Impact of preoperative myocardial infarction on surgical outcomes in inpatient orthopaedic surgery

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Abstract

Purpose The purpose of this study was to evaluate the impact of a preoperative myocardial infarction (MI) on outcomes of inpatient orthopaedic operations.

Methods The National Surgical Quality Improvement Program database was used to identify patients who underwent common orthopaedic operations from 2006 to 2010. Patient demographic data, comorbidities, complications, and lengths of stay were collected. Multivariate logistic regression and linear regression models were used to compare outcomes for patients with and without a history of MI in the six months prior to surgery.

Results Of the 32,462 patients identified, 86 had sustained an MI in the six months prior to surgery. The MI cohort had no cardiac complications but had increased incidences of superficial surgical site infection, unplanned re-intubation, ventilator-assisted respiration for more than 48 hours, pneumonia, sepsis or septic shock, and postoperative mortality within 30 days of surgery, as well as prolonged lengths of stay. Following logistic regression to adjust for baseline differences, a history of MI showed no association with

cardiac complications and was significantly associated with superficial surgical site infection (OR 3.6, 95 % CI 1.1–11.8), ventilator dependence for over 48 hours (OR 4.0, 95 % CI 1.1–14.0), and extended length of stay (median with interquartile range 4 [4–4] vs. 5 [5–5] days).

Conclusions A myocardial infarction within six months prior to orthopaedic surgery is not associated with a higher risk of 30-day perioperative cardiac complications; however, it is associated with increased rates of surgical site infection, prolonged ventilator dependence, and longer hospital stay.

Introduction

The number of orthopaedic operations performed in the United States is expected to grow substantially over the coming decades [1]. These interventions will take place in the setting of an increasingly elderly population; by the year 2020, 16.3 % of the US population is projected to be 65 years or older [2]. Given the correlation of increasing age and the prevalence of cardiovascular disease [3], a thorough understanding of the interplay between pre-existing cardiovascular disease and surgical outcomes will be vital to optimise clinical decision-making and appropriate counselling of patients prior to surgery.

While many prior studies have concentrated on the impact of pre-existing cardiac disease on postoperative cardiac complications [4–7], few have investigated the effect of cardiac disease on all outcomes, including non-cardiac complications. This study aimed to use the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database to examine adverse surgical outcomes associated with a prior history of myocardial infarction (MI) among patients who underwent common inpatient orthopaedic procedures.

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Materials and methods

A retrospective analysis was performed using the NSQIP participant use files from 2006 to 2010. The NSQIP prospectively collects data on surgical patients from over 250 participating institutions in the United States. These records include patient demographics, preoperative comorbidities, intraoperative data, and surgical outcomes for 30 days following the index procedure. All data is transcribed by highly trained surgical certified reviewers, and regular data quality checks ensure the integrity of the database, as described elsewhere [8–10]. Notably, patients that enter the hospital following trauma are over 18 years of age, or are listed as ‘minor cases’ are excluded from the database.

In this investigation, the NSQIP database was queried using the current procedural terminology (CPT) codes for inpatient orthopaedic procedures with more than 1,000 cases logged during the sampling period. All patients who were identified as outpatient or with MI listed as ‘null’ were excluded from the analysis (see Table 1). Patient characteristics obtained for this study included the demographic factors age, gender, race, and BMI; the preoperative comorbidities dyspnea, hypertension, chronic obstructive pulmonary disease, congestive heart failure, bleeding disorders, previous percutaneous coronary intervention or cardiac surgery, previous stroke, and history of transient ischemic attack, as well as smoking status, recent steroid use, recent chemo- or radiotherapy, and recent prior operation. Surgical outcomes were all tracked for 30 days after the index procedure and included the cardiac complications of MI, stroke, and cardiac arrest as well as the non-cardiac complications of superficial or deep surgical site infection, organ space infection, wound disruption, venous thromboembolism, acute renal failure, unplanned re-intubation, peripheral nerve injury, pneumonia, urinary tract infection (UTI), transfusion, sepsis or septic shock, and ventilator dependence for over 48 h as well as rates of re-operation, lengths of stay, and 30-day mortality.

