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Obesity Increases Early Complications After High-Energy Pelvic and Acetabular Fractures

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Orthopedics

October 2015 - Volume 38 · Issue 10: e881-e887

Posted October 14, 2015

DOI: 10.3928/01477447-20151002-54

Abstract

Elevated body mass index has been identified as a potential risk factor for complications in operatively treated pelvic trauma. Although obesity is an independent risk factor for morbidity and mortality following high-energy blunt force trauma, there is little information on the immediate complications following isolated pelvic and acetabular fractures in obese patients with trauma. The authors hypothesized that obesity (body mass index ≥30 kg/m^2) is a risk factor for complications in both operative and nonoperative pelvic and acetabular fractures. The authors conducted a 5-year retrospective data collection of all patients with isolated pelvic and acetabular fractures presenting to a Level I trauma center, excluding pediatric (age <18 years) patients, those with ballistic injuries, and those with concomitant long bone fractures or an Abbreviated Injury Scale score of greater than 2 in any other body region. Complications during the immediate hospitalization period were identified by the institution's Trauma Registry of the American College of Surgeons database, including wound infection, dehiscence, deep venous thrombosis, pulmonary embolus, pneumonia, and development of decubitus ulcers. Mean body mass index was 27.4±6.8 kg/m^2, with 68 (27.0%) obese patients. Mean body mass index of patients with complications was significantly higher (31.9±9.5 vs 27.0±6.5 kg/m^2; P=.001). Logistic regression showed that obesity was a significant risk factor for complications (odds ratio, 2.87; 95% confidence interval, 1.02–8.04), after adjusting for age (odds ratio, 1.03; 95% confidence interval, 1.01–1.06) and Injury Severity Score (odds ratio, 1.20; 95% confidence interval, 1.10–1.32). Obesity is associated with increasing complications following operative fixation of pelvic and acetabular fractures. However, it is important to recognize that even nonoperative management of pelvic and acetabular fractures in obese patients can have early complications. This study showed a significant obesity-related risk of complications after trauma in both operative and nonoperative pelvic injuries. [*Orthopedics.* 2015; 38(10):e881–e887.]

Obesity is a growing problem in the United States. Nearly 34% of adults are obese, with the incidence of obesity increasing 24% between 2000 and 2005.[1–3] Obesity is an independent risk factor for morbidity and mortality after high-energy blunt force trauma.[4–8] Obese patients have higher rates of pulmonary and renal complications and increased ventilator dependence.[8] These patients also have a twofold increase in urinary tract and bloodstream infections, a sevenfold increase in mortality during the immediate hospitalization period, and longer hospital and intensive care unit length of stay.[4,7,9]

Few data are available on immediate complications after isolated pelvic and acetabular fractures in obese patients with traumatic injuries. Although previous studies focused on postoperative complications,[10–13] few studies in the current literature have addressed potential complications during acute hospitalization in patients treated nonoperatively after pelvic or acetabular trauma. Based on the known effect of body mass index on morbidity and mortality after blunt trauma, the authors hypothesized that obesity is an independent risk factor for early complications in both operative and nonoperative pelvic and acetabular fractures.

Materials and Methods

The authors performed a retrospective cohort study of all patients who presented to a single Level I trauma center with pelvic or acetabular fractures classified as Orthopaedic Trauma Association[14] type 61 or 62, respectively, over a 5-year period. Patients were identified from the institution's Trauma Registry of the American College of Surgeons (TRACS) database. Demographic data, Injury Severity Score,[15] duration of mechanical ventilation, hospital length of stay, and data on complications were collected from the registry. To best identify patients with isolated pelvic and acetabular trauma, exclusion criteria consisted of significant concomitant injuries to other body systems, as indicated by an Abbreviated Injury Scale score of greater than 2, as shown in previous literature on pelvic and acetabular fractures.[16] Complete inclusion and exclusion criteria are shown in **Table 1**. Institutional review board approval was obtained before initiation of the study.

Table 1

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Fracture of the bony pelvis or acetabulum	Abbreviated Injury Scale score >2
Skeletally mature	Long bone fracture[a]
Complete body mass index data	Ballistic injuries
	Pediatric fractures
	Avulsion injuries

[a]*Fracture of the humerus, radius and ulna, femur, or tibia.*

Table 1: Inclusion and Exclusion Criteria

Body mass index was calculated from data obtained as part of the initial trauma admission history and physical examination. In most cases, data represented patient-reported values. Obesity was described and quantified by body mass index, defined as weight (kilograms) divided by the square of height (meters), greater than or equal to 30 kg/m^2.[1,17]

Review of diagnostic imaging studies was supervised by a fellowship-trained orthopedic trauma surgeon (P.J.K.) with more than 15 years of experience, who served as the institution's senior pelvic and acetabular surgeon. Images included admission anteroposterior, inlet, and outlet views of the pelvis for patients with pelvic ring injuries and anteroposterior, iliac oblique, and obturator oblique images for patients with fractures of the acetabulum. Computed tomography (CT) scans of the pelvis were cross-referenced when fracture patterns were not clearly shown on radiographs. Fractures were categorized as pelvic, acetabular, or combined pelvic and acetabular fractures. Pelvic fractures were further delineated based on the classification system developed by Pennal and further modified by Burgess et al.[18] Acetabular fractures were further classified according to the system described by Letournel et al.[19] Fractures that underwent operative fixation were documented from review of the patient's medical record. All fractures were evaluated by fellowship-trained orthopedic trauma surgeons, and the need for operative intervention was determined at the discretion of the treating surgeon after clinical and radiologic examination and discussion with the patient or surrogate. Subsequently, postfracture mobilization instructions were at the discretion of the treating surgeon and were based on fracture stability. Throughout the study period, the orthopedic trauma service protocol was that all patients with a fracture of the pelvis or acetabulum received anticoagulation chemical prophylaxis with low–molecular-weight heparin. For patients who underwent operative fixation for fracture stabilization, this regimen was discontinued on the morning of surgical intervention and resumed on postoperative day 1. Mechanical prophylaxis with a sequential compression device was used when patients were not treated with chemical anticoagulation.

