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ORIGINAL ARTICLE

Body mass index predicts perioperative complications following orthopaedic trauma surgery: an ACS-NSQIP analysis

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Abstract
Purpose The impact of obesity on outcomes has been documented extensively in the elective orthopaedic literature, but little is known about the impact of obesity on outcomes following orthopaedic trauma surgery. Utilizing the ACS-NSQIP database, we sought to investigate the relationship between BMI and perioperative complications in orthopaedic trauma patients.
Methods 53,219 orthopaedic trauma patients were identified using a CPT code search between 2005 and 2013 in the NSQIP database. Patient demographics, and perioperative complications (including minor, major, and total) were collected. Multivariate regression analysis was performed to control for baseline demographics and comorbidities.
Results Compared with patients of normal weight, underweight patients had significantly greater odds of minor [OR 1.12, 95 % CI (1.0, 1.26), $p = 0.04$], major [OR 1.20, 95 % CI (1.1, 1.3), $p = 0.0009$], and total complications [OR 1.18, 95 % CI (1.1, 1.3), $p = 0.0003$]. Morbidly obese patients had significantly greater odds of major [OR 1.22, 95 % CI (1.0, 1.5), $p = 0.023$] and total complications [OR 1.18, 95 % CI (1.0, 1.4), $p = 0.023$] compared to normal weight patients. When wound-related complications were examined independently, obesity was associated with increased odds of superficial [OR 1.67, 95 % CI (1.3, 2.1), $p < 0.0001$] and deep wound infection [OR 1.52, 95 % CI (1.075, 2.144), $p = 0.018$], and morbid obesity was associated with increased odds of wound dehiscence [OR 2.29, 95 % CI (1.1, 4.9), $p = 0.034$] and deep infection [OR 2.51, 95 % CI (1.6, 3.9), $p < 0.0001$].
Conclusions Morbidly obese patients have significantly greater odds of wound dehiscence, deep wound infection, major complications, and total complications compared to patients of normal weight. Additionally, BMI under 18.5 is associated with increased odds of minor, major, and total perioperative complications. Interventions aimed at decreasing complication rates should be targeted at these high-risk patient populations on both ends of the BMI spectrum.

Keywords Obesity · Underweight · Orthopaedic trauma · Complications · Wound infection · Obesity paradox

Introduction

Obesity is among the most common health conditions affecting orthopaedic patients. The current prevalence of obesity in the United States is approximately 35 %, and this figure is projected to increase to 45–50 % of the population by 2030 [1]. Rising obesity rates are estimated to result in additional obesity-related healthcare costs of $50 billion each year [2]. Obesity affects nearly every organ system and is associated with significant medical comorbidities [3].

The impact of body mass index (BMI) on surgical outcomes and costs has been studied extensively in the elective orthopaedic literature. A meta-analysis and systematic review

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exploring the impact of obesity on outcomes following total knee arthroplasty (TKA) demonstrated that obese patients had increased odds of postoperative infection (OR 1.90), deep infection requiring surgical debridement (OR 2.38), and all-cause revision surgery (OR 1.30) compared to patients of normal weight [4]. Following elective total hip arthroplasty (THA), Batsis et al. showed that morbidly obese patients were more likely to be transferred to a nursing facility than normal weight, overweight, or obese patients [5]. Following multi-level spinal arthrodesis, BMI >30 is associated with increased hospital length-of-stay and complications at 1- and 2-year follow-up [6]. Morbidly obese patients have complication rates three times greater than rates in underweight patients and eight times greater than rates in patients of normal weight [6].

Relatively little is known about the impact of obesity on outcomes following orthopaedic trauma. Increased complication rates have been reported in obese patients following specific injury patterns including acetabular fractures [7], pelvic ring injuries [8], and spine trauma [9]. However, very few studies have explored the impact of BMI on outcomes in the general orthopaedic trauma population. Utilizing the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, we sought to investigate the relationship between BMI and perioperative complications in orthopaedic trauma patients.

Materials and methods

Data extraction

Access to the NSQIP dataset collected between 2005 and 2013 was granted by the American College of Surgeons. The 135 patient variables reported within this multi-centre database include preoperative risk factors, intraoperative variables, and 30-day postoperative mortality and morbidity outcomes for patients undergoing major surgical procedures in both inpatient and outpatient settings. At each participating institution, two risk-assessment nurses trained as surgical clinical reviewers (SCR) were appointed to collect data directly from patients' medical records. Inter-rater reliability disagreement of <5 % per site was considered acceptable. Audit reports of NSQIP data collection have identified disagreement rates of <1.8 % [10].