Patients were divided into two groups based on the presence or absence of a MI within six months prior to surgery. Patient characteristics and surgical outcomes for the two

groups were initially compared using chi-squared or Fisher’s exact test. Logistic regression analysis was performed to adjust for baseline differences. For each regression analysis, categorical preoperative variables were selected among NSQIP preoperative variables using bivariate screening with $p < 0.2$ and ten or more occurrences. Continuous preoperative variables such as age, total operation time, work relative value unit, and BMI with $p < 0.2$ were also included as covariates in the regression analysis. Hosmer-Lemeshow (HL) and receiver operating characteristic (ROC) tests were performed to test the sensitivity of regression analysis. Linear regression analysis was used to calculate the length of hospital stay while adjusting for age, gender, history of cerebrovascular accident, preoperative serum creatine level ≥ 2.0 mg/dl, American Society of Anesthesiology (ASA) classification, and procedure type. The level of significance was set at $p < 0.05$.

Results

Demographic and comorbid profile

A total of 32,462 patients were identified with the CPT codes listed in Table 1; 86 of these patients were identified as having had a MI within six months prior to surgery, while the remaining 32,376 had not. The MI group was older (75.1 ± 12.5 years vs. 66.0 ± 13.0 years, $p < 0.001$) and had a lower body mass index (BMI) (26.6 ± 6.6 kg/m² vs. 31.1 ± 7.2 kg/m², $p < 0.001$).

Patient comorbidity data was significantly different between the two groups. The preoperative MI group had a greater proportion of patients with diabetes (31.4 % vs. 16.0 %, $p < 0.001$), dyspnea (22.1 % vs. 8.7 %, $p < 0.001$), hypertension (86.0 % vs. 64.3 %, $p < 0.001$), chronic obstructive pulmonary disease (COPD) (18.6 % vs. 4.5 %, $p < 0.001$), congestive heart failure (15.1 % vs. 0.4 %, $p < 0.001$), bleeding disorder (17.4 % vs. 3.6 %, $p < 0.001$), previous stroke (15.1 % vs. 3.8 %, $p < 0.001$), and previous transient ischemic attack (TIA) (8.1 % vs. 3.1 %, $p = 0.017$). The preoperative MI group also demonstrated a greater

Table 1 CPT code frequency

CPT	Procedure	n (%)
27447	Total knee arthroplasty	15372 (47.4)
27130	Total hip arthroplasty	8180 (25.2)
27236	Open treatment of femoral fracture, proximal end, neck, internal fixation	1365 (4.2)
27245	Treatment of intertrochanteric, peritrochanteric, or subtrochanteric femoral fracture	1239 (3.8)
27446	Arthroplasty, knee, condyle and plateau; medial OR lateral compartment	862 (2.7)
63030	Laminotomy (hemilaminectomy), with decompression of nerve root(s)	2962 (8.8)
63047	Laminectomy, facetectomy and foraminotomy	2582 (8.0)

proportion of patients taking steroids for a chronic condition (9.3 % vs. 3.0 %, $p=0.004$), previous operation less than 30 days prior to surgery (3.5 % vs. 0.5 %, $p=0.010$), and previous percutaneous coronary intervention (PCI) or cardiac surgery (45.3 % vs. 10.5 %, $p<0.001$). Results are summarised in Table 2.

Outcomes profile

There were no significant differences between the MI and non-MI cohorts in postoperative cardiac complications of stroke (0.0 % vs. 0.2 %, $p=1.0$), cardiac arrest (0.0 % vs. 0.2 %, $p=1.0$) and MI (0.0 % vs. 0.3 %, $p=1.0$). Among non-cardiac complications, superficial surgical site infection (3.5 % vs. 0.9 %, $p=0.040$), unplanned re-intubation (3.5 % vs. 0.4 %, $p=0.005$), ventilation for over 48 hours (3.5 % vs. 0.2 %, $p=0.001$), pneumonia (5.8 % vs. 0.6 %, $p<0.001$), and sepsis or septic shock (4.7 % vs. 0.9 %, $p=0.003$) were all more prevalent in the preoperative MI group.

