B	ICD-10-D-M84559K
ICD-9-D-82031	ICD-10-D-S72051B	ICD-10-D-S72101E	ICD-10-D-M84559S
ICD-9-D-82013	ICD-10-D-S72044B	ICD-10-D-S72012C	ICD-10-D-M84659A
ICD-9-D-82030	ICD-10-D-S72142C	ICD-10-D-S72009B	ICD-10-D-M84659D
ICD-9-D-82010	ICD-10-D-S72052B	ICD-10-D-S72051A	ICD-10-D-M84659G
ICD-9-D-82019	ICD-10-D-S72046B	ICD-10-D-S72019B	ICD-10-D-M84659K
ICD-9-D-82012	ICD-10-D-S72143B	ICD-10-D-S72002C	ICD-10-D-M84659P
ICD-9-D-82032	ICD-10-D-S72061B	ICD-10-D-S72101J	ICD-10-D-M84659S
ICD-9-D-73314	ICD-10-D-S72091B	ICD-10-D-S72052A	
ICD-10-D-S72009C	ICD-10-D-S72143C	ICD-10-D-S72001C	
ICD-10-D-S72062A	ICD-10-D-S72063A	ICD-10-D-S72102B	
ICD-10-D-S72041B	ICD-10-D-S72091C	ICD-10-D-S72061A	
ICD-10-D-S72109B	ICD-10-D-S72144B	ICD-10-D-M84459A	
ICD-10-D-S72059A	ICD-10-D-S72092B	ICD-10-D-M84459D	
ICD-10-D-S72042B	ICD-10-D-S72066A	ICD-10-D-M84459G	
ICD-10-D-S72141B	ICD-10-D-S72101B	ICD-10-D-M84459K	
ICD-10-D-S72065A	ICD-10-D-S72145B	ICD-10-D-M84459P	
ICD-10-D-S72043B	ICD-10-D-S72011B	ICD-10-D-M84459S	

Table A2
Codes used to evaluate for Hip joint complications

Joint Infection			
ICD-9-D-99667	ICD-10-D-T8451XS	ICD-10-D-T8453XA	ICD-10-D-T8454XD
ICD-9-D-99666	ICD-10-D-T8452XA	ICD-10-D-T8453XD	ICD-10-D-T8454XS
ICD-10-D-T8451XA	ICD-10-D-T8452XD	ICD-10-D-T8453XS	

(*continued on next page*)

Table A2 (*continued*)

Joint Infection			
ICD-10-D-T8451XD	ICD-10-D-T8452XS	ICD-10-D-T8454XA	
Periprosthetic Fracture			
ICD-9-D-99644	ICD-10-D-M9711XA	ICD-10-D-M9712XD	ICD-10-D-T84042S
ICD-9-D-99644	ICD-10-D-M9711XD	ICD-10-D-M9712XS	ICD-10-D-T84043A
ICD-10-D-M9701XA	ICD-10-D-M9711XS	ICD-10-D-T84042A	ICD-10-D-T84043D
ICD-10-D-M9702XA	ICD-10-D-M9712XA	ICD-10-D-T84042D	ICD-10-D-T84043S
Aseptic Loosening			
ICD-9-D-99641	ICD-10-D-T84030S	ICD-10-D-T84032A	ICD-10-D-T84033D
ICD-9-D-99641	ICD-10-D-T84031A	ICD-10-D-T84032D	ICD-10-D-T84033S
ICD-10-D-T84030A	ICD-10-D-T84031D	ICD-10-D-T84032S	
ICD-10-D-T84030D	ICD-10-D-T84031S	ICD-10-D-T84033A	
Prosthetic Dislocation			
ICD-9-P-7975	ICD-10-P-0SS93ZZ	ICD-10-P-0SSB44Z	ICD-10-P-0SSCXZZ
ICD-9-P-7985	ICD-10-P-0SS944Z	ICD-10-P-0SSBX4Z	ICD-10-P-0SSD04Z
ICD-9-P-7976	ICD-10-P-0SS9X4Z	ICD-10-P-0SSBX5Z	ICD-10-P-0SSD0ZZ
ICD-9-P-7986	ICD-10-P-0SS9XZZ	ICD-10-P-0SSBXZZ	ICD-10-P-0SSDX5Z
ICD-10-P-0SS904Z	ICD-10-P-0SSB04Z	ICD-10-P-0SSC04Z	ICD-10-P-0SSDXZZ
ICD-10-P-0SS905Z	ICD-10-P-0SSB0ZZ	ICD-10-P-0SSC0ZZ	
ICD-10-P-0SS90ZZ	ICD-10-P-0SSB34Z	ICD-10-P-0SSC3ZZ	
ICD-10-P-0SS934Z	ICD-10-P-0SSB3ZZ	ICD-10-P-0SSC4ZZ	
Prosthetic Revision			
ICD-9-P-0070	ICD-10-P-0SW909Z	ICD-10-P-0SWA0JZ	ICD-10-P-0SWB3JZ
ICD-9-P-0071	ICD-10-P-0SW90BZ	ICD-10-P-0SWAXJZ	ICD-10-P-0SWBXJZ
ICD-9-P-0072	ICD-10-P-0SW90JZ	ICD-10-P-0SWB04Z	
ICD-9-P-0073	ICD-10-P-0SW93JZ	ICD-10-P-0SWB08Z	
ICD-10-P-0SW904Z	ICD-10-P-0SW9X8Z	ICD-10-P-0SWB09Z	
ICD-10-P-0SW908Z	ICD-10-P-0SW9XJZ	ICD-10-P-0SWB0JZ	