Patient selection

All patients who underwent an orthopaedic trauma procedure during the study period were identified from the NSQIP dataset using current procedural terminology (CPT) codes for orthopaedic trauma ($n = 89$). A description for each CPT code used is provided in the Appendix. Patient demographics including age, gender, and race were recorded, along with preoperative comorbidities including body mass index (BMI), recent weight loss (greater than 10 % in the last 6 months), insulin-dependent diabetes mellitus, smoking status, alcohol use, functional status, dyspnea, history of chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), hypertension requiring medication, history of esophageal varices, disseminated cancer, steroid use, bleeding disorders, hemodialysis, chemotherapy within 30 days of surgery, and radiotherapy within 90 days of surgery. Operative factors including systemic inflammatory response syndrome (SIRS), sepsis, or septic shock at time of surgery, operative time, wound class, and American Society of Anesthesiologists (ASA) score were also recorded.

Preoperative BMI was used to group patients into one of five categories: underweight (BMI <18.5), normal weight (18.5–24.9), overweight (25–29.9), obese (30–39.9), or morbidly obese (40 or higher) [3]. Patients without a recorded BMI were excluded from the analysis.

Outcome measures

Perioperative complications within 30 days were categorized as either minor or major based on previously published literature using the NSQIP database [11–16]. Minor complications included wound dehiscence, superficial wound infection, pneumonia, and urinary tract infection. Major complications included deep wound infection, organ space infection, myocardial infarction, pulmonary embolism, deep venous thrombosis, cerebrovascular accident, postoperative neurologic deficit, sepsis, septic shock, coma, and death. A third outcome measure—total complications—was determined by identifying all patients who developed at least one minor and/or major complication.

Data analysis

Rates of minor, major, and total complications for each BMI category were calculated and compared using a Chi-square test.

Using a multivariate logistic regression analysis controlling for age, smoking status, ASA score, and medical comorbidities, odds ratios (ORs) for minor, major, and total complications were calculated for each BMI category. Patients with a BMI in the normal range were used as the reference group. This analysis was then repeated using wound-related complications (wound dehiscence, superficial wound infection, and deep wound infection) as the outcomes of interest.

The complete multivariate model is included in the "Appendix". Predictive accuracy of the logistic regression models was assessed using the concordance statistic (c-statistic), or the area under the ROC curve. Statistical analysis was performed using Stata 12 (StataCorp. 2011. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP) and SSPS Statistics (IBM Corp. Released 2013.

IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). Significance was set at $p < 0.05$.

Results

56,299 patients were identified from the NSQIP dataset using CPT codes for orthopaedic trauma procedures ($n = 89$). As depicted in Fig. 1, 3080 patients without a recorded preoperative BMI were excluded, leaving 53,219 patients available for analysis. Average age was 67.3 years, and 35.6 % of patients were male. As shown in Table 1, among the patients with a recorded preoperative BMI, 10.1 % were underweight, 37.3 % were of normal weight, 28.4 % were overweight, 19.7 % were obese, and 4.6 % were morbidly obese.

Rates of minor, major, and total complications by BMI category are displayed in Table 2. Among the 53,219 patients, 6.5 % had minor complications and 7.3 % had major complications, with an overall rate of 11.9 % for total complications. There were statistically significant differences in rates of minor, major, and total perioperative complications between groups, with the highest rates of complications occurring in underweight patients (8.9 % for minor, 10.8 % for major, and 16.9 % for total complications).

Results of the multivariate analysis are displayed in Table 3. Compared with patients of normal weight, underweight patients had significantly greater odds of minor [OR 1.12, 95 % CI (1.0, 1.3), $p = 0.04$], major [OR 1.20, 95 % CI (1.1–1.3), $p = 0.0009$], and total complications [OR 1.18, 95 % CI (1.1, 1.3), $p = 0.0003$]. Morbidly obese patients had significantly greater odds of major [OR 1.22, 95 % CI (1.0, 1.5), $p = 0.023$] and total complications [OR 1.18, 95 % CI (1.1–1.4), $p = 0.023$] than did patients of normal weight. There was a trend toward greater odds of minor complications in morbidly obese patients [OR 1.18, 95 % CI (1.0, 1.4), $p = 0.077$]. Having a BMI in the overweight or obese range did not significantly increase the odds of minor, major, or total complications.

