The Journal of Arthroplasty 32 (2017) 1739–1746

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Health Policy & Economics

Ten-Year Trends and Independent Risk Factors for Unplanned Readmission Following Elective Total Joint Arthroplasty at a Large Urban Academic Hospital

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ARTICLE INFO

Article history:
Received 23 July 2016
Received in revised form
11 December 2016
Accepted 19 December 2016
Available online 27 December 2016

Keywords:
primary THA
primary TKA
primary TJA
readmission
bundled payments

ABSTRACT

Background: Total joint arthroplasty procedures continue to provide consistent, long-term success and high patient satisfaction scores. However, early unplanned readmission to the hospital imparts significant financial risks to individual institutions as we shift away from the traditional fee-for-service payment model.
Methods: Using a combination of our hospital's administrative database and retrospective chart reviews, we report the 30-day and 90-day readmission rates and all causes of readmission following all unilateral, primary elective total hip and knee arthroplasty procedures at a large, urban, academic hospital from 2004 to 2013.
Results: In total, 1165 primary total hip (511) and knee (654) arthroplasty procedures were identified, and the 30-day and 90-day unplanned readmission rates were 4.6% and 7.3%, respectively. A multivariate regression model controlled for a variety of potential clinical and surgical confounders. Increasing body mass index levels, an American Society of Anesthesiologists score of $\geq$3, and discharge to an inpatient rehab facility each independently correlated with risk of both 30-day and 90-day unplanned readmission to our institution. Additionally, use of general anesthesia during the procedure independently correlated with risk of readmission at 30 days only, while congestive heart failure independently correlated with risk of 90-day unplanned readmission. Readmissions related directly to the surgical site accounted for 47% of the cases, and collectively totaled more than any single medical or clinical complication leading to unplanned readmission within the 90-day period.
Conclusion: Increasing body mass index values, general anesthesia, an American Society of Anesthesiologists score of $\geq$3, and discharge to an inpatient rehab facility each were independent risk factors for early unplanned readmission.

Total hip (THA) and total knee arthroplasty (TKA) procedures are 2 of the most cost-effective, consistently successful surgeries performed in orthopedics [1]. However, they also collectively account for the largest procedural costs in Medicare expenditures [2], and unplanned readmissions to the hospital shortly after discharge have been identified as a specific area of financial concern in the last 5 years [3-8]. In 2014, the Centers for Medicare and Medicaid Services (CMS) expanded its Hospital Readmission Reduction Program to include elective total joint arthroplasty (TJA) procedures with the goal of achieving overall reductions in unplanned readmissions rates (URRs) within 30 days of discharge [9-11]. CMS has already instituted several methods to account for payment adjustments and penalties to hospitals demonstrating inappropriately high URRs based on the regional comparison and national data [10,12,13].

An abundance of reports from national and state TJA registries have suggested standard ranges for “acceptable” 30-day URRs while simultaneously attempting to identify various independent risk factors which may increase the likelihood of early unplanned readmission following primary elective THA and TKA procedures [11,12,14,15]. Taken collectively, the results of these studies

No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2016.12.035.

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http://dx.doi.org/10.1016/j.arth.2016.12.035
0883-5403/

demonstrate wide variations in reported ranges over 30-day and/or 90-day periods, and the statistical relevance of the clinical variables and operative parameters investigated has been poorly reproduced [11,16-25]. Furthermore, variables such as total length of stay (LOS) and body mass index (BMI) are often not reported as continuous variables, and BMI data are often inaccurately obtained from either administrative data or "V codes" [20,26,27]. Despite these limitations, it is important to note that these studies have improved our overall understanding of key patient demographic, lifestyle, clinical, and surgical factors worth targeting to attempt to reduce high URRs.

A key analytical component to more accurately interpret these data is to define each ones relative risk at the institutional level [28]. The purpose of this study is to report on our institutional trends over a decade of elective primary THA and TKA procedures, including the cumulative 30-day and 90-day URRs, and the specific causes and independent risk factors linked to these early unplanned readmissions.

Materials and Methods

After obtaining Institutional Review Board approval, we used our hospital's administrative database to identify all patients undergoing elective primary THA and TKA at our institution from 2004 to 2013. Patients who expired during the index admission, had bilateral TJA or unicondylar knee arthroplasty procedures, or ones returning for a subsequent planned elective TJA procedure were excluded. A combination of administrative data mining and retrospective chart reviews was employed to collect patient demographic, clinical, and operative-related data (Tables 1 and 2).

