Research Article

Obese trauma patients who sustain orthopaedic fractures experience increased length of stay, ICU admissions and mortality

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Background

The rising trend of obesity in the United States has been a growing concern within the healthcare system for decades. Since the early 1960s, the prevalence of obesity has more than doubled among U.S. adults, and one out of every three Americans is now considered obese according to the National Health and Nutrition Examination Survey [1,2]. Significant medical comorbidities have been associated with obesity and increased Body Mass Index (BMI); these include hypertension, dyslipidemia, coronary artery disease, stroke, sleep apnea, type II diabetes mellitus and certain types of cancer. Trauma patients with higher BMIs are more likely to have increased complication rates, develop multiple system organ failure, acute respiratory distress syndrome and infections [3-5]. Additionally, obesity is an independent risk factor for increased morbidity and mortality following high-impact blunt force trauma and has been associated with significantly longer Intensive Care Unit (ICU) lengths of stay with greater anticipated hospital costs [6,7].

There is a well-established association between increasing BMI and the probability of sustaining a musculoskeletal injury, including certain types of fractures [8]. Furthermore,

several retrospective studies have identified an increased risk of postoperative complications for fractures involving the ankle, tibia, femur, humerus and pelvis [7,9-15]. However, the literature regarding the clinical outcomes of hospitalized obese trauma patients who sustain fractures is limited despite the increasing prevalence of obesity among this population.

The purpose of this study was to investigate whether obesity (BMI $\geq$ 30kg/m^2) is an independent risk factor for worse outcomes in orthopaedic trauma patients who sustained a fracture or multiple fractures, utilizing a large institutional database at a level I trauma center. We hypothesized that obese patients who sustained fractures would have worse outcomes including longer hospital and ICU lengths of stay, more frequent admissions to the ICU, and increased mortality rates compared to their nonobese counterparts. Furthermore, we sought to investigate the influence of fracture site and the impact of fracture fixation on the aforementioned outcomes.

Methods

This was a retrospective evaluation using data from an institutional trauma registry at an academic level I trauma center that is part of the American College of Surgeons National

Trauma Data Bank (NTDB). Between January 2001 and March 2015, all trauma patients who sustained orthopaedic fractures including fractures of the pelvis, clavicle, scapula, upper and lower extremity, and foot were identified using International Classification of Diseases, Ninth Revision (ICD-9) codes. Trauma patients were identified as all patients who sustained a traumatic injury and were diagnosed with an injury in the ICD-9-CM range of 800.0-959.9. Further inclusion criteria for trauma patients included admission to the hospital or an observation unit, transportation via emergency medical service and/or death from the traumatic injury prior to admission.

Obesity was determined as a pre-existing comorbidity documented in the trauma registry data and calculated from height and weight measurements when available (BMI= kilogram/meters^2). The latter was defined as obesity by a BMI≥30 kg/m^2 and used to validate the diagnosis in the registry. All patients without a diagnosis of obesity were considered nonobese (BMI<30 kg/m^2) [16].

Outcomes of interest were hospital Length of Stay (LOS), admission to the ICU, length of ICU stay and in-hospital mortality. Length of stay was dichotomized by the overall median value observed (4 days for hospital LOS, 5 days for ICU LOS). All statistical analyses were performed using SAS®, version 9.4 (SAS Institute, Cary, NC). Differences in outcome between obese and nonobese patients were compared using independent sample t-tests and Chi square tests for continuous and categorical variables, respectively. P values less than 0.05 were considered to be statistically significant. Odds ratios adjusted for age, sex and race describing the association between obesity and the aforementioned outcomes were generated using multiple logistic regression. Additionally, patient comorbidities that exceeded 5% prevalence in this cohort were used to generate a composite variable to control for the effect of presence versus absence of any of these comorbidities in the multiple logistic regression model. Odds ratios adjusted for age, sex, race and the composite patient comorbidity were then also calculated. Associations were analyzed for all orthopaedic fractures collectively and stratified by fracture site to evaluate both isolated fractures and multiple concomitant fractures.

