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Original Article

Perioperative and acute care outcomes in morbidly obese patients with acetabular fractures at a Level 1 trauma center

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ABSTRACT

Background: Controversy exists regarding obesity-related injury severity and clinical outcomes after orthopedic trauma.

Purpose: The purposes of this study were to expand our understanding of the effect of morbid obesity on perioperative and acute care outcomes after acetabular fracture.

Methods: This was a retrospective review of patients with acetabular fracture after trauma. Non-morbidly obese (BMI < 35 kg/m²) and morbidly obese (BMI ≥ 35 kg/m²; N = 81). Injury severity scores and Glasgow Coma Scale scores (GCS) were collected. Perioperative and acute care outcomes were positioning and operative time, extra fractures, estimated blood loss, complications, hospital charges, ventilator days, transfusions, length of stay (LOS) and discharge destination. Positioning and operative times were longer in morbidly obese patients ($p < 0.05$). No other differences existed between groups.

Conclusions: Orthopedic trauma surgeons and care teams can expect similar acute care outcomes in morbidly obese and non-morbidly obese patients with acetabular fracture.

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1. Introduction

Injuries to the pelvic ring are serious and potentially life-threatening injuries that typically occur after a high velocity or impact blunt trauma.¹ Acetabular fracture treatment is challenging and often involves stabilization of the patient followed by anatomic reduction with rigid internal fixation.² Stabilization and anatomic restoration of these articular

fractures in patients can result in a very good prognosis in over >70% of persons with healthy weight.^{3,4} Morbidly obese patients admitted with orthopedic trauma have unique physical challenges and pathophysiology, which can affect the trauma team's decision-making processes.⁵ Morbid obesity is commonly perceived to adversely affect the surgical repair process and perisurgical outcomes and to incur significant hospital resource use. Modifications in pre-operative planning and intraoperative strategies may be required in

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order to accommodate the morbidly obese patient and minimize risk.⁶

It has been documented that morbidly obese patients may be the most complicated to treat, due to the need for special surgical tables, extra staffing and additional diagnostic imaging to obtain appropriate views of the fracture area.^{7,8} Obesity can significantly increase the technical difficulty of performing pelvic and acetabular surgeries,⁹ can increase the length of the surgical incision and amount of dissection,¹⁰ and may contribute to a greater likelihood of perioperative complications after acetabular fracture repair.^{11,12} On the operating table, challenges include intubation, positioning, intra-operative fluoroscopy, and accessions of blood vessels.⁸ These obesity-related difficulties are assumed to be associated with higher utilization of hospital resources and hospital charges, but this has yet to be shown. Controversy exists regarding obesity-related injury severity and clinical outcomes.¹³ In our recent work, we found that obese patients with orthopedic trauma who underwent inpatient rehabilitation actually had similar clinical outcomes and functional gain by discharge.¹⁴ Furthermore, even morbidly obese patients achieved meaningful functional gains and were discharged within similar time frames as the non-obese patients. It remained unclear whether or not there were biases of these outcomes due to the selection of patients who could tolerate aggressive therapies into a post-acute inpatient rehabilitation setting. Examination of the effect of morbid obesity on perioperative and acute care outcomes and discharge destination would eliminate this bias. Hence, the main purposes of this study were to expand our understanding of the effect of morbid obesity on perioperative and acute care outcomes after acetabular fracture. We hypothesized that patients with body mass index values ($\text{BMI} \geq 35 \text{ kg/m}^2$) would demonstrate worse perioperative and acute care outcomes and greater hospital resource utilization than non-morbidly obese patients with $\text{BMI} < 35 \text{ kg/m}^2$.

2. Patients and methods

2.1. Study design

This was a retrospective study using data compiled from computerized medical records systems and billing, the Trauma Registry and patient charts from a Level 1 regional referral trauma center. This investigation was approved by the Institutional Review Board at the University of Florida. A waiver of informed consent was obtained because of the de-identified nature of the data. Team members collected and verified all data (EH, HKV). Data were entered into the statistical software (EH), cleaned, and verified by other study team members (ST, HKV). Reliability was periodically checked by the primary author in a process of randomly reviewing charts and the electronic transcription.