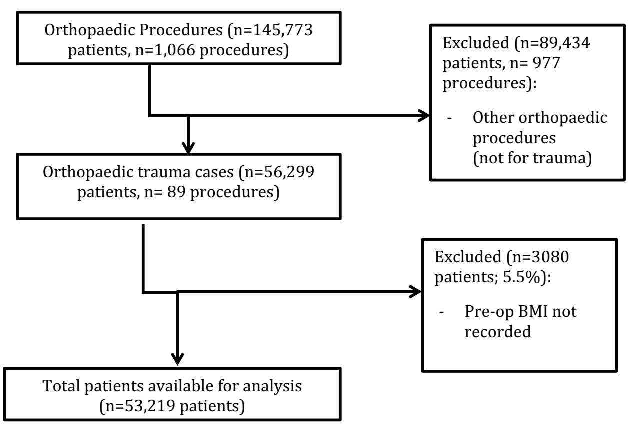

Fig. 1 Flowchart showing patient selection from ACS-NSQIP database

Table 1 Demographic characteristics of included patients ($n = 53{,}219$)

Age (mean ± SD)	67.3 (±20.2)
Gender	
Male	18,921 (35.6 %)
Female	34,263 (64.4 %)
BMI category	
Underweight (BMI <18.5)	5369 (10.1 %)
Normal weight (BMI 18.5–24.9)	19,831 (37.3 %)
Overweight (BMI 25–29.9)	15,097 (28.4 %)
Obese (BMI 30–39.9)	10, 467 (19.7 %)
Morbidly obese (BMI >40)	2454 (4.6 %)
ASA class	
1	5159 (9.7 %)
2	16,962 (31.9 %)
3	24,751 (46.6 %)
4	6231 (11.7 %)
Smoking status	
Smoker	9406 (17.7 %)
Nonsmoker	43,814 (82.3 %)
Diabetes	
Yes	8635 (16.2 %)
No	44,584 (83.8 %)

Table 2 Rates of minor, major, and total complications by BMI category

Complications	Underweight $n = 5369$ (%)	Normal weight $n = 19{,}831$ (%)	Overweight $n = 15{,}098$ (%)	Obese $n = 10{,}467$ (%)	Morbidly obese $n = 2454$ (%)	p value (between groups)
Minor complications	8.9	7.1	5.8	5.3	6.0	**<0.0001**
Major complications	10.8	8.2	6.2	5.4	6.8	**<0.0001**
Total complications	16.9	13.3	10.3	9.3	11.1	**<0.0001**

Significant values are indicated in bold

When wound-related complications were examined independently, obesity was associated with increased odds of superficial [OR 1.67, 95 % CI (1.3, 2.1), $p < 0.0001$] and deep wound infection [OR 1.52, 95 % CI (1.1, 2.1), $p = 0.018$] compared with patients of normal weight, as shown in Table 4. Morbid obesity was associated with increased odds of wound dehiscence [OR 2.29, 95 % CI (1.1, 4.9), $p = 0.034$] and deep infection [OR 2.51, 95 % CI (1.6, 3.9), $p < 0.0001$]. Trends toward increased odds of wound dehiscence in overweight [OR 1.72, 95 % CI (1.0, 3.1), $p = 0.053$] and obese [OR 1.71, 95 % CI (1.0, 3.1), $p = 0.07$] patients did not reach statistical significance. The complete multivariate model is included in the Appendix.

Discussion

We utilized the ACS-NSQIP database to investigate the relationship between BMI and perioperative complications following orthopaedic trauma surgery. Our multivariate analysis demonstrates that patients with morbid obesity have significantly increased odds of major and total perioperative complications compared with patients of normal weight. These findings corroborate previous reports demonstrating an association between obesity and complications in specific orthopaedic trauma injury patterns, including acetabular fractures [7], pelvic ring injuries [8], and spine trauma [9]. A similar study by Hoffmann et al. also demonstrated a trend between BMI and mortality among orthopaedic polytrauma patients in Germany [17]. However, our study is the first to document an association between increased perioperative complications and morbid obesity among a large orthopaedic trauma population in North America.