Table A3
Codes used to evaluate for systemic complications

Acute Renal Failure			
ICD-9-D-5845	ICD-9-D-58081	ICD-10-D-N179	ICD-10-D-N004
ICD-9-D-5846	ICD-9-D-58089	ICD-10-D-N19	ICD-10-D-N005
ICD-9-D-5847	ICD-9-D-5809	ICD-10-D-N990	ICD-10-D-N006
ICD-9-D-5848	ICD-10-D-N170	ICD-10-D-N000	ICD-10-D-N007
ICD-9-D-5849	ICD-10-D-N171	ICD-10-D-N001	ICD-10-D-N008
ICD-9-D-5800	ICD-10-D-N172	ICD-10-D-N002	ICD-10-D-N009
ICD-9-D-5804	ICD-10-D-N178	ICD-10-D-N003	
Anemia			
ICD-9-D-2851	ICD-9-D-2800	ICD-10-D-D500	ICD-10-D-D62
Altered Mental Status			
ICD-9-D-78097	ICD-10-D-R4182		
Cerebrovascular Event			
ICD-9-D-430	ICD-10-D-I610	ICD-10-D-I6320	ICD-10-D-I63442
ICD-9-D-431	ICD-10-D-I611	ICD-10-D-I6329	ICD-10-D-I63443
ICD-9-D-4320	ICD-10-D-I612	ICD-10-D-I658	ICD-10-D-I63449
ICD-9-D-4321	ICD-10-D-I613	ICD-10-D-I659	ICD-10-D-I6349
ICD-9-D-4329	ICD-10-D-I614	ICD-10-D-I6501	ICD-10-D-I6350
ICD-9-D-4359	ICD-10-D-I615	ICD-10-D-I6502	ICD-10-D-I63511
ICD-9-D-4358	ICD-10-D-I616	ICD-10-D-I6503	ICD-10-D-I63512
ICD-9-D-43300	ICD-10-D-I618	ICD-10-D-I6509	ICD-10-D-I63513
ICD-9-D-43301	ICD-10-D-I619	ICD-10-D-I6521	ICD-10-D-I63519
ICD-9-D-43310	ICD-10-D-I6200	ICD-10-D-I6522	ICD-10-D-I63521
ICD-9-D-43311	ICD-10-D-I6201	ICD-10-D-I6523	ICD-10-D-I63522
ICD-9-D-43320	ICD-10-D-I6202	ICD-10-D-I6529	ICD-10-D-I63523
ICD-9-D-43321	ICD-10-D-I6203	ICD-10-D-G458	ICD-10-D-I63529
ICD-9-D-43330	ICD-10-D-I629	ICD-10-D-G459	ICD-10-D-I63531
ICD-9-D-43331	ICD-10-D-I6302	ICD-10-D-I6330	ICD-10-D-I63532
ICD-9-D-43380	ICD-10-D-I6312	ICD-10-D-I63311	ICD-10-D-I63533
ICD-9-D-43381	ICD-10-D-I6322	ICD-10-D-I63312	ICD-10-D-I63539
ICD-9-D-43390	ICD-10-D-I651	ICD-10-D-I63313	ICD-10-D-I63541
ICD-9-D-43391	ICD-10-D-I63031	ICD-10-D-I63319	ICD-10-D-I63542
ICD-9-D-43400	ICD-10-D-I63032	ICD-10-D-I63321	ICD-10-D-I63543
ICD-9-D-43401	ICD-10-D-I63033	ICD-10-D-I63322	ICD-10-D-I63549
ICD-9-D-43410	ICD-10-D-I63039	ICD-10-D-I63323	ICD-10-D-I6359
ICD-9-D-43411	ICD-10-D-I63131	ICD-10-D-I63329	ICD-10-D-I636
ICD-9-D-43490	ICD-10-D-I63132	ICD-10-D-I63331	ICD-10-D-I638
ICD-9-D-43491	ICD-10-D-I63133	ICD-10-D-I63332	ICD-10-D-I639
ICD-10-D-I6000	ICD-10-D-I63139	ICD-10-D-I63333	ICD-10-D-I6601
ICD-10-D-I6001	ICD-10-D-I63231	ICD-10-D-I63339	ICD-10-D-I6602
ICD-10-D-I6002	ICD-10-D-I63232	ICD-10-D-I63341	ICD-10-D-I6603
ICD-10-D-I6010	ICD-10-D-I63233	ICD-10-D-I63342	ICD-10-D-I6609
ICD-10-D-I6011	ICD-10-D-I63239	ICD-10-D-I63343	ICD-10-D-I6611