BMI (continuous variable), insurance type (government-based vs private), LOS (continuous variable), American Society of Anesthesiologists physical status scores (ASA scores: "high" (3 or 4) vs "low" (1 or 2)), intraoperative anesthesia technique (general vs neuraxial), relevant medical comorbidities, and discharge disposition status (rehab vs home) were among the parameters obtained. Medical comorbidities were initially obtained via administrative diagnosis codes from our hospital's administrative database, but this was supplemented and modified as necessary by verifying each diagnosis with the history and physical (H&P) document associated with the index admission. Surgical variables collected included total time spent in the operating room, total surgical times, total tourniquet times for all TKA procedures, estimated blood loss (EBL) during the operation, and perioperative transfusion rates. For the latter, we combined intraoperative and postoperative blood transfusions into one "perioperative" category, and any instances of multiple or subsequent blood transfusions for the same patient were not factored into the analysis.

Distribution parameters (means, standard deviations, frequencies, and proportions) were used to describe the study patient sample. For the final multivariate model, risk factors that demonstrated at least 10 total occurrences in the total sample population as well as statistically significant different distributions noted by univariate analyses between the readmission and non-readmission populations at the $P < .20$ significance level were included (Table 1). The final multivariate logistic regression model was used to evaluate the relationship between 30-day and 90-day readmission with each risk factor in consideration. Crude and adjusted estimates of the likelihood of readmission for each risk factor are demonstrated as odds ratio (OR) and 95% confidence interval (CI) calculations (Table 3). In the final model, we used $\alpha = 0.05$ as our significance level. Finally, Hosmer-Lemeshow and C-statistics were computed to assess the goodness-of-fit and predictive ability of the model. Data were analyzed using SPSS Statistical Software (IBM Corporation 2012, Somers, NY).

The 30-day and 90-day URRs were calculated as percentages of the total primary elective TJA cohort (Tables 1 and 2). The International Classification of Diseases, 9th Revision (ICD-9) diagnosis codes linked to readmission encounters were used to identify reasons for unplanned readmission via the hospital's administrative database with chart review cross-checking to ensure diagnostic accuracy (Table 4). Finally, the 10-year trends in patient demographic, clinical, and procedure-related data are reported in a final model consisting of multiple 2-tailed tests at the $\alpha = 0.05$ significance level to identify statistically significant differences between all years during the study period, followed by determining statistically significant differences in the setting of a yearly progression format beginning with the year 2004 ("year 1") to the final year in 2013 ("year 10") (Table 2).

Results

General Characteristics of the Elective TJA Cohort

A total of 1535 TJA cases were initially identified prior to applying our exclusion criteria. The final cohort of elective primary unilateral THA and TKA cases totaled 1165, consisting of 654 (56.1%) TKA and 511 (43.9%) THA cases. Patient demographics during the decade are broken down by year and presented in Tables 1 and 2. In total, nearly two-thirds of cases were performed on women (745/1165, 64.0%), 54.4% of the patients were black, and 72.7% of the patients had government-based insurance (ie, Medicare or Medicaid). The vast majority of all TJA (958/1165, 82.2%) cases were performed by the senior author of this study (N. A. J.).

Trending the Decade

A year-by-year analysis was performed to check for any disproportionately high annual URRs, and to note any statistically significant trends with respect to the "average" elective TJA patient presenting during each year (Table 2). The annual URR variations did not reach the level of statistical significance at 30 days or 90 days ($P = .751$ and $P = .529$).

With respect to the yearly progression model, a shift toward more government-based insurance programs ($P = .001$), an increase in patients' total number of medical comorbidities ($P < .001$), and relatively more ASA scores ≥ 3 ($P = .033$) were noted in the setting of decreasing total LOS ($P = .013$) and more discharges to home as opposed to rehab facilities ($P < .001$). Surgical parameters demonstrating statistical significance included more intraoperative use of general anesthesia (GA) as opposed to neuraxial methods ($P < .001$), increasing total time spent in the operating room ($P < .001$), and an increase in the amount of EBL per case ($P = .038$). Average tourniquet times for primary elective TKA cases ($P = .016$) and perioperative transfusion rates decreased as well ($P < .001$).

Reasons for Readmission and Unplanned Hospital Readmission Rates

Overall, the URRs were 4.6% (54/1165) and 7.3% (85/1165) for the 30-day and 90-day periods, respectively. Complications attributed to the surgical site directly (ie, surgical site infection, periprosthetic fracture) accounted for 47.1% (40/85) of readmissions, and collectively totaled more than any single medical or clinical complication causing readmission. Anemia, chest pain, and pneumonia were other common reasons attributed to unplanned readmission (Table 4).