In our study, obesity and morbid obesity were also associated with significantly increased odds of wound complications including superficial or deep infection and wound dehiscence, as shown in Table 4. These findings are in keeping with other published studies that document higher rates of perioperative wound complications in obese patients. In a retrospective study of more than 7500 lower extremity vascular bypass procedures, Giles et al. identified obesity as an independent risk factor for surgical site infections [18]. In a retrospective comparative study of patients with operatively treated acetabular fractures, morbidly obese patients had a 46 % wound complication rate compared with only 12 % in patients with BMI <40 [7]. Sems et al. reported a wound complication rate of 11 % in a series of obese patients who underwent surgical treatment of pelvic ring injuries [8]. Patients with a BMI >30 were 6.87 times more likely to develop a complication and 4.68 times more likely to require reoperation than those with a BMI <30.

Table 3 Multivariate analysis displaying odds ratios (ORs) of minor, major, and total complications by BMI category

BMI category	Underweight $n = 5369$ (10.1 %)	Normal weight (reference) $n = 19{,}831$ (37.3 %)	Overweight $n = 15{,}098$ (28.4 %)	Obese $n = 10{,}467$ (19.7 %)	Morbidly obese $n = 2454$ (4.6 %)	Predictive accuracy C-statistic Somer's D Tau-a
Minor complications	**1.12** (1.01–1.26) **$p = 0.04$**	1	0.96 (0.87–1.05) $p = 0.32$	1.01 (0.91–1.12) $p = 0.87$	1.18 (0.98–1.43) $p = 0.077$	0.71 0.42 0.05
Major complications	**1.20** (1.08–1.33) **$p < 0.0009$**	1	**0.88** (0.81–0.96) **$p = 0.004$**	0.90 (0.81–1.00) $p = 0.053$	**1.22** (1.02–1.46) **$p = 0.023$**	0.77 0.54 0.07
Total complications	**1.18** (1.08–1.28) **$p < 0.0003$**	1	**0.90** (0.84–0.96) **$p = 0.002$**	0.94 (0.87–1.03) $p = 0.17$	**1.18** (1.02–1.37) **$p = 0.023$**	0.74 0.49 0.10

Significant values are indicated in bold

Table 4 Multivariate analysis displaying odds ratios (ORs) of wound complications by BMI category

BMI category	Underweight $n = 5369$ (10.1 %)	Normal weight (reference) $n = 19{,}831$ (37.3 %)	Overweight $n = 15{,}098$ (28.4 %)	Obese $n = 10{,}467$ (19.7 %)	Morbidly obese $n = 2454$ (4.6 %)	Predictive accuracy C-statistic Somer's D Tau-a
Wound dehiscence	0.69 (0.24–2.02) $p = 0.50$	1	1.72 (0.99–2.98) $p = 0.054$)	1.71 (0.96–3.06) $p = 0.07$	**2.29** **(1.07–4.92)** $\boldsymbol{p = 0.034}$	0.68 0.36 0.001
Superficial wound infection	0.96 (0.66–1.38) $p = 0.82$	1	1.09 (0.85–1.40) $p = 0.48$	**1.67** **(1.30–2.15)** $\boldsymbol{p < 0.0001}$	1.37 (0.89–2.11) $p = 0.15$	0.63 0.26 0.004
Deep wound infection	0.96 (0.58–1.58) $p = 0.87$	1	1.01 (0.71–1.44) $p = 0.95$	**1.52** **(1.08–2.14)** $\boldsymbol{p = 0.018}$	**2.51** **(1.60–3.93)** $\boldsymbol{p < 0.0001}$	0.70 0.40 0.004

Significant values are indicated in bold

In addition to identifying morbid obesity as a risk factor for perioperative complications, our results demonstrate that orthopaedic trauma patients with a BMI less than 18.5 have significantly increased odds of minor, major, and total complications compared with patients of normal weight. To our knowledge, this finding has not been previously reported in the orthopaedic trauma literature. In elective total joint arthroplasty, underweight patients are at increased risk for 90-day readmission following THA [19]. In the surgical oncology literature, underweight status has been shown to be a risk factor for increased length-of-stay in patients undergoing thoracotomy for lung cancer [20]. Similarly, in patients with gastric adenocarcinoma, underweight status and low serum albumin were shown to be independent risk factors for mortality following gastrectomy [21]. In our study, underweight orthopaedic trauma patients had significantly increased odds of minor (OR 1.12), major (OR 1.20), and total (OR 1.18) perioperative complications compared with patients of normal weight.