To further investigate the effect of fracture fixation on the aforementioned outcomes, an additional analysis was performed utilizing a subset of the larger cohort including only patients treated in 2011 or later, as these patients had complete Electronic Medical Record (EMR) data available. The obese patients were stratified by fracture type and a group of nonobese patients with equal proportions of those fracture types were randomly selected from the overall subset for comparison. The EMR was reviewed to determine which patients received operative versus non-operative management of their fractures. Adjusted odds ratios were then calculated to examine the effect of obesity on the outcomes of interest for patients with and without surgery.

Results

During the study period from 2001 to 2015, 10,959 trauma patients sustained a total of 16,495 orthopaedic fractures.

Of these patients, 799 obese patients (7.3%) were identified. Obese patients were significantly older than nonobese patients (47.5±16.8 years vs. 43.4±19.1 years, P<0.0001). Furthermore, there were significantly more female patients in the obese cohort compared to the nonobese cohort (48.2% vs. 34.8%, P<0.0001) (Table 1). Obese patients had more comorbidities including higher rates of diabetes (28.4% vs. 8.4%, P <0.0001), congestive heart failure (7.3% vs. 2.4%, P<0.0001), chronic obstructive pulmonary disease (COPD) (15.0% vs. 8.6%, P <0.0001), hypertension (45.9% vs. 21.8%, P<0.0001) and renal failure (3.0% vs. 1.7%, P<0.0001).

The number of orthopaedic fractures sustained by obese and nonobese patients according to fracture type as defined by ICD-9 codes is presented in Table 2. Obese patients sustained significantly more pelvic fractures (22.7% vs. 19.2%, P= 0.02), tibia and fibula fractures (30.9% vs. 27.2%, P= 0.02) and ankle fractures (25.2% vs. 16.1%, P<0.0001) than nonobese patients. Conversely, nonobese patients sustained significantly more femoral neck fractures (14.3% vs. 10.3%, P= 0.002) than obese patients.

Obese patients experienced a longer total length of hospital stay (mean 8.5 vs. 6.7 days, P<0.0001), were more likely to be admitted to the ICU (32.4% vs. 25.2%, P<0.0001) and had longer ICU stays when admitted (11.1 vs. 8.5 days, P= 0.04). Obese patients also had increased rates of mortality (3.3% vs. 1.9%, P= 0.006). adjusted Odds Ratio (aOR) accounting for age (Model I), age, sex and race (Model II), and age, sex, race and presence of at least one comorbidity (Model III) were calculated for the above outcomes (Table 3). After adjusting for age, race and sex, obese patients were more likely to have hospital lengths of stay ≥4 days (aOR= 1.52, 95% Confidence Interval (CI): 1.30 to 1.77), be admitted to the ICU (aOR=1.43, CI: 1.22 to

Table 1: Patient Demographics and Comorbidities

	All patients	Obese	Non-obese	P Value
N	10,959	799	10,160	
Demographics				
Mean Age (years)	43.7 (19.0)	47.5 (16.8)	43.4 (19.1)	<0.0001
Female Sex	3925 (35.8)	385 (48.2)	3540 (34.8)	<0.0001
Comorbidities				
CVA	108 (1.0)	20 (2.5)	99 (0.9)	<0.0001
Diabetes (Type 1 & 2)	1,085 (9.9)	227 (28.4)	858 (8.4)	<0.0001
Tobacco Use	1,854 (16.9)	179 (22.4)	1,675 (16.5)	<0.0001
Alcohol Misuse	1,505 (13.7)	77 (9.6)	1,428 (14.1)	0.001
CHF	303 (2.8)	58 (7.3)	245 (2.4)	<0.0001
PVD	40 (0.4)	9 (1.1)	31 (0.3)	0.0002
Psychiatric Disorder	1,310 (12.0)	164 (20.5)	1,146 (11.3)	<0.0001
Bleeding Disorder	510 (4.7)	68 (8.5)	442 (4.4)	<0.0001
COPD	997 (9.1)	120 (15.0)	877 (8.6)	<0.0001
Dementia	176 (1.6)	11 (1.4)	165 (1.6)	.59
Hypertension	2,581 (23.6)	367 (45.9)	2,214 (21.8)	<0.0001
Renal Failure	194 (1.8)	24 (3.0)	170 (1.7)	<0.0001

CVA: Cerebrovascular Accident; CHF: Congestive Heart Failure; PVD: Peripheral Vascular Disease; COPD; Chronic Obstructive Pulmonary Disease.

