Published in final edited form as:

J Trauma Acute Care Surg. 2012 October ; 73(4): 966–971. doi:10.1097/TA.0b013e31825a78fa.

Pediatric Obesity and Traumatic Lower Extremity Long Bone Fracture Outcomes

Ian C. Backstrom, B.S.,

Department of Surgery, University of Alabama at Birmingham, Birmingham, Alabama

Paul A. MacLennan, Ph.D.,

Department of Surgery, University of Alabama at Birmingham, Birmingham, Alabama

Jeffrey R. Sawyer, M.D.,

Department of Orthopaedic Surgery, University of Tennessee-Campbell Clinic, Memphis, Tennessee

Aaron T. Creek, B.S.,

Department of Orthopaedic Surgery, University of Tennessee-Campbell Clinic, Memphis, Tennessee

Loring W. Rue III, M.D., and

Department of Surgery, University of Alabama at Birmingham, Birmingham, Alabama

Shawn R. Gilbert, M.D.

Department of Surgery, University of Alabama at Birmingham, Birmingham, Alabama

Abstract

Background—Pediatric obesity is associated with lower extremity injuries and poor outcomes after blunt trauma. Our aim was to determine if obese pediatric patients with femur and tibia fractures have more severe injury patterns and worse outcomes compared to non-obese patients.

Methods—We performed a retrospective cohort study of obese and non-obese pediatric patients with femur or tibia fractures treated at two Level-1 trauma centers from 2004-2010. Patients weighing 95th percentile for age and gender were classified as obese. Patients were compared regarding demographics, Injury Severity Score (ISS), intra-abdominal, and orthopedic injuries. Outcomes included fracture treatment, orthopedic complications, ICU and hospital length of stay, ventilator days, and mortality.

Results—Of the 356 patients included in the study, 78 (21.9%) were obese and 278 (78.1%) were non-obese. Obese patients were older (9.9 ± 3.7 vs. 8.8 ± 3.9 years; $p=0.0162$), had a higher ISS (20.8 ± 13.4 vs. 14.5 ± 10.8 ; $p=0.0002$), and sustained more intra-abdominal solid organ (24.4% vs. 13.5%; $p=0.0200$) and hollow viscus (3.9% vs. 0.0%; $p=0.0105$) injuries. They had more pelvic fractures (15.4% vs. 6.9%; $p=0.0196$), bilateral tibia fractures (8.0% vs. 0.0%; $p=0.0332$), and operatively-treated femur fractures (89.9% vs. 79.1%; $p=0.0484$). Adjusting for age, obese patients were more likely to be admitted to the ICU [relative risk (RR), 1.68; 95% confidence interval (CI), 1.10-2.55] and die in the hospital (RR, 3.45; 95% CI, 1.14-10.41). Adjusting for ISS, these associations were non-significant.

Correspondence: Shawn R. Gilbert, M.D., Department of Surgery, University of Alabama at Birmingham, 1600 7th Ave South ACC # 316 Birmingham AL, 35233. Telephone: 205-939-5386, Fax: 205-939-9833 shawng@uab.edu.
I.C.B. (ianb@uab.edu), P.A.W. (Paul.MacLennan@ccc.uab.edu), J.R.S. (jsawyer@campbellclinic.com), A.T.C. (aaron.creek@gmail.com), L.W.R. (lrue@uab.edu), S.R.G. (shawng@uab.edu)

Conclusions—Obese patients with femur and tibia fractures have more severe injuries which may predispose them to greater inpatient morbidity and mortality than non-obese patients.

Keywords

obesity; lower extremity fractures; inpatient outcomes

INTRODUCTION

Based on the 2007-2008 National Health and Nutrition Examination Survey, 17% of children and adolescents are obese, with an additional 15% considered overweight.¹ Childhood obesity is associated with many comorbid medical conditions including hypertension, hyperlipidemia, glucose intolerance, and sleep apnea.² Childhood obesity is also associated with orthopaedic problems, including Slipped Capital Femoral Epiphysis, Blount's Disease, and musculoskeletal pain.³