2.2. Patients

Patients with a major primary diagnosis of a traumatic acetabular fracture (without brain injury or paralysis) were included in the patient pool. Attempts were made to match patients by age, race and sex where possible to reduce possible

confounders in the analysis. Patients with high impact trauma-related event such as motor vehicle accidents (E810–E819) were included. The diagnosis was identified by the primary International Code of Disease (ICD-9) number of the patient file, and was confirmed within the medical record discharge summary. A total of 85 patients were identified within the study time frame, and four were eliminated due to incomplete data. The goal was to match 3 non-morbidly obese patients for every morbidly obese patient as a matched pair comparison. All patients were treated within a standardized trauma protocol, under the care of one of three surgeons. Patients were classified as non-morbidly obese if the BMI was $< 35 \text{ kg/m}^2$, and patients were classified as morbidly obese when BMI was $\geq 35 \text{ kg/m}^2$ with at least one other comorbidity.¹⁵

2.3. Characteristics

Demographic variables, the type and number of comorbidities, were obtained from the admission notes of the electronic medical record. Specific characteristics included age, gender, race, ethnic group, BMI, insurance status (private; public; none), number of comorbidities, Injury Severity Score (ISS),¹⁶ Abbreviated Injury Scale (AIS) score,¹⁷ Glasgow Coma Scale (GCS)¹⁸ and fracture type. The ISS can be used as a proxy for trauma severity,¹⁹ and is recommended for use in research involving hospital length of stay.²⁰ The AIS is considered a more accurate consensus-derived injury severity than the ISS, but when used together (with age and physiological variables), these measures can predict clinical outcomes after trauma.²¹ The AIS for the primary, secondary and tertiary sites were obtained. The GCS is a standardized measurement for assessing the degree of consciousness and predicting the duration and ultimate outcome of coma. The assessment includes eye opening, verbal response, and motor response; each response is evaluated independently according to a rank order that indicates the level of consciousness and functional impairment. The GCS has moderate levels of inter-rater agreement when administered in the emergency department, with a Spearman rho of 0.808.²² If applicable, the number of other fractures was recorded from the admission notes. The GCS measures were obtained at the time of paramedic arrival, and the ISS and AIS were obtained upon admission to the acute care service.

2.4. Perioperative outcomes

Several perioperative parameters were collected from the surgeon's notes. The research team followed specific instructions for chart abstraction procedures. Three trauma surgeons performed the surgeries documented in this study, and the surgical approach was documented. Perioperative outcomes included positioning time, total operative time and estimated blood loss. If applicable, postoperative complications were recorded, and these included renal insufficiency, respiratory complications (acute distress, difficult ventilation during surgery, respiratory insufficiency, bilateral effusions, pneumonia), cardiac arrhythmias, vascular complications including deep venous thrombosis or pulmonary embolism and infections (urinary tract infection, respiratory infection, methicillin-resistant *Staphylococcus aureus* and others).

2.5. Acute care outcomes

The total number of days on a ventilator days and total hospital length of stay (LOS) were collected from the Intensive Care Unit attending notes and confirmed in the discharge summary. The details of the number of blood units transfused were obtained from the University Blood Bank.

To provide an estimate of the financial impact of morbid obesity on outcomes, the charges related to the acetabular fracture repair, and the total hospital charges were obtained from the University of Florida Faculty Group Practice administration office. While we acknowledge the limitations of using charges, access to the actual costs obtained by the group practice was not available to the study team. Hospital charges have been used in our earlier studies of elective surgical procedures as a method of estimating resource use for the hospital LOS.^{23–27} The discharge destination was determined from the discharge summary from each patient record. All patients were discharged with a non-weight bearing status.

2.6. Statistical analyses

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS, version 21.0) software. Data are expressed as mean $\pm$ standard deviation of measurement (SD). Baseline characteristics were analyzed using Chi-Square tests (χ^2) for frequency distributions of all categorical variables (demographics, comorbidity prevalence, surgical type). All data were tested for normalcy using the Kolmogorov–Smirnov test; the study variables were not found to be normally distributed. Kruskal–Wallis non-parametric tests were used to determine whether differences existed between the three BMI strata in continuous characteristic variables. Normally distributed continuous variables were analyzed using a one way analysis of variance, with the BMI group serving as the independent variable (non-morbidly obese, morbidly obese). To determine whether BMI predicted hospital resource use (represented by total hospital charges) or LOS, two hierarchical regression models were generated to include factors that have been shown to be related to these variables. After accounting for variables that might contribute to variations in hospital charges or LOS (gender and age, Abbreviated Injury Severity score (primary, secondary and tertiary sites,²¹ ventilator days, blood units)), BMI was then added as the final variable in each model. Significance was established at an α level of 0.05 for all statistical tests.