Table 2: Orthopaedic Fractures by ICD-9 Code.

ICD-9 Code	All patients = 10,959	Obese = 799	Non-obese = 10,160	P value
808.* Fracture of pelvis	2134 (19.5)	181 (22.7)	1953 (19.2)	0.02
810.* Fracture of clavicle	616 (5.6)	38 (4.8)	578 (5.7)	0.27
811.* Fracture of scapula	505 (4.6)	32 (4.0)	473 (4.7)	0.40
812.* Fracture of humerus	1080 (9.9)	85 (10.6)	995 (9.8)	0.44
813.* Fracture of radius and ulna	2168 (19.8)	145 (18.1)	2023 (19.9)	0.23
820.* Fracture of neck of femur	1535 (14.0)	82 (10.3)	1453 (14.3)	0.002
821.* Fracture of other and unspecified parts of the femur	1820 (16.6)	142 (17.8)	1678 (16.5)	0.36
822.* Fracture of patella	470 (4.3)	31 (3.9)	439 (4.3)	0.55
823.* Fracture of tibia and fibula	3008 (27.4)	247 (30.9)	2761 (27.2)	0.02
824.* Fracture of ankle	1839 (16.8)	201 (25.2)	1638 (16.1)	<0.0001
825.* Fracture of one or more tarsal and metatarsal bones	1103 (10.1)	88 (11.0)	1015 (10.0)	0.35
826* Fracture of one of more phalanges of the foot	217 (2.0)	21 (2.6)	196 (1.9)	0.17

Table 3: Adjusted Odds Ratios of Outcomes for Obese versus Nonobese Patients.

Outcome	Adjusted Odds Ratio I (95% CI)	Adjusted Odds Ratio II (95% CI)	Adjusted Odds Ratio III (95% CI)
Hospital length of stay ≥4 days			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.50 (1.29, 1.75)	1.52 (1.30, 1.77)	1.48 (1.27, 1.73)
Admission to ICU			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.39 (1.19, 1.62)	1.43 (1.22, 1.67)	1.33 (1.14, 1.56)
ICU length of stay ≥5 days			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.47 (1.13, 1.92)	1.48 (1.14, 1.93)	1.44 (1.10, 1.88)
In-hospital mortality			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.70 (1.12, 2.58)	1.72 (1.13, 2.62)	1.98 (1.29, 3.03)

CI, confidence interval
Adjusted Odds Ratio I- Adjusted for age
Adjusted Odds Ratio II- Adjusted for age, sex, and race
Adjusted Odds Ratio III- Adjusted for age, sex, race and for presence of one or more of the following comorbidities: Diabetes, congestive heart failure, psychiatric disorders, bleeding disorders, chronic obstructive pulmonary disease, hypertension, tobacco use, osteoporosis, drug use disorders.

1.67), have a LOS ≥5 days in the ICU (aOR = 1.48, CI: 1.14 to 1.93) and die prior to discharge (aOR=1.72, CI: 1.13 to 2.62). After adjusting for the patient composite comorbidity as well, obese patients were still found to have significantly higher odds for each of these outcomes.

Adjusted odds ratios describing the association between obesity and adverse outcomes for each fracture site are displayed in Table 4. Obese patients with isolated humerus and isolated femoral neck fractures had significantly increased odds of mortality, compared to those patients who were not obese. Additionally, obese patients with patella fractures in the setting of multiple fractures also had significantly higher odds of mortality.