(*continued on next page*)

Table A3 (*continued*)

Acute Renal Failure			
ICD-10-D-I6012	ICD-10-D-I63011	ICD-10-D-I63349	ICD-10-D-I6612
ICD-10-D-I602	ICD-10-D-I63012	ICD-10-D-I6339	ICD-10-D-I6613
ICD-10-D-I6020	ICD-10-D-I63013	ICD-10-D-I6340	ICD-10-D-I6619
ICD-10-D-I6021	ICD-10-D-I63019	ICD-10-D-I63411	ICD-10-D-I6621
ICD-10-D-I6022	ICD-10-D-I63111	ICD-10-D-I63412	ICD-10-D-I6622
ICD-10-D-I6030	ICD-10-D-I63112	ICD-10-D-I63413	ICD-10-D-I6623
ICD-10-D-I6031	ICD-10-D-I63113	ICD-10-D-I63419	ICD-10-D-I6629
ICD-10-D-I6032	ICD-10-D-I63119	ICD-10-D-I63421	ICD-10-D-I668
ICD-10-D-I604	ICD-10-D-I63211	ICD-10-D-I63422	ICD-10-D-I669
ICD-10-D-I6050	ICD-10-D-I63212	ICD-10-D-I63423	
ICD-10-D-I6051	ICD-10-D-I63213	ICD-10-D-I63429	
ICD-10-D-I6052	ICD-10-D-I63219	ICD-10-D-I63431	
ICD-10-D-I606	ICD-10-D-I6300	ICD-10-D-I63432	
ICD-10-D-I607	ICD-10-D-I6309	ICD-10-D-I63433	
ICD-10-D-I608	ICD-10-D-I6310	ICD-10-D-I63439	
ICD-10-D-I609	ICD-10-D-I6319	ICD-10-D-I63441	
Deep Vein Thrombosis			
ICD-9-D-45340	ICD-10-D-I82403	ICD-10-D-I824Z9	ICD-10-D-I825Z1
ICD-9-D-45341	ICD-10-D-I82409	ICD-10-D-I82501	ICD-10-D-I825Z2
ICD-9-D-45342	ICD-10-D-I82491	ICD-10-D-I82502	ICD-10-D-I825Z3
ICD-9-D-45111	ICD-10-D-I82492	ICD-10-D-I82503	ICD-10-D-I825Z9
ICD-9-D-45119	ICD-10-D-I82493	ICD-10-D-I82509	
ICD-9-D-45389	ICD-10-D-I82499	ICD-10-D-I82591	
ICD-9-D-4539	ICD-10-D-I824Y1	ICD-10-D-I82592	
ICD-9-D-4512	ICD-10-D-I824Y2	ICD-10-D-I82593	
ICD-9-D-45350	ICD-10-D-I824Y3	ICD-10-D-I82599	
ICD-9-D-45351	ICD-10-D-I824Y9	ICD-10-D-I825Y1	
ICD-9-D-45352	ICD-10-D-I824Z1	ICD-10-D-I825Y2	
ICD-10-D-I82401	ICD-10-D-I824Z2	ICD-10-D-I825Y3	
ICD-10-D-I82402	ICD-10-D-I824Z3	ICD-10-D-I825Y9	
Myocardial Infarction			
ICD-9-D-41000	ICD-9-D-41041	ICD-9-D-41072	ICD-10-D-I2121
ICD-9-D-41001	ICD-9-D-41042	ICD-9-D-41060	ICD-10-D-I229