The preoperative MI group also had a greater proportion of patients needing reoperation (5.8 % vs. 2.0 %, $p=0.030$) and postoperative mortality within 30 days of surgery (4.7 % vs. 0.7 %, $p=0.003$). The same patient group also had

extended length of hospital stay (7.7 ± 8.6 days vs. 3.7 ± 4.6 days, $p<0.001$). Results are summarised in Table 3.

Logistic regression analysis

The results of logistic regression analysis are displayed in Table 4. Adjustment for baseline differences revealed that preoperative MI showed no association with cardiac complications but is significantly associated with superficial surgical site infection (OR 3.6, 95 % CI 1.1–11.8) and ventilator dependence for over 48 hours (OR 4.0, 95 % CI 1.1–14.0). HL test and C-statistics demonstrated sufficient discrimination and calibration for these models.

Linear regression analysis

Following adjustment for age, sex, race, history of cerebrovascular accident, preoperative serum creatine level ≥ 2.0 mg/dl, ASA class, and procedure type, the preoperative MI group had longer hospital stays (median with interquartile range, 5 [5–5] vs. 4 [4–4] days, $p<0.001$). Additional adjustment for postoperative complications did not alter this result (5 [5–6] vs. 4 [4–4] days, $p<0.001$). Results are summarised in Table 5.

Table 2 Patient demographics stratified by history of myocardial infarction (MI)

Preoperative variable	No history of MI <i>n</i> (%)	History of MI <i>n</i> (%)	<i>p</i> -value
Age (years, mean $\pm$ SD)	66.0 $\pm$ 13.0	75.1 $\pm$ 12.5	* <0.001
BMI (kg/m ² , mean $\pm$ SD)	31.1 $\pm$ 7.2	26.6 $\pm$ 6.6	* <0.001
Race			
White	27197	72	
Black	2143	11	
Asian	406	1	
Other	2630	2	
Clinical characteristics			
Active smoker	4131 (12.8)	10 (11.6)	0.753
Steroid use	956 (3.0)	8 (9.3)	*0.004
Radiotherapy <90 days	44 (0.1)	0 (0)	1.000
Chemotherapy <30 days	92 (0.3)	1 (1.2)	0.219
Previous operation <30 days	164 (0.5)	3 (3.5)	*0.010
Comorbidities			
Diabetes	5186 (16.0)	27 (31.4)	* <0.001
Dyspnea	2817 (8.7)	19 (22.1)	* <0.001
Hypertension	20833 (64.3)	74 (86.0)	* <0.001
COPD	1454 (4.5)	16 (18.6)	* <0.001
Congestive heart failure	136 (0.4)	13 (15.1)	* <0.001
Bleeding disorders	1181 (3.6)	15 (17.4)	* <0.001
Previous PCI/cardiac surgery	3414 (10.5)	39 (45.3)	* <0.001
Previous stroke	1235 (3.8)	13 (15.1)	* <0.001
Previous TIA	988 (3.1)	7 (8.1)	*0.017

* Denotes significant value, $p<05$

Table 3 Postoperative outcomes stratified by history of myocardial infarction (MI)

Postoperative outcome	No history of MI <i>N</i> (%)	History of MI <i>N</i> (%)	<i>p</i> -value
Cardiac complications			
Stroke	53 (0.2)	0 (0.0)	1.000
Cardiac arrest	61 (0.2)	0 (0.0)	1.000
Myocardial infarction	107 (0.3)	0 (0.0)	1.000
Non-cardiac complications			
Superficial infection	282 (0.9)	3 (3.5)	0.040*
Deep infection	121 (0.4)	0 (0.0)	1.000
Organ space infection	62 (0.2)	1 (1.2)	0.154
Wound disruption	72 (0.2)	0 (0.0)	1.000
Flap failure	16 (0.0)	0 (0.0)	1.000
DVT	324 (1.0)	1 (1.2)	0.58
Pulmonary embolism	199 (0.6)	0 (0.0)	1.000
Unplanned re-intubation	131 (0.4)	3 (3.5)	0.005*
Vent. >48 h	63 (0.2)	3 (3.5)	0.001*
Renal insufficiency	47 (0.1)	1 (1.2)	0.120
Acute renal failure	31 (0.1)	0 (0.0)	1.000
Coma>24 h	9 (0.0)	0 (0.0)	1.000
Peripheral nerve injury	41 (0.1)	0 (0.0)	1.000
Pneumonia	209 (0.6)	5 (5.8)	<0.001*
UTI	623 (1.9)	2 (2.3)	0.683
Transfusion	1991 (6.1)	7 (8.1)	0.373
Sepsis/septic shock	294 (0.9)	4 (4.7)	0.008*
Reoperation	650 (2.0)	5 (5.8)	0.030*
Postop mortality <30 days	224 (0.7)	4 (4.7)	0.003*
Length of stay (days, mean±SD)	3.76±4.6	7.7±8.6	<0.001*