Of the subset of 5,906 patients treated during or after 2011, all 665 obese patients were included and 980 nonobese patients (1,645 total patients) with comparable fracture types were randomly selected as comparators to evaluate the effect of surgical and non-operative treatment of fractures on the outcomes of interest. Odds ratios adjusted for age, sex, and race were again calculated. Among the 1,109 patients who underwent surgery (67.4 %), obesity was associated with increased odds of a hospital LOS ≥4 days (aOR= 1.49, CI: 1.16 to 1.90) and a LOS≥5 days for those admitted to the ICU (aOR= 1.95, CI: 1.20 to 3.18). Among those patients who did not undergo surgery or received non-operative management of their fracture (n= 536), obese patients were more likely to be admitted to the ICU (aOR =1.49, CI: 1.03 to 2.17). In this subset of patients treated after 2011, obesity did not significantly increase the odds of mortality for patients who received surgery (aOR =1.15, CI: 0.32 to 4.05) or those that did not (aOR= 1.84, CI: 0.89 to 3.79) (Table 5, 6).

Discussion

Obesity represents one of the largest growing public health concerns worldwide. By 2030, it is projected that up to 51%

Table 4: Adjusted Odds Ratios of Outcomes for Obese versus Nonobese Patients by Fracture Site.

Fracture site	N	Hospital length of stay ≥4 days aOR (95% CI)	In-hospital mortality aOR (95% CI)	Admission to ICU aOR (95% CI)
Pelvis				
Multiple fractures	2,134 (19.5)	2.36 (1.23, 4.54)	1.16 (0.59, 2.29)	1.37 (1.01, 1.87)
Isolated fracture	570 (5.2)	1.35 (0.59, 3.09)	1.65 (0.54, 5.03)	0.91 (0.51, 1.65)
Clavicle				
Multiple fractures	616 (5.6)	0.79 (0.35, 1.78)	0.84 (0.19, 3.73)	1.50 (0.71, 3.16)
Isolated fracture	189 (1.7)	0.87 (0.21, 3.53)	1.65 (0.18, 15.53)	1.61 (0.40, 6.39)
Scapula				
Multiple fractures	505 (4.6)	1.89 (0.56, 6.42)	1.39 (0.40, 4.83)	1.91 (0.76, 4.77)
Isolated fracture	98 (0.9)	N/A	N/A	N/A
Humerus				
Multiple fractures	1,080 (9.9)	1.53 (0.93, 2.52)	2.30 (0.76, 6.95)	1.85 (1.18, 2.90)
Isolated fracture	432 (3.9)	1.59 (0.67, 3.75)	11.36 (1.84, 70.25)	2.10 (0.81, 5.40)
Radius/ulna				
Multiple fractures	2,168 (19.8)	1.52 (1.05, 2.19)	1.76 (0.61, 5.10)	2.53 (1.79, 3.56)
Isolated fracture	546 (5.0)	0.73 (0.29, 1.88)	N/A	2.04 (0.80, 5.24)
Neck of Femur				
Multiple fractures	1,535 (14.0)	1.60 (0.88, 2.90)	1.90 (0.56, 6.42)	1.06 (0.65, 1.74)
Isolated fracture	911 (8.3)	0.98 (0.48, 1.96)	4.85 (1.02, 23.10)	0.78 (0.30, 2.03)
Other/unspecified femur				
Multiple fractures	1,820 (16.6)	2.19 (1.37, 3.49)	0.95 (0.33, 2.75)	1.73 (1.21, 2.47)
Isolated fracture	849 (7.7)	1.74 (0.96, 3.17)	1.08 (0.13, 9.01)	2.11 (1.09, 4.10)
Patella				
Multiple fractures	470 (4.3)	3.55 (1.32, 9.51)	7.85 (1.82, 33.85)	3.98 (1.84, 8.60)
Isolated fracture	133 (1.2)	0.84 (0.08, 8.48)	N/A	4.29 (0.29, 64.58)
Tibia/fibula				
Multiple fractures	3,008 (27.4)	1.85 (1.39, 2.46)	0.84 (0.30, 2.38)	1.61 (1.22, 2.13)
Isolated fracture	660 (6.0)	1.49 (0.76, 2.91)	N/A	0.96 (0.36, 2.57)
Ankle				
Multiple fractures	1,839 (16.8)	1.43 (1.05, 1.94)	1.06 (0.24, 4.79)	1.07 (0.74, 1.55)
Isolated fracture	857 (7.8)	2.01 (1.24, 3.25)	7.51 (0.46, 123.11)	1.14 (0.51, 2.53)
Tarsal/metatarsal				
Multiple fractures	1,103 (10.1)	2.03 (1.17, 3.49)	2.40 (0.48, 12.08)	1.61 (1.02, 2.54)
Isolated fracture	142 (1.3)	1.55 (0.30, 8.00)	N/A	2.54 (0.47, 13.60)
Phalanges of the foot				
Multiple fractures	217 (2.0)	3.25 (0.99, 10.6)	N/A	2.70 (1.08, 7.18)
Isolated fracture	38 (0.3)	N/A	N/A	N/A