3. Results

3.1. Patient characteristics

As expected, body weight, BMI and values were different for non-morbidly obese, and morbidly obese patients (Table 1). No differences were detected in proportions of patients for race, diabetes mellitus, hypertension or insurance status among non-obese, overweight and obese patients. The number of extra fractures sustained by the study groups was not different between groups (2.5 ± 3.7 fractures versus 2.1 ± 2.5 ; $p = 0.619$). In non-morbidly obese and morbidly obese

Table 1 – Patient characteristics. Values are means $\pm$ SD, or % of the group.

	Non-morbidly obese BMI <35 kg/m ² (n = 61)	Morbidly obese BMI $\geq$ 35 kg/m ² (n = 20)	p (sig)
Age (yrs)	38.3 $\pm$ 17.3	37.4 $\pm$ 13.3	0.834
Weight (kg)	63.5 $\pm$ 11.5	88.2 $\pm$ 10.1	<0.0001
Height (cm)	170 $\pm$ 10	179 $\pm$ 10	0.074
BMI (kg/m ²)	21.1 $\pm$ 2.5	27.2 $\pm$ 1.6	<0.0001
Women (%)	35.8	50.0	0.004
Race (%)			
Caucasian	75.8	70.0	
African–American	19.4	25.0	
Hispanic	3.2	5.0	
Other	1.6	0.0	0.630
Comorbidities (#)	2.1 $\pm$ 1.8	2.2 $\pm$ 1.3	0.827
Diabetes mellitus (%)	12.9	5.0	0.328
Hypertension (%)	25.8	20.0	0.601
Current smoker (%)	54.2	60.0	0.713
Insurance status (%)			
Medicaid	6.5	5.0	
Medicare	11.3	5.0	
Self-pay/Medipass	16.1	15.0	
Insured	41.9	50.0	
Other	24.2	25.0	0.456

BMI = body mass index.

patients, the proportions of patients with head fractures was 12.9% and 0.0%, with lower extremity fractures was 40.3% and 45.0%, and with upper extremity fractures was 9.7% and 10.0%, respectively (all $p > 0.05$). The percent of patients with spine and rib fractures was 33.9% and 30.0% in non-morbidly obese and morbidly obese groups, respectively.

3.2. Perioperative outcomes

Table 2 provides the perioperative variables for acetabular fracture repair. Positioning time and operative times were longer in the morbidly obese group compared to the non-morbidly obese group ($p = 0.033$ and $p = 0.030$). Perioperative complications are reported in Table 3. Only the proportion of patients with cardiac complications was different based on BMI, whereas the incidence of the other complications was not different between the two patient groups.

3.3. Injury Severity Scores

The scores for the three instruments used to indicate the injury severity after trauma are presented in Table 4. There were no statistical differences in either the Injury Severity

Table 2 – Perioperative variables in trauma patients with acetabular fracture. Values are means $\pm$ SD.

	Non-morbidly obese BMI <35 kg/m ²	Morbidly obese BMI $\geq$ 35 kg/m ²	p (sig)
Positioning time (hrs)	3.1 $\pm$ 1.4	3.9 $\pm$ 1.4	0.033
Operative time (hrs)	4.4 $\pm$ 1.5	5.3 $\pm$ 1.3	0.030
Ventilator time (days)	1.1 $\pm$ 4.0	0.4 $\pm$ 0.8	0.447
Estimated blood loss (ml)	752 $\pm$ 751	881 $\pm$ 729	0.565

Table 3 – Perisurgical complications.

	Non-morbidly obese BMI <35 kg/m ² # (%)	Morbidly obese BMI ≥35 kg/m ² # (%)	p (sig)
Renal insufficiency (#)	2 (3.2)	0 (0.0)	0.415
Respiratory complications (#)	11 (18.0)	4 (20.0)	0.736
Respiratory failure (#)	7 (12.9)	1 (5.0)	0.319
Cardiac arrhythmias (#)	4 (6.4)	6 (25.0)	0.024
Vascular complications (#)	3 (5.8)	0 (0.0)	0.315
Sciatic nerve palsy	5 (8.3)	1 (5.0)	0.626
Infection	5 (8.3)	4 (20.0)	0.155
Respiratory complications = acute distress, difficult ventilation during surgery, respiratory insufficiency, bilateral effusions, pneumonia.			
Cardiac arrhythmias = tachycardia, atrial fibrillation.			
Vascular complications = deep vein thrombosis. Emboli.			
Infections = urinary tract infection, respiratory infection, MRSA, salmonella in stool.			

Scores, Abbreviated Injury Scores and the Glasgow Coma Scale scores between the two BMI groups.