*Denotes significant value,
 $p<0.05$

Discussion

This study sought to characterise the impact of a prior MI on postoperative complications among patients undergoing orthopaedic surgery. We found that a history of MI within six-months prior to surgery had no association with postoperative

cardiac complications, but was significantly associated with superficial surgical site infections, ventilator dependence for over 48 hours, and prolonged hospital stay.

Adverse cardiac events are known to be frequent postoperative complications. For all-comers undergoing any type of non-cardiac surgery, the incidence of major cardiac

Table 4 Logistic regression analysis: preoperative myocardial infarction (MI) vs. complications

Outcomes	<i>P</i> -value	OR	95 % CI	<i>HL</i> -value	<i>C</i> -value
Cardiac complications					
Myocardial infarction	0.997	0.0	0-.	0.321	0.840
Cardiac arrest	0.997	0.0	0-.	0.307	0.866
Stroke	0.997	0.0	0-.	0.475	0.783
Non-cardiac complications					
Superficial SSI	0.034*	3.6	1.1–11.8	0.701	0.663
Unplanned reintubation	0.262	2.0	0.6–6.8	0.853	0.813
Ventilation>48 h	0.029*	4.0	1.1–14.0	0.561	0.865
Pneumonia	0.087	2.3	0.9–6.2	0.798	0.804
Sepsis/septic shock	0.291	1.8	0.6–5.0	0.217	0.754
Reoperation	0.223	1.8	0.7–4.5	0.433	0.643
Post-OP mortality	0.423	0.6	0.2–2.1	0.156	0.915

* Denotes statistical significance,
 $p<0.05$

Table 5 Effect of history of myocardial infarction (MI) on length of hospital stay

History	Length of hospital stay, in days (Interquartile Range) ^a	Length of hospital stay, in days (Interquartile Range) ^b
No history of MI	4 (4–4)	4 (4–4)
History of MI	5 (5–5)	5 (5–6)
<i>p</i> -value<0.001		

^a Adjusted for age, gender, race, history of cerebrovascular accident, preoperative creatine level >2.0 mg/dL, ASA class, and procedure type

^b Adjusted for postoperative cofounders in addition to the factors listed in ^a

complications ranges from one to over five percent [4–7, 11]. One review finds the rate of MI alone among unselected patients over 40 years undergoing any type of surgery to be 1.4 % [12]. A case series of intermediate-risk noncardiac procedures such as orthopaedic operations found serious cardiac complications in 3.3 % of cases [13].

For patients with pre-existing coronary artery disease (CAD), the risk of cardiac complications is known to be higher. One study of men with a history of CAD undergoing noncardiac surgery found a postoperative MI rate of 4.1 % [7]. A retrospective study of patients with a history of MI undergoing noncardiac surgery found reinfarction rates of 2.3 % for those whose surgery was three to six months after MI and 5.7 % for those whose surgery was less than three months after MI [14].

Cardiac risk factors have also been shown to affect non-cardiac outcomes. One prospective study of 3,970 patients over 50 years of age undergoing non-cardiac surgery found a greatly increased risk of non-cardiac complications in patients that also had cardiac complications, even after adjustment for preoperative clinical factors (OR 6.4) [15]. The same study also found that in patients with multiple complications, a MI was often the sentinel event. Another prospective study of 560 patients undergoing elective primary and revision hip and knee procedures showed a significant correlation between elevated preoperative cardiac risk index score and non-cardiac complications (RR 1.7) [16].

