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Same Day Discharge Total Knee and Total Hip Arthroplasty are associated with Increased Risk of Perioperative Complications

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Title: Same Day Discharge Total Knee and Total Hip Arthroplasty are associated with Increased Risk of Perioperative Complications

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JL and NME were involved in attaining data from NSQIP. JL, NME, AGDV, and SGM were involved in designing the study. JL analyzed data with help from JP and SGM. All authors contributed to the interpretation of the results, including JL, NME, JP, AGDV, DHM, DBM, and SGM. All authors reviewed, revised, and approved the final document. JL and SGM are the study guarantors, and take responsibility for the completeness of the data and the accuracy of the analysis.

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Abstract:

Objective: To determine if same-day discharge total knee or total hip arthroplasty is not associated with increased risk of unplanned readmission and adverse outcomes within 30 days of surgery.

Design: This is a population-based observational study.

Setting: Patients who underwent primary TKA or primary total hip arthroplasty (THA) between 2011 and 2017 were divided into three groups by length of stay (LOS 0, 1, and 2-3 days). All patients with LOS > 3 days were excluded from the current study. Regression analysis and propensity score matching were performed.

Data sources: American College of Surgeons -National Surgical Quality Improvement Program database.

Main Outcomes and Measures: Primary outcomes included unplanned readmission and cardiac/pulmonary complications within 30 days of surgery.

Results: We identified 226,481 TKA (LOS 0=3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 THA patients (LOS 0=2,652, LOS 1=29,617, and LOS 2-3=108,288). There were no differences in 30-day mortality. After adjusting for relevant covariates, LOS 0 (compared to LOS 1) was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; 0.67% versus 0.37%) and THA (OR 1.96, 95% CI 1.05~3.64; 0.57% versus 0.26%). There were no statistical differences in unplanned readmissions between LOS 0 and LOS 1 groups in TKA (2.41% vs 2.31%) and THA (1.62% vs 2.04%).

Conclusions: LOS 0 discharge after TKA and THA was associated with higher odds of cardiac/pulmonary complications compared to LOS 1 discharge. While the overall

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burden of complications is relatively low, until future studies can confirm or challenge our findings, a measured approach is advisable when recommending discharge of patients on the same day of surgery.

Strength and limitations of this study:

- Government policy changes in USA cast significant pressure on hospitals and
 healthcare providers to fast track patients, and expedite a push towards performing
 surgery at free-standing ambulatory surgery centers. However, there are safety
 concerns on same-day discharge after total knee arthroplasty (TKA) and total hip
 arthroplasty (THA).
- After adjustment for relevant covariates, same-day discharge after TKA and THA
 was associated with higher odds of 30-day cardiac/pulmonary complications
 comparing to next day discharged patients.
- A measured approach is advisable when recommending discharge of patients on the same day of TKA or THA surgery.
- This is a population-based observational study.

Data sharing statement:

All data utilized for the current study is available via https://www.facs.org/quality-programs/acs-nsqip.

Ethics and dissemination:

The study was exempted by the institutional review board. Results will be communicated through publication in scientific journal and conference.

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Joint arthroplasty is amongst the most commonly performed procedures in the United States with projections of continuous growth in parallel with an aging population. Total knee arthroplasty (TKA) is projected at 3.48 million procedures annually, while total hip arthroplasty (THA) at 700,000 per year by 2030 \(^1\). Until recently, TKA and THA were listed as Inpatient Only (IPO) procedures by the Center for Medicare and Medicaid Service (CMS), which requires greater than 24 hours of postoperative care. Financial pressures, advances in surgical techniques, improved pain management, and early physical rehabilitation have led to a continuous reduction in total hospital length of stay (LOS) after surgery ². This trend has made ambulatory joint arthroplasty practice feasible. In fact, CMS removed TKA from the IPO list in January 2018 with the expectation of reducing healthcare cost ³. It is likely that CMS might remove THA from the IPO list in the near future, especially since the American Association of Orthopaedic Surgeons (AAOS) has also provided supportive statements for outpatient total hip arthroplasty 4. Such policy decisions by CMS cast significant pressure on hospitals and healthcare providers to fast track patients, and expedite a push towards performing surgery at freestanding ambulatory surgery centers.

However, practical and logistical concerns remain regarding the safety of fast track approaches, especially the true ambulatory practice with same day discharge. While mostly focused on patient selection and optimization of peri-operative care guided under well-defined clinical pathways, actual outcome data are scarce. Several studies found no difference in short-term complications after comparing shorter inpatient stay with LOS≥

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2 days ⁵⁻⁷. Additional studies comparing admission status of outpatient versus inpatient, and concluded that outpatient joint arthroplasty is safe and effective ⁸⁻¹¹. None of these studies focused on true ambulatory population (LOS 0) and the fast track group (LOS 1). Only one previous study by Otero et al. included a small group of LOS 0 patients, and did not identify differences among TKA patients but increased complication rate in THA patients ¹². However, this earlier study was limited by the small sample size to be conclusive, and their study cohort included both emergent procedures and bilateral arthroplasties.

Given the current push towards same-say discharge after lower extremity joint arthroplasty surgery and lack of large-scale data on crucial comparisons, we therefore sought to study the safety of ambulatory surgical practice of TKA and THA with the access of several folds of more subjects to hopefully draw more convincing conclusion. For this purpose, we studied and compared complications and readmission rate and risk in patients discharged on the day of surgery (LOS 0) to those with a LOS of 1 day (LOS 1). We also included the standard practice group with LOS 2-3 days as a reference group. We hypothesized that there would be no difference in complications and readmission rates and risks among patients discharged same day of TKA or THA surgery.

Methods:

This study was exempted by the institutional review board (IRB# 2017-0716) as data accessed and analyzed were de-identified. The population-based observational study follows the STROBE statement.

Cohort description

The current study involved prospectively collected patient information without any identifiable patient specific information. None of these included study subjects would benefit from the current study. However, future patients may benefit from the knowledge highlighted in the current study once it is publicly available.

Patient and Public Involvement

We acquired the data from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) from 2011 to 2017 (http://site.acsnsqip.org). NSQIP prospectively collects data on over 200 variables, including demographic information, comorbidities, intraoperative variables, 30-day postoperative complications, and readmission. NSQIP conducted independent follow-ups of all registered patients for 30 days even after discharged from hospital, therefore NSQIP was able to capture post-surgical events for 30 days no matter whether patients were still in hospital or were discharged to other destination. NSQIP database does not include surgical procedures performed at ambulatory surgical center as of 2017. To define our study cohort, we only included patients with the principal Current Procedural Terminology (CPT) code for primary TKA (CPT 27447) or primary THA (CPT 27130). We only included patients

from 2011 to 2017, as the NSQIP dataset provides information on the readmission incidence within 30 days of surgery during this time frame. There were a total of N=232,218 and N=141,767 entries for TKA and THA with LOS from 0 to 3 calendar days, respectively. We first excluded patients categorized as "emergency" to establish a more homogenous study cohort (N=193 & 435 respectively). We then excluded patients who received bilateral arthroplasty as defined by the relevant concurrent CPT code (N=5,544 & 775 respectively). The final cohort included 226,481 and 140,557 subjects for TKA and THA, respectively.

Study variables

Patients were separated into 3 groups based on LOS calculated based on calendar days (LOS 0 for same day discharge; LOS 1 for patients with next day discharge; and LOS 2-3 for patients with a traditional LOS of 2 to 3 days). The outcomes of interest were readmission within 30 days and six composite complication variables, including: wound infection, systemic infection, cardiac/pulmonary complications, major complications (including any cardiac, pulmonary, central nerve system, renal, or systemic infection complications), any complication (including any complications enlisted in the NSQIP database), and any complication excluding blood transfusion.

Statistical analysis

Data analysis was executed using STATA 14.2 statistical software (StataCorp LP, College Station, TX). Analysis of variance was used to analyze continuous variables.

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Pearson chi-square tests were applied for categorical variables. After applying Bonferroni correction, p-value less than 0.0036 (0.05/14 variables) was used as the cutoff for statistical significance.

We next conducted single variable and multi-variable regression analysis to examine the impact of LOS on readmission and complications. The confounding variables included age, sex, race, body mass index (BMI), surgical duration, year of surgery, and ASA classification. In the regression analysis we treated the LOS 1 group as the reference. The odds ratio (OR) and 95% confidence interval (CI) were reported. We elected to report output from the multi-variable regression analysis in the result section. To further evaluate robustness of our results, we also performed a propensity score matched analysis where the same covariates were entered to calculate the propensity score to receive either same day (LOS 0) or fast track (LOS 1) surgery. We employed the Kernel matching algorithm based on the weighted average of all controls, and the weights are inversely proportional to the distance between the propensity scores.

Results:

We identified N=226,481 primary TKA (LOS 0= 3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 primary THA patients (LOS 0= 2,652, LOS 1=29,617, and LOS 2-3=108,288), respectively. There were no major clinically significant differences in the comorbidity burden between LOS 0 and LOS 1 groups, while LOS 2-3 group carried a higher comorbidity burden (Table 1). Between 2011 and 2017, LOS trended downwards, with an increasing number of patients being discharged on the day of surgery or the next day (TKA 1.04% in 2011, and 26.55% in 2017; THA 3.44% in 2011, and 34.91% in 2017, respectively). The discharge destination was most frequently to home amongst the various TKA groups (LOS 0 group 89.48%, LOS 1 group 97.62%, and 76.39% in LOS 2-3 group). Home discharge was the most prominent disposition in THA as well (LOS 0 group 94.72%, LOS 1 group 97.92%, and 78.37% in LOS 2-3 group). There were no differences in 30-day mortality in either TKA or THA groups (Table 2). The incidences of 30-day major complications and unplanned readmissions were low in the LOS 1 discharge group (0.53% and 2.31% in TKA; 0.43% and 2.04% in THA respectively). There were no statistically significant differences in unplanned readmission between LOS 0 and LOS 1 group in TKA patients (2.41% vs 2.31% in TKA, OR 1.10, 95% CI: 0.86~1.42), nor among THA patients (1.62% vs 2.04% in THA, OR 0.84, 95% CI: 0.60~1.16). LOS 2-3 group otherwise carried the highest incidence of unplanned readmission (Table 2).