Table 1
TJA Study Sample Patient Characteristics by 30-Day and 90-Day Readmission Status, 2004-2013.

Variable	Total Sample (*N* = 1165)		Readmitted Within 30 d?			Readmitted Within 90 d?		
	Mean (SD)	Number (%)	Yes ((*n* = 54) [4.6%])	No ((*n* = 1111) [95.4%])	*P* Value	Yes ((*n* = 85) [7.3%])	No ((*n* = 1080) [92.7%])	*P* Value
Demographics								
Age (y, continuous)	59.1 ± 12.2		60.2 ± 13.9	59.0 ± 12.2	**.155**	59.1 ± 13.7	59.1 ± 12.1	**.045**
Sex								
Female		745 (64)	37	708	.474	56	689	.700
Male		420 (36)	17	403		29	391	
Government-based insurance		847 (73)	49	798	**.002**	74	773	**.002**
Race								
White		423 (36)	12	411	**.028**	22	389	**.038**
Black		634 (55)	40	594		59	535	
Other		108 (9)	2	106		4	102	
Smoking status								
Never		703 (60)	28	675	**.198**	46	629	.230
Yes		339 (29)	17	322		27	295	
Quit		124 (11)	9	115		12	103	
Current drug/alcohol abuse		144 (12)	9	135	.326	12	132	.611
Clinical								
BMI (kg/m^2, continuous)	32.7 ± 7.8		31.2 ± 7.8	32.8 ± 7.8	**.072**	32.2 ± 8.0	32.8 ± 7.8	**.183**
ASA score								
Low (1 or 2)		564 (48)	11	553	**<.001**	21	543	**<.001**
High (3 or 4)		601 (52)	43	558		64	537	
Medical comorbidities								
Hypertension		795 (68)	42	753	**.121**	63	732	.220
Chronic anemia		283 (24)	16	267	.349	26	257	**.160**
Asthma		214 (18)	10	204	.977	20	194	.202
OSA		164 (14)	9	155	.575	15	140	.326
COPD		99 (9)	15	84	**.004**	18	66	**.011**
CHF		61 (5)	5	56	**.174**	13	43	**<.001**
CAD/MI history		141 (12)	8	133	.530	13	128	.349
Afib/cardiac dysrhythmia		89 (8)	6	83	.324	8	81	.523
Diabetes		281 (24)	19	262	**.051**	26	255	**.142**
CVA/TIA history		22 (2)	4	18	**.002**	7	11	**<.001**
Coagulopathy		32 (3)	1	31	.680	4	27	.251
Depression/anxiety		210 (18)	12	198	.411	18	180	.433
Psychoses		39 (3)	3	36	.356	6	30	**.048**
GERD		450 (39)	21	429	.968	36	393	.464
HIV		48 (4)	5	43	**.052**	7	36	**.047**
Hepatitis C		55 (5)	6	49	**.023**	12	37	**<.001**
Renal disease		92 (8)	10	82	**.003**	16	66	**<.001**
Liver disease		15 (1)	1	14	.706	4	10	**.004**
HLD		405 (35)	21	384	.515	32	352	.562
Rheumatic/inflammatory disease		156 (13)	9	147	.469	17	130	**.063**
Hypothyroid		87 (8)	6	81	.296	11	76	**.046**
BPH/genitourinary disorder		40 (3)	1	39	.514	2	38	.570
Total LOS (d)	4.7 ± 2.1		5.0 ± 3.0	4.7 ± 2.0	.721	5.0 ± 2.9	4.7 ± 2.0	.518
Dispo								
Home		442 (38)	11	431	**.006**	18	424	**<.001**
Inpatient rehab		723 (62)	43	680		67	656	
Surgical								
Procedure								
THA		511 (44)	22	489	.636			.871
TKA		654 (56)	32	622				
Anesthesia								
Neuraxial		332 (29)	6	326	**.004**	19	313	**.192**
General		833 (72)	48	785		66	767	
Total time in room (min)	169 ± 32.0		172.0 ± 36.0	168.7 ± 32.0	**.189**	168 ± 33.3	169 ± 32.0	**.126**
Total surgical time (min)	98.4 ± 26.0		100.2 ± 29.5	98.4 ± 26.3	.220	97.1 ± 25.5	98.6 ± 26.5	.938
Tourniquet time (TKA, min)	71 ± 26.0		70.6 ± 25.4	71.0 ± 26.1	.883	70.0 ± 22.9	71.1 ± 26.2	.847
EBL (mL)	340.7 ± 396.2		447.3 ± 892.1	335.5 ± 355.0	.846	405.4 ± 723.9	335.6 ± 358.0	.762
Perioperative transfusions		239 (21)	15	224	**.178**	22	217	.203
Postop ICU admit/transfers		54 (5)	4	50	.321	8	46	**.030**