Increased complication rates at the extremes of the BMI spectrum—a phenomenon often referred to as the "obesity paradox"—have been previously published in the general surgical literature. In patients undergoing non-bariatric general surgery, Mullen et al. reported the highest mortality rates in underweight and morbidly obese patients, with lower mortality rates seen in overweight and moderately obese patients [22]. Davenport et al. reported similar results for patients undergoing vascular surgery [23]. Our results demonstrated similar findings: compared with patients of normal weight, overweight patients actually had slightly decreased odds of major (OR 0.88, $p = 0.004$) and total (OR 0.90, $p = 0.002$) complications, as shown in Table 3. In a systematic review of the cardiac and non-cardiac surgery literature, Valentijn et al. identified this phenomenon—worse outcomes in patients at the extremes of the BMI spectrum, with a slight protective effect seen in overweight and slightly obese patients—in multiple surgical subspecialties [24]. Hypotheses proposed to account for the obesity paradox include genetic factors as well as the potentially protective effect of lean body mass and moderate amounts of peripheral body fat. To our knowledge, the current study is the first to demonstrate the "obesity paradox" in patients undergoing orthopaedic surgery.

Our study has some limitations. First, the study was conducted in a retrospective manner. However, the fact that the NSQIP database contains prospectively collected data and is quite comprehensive in its scope largely mitigates this limitation. Multi-centre, prospective randomized controlled trials are associated with significant expense and other logistical challenges. Large multi-centre studies such as ours, which use a high-quality, prospectively collected database, provide the opportunity to answer relevant clinical questions while avoiding the expense and inconvenience of prospective trials [11–16]. Second, the NSQIP database does not capture any complications that occur more than 30 days after surgery. While many postoperative complications do not occur within the first month, the fact that we identified significant differences in 30-day complication rates between groups underscores the significance of these findings. In addition, the NSQIP database does not currently record polytraumas, which might also serve as a good predictor for complications. Finally, the nutritional status of patients in our cohort could not be determined since serum albumin is not a variable recorded in the NSQIP database. Further research may lead to an improved understanding of the role of nutrition in outcomes following orthopaedic trauma, especially in underweight patients.

Using the ACS-NSQIP database, we demonstrate that, compared with patients of normal weight, morbidly obese patients have significantly increased odds of wound dehiscence (OR 2.29), deep wound infection (OR 2.51), major complications (OR 1.22), and total complications (OR 1.18) following orthopaedic trauma surgery. Additionally, having a BMI under 18.5 is associated with increased odds of minor, major, and total perioperative complications. Interventions aimed at decreasing complication rates should be targeted at these high-risk patient populations on both ends of the BMI spectrum.

Compliance with ethical standards

Conflict of interest and source of funding Author William T. Obremskey (WTO) has done expert testimony in legal matters. The institution of one or more authors (WTO) has received a grant from the Department of Defense. Paul S. Whiting, Gabrielle A. White-Dzuro, Frank R. Avilucea, Ashley C. Dodd, Nikita Lakomkin, Cory A. Collinge, and Manish K. Sethi declare that they have no conflict of interest.

Compliance with ethical requirements This study was performed in accordance with the relevant regulations of the US Health Insurance Portability and Accountability Act (HIPPA) and the ethical standards of the 1964 Declaration of Helsinki. The protocol was approved by the Vanderbilt Institution Review Board.

Appendix

See Tables 5, 6, 7, 8.

Table 5 Trauma CPT code descriptions

CPT code	Description
23515	Open treatment of clavicular fracture, includes internal fixation, when performed
23585	Open treatment of scapular fracture (body, glenoid or acromion) includes internal fixation, when performed
23615	Open treatment of proximal humeral (surgical or anatomical neck) fracture, includes internal fixation, when performed, includes repair of tuberosity(s), when performed
23616	Open treatment of proximal humeral (surgical or anatomical neck) fracture, includes internal fixation, when performed, includes repair of tuberosity(s), when performed; with proximal humeral prosthetic replacement
23630	Open treatment of greater humeral tuberosity fracture, includes internal fixation, when performed
24515	Open treatment of humeral shaft fracture with plate/screws, with or without cerclage
24516	Treatment of humeral shaft fracture, with insertion of intramedullary implant, with or without cerclage and/or locking screws
24538	Percutaneous skeletal fixation of supracondylar or transcondylar humeral fracture, with or without intercondylar extension
24545	Open treatment of humeral supracondylar or transcondylar fracture, includes internal fixation, when performed; without intercondylar extension
24546	Open treatment of humeral supracondylar or transcondylar fracture, includes internal fixation, when performed; with intercondylar extension
24566	Percutaneous skeletal fixation of humeral epicondylar fracture, medial or lateral, with manipulation
24575	Open treatment of humeral epicondylar fracture, medial or lateral, includes fixation, when performed
24579	Open treatment of humeral condylar fracture, medial or lateral, with or without internal or external fixation
24586	Open treatment of periarticular fracture and/or dislocation of the elbow (fracture distal humerus and proximal ulna and/or proximal radius)
24587	Open treatment of periarticular fracture and/or dislocation of the elbow (fracture distal humerus and proximal ulna and/or proximal radius); with implant arthroplasty
24615	Open treatment of acute or chronic elbow dislocation
24635	Open treatment of Monteggia type of fracture dislocation at elbow (fracture proximal end of ulna with dislocation of radial head), with or without internal or external fixation
24665	Closed treatment of radial head or neck fracture; with manipulation
24666	Open treatment of radial head or neck fracture, with or without internal fixation or radial head excision; with radial head prosthetic replacement
24685	Open treatment of ulnar fracture proximal end (olecranon process), with our without internal or external fixation
24800	Arthrodesis, elbow joint; local
24900	Amputation, arm through humerus; with primary closure
24930	Amputation, arm through humerus; re-amputation
25515	Open treatment of radial shaft fracture, with or without internal or external fixation