The primary outcome variable of inhospital complications identified in the TRACS database was characterized as an event that deviated from the anticipated uneventful recovery from illness or surgery. To identify potential events that complicate the general care of patients with pelvic and acetabular injuries and that are not limited to operative intervention (ie, surgical site infection, wound dehiscence, and incidence of reoperation), specific complications that were noted in the final study analysis included deep venous thrombosis, pulmonary embolism, pneumonia, respiratory failure, cardiac arrhythmia, and death. Deep venous thrombosis was diagnosed by duplex ultrasonography in patients with clinical suspicion. Duplex scanning was not routinely performed unless it was clinically warranted. A diagnosis of pulmonary embolism was determined by a combination of clinical suspicion and confirmation with radiologic imaging. During the early study period of data collection, this was achieved with a ventilation-perfusion scan and later with a spiral CT scan. Pneumonia was recorded in patients with documented fever, leukocytosis, and radiologic evidence (either chest radiograph or CT) of pulmonary consolidation. Respiratory failure was recorded in patients with prolonged (>24 hours) mechanical ventilation. Significant cardiac arrhythmia was recorded in patients with the need for intravenous infusion of anti-arrhythmic medication, in conjunction with cardiology consultation, for control of heart rate and rhythm.

Subgroup analysis of patients who were treated operatively for pelvic or acetabular fractures was also performed to determine the rate of operative complications, consistent with previous reports.[12,13] Recorded outcome events in the acute postoperative period included superficial wound dehiscence, deep infection, pneumonia, thromboembolic disorders, development of decubitus ulcers, and death. Wound complications that required only treatment with antibiotics and wounds in which the deep fascia was intact at the time of repeat surgical irrigation and debridement were considered superficial. Infections in which the fascia was not intact at the time of the secondary procedure were considered deep.

Descriptive statistics were used to summarize all study variables and determine distribution with respect to the primary outcome of in-hospital complications. Results for continuous variables were reported as mean±SD, and dichotomous variables were represented as a percentage of frequency. Body mass index was considered as a continuous variable. Additionally, obesity (body mass index ≥30 kg/m^2) was evaluated separately as a dichotomous variable, as shown in previous studies of pelvic and acetabular fractures. Patients with body mass index of less than 30 kg/m^2 were considered non-obese. Further analysis of obese patients was performed to evaluate for patients considered morbidly obese (body mass index ≥40 kg/m^2). Parametric continuous variables were evaluated with Student's *t* test, and nonparametric variables were analyzed with the Mann-Whitney *U* test. Dichotomous variables were tested with the chi-square test or Fisher's exact test when indicated. A multivariable logistic regression model was used to evaluate the effect of obesity on the primary outcome, after adjusting for age and Injury Severity Score. Results were reported as an odds ratio with 95% confidence interval. Statistical analysis was performed with Stata version 11.0 software (Stata Corp, College Station, Texas). Significance was defined as $P<.05$.

Results

During the study period, 14,906 trauma admissions occurred. A total of 382 patients who met the study criteria were identified from the trauma registry. Complete radiographic and body mass index findings were available for 244 of 382 patients (63.9%). Average age was 38.6±17.3 years, and 170 of 244 patients (69.7%) were men. Mean Injury Severity Score was 12.8±4.4, and motor vehicle collision was the most common mechanism of injury (185 of 244, 75.8%), with falls from greater than a standing height (38 of 244, 20.1%) and "other" (4 of 244, 1.7%) describing the remaining study population. Average body mass index for the entire population was 27.4±6.8 kg/m^2 (range, 17–52 kg/m^2), and 69 of 244 patients (28.3%) were considered obese. Evaluation of the obese population identified 18 patients with body mass index of 40 kg/m^2 or greater.

Isolated pelvic fractures were identified in 95 of 244 patients (38.9%). Isolated acetabular fractures were documented in 118 of 244 patients (48.4%). Of the study population, 31 of 244 patients (12.7%) had combined pelvic and acetabular fractures. There was no difference in the distribution of pelvic, acetabular, and combined pelvic and acetabular fractures in the obese and nonobese cohorts (**Table 2**). In patients with combined pelvic and acetabular injuries, open book fractures (anterior-posterior compression types 2 and 3) were the most common pelvic fractures (6 of 31, 19.4%), and a transverse-type fracture was the most common acetabular injury (15 of 31, 48.4%). Operative fixation was performed in 142 of 244 patients (58.2%). Isolated acetabular fractures and combined pelvic and acetabular fractures were more likely to undergo surgical intervention than isolated pelvic fractures (91 of 118, 76.9% vs 23 of 31, 74.2% vs 28 of 95, 30.2%; $P<.001$). There was no difference in operative interventions in obese and nonobese patients (**Table 2**). Patients with body mass index of 30 kg/m^2 or greater had a significantly longer hospital length of stay compared with nonobese patients (5.7±2.9 vs 4.4±2.5 days; $P=.001$).