Means and standard deviations are calculated for continuous variables, while counts and percentages summarize categorical variables.
OSA, obstructive sleep apnea; COPD, chronic obstructive pulmonary disease; CAD, coronary artery disease; MI, myocardial infarction; CVA/TIA, cerebrovascular accident/transient ischemic attack; GERD, gastroesophageal reflux disease; HLD, hyperlipidemia; BPH, benign prostatic hypertrophy; ICU, intensive care unit.
Variables demonstrating a statistically significant difference between readmission and non readmission populations at 30- and/or 90-days at $P < .20$ level are displayed in bold and were included in the final multivariate model.

Table 2
Ten-Year Institutional Trend Analysis of Patient Demographics, Clinical Variables (Upper), and Surgical Factors (Lower) From 2004 to 2013 at a Single High-Volume TJA Hospital.

Year (Integer)	Case Volume	30-d URR	90-d URR	Mean Age (y)	%Government Insurance	Mean #CMs	%Obese[a]	Mean BMI (kg/m^2)	Mean LOS (d)	%Dispo Home
P value[b]	–	.780	.543	.690	.080	**<.001**	**<.001**	.094	**.010**	**<.001**
P value[c]	–	.751	.529	.694	**.001**	**<.001**	**<.001**	.057	**.013**	**<.001**
2004 (1)	175	5.7	8.0	59.3	68.6	2.6	52.6	31.5	4.5	13.1
2005 (2)	138	3.6	7.2	57.9	65.2	3.0	58.0	32.6	5.4	29.7
2006 (3)	124	4.8	7.3	58.8	66.1	3.3	55.7	32.7	4.3	29.0
2007 (4)	61	4.9	6.6	61.8	75.4	3.4	55.7	32.9	5.0	16.4
2008 (5)	57	10.5	15.8	59.1	64.9	3.9	59.7	34.2	5.1	38.6
2009 (6)	91	2.2	5.4	61.8	81.3	4.3	58.7	31.8	5.4	34.1
2010 (7)	111	0.9	5.4	58.7	73.9	4.4	66.7	33.5	5.0	43.2
2011 (8)	102	3.9	4.9	59.1	79.4	4.2	61.8	32.8	4.4	60.8
2012 (9)	136	8.1	10.3	58.0	76.5	4.2	63.2	32.7	4.1	43.4
2013 (10)	170	3.5	5.3	58.7	77.1	3.9	71.8	33.4	4.4	64.7
Total	**1165**	**4.6**	**7.3**	**59.1**	**72.7**	**3.7**	**60.7**	**32.7**	**4.7**	**37.9**

	%ASA = 3	%ASA ≥3	%Gen Anesth	Mean Time in Operating Room (min)	Mean Surgical Time (min)	Mean Tourniquet Time (min)	%Periop transfuse	%ICU Postop Admit or Transfer	Mean EBL (mL)
P value[b]	**.002**	**.002**	**<.001**	**<.001**	.667	**.020**	**<.001**	.164	**.026**
P value[c]	**.034**	**.033**	**<.001**	**<.001**	.739	**.016**	**<.001**	.884	**.038**
2004 (1)	44.6	46.3	58.9	155.8	92.4	77.8	20.0	5.7	281.3
2005 (2)	47.8	49.3	64.5	168.1	99.9	77.2	27.5	5.8	330.1
2006 (3)	41.1	42.7	56.5	169.9	100.1	62.2	22.6	0.8	317.6
2007 (4)	41.0	49.2	59.0	164.2	95.4	63.7	26.2	8.2	389.8
2008 (5)	63.2	64.9	70.2	175.7	105.6	70.9	28.1	3.5	347.9
2009 (6)	52.8	52.7	70.3	170.0	101.2	78.0	27.5	4.4	326.2
2010 (7)	56.8	59.5	70.3	177.2	104.2	73.0	20.7	5.4	398.5
2011 (8)	58.8	61.8	84.3	185.3	105.8	74.4	28.4	1.0	388.0
2012 (9)	41.2	44.1	85.3	168.2	97.2	70.8	18.4	7.4	378.1
2013 (10)	55.3	55.9	88.8	166.2	91.9	63.2	2.4	4.1	326.7
Total	**49.5**	**51.6**	**71.5**	**169.0**	**98.4**	**71.0**	**20.5**	**4.6**	**340.7**

#CMs, number of medical comorbidities per patient; ICU, intensive care unit.
[a] Annual percentage of "obese" patients, as defined by a BMI ≥30 kg/m^2.
[b] Relationship between all years with bold values indicating statistical significance at the $P < .05$ level.
[c] Bold values indicate statistical significance at the $P < .05$ level and are with respect to the yearly progression model.