3.4. Acute care outcomes and resource utilization

Table 5 provides the data for the acute care clinical outcomes and hospital resource utilization in non-morbidly obese and obese groups. The acute care LOS, total blood units transfused, and number of ventilator days were not found to be different in the three BMI groups. The daily hospital charges were 23%–55% higher in the overweight patients compared to the non-obese and obese patients, respectively ($p = 0.032$). However, the charges that were directly attributed to the acetabular fracture repair itself and the total hospital charges were not different among the three groups.

3.5. Regression models

For the regression model of LOS, the AIS, the number of days on a ventilator and the number of blood units transfused were

Table 4 – Injury severity scores and Glasgow Coma Scale scores in patients with acetabular fracture. Values are means ± SD.

	Non-morbidly obese BMI <35 kg/m ²	Morbidly obese BMI ≥35 kg/m ²	p (sig)
ISS	2.7 ± 0.5	2.8 ± 0.4	0.805
ISS 2nd	1.7 ± 1.5	2.1 ± 1.1	0.321
ISS 3rd	0.8 ± 1.3	1.0 ± 1.3	0.500
AIS	15.0 ± 10.8	15.7 ± 7.1	0.774
GCS	13.5 ± 3.5	14.7 ± 1.2	0.161

ISS = Injury Severity Score (2nd = second body region, 3rd = third body region).

AIS = Abbreviated Injury Score.

GCS = Glasgow Coma Scale.

all found to significantly contribute to contribute to the variance of the model for LOS (Table 6). However, BMI did not improve the predictive power of the model and was not a significant contributor. For total hospital charges, number of days on a ventilator and the number of blood units transfused were significant contributors to the model. BMI did not explain any additional variance of the model.

4. Discussion

This study examined whether or not morbidly obese patients demonstrated worse clinical outcomes and utilized more hospital resources during the acute care stay compared to non-morbidly obese counterparts after an orthopedic trauma-induced acetabular fracture. In contrast to our expectations, we did not find that high BMI was related to worse perioperative or acute care outcomes and hospital resource utilization.

Mean injury severity scores (ISS, AIS) were not different in the two BMI groups in the present study. Current evidence is mixed, showing that ISS scores are not different^{1,13,28,29} whereas other studies show that the prevalence of poor ISS scores is worse in progressively heavier patients.²⁹ After high impact trauma (car crash), mean ISS and AIS scores were nearly identical in obese and non-obese persons.¹³ A recent meta-analysis,³⁰ found that from 18 systematically reviewed studies there were comparable injury severity scores among obese and non-obese patients. The obese patients in the present study did not have higher mean numbers of extra fractures, but revealed a higher prevalence of cardiac arrhythmias in the morbidly obese patients compared to the non-morbidly obese patients. Several studies have similarly shown higher perisurgical complication rates in obese patients, especially morbidly obese patients, with trauma.^{7,29,31,32} A BMI of >30 kg/m² is associated with an elevated complication rate and need for reoperation after pelvic ring injuries.³² Postoperative wound infections are more frequent in patients with higher BMI values³³ (22% in patients with BMIs 40.1–64.1 kg/m² versus 3% in patients with BMI ranging 16.1–39.5 kg/m²).⁷ BMI of ≥30 kg/m² was associated with a 2.1 times greater likelihood of significant blood loss and deep vein thrombosis, and those with BMI ≥ 40 kg/m² were five times more likely to develop a wound infection after acetabular repair.¹² Among obese general trauma patients, the odds risks of fatal complications such as acute care respiratory distress syndrome ranged from 1.02 to 1.97, ranged from .085 to 6.25 for acute renal failure, and ranged from 1.1 to 1.71 for multiple organ failure.³⁰

Some available evidence indicates that obesity is associated with longer LOS after trauma,³⁴ whereas other studies do not.^{13,28,29} Porter et al found a difference of 6.5 days between healthy weight and obese patients after an acetabular fracture repair (12.5 days vs 19 days).¹ The pooled effect of obesity on LOS in the acute care unit was previously found to be a 1.97 day longer in obese compared to non-obese patients, and this was attributed to the additional time required for stabilization of complications and infection control.³⁰ Among obese patients with other orthopedic trauma such as fall-related hip fracture, the American Society of Anesthesiologists (ASA) classification, but not BMI, predicted LOS.³⁵ The chronicity or

Table 5 – Clinical outcomes and resource utilization in patients with acetabular fracture after an orthopedic trauma. Values are means $\pm$ SD, or percent of the group.

