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ORIGINAL PAPER

The impact of obesity on resource utilization among patients undergoing total joint arthroplasty

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Abstract

Purpose The presence of obesity poses a challenge for clinical and administrative staff in the peri-operative setting. Evidence indicates that obesity may increase peri-operative complications. However, data on resource utilization in patients undergoing total knee and hip arthroplasty remain rare. Using national data, we sought to determine whether increasing levels of patient obesity is associated with greater resource utilization. We hypothesized that patient care in individuals with a body mass index (BMI) greater than 40 is associated with longer operative and anaesthetic times, longer hospital stays, and greater readmission rates.

Methods We utilized national data from the National Surgical Quality Improvement Project and identified patients who underwent primary total knee arthroplasty (TKA) and total hip arthroplasty (THA). Patients were divided into three groups according to their BMI (18.5 BMI < 30, 40 BMI < 45, and 45 BMI). The groups were compared regarding associated operating room utilization, length of stay, and readmission rates.

Results Our study showed that TKA and THA patients with higher BMI required significantly longer operation-related times and had higher total length of hospital stay. Higher BMI patients also carried higher odds of readmissions within 30 days in both TKA and THA groups.

Conclusion We conclude that BMI status needs to be considered for both medical and economic reasons by health care institutions and payers, in order to make prudent decisions in a world where health care expenses are rising rapidly alongside the increasing obesity epidemic, and resources are becoming increasingly scarce.

Keywords Obesity · Body mass index · Resource utilization · Total knee arthroplasty · Total hip arthroplasty

Introduction

The high and increasing prevalence of obesity in the developed world represents a growing health care problem affecting the entire health care system. Among orthopaedic patients, it is the most important reason for premature osteoarthritis leading to the need for joint arthroplasty procedures [1–3].

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Aside from the fact that a number of studies identified obesity to be an independent risk factor for various peri-operative complications and adverse outcomes, an increased BMI most certainly represents technical and logistic challenges to caretakers, including physicians, nurses, and other operating-room staff [4–7]. Reported difficulties range from challenges to secure vascular access, achieve adequate surgical conditions, and provide staff and equipment for transport and positioning, as well as account for difficult anaesthetic management, all of which require additional time and resources [3]. Obesity is associated with more implant failure by various studies [7–10]. However, optimization of obesity such as gastric bypass surgery has not been proven to lower surgical complications after arthroplasty [11].

To date, however, the differential impact of obesity on peri-operative resource utilization remains poorly defined. Information on this aspect of care is of importance, because of the large and increasing number of obese patients undergoing surgery and because hospitals of the need to account and quantify physical and time resources in order to prepare adequately for procedures involving high-BMI individuals.

Therefore, we undertook this study utilizing data collected for the National Surgical Quality Improvement Project to determine if patients with various BMI ranges utilized joint arthroplasty-related operating-room time and resources differentially. We hypothesized (1) that care of patients with increased BMI would be associated with prolonged surgical and anaesthetic times, and (2) that a positive correlation between increasing levels of BMI and an increase of resource, such as readmissions, would exist.

Materials and methods

This study was exempted by the institutional review board (Hospital for Special Surgery, no. 2017-0716, New York, NY 10021, USA).

Study sample

We acquired the data from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) from 2006 to 2015 (http://site.acsnsqip.org). NSQIP prospectively collects data for over 140 variables under a standardized protocol. The data includes demographic information, comorbidities, pre-operative laboratory results, intra-operative variables, and 30-day post-operative complications. To define our study cohort, we only included patients with the principal Current Procedural Terminology (CPT) code for primary total knee arthroplasty (TKA) (CPT 27447) or primary total hip arthroplasty (THA) (CPT 27130). There were 167,201 and 104,732 subjects respectively. We first excluded patients categorized as "emergency" (255 and 791 subjects), or American Society of Anesthesiologist (ASA) Class 4 and Class 5 (2671 and 1992 subjects). We next eliminated patients with missing information on BMI or BMI < 18.5 kg/m^2 (882 and 1672 subjects). Then we removed patients receiving bilateral arthroplasty procedures (4571 and 585 subjects). Last, we excluded patients with BMI > =30.0 kg/m^2 and BMI < 40.0 kg/m^2 to minimize cutoff bias in our study (75,377 and 37,906 subjects). The final study cohort included 83,445 and 61,786 subjects for TKA and THA, respectively.

Study variables

We focused on seven available variables in the database related to resource utilization during the hospitalization, including anaesthesia start to surgery start, end of surgery to end of anaesthesia, total time in the operating room, total length of hospital stays, percent of patients remaining in hospital after 30 days, and readmissions within 30 days.