Table 3 provides results from the univariable regression, multivariable regression, and the propensity score matching analysis comparing the LOS 0 to the LOS 1 groups. The LOS

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0 group was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; unadjusted prevalence 0.67% versus 0.37%) and THA (OR 1.96, 95% CI 1.05~3.64; unadjusted prevalence 0.57% versus 0.26%) when compared to the LOS 1 group. Propensity score matching analysis confirmed such increased incidence of cardiac/pulmonary complications in LOS 0 group (Table 2). The incidence was even higher when compared to the LOS 2-3 group (Table 2).

LOS 0 group was associated higher odds of major complications in TKA recipients (OR 1.94, 95% CI: 1.29~2.92), but not in THA patients (OR 1.55, 95% CI: 0.90~2.67) compared to LOS 1 patients (Table 3 & 4). Similar patterns of differences were also observed in the outcomes for any complications, and any complications excluding transfusion. These differences were statistically significant only in TKA but not in THA (Table 3 & 4). Propensity score matching analysis further confirmed all significances (Table 2). There were no differences in wound infection and systemic infection between LOS 0 and LOS 1 groups in either TKA or THA.

In this analysis of data collected by NSQIP, we present data using population data that challenge the assumed safety of same day discharge after TKA or THA surgery. Our analysis showed somewhat surprising results that LOS 0 group had higher risks of cardiac/pulmonary complications within 30 days after surgery in both TKA and THA, compared to patients in the LOS 1 group. Our study also identified significantly increased odds for major complications with LOS 0 discharge status compared to LOS 1 group amongst TKA recipients.

The average LOS after TKA decreased from 3.42 days in 2011 to 2.38 days in 2017, and from 3.54 days in 2011 to 2.31 days in 2017 after THA surgery (NSQIP data).

Accordingly, more patients received fast-track care in more recent years. Previous studies have not shown a difference in readmission rates and complications among fast-track TKA and THA patients ¹³⁻¹⁸. Definition of fast-track practice has also been evolving, from previously LOS 2-3 days to as short as LOS 1 day. It is foreseeable that fast-track practice will gear towards LOS 0 day status in the future. Otero et al. studied patients from 2011 and 2013, which they concluded that there were no differences in readmission and 30-day complication in TKA between LOS 0 and LOS 1 status, while THA patients with LOS 0 status were associated with a higher 30-day complication rate ¹². However, this study is limited by the small number of patients in the LOS 0 and LOS 1 groups. In addition, the authors did not exclude patients with emergent admission status and patients who received bilateral arthroplasty procedures. Other researchers have attempted to study the difference in complications in arthroplasty based on the admission

In order to achieve these goals, clinicians have attempted to identify patients at risk of readmission or complications, and thus triage them accordingly. Many independent risk factors have been identified, including advanced age, gender, high body mass index, increased ASA classification, the presence of chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease, cirrhosis, and chronic kidney disease ⁵ 12 ²⁰⁻²⁴. In addition, poor living conditions, use of mobility aids, and social economic factors are also likely to influence LOS and outcomes ⁶ ²¹ ²⁵. Clinicians further developed prediction models to determine a patient's candidacy for fast-track surgical care with moderate success ⁵ ⁶ ²⁶. It should be mentioned, however, that some data suggest that the majority of patients suffering from a complication after joint arthroplasty may not have any identifiable risk factors²⁰, thus putting strategies currently being used to identify patients at risk into question.

The majority of major complications, such as cardiac/pulmonary complications, likely occur past 24 hours ⁵. This timeframe may therefore fall outside the in-hospital observation period as it relates to fast-track patients. It also has been shown that over 50% of patients with major complications do not carry any of these predisposing risk factors ²⁰. Therefore, identifying risk factors and risk stratification of patient populations

may be of limited use in predicting successful fast-track patients without risk of readmission or complications. The current approach seeks to identify higher risk patients and subsequently exclude them from the fast track pathway. This is supported by our findings that patients in the LOS2-3 group have higher comorbidity burden and are older than those in the LOS0 and LOS1 groups.

Many institutions have established enhanced recovery after surgery (ERAS) pathways for TKA and THA. These pathways seek to improve outcomes by standardizing the routine use of potentially beneficial interventions that improve outcomes and by employing patient selection strategies. Consequently they include younger and healthier patients with sufficient social support to facilitate early discharge. However, such approaches may not be sufficient to reconcile them with unaltered or lower level of complications while gearing towards true ambulatory surgical model.

We conducted this NSQIP data analysis with the hypothesis that ambulatory patients were not at increased risk comparing to other fast track surgical patients after TKA or THA. It is reasonable to assume that these fast-tracked patients were carefully selected without major comorbidity concerns. Further, it is reasonable to assume that these patients met the discharge criteria established across various institutions. Assuming such safe practice model were established and applied, our finding raise concern regarding the safety of same day discharge after TKA or THA surgery. This is especially problematic if the increased risk of complications among this group is related to gaps in continuity of care and lack of necessary early intervention when indicated. However, despite this

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possibility, our data is not able to establish this causal relationship at this time, and future studies are needed to identify the etiology and mechanism by which complications may develop.

Our study has several limitations. First, this is a retrospective cohort study and related limitations in respect to establishing causality apply. Although NSQIP has rigorous quality measures to ensure high quality data collection, there was still missing information on several interesting pre-existing comorbidity variables, such as stroke and myocardial infarction. Our study is therefore limited by the inclusion of available variables and recorded information only. Second, patients were categorized retrospectively based on their actual LOS determined by calendar days. Future research is indicated to prospectively assign clinical pathways and compare readmission and complications. Third, NSQIP only contains outcome information within 30 days, thus outcomes beyond this point but still related to the index procedure remain elusive. Fourth, NSQIP prohibits identifying hospital and surgeon, while studying surgical volume, inpatient hospital versus free-standing surgical center, and other practice pattern might be insightful. Last, readmission indicator in NSQIP database only included inpatient readmission. Information on emergency department visit would also be important. However, it is beyond the scope of our analysis.

Conclusion

Our study is the first comprehensive study to focus on LOS 0 TKA and THA patients.

Although same day discharge after TKA and THA surgery is not associated with

increased risk of unplanned readmission, these patients carry increased risk of complications. Therefore, the current trend towards increasing discharges on the same day of surgery after TKA and THA should be approached with caution and requires reconsideration. Future prospective studies are needed to confirm our finding and identify if ambulatory joint arthroplasty is associated with acceptable risk for complications and readmissions, as well as its financial impact on our healthcare system.

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Table 1. Patient demographic information and comorbidity

				Т	otal Knee	e Arthroplas	sty			LOS 0 LOS 1							
		LOS	5 0	LOS	1		LOS	2-3		LOS	S 0	LOS	5 1	emb Ens	LOS	2-3	
		Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**	Mean/N	Std/%	Mean/N	Std/%	reposition of the second of th	Mean/N	Std/%	P value**
Age (year)		65.18	9.67	65.40	8.98	0.194	66.61	9.49	<0.001	61.46	10.67	62.13	10.68	6 H .692	65.07	11.33	< 0.001
Sex														o tex			
	Female	1682	53.94	16363	52.10	0.050	120447	62.77	< 0.001	1214	45.78	13254	44.75	tano	61006	56.37	< 0.001
	Male	1436	46.06	15041	47.90		71427	37.23		1438	54.22	16363	55.25	yed f eur (47225	43.63	
Race														rom ABE			
	White	2512	88.98	26698	89.60	0.354	148875	88.45	< 0.001	2213	90.40	25540	90.76		83651	89.17	< 0.001
	Black	200	7.08	2080	6.98		14103	8.38		162	6.62	1920	6.82	. Al :	8108	8.64	
	Others	111	3.93	1020	3.42		5330	3.17		73	2.98	681	2.42	njopo train	2054	2.19	
BMI		32.09	6.39	32.18	6.17	0.419	33.06	6.91	< 0.001	29.16	5.39	29.69	5.73	5 <0.	30.33	6.41	< 0.001
OR time (mir	ns)	84.58	33.48	86.24	29.24	0.003	90.23	34.88	< 0.001	82.60	33.49	87.67	32.02	omecom/ onJune ′	91.43	38.26	< 0.001
ASA classific	cation													simi o			
	I/II	1882	60.42	17957	57.21	0.001	99497	51.87	< 0.001	1958	73.83	20148	68.07	ਬਾ<0.ਲੀ1 ਫ	62496	57.76	< 0.001
	>=[[[1233	39.58	13432	42.79		92336	48.13		694	26.17	9451	31.93	achn	45696	42.24	
Diabetes														ဇ္က ႏွ			
	Type II	367	11.77	3699	11.78	0.983	25932	13.51	< 0.001	182	6.86	2152	7.27		9967	9.20	< 0.001
	Type I	93	2.98	955	3.04		7901	4.12		46	1.73	537	1.81	at A	2892	2.67	
Smoker		234	7.50	2565	8.17	0.196	16263	8.47	0.036	294	11.09	3696	12.48	at Agences	14317	13.22	< 0.001
Function state	us	11	0.35	139	0.45	0.647	1932	1.01	< 0.001	14	0.53	211	0.71	0. 45 4	1885	1.75	< 0.001
CHF		4	0.13	43	0.14	0.901	483	0.25	< 0.001	2	0.08	25	0.08	0. 45 4 0. 65ib][8 0. 65grap	272	0.25	< 0.001
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2019-03 pyright,<0.03			
	61084	56.41	< 0.001
2.23 ट 0. 8 2	4108	3.79	< 0.001