Table 5 continued

CPT code	Description
25525	Open treatment of radial shaft fracture, with internal and/or external fixation and closed treatment of dislocation of distal radioulnar joint; with or without percutaneous fixation
25526	Open treatment of radial shaft fracture, with internal and/or external fixation and closed treatment of dislocation of distal radioulnar joint, includes repair of triangular fibrocartilage complex
25545	Open treatment of ulnar shaft fracture, with or without internal or external fixation
25574	Open treatment of radial AND ulnar shaft fractures, with internal or external fixation; of radius OR ulna
25575	Open treatment of radial AND ulnar shaft fractures, with internal or external fixation; of radius AND ulna
25606	Percutaneous skeletal fixation of distal radial fracture or epiphyseal separation
25607	Open treatment of distal radial extra-articular fracture or epiphyseal separation, with internal fixation
25608	Open treatment of distal radial intra-articular fracture or epiphyseal separation; with internal fixation
25609	With internal fixation of 3 or more fragments
25628	Open treatment of carpal scaphoid (navicular) fracture, with or without internal or external fixation
25920	Disarticulation through wrist
27125	Hemiarthroplasty, hip, partial (e.g. femoral stem prosthesis, bipolar arthroplasty)
27187	Prophylactic treatment (nailing, pinning, plating or wiring) with or without methylmethacrylate, femoral neck and proximal femur
27215	Open treatment of iliac spine(s), tuberosity avulsion, or iliac wing fracture(s), unilateral, for pelvic bone fracture patterns that do not disrupt the pelvic ring, includes internal fixation, when performed
27217	Open treatment of anterior pelvic bone fracture and/or dislocation for fracture patterns that disrupt the pelvic ring, unilateral, includes internal fixation, when performed (includes pubic symphysis and/or ipsilateral superior/inferior rami)
27218	Open treatment of posterior pelvic bone fracture and/or dislocation, for fracture patterns that disrupt the pelvic ring, unilateral, includes internal fixation, when performed (includes ipsilateral ilium, sacroiliac joint and/or sacrum)
27226	Open treatment of posterior or anterior acetabular wall fracture, with internal fixation
27227	Open treatment of acetabular fracture(s) involving anterior or posterior (one) column, or a fracture running transversely across the acetabulum, with internal fixation
27228	Open treatment of acetabular fracture(s) involving anterior and posterior (two) columns, includes T-fracture and both column fracture with complete articular detachment, or single column or transverse fracture with associated acetabular wall fracture, with internal fixation
27235	Percutaneous skeletal fixation of femoral fracture, proximal end, neck
27236	Open treatment of femoral fracture, proximal end, neck, internal fixation or prosthetic replacement
27244	Treatment of intertrochanteric, pertrochanteric, or subtrochanteric femoral fracture; with plate/screw type implant, with or without cerclage
27245	Treatment of intertrochanteric, pertrochanteric, or subtrochanteric femoral fracture; with intramedullary implant, with or without interlocking screws and/or cerclage
27248	Open treatment of greater trochanteric fracture, with or without internal or external fixation
27253	Open treatment of hip dislocation, traumatic, without internal fixation
27254	Open treatment of hip dislocation, traumatic, with acetabular wall and femoral head fracture, with or without internal or external fixation
27256	Treatment of spontaneous hip dislocation (developmental, including congenital or pathological), by abduction, splint or traction; without anesthesia, without manipulation
27258	Open treatment of spontaneous hip dislocation (developmental, including congenital or pathological), replacement of femoral head in acetabulum (including tenotomy, etc.)
27259	Open treatment of spontaneous hip dislocation (developmental, including congential or pathological), replacement of femoral head in acetabulum (including tenotomy, etc.); with femoral shaft shortening
27269	Open treatment of femoral fracture, proximal end, head, includes internal fixation, when performed
27506	Open treatment of femoral shaft fracture, with or without external fixation, with insertion of intramedullary implant, with or without cerclage and/or locking screws