Table 2

Demographic and Injury-Related Variables			
Variable	**Obese (n=69)**	**Nonobese (n=175)**	***P***
Age, mean (SD), y	40.5 (15.4)	37.9 (18.1)	.11
Male, No. (%)	47 (68.1)	123 (70.3)	.74
Injury Severity Score, mean (SD)	12.6 (3.8)	12.9 (4.6)	.9
Body mass index, average (SD), kg/m^2	36.2 (6.0)	23.9 (2.7)	<.0001
Fracture, No. (%)			.06
Isolated pelvic	19 (27.5)	76 (43.4)	
Isolated acetabular	41 (59.4)	77 (44.0)	
Combined pelvic and acetabular	9 (13.0)	22 (12.6)	
Operative fixation, No. (%)	46 (66.7)	96 (54.9)	.09
Duration of mechanical ventilation, mean (SD), d	0.3 (1.4)	0.2 (0.8)	.87
Hospital length of stay, mean (SD), d	5.7 (2.9)	4.4 (2.5)	.001

Table 2: Demographic and Injury-Related Variables

Complications were recorded in 19 of 244 patients (7.8%). Specific complications are shown in **Table 3**. Two patients died during hospitalization. Deep venous thrombosis was diagnosed in 3 patients who underwent surgical intervention. All 3 patients, 2 with pelvic fractures and 1 with acetabular fracture, were treated with operative fixation. Two of these patients received an inferior vena cava filter before fixation because the thrombosis was identified preoperatively. All 3 patients had appropriate long-term oral anticoagulation after hospital discharge. Significant cardiac arrhythmias, consisting of atrial fibrillation with rapid ventricular response, were identified in 2 patients. Finally, 3 obese patients had pulmonary complications consisting of pneumonia and respiratory failure. Complications in obese patients are shown in **Table 4**.

Table 3

Complications

Complication	No. (%) Obese (n=69)	Nonobese (n=175)	*P*
Any	9 (13.0)	10 (5.7)	.05
Deep venous thrombosis	3 (4.4)	5 (2.9)	NS
Pulmonary embolism	0 (0)	0 (0)	NS
Pneumonia	2 (2.9)	4 (2.3)	NS
Respiratory failure	3 (4.4)	2 (1.1)	NS
Cardiac arrhythmia	2 (2.9)	1 (0.6)	NS
Death	1 (1.5)	1 (0.57)	NS

Abbreviation: NS, not significant.

Table 3: Complications

Table 4

Complications in Obese Patients

Patient No./Age, y	BMI, kg/m^2	Complications	Treatment Group	LOS, d	Discharge Disposition
1/68	36	Deep venous thrombosis	Operative	8	Skilled nursing facility
2/42	31	Atrial fibrillation	Nonoperative	9	Home
3/24	45	Respiratory failure	Operative	5	Home
4/73	44	Respiratory failure	Nonoperative	10	Rehabilitation
5/19	44	Deep venous thrombosis	Operative	7	Rehabilitation
6/47	42	Respiratory failure, pneumonia, sepsis, wound infection	Operative	11	Skilled nursing facility
7/67	30	Atelectasis, pneumonia	Nonoperative	4	Rehabilitation
8/58	38	Atrial fibrillation	Operative	9	Rehabilitation
9/45	34	Respiratory failure, acute respiratory distress syndrome, death	Operative	18	Death

Abbreviations: BMI, body mass index; LOS, length of stay.

Table 4: Complications in Obese Patients

There were no differences in the rate of complications in fractures managed operatively vs nonoperatively (11 of 142, 7.7% vs 8 of 102, 7.8%; *P*=.98). The incidence of complications in pelvic, acetabular, and combined pelvic and acetabular fractures was similar (**Table 5**). Patients with complications had injuries of greater severity, as determined by the Injury Severity Score (15.9±5.5 vs 12.6±4.2; *P*=.001), were significantly older (48.4±21.7 vs 37.8±16.8 years; *P*=.04), and had a significantly greater body mass index (31.1±8.1 vs 27.1±6.6 kg/m^2; *P*=.03) than patients without complications. In addition, complications were more frequent in obese patients (9 of 69, 13.0% vs 10 of 175, 5.7%; *P*=.05). Further analysis of obese patients showed that morbid obesity (body mass index ≥40 kg/m^2) led to complications in 4 of 18 patients (22.2%). The difference in complication rates among patients with a body mass index of less than 30 kg/m^2, 30 to 39 kg/m^2, and 40 kg/m^2 or greater was statistically significant (10 of 176, 5.7% vs 5 of 50, 10.0% vs 4 of 18, 22.2%; *P*=.03). A multivariable logistic regression model, adjusting for potential confounding variables, showed that obesity was a significant independent risk factor for complications after injury (odds ratio, 2.82; 95% confidence interval, 1.03–7.72), after adjusting for age (odds ratio, 1.03; 95% confidence interval, 1.00–1.06) and Injury Severity Score (odds ratio, 1.13; 95% confidence interval, 1.04–1.24).

Table 5

Demographic and Injury Characteristics by Complication

Characteristic	Complication (n=19)	No Complication (n=225)	*P*
Age, mean (SD), y	48.4 (21.4)	37.8 (16.8)	.04
Male, No. (%)	14 (73.7)	156 (69.3)	NS
Fracture, No. (%)			NS
Pelvic	5 (26.3)	90 (40.0)	
Acetabular	11 (57.9)	107 (47.6)	
Combined pelvic and acetabular	3 (15.8)	28 (12.4)	
Injury Severity Score, mean (SD)	15.9 (5.5)	12.6 (4.2)	.001
Operative fixation, No. (%)	11 (57.9)	131 (58.2)	NS
Body mass index, mean (SD), kg/m^2	31.1 (8.1)	27.1 (6.6)	.03
Body mass index ≥30 kg/m^2, No. (%)	9 (47.4)	60 (26.7)	.05

Abbreviation: NS, not significant.