Independent Risk Factors for Unplanned Hospital Readmission

After adjusting for all other variables, an ASA score of ≥3 correlated with risk of unplanned readmission at both 30 days and 90 days (OR 2.196, 95% CI 1.093-4.412 (30 days)). Discharge to inpatient rehab (OR 2.593, 95% CI 1.231-5.463 (30 days)), undergoing GA during the operation (OR 3.048, 95% CI 1.256-7.396 (30 days)), and increasing BMI levels (OR 1.074, 95% CI 1.026-1.125 (30 days)) were all associated with increased likelihood of readmission at 30 days. With the exception of GA, each of these factors also demonstrated statistical significance in the adjusted model at 90 days as well. While several medical comorbidities trended toward statistical significance, only congestive heart failure (CHF) reached statistical significance at the 90-day time period in the final multivariate model (OR 2.722, 95% CI 1.252-5.916 (90 days)) (Table 3).

Discussion

The current healthcare environment is forcing individual institutions to better understand the specific population it serves in order to target and risk stratify patients based on the risk factors for unplanned readmission. The literature contains a significant number of patient-related, institution-related, and surgically related variables with wide variation in reported clinical and statistical significance, and understanding the relative risk of each of these factors is challenging. The challenge for each institution is to identify the relative risk of these variables and use the data to trend and follow each one's relationship as it applies to the quality of care being provided. The data presented in this report represent a group of independent risk factors associated with increased likelihood of unplanned readmission to our institution within 30-day and 90-day periods following elective primary TJA.

From 2004 to 2013, our institution cared for an increasing number of patients with higher BMIs and poorer overall health profiles as demonstrated by the increasing total number of medical comorbidities and higher ASA scores. There was even a statistically significant increase in the relative rates of government-based insurance coverage. In 2009, over 80% of primary elective TJA patients treated at our institution were covered by Medicare-based or Medicaid-based programs (Table 2). Average BMI values also trended higher during the decade, and the relative percentage of obese patients, as defined by a BMI of ≥30 kg/m^2, increased by nearly 20% during the study (Table 2). In addition, more patients received GA during surgery, average total time spent in the operating room increased per patient, and the average EBL per case increased. The former is surprising given the national trend in the opposite direction in favor of regional anesthesia. Our institution has more recently started to trend away from GA in favor of regional anesthesia for elective TJA cases, but this is not captured during the study period.

The continued use of GA despite the national trend can be explained at least in part by anesthesiologist preference, the persistent culture and practice at the institution, and the overall health profile of the patient population. The increase in GA cases during this study period can explain the increased average total operating room time per patient in the setting of unchanged average surgical times (Table 2). In addition, average TKA tourniquet times and perioperative transfusion rates demonstrated statistically significant declines during the study period. The former is explained by an increased TJA operating room staff and surgical team efficiency over time, and the latter is most likely explained by

Table 3
Adjusted Associations of Patient Demographics, Clinical Variables, and Surgical Factors With Likelihood of 30-d and 90-d Readmission After TJA.