Table 5 continued

CPT code	Description
27507	Open treatment of femoral shaft fracture with plate/screws, with or without cerclage
27509	Percutaneous skeletal fixation of femoral fracture, distal end, medial or lateral condyle, or supracondylar or transcondylar, with or without intercondylar extension, or distal femoral epiphyseal
27511	Open treatment of femoral supracondylar or transcondylar fracture without intercondylar extension, with or without internal or external fixation
27513	Open treatment of femoral supracondylar or transcondylar fracture with intercondylar extension, with or without internal or external fixation
27514	Open treatment of femoral fracture, distal end, medial or lateral condyle, includes internal fixation, when performed
27519	Open treatment of distal femoral epiphyseal separation, with or without internal or external fixation
27535	Open treatment of tibial fracture, proximal (plateau); unicondylar, includes internal fixation, when performed
27536	Open treatment of tibial fracture, proximal (plateau); bicondylar, with or without internal fixation
27590	Amputation, thigh, through femur, any level
27591	Amputation, thigh, through femur, any level; immediate fitting technique including first cast
27592	Amputation, thigh, through femur, any level; open circular (guillotine)
27756	Percutaneous skeletal fixation of tibial shaft fracture (with or without fibular fracture) (e.g. Pins or screws)
27758	Open treatment of tibial shaft fracture, (with or without fibular fracture) with plate/screws, with or without cerclage
27759	Treatment of tibial shaft fracture (with or without fibular fracture) by intramedullary implant, with or without interlocking screws and/or cerclage
27766	Open treatment of medial malleolus fracture, with or without internal or external fixation
27769	Open treatment of posterior malleolus fracture, includes internal fixation, when performed
27784	Open treatment of proximal fibula or shaft fracture, with or without internal or external fixation
27792	Open treatment of distal fibular fracture (lateral malleolus), with or without internal or external fixation
27814	Open treatment of bimalleolar ankle fracture, with or without internal or external fixation
27822	Open treatment of trimalleolar ankle fracture, with or without internal or external fixation, medial and/or lateral malleolus; without fixation of posterior lip
27823	Open treatment of trimalleolar ankle fracture, with or without internal or external fixation, medial and/or lateral malleolus; with fixation of posterior lip
27826	Open treatment of fracture of weight bearing articular surface/portion of distal tibia (e.g. pilon or tibial plafond), with internal or external fixation; of fibula only
27827	Open treatment of fracture of weight bearing articular surface/portion of distal tibia (e.g. pilon or tibial plafond), with internal or external fixation; of tibia only
27828	Open treatment of fracture of weight bearing articular surface/portion of distal tibia (e.g. pilon or tibial plafond), with internal or external fixation; of both tibia and fibula
27880	Amputation, leg, through tibia and fibula
27881	Amputation, leg, through tibia and fibula; with immediate fitting technique including application of first cast
27882	Amputation, leg, through tibia and fibula; open, circular (guillotine)
27888	Amputation, ankle, through malleoli of tibia and fibula (e.g. Syme, Pirogoff type procedures), with plastic closure and resection of nerves
27889	Ankle disarticulation
28420	Open treatment of calcaneal fracture, with or without internal or external fixation; with primary iliac or other autogenous bone graft (includes obtaining graft)
28445	Open treatment of talus fracture, with or without internal or external fixation
28800	Amputation, foot; midtarsal (e.g. Chopart type procedure)
28805	Amputation, foot; transmetatarsal