Odds ratios adjusted for age, sex and race. N/A indicates lack of convergence of the adjusted models resulting from an insufficient number of patients. As a result, adjusted odds ratios could not be calculated.

aOR, adjusted odds ratio, CI, confidence interval.

of men and 52% of women in the United States will be obese [17]. While a great deal of research has focused on the disease burden of medical comorbidities associated with obesity, trauma remains the leading cause of death in individuals 46 years old or younger and is the third leading cause of death among all age groups [18]. Previous work has demonstrated that obese patients have higher odds of sustaining medically-treated injuries [8,19]. Although the effect of obesity on traumatically injured patients has produced inconsistent results in the literature [5,20-23], the present study contributes to a growing body of work reporting that obese trauma patients have significantly higher mortality, increased complications and worse outcomes compared to their nonobese counterparts [3,6,12,13,24].

Consistent with previous studies, obese patients who sustained fractures were found to be significantly more likely to have increased hospital lengths of stay [6,7,23,25-28], more frequent admissions to the ICU and longer associated lengths of stay in the ICU [6,13,28,29]. Furthermore, after adjusting for

Table 5: Adjusted Odds Ratios of Outcomes for Obese versus Nonobese Patients who Received Operative Fracture Fixation

Outcome	Adjusted Odds Ratio I (95% CI)	Adjusted Odds Ratio II (95% CI)	Adjusted Odds Ratio III (95% CI)
Hospital length of stay ≥4 days			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.48 (1.16, 1.89)	1.49 (1.16, 1.90)	1.45 (1.14, 1.86)
Admission to ICU			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.22 (0.93, 1.60)	1.24 (0.95, 1.64)	1.22 (0.93, 1.61)
ICU length of stay ≥5 days			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.89 (1.17, 3.06)	1.95 (1.20, 3.18)	1.93 (1.19, 3.14)
In-hospital mortality			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.23 (0.35, 4.29)	1.15 (0.32, 4.05)	1.14 (0.32, 4.07)

CI, confidence interval
Adjusted Odds Ratio I- Adjusted for age
Adjusted Odds Ratio II- Adjusted for age, sex, and race
Adjusted Odds Ratio III- Adjusted for age, sex, race and for presence of one or more of the following comorbidities: Diabetes, congestive heart failure, psychiatric disorders, bleeding disorders, chronic obstructive pulmonary disease, hypertension, tobacco use, osteoporosis, drug use disorders.

Table 6: Adjusted Odds Ratios of Outcomes for Obese versus Nonobese Patients who Received Non-operative Treatment of Fractures.

Outcome	Adjusted Odds Ratio I (95% CI)	Adjusted Odds Ratio II (95% CI)	Adjusted Odds Ratio III (95% CI)
Hospital length of stay ≥4 days			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.43 (0.98, 2.08)	1.41 (0.97, 2.06)	1.38 (0.95, 2.02)
Admission to ICU			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.45 (1.00, 2.10)	1.49 (1.03, 2.17)	1.50 (1.03, 2.18)
ICU length of stay ≥5 days			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	0.94 (0.55, 1.62)	0.93 (0.54, 1.61)	0.93 (0.54, 1.61)
In-hospital mortality			
Non-obese	1.00 (ref)	1.00 (ref)	1.00 (ref)
Obese	1.74 (0.85, 3.56)	1.84 (0.89, 3.79)	1.91 (0.92, 3.96)