HTN	1811	58.08	19187	61.10	0.001	124958	65.10	< 0.001	1185	44.68	14516	49.01 = <0.	61084	56.41	< 0.001
COPD	82	2.63	732	2.33	0.294	6404	3.34	< 0.001	67	2.53	660	2.23 c 0. 2	4108	3.79	< 0.001
Liver disease	0		4	0.01	0.529	27	0.01	0.792	1	0.04	2	0.01 g 0. 11 3	22	0.02	0.222
Renal insufficiency	3	0.10	28	0.09	0.900	242	0.13	0.201	3	0.11	22	0.07	191	0.18	< 0.001
Cancer	1	0.03	21	0.07	0.463	190	0.10	0.119	3	0.11	41		254	0.23	0.003
Bleeding disorder	49	1.57	445	1.42	0.488	3987	2.08	< 0.001	19	0.72	354	1.20	2168	2.00	< 0.001

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congestive heart failure; HTN: hypertension; COPD: Chronic obstructive pulmonary disease

^{*} p value analysis between LOS 0 and LOS 1 groups

^{**} p value analysis among LOS 0, LOS 1, and LOS 2-3 groups

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Table 2. Incidence of complications with various length of stay (LOS, Per 100 patients)

Table 2. Incidence of complications w	ith various l	ength of		Open Per 100 patie		6/bmjopen-2019-031260 cted by copyright, inclu		F	age 24 of 28				
		TKA				TETIA ON SERVICE SERVI							
	LOS 0	LOS 1	P value*	LOS 2-3	P value**	LOS 0	₹ 0\$ ₽	P value*	LOS 2-3	P value**			
Mortality	0.16	0.08	0.123	0.1	0.253	0.11	Ses r	0.939	0.11	0.978			
Unplanned readmission	2.41	2.31	0.749	2.89	< 0.001	1.62	yr 2019 12019 130nem 191atec	0.144	3.26	< 0.001			
Major complication	0.96	0.53	0.003	0.64	0.006	0.72	nent (solution te	0.034	0.65	< 0.001			
Any complication excluding transfusion	2.98	1.99	< 0.001	2.74	< 0.001	1.73	vnioa Superi ext an	0.849	2.67	< 0.001			
Any complication	4.49	2.16	<0.001	6.95	< 0.001	3.13	d = 2086 d dat	0.420	9.76	< 0.001			
Systemic infection	1.67	1.28	0.070	1.73	< 0.001	1.06	rom26 ABES	0.372	2.03	< 0.001			
Wound infection	0.77	0.72	0.753	0.88	0.015	0.49	ing, 2	0.113	1.11	< 0.001			
Cardiac/pulmonary complications	0.67	0.37	0.009	0.44	0.023	0.57	om@pe	0.005	0.39	0.002			

TKA: Total knee arthroplasty; THA: Total hip arthroplasty

^{*} p value from analysis between LOS 0 and LOS 1 groups

^{**} p value from analysis among LOS 0, LOS 1, and LOS 2-3 groups

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Table 3. Odds ratio (OR) analysis and propensity score matching (PM) analysis of complications in total kneed art throplasty (TKA)

	TKA	/Single variab	le regress	sion		TKA	/Multi-variabl	e regress	DKA/PM/Incidence (%)**				
	OR	P value	95% (OR	P value	95% CI		or Less 0	LOS 1	P value	
Mortality	2.10	0.132	0.80	5.51		1.78	0.295	0.60	5.27	embe Ense			
Unplanned readmission	1.04	0.749	0.82	1.32		1.10	0.445	0.86	1.42	r 2019 ignem elated			
Major complication	1.81	0.003	1.22	2.67	*	1.94	0.001	1.29	2.92	*0 te	0.32	0.003	*
Any complication excluding transfusion	1.51	< 0.001	1.21	1.89	*	1.55	< 0.001	1.22	1.96	vnloa *an	1.53	< 0.001	*
Any complication	2.13	< 0.001	1.77	2.57	*	2.03	< 0.001	1.66	2.47	aded from the state of the stat	1.85	< 0.001	*
Systemic infection	1.31	0.071	0.98	1.75		1.30	0.098	0.95	1.79	rom h ABES ta mini			
Wound infection	1.07	0.753	0.70	1.63		0.99	0.963	0.61	1.59	ng. 🏺			
Cardiac/pulmonary complications	1.84	0.010	1.16	2.94	*	1.95	0.007	1.20	3.16	/bm/ope Al traini	0.25	0.018	*

^{*} indicates significance; **: propensity score matched 2805 patients per group

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Table 4. Odds ratio (OR) analysis and propensity score matching (PM) analysis of complications in total hip analysis (THA)

	THA	Single variable	le regress	sion	THA	/Multi-variabl	e regress	DHA/PM/Incidence (%)**			
	OR	P value	95% CI		OR	P value	95% CI		₫ IØ S 0	LOS 1	P value
Mortality	1.05	0.939	0.32	3.42	0.84	0.786	0.24	2.99	cember Ensei uses re		
Unplanned readmission	0.79	0.145	0.58	1.08	0.84	0.292	0.60	1.16	r 2019 ignem elated		
Major complication	1.68	0.036	1.03	2.72	1.55	0.112	0.90	2.67	lent to t		
Any complication excluding transfusion	1.03	0.849	0.76	1.4	1.00	0.979	0.72	1.41	/nloa juper xt an		
Any complication	1.1	0.420	0.87	1.38	1.12	0.363	0.87	1.44	2		
Systemic infection	0.84	0.373	0.57	1.23	0.77	0.259	0.49	1.20	rom h ABES		
Wound infection	0.64	0.116	0.36	1.12	0.75	0.334	0.42	1.35	ing.		
Cardiac/pulmonary complications	2.15	0.007	1.24	3.75 *	1.96	0.034	1.05	3.64	, Al traini	0.12	0.020

^{*} indicates significance; **: propensity score matched 2443 patients per group

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STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract
		(b) Provide in the abstract an informative and balanced summary of what was done
		and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment,
		exposure, follow-up, and data collection
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of
		participants. Describe methods of follow-up
		(b) For matched studies, give matching criteria and number of exposed and
		unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect
		modifiers. Give diagnostic criteria, if applicable
Data sources/	8*	For each variable of interest, give sources of data and details of methods of
measurement		assessment (measurement). Describe comparability of assessment methods if there is
		more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable,
		describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
		(b) Describe any methods used to examine subgroups and interactions
		(c) Explain how missing data were addressed
		(d) If applicable, explain how loss to follow-up was addressed
		(<u>e</u>) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially
		eligible, examined for eligibility, confirmed eligible, included in the study,
		completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and
		information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	15*	Report numbers of outcome events or summary measures over time
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and
		their precision (eg, 95% confidence interval). Make clear which confounders were
		adjusted for and why they were included
		(b) Report category boundaries when continuous variables were categorized
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a
		meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or
		imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations,
		multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if
		applicable, for the original study on which the present article is based

^{*}Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Same Day Discharge Total Knee and Total Hip Arthroplasty are associated with Increased Risk of Cardiac/Pulmonary Complications but not Readmission Risk, a Population-based Observational Study

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Title: Same Day Discharge Total Knee and Total Hip Arthroplasty are associated with Increased Risk of Cardiac/Pulmonary Complications but not Readmission Risk, a Population-based Observational Study

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JL and NME were involved in attaining data from NSQIP. JL, NME, AGDV, and SGM were involved in designing the study. JL analyzed data with help from JP and SGM. All authors contributed to the interpretation of the results, including JL, NME, JP, AGDV, DHK, DBM, and SGM. All authors reviewed, revised, and approved the final document. JL and SGM are the study guarantors, and take responsibility for the completeness of the data and the accuracy of the analysis.

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Abstract:

Objective: To determine if same-day discharge total knee or total hip arthroplasty is not associated with increased risk of unplanned readmission and adverse outcomes within 30 days of surgery.

Design: This is a population-based observational study.

Setting: Patients from 708 participating institutions who underwent primary TKA or primary total hip arthroplasty (THA) between 2011 and 2017 were divided into three groups by length of stay (LOS 0, 1, and 2-3 days). All patients with LOS > 3 days were excluded from the current study. Regression analysis and propensity score matching were performed.

Data sources: American College of Surgeons -National Surgical Quality Improvement Program database.

Main Outcomes and Measures: Primary outcomes included unplanned readmission and cardiac/pulmonary complications within 30 days of surgery.

Results: We identified 226,481 TKA (LOS 0=3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 THA patients (LOS 0=2,652, LOS 1=29,617, and LOS 2-3=108,288). There were no differences in 30-day mortality. After adjusting for relevant covariates, LOS 0 (compared to LOS 1) was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; 0.67% versus 0.37%) and THA (OR 1.96, 95% CI 1.05~3.64; 0.57% versus 0.26%). There were no statistical differences in unplanned readmissions between LOS 0 and LOS 1 groups in TKA (2.41% vs 2.31%) and THA (1.62% vs 2.04%).