Unintentional injury is the leading cause of death among U.S. children and adolescents and represents a significant source of morbidity in this age group.⁴ Results from several large trauma studies suggest that obese children have different injury patterns and severity compared to non-obese children. For reasons that are poorly understood, a common finding in these studies is that obese children experience more injuries to their extremities,⁵⁻⁸ including more severe lower extremity injuries⁶⁻⁸ and fractures requiring orthopedic surgical intervention.⁵ In addition, retrospective trauma studies have shown that obesity is associated with increased inpatient morbidity in children.^{5,9}

Femur and tibia fractures are common injuries in children, accounting for 22% and 12% of orthopaedic injuries in pediatric trauma patients, respectively.¹⁰ Despite an increasing prevalence of pediatric obesity and studies demonstrating that pediatric obesity is associated with severe lower extremity injuries after blunt trauma, no studies have examined the association between weight, injury patterns, or inpatient morbidity and mortality in pediatric patients with lower extremity long bone fracture. In order to investigate this, we performed a retrospective review of children, age 2-14, with traumatic tibia and femur fractures at two pediatric Level-1 trauma centers. We hypothesized that obese patients with lower extremity long bone fracture would have more severe injury patterns and increased inpatient morbidity and mortality compared to non-obese patients.

MATERIALS AND METHODS

Approval from the Institutional Review Boards of The University of Alabama at Birmingham, The University of Tennessee Health and Science Center, and LeBonheur Children's Hospital was obtained before conducting this study.

Patient Population

This was a retrospective cohort study of blunt trauma patients, age 2-14, with tibia or femur fractures treated at two Level-1 regional pediatric trauma centers [Children's of Alabama (Birmingham, Alabama) and Le Bonheur Children's Hospital (Memphis, Tennessee)] between January 2004 and December 2010. The hospitals' trauma registries (National TRACS software, Digital Innovation) were queried for patients, age 2-14, admitted with tibia/fibula or femur fracture sustained in high-energy traumas that resulted in alert or activation of institutional trauma teams based on mechanistic or physiologic criteria. Patients with traumatic amputations, isolated fibula fractures, mechanism of injury other than blunt, or incomplete medical charts were excluded from the study. Patients were classified as obese or non-obese based on admission weights using the CDC's gender-

specific growth charts¹¹ and weight-for-age percentile (WFA%) 95th percentile as the definition of obesity. WFA% was used instead of Body Mass Index (BMI) because patient height is not regularly measured and recorded in the medical chart at either institution.

Data Source

For the pediatric patients identified, the trauma registries provided information regarding patient demographics (age, gender, race), External Cause of Injury Codes (E-codes), Injury Severity Score (ISS), body-region specific Abbreviated Injury Scale (AIS) scores, and International Classification of Disease, Ninth Revision (ICD-9) codes. E-codes were classified based on the CDC's recommended framework.¹² The five most common E-code categories were included for analysis (i.e., motor vehicle traffic occupant, motor vehicle traffic pedestrian, motor vehicle traffic cyclist, fall, and transportation other). Motor vehicle traffic pedestrian and motor vehicle traffic cyclist were combined for the purpose of analysis. AIS scores of three or greater were considered severe injuries and were collected by body-region, including the head and neck, chest, abdomen, and extremities. ICD-9 codes obtained from the trauma registries were used to identify intra-abdominal solid organ injuries (kidney, liver, spleen, or pancreas), intra-abdominal hollow viscus injuries (stomach, duodenum, small bowel, or large bowel), pelvic fractures, and spinal column injuries. ICU length of stay, days of mechanical ventilation, length of hospitalization, and mortality were also abstracted from the trauma registries. Medical charts were reviewed to obtain information on patient weight, fracture characteristics (open vs. closed fractures, bilateral fractures, multiple fractures in the same bone), fracture treatment classified as operative (internal or external fixation) or non-operative (casting or traction), and inpatient orthopedic complications (re-fracture, loss of reduction, compartment syndrome, wound infection, and decubitus ulcer).