CI, confidence interval
Adjusted Odds Ratio I- Adjusted for age
Adjusted Odds Ratio II- Adjusted for age, sex, and race
Adjusted Odds Ratio III- Adjusted for age, sex, race and for presence of one or more of the following comorbidities: Diabetes, congestive heart failure, psychiatric disorders, bleeding disorders, chronic obstructive pulmonary disease, hypertension, tobacco use, osteoporosis, drug use disorders.

age, sex, race and medical comorbidities, obesity was identified as an independent risk factor for in-hospital mortality in this cohort of patients. Within the trauma literature, discrepant findings have been reported in regards to the influence of obesity on mortality [21,22,24,30-34]. However Liu, et al. conducted a recent meta-analysis of 18 studies on this topic, determining that obese trauma patients had a significantly increased risk of death compared to their nonobese counterparts (OR= 1.45; 95% CI, 1.31–1.60; *P*<0.001).

The influence of obesity on mortality within the orthopaedic trauma literature has not been extensively investigated and remains unclear. In a prospective study by Childs, et al. more complications were observed in obese orthopaedic trauma patients who had significantly more infections and acute renal failure as well as longer LOS in the ICU, mechanical ventilation time and hospital LOS. However, no difference in mortality was observed between obese and nonobese patients (*P*= 0.67). The authors noted that the study was underpowered to detect a statistical difference between these two groups in terms of pulmonary complications, multiple organ failure and mortality [6]. In a study utilizing data from the NTDB, Belmont, et al. found that while obesity was a significant risk factor for pulmonary and cardiac complications following hip fractures, it was not a risk factor for mortality [35]. Another study by Prieto-Alhambra, et al. demonstrated that overweight (25 to <30kg/m²) and obesity actually had a protective effective against mortality following hip fractures in individuals ≥ 40 years of age [36].

Divergent findings regarding the effects of morbid obesity have also been observed in patients who have sustained femoral shaft fractures. While Baldwin, et al. found no significant difference in mortality between obese and nonobese patients using NTDB data (OR= 1.30, *P*= 0.799), Weinlen et al. demonstrated that morbid obesity significantly increased, the odds of mortality (OR= 46.77, *P*= 0.01) [13,23]. In another study investigating the impact of obesity on pediatric patients who sustained lower extremity fractures, obese patients were found to have sustained more severe injuries and thus were more likely to be admitted to the ICU (Relative Risk (RR) = 1.68; 95% CI, 1.10–2.55) and die during the hospitalization (RR= 3.45; 95% CI, 1.14–10.41). However, when adjusting for Injury Severity Score (ISS), these associations were no longer significant [29]. In light of these varied findings, further investigation is warranted to characterize the effect of obesity on mortality in patients sustaining orthopaedic fractures.

Recent literature suggests that obesity is protective against hip fractures and is associated with decreased mortality, the so called "obesity paradox" [36-40]. However, an analysis conducted across fracture sites in this study demonstrated that isolated femoral neck fractures were significantly associated with mortality in this cohort of orthopaedic trauma patients. Additionally, isolated humerus fractures were also found to increase the risk of mortality in obese individuals. Obese post-menopausal women have previously been shown to be at a significantly increased risk of sustaining proximal humerus fractures compared to their nonobese counterparts (RR= 1.28, *P*= 0.018) [39]. In a study by Bercik et al., humerus fractures were found to be associated with a relatively high mortality rate (11.96%) which the authors attributed to the association with a high energy mechanism and close proximity to the vital structures of the head and thorax [41].