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Conclusions: LOS 0 discharge after TKA and THA was associated with higher odds of cardiac/pulmonary complications compared to LOS 1 discharge. While the overall burden of complications is relatively low, until future studies can confirm or challenge our findings, a measured approach is advisable when recommending discharge of patients on the same day of surgery.

Strength and limitations of this study:

- Information on safety of same-day discharge after total knee arthroplasty (TKA) and total hip arthroplasty (THA) is lacking
- This is the first comprehensive study to focus on length of stay (LOS) 0 and LOS 1
 TKA and THA patients.
- This is a population-based observational study.

Data sharing statement:

All data utilized for the current study is available via https://www.facs.org/quality-programs/acs-nsqip. All data is available and free of charge for any researchers within these participating institutions of NSQIP (https://www.facs.org/quality-programs/acs-nsqip/participant-use).

Ethics and dissemination:

The study was exempted by the institutional review board. Results will be communicated through publication in scientific journal and conference.

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Introduction:

Joint arthroplasty is amongst the most commonly performed procedures in the United States with projections of continuous growth in parallel with an aging population. Total knee arthroplasty (TKA) is projected at 3.48 million procedures annually, while total hip arthroplasty (THA) at 700,000 per year by 2030 \(^1\). Until recently, TKA and THA were listed as Inpatient Only (IPO) procedures by the Center for Medicare and Medicaid Service (CMS), which requires greater than 24 hours of postoperative care. Financial necessity, advances in surgical techniques, improved pain management, and early physical rehabilitation have led to a continuous reduction in total hospital length of stay (LOS) after surgery ². This trend has made ambulatory joint arthroplasty practice feasible. In fact, CMS removed TKA from the IPO list in January 2018 with the expectation of reducing healthcare cost ³. It is likely that CMS might remove THA from the IPO list in the near future, especially since the American Association of Orthopaedic Surgeons (AAOS) has also provided supportive statements for outpatient total hip arthroplasty 4. Such policy decisions by CMS cast significant pressure on hospitals and healthcare providers to fast track patients, and expedite a push towards performing surgery at freestanding ambulatory surgery centers.

However, practical and logistical concerns remain regarding the safety of fast track approaches, especially the true ambulatory practice with same day discharge. While mostly focused on patient selection and optimization of peri-operative care guided under well-defined clinical pathways, actual outcome data are scarce. Several studies found no difference in short-term complications after comparing shorter inpatient stay with LOS≥

This study was exempted by the institutional review board (IRB# 2017-0716) as data accessed and analyzed were de-identified. The population-based observational study follows the STROBE statement (second paragraph of "Patient and Public Involvement" section).

Cohort description

The current study involved prospectively collected patient information without any identifiable patient specific information. None of these included study subjects would benefit from the current study. However, future patients may benefit from the knowledge highlighted in the current study once it is publicly available.

Patient and Public Involvement

We acquired the data from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) from 2011 to 2017 (http://site.acsnsqip.org). NSQIP prospectively collects data on over 200 variables, including demographic information, comorbidities, intraoperative variables, 30-day postoperative complications, and readmission. NSQIP conducted independent follow-ups of all registered patients for 30 days even after discharged from hospital, therefore NSQIP was able to capture post-surgical events for 30 days no matter whether patients were still in hospital or were discharged to other destination. NSQIP database does not include surgical procedures performed at ambulatory surgical center as of 2017. To define our study cohort, we only included patients with the principal Current Procedural Terminology (CPT) code for

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There were a total of N=232,218 and N=141,767 entries for TKA and THA with LOS from 0 to 3 calendar days, respectively. We first excluded patients categorized as "emergency" to establish a more homogenous study cohort (N=193 & 435 respectively). We then excluded patients who received bilateral arthroplasty as defined by the relevant concurrent CPT code (N=5,544 & 775 respectively). The final cohort included 226,481 and 140,557 subjects for TKA and THA, respectively.

Study variables

Patients were separated into 3 groups based on LOS calculated based on calendar days (LOS 0 for same day discharge; LOS 1 for patients with next day discharge; and LOS 2-3 for patients with a traditional LOS of 2 to 3 days). The outcomes of interest were readmission within 30 days and six composite complication variables, including: wound infection, systemic infection, cardiac/pulmonary complications (including cardiac arrest requiring CPR, myocardial infarction, pulmonary embolism, unplanned intubation, and/or on ventilator >48 hours), major complications (including any cardiac, pulmonary, central nerve system, renal, or systemic infection complications), any complication (including any complications enlisted in the NSQIP database), and any complication excluding blood transfusion.

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Statistical analysis

Data analysis was executed using STATA 14.2 statistical software (StataCorp LP, College Station, TX). Analysis of variance was used to analyze continuous variables. Pearson chi-square tests were applied for categorical variables. After applying Bonferroni correction, p-value less than 0.0036 (0.05/14 variables) was used as the cutoff for statistical significance.

We next conducted single variable and multi-variable regression analysis to examine the impact of LOS on readmission and complications. The confounding variables included age, sex, race, body mass index (BMI), surgical duration, year of surgery, and ASA classification. In the regression analysis we treated the LOS 1 group as the reference. The odds ratio (OR) and 95% confidence interval (CI) were reported. We elected to report output from the multi-variable regression analysis in the result section. To further evaluate robustness of our results, we also performed a propensity score matched analysis where the significant covariates were entered to calculate the propensity score to receive either same day (LOS 0) or fast track (LOS 1) surgery. We employed the Kernel matching algorithm based on the weighted average of all controls, and the weights are inversely proportional to the distance between the propensity scores.

Patient and Public Involvement

Patients were not involved in the design and conduct of current study. All patient related information was de-identified from the database to preserve privacy.

We identified N=226,481 primary TKA (LOS 0= 3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 primary THA patients (LOS 0= 2,652, LOS 1=29,617, and LOS 2-3=108,288), respectively. There were no major clinically significant differences in the comorbidity burden between LOS 0 and LOS 1 groups, while LOS 2-3 group carried a higher comorbidity burden (Table 1). Between 2011 and 2017, LOS trended downwards, with an increasing number of patients being discharged on the day of surgery or the next day (TKA 1.04% in 2011, and 26.55% in 2017; THA 3.44% in 2011, and 34.91% in 2017, respectively). The discharge destination was most frequently to home amongst the various TKA groups (LOS 0 group 89.48%, LOS 1 group 97.62%, and 76.39% in LOS 2-3 group). Home discharge was the most prominent disposition in THA as well (LOS 0 group 94.72%, LOS 1 group 97.92%, and 78.37% in LOS 2-3 group). There were no differences in 30-day mortality in either TKA (Table 2) or THA groups (Table 3). The incidences of 30-day major complications and unplanned readmissions were low in the LOS 1 discharge group (0.53% and 2.31% in TKA; 0.43% and 2.04% in THA respectively). There were no statistically significant differences in unplanned readmission between LOS 0 and LOS 1 group in TKA patients (2.41% vs 2.31% in TKA, OR 1.10, 95% CI: 0.86~1.42, Table 2), nor among THA patients (1.62% vs 2.04% in THA, OR 0.84, 95% CI: 0.60~1.16, Table 3). LOS 2-3 group otherwise carried the highest incidence of unplanned readmission (Table 2&3).

Table 2&3 also provides results from the univariable regression, multivariable regression, and the propensity score matching analysis comparing the LOS 0 to the LOS 1 groups.

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The LOS 0 group was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; unadjusted prevalence 0.67% versus 0.37%, Table 2) and THA (OR 1.96, 95% CI 1.05~3.64; unadjusted prevalence 0.57% versus 0.26%, Table 3) when compared to the LOS 1 group. Propensity score matching analysis confirmed such increased incidence of cardiac/pulmonary complications in LOS 0 group (Table 2&3). The incidence was even higher when compared to the LOS 2-3 group (Table 2&3).

LOS 0 group was associated with higher odds of major complications in TKA recipients (OR 1.94, 95% CI: 1.29~2.92, Table 2), but not in THA patients (OR 1.55, 95% CI: 0.90~2.67, Table 3) compared to LOS 1 patients. Similar patterns of differences were also observed in the outcomes for any complications, and any complications excluding transfusion. These differences were statistically significant only in TKA (Table 2) but not in THA (Table 3). Propensity score matching analysis further confirmed all significances (Table 2&3). There were no differences in wound infection and systemic infection between LOS 0 and LOS 1 groups in either TKA or THA.

In this analysis of data collected by NSQIP, we present data using population data that challenge the assumed safety of same day discharge after TKA or THA surgery. Our analysis showed somewhat surprising results that LOS 0 group had higher risks of cardiac/pulmonary complications within 30 days after surgery in both TKA and THA, compared to patients in the LOS 1 group. Our study also identified significantly increased odds for major complications with LOS 0 discharge status compared to LOS 1 group amongst TKA recipients.

The average LOS after TKA decreased from 3.42 days in 2011 to 2.38 days in 2017, and from 3.54 days in 2011 to 2.31 days in 2017 after THA surgery (NSQIP data).