Statistical Analysis

Statistical analysis was performed using SAS version 9.2 (SAS Institute Inc., Cary, NC). Patient level characteristics of obese and non-obese patient groups were compared using Chi-square test or, when appropriate, Fisher's exact test for categorical variables and two-sided Student t-test for continuous variables. P-values less than or equal to 0.05 alpha were considered statistically significant. Patient outcomes of interest included in-hospital mortality, ICU admission, and need for mechanical ventilation. Multivariate linear regression was used to compute mean length of stay, mean ICU days, and mean days of mechanical ventilation adjusted for age and ISS. Multivariate models were also used to compute adjusted risk ratios (RRs) and 95% confidence intervals (CIs) for ICU admission, need for mechanical ventilation, and mortality in order to control for confounding variables, i.e., age and ISS. Similar methods were used in the analysis of fracture treatment. Adjusted p-values for fracture treatment were obtained through logistic regression modeling which included as independent variables obesity and age. Because the obese patient group was slightly older than the non-obese group, patient age was included as a continuous variable in the multivariate analysis. The inclusion of age in these models had very little impact on the magnitude and statistical significance of measures of association. Given that some patients had multiple fractures, the unit of observation for this analysis was at the level of injury which assumed independence of observations.

RESULTS

Of the 2,858 patients, age 2-14, recorded in institutional trauma registries, 397 patients sustained femur or tibia/fibula fractures (Memphis = 132; Birmingham = 265). Of these patients, 356 (89.7%) met inclusion criteria for the study (Memphis = 117; Birmingham = 239). Hospitals were similar regarding patient age, gender, mechanism of injury, mean ISS,

fracture characteristics (proportion of patients with femur or tibia fracture, open femur or tibia fractures, bilateral fractures), mean ICU days, mean ventilator support days, proportion of patients with musculoskeletal complications, and mortality ($p > .05$). Patients from Memphis had a longer length of stay (9.1 ± 9.2 vs. 6.7 ± 9.1 , $p = 0.0228$) and a higher proportion of African American patients (49.6% vs. 37.7%, $p = 0.0321$). The proportion of obese patients was similar between Memphis and Birmingham (21.4% vs. 22.2%, $p = 0.8625$). Overall, there were 78 (21.9%) obese patients and 278 (78.1%) non-obese patients. The obese group was significantly older than the non-obese group (9.9 ± 3.7 years vs. 8.8 ± 3.9 years, $p = 0.0162$), but there were no significant differences between groups regarding race, gender, or mechanism of injury (Table 1).

Table 2 compares injury patterns and severity between groups. Obese patients were more severely injured than the non-obese patients. They had a significantly higher mean ISS (20.8 ± 13.4 vs. 14.5 ± 10.8 , $p = 0.0002$) and more severe injuries (AIS 3) to the head and neck (30.8% vs. 19.1%, $p = 0.0265$), chest (37.2% vs. 19.1%, $p = 0.0008$), abdomen (12.8% vs. 6.5%, $p = 0.0658$) and extremities (70.5% vs. 57.2%, $p = 0.0338$). Obese patients had more intra-abdominal solid organ (24.4% vs. 13.5%, $p = 0.0200$) and hollow viscus injuries (3.9% vs. 0.0%, $p = 0.0105$). They also had a higher frequency of pelvic fractures (15.4% vs. 6.9%, $p = 0.0196$) and more spinal column injuries (12.8% vs. 6.6%, $p = 0.0703$). Obese and non-obese cohorts had similar frequencies of femur fracture, tibia fracture, and combined femur and tibia fracture. They also had similar proportions of patients with open fractures and multiple fractures of the femur and tibia. However, obese patients were more likely to have bilateral femur fractures (14.8% and 7.4%, $p = 0.0811$) and tibia fractures (8.0% vs. 0.0%, $p = 0.0332$).

The patients in this study sustained a total of 279 femur and 142 tibia fractures (Table 3). Adjusting for age, obese patients had a higher proportion of fractures treated operatively with internal or external fixation (74.7% vs. 59.9%, $p = 0.0220$). When femur and tibia fractures were analyzed separately, the obese group had a higher proportion of femur fractures treated operatively (89.9% vs. 79.1%, $p = 0.0484$) but similar proportions of tibia fractures treated operatively compared to the non-obese group.

Table 4 compares inpatient outcomes between groups. Obese and non-obese cohorts were similar regarding mean ICU stay, proportion requiring mechanical ventilation, mean days on mechanical ventilation, and frequency of musculoskeletal complications. However, obese patients were more likely to be admitted to the ICU (41.6% vs. 26.3%, $p = 0.009$), had longer hospital stays (9.6 ± 8.8 vs. 6.9 ± 8.8 , $p = 0.0410$), and greater mortality (7.7% vs. 2.5%, $p = 0.0423$) than non-obese patients. These findings were significant after adjusting for patient age but were not significant after adjusting for patient age and ISS (Tables 5 and 6).