Table 6 Multivariate regression for MINOR complication

Variable	Odds ratio	95 % CI		*p* value
		Lower	Upper	
BMI				
Normal	Reference	–	–	–
Morbidly obese	1.183	0.982	1.425	0.0773
Obese	1.009	0.906	1.123	0.8727
Overweight	0.955	0.873	1.046	0.3230
Underweight	1.124	1.005	1.258	0.0400
Male	1.014	0.937	1.098	0.7250
Age	1.030	1.026	1.033	<0.0001
Smoking	1.181	1.055	1.322	0.0038
Dyspnea at rest	1.381	1.076	1.774	0.0113
Dyspnea with moderate exertion	1.104	0.966	1.260	0.1456
Functional status: partially dependent	1.255	1.153	1.366	<0.0001
Functional status: totally dependent	1.470	1.262	1.711	<0.0001
History of COPD	1.317	1.177	1.473	<0.0001
History of CHF	1.260	1.055	1.504	0.0106
Dialysis	0.715	0.540	0.945	0.0185
Disseminated cancer	1.239	1.009	1.522	0.0412
Steroid use	1.173	1.012	1.361	0.0348
Weight loss	0.937	0.697	1.260	0.6669
Bleeding disorder	1.273	1.159	1.399	<0.0001
ASA class: 1	Reference	–	–	–
ASA class: 2	1.343	1.016	1.776	0.0386
ASA class: 3	2.423	1.830	3.207	<0.0001
ASA class: 4	2.943	2.196	3.945	<0.0001
ASA class: 5	1.485	0.439	5.020	0.5246
Operative time	1.001	1.000	1.002	0.0015

Table 7 Multivariate regression for major complications

Variable	Odds ratio	95 % CI		*p* value
		Lower	Upper	
BMI				
Normal	Reference	–	–	–
Morbidly obese	1.222	1.022	1.461	0.0282
Obese	0.900	0.809	1.001	0.0531
Overweight	0.879	0.805	0.960	0.0042
Underweight	1.197	1.077	1.331	0.0009
Male	1.417	1.316	1.525	<0.0001
Age	1.031	1.028	1.035	<0.0001
Smoking	1.067	0.954	1.193	0.2582
Dyspnea at rest	1.879	1.516	2.328	<0.0001
Dyspnea with moderate exertion	1.282	1.136	1.447	<0.0001
Functional status: partially dependent	1.561	1.442	1.689	<0.0001
Functional status: totally dependent	2.405	2.111	2.740	<0.0001
History of COPD	1.240	1.115	1.379	<0.0001
History of CHF	1.536	1.318	1.788	<0.0001
Dialysis	1.875	1.562	2.250	<0.0001
Disseminated cancer	2.731	2.337	3.193	<0.0001
Steroid use	1.267	1.106	1.452	0.0006
Weight loss	1.303	1.031	1.647	0.0265
Bleeding disorder	1.269	1.161	1.387	<0.0001
ASA class: 1	Reference	–	–	–
ASA class: 2	1.468	1.075	2.006	0.0159
ASA class: 3	2.754	2.018	3.758	<0.0001
ASA class: 4	4.978	3.620	6.846	<0.0001
ASA class: 5	8.979	4.327	18.633	<0.0001
Operative time	1.002	1.001	1.002	<0.0001

Table 8 Multivariate regression for total complications

Variable	Odds ratio	95 % CI		*p* value
		Lower	Upper	
BMI				
Normal	Reference	–	–	–
Morbidly obese	1.182	1.024	1.366	0.0228
Obese	0.943	0.867	1.026	0.1705
Overweight	0.896	0.835	0.962	0.0024
Underweight	1.177	1.079	1.284	0.0003
Male	1.177	1.108	1.251	<0.0001
Age	1.031	1.029	1.034	<0.0001
Smoking	1.117	1.023	1.221	0.0141
Dyspnea at rest	1.677	1.379	2.039	<0.0001
Dyspnea with moderate exertion	1.217	1.099	1.348	0.0002
Functional status: partially dependent	1.403	1.314	1.499	<0.0001
Functional status: totally dependent	1.991	1.774	2.234	<0.0001
History of COPD	1.276	1.167	1.394	<0.0001
History of CHF	1.526	1.333	1.748	<0.0001
Dialysis	1.450	1.225	1.717	<0.0001
Disseminated cancer	2.102	1.825	2.422	<0.0001
Steroid use	1.230	1.096	1.380	0.0004
Weight loss	1.207	0.980	1.488	0.0774
Bleeding disorder	1.305	1.212	1.405	<0.0001
ASA class: 1	Reference	–	–	–
ASA class: 2	1.370	1.101	1.705	0.0048
ASA class: 3	2.486	1.996	3.095	<0.0001
ASA class: 4	3.802	3.027	4.775	<0.0001
ASA class: 5	5.249	2.657	10.373	<0.0001
Operative time	1.002	1.001	1.002	<0.0001

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