Accordingly, more patients received fast-track care in more recent years. Previous studies have not shown a difference in readmission rates and complications among fast-track TKA and THA patients ¹⁴⁻¹⁹. Definition of fast-track practice has also been evolving, from previously LOS 2-3 days to as short as LOS 1 day. It is foreseeable that fast-track practice will gear towards LOS 0 day status in the future. Otero et al. studied patients from 2011 and 2013, which they concluded that there were no differences in readmission and 30-day complication in TKA between LOS 0 and LOS 1 status, while THA patients with LOS 0 status were associated with a higher 30-day complication rate ¹². However, this study is limited by the small number of patients in the LOS 0 and LOS 1 groups. In addition, the authors did not exclude patients with emergent admission status and patients who received bilateral arthroplasty procedures. Lately, Gromov et al studied LOS 0 patients with a matching cohort of controls with LOS 1 to 9 days ¹³. The

authors concluded that readmission rates were comparable. However, such comparison might not be fair since LOS 1-9 patients, especially patients with longer LOS usually have indications for hospitalization. The staying in hospital would decrease chances of readmission, nor with recorded diagnosis for readmission. Other researchers have attempted to study the difference in complications in arthroplasty based on the admission status either as outpatient or inpatient ²⁰. However, such categorization among arthroplasty recipients was arbitrary which was most likely influenced by the type of patients' insurance. Nonetheless, concerns remained amongst clinicians regarding the balance of safe clinical practice and fast-track efficiency.

In order to achieve these goals, clinicians have attempted to identify patients at risk of readmission or complications, and thus triage them accordingly. Many independent risk factors have been identified, including advanced age, gender, high body mass index, increased ASA classification, the presence of chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease, cirrhosis, and chronic kidney disease 5 12 ²¹⁻²⁵. In addition, poor living conditions, use of mobility aids, and social economic factors are also likely to influence LOS and outcomes 6 22 26. Clinicians further developed prediction models to determine a patient's candidacy for fast-track surgical care with moderate success ^{5 6 27}. It should be mentioned, however, that some data suggest that the majority of patients suffering from a complication after joint arthroplasty may not have any identifiable risk factors²¹, thus putting strategies currently being used to identify patients at risk into question.

The majority of major complications, such as cardiac/pulmonary complications, likely occur past 24 hours, and more likely peak on post-operative day 2 to 3. ^{5 28 29} This timeframe may therefore fall outside the in-hospital observation period as it relates to fast-track patients. It also has been shown that over 50% of patients with major complications do not carry any of these predisposing risk factors ²¹. Therefore, identifying risk factors and risk stratification of patient populations may be of limited use in predicting successful fast-track patients without risk of readmission or complications. The current approach seeks to identify higher risk patients and subsequently exclude them from the fast track pathway. This is supported by our findings that patients in the LOS2-3 group have higher comorbidity burden and are older than those in the LOS0 and LOS1 groups.

Many institutions have established enhanced recovery after surgery (ERAS) pathways for TKA and THA. These pathways seek to improve outcomes by standardizing the routine use of potentially beneficial interventions that improve outcomes and by employing patient selection strategies. Consequently they include younger and healthier patients with sufficient social support to facilitate early discharge. However, such approaches may not be sufficient to reconcile them with unaltered or lower level of complications while gearing towards true ambulatory surgical model.

We conducted this NSQIP data analysis with the hypothesis that ambulatory patients were not at increased risk comparing to other fast track surgical patients after TKA or THA. It is reasonable to assume that these fast-tracked patients were carefully selected

without major comorbidity concerns. Further, it is reasonable to assume that these patients met the discharge criteria established across various institutions. Assuming such safe practice model were established and applied, our finding raise concern regarding the safety of same day discharge after TKA or THA surgery. This is especially problematic if the increased risk of complications among this group is related to gaps in continuity of care and lack of necessary early intervention when indicated. However, despite this possibility, our data is not able to establish this causal relationship at this time, and future studies are needed to identify the etiology and mechanism by which complications may develop.

Our study has several limitations. First, this is a retrospective cohort study and related limitations in respect to establishing causality apply. Although NSQIP has rigorous quality measures to ensure high quality data collection, there was still missing information on several interesting pre-existing comorbidity variables, such as stroke and myocardial infarction. Our study is therefore limited by the accuracy and completeness of data collection, inclusion of available variables, and recorded information only.

Second, patients were categorized retrospectively based on their actual LOS determined by calendar days. Future research is indicated to prospectively assign clinical pathways and compare readmission and complications. Third, NSQIP only contains outcome information within 30 days, thus outcomes beyond this point but still related to the index procedure remain elusive. Fourth, NSQIP prohibits identifying hospital and surgeon, while studying surgical volume, inpatient hospital versus free-standing surgical center, and other practice pattern might be insightful. Last, readmission indicator in NSQIP

database only included inpatient readmission. Information on emergency department visit would also be important. However, it is beyond the scope of our analysis.

Conclusion

Our study is the first comprehensive study to focus on LOS 0 TKA and THA patients. Although same day discharge after TKA and THA surgery is not associated with increased risk of unplanned readmission, these patients carry increased risk of complications. Therefore, the current trend towards increasing discharges on the same day of surgery after TKA and THA should be approached with caution and requires reconsideration. Future prospective studies are needed to confirm our finding and identify if ambulatory joint arthroplasty is associated with acceptable risk for complications and readmissions, as well as its financial impact on our healthcare system.

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Table 1. Patient demographic information and comorbidity

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Table 1. I	Patient o	demogra	phic in				-						cted by copyright, including t				
				Т	otal Knee	Arthroplas	sty						Total H¥	Artaropla	isty		
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		Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**	Mean/N	Std/%	Mean/N	Std/% and the state of the stat	Palue*	Mean/N	Std/%	P value**
Age (year)		65.18	9.67	65.40	8.98	0.194	66.61	9.49	< 0.001	61.46	10.67	62.13	10.68	<u><u><u></u> <u> </u></u></u>	65.07	11.33	< 0.001
Sex													tex	Downleaded from hent Superieur (ABES			
	Female	1682	53.94	16363	52.10	0.050	120447	62.77	< 0.001	1214	45.78	13254	44.75	perio 9	61006	56.37	< 0.001
	Male	1436	46.06	15041	47.90		71427	37.23		1438	54.22	16363	55.25	ded feur (47225	43.63	
Race													ia m	rom			
	White	2512	88.98	26698	89.60	0.354	148875	88.45	< 0.001	2213	90.40	25540	90.76	· 3 7	83651	89.17	< 0.001
	Black	200	7.08	2080	6.98		14103	8.38		162	6.62	1920	6.82 >)/br	8108	8.64	
	Others	111	3.93	1020	3.42		5330	3.17		73	2.98	681	2.42 ET	njop	2054	2.19	
BMI		32.09	6.39	32.18	6.17	0.419	33.06	6.91	< 0.001	29.16	5.39	29.69	6.82 Al training 5.73 g	. <0.	30.33	6.41	< 0.001
OR time (min	ns)	84.58	33.48	86.24	29.24	0.003	90.23	34.88	< 0.001	82.60	33.49	87.67	32.02	0.002	91.43	38.26	< 0.001
ASA classific	cation												sim	. ø			
	I/II	1882	60.42	17957	57.21	0.001	99497	51.87	< 0.001	1958	73.83	20148	68.07	: om/ ondune ↑	62496	57.76	< 0.001
	>=[[[1233	39.58	13432	42.79		92336	48.13		694	26.17	9451	31.93	une	45696	42.24	
Diabetes													jolor	. j3 . x			
	Type II	367	11.77	3699	11.78	0.983	25932	13.51	< 0.001	182	6.86	2152	31.93 hologies.	0.197	9967	9.20	< 0.001
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Smoker		234	7.50	2565	8.17	0.196	16263	8.47	0.036	294	11.09	3696	12.48	9€ 7	14317	13.22	< 0.001
Function statu	us	11	0.35	139	0.45	0.647	1932	1.01	< 0.001	14	0.53	211	0.71	ió 0. 4<u>6</u>54	1885	1.75	< 0.001
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	1811	58.08	19187	61.10	0.001	124958	65.10	<0.001	1185	44.68	14516	49.01 ; <0).(8) 1 20	61084	56.41	<0.001
OPD	82	2.63	732	2.33	0.294	6404	3.34	<0.001	67	2.53	660	2.23 L 0). 8 2 . 9 2	4108	3.79	<0.001
iver disease	0	0.10	4	0.01	0.529	27	0.01	0.792	1	0.04	2	0.01 10 0). □ 3 . □ .	22	0.02	0.222
enal insufficiency	3	0.10	28	0.09	0.900	242	0.13	0.201	3	0.11	22	0.07	7.460√1 C	191	0.18	<0.001
ancer	1	0.03	21	0.07	0.463	190	0.10	0.119	3	0.11	41	0.07 for uses related to	7. <u>10</u> 0 0. ee 2. 607	254	0.23	0.003
leeding disorder	49	1.57	445	1.42	0.488	3987	2.08	<0.001	19	0.72	354		. (20) 0.	2168	2.00	<0.001
* p value analysi	s among	LOS 0	, LOS 1	, and	LOS 2-3	groups						rieur (ABES) . nd data mining, Al training, and similar technologies.	tp://bmjc			