The 13 fatalities included seven who were passengers in an MVC, three were pedestrians struck by a car, and one each ATV, bicycle vs. car and motorcycle crash. All incurred traumatic brain injury, which was the cause of death in 12/13. One patient had massive hemorrhage due to multiple abdominal injuries following motorcycle crash. Ten died within the first 48 hours, and one patient died at each of the following time points: 3 days, 5 days and 28 days. The mean ISS of patients who had died was 43 (range 33-75) in the obese group, and 40 (range 19-57) in the non-obese group.

DISCUSSION

According to the National Center for Injury Prevention and Control, over eight million U.S. children and adolescents sustained non-fatal unintentional injuries and 10,000 children

sustained fatal unintentional injuries in 2007 alone.¹³ With increasing prevalence of pediatric obesity combined with studies that have demonstrated an increased risk of lower extremity injury in obese children,⁶⁻⁸ it can be expected that the number of obese children with lower extremity long bone fracture will increase. With this in mind, it is important for clinicians to understand how obesity influences injury patterns and associated outcomes in the subset of pediatric trauma patients with femur and tibia fractures.

The proportion of obese patients in this study was 22%, which is slightly higher than the national prevalence of pediatric obesity (17%)¹ but similar to the proportion of obese patients in other studies of pediatric obesity and blunt trauma.^{5,6} Our study population's increased prevalence of obesity may be explained by the fact that among U.S. states, Tennessee and Alabama rank 4th and 5th for childhood obesity, respectively.¹⁴

The influence of body mass on traumatic injury patterns has been evaluated in both adults and children. A common theme in these studies is that obesity predisposes patients to different injury patterns without necessarily increasing the cumulative severity of their injuries.^{5,9,15} An exception to this is a study by Ryb and colleagues¹⁶ who reviewed the outcomes of 1,615 adult patients involved in motor vehicle collisions and found increased injury severity among overweight patients. In the present study, obese pediatric patients with lower extremity long bone fracture had a higher mean ISS than non-obese patients. Obese patients also had more severe injuries (AIS 3) in every major body region, including the head and neck, chest, abdomen, and extremities. In addition, obese patients had more intra-abdominal solid organ and hollow viscus injuries, pelvic fractures, and spinal column injuries.

To our knowledge, this is the first study demonstrating increased ISS in obese pediatric blunt trauma patients with lower extremity long bone fracture. Our results contrast with the findings of Arbabi *et al.*,¹⁷ who suggested that the excess adipose tissue associated with obesity dissipates energy during blunt trauma, providing a protective effect against severe injuries, particularly severe abdominal injuries (the "cushion effect"). One possible explanation for our findings is that obesity is protective against on-scene mortality, resulting in a higher proportion of obese patients surviving the initial traumatic event to present to the emergency department with more severe injuries. Another possibility is that the increased kinetic energy associated with increased body mass ($k = \frac{1}{2}mv^2$) may have overwhelmed the "cushion effect," resulting in more severe injury patterns.¹⁷ Finally, early graduation to seat belts and poor-fitting vehicle restraints may increase the risk of severe injury in obese children involved in motor vehicle collisions.^{6,18} We did not include data on collision forces or vehicle restraint use; therefore, the results of our study cannot support or refute the aforementioned possibilities.

Analysis of fracture characteristics revealed similarities between groups regarding the proportion of patients with femur or tibia fracture, open vs. closed fractures, and multiple fractures in the same bone. Obese patients with tibia fracture were more likely to have bilateral injuries, which was similar to patients with femur fractures. The higher frequency of bilateral fractures in the obese group supports the growing body of evidence that obese patients suffer more severe lower extremity injuries during blunt trauma.⁶⁻⁸ A proposed mechanism behind this pattern of injury is that the increased mass associated with obesity results in greater energy and force distribution to the lower extremity after blunt trauma.⁶

Comparing the treatment of all fractures between groups, obese patients were more likely to receive operative intervention for their femur fractures. This is consistent with a study by Rana and colleagues⁵ who reviewed 1,314 pediatric trauma patients and found that obese patients had a higher incidence of orthopedic surgical intervention for extremity fractures.