Risk Factor	30-d Adjusted OR (95% CI)	*P* Value[a]	90-day Adjusted OR (95% CI)	*P* Value[a]
Age (y)[b]	0.982 (0.956-1.008)	.176	0.981 (0.961-1.001)	.064
Insurance: government vs private	2.408 (0.903-6.423)	.079	1.75 (0.869-3.525)	.117
Race (reference: white)		.151		.064
Black	1.687 (0.811-3.508)	.161	1.787 (0.994-3.212)	.052
Other	0.534 (0.111-2.557)	.432	0.740 (0.236-2.324)	.607
Smoking status (reference: never)		.889	–	–
Yes	1.027 (0.499-2.112)	.943	–	–
Quit	1.234 (0.525-2.904)	.630	–	–
BMI (kg/m^2)[b]	**1.074 (1.026-1.125)**	**.002**[a]	**1.038 (1.003-1.074)**	**.034**[a]
ASA score: high vs low	**2.196 (1.093-4.412)**	**.027**[a]	**1.952 (1.121-3.400)**	**.018**[a]
Medical comorbidities				
Hypertension	1.958 (0.918-4.177)	.082	–	–
Chronic anemia	–	–	0.896 (0.521-1.541)	.691
COPD	1.979 (0.878-4.462)	.100	1.436 (0.708-2.912)	.316
CHF	1.479 (0.515-4.253)	.467	**2.722 (1.252-5.916)**	**.011**[a]
Diabetes	1.690 (0.864-3.307)	.125	1.172 (0.669-2.055)	.579
CVA/TIA history	3.323 (0.969-11.402)	.056	3.632 (1.238-10.659)	.019
Psychoses	–	–	2.067 (0.754-5.665)	.158
HIV	1.394 (0.454-4.279)	.562	1.081 (0.400-2.920)	.877
Hep C	1.052 (0.376-2.948)	.923	1.729 (0.739-4.048)	.207
Renal disease	1.798 (0.778-4.155)	.170	1.727 (0.881-3.387)	.112
Liver disease	–	–	1.451 (0.287-7.337)	.653
Rheumatic/inflammatory disorder	–	–	1.170 (0.624-2.194)	.625
Hypothyroid	–	–	1.780 (0.810-3.914)	.151
Disposition: rehab vs home	**2.590 (1.231-5.463)**	**.012**[a]	**2.471 (1.357-4.502)**	**.003**[a]
Anesthesia: GA vs neuraxial	**3.048 (1.256-7.396)**	**.014**	1.243 (0.708-2.184)	.448
Total time in room (min)[b]	1.003 (0.994-1.013)	.460	0.998 (0.990-1.006)	.630
Perioperative transfusion	0.951 (0.477-1.899)	.887	–	–
Postop ICU admit	–	–	1.689 (0.668-4.273)	.268

COPD, chronic obstructive pulmonary disease; CVA/TIA, cerebrovascular accident/transient ischemic attack.
[a] Final multivariate model (N = 1165) with bolded values indicating statistical significance at the $P < .05$ level.
[b] Odds ratios for continuous variables represent increases in likelihood per unit change with a C-statistic of 0.804.

a more conservative approach to blood transfusions. While no formal protocol was implemented per se, the overall clinical picture and presence of patient symptoms progressively carried more weight in the decision-making process, rather than treating a specific laboratory value. As a result, transfusion rates went from 28.4% in 2008 to just 2.4% by 2013 (Table 2).

With respect to the 90-day readmission rates for THA and TKA, the reported ranges in the literature are from 2.9% to 10.9% for THA and 3.5% to 15.6% for TKA [22]. Our institution's URRs are comparable to these reports [11,16-25]. The independent risk factors associated with increased likelihood of unplanned readmission over the 10-year period included an ASA score of ≥3, undergoing GA during surgery, being discharged to an inpatient rehab facility as opposed to home, and increasing patient BMI levels.

ASA Scores

A high ASA score as a predictor of early unplanned readmission is becoming an increasingly popular topic in the orthopedic literature. Sathiyakumar et al recently demonstrated that after controlling for age, gender, race, and medical comorbidities, the ASA score demonstrated a significant association with 30-day

Table 4
Top ICD-9 Codes and Associated Clinical Category for Individual Unplanned Readmission Encounters.

ICD-9 Codes		Totals[a] ($n = 85$)	% of 90-d Readmissions
	Direct surgical site related[b]	**40**[a]	**47.1**[a]
	Infection/wound related	19	22.4
998.59	Other postoperative infection	8	9.4
682.6	Cellulitis and abscess of leg, except foot	3	3.5
996.66	Infection and inflammatory reaction due to internal joint prosthesis	3	3.5
	Pain/swelling	16	18.8
719.45, 719.46, 729.5	Pain in joint, pelvic region, and thigh; pain in joint, lower leg; pain in limb	10	11.8
996.77	Other complications due to internal joint prosthesis	3	3.5
	Mechanical/periprosthetic Fx	5	5.9
996.47	Other mechanical complication of prosthetic joint implant	2	2.4
	Other causes[b]	**45**[a]	**52.9**[a]
285.89	*Anemia, unspecified*	5	5.9
	Chest pain		
786.59, 786.5	Other chest pain, chest pain unspecified	5	5.9
486	*Pneumonia, organism, unspecified*	3	3.5

[a] Totals are listed for the different clinical categories ([b]) and subcategories (italics) provided and the various ICD-9 diagnosis codes; totals for all are listed as a percentage of 90-d readmissions ($N = 85$). Note the list provided excludes ICD-9 codes with the fewest occurrences and the totals ([a]) by category reflect all readmissions.

readmission in almost 9000 orthopedic trauma patients. Specifically, an ASA score of 2, 3, or 4 correlated with a 1.04, 3.77, or 13.7 times increase in the risk of readmission at 30 days, respectively [29]. Another study by Phan et al [30] found an ASA score of 4 correlated with a 5.7 times risk for being readmitted within 30 days after an elective anterior cervical discectomy and fusion procedure. Finally, Bernatz et al [31] investigated the independent risk factors for 30-day unplanned readmission across all orthopedic subspecialties over a 24-month period, and found that higher ASA scores conferred a nearly 2-fold increased risk after accounting for other relevant confounding variables.