To our knowledge, this is the first multi-institutional study of the impact of prior MI on all postoperative complications in an orthopaedic population. The cohort of patients with pre-operative MI had much higher rates of comorbidities and suffered increased rates of multiple complications. After adjustment for differences in pre-existing illnesses, we found prior MI to be associated with increased rates of superficial surgical site infection (OR 3.6, 95 % CI 1.1–11.8) and ventilator dependence for over 48 hours (OR 4.0, 95 % CI 1.1–14.0). However, prior MI did not correlate with postoperative cardiac complications (MI, cardiac arrest, stroke), as there were none of these events in the preoperative MI cohort.

Surgical site infection (SSI) is associated with significant morbidity and cost to the healthcare system. Approximately

500,000 occur in the US annually at an estimated total cost of ten billion dollars; each SSI is associated with seven to ten additional postoperative hospital days and a two to 11 times higher risk of death [17]. Various risk factors correlate with SSI. These include patient related factors such as age, obesity, diabetes, prior SSI, urinary incontinence, tobacco use, nutritional status, complete neurological deficit, use of NSAIDs, and the presence of more than three comorbid diseases [18–20]. Intraoperative factors also play a key role in risk for SSI, including prolonged surgical time, transfusion, skin preparation and draping techniques, and operating room behaviour [18, 21]. This investigation, to our knowledge, is the first to report prior MI as an independent risk factor for surgical site infections following inpatient orthopaedic surgery.

The inability to extubate for more than 48 hours after surgery is often used as the definition of postoperative respiratory failure (PRF) [22]. Previous studies have shown an association between pre-existing cardiac disease, specifically heart failure, and PRF. A systematic review found that heart failure patients were at significantly higher risk for postoperative pulmonary complications (OR 2.93) [23]. One large Veterans Affairs study of major noncardiac operations found that patients with PRF were more likely to have had a preoperative MI (3 % vs. 1 %), however this study did not include preoperative MI in risk-adjusted analyses [22]. In developing a risk index for PRF, this same study identified the type of surgery and anaesthesia type as key predictors of PRF. It may be that patients in the preoperative MI cohort underwent higher risk procedures or tended to have general as opposed to neuraxial anaesthesia. The preoperative MI cohort, being composed of higher-risk patients, who probably underwent more urgent or emergency cases, as purely elective surgical intervention may have been deferred. If present, this procedural bias could explain our finding of increased risk for PRF in the MI group. We could expect PRF to correlate with postoperative cardiac complications, however there were no adverse cardiac events in the preoperative MI group to account for the increased incidence of PRF.

Our study also revealed a significantly longer postoperative length of stay for patients with a prior MI following adjustment for baseline differences (five days vs. four days). Prolonged length of stay is a major driver of the overall cost of care and resource use for surgical patients [24]. It is also frequently used as a proxy for quality of care for surgical patients and may come under increased scrutiny as our healthcare delivery paradigm continues to evolve. Postoperative complications are known to increase the length of stay significantly [25]; however, our analysis shows preoperative MI to be an independent predictor of prolonged length of stay even after additional adjustment for complications (five days vs. four days).

Our study has several limitations, many of which are related to the database itself. The NSQIP database does not

have functional outcomes and quality of life measures recorded for comparison. The 30-day duration of follow up precludes our ability to track delayed complications occurring beyond this time frame. In addition, the relatively low number of patients in the MI group limits our ability to track rare complications. This study also does not include patients coded as ‘trauma’, ‘paediatric’, or ‘minor’, which limits the general application of our findings. Furthermore, our risk-adjustment models are limited to the variables tracked in the database and the potential for confounding cannot be fully avoided. Any large database study carries the risk of identifying statistically significant differences that do not represent clinical realities. Lastly, the database does not allow for assessment of the degree of preoperative risk factor optimisation, which may confound our results.

In summary, our results indicate that a MI within six months prior to surgery is not associated with increased risk of post-operative stroke, MI, or cardiac arrest. A prior MI does correlate with increased risk of superficial surgical site infection and ventilator dependence for over 48 hours, as well as prolonged hospital stay. These results can help guide decision-making in orthopaedic patients with cardiac comorbidities.

Disclaimer The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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

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