In the subset analysis of obese and nonobese trauma patients with operatively versus non-operatively treated fractures, varying results were observed in regards to the outcomes of interest. Obese patients who were treated operatively had significantly greater likelihood of hospital lengths of stay ≥4 days and ICU admissions ≥5 days compared to their nonobese counterparts. One reason for these longer stays could have been the need for preoperative optimization given the higher rates of medical comorbidities observed in obese individuals [42]. In the study by Childs, et al. they found that regardless of injury severity or concomitant injuries, obese patients experienced longer delays to surgery for definitive fixation when compared to nonobese patients. These delays were primarily a result of surgeon preference and the authors conjectured that surgeons likely chose to defer these technically challenging and longer surgeries until sufficient time and skilled personnel were available [6]. More specifically, obesity can pose significant challenges during surgery in terms of operating room table selection, choice of anesthesia, patient positioning, intraoperative imaging, achieving reduction and selection of implant [42-45]. Postoperativley, obese patients may have required longer admissions to the ICU if they had significant comorbidities or related injuries or required mechanical ventilation after surgery. Previous work has demonstrated that obese trauma patients require longer mechanical ventilation times and ICU stays than nonobese patients [6,13,24,46]. This has been attributed to a diminished respiratory reserve and an increased risk of respiratory failure [46].

For the minority of obese patients sustaining fractures treated non-operatively (32.6%), these patients were more likely to be admitted to the ICU, without an associated increase in length of stay. As with patients receiving operative treatment, these patients likely had more significant medical comorbidities which warranted admission to the ICU and also potentially made them poor surgical candidates. It is also possible that they sustained non-displaced or minimally displaced fractures for which non-operative treatment was preferred. Finally, it is possible that some patients died prior to surgery, thus having shorter stays. Interestingly within this subset of patients who received both operative and non-operative treatment after 2011, obesity was no longer associated with increased mortality (aOR= 1.04, CI: 0.64 to 1.70). While the reason for this is unclear, this change may indicate an increasing awareness of the poor outcomes associated with obese trauma patients, resulting in an increased vigilance and closer management over this 14 year time period.

Limitations

Several limitations should be noted in the present study. By utilizing a diagnosis of obesity from the trauma registry data, we may have failed to identify all of the obese patients (BMI≥ 30kg/m²) in the study population. Only 7.3% of our study cohort was considered obese, which is well below the prevalence of obesity in our state during the time period investigated (20.6%–32.6%) [47]. However, the most likely consequence of missing patients with obesity is attenuation of the observed results. To confirm the validity of recorded obesity, an analysis was conducted

utilizing weight and height measurements from the EMR to calculate body mass index (BMI= kilogram/meters²) for the subset of 938 patients who had complete data available. High concordance (99.0%) was observed between calculated and diagnosed comorbid obesity within this cohort, providing us with confidence in the accuracy of the diagnosis. Furthermore, obesity is typically further stratified into multiple categories based on BMI: severe obesity (BMI≥ 35 to 40kg/m²), morbid obesity (BMI≥ 40 to 45kg/m²), and super obesity (BMI of ≥45 to 50kg/m²). While previous research has demonstrated that increasing BMI is associated with greater complications and worse perioperative outcomes [6,30], this study design based on a diagnosed comorbidity did not allow for such an analysis to be conducted. Additionally, the nonobese cohort in this study did not exclude underweight trauma patients (BMI<18.5), who have also been shown to have inferior outcomes as well [4,48,49]. Thus, this may have minimized the differences observed in outcomes between obese and nonobese patients. Finally, utilizing our institution's trauma registry allowed us to evaluate the outcomes of a very large patient population, but also limited the number of outcomes that could be investigated.

Conclusion

The growing epidemic of obesity has profound implications for the care of orthopaedic trauma patients. This study provides further evidence demonstrating inferior outcomes associated with this challenging population and highlights the need for continued research on optimization of care of obese patients. Orthopaedic surgeons must be aware of the potential complications associated with obesity and have strategies in place to avoid and judiciously manage these complications should they arise. Furthermore, as our healthcare system transitions to a bundled payment format, it is imperative for orthopaedic surgeons to understand the impact that non-modifiable risk factors portend in optimizing patient care in the acute fracture care setting. By better understanding the risks related to obesity and its associated comorbidities, treatment strategies can be tailored to patients with the goal of improving outcomes and minimizing healthcare cost.

Conflicts of interest

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