The relationship between higher ASA scores and risk of early unplanned readmission is not well delineated with respect to TJA literature. Schaeffer et al recently investigated about 500 primary elective THA and TKA cases and found that an ASA score of ≥3 was associated with a 3-fold increased likelihood of 30-day readmission. However, this study omitted patient medical comorbidities from the data analysis and no multivariate analysis was performed. The only other variables included from the index admission were patient age and total LOS [32]. Our study is able to make a much stronger conclusion in this regard. Over the 10-year period, having an ASA score of ≥3 was associated with a greater than 2-fold risk of unplanned readmission at 30 days. This association was statistically significant in the final multivariate model accounting for many other variables and potential confounding risk factors, including patient medical comorbidities (Table 3).

General Anesthesia

To our knowledge, no study has reported GA as an independent risk factor for unplanned readmission to the hospital within 30 days. A recent study compared GA and spinal anesthesia in primary elective THA procedures with several different outcomes of interest including operative times, postoperative complications, and risk of unplanned readmission. The authors reported an increase in both total time spent in the operating room as well as total surgical times for cases using GA. However, no difference was found between the groups with respect to risk of 30-day unplanned readmission [33]. We found after adjusting for all other variables and patient comorbidities that GA was an independent risk factor for 30-day readmission at our institution (Table 3). Aside from GA, no other surgical factors were found to be independently associated with an increased likelihood of readmission during the study period.

Discharge Disposition

Patient discharge disposition remains a controversial topic with respect to risk of early unplanned readmission [11]. Over the last 20 years, there has been a gradual shift away from discharging the majority of patients to inpatient rehab facilities in favor of sending more patients home with home health services (HHS) or home under self-care. From 1998 to 2009, reported discharge rates to home with HHS increased from 15% to 35% [34]. Our institution also followed a similar trend from 2004 to 2013, with the annual percentage of primary elective TJA patients being discharged home increasing from fewer than 15% to almost 65% (Table 2). This is likely explained by more early, aggressive physical therapy regimens that are started quickly after surgery, and an increasingly active role from the social services department in coordinating the utilization of HHS and outpatient physical therapy programs.

Many recent publications have reported lower 30-day URRs in patients being discharged home as opposed to inpatient rehab facilities [8,9,20]. However, most studies are less than comprehensive in terms of patient, clinical, and operative variables under investigation. We accounted for a large range of variables, including patient demographics (age, sex, race), individual medical comorbidities, insurance statuses, ASA scores, BMIs, and total LOS, to limit potential confounding in our model. Being discharged to an inpatient rehab facility conferred a 2.6- and 2.5-times increased risk for unplanned readmission at 30 days and 90 days, respectively (Table 3).

The overall health profile of patients being discharged to inpatient rehab facilities remained poor by comparison to the discharge home cohort throughout the study period. On average, patients were older (61.7 vs 54.7 years), had higher average BMI values (33.4 vs 31.7 kg/m^2), and had higher average number of medical comorbidities (3.8 vs 3.3) compared to the discharge home cohort. Furthermore, we performed a separate interaction model for discharge disposition status by yearly progression with the outcomes of both 30-day and 90-day unplanned readmission. Thus, we were able to account for evolving trends in discharge practices at our institution and rule out a confounding relationship.

Body Mass Index

BMI values and the various obesity categories being reported as independent risk factors for unplanned readmission following elective TJA remain controversial, heterogeneous in nature, and largely inconclusive. Part of the limitations in reporting BMI data comes from the fact that the ICD-9 diagnosis coding system comprised 2 separate BMI coding systems: the first being the diagnoses codes ("278.x") which establish overweight, obese, morbidly obese, and super obese categories, and the second system uses V-codes ("85.x") which record BMI in 5-10 unit increments [27]. Lau et al reported on a review of BMI data for over 700 primary THA and TKA cases among 3 high-volume TJA centers from 2010 to 2014. The authors found concerning discrepancies and inaccuracies in both coding systems compared to the actual calculated BMIs that were obtained from individual chart reviews [27]. We chose to include BMI as a continuous variable and calculated each patient's BMI value from the preoperative anesthesia H&P document. In the final multivariate model, increasing BMI values were associated with increased likelihood of 30-day and 90-day unplanned readmission (Table 3).