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Table 2. Incidence of complications							en-2019-031260 copyright, inclu					
PM) analysis of complications in to				r 100 patien	ts), Odds ratio	o (OR) ana	alysis, and an December of Uses and Another State of Company of Co	ropens	ity sco	re m		
						TKA	/Single variation	e regres	sion			\/Multi-variab
	LOS 0	LOS 1	P value*	LOS 2-3	P value**	OR	P vales 2019.	95%			OR	P value
Mortality	0.16	0.08	0.123	0.1	0.253	2.10	0 ä. ∰.ō	0.80	5.51		1.78	0.295
Inplanned readmission	2.41	2.31	0.749	2.89	< 0.001	1.04). Downloade de	0.82	1.32		1.10	0.445
fajor complication	0.96	0.53	0.003	0.64	0.006	1.81	0.000	1.22	2.67	*	1.94	0.001
ny complication excluding transfusion	2.98	1.99	< 0.001	2.74	< 0.001	1.51	<0 କ ୍ଲିଅ ଅ	1.21	1.89	*	1.55	< 0.001
ny complication	4.49	2.16	< 0.001	6.95	< 0.001	2.13	。 <()可能 c	1.77	2.57	*	2.03	< 0.001
ystemic infection	1.67	1.28	0.070	1.73	< 0.001	1.31		0.98	1.75		1.30	0.098
Vound infection Cardiac/pulmonary complications	0.77 0.67	0.72 0.37	0.753 0.009	0.88 0.44	0.015 0.023	1.07 1.84		0.70 1.16	1.63 2.94	*	0.99 1.95	0.963 0.007
					5 patients per		025 at jies.					
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Table 3. Incidence of complications (PM) analysis of complications in to Mortality Unplanned readmission Major complication Any complication excluding transfusion	with varic	ous length	of stay (Per	: 100 patients	s), Odds ratio) (OR) ana	yrightd pticluding lysis ancluding	opensit	y score r	natching	
						THA	—————————————————————————————————————	le regres	sion	TH2	A/Multi-variable
	LOS 0	LOS 1	P value*	LOS 2-3	P value**	OR	P value m	95%	CI	OR	P value
Mortality	0.11	0.11	0.939	0.11	0.978	1.05	0.50.50	0.32	3.42	0.84	0.786
Unplanned readmission	1.62	2.04	0.144	3.26	< 0.001	0.79	0 3 € 7	0.58	1.08	0.84	0.292
Major complication	0.72	0.43	0.034	0.65	< 0.001	1.68	1019. Do hexpress of the control of	1.03	2.72	1.55	0.112
Any complication excluding transfusion	1.73	1.68	0.849	2.67	< 0.001	1.03	0 ≅ ∰	0.76	1.4	1.00	0.979
Any complication	3.13	2.86	0.420	9.76	< 0.001	1.1	0 ⊕∑9 ≷	0.87	1.38	1.12	0.363
Systemic infection	1.06	1.26	0.372	2.03	< 0.001	0.84	0겲듛=	0.57	1.23	0.77	0.259
Wound infection	0.49	0.77	0.113	1.11	< 0.001	0.64	0 a ‡ oad	0.36	1.12	0.75	0.334
Cardiac/pulmonary complications OS; length of stay; * indicates sign	0.57	0.26	0.005	0.39	0.002	2.15	0 ஓ€78_	1.24	3.75	* 1.96	0.034
					3 patients per		ownloaded from http://bmjopen.bmj.com/ on June 13, 2025 a (\$诉的e拍e谢 (ABES) . 转文代ard gata mining, Al training, and similar technologies.				
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Association between Same Day Discharge Total Knee and Total Hip Arthroplasty and Risks of Cardiac/Pulmonary Complications and Readmission: a Population-based Observational Study

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JL and NME were involved in attaining data from NSQIP. JL, NME, AGDV, and SGM were involved in designing the study. JL analyzed data with help from JP and SGM. All authors contributed to the interpretation of the results, including JL, NME, JP, AGDV, DHK, DBM, and SGM. All authors reviewed, revised, and approved the final document. JL and SGM are the study guarantors, and take responsibility for the completeness of the data and the accuracy of the analysis.

Abstract:

Objective: To determine if same-day discharge total knee or total hip arthroplasty is not associated with increased risk of unplanned readmission and adverse outcomes within 30 days of surgery.

Design: This is a population-based observational study.

Setting: Patients from 708 participating institutions who underwent primary TKA or primary total hip arthroplasty (THA) between 2011 and 2017 were divided into three groups by length of stay (LOS 0, 1, and 2-3 days). All patients with LOS > 3 days were excluded from the current study. Regression analysis and propensity score matching were performed.

Data sources: American College of Surgeons -National Surgical Quality Improvement Program database.

Main Outcomes and Measures: Primary outcomes included unplanned readmission and cardiac/pulmonary complications within 30 days of surgery.

Results: We identified 226,481 TKA (LOS 0=3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 THA patients (LOS 0=2,652, LOS 1=29,617, and LOS 2-3=108,288). There were no differences in 30-day mortality. After adjusting for relevant covariates, LOS 0 (compared to LOS 1) was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; 0.67% versus 0.37%) and THA (OR 1.96, 95% CI 1.05~3.64; 0.57% versus 0.26%). There were no statistical differences in unplanned readmissions between LOS 0 and LOS 1 groups in TKA (2.41% vs 2.31%) and THA (1.62% vs 2.04%).

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Conclusions: LOS 0 discharge after TKA and THA was associated with higher odds of cardiac/pulmonary complications compared to LOS 1 discharge. While the overall burden of complications is relatively low, until future studies can confirm or challenge our findings, a measured approach is advisable when recommending discharge of patients on the same day of surgery.

Strength and limitations of this study:

- Information on safety of same-day discharge after total knee arthroplasty (TKA) and total hip arthroplasty (THA) is lacking
- This is the first comprehensive study to focus on length of stay (LOS) 0 and LOS 1 TKA and THA patients.
- This is a population-based observational study, and cannot establish causal relationships.

Data sharing statement:

All data utilized for the current study is available via https://www.facs.org/qualityprograms/acs-nsqip. All data is available and free of charge for any researchers within these participating institutions of NSQIP (https://www.facs.org/quality-programs/acsnsqip/participant-use).

Ethics and dissemination:

The study was exempted by the institutional review board. Results will be communicated through publication in scientific journal and conference.

Introduction:

Joint arthroplasty is amongst the most commonly performed procedures in the United States with projections of continuous growth in parallel with an aging population. Total knee arthroplasty (TKA) is projected at 3.48 million procedures annually, while total hip arthroplasty (THA) at 700,000 per year by 2030 ¹. Until recently, TKA and THA were listed as Inpatient Only (IPO) procedures by the Center for Medicare and Medicaid Service (CMS), which requires greater than 24 hours of postoperative care. Financial necessity, advances in surgical techniques, improved pain management, and early physical rehabilitation have led to a continuous reduction in total hospital length of stay (LOS) after surgery ². This trend has made ambulatory joint arthroplasty practice feasible. In fact, CMS removed TKA from the IPO list in January 2018 with the expectation of reducing healthcare cost ³. It is likely that CMS might remove THA from the IPO list in the near future, especially since the American Association of Orthopaedic Surgeons (AAOS) has also provided supportive statements for outpatient total hip arthroplasty 4. Such policy decisions by CMS cast significant pressure on hospitals and healthcare providers to fast track patients, and expedite a push towards performing surgery at freestanding ambulatory surgery centers.

However, practical and logistical concerns remain regarding the safety of fast track approaches, especially the true ambulatory practice with same day discharge. While mostly focused on patient selection and optimization of peri-operative care guided under well-defined clinical pathways, actual outcome data are scarce. Several studies found no difference in short-term complications after comparing shorter inpatient stay with LOS≥

2 days ⁵⁻⁷. Additional studies comparing admission status of outpatient versus inpatient, and concluded that outpatient joint arthroplasty is safe and effective ⁸⁻¹¹. None of these studies focused on true ambulatory population (LOS 0) and the fast track group (LOS 1). One previous study by Otero et al. included a small group of LOS 0 patients, and did not identify differences among TKA patients but increased complication rate in THA patients ¹². Gromov et al. studied 116 LOS 0 patients with matching cohort of 339 patients (LOS 1 to 9 days), and found no readmissions within 48 hours and comparable incidence of readmission within 90 days ¹³. However, these earlier studies were limited by the small sample size to be conclusive, and study cohort included emergent procedures, bilateral arthroplasties, or mixed TKA/THA patient population.

Given the current push towards same-say discharge after lower extremity joint arthroplasty surgery and lack of large-scale data on crucial comparisons, we therefore sought to study the safety of ambulatory surgical practice of TKA and THA with the access of several folds of more subjects to hopefully draw more convincing conclusion. For this purpose, we studied and compared complications and readmission rate and risk in patients discharged on the day of surgery (LOS 0) to those with a LOS of 1 day (LOS 1). We also included the standard practice group with LOS 2-3 days as a reference group. We hypothesized that there would be no difference in complications and readmission rates and risks among patients discharged same day of TKA or THA surgery.

This study was exempted by the institutional review board (IRB# 2017-0716) as data accessed and analyzed were de-identified. The population-based observational study follows the STROBE statement (second paragraph of "Patient and Public Involvement" section).

Cohort description

We acquired the data from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) from 2011 to 2017 (http://site.acsnsqip.org). NSQIP prospectively collects data on over 200 variables, including demographic information, comorbidities, intraoperative variables, 30-day postoperative complications, and readmission. NSQIP conducted independent follow-ups of all registered patients for 30 days even after discharged from hospital, therefore NSQIP was able to capture post-surgical events for 30 days no matter whether patients were still in hospital or were discharged to other destination. NSQIP database does not include surgical procedures performed at ambulatory surgical center as of 2017. To define our study cohort, we only included patients with the principal Current Procedural Terminology (CPT) code for primary TKA (CPT 27447) or primary THA (CPT 27130). We only included patients from 2011 to 2017, as the NSQIP dataset provides information on the readmission incidence within 30 days of surgery during this time frame.