The higher frequency of operatively treated femur fractures may be indicative of more severe fracture patterns. It may also be a result of altered decision making by orthopedic surgeons because of the perceived difficulty of closed fracture management in obese children. Obese children have more subcutaneous fat around their thighs, making it more difficult to achieve proper cast molding and fracture stabilization.¹⁹ In addition, caregiver burden may be higher for larger children immobilized in spica casts, which may lead surgeons to choose operative techniques that allow for a faster return to independent ambulation.²⁰

Studies of adult trauma patients have shown that obesity is associated with increased inpatient morbidity and mortality. Bochicchio *et al.*²¹ collected prospective data on 1,167 critically ill trauma patients and found that obesity was significantly associated with bloodstream infections, urinary tract infections, respiratory infections, ICU admission, and mortality. Few studies have investigated outcomes in obese pediatric trauma patients. Brown *et al.*⁹ retrospectively reviewed 316 pediatric and adolescent trauma patients and found that obese patients had more inpatient complications and longer ICU stays. Rana and colleagues⁵ found that obese patients were more likely to suffer from deep vein thrombosis and decubitus ulcers. Neither study reported differences in hospital length of stay, ventilator days, or mortality. Similar to these studies, obese patients with femur or tibia had poor outcomes compared to non-obese patients. Based on univariate and multivariate analysis adjusting for age, obese patients with lower extremity long bone fracture were more likely to be admitted to the ICU, had longer lengths of stay, and higher mortality than non-obese patients. These findings were not statistically significant after adjusting for ISS, suggesting that injury severity and not obesity had the greatest influence on poor outcomes in the obese patients in the current study.

Obese patients and non-obese patients had similar frequencies of musculoskeletal complications (5.1% vs. 2.9%). This is consistent with the findings of Maheshwari and colleagues,²² who studied 665 adult patients with femur and tibia fractures sustained in motor vehicle collisions, and found that obese and non-obese groups had similar frequencies of inpatient musculoskeletal complications (2.9% vs. 3.0%). Retrospective studies of children with operatively treated femur fractures suggest that obese patients may be at increased risk for complications, including re-fracture, loss of reduction, wound infection, compartment syndrome, and malunion.^{23,24} The current study was limited to complications that occurred during the inpatient stay, which may explain why no difference in musculoskeletal complications was observed between groups.

The results of this study should be interpreted in light of several limitations. We identified the patient population by query of institutional trauma registries for patients with femur and tibia fracture sustained in high-energy blunt trauma, therefore our results may not be generalizable to pediatric patients with lower extremity long bone fracture due to lower energy mechanisms. Another limitation is that we used WFA% instead of BMI, which could theoretically lead to misclassification of obesity. The use of WFA% was necessary because heights were not available for 16.6% of patients, and many of the heights were parent reported rather than directly measured. Excluding the patients without recorded heights would have introduced selection bias, as they had a higher rate of mortality than those with recorded heights. Further, parent reported heights tend to be underestimates, which could lead to overestimating the rate of obesity.^{8,25} Previous studies of pediatric injury patterns and orthopedic outcomes have used WFA% to classify patients as obese or non-obese when height data is not routinely recorded in the medical chart.^{7,23}

An additional limitation was the absence of complete data on pre-existing co-morbidities. We were unable to determine reliably whether the groups differed in terms of important co-

morbidities such as asthma, diabetes, smoking, etc, due to the retrospective chart review study design. Further, obesity related co-morbidities are often not diagnosed until adolescence or adulthood, and so may be under recognized in the 2-14 year patient population of the present study (e.g. adolescent diabetes is diagnosed at an average age of 13.^{8,26}). Finally, important crash factors such as the use of vehicle restraints, restraint type, number of occupants, and impact direction and velocity were not controlled for in the analysis of injury patterns and severity.

To our knowledge this is the first study demonstrating an association between obesity and ISS, hospital length of stay, and mortality in pediatric blunt trauma patients with lower extremity long bone fractures. Obese pediatric patients with femur and tibia fractures may represent an at risk population of patients, presenting with more severe injuries after blunt trauma. More severe injuries may predispose them to greater inpatient morbidity and mortality. Obesity alone was not associated with poor outcomes; however, additional studies utilizing larger patient populations with more detailed mechanistic and anthropometric data will be needed to further assess the association between pediatric obesity and traumatic outcomes.