Medical Comorbidities

Several medical comorbidities trended toward statistical significance with respect to increased risk of readmission, but only CHF demonstrated significance at 90 days based on the final multivariate model (Table 3). CHF has previously been shown to be an independent risk factor for both postoperative complications [35] and unplanned readmission [36] following primary elective TJA. To ensure the accuracy of all reported patient medical comorbidities, we reviewed H&P documentation at the index admission, as this has been shown to be more reliable than administrative claims data which often underreports chronic medical comorbidities [37,38]. Thus, we are also able to more confidently conclude that CHF appears to be an independent risk factor for 90-day readmission in our study population.

Causes of Readmission

We used ICD-9 diagnosis codes linked to each individual readmission encounter to determine the most common reasons for readmission. As has been previously demonstrated in the literature [39], all readmission encounters also underwent a chart review to verify the accuracy of the principal diagnosis codes upon readmission. Reasons for readmission were labeled as either "Direct/Surgical Site-Related" or "Other Causes." Our study agrees with several reports in the literature as we found that about half of our readmissions could be attributed to complications or symptoms directly involving the surgical components or directly involving the surgical site (ie, the "Direct" group) (Table 4) [6,22,40].

The most common ICD-9 diagnosis code upon readmission within 90 days was 998.59 signifying "Other postoperative infection," accounting for 9.4% (8/85) of readmissions. Clement et al [6] also found 998.59 to be the most common ICD-9 diagnosis code linked to early readmission following primary elective THA procedures at a single institution. In addition, Saucedo et al [22] studied both 30-day and 90-day readmissions after elective primary TJA cases at a single center from 2006 to 2010 and reported that about half of the readmissions were medically related. Overall, the top 5 reasons for unplanned readmission within 90 days were infection related (postoperative infection and cellulitis involving the surgical site), pain involving the surgical site or operative limb, anemia, chest pain, and pneumonia (Table 4).

Our study has several limitations. First, the data lack generalizability. Although we did find some similar findings to previous reports which have analyzed much larger sample sizes via national and statewide TJA registry databases, the goal of our study was to report from the institutional level only in order to better define all relevant risk factors in the context of our specific inner-city patient population. Our location provides unique insight into a specific sector of the inner-city, largely government-based insurance elective TJA population. Second, our study is limited by its retrospective nature. Third, we chose to omit postoperative complications in our analysis as we found significant discrepancies and inaccuracies between administrative coding of complications and actual clinical documentation. These discrepancies happened most often with minor complications such as urinary tract infections and postoperative hypotension episodes. Furthermore, our reported case volumes could be considered on the lower end of the spectrum for high-volume elective TJA hospitals. The reasons for this finding are multifactorial. One reason is related to our location being in an area surrounded by several other well-respected TJA institutions. The second reason is the majority of our cases were performed by a single, high-volume, total joint surgeon who has dedicated operative time between 2 separate institutions (one not included in this database). Finally, we are unable to identify patients who may have presented as readmissions to other hospitals within 90 days, and thus our URRs may be slightly underreported.

Our study has several strengths. First, we included all elective primary THA and TKA cases at our institution over a 10-year period. Most institutional studies are limited to 2-year to 4-year periods. We were able to simultaneously encompass a decade of elective TJA data while also accounting for changing clinical practices and trends over shorter periods to ensure our data were not skewed. Second, we verified all administrative claims data and ICD-9 diagnosis codes for readmission with thorough chart reviews to ensure coding accuracy. Third, we were able to factor in a large number of different patient demographic, clinical, and surgical variables over the entire study period. To our knowledge, this is the first study encompassing such a large range of different variables factored together over several years. Finally, although the decision to include up to 90 days in the unplanned readmission period remains controversial, we have reported on both 30-day and 90-day time periods in order to facilitate comparison of our data with all relevant studies in the literature. Additionally, with the advent of bundled payment programs for the primary elective TJA episode of care (EOC), CMS considers the 90-day period after discharge from the hospital as the total EOC. Unplanned readmission within 90 days carries significant financial risk to individual institutions in the bundled payment model. We recommend that future studies consider including the entire 90-day period in order to better understand independent risk factors and cost-drivers for the entire EOC.

In conclusion, URRs are being used as quality performance indicators and all institutions will eventually be held to the regional and national standards. Understanding the relevant risk factors in the context of unique populations served will better help individual hospitals and orthopedic surgeons stratify patients appropriately based on the potential risk of unplanned early readmission. Finally, we advocate for future studies to consider reporting from the perspective of the entire 90-day postdischarge period.

Acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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