Statistical analysis

Data analysis was executed using STATA 14.2 statistical software (StataCorp LP, College Station, TX). To examine the impact of BMI on resource utilization, patients were separated into three groups based on BMI (18.5–30 kg/m^2, 40.0–44.9 kg/m^2, and > =45.0 kg/m^2). We intentionally excluded patients with BMI between 30.0 and 40.0 kg/m^2 a priori in order to minimize bias introduced by the arbitrary BMI cutoff selection. We conducted multivariable logistic regression analysis while adjusting age, gender, race, and ASA classification. All analyses without specification treated the BMI 18.5–30.0 kg/m^2 group as the control group. The adjusted odds ratio (OR) and 95% confidence intervals (CI) were reported. The statistical significance was adjusted using Bonferroni correction to two-sided $p < 0.0056$ (0.05/9 comparisons) to account for the multiple models examined in this study.

Results

For our samples, we identified N = patients that underwent primary TKA and THA. These samples were divided into three groups based on BMI (BMI ≥ 18.5 and < 30 kg/m^2, BMI ≥ 40 and < 45 kg/m^2, and BMI ≥ 45 kg/m^2). Demographic information is shown in Table 1 (TKA) and Table 2 (THA).

The analyses showed that for both THA and TKA patients, the three BMI groups were associated with a statistically significant difference average age. Patients with higher BMI tended to be younger ($p < 0.0001$). Additionally, there was a significant difference in gender as more female subjects were represented in the high-BMI groups ($p < 0.001$). Differences in race distribution among the three groups with more African American in the high BMI groups were recorded. There was a higher prevalence of diabetes and chronic obstructive pulmonary disease as well as higher rates of ASA II status in the higher BMI categories ($p < 0.001$) (Tables 1 and 2).

Table 3 (TKA) and Table 4 (THA) summarized resource utilization and readmission rates across the three BMI groups. TKA and THA patients with higher BMI required significantly longer total duration of anaesthesia ($p < 0.0001$), total operation time ($p < 0.0001$), total time in the operating room ($p < 0.0001$), total length of hospital

Table 1 Demographic information and comorbidities of all TKA patients

		BMI ≥ 18.5 and < 30		BMI ≥ 40 and BMI < 45		BMI ≥ 45		
		N/average	%/st. dev.	*N*/average	%/st. dev.	*N*/average	%/st. dev.	*p* value
Subjects		59,567		14,816		9062		
Age		69.55	10.07	62.61	8.50	60.64	8.24	< 0.0001
Sex	Male	24,315	40.85	4138	27.95	2113	23.32	< 0.001
	Female	35,202	59.15	10,669	72.05	6946	76.68	
Race	White	47,029	79.02	11,534	77.90	6914	76.32	< 0.001
	Black	2790	4.69	1631	11.02	1167	12.88	
	Hispanic	64	0.11	8	0.05	1	0.01	
	Other	2485	4.18	236	1.59	121	1.34	
ASA classification	I	2163	3.63	59	0.40	28	0.31	< 0.001
	II	36,022	60.52	4347	29.36	1675	18.49	
	III	21,315	35.81	10,400	70.24	7347	81.10	
Diabetes		7631	12.82	5092	34.39	3612	39.87	< 0.001
Chronic obstructive pulmonary disease		1783	3.00	637	4.30	442	4.88	< 0.001
History of congestive heart failure		109	0.18	47	0.32	29	0.32	< 0.001
History of end-stage liver disease		12	0.02	1	0.01	1	0.01	0.780
Coronary disease		1009	1.70	172	1.16	84	0.93	< 0.001
Peripheral vascular disease		51	0.09	8	0.05	4	0.04	0.221
Kidney failure		78	0.13	20	0.14	11	0.12	0.752
Central nervous disease		563	0.95	101	0.68	49	0.54	0.010
Spinal cord injury		32	0.05	4	0.03	3	0.03	0.456
Active malignancy		86	0.14	7	0.05	3	0.03	< 0.001

Table 2 Demographic Information and Comorbidities of All THA Patients

		BMI ≥ 18.5 and < 30		BMI ≥ 40 and BMI< 45		BMI ≥ 45		
		N/average	%/st. dev.	*N*/average	%/st. dev.	*N*/average	%/st. dev.	*p* value
Subjects		54,670		4890		2226		
Age		66.33	12.25	60.84	9.88	59.60	9.89	< 0.0001
Sex	Male	23,179	42.44	2022	41.38	845	37.96	< 0.001
	Female	31,439	57.56	2865	58.62	1381	62.04	
Race	White	43,362	79.39	3819	78.15	1724	77.45	< 0.001
	Black	3128	5.73	527	10.78	276	12.40	
	Hispanic	24	0.04	2	0.04	0	0.00	
	Other	1273	2.33	55	1.13	21	0.94	
ASA classification	I	3273	5.99	18	0.37	10	0.45	< 0.001
	II	32,988	60.40	1492	30.53	449	20.17	
	III	18,345	33.59	3377	69.10	1764	79.25	
Diabetes		4653	8.52	1456	29.79	715	32.12	< 0.001
Chronic obstructive pulmonary disease		1986	3.64	217	4.44	103	4.63	0.001
History of congestive heart failure		123	0.23	10	0.20	8	0.36	0.401
History of end-stage liver disease		13	0.02	1	0.02	0	0.00	0.761
Coronary disease		661	1.21	53	1.08	22	0.99	0.431
Peripheral vascular disease		62	0.11	4	0.08	0	0.00	0.231
Kidney failure		113	0.21	6	0.12	0	0.00	0.047
Central nervous disease		429	0.79	24	0.49	12	0.54	0.046
Spinal cord injury		21	0.04	2	0.04	1	0.04	0.982
Active malignancy		236	0.43	8	0.16	5	0.22	0.007