Table 5: Demographic and Injury Characteristics by Complication

Subgroup analysis of the 142 patients treated operatively showed complications in 13 patients (9.2%). There was no difference in the rate of complications in patients with pelvic or acetabular fractures (4 of 30, 13.3% vs 9 of 112, 8.0%; *P*=.37) or in patients with combined pelvic and acetabular fractures (3 of 22, 13.6% vs 10 of 120, 8.3%; *P*=.43). Injury Severity Score (15.7±5.5 vs 12.1±3.4; *P*=.008) and body mass index (35.0±9.1 vs 27.5±6.5 kg/m^2; *P*=.006) were significantly greater in operatively treated patients who had a complication; however, there was no difference in age (43.9±18.8 vs 12.1±3.4; *P*=.16). The rate of postoperative complications in obese patients was significantly greater than that in nonobese patients (9 of 45, 20.0% vs 4 of 97, 4.1%; *P*=.002). Further stratification of operatively treated patients by nonobese, obese, and morbidly obese showed a significantly increasing rate of complications, respectively (4 of 97, 4.1% vs 4 of 32, 12.5% vs 5 of 13, 38.5%; *P*=.0001).

Discussion

Obesity in the United States has grown to nearly epidemic proportions, and obese patients pose many challenges to the treating physician and the trauma care team.[6,8,20] Obese patients have increased morbidity and mortality, longer hospital length of stay, and increased postoperative complications.[4–8] Few studies have investigated the effect of body mass index on hospitalization immediately after trauma in patients treated nonoperatively. This study evaluated the relationship of body mass index and early complications in patients treated operatively and nonoperatively for high-energy pelvic and acetabular fractures. Body mass index was associated with complications after operative and nonoperative treatment. Further, the authors found that obesity was a significant independent risk factor for early complications, even in fractures treated nonoperatively, after adjusting for potential confounding variables.

Preexisting comorbidities and altered physiology present numerous challenges in the management of obese patients.[21] These challenges are magnified when combined with traumatic injury, resulting in increased complications and mortality.[4,6,8] Medical comorbidities in obese patients may include coronary artery disease, hyperlipidemia, type 2 diabetes, stroke, sleep apnea, and hypertension. Such conditions in these patients contribute to an increased risk of pulmonary and cardiovascular complications, including hypoventilation syndrome, acute myocardial ischemia, and congestive heart failure.[21]

There are known complications of operative fixation of pelvic and acetabular fractures in obese patients. Karunakar et al[10] showed that obese patients were significantly more likely to have deep venous thrombosis, wound infections, and estimated blood loss of greater than 750 mL after open reduction and internal fixation of acetabular fractures. These results were confirmed in subsequent studies of acetabular injuries.[12] Recent findings also showed that obese patients with pelvic fractures were at greater risk for complications (including wound infection, loss of fixation, deep venous thrombosis, pulmonary embolism, decubitus ulcer, and iatrogenic nerve injury) and were more likely to undergo reoperation after operative fixation of pelvic ring injuries.[13]

Postoperatively, obese patients have an increased risk of myocardial infarction and cardiac arrest, wound infection, peripheral nerve injury, urinary tract infection, atelectasis, pneumonia, and symptomatic deep venous thrombus or pulmonary embolism.[22–24] Obesity is an independent risk factor for perioperative morbidity, and morbid obesity is a risk factor for postoperative mortality.[23]

This study included a large database of pelvic and acetabular fractures and addressed complications occurring in both operative and nonoperative patients. In the authors' final analysis of operatively and nonoperatively treated fractures, complications were defined as those that can occur with or without surgical intervention. The authors did not include complications limited to operative intervention that were addressed by others, including superficial and deep infections, operative blood loss, intraoperative nerve injuries, return to the operating room, and hardware failure.[10–13] Subgroup analysis of surgically treated fractures showed that obesity and morbid obesity were associated with certain perioperative complications, in agreement with the results of previous studies.[13] A limited number of complications in the operative intervention group precluded a multivariable regression model adjusting for injury severity in the subgroup analysis. Further, previous studies in the orthopedic literature did not address the potential confounding effect of injury severity and advanced age on the risk of complications after trauma in patients with pelvic or acetabular injuries. Although Injury Severity Score and older age are risk factors for complications, obesity was the most significant independent risk factor in both operatively and nonoperatively treated fractures.

Limitations

Several limitations of this study must be considered. A retrospective evaluation conducted at a single institution contains inherent bias. An error in retrospective calculation of patient-reported height and weight includes the potential for under-reporting the prevalence of obesity and morbid obesity.[25] Geographic location and patient demographics vary accordingly. The current study reported a prevalence of obesity and morbid obesity of 28.3% and 7.4%, respectively. These figures closely resemble data for the US adult population.[1,2] Although the sample size of obese patients and the relatively low number of complications in this study are limitations, they have been noted and discussed in other reports on the relationship of body mass index and potential complications.[7] Caution should be exercised with interpretation of the final multivariable regression model. Further, given the retrospective nature of the study, the authors cannot provide definitive criteria for the final determination of operative vs nonoperative treatment for each patient because treatment decisions were based on the discretion of the treating fellowship-trained orthopedic trauma surgeon.

Conclusion

Obesity and morbid obesity are associated with increasing complications after operative fixation of pelvic and acetabular fractures. However, even nonoperative management of pelvic and acetabular fractures in obese patients can be accompanied by early complications. This study showed that obesity is a significant independent risk factor for complications after pelvic and acetabular trauma, even after controlling for age and Injury Severity Score. Although the authors did not provide recommendations for which fracture patterns require surgical fixation, the study findings suggest that obese patients with pelvic injuries are at risk for significant complications. The risk should be carefully communicated among the treating orthopedic surgeon, the trauma team, and the patient or patient's family. Future studies are necessary to further delineate the ever-increasing prevalence of obesity and subsequent challenges in the management of pelvic and acetabular fractures in these patients.

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The authors have no relevant financial relationships to disclose.