Acknowledgments

Funding: Ian C. Backstrom was funded by an NIH training grant through the University of Alabama at Birmingham Center for Clinical and Translational Science: grant # 5UL1 RR025777

REFERENCES

1. Ogden CL, Carroll MD, Curtin LR, Lamb MM, et al. Prevalence of high body mass index in US children and adolescents, 2007-2008. *JAMA*. 2010; 303(3):242-249. [PubMed: 20071470]
2. Dietz WH. Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics*. 1998; 101(3 Pt 2):518-525. [PubMed: 12224658]
3. Chan G, Chen CT. Musculoskeletal effects of obesity. *Curr. Opin. Pediatr*. 2009; 21(1):65-70. [PubMed: 19242242]
4. Valadka S, Poenaru D, Dueck A. Long-term disability after trauma in children. *J. Pediatr. Surg*. 2000; 35(5):684-687. [PubMed: 10813323]
5. Rana AR, Michalsky MP, Teich S, et al. Childhood obesity: a risk factor for injuries observed at a level-1 trauma center. *J. Pediatr. Surg*. 2009; 44(8):1601-1605. [PubMed: 19635312]
6. Haricharan RN, Griffin RL, Barnhart DC, et al. Injury patterns among obese children involved in motor vehicle collisions. *J. Pediatr. Surg*. 2009; 44(6):1218-1222. discussion 1222. [PubMed: 19524744]
7. Pomerantz WJ, Timm NL, Gittelman MA. Injury patterns in obese versus nonobese children presenting to a pediatric emergency department. *Pediatrics*. 2010; 125(4):681-685. [PubMed: 20194280]
8. Zonfrillo MR, Nelson KA, Durbin DR, et al. The association of weight percentile and motor vehicle crash injury among 3 to 8 year old children. *Ann Adv Automot Med*. 2010; 54:193-199. [PubMed: 21050602]
9. Brown CVR, Neville AL, Salim A, et al. The impact of obesity on severely injured children and adolescents. *J. Pediatr. Surg*. 2006; 41(1):88-91. discussion 88-91. [PubMed: 16410114]
10. Buckley SL, Gotschall C, Robertson W, et al. The relationships of skeletal injuries with trauma score, injury severity score, length of hospital stay, hospital charges, and mortality in children admitted to a regional pediatric trauma center. *J Pediatr Orthop*. 1994; 14(4):449-453. [PubMed: 8077425]
11. Anon. [Accessed June 14, 2011] CDC - Growth Charts - Clinical Growth Charts. Available at: http://www.cdc.gov/growthcharts/clinical_charts.htm
12. Anon. [Accessed June 14, 2011] CDC - Proposed Matrix of E-code Groupings. Available at: http://www.cdc.gov/injury/wisqars/ecode_matrix.html

13. Anon. [Accessed December 10, 2010] CDC - Injury - WISQARS (Web-based Injury Statistics Query and Reporting System). Available at: <http://www.cdc.gov/injury/wisqars/index.html>
14. Anon. [Accessed May 31, 2011] National Survey of Children's Health. National Survey of Children's Health. Available at: <http://www.nschdata.org/content/07obesityreportcards.aspx>
15. Brown CVR, Neville AL, Rhee P, et al. The impact of obesity on the outcomes of 1,153 critically injured blunt trauma patients. *J Trauma*. 2005; 59(5):1048–1051. discussion 1051. [PubMed: 16385276]
16. Ryb GE, Dischinger PC. Injury severity and outcome of overweight and obese patients after vehicular trauma: a crash injury research and engineering network (CIREN) study. *J Trauma*. 2008; 64(2):406–411. [PubMed: 18301206]
17. Arbabi S, Wahl WL, Hemmilla MR, et al. The cushion effect. *J Trauma*. 2003; 54(6):1090–1093. [PubMed: 12813327]
18. Trifiletti LB, Shields W, Bishai D, et al. Tipping the scales: obese children and child safety seats. *Pediatrics*. 2006; 117(4):1197–1202. [PubMed: 16585315]
19. Gettys FK, Jackson JB, Frick SL. Obesity in pediatric orthopaedics. *Orthop. Clin. North Am.* 2011; 42(1):95–105. vii. [PubMed: 21095438]
20. Kasser, JRBJ. Rockwood and Wilkins' Fractures in Children. sixth edition. Lippincott Williams and Wilkins; 2006. Femoral Shaft Fractures; p