Table 3 Summary statistics of time utilization and incidence of events among TKA patients

	BMI ≥ 18.5 and < 30		BMI ≥ 40 and BMI < 45		BMI ≥ 45		
	N/average	%/st. dev.	*N*/average	%/st. dev.	*N*/average	%/st. dev.	*p* value
Time from start of anaesthesia to start of surgery (minutes)	42.36	52.03	45.91	56.57	45.47	46.90	0.0033
Time from end of surgery to end of anaesthesia (minutes)	13.67	19.17	14.90	29.19	15.31	14.27	0.0019
Total time in operating room (minutes)	137.46	44.04	146.87	45.32	151.88	49.52	< 0.0001
Total length of hospital stay (day)	3.09	3.53	3.18	4.12	3.33	4.62	< 0.0001
Time from end of surgery to discharge (day)	3.04	2.33	3.11	2.16	3.26	2.45	< 0.0001
Patients remaining in hospital after 30 days	27	0.06	4	0.03	3	0.04	0.538
Readmissions within 30 days	1075	2.15	358	2.81	257	3.34	< 0.001

stay ($p < 0.0001$), and increased time from day of surgery to discharge ($p < 0.0001$). However, incidences of remaining in hospital after 30 days of surgery did not show statistical differences in neither TKA nor THA patients. Although a trend towards longer was noticed for anaesthesia induction and anaesthesia emergence time among TKA patients, this finding reached statistical difference only among individuals undergoing THA.

Logistic regression analysis was applied to further test the independent influence of various BMI levels on these seven outcome variables. The most significant finding was the consistently higher odds of readmissions within 30 days with both the three-group regression analysis and pairwise regression analysis in both TKA and THA patients (Tables 5 and 6). Higher BMI patients were associated with higher odds of total length of hospital stay and time from end of surgery to discharge. However, the analysis could not show consistent statistical significance.

Discussion

Our results suggest that obese patients require more peri-operative resources and carry higher odds of readmissions within 30 days in both TKA and THA patients. Recognition of increased resource requirements should be accompanied by management strategy adjustments to optimize resource allocation.

Peri-operative risk factor identification, risk stratification, and peri-operative complication optimization have drawn broad attention in recent years. Increased BMI alone has been a major risk factor of post-operative complications in TKA and THA, including mortality [4, 7, 9, 12–14]. Despite the increased risks for adverse events and failure rate, obese patients might still benefit from joint arthroplasty. One potential hurdle for obese patients to receive quality treatment is the punitive merit-based reimbursement system which disincentives operations on higher risk individuals, including the obese [15]. In this context, resource allocation and cost management are thus becoming more important in making management decisions especially for elective surgeries. Good patient selection, optimization, and appropriate resource allocation might be helpful in achieving better outcomes while minimizing potential risks among such higher risk patient population.

Several studies have compared length of stay (LOS) and hospital cost among obese and non-obese patients in

Table 4 Summary statistics of time utilization and incidence of events among THA patients

	BMI ≥ 18.5 and < 30		BMI ≥ 40 and BMI < 45		BMI ≥ 45		
	N/average	%/st. dev.	*N*/average	%/st. dev.	*N*/average	%/st. dev.	*p* value
Time from start of anesthesia to start of surgery (minutes)	45.23	48.05	45.99	29.31	52.30	52.41	0.0189
Time from end of surgery to end of anaesthesia (minutes)	14.71	12.55	15.37	12.02	16.21	8.55	0.0372
Total time in operating room (minutes)	141.91	46.15	157.85	49.57	170.35	55.63	< 0.0001
Total length of hospital stay (day)	2.99	3.54	3.07	2.29	3.27	3.19	0.0004
Time from end of surgery to discharge (day)	2.89	2.22	3.03	2.19	3.21	2.93	< 0.0001
Patients remaining in hospital after 30 days	28	0.06	2	0.05	4	0.22	0.036
Readmissions within 30 days	964	2.14	160	3.90	105	5.73	< 0.001