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Received: January 26, 2014
Accepted: February 13, 2015
10.3928/01477447-20151002-54

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Abstract

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Elevated body mass index has been identified as a potential risk factor for complications in operatively treated pelvic trauma. Although obesity is an independent risk factor for morbidity and mortality following high-energy blunt force trauma, there is little information on the immediate complications following isolated pelvic and acetabular fractures in obese patients with trauma. The authors hypothesized that obesity (body mass index ≥30 kg/m^2) is a risk factor for complications in both operative and nonoperative pelvic and acetabular fractures. The authors conducted a 5-year retrospective data collection of all patients with isolated pelvic and acetabular fractures presenting to a Level I trauma center, excluding pediatric (age <18 years) patients, those with ballistic injuries, and those with concomitant long bone fractures or an Abbreviated

Injury Scale score of greater than 2 in any other body region. Complications during the immediate hospitalization period were identified by the institution's Trauma Registry of the American College of Surgeons database, including wound infection, dehiscence, deep venous thrombosis, pulmonary embolus, pneumonia, and development of decubitus ulcers. Mean body mass index was 27.4±6.8 kg/m^2, with 68 (27.0%) obese patients. Mean body mass index of patients with complications was significantly higher (31.9±9.5 vs 27.0±6.5 kg/m^2; P=.001). Logistic regression showed that obesity was a significant risk factor for complications (odds ratio, 2.87; 95% confidence interval, 1.02–8.04), after adjusting for age (odds ratio, 1.03; 95% confidence interval, 1.01–1.06) and Injury Severity Score (odds ratio, 1.20; 95% confidence interval, 1.10–1.32). Obesity is associated with increasing complications following operative fixation of pelvic and acetabular fractures. However, it is important to recognize that even nonoperative management of pelvic and acetabular fractures in obese patients can have early complications. This study showed a significant obesity-related risk of complications after trauma in both operative and nonoperative pelvic injuries. [*Orthopedics.* 2015; 38(10):e881–e887.]

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Received: January 26, 2014
Accepted: February 13, 2015

Obesity is a growing problem in the United States. Nearly 34% of adults are obese, with the incidence of obesity increasing 24% between 2000 and 2005.[1–3] Obesity is an independent risk factor for morbidity and mortality after high-energy blunt force trauma.[4–8] Obese patients have higher rates of pulmonary and renal complications and increased ventilator dependence.[8] These patients also have a twofold increase in urinary tract and bloodstream infections, a sevenfold increase in mortality during the immediate hospitalization period, and longer hospital and intensive care unit length of stay.[4,7,9]

Few data are available on immediate complications after isolated pelvic and acetabular fractures in obese patients with traumatic injuries. Although previous studies focused on postoperative complications,[10–13] few studies in the current literature have addressed potential complications during acute hospitalization in patients treated nonoperatively after pelvic or acetabular trauma. Based on the known effect of body mass index on morbidity and mortality after blunt trauma, the authors hypothesized that obesity is an independent risk factor for early complications in both operative and nonoperative pelvic and acetabular fractures.

Materials and Methods

The authors performed a retrospective cohort study of all patients who presented to a single Level I trauma center with pelvic or acetabular fractures classified as Orthopaedic Trauma Association[14] type 61 or 62, respectively, over a 5-year period. Patients were identified from the institution's Trauma Registry of the American College of Surgeons (TRACS) database. Demographic data, Injury Severity Score,[15] duration of mechanical ventilation, hospital length of stay, and data on complications were collected from the registry. To best identify patients with isolated pelvic and acetabular trauma, exclusion criteria consisted of significant concomitant injuries to other body systems, as indicated by an Abbreviated Injury Scale score of greater than 2, as shown in previous literature on pelvic and acetabular fractures.[16] Complete inclusion and exclusion criteria are shown in **Table 1**. Institutional review board approval was obtained before initiation of the study.

Table 1

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Fracture of the bony pelvis or acetabulum	Abbreviated Injury Scale score >2
Skeletally mature	Long bone fracture[a]
Complete body mass index data	Ballistic injuries
	Pediatric fractures
	Avulsion injuries

[a]*Fracture of the humerus, radius and ulna, femur, or tibia.*

Table 1: Inclusion and Exclusion Criteria

Body mass index was calculated from data obtained as part of the initial trauma admission history and physical examination. In most cases, data represented patient-reported values. Obesity was described and quantified by body mass index, defined as weight (kilograms) divided by the square of height (meters), greater than or equal to 30 kg/m^2.[1,17]

Review of diagnostic imaging studies was supervised by a fellowship-trained orthopedic trauma surgeon (P.J.K.) with more than 15 years of experience, who served as the institution's senior pelvic and acetabular surgeon. Images included admission anteroposterior, inlet, and outlet views of the pelvis for patients with pelvic ring injuries and anteroposterior, iliac oblique, and obturator oblique images for patients with fractures of the acetabulum. Computed tomography (CT) scans of the pelvis were cross-referenced when fracture patterns were not clearly shown on radiographs. Fractures were categorized as pelvic, acetabular, or combined pelvic and acetabular fractures. Pelvic fractures were further delineated based on the classification system developed by Pennal and further modified by Burgess et al.[18] Acetabular fractures were further classified according to the system described by Letournel et al.[19] Fractures that underwent operative fixation were documented from review of the patient's medical record. All fractures were evaluated by fellowship-trained orthopedic trauma surgeons, and the need for operative intervention was determined at the discretion of the treating surgeon after clinical and radiologic examination and discussion with the patient or surrogate. Subsequently, postfracture mobilization instructions were at the discretion of the treating surgeon and were based on fracture stability. Throughout the study period, the orthopedic trauma service protocol was that all patients with a fracture of the pelvis or acetabulum received anticoagulation chemical prophylaxis with low–molecular-weight heparin. For patients who underwent operative fixation for fracture stabilization, this regimen was discontinued on the morning of surgical intervention and resumed on postoperative day 1. Mechanical prophylaxis with a sequential compression device was used when patients were not treated with chemical anticoagulation.