There were a total of N=232,218 and N=141,767 entries for TKA and THA with LOS from 0 to 3 calendar days, respectively. We first excluded patients categorized as

"emergency" to establish a more homogenous study cohort (N=193 & 435 respectively). We then excluded patients who received bilateral arthroplasty as defined by the relevant concurrent CPT code (N= 5,544 & 775 respectively). The final cohort included 226,481 and 140,557 subjects for TKA and THA, respectively.

Study variables

Patients were separated into 3 groups based on LOS calculated based on calendar days (LOS 0 for same day discharge; LOS 1 for patients with next day discharge; and LOS 2-3 for patients with a traditional LOS of 2 to 3 days). The outcomes of interest were readmission within 30 days and six composite complication variables, including: wound infection, systemic infection, cardiac/pulmonary complications (including cardiac arrest requiring CPR, myocardial infarction, pulmonary embolism, unplanned intubation, and/or on ventilator >48 hours), major complications (including any cardiac, pulmonary, central nerve system, renal, or systemic infection complications), any complication (including any complications enlisted in the NSQIP database), and any complication excluding blood transfusion.

Statistical analysis

Data analysis was executed using STATA 14.2 statistical software (StataCorp LP, College Station, TX). Analysis of variance was used to analyze continuous variables. Pearson chi-square tests were applied for categorical variables. After applying Bonferroni correction, p-value less than 0.0036 (0.05/14 variables) was used as the cutoff for statistical significance.

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We next conducted single variable and multi-variable regression analysis to examine the impact of LOS on readmission and complications. The confounding variables included age, sex, race, body mass index (BMI), surgical duration, year of surgery, and ASA classification. In the regression analysis we treated the LOS 1 group as the reference. The odds ratio (OR) and 95% confidence interval (CI) were reported. We elected to report output from the multi-variable regression analysis in the result section. To further evaluate robustness of our results, we also performed a propensity score matched analysis where the significant covariates were entered to calculate the propensity score to receive either same day (LOS 0) or fast track (LOS 1) surgery. We employed the Kernel matching algorithm based on the weighted average of all controls, and the weights are inversely proportional to the distance between the propensity scores.

Patient and Public Involvement

The current study involved prospectively collected patient information without any identifiable patient specific information. None of these included study subjects would benefit from the current study. However, future patients may benefit from the knowledge highlighted in the current study once it is publicly available. Patients were not involved in the design and conduct of current study. All patient related information was deidentified from the database to preserve privacy.

We identified N=226,481 primary TKA (LOS 0= 3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 primary THA patients (LOS 0= 2,652, LOS 1=29,617, and LOS 2-3=108,288), respectively. There were no major clinically significant differences in the comorbidity burden between LOS 0 and LOS 1 groups, while LOS 2-3 group carried a higher comorbidity burden (Table 1). Between 2011 and 2017, LOS trended downwards, with an increasing number of patients being discharged on the day of surgery or the next day (TKA 1.04% in 2011, and 26.55% in 2017; THA 3.44% in 2011, and 34.91% in 2017, respectively). The discharge destination was most frequently to home amongst the various TKA groups (LOS 0 group 89.48%, LOS 1 group 97.62%, and 76.39% in LOS 2-3 group). Home discharge was the most prominent disposition in THA as well (LOS 0 group 94.72%, LOS 1 group 97.92%, and 78.37% in LOS 2-3 group). There were no differences in 30-day mortality in either TKA (Table 2) or THA groups (Table 3). The incidences of 30-day major complications and unplanned readmissions were low in the LOS 1 discharge group (0.53% and 2.31% in TKA; 0.43% and 2.04% in THA respectively). There were no statistically significant differences in unplanned readmission between LOS 0 and LOS 1 group in TKA patients (2.41% vs 2.31% in TKA, OR 1.10, 95% CI: 0.86~1.42, Table 2), nor among THA patients (1.62% vs 2.04% in THA, OR 0.84, 95% CI: 0.60~1.16, Table 3). LOS 2-3 group otherwise carried the highest incidence of unplanned readmission (Table 2&3).

Table 2&3 also provides results from the univariable regression, multivariable regression, and the propensity score matching analysis comparing the LOS 0 to the LOS 1 groups.

The LOS 0 group was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; unadjusted prevalence 0.67% versus 0.37%, Table 2) and THA (OR 1.96, 95% CI 1.05~3.64; unadjusted prevalence 0.57% versus 0.26%, Table 3) when compared to the LOS 1 group. Propensity score matching analysis confirmed such increased incidence of cardiac/pulmonary complications in LOS 0 group (Table 2&3). The incidence was even higher when compared to the LOS 2-3 group (Table 2&3).

LOS 0 group was associated with higher odds of major complications in TKA recipients (OR 1.94, 95% CI: 1.29~2.92, Table 2), but not in THA patients (OR 1.55, 95% CI: 0.90~2.67, Table 3) compared to LOS 1 patients. Similar patterns of differences were also observed in the outcomes for any complications, and any complications excluding transfusion. These differences were statistically significant only in TKA (Table 2) but not in THA (Table 3). Propensity score matching analysis further confirmed all significances (Table 2&3). There were no differences in wound infection and systemic infection between LOS 0 and LOS 1 groups in either TKA or THA.

In this analysis of data collected by NSQIP, we present data using population data that challenge the assumed safety of same day discharge after TKA or THA surgery. Our analysis showed somewhat surprising results that LOS 0 group had higher risks of cardiac/pulmonary complications within 30 days after surgery in both TKA and THA, compared to patients in the LOS 1 group. Our study also identified significantly increased odds for major complications with LOS 0 discharge status compared to LOS 1 group amongst TKA recipients.

The average LOS after TKA decreased from 3.42 days in 2011 to 2.38 days in 2017, and from 3.54 days in 2011 to 2.31 days in 2017 after THA surgery (NSQIP data).

Accordingly, more patients received fast-track care in more recent years. Previous studies have not shown a difference in readmission rates and complications among fast-track TKA and THA patients ¹⁴⁻¹⁹. Definition of fast-track practice has also been evolving, from previously LOS 2-3 days to as short as LOS 1 day. It is foreseeable that fast-track practice will gear towards LOS 0 day status in the future. Otero et al. studied patients from 2011 and 2013, which they concluded that there were no differences in readmission and 30-day complication in TKA between LOS 0 and LOS 1 status, while THA patients with LOS 0 status were associated with a higher 30-day complication rate ¹². However, this study is limited by the small number of patients in the LOS 0 and LOS 1 groups. In addition, the authors did not exclude patients with emergent admission status and patients who received bilateral arthroplasty procedures. Lately, Gromov et al studied LOS 0 patients with a matching cohort of controls with LOS 1 to 9 days ¹³. The

authors concluded that readmission rates were comparable. However, such comparison might not be fair since LOS 1-9 patients, especially patients with longer LOS usually have indications for hospitalization. The staying in hospital would decrease chances of readmission, nor with recorded diagnosis for readmission. Other researchers have attempted to study the difference in complications in arthroplasty based on the admission status either as outpatient or inpatient ²⁰. However, such categorization among arthroplasty recipients was arbitrary which was most likely influenced by the type of patients' insurance. Nonetheless, concerns remained amongst clinicians regarding the balance of safe clinical practice and fast-track efficiency.

In order to achieve these goals, clinicians have attempted to identify patients at risk of readmission or complications, and thus triage them accordingly. Many independent risk factors have been identified, including advanced age, gender, high body mass index, increased ASA classification, the presence of chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease, cirrhosis, and chronic kidney disease ⁵ 12 ²¹⁻²⁵. In addition, poor living conditions, use of mobility aids, and social economic factors are also likely to influence LOS and outcomes ⁶ ²² ²⁶. Clinicians further developed prediction models to determine a patient's candidacy for fast-track surgical care with moderate success ⁵ ⁶ ²⁷. It should be mentioned, however, that some data suggest that the majority of patients suffering from a complication after joint arthroplasty may not have any identifiable risk factors²¹, thus putting strategies currently being used to identify patients at risk into question.

The majority of major complications, such as cardiac/pulmonary complications, likely occur past 24 hours, and more likely peak on post-operative day 2 to 3. ^{5 28 29} This timeframe may therefore fall outside the in-hospital observation period as it relates to fast-track patients. It also has been shown that over 50% of patients with major complications do not carry any of these predisposing risk factors ²¹. Therefore, identifying risk factors and risk stratification of patient populations may be of limited use in predicting successful fast-track patients without risk of readmission or complications. The current approach seeks to identify higher risk patients and subsequently exclude them from the fast track pathway. This is supported by our findings that patients in the LOS2-3 group have higher comorbidity burden and are older than those in the LOS0 and LOS1 groups.

Many institutions have established enhanced recovery after surgery (ERAS) pathways for TKA and THA. These pathways seek to improve outcomes by standardizing the routine use of potentially beneficial interventions that improve outcomes and by employing patient selection strategies. Consequently they include younger and healthier patients with sufficient social support to facilitate early discharge. However, such approaches may not be sufficient to reconcile them with unaltered or lower level of complications while gearing towards true ambulatory surgical model.

We conducted this NSQIP data analysis with the hypothesis that ambulatory patients were not at increased risk comparing to other fast track surgical patients after TKA or THA. It is reasonable to assume that these fast-tracked patients were carefully selected

without major comorbidity concerns. Further, it is reasonable to assume that these patients met the discharge criteria established across various institutions. Assuming such safe practice model were established and applied, our finding raise concern regarding the safety of same day discharge after TKA or THA surgery. This is especially problematic if the increased risk of complications among this group is related to gaps in continuity of care and lack of necessary early intervention when indicated. However, despite this possibility, our data is not able to establish this causal relationship at this time, and future studies are needed to identify the etiology and mechanism by which complications may develop.