Table 5 Multivariable regression analysis of BMI on time utilization and incidence of events among TKA patients

	3-group comparison			BMI ≥ 18.5 and < 30 vs. BMI ≥ 40 and BMI < 45 kg/m^2			BMI ≥ 18.5 and < 30 vs. BMI ≥ 45 kg/m^2		
	Odds ratio	*p* value	95% CI	Odds ratio	*p* value	95% CI	Odds ratio	*p* value	95% CI
Time from start of anesthesia to start of surgery (minutes)	1.13	0.706	0.60–2.11	2.01	0.289	0.55–7.29	1.18	0.590	0.65–2.14
Time from end of surgery to end of anaesthesia (minutes)	0.93	0.858	0.44–1.99	0.99	0.993	0.26–3.79	0.99	0.984	0.44–2.22
Time from end of surgery to discharge (day)	1.22	0.018	1.03–1.44	1.51	0.005	1.13–2.00	1.15	0.101	0.97–1.37
Total time in operating room (minutes)	0.87	0.464	0.59–1.27	0.74	0.357	0.39–1.40	0.96	0.850	0.62–1.49
Total length of hospital stay (day)	1.21	0.022	1.03–1.43	1.51	0.005	1.14–2.01	1.15	0.109	0.97–1.37
Patients remaining in hospital after 30 days	0.72	0.393	0.34–1.53	0.62	0.445	0.19–2.09	0.67	0.327	0.30–1.49
Readmissions within 30 days	1.27	0.000	1.17–1.37	1.31	0.000	1.14–1.52	1.27	0.000	1.16–1.38

THA and TKA surgery. D'Apuzzo et al. reported 3.1% higher total hospital cost and a small increase in LOS (3.6 days vs 3.5 days) when comparing morbidly obese patients and non-obese TKA patients [16]. Similarly, Kim reported 7–9% higher costs among morbidly obese receiving THA and TKA surgery [17]. However, Batsis et al. did not observe a correlation between BMI and hospital resource use among 5521 TKA patients [18] and 5642 THA patients [19]. Detailed analysis indicated potential correlation between increasing BMI and operating room cost in addition to anaesthesia cost [19]. However, no further details were provided.

Our study adds to the available body of information on peri-operative resource utilization of TKA and THA among the obese population. The results suggest the increased need for time to perform intra-operative tasks in obese patients. The only exception found was for induction time and emerge time among THA patients, which were only minimally influenced by BMI. Our study also indicated longer length of stay with increase of BMI. The incidences of readmission within 30 days increased with the increase of BMI levels in both TKA and THA patients. However, our analysis did not indicate that increased BMI was associated with incidence of excessive longer duration of hospital stay beyond 30 days.

Our study has limitations. First, this was a retrospective observational study with administrative data. Second, this study is limited by the number of variables listed in the NSQIP database. Third, NSQIP prohibits identifying hospital and physician, while studying the surgical volume and physician practice pattern might be informative.

In conclusion, our study indicated that the care of TKA and THA patients with higher BMI is associated with significantly more intra-operative time, longer length of hospital stays, and higher incidence of readmissions within 30 days. Special considerations need to be given and necessary resources allocated, when making the decision to operate on obese patients.

Table 6 Multivariable regression analysis of BMI on time utilization and incidence of events among THA patients

	3-group comparison			BMI ≥ 18.5 and < 30 vs. BMI ≥ 40 and BMI< 45 kg/m^2			BMI ≥ 18.5 and < 30 vs. BMI ≥ 45 kg/m^2		
	Odds ratio	*p* value	95% CI	Odds ratio	*p* value	95% CI	Odds ratio	*p* value	95% CI
Time from start of anesthesia to start of surgery (minutes)	0.87	0.729	0.39–1.93	2.26	0.432	0.30–17.33	0.73	0.409	0.34–1.55
Time from end of surgery to end of anaesthesia (minutes)	0.44	0.022	0.21–0.89	0.31	0.080	0.08–1.15	0.51	0.099	0.23–1.13
Time from end of surgery to discharge (day)	1.40	0.020	1.06–1.86	2.20	0.002	1.32–3.67	1.12	0.437	0.84–1.51
Total time in operating room (minutes)	0.77	0.255	0.50–1.20	2.17	0.196	0.67–7.05	0.65	0.037	0.43–0.97
Total length of hospital stay (day)	1.44	0.015	1.07–1.94	2.26	0.002	1.34–3.83	1.15	0.368	0.85–1.57
Patients remaining in hospital after 30 days	1.65	0.172	0.80–3.38	1.11	0.901	0.23–5.34	1.64	0.163	0.82–3.30
Readmissions within 30 days	1.53	0.000	1.37–1.70	1.60	0.000	1.33–1.94	1.49	0.000	1.32–1.67

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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