The primary outcome variable of inhospital complications identified in the TRACS database was characterized as an event that deviated from the anticipated uneventful recovery from illness or surgery. To identify potential events that complicate the general care of patients with pelvic and acetabular injuries and that are not limited to operative intervention (ie, surgical site infection, wound dehiscence, and incidence of reoperation), specific complications that were noted in the final study analysis included deep venous thrombosis, pulmonary embolism, pneumonia, respiratory failure, cardiac arrhythmia, and death. Deep venous thrombosis was diagnosed by duplex ultrasonography in patients with clinical suspicion. Duplex scanning was not routinely performed unless it was clinically warranted. A diagnosis of pulmonary embolism was determined by a combination of clinical suspicion and confirmation with radiologic imaging. During the early study period of data collection, this was achieved with a ventilation-perfusion scan and later with a spiral CT scan. Pneumonia was recorded in patients with documented fever, leukocytosis, and radiologic evidence (either chest radiograph or CT) of pulmonary consolidation. Respiratory failure was recorded in patients with prolonged (>24 hours) mechanical ventilation. Significant cardiac arrhythmia was recorded in patients with the need for intravenous infusion of anti-arrhythmic medication, in conjunction with cardiology consultation, for control of heart rate and rhythm.

Subgroup analysis of patients who were treated operatively for pelvic or acetabular fractures was also performed to determine the rate of operative complications, consistent with previous reports.[12,13] Recorded outcome events in the acute postoperative period included superficial wound dehiscence, deep infection, pneumonia, thromboembolic disorders, development of decubitus ulcers, and death. Wound complications that required only treatment with antibiotics and wounds in which the deep fascia was intact at the time of repeat surgical irrigation and debridement were considered superficial. Infections in which the fascia was not intact at the time of the secondary procedure were considered deep.

Descriptive statistics were used to summarize all study variables and determine distribution with respect to the primary outcome of in-hospital complications. Results for continuous variables were reported as mean±SD, and dichotomous variables were represented as a percentage of frequency. Body mass index was considered as a continuous variable. Additionally, obesity (body mass index ≥30 kg/m^2) was evaluated separately as a dichotomous variable, as shown in previous studies of pelvic and acetabular fractures. Patients with body mass index of less than 30 kg/m^2 were considered non-obese. Further analysis of obese patients was performed to evaluate for patients considered morbidly obese (body mass index ≥40 kg/m^2). Parametric continuous variables were evaluated with Student's *t* test, and nonparametric variables were analyzed with the Mann-Whitney *U* test. Dichotomous variables were tested with the chi-square test or Fisher's exact test when indicated. A multivariable logistic regression model was used to evaluate the effect of obesity on the primary outcome, after adjusting for age and Injury Severity Score. Results were reported as an odds ratio with 95% confidence interval. Statistical analysis was performed with Stata version 11.0 software (Stata Corp, College Station, Texas). Significance was defined as $P<.05$.

Results

During the study period, 14,906 trauma admissions occurred. A total of 382 patients who met the study criteria were identified from the trauma registry. Complete radiographic and body mass index findings were available for 244 of 382 patients (63.9%). Average age was 38.6±17.3 years, and 170 of 244 patients (69.7%) were men. Mean Injury Severity Score was 12.8±4.4, and motor vehicle collision was the most common mechanism of injury (185 of 244, 75.8%), with falls from greater than a standing height (38 of 244, 20.1%) and "other" (4 of 244, 1.7%) describing the remaining study population. Average body mass index for the entire population was 27.4±6.8 kg/m^2 (range, 17–52 kg/m^2), and 69 of 244 patients (28.3%) were considered obese. Evaluation of the obese population identified 18 patients with body mass index of 40 kg/m^2 or greater.

Isolated pelvic fractures were identified in 95 of 244 patients (38.9%). Isolated acetabular fractures were documented in 118 of 244 patients (48.4%). Of the study population, 31 of 244 patients (12.7%) had combined pelvic and acetabular fractures. There was no difference in the distribution of pelvic, acetabular, and combined pelvic and acetabular fractures in the obese and nonobese cohorts (**Table 2**). In patients with combined pelvic and acetabular injuries, open book fractures (anterior-posterior compression types 2 and 3) were the most common pelvic fractures (6 of 31, 19.4%), and a transverse-type fracture was the most common acetabular injury (15 of 31, 48.4%). Operative fixation was performed in 142 of 244 patients (58.2%). Isolated acetabular fractures and combined pelvic and acetabular fractures were more likely to undergo surgical intervention than isolated pelvic fractures (91 of 118, 76.9% vs 23 of 31, 74.2% vs 28 of 95, 30.2%; P<.001). There was no difference in operative interventions in obese and nonobese patients (**Table 2**). Patients with body mass index of 30 kg/m^2 or greater had a significantly longer hospital length of stay compared with nonobese patients (5.7±2.9 vs 4.4±2.5 days; P=.001).