ICD-9-D-41002	ICD-9-D-41050	ICD-9-D-41061	ICD-10-D-I2101
ICD-9-D-41010	ICD-9-D-41051	ICD-9-D-41062	ICD-10-D-I221
ICD-9-D-41011	ICD-9-D-41052	ICD-10-D-I214	ICD-10-D-I220
ICD-9-D-41012	ICD-9-D-41080	ICD-10-D-$I2_13$	ICD-10-D-I228
ICD-9-D-41020	ICD-9-D-41081	ICD-10-D-I2119	
ICD-9-D-41021	ICD-9-D-41082	ICD-10-D-I2109	
ICD-9-D-41022	ICD-9-D-41090	ICD-10-D-I2129	
ICD-9-D-41030	ICD-9-D-41091	ICD-10-D-I240	
ICD-9-D-41031	ICD-9-D-41092	ICD-10-D-I2111	
ICD-9-D-41032	ICD-9-D-41070	ICD-10-D-I2102	
ICD-9-D-41040	ICD-9-D-41071	ICD-10-D-*I222*	
Pneumonia			
ICD-9-D-413	ICD-9-D-48232	ICD-9-D-4831	ICD-10-D-J150
ICD-9-D-4800	ICD-9-D-48239	ICD-9-D-4838	ICD-10-D-J1289
ICD-9-D-4801	ICD-9-D-48240	ICD-9-D-4841	ICD-10-D-J09X1
ICD-9-D-4802	ICD-9-D-48241	ICD-9-D-485	ICD-10-D-J851
ICD-9-D-4803	ICD-9-D-48242	ICD-9-D-486	ICD-10-D-J1001
ICD-9-D-4808	ICD-9-D-48249	ICD-9-D-4870	ICD-10-D-J1108
ICD-9-D-4809	ICD-9-D-48281	ICD-9-D-99731	ICD-10-D-J153
ICD-9-D-481	ICD-9-D-48282	ICD-9-D-99732	ICD-10-D-J122
ICD-9-D-4820	ICD-9-D-48283	ICD-10-D-J189	ICD-10-D-J1281
ICD-9-D-4821	ICD-9-D-48284	ICD-10-D-J188	
ICD-9-D-4822	ICD-9-D-48289	ICD-10-D-J180	
ICD-9-D-48230	ICD-9-D-4829	ICD-10-D-J151	
ICD-9-D-48231	ICD-9-D-4830	ICD-10-D-J157	
Pulmonary Embolism			
ICD-9-D-41511	ICD-9-D-41519	ICD-10-D-I2609	ICD-10-D-I2782
ICD-9-D-41513	ICD-9-D-4162	ICD-10-D-I2699	
Respiratory Failure			
ICD-9-D-51853	ICD-9-D-51882	ICD-10-D-J9611	ICD-10-D-J9612
ICD-9-D-51851	ICD-10-D-J9601	ICD-10-D-J9602	ICD-10-D-J9692
ICD-9-D-51883	ICD-10-D-J9600	ICD-10-D-J9620	ICD-10-D-J95822
ICD-9-D-51884	ICD-10-D-J9690	ICD-10-D-J9622	ICD-10-D-J952
ICD-9-D-51881	ICD-10-D-J9621	ICD-10-D-J9691	ICD-10-D-J953
ICD-9-D-51852	ICD-10-D-J9610	ICD-10-D-J95821	
Urinary Tract Infection			
ICD-9-D-5990	ICD-10-D-N390		

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