	Non-morbidly obese BMI <35 kg/m ²	Morbidly obese BMI $\geq$ 35 kg/m ²	p (sig)
Acute care LOS (days)	12.1 $\pm$ 10.5	11.6 $\pm$ 10.1	0.848
Total blood units used (#)	6.0 $\pm$ 9.3	6.5 $\pm$ 12.0	0.833
Ventilator days (#)	1.1 $\pm$ 4.0	0.4 $\pm$ 0.8	0.447
Charges related to acetabular fracture (\$)	10,058 $\pm$ 6150	9,984 $\pm$ 6033	0.963
Total hospital charges (\$)	34,057 $\pm$ 33,971	31,493 $\pm$ 30,749	0.765
Discharge destination (%)			
Home (with or without home care)	53.3	63.1	
IRF	25.0	21.1	
SNF	13.3	15.8	
Other	6.6	0.0	
Death in acute care	1.6	0	0.411

IRF = inpatient rehabilitation facility.

SNF = skilled nursing facility.

severity of comorbid conditions in obesity (e.g., pulmonary conditions, hypertension, diabetes)²⁹ may also extend the time required for stabilization in acute care. The overall comorbid burden may better predict LOS rather than an individual comorbidity of obesity.

Novel findings from this study were that the BMI did not contribute to the variance of the regression models for LOS or hospital charges. While there are not comparable acute care charges or cost data for acetabular fracture repair based on BMI, available data from patients with traumatic tibial and femoral fractures indicated that obesity did not increase total hospital charges.³⁶ There are potential explanations for the differences observed in the present study with previously published studies. Due to the uncontrolled nature of traumatic injury, the study of obesity is challenging in this orthopedic population. Fracture patterns can be different based on BMI, such that obese patients tend to sustain fewer head injuries, more lower extremity fractures⁵ and more severe lower extremity injuries and rib fractures after trauma^{37,38} compared to non-obese counterparts. Alternatively, the variation among studies may be due to injury heterogeneity of orthopedic trauma cohorts and functional status on discharge. Each patient can have different extra fractures or internal organ injuries which may cause variation in LOS and

hospital resource use, irrespective of BMI. In the present study, all patients were discharged in a non-weight bearing status category, thereby controlling functional status. Another novel finding was that there were similar proportions of morbidly obese and non-morbidly obese patients who went home, to rehabilitation, to a skilled nursing facility or other locations. This finding indicates that high BMI was not the key variable used by the care team to decide post-acute care location and discharge placement was no more complicated than the non-obese population. The grouping of patients by BMI is different in each study, as some use one cutoff of < or $\geq$ 30 kg/m² or < or $\geq$ 40 kg/m²,^{21,7} while others use a spectrum of BMI brackets for outcomes analysis.^{2,28,29} Future studies may benefit from stratification of patients with similar mechanisms of other orthopedic injury.

5. Conclusions

In this study, perioperative and acute care trauma outcomes in patients with acetabular fracture were not worse in morbidly obese patients compared to non-morbidly obese patients with acetabular fracture. The ISS scores were highly predictive of LOS and hospital charges, whereas BMI was not a

Table 6 – Hierarchical regression analyses for total hospital charges during an acute care stay for surgical repair of an acetabular fracture.

Block	R	R ²	R ² change	p of the F change	B (CI)
<i>Model 1. Length of stay</i>					
Gender code	.073	.005	.005	.189 (.828)	1.051 (–2.02 to 4.121)
ISS score	.359	.129	.123	9.77 (.003)	.152 (–.257 to .575)
ISS 2nd, ISS 3rd	.398	.159	.030	1.19 (.309)	.629 (–1.714 to 2.972)
Ventilator days	.462	.213	.054	4.56 (.036)	.445 (.042 to .849)
Blood units used	.700	.490	.277	35.31 (.0001)	.598 (.404 to .792)
BMI	.718	.515	.025	3.26 (.076)	.162 (–.017 to .340)
<i>Model 2. Hospital charges</i>					
Gender code	.054	.003	.003	.102 (.904)	–2292.9 (–10149.6 to 5563.7)
ISS score	.226	.051	.048	3.52 (.065)	–752.5 (–1834.0 to 329.1)
ISS 2nd, ISS 3rd	.330	.109	.058	2.17 (.122)	2305.4 (–3690.7 to 8301.5)
Ventilator days	.790	.624	.515	90.50 (.0001)	5345.3 (4313.8 to 6376.7)
Blood units used	.842	.709	.085	18.94 (.0001)	1075.9 (578.6 to 1573.2)
BMI	.842	.709	.000	0.31 (.862)	40.1 (–417.4 to .497.5)

BMI = body mass index; B (CI) indicates that these B coefficients are unstandardized (confidence interval).

significant predictor of these outcomes. Orthopedic trauma care teams can expect similar acute care outcomes in persons with high and low BMI with this injury.

Conflicts of interest

All authors have none to declare.

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