Our study has several limitations. First, this is a retrospective cohort study and related limitations in respect to establishing causality apply. Although NSQIP has rigorous quality measures to ensure high quality data collection, there was still missing information on several interesting pre-existing comorbidity variables, such as stroke and myocardial infarction. Our study is therefore limited by the accuracy and completeness of data collection, inclusion of available variables, and recorded information only. Second, patients were categorized retrospectively based on their actual LOS determined by calendar days. Future research is indicated to prospectively assign clinical pathways and compare readmission and complications. Third, NSQIP only contains outcome information within 30 days, thus outcomes beyond this point but still related to the index procedure remain elusive. Fourth, NSQIP prohibits identifying hospital and surgeon, while studying surgical volume, inpatient hospital versus free-standing surgical center, and other practice pattern might be insightful. Last, readmission indicator in NSQIP

Conclusion

Our study is the first comprehensive study to focus on LOS 0 TKA and THA patients. Although same day discharge after TKA and THA surgery is not associated with increased risk of unplanned readmission, these patients carry increased risk of complications. Therefore, the current trend towards increasing discharges on the same day of surgery after TKA and THA should be approached with caution and requires reconsideration. Future prospective studies are needed to confirm our finding and identify if ambulatory joint arthroplasty is associated with acceptable risk for complications and readmissions, as well as its financial impact on our healthcare system.

Acknowledge:

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Table 1. Patient demographic information and comorbidity

				T	otal Knee	Arthroplas	sty						Total Ha Artarop	lasty		
		LOS	5 0	LOS	1		LOS	2-3		LOS	S 0	LOS	cember Ense	LOS	2-3	
		Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**	Mean/N	Std/%	Mean/N	Std/% re en	Mean/N	Std/%	P value**
Age (year)		65.18	9.67	65.40	8.98	0.194	66.61	9.49	< 0.001	61.46	10.67	62.13		65.07	11.33	< 0.001
Sex													10.68 to text and data mining, Al training, a 2.42 5.73 g, 44.75 55.25 to data mining, Al training, a 2.42 5.73 g, 40.00			
	Female	1682	53.94	16363	52.10	0.050	120447	62.77	< 0.001	1214	45.78	13254	44.75 and 9	61006	56.37	< 0.001
	Male	1436	46.06	15041	47.90		71427	37.23		1438	54.22	16363	55.25 dat (47225	43.63	
Race													rom ABE a mi			
	White	2512	88.98	26698	89.60	0.354	148875	88.45	< 0.001	2213	90.40	25540	90.76 a. 9 . 7	83651	89.17	< 0.001
	Black	200	7.08	2080	6.98		14103	8.38		162	6.62	1920	6.82	8108	8.64	
	Others	111	3.93	1020	3.42		5330	3.17		73	2.98	681	2.42 a. o	2054	2.19	
BMI		32.09	6.39	32.18	6.17	0.419	33.06	6.91	< 0.001	29.16	5.39	29.69	5.73 حوادة المجاوعة ا	30.33	6.41	< 0.001
OR time (mins)		84.58	33.48	86.24	29.24	0.003	90.23	34.88	< 0.001	82.60	33.49	87.67	32.02 0.002	91.43	38.26	< 0.001
ASA classificat	ion												om/ on/ on/ on/ on/ on/ on/ on/ on/ on/ on			
	I/II	1882	60.42	17957	57.21	0.001	99497	51.87	< 0.001	1958	73.83	20148	e L	62496	57.76	< 0.001
	>=[[[1233	39.58	13432	42.79		92336	48.13		694	26.17	9451	31.93 chnologies 7.27 0.287	45696	42.24	
Diabetes													13, 20 nolog			
	Type II	367	11.77	3699	11.78	0.983	25932	13.51	< 0.001	182	6.86	2152	· · · · · ·	9967	9.20	< 0.001
	Type I	93	2.98	955	3.04		7901	4.12		46	1.73	537	1.81 at A	2892	2.67	
Smoker		234	7.50	2565	8.17	0.196	16263	8.47	0.036	294	11.09	3696	12.48 0. \frac{1}{12}	14317	13.22	< 0.001
Function status		11	0.35	139	0.45	0.647	1932	1.01	< 0.001	14	0.53	211	0.71 0. 46 4	1885	1.75	< 0.001
CHF		4	0.13	43	0.14	0.901	483	0.25	< 0.001	2	0.08	25	0.08 0. 55 8 0.08 0.557 8	272	0.25	< 0.001

j	2 2 5	254	0.23	0.003
	0 27	2168	2.00	< 0.001
Avergreinen Jugeneur (Aber) . Avergreinen Jugeneur (Aber) .	ts is is is is is is is is is i	Classi	fication	n; CHF:

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HTN	1811	58.08	19187	61.10	0.001	124958	65.10	< 0.001	1185	44.68	14516	49.01 = <0.	61084	56.41	< 0.001
COPD	82	2.63	732	2.33	0.294	6404	3.34	< 0.001	67	2.53	660	2.23 ਨੂੰ 0. 8 2	4108	3.79	< 0.001
Liver disease	0		4	0.01	0.529	27	0.01	0.792	1	0.04	2		22	0.02	0.222
Renal insufficiency	3	0.10	28	0.09	0.900	242	0.13	0.201	3	0.11	22	0.07	191	0.18	< 0.001
Cancer	1	0.03	21	0.07	0.463	190	0.10	0.119	3	0.11	41		254	0.23	0.003
Bleeding disorder	49	1.57	445	1.42	0.488	3987	2.08	< 0.001	19	0.72	354	1.20 e e 027	2168	2.00	< 0.001

LOS: length of stay (days); BMI: Body Mass Index; OR: Operating Room; ASA: American Society of Anestle congestive heart failure; HTN: hypertension; COPD: Chronic obstructive pulmonary disease

^{*} p value analysis between LOS 0 and LOS 1 groups

^{**} p value analysis among LOS 0, LOS 1, and LOS 2-3 groups

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Table 2. Incidence of complications							pen-2019-031260 y copyright, inclu					
Sable 2. Incidence of complications PM) analysis of complications in to				r 100 patien	ts), Odds ratio	O(OR) and	alysis, and	ropens	ity sco	re m		
	T 0000	1001	D 1 4	1000	To 1 deals	TKA	/Single water	e regres	sion			/Multi-variab
	LOS 0	LOS 1	P value*	LOS 2-3	P value**	OR	P vales and 19.	95%			OR	P value
fortality	0.16	0.08	0.123	0.1	0.253	2.10	0 d .⊞.o	0.80	5.51		1.78	0.295
nplanned readmission	2.41	2.31	0.749	2.89	< 0.001	1.04	09/49/0	0.82	1.32	*	1.10	0.445
lajor complication	0.96	0.53	0.003	0.64	0.006	1.81	2. Downloade 全報 Supprior 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0	1.22	2.67	*	1.94	0.001
ny complication excluding transfusion	2.98 4.49	1.99 2.16	<0.001 <0.001	2.74 6.95	<0.001 <0.001	1.51 2.13	~∪37⊈73 ~∩an@10	1.21 1.77	1.89 2.57		1.55 2.03	<0.001 <0.001
ny complication ystemic infection	4.49 1.67	1.28	0.001	1.73	< 0.001	1.31		0.98	1.75	,	1.30	0.001
Yound infection	0.77	0.72	0.070	0.88	0.001	1.31	0 ab /1 - 1 0 ab (3x - 1	0.98	1.73		0.99	0.098
ardiac/pulmonary complications	0.77	0.72	0.733	0.88	0.013	1.84	~ ##S	1.16	2.94	*	1.95	0.903
					6 patients per		from http://bmjopen.bmj.com/ on June 13, 2025 (保BES) ttamhing, Al training, and similar technologies.					
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Table 3. Incidence of complications PM) analysis of complications in to				100 patients	s), Odds ratio	(OR) ana	1-2019-03(260 on 8 opyrightancluding lysis a	opensit	y score	e mate	ching	
						THA	/Single varia	e regres	sion		THA	/Multi-variabl
	LOS 0	LOS 1	P value*	LOS 2-3	P value**	OR	P val	95%		_	OR	P value
Mortality	0.11	0.11	0.939	0.11	0.978	1.05	0 % \$\$\$\$\$	0.32	3.42		0.84	0.786
Unplanned readmission	1.62	2.04	0.144	3.26	< 0.001	0.79	0 ₽₽ ₹	0.58	1.08		0.84	0.292
Major complication	0.72	0.43	0.034	0.65	< 0.001	1.68	0 ₹	1.03	2.72		1.55	0.112
any complication excluding transfusion	1.73	1.68	0.849	2.67	< 0.001	1.03	08්∰ _	0.76	1.4		1.00	0.979
ny complication	3.13	2.86	0.420	9.76	< 0.001	1.1	0#209≷	0.87	1.38		1.12	0.363
ystemic infection	1.06	1.26	0.372	2.03	< 0.001	0.84	0충등	0.57	1.23		0.77	0.259
Vound infection	0.49	0.77	0.113	1.11	< 0.001	0.64	0 ∄ ∯aa	0.36	1.12		0.75	0.334
Cardiac/pulmonary complications OS; length of stay; * indicates sign	0.57	0.26	0.005	0.39	0.002	2.15	0 a E78	1.24	3.75	*	1.96	0.034
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Title and Astract 1) In Indicate the study's design with a commonly used term an the taile or the abbract of the paper of individual paper of ind		Item No Recommendation	Yes/No	Location in manuscript
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