Table 2

Demographic and Injury-Related Variables

Variable	Obese (n=69)	Nonobese (n=175)	*P*
Age, mean (SD), y	40.5 (15.4)	37.9 (18.1)	.11
Male, No. (%)	47 (68.1)	123 (70.3)	.74
Injury Severity Score, mean (SD)	12.6 (3.8)	12.9 (4.6)	.9
Body mass index, average (SD), kg/m^2	36.2 (6.0)	23.9 (2.7)	<.0001
Fracture, No. (%)			.06
Isolated pelvic	19 (27.5)	76 (43.4)	
Isolated acetabular	41 (59.4)	77 (44.0)	
Combined pelvic and acetabular	9 (13.0)	22 (12.6)	
Operative fixation, No. (%)	46 (66.7)	96 (54.9)	.09
Duration of mechanical ventilation, mean (SD), d	0.3 (1.4)	0.2 (0.8)	.87
Hospital length of stay, mean (SD), d	5.7 (2.9)	4.4 (2.5)	.001

Table 2: Demographic and Injury-Related Variables

Complications were recorded in 19 of 244 patients (7.8%). Specific complications are shown in **Table 3**. Two patients died during hospitalization. Deep venous thrombosis was diagnosed in 3 patients who underwent surgical intervention. All 3 patients, 2 with pelvic fractures and 1 with acetabular fracture, were treated with operative fixation. Two of these patients received an inferior vena cava filter before fixation because the thrombosis was identified preoperatively. All 3 patients had appropriate long-term oral anticoagulation after hospital discharge.

Significant cardiac arrhythmias, consisting of atrial fibrillation with rapid ventricular response, were identified in 2 patients. Finally, 3 obese patients had pulmonary complications consisting of pneumonia and respiratory failure. Complications in obese patients are shown in **Table 4**.

Table 3

Complications

	No. (%)		
Complication	**Obese (n=69)**	**Nonobese (n=175)**	***P***
Any	9 (13.0)	10 (5.7)	.05
Deep venous thrombosis	3 (4.4)	5 (2.9)	NS
Pulmonary embolism	0 (0)	0 (0)	NS
Pneumonia	2 (2.9)	4 (2.3)	NS
Respiratory failure	3 (4.4)	2 (1.1)	NS
Cardiac arrhythmia	2 (2.9)	1 (0.6)	NS
Death	1 (1.5)	1 (0.57)	NS

Abbreviation: NS, not significant.

Table 3: Complications

Table 4:

Table 4

Complications in Obese Patients

Patient No./Age, y	BMI, kg/m^2	Complications	Treatment Group	LOS, d	Discharge Disposition
1/68	36	Deep venous thrombosis	Operative	8	Skilled nursing facility
2/42	31	Atrial fibrillation	Nonoperative	9	Home
3/24	45	Respiratory failure	Operative	5	Home
4/73	44	Respiratory failure	Nonoperative	10	Rehabilitation
5/19	44	Deep venous thrombosis	Operative	7	Rehabilitation
6/47	42	Respiratory failure, pneumonia, sepsis, wound infection	Operative	11	Skilled nursing facility
7/67	30	Atelectasis, pneumonia	Nonoperative	4	Rehabilitation
8/58	38	Atrial fibrillation	Operative	9	Rehabilitation
9/45	34	Respiratory failure, acute respiratory distress syndrome, death	Operative	18	Death

Abbreviations: BMI, body mass index; LOS, length of stay.

Complications in Obese Patients

There were no differences in the rate of complications in fractures managed operatively vs nonoperatively (11 of 142, 7.7% vs 8 of 102, 7.8%; *P*=.98). The incidence of complications in pelvic, acetabular, and combined pelvic and acetabular fractures was similar (**Table 5**). Patients with complications had injuries of greater severity, as determined by the Injury Severity Score (15.9±5.5 vs 12.6±4.2; *P*=.001), were significantly older (48.4±21.7 vs 37.8±16.8 years; *P*=.04), and had a significantly greater body mass index (31.1±8.1 vs 27.1±6.6 kg/m^2; *P*=.03) than patients without complications. In addition, complications were more frequent in obese patients (9 of 69, 13.0% vs 10 of 175, 5.7%; *P*=.05). Further analysis of obese patients showed that morbid obesity (body mass index ≥40 kg/m^2) led to complications in 4 of 18 patients (22.2%). The difference in complication rates among patients with a body mass index of less than 30 kg/m^2, 30 to 39 kg/m^2, and 40 kg/m^2 or greater was statistically significant (10 of 176, 5.7% vs 5 of 50, 10.0% vs 4 of 18, 22.2%; *P*=.03). A multivariable logistic regression model, adjusting for potential confounding variables, showed that obesity was a significant independent risk factor for complications after injury (odds ratio, 2.82; 95% confidence interval, 1.03–7.72), after adjusting for age (odds ratio, 1.03; 95% confidence interval, 1.00–1.06) and Injury Severity Score (odds ratio, 1.13; 95% confidence interval, 1.04–1.24).

Table 5

Demographic and Injury Characteristics by Complication

Characteristic	Complication (n=19)	No Complication (n=225)	*P*
Age, mean (SD), y	48.4 (21.4)	37.8 (16.8)	.04
Male, No. (%)	14 (73.7)	156 (69.3)	NS
Fracture, No. (%)			NS
Pelvic	5 (26.3)	90 (40.0)	
Acetabular	11 (57.9)	107 (47.6)	
Combined pelvic and acetabular	3 (15.8)	28 (12.4)	
Injury Severity Score, mean (SD)	15.9 (5.5)	12.6 (4.2)	.001
Operative fixation, No. (%)	11 (57.9)	131 (58.2)	NS
Body mass index, mean (SD), kg/m^2	31.1 (8.1)	27.1 (6.6)	.03
Body mass index ≥30 kg/m^2, No. (%)	9 (47.4)	60 (26.7)	.05

Abbreviation: NS, not significant.

Table 5: Demographic and Injury Characteristics by Complication

Subgroup analysis of the 142 patients treated operatively showed complications in 13 patients (9.2%). There was no difference in the rate of complications in patients with pelvic or acetabular fractures (4 of 30, 13.3% vs 9 of 112, 8.0%; *P*=.37) or in patients with combined pelvic and acetabular fractures (3 of 22, 13.6% vs 10 of 120, 8.3%; *P*=.43). Injury Severity Score (15.7±5.5 vs 12.1±3.4; *P*=.008) and body mass index (35.0±9.1 vs 27.5±6.5 kg/m^2; *P*=.006) were significantly greater in operatively treated patients who had a complication; however, there was no difference in age (43.9±18.8 vs 12.1±3.4; *P*=.16). The rate of postoperative complications in obese patients was significantly greater than that in nonobese patients (9 of 45, 20.0% vs 4 of 97, 4.1%; *P*=.002). Further stratification of operatively treated patients by nonobese, obese, and morbidly obese showed a significantly increasing rate of complications, respectively (4 of 97, 4.1% vs 4 of 32, 12.5% vs 5 of 13, 38.5%; *P*=.0001).

Discussion

Obesity in the United States has grown to nearly epidemic proportions, and obese patients pose many challenges to the treating physician and the trauma care team.[6,8,20] Obese patients have increased morbidity and mortality, longer hospital length of stay, and increased postoperative complications.[4–8] Few studies have investigated the effect of body mass index on hospitalization immediately after trauma in patients treated nonoperatively. This study evaluated the relationship of body mass index and early complications in patients treated operatively and nonoperatively for high-energy pelvic and acetabular fractures. Body mass index was associated with complications after operative and nonoperative treatment. Further, the authors found that obesity was a significant independent risk factor for early complications, even in fractures treated nonoperatively, after adjusting for potential confounding variables.

Preexisting comorbidities and altered physiology present numerous challenges in the management of obese patients.[21] These challenges are magnified when combined with traumatic injury, resulting in increased complications and mortality.[4,6,8] Medical comorbidities in obese patients may include coronary artery disease, hyperlipidemia, type 2 diabetes, stroke, sleep apnea, and hypertension. Such conditions in these patients contribute to an increased risk of pulmonary and cardiovascular complications, including hypoventilation syndrome, acute myocardial ischemia, and congestive heart failure.[21]

There are known complications of operative fixation of pelvic and acetabular fractures in obese patients. Karunakar et al[10] showed that obese patients were significantly more likely to have deep venous thrombosis, wound infections, and estimated blood loss of greater than 750 mL after open reduction and internal fixation of acetabular fractures. These results were confirmed in subsequent studies of acetabular injuries.[12] Recent findings also showed that obese patients with pelvic fractures were at greater risk for complications (including wound infection, loss of fixation, deep venous thrombosis, pulmonary embolism, decubitus ulcer, and iatrogenic nerve injury) and were more likely to undergo reoperation after operative fixation of pelvic ring injuries.[13]

Postoperatively, obese patients have an increased risk of myocardial infarction and cardiac arrest, wound infection, peripheral nerve injury, urinary tract infection, atelectasis, pneumonia, and symptomatic deep venous thrombus or pulmonary embolism.[22–24] Obesity is an independent risk factor for perioperative morbidity, and morbid obesity is a risk factor for postoperative mortality.[23]

This study included a large database of pelvic and acetabular fractures and addressed complications occurring in both operative and nonoperative patients. In the authors' final analysis of operatively and nonoperatively treated fractures, complications were defined as those that can occur with or without surgical intervention. The authors did not include complications limited to operative intervention that were addressed by others, including superficial and deep infections, operative blood loss, intraoperative nerve injuries, return to the operating room, and hardware failure.[10–13] Subgroup analysis of surgically treated fractures showed that obesity and morbid obesity were associated with certain perioperative complications, in agreement with the results of previous studies.[13] A limited number of complications in the operative intervention group precluded a multivariable regression model adjusting for injury severity in the subgroup analysis. Further, previous studies in the orthopedic literature did not address the potential confounding effect of injury severity and advanced age on the risk of complications after trauma in patients with pelvic or acetabular injuries. Although Injury Severity Score and older age are risk factors for complications, obesity was the most significant independent risk factor in both operatively and nonoperatively treated fractures.

Limitations

Several limitations of this study must be considered. A retrospective evaluation conducted at a single institution contains inherent bias. An error in retrospective calculation of patient-reported height and weight includes the potential for under-reporting the prevalence of obesity and morbid obesity.[25] Geographic location and patient demographics vary accordingly. The current study reported a prevalence of obesity and morbid obesity of 28.3% and 7.4%, respectively. These figures closely resemble data for the US adult population.[1,2] Although the sample size of obese patients and the relatively low number of complications in this study are limitations, they have been noted and discussed in other reports on the relationship of body mass index and potential complications.[7] Caution should be exercised with interpretation of the final multivariable regression model. Further, given the retrospective nature of the study, the authors cannot provide definitive criteria for the final determination of operative vs nonoperative treatment for each patient because treatment decisions were based on the discretion of the treating fellowship-trained orthopedic trauma surgeon.

Conclusion

Obesity and morbid obesity are associated with increasing complications after operative fixation of pelvic and acetabular fractures. However, even nonoperative management of pelvic and acetabular fractures in obese patients can be accompanied by early complications. This study showed that obesity is a significant independent risk factor for complications after pelvic and acetabular trauma, even after controlling for age and Injury Severity Score. Although the authors did not provide recommendations for which fracture patterns require surgical fixation, the study findings suggest that obese patients with pelvic injuries are at risk for significant complications. The risk should be carefully communicated among the treating orthopedic surgeon, the trauma team, and the patient or patient's family. Future studies are necessary to further delineate the ever-increasing prevalence of obesity and subsequent challenges in the management of pelvic and acetabular fractures in these patients.

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Received: January 26, 2014
Accepted: February 13, 2015

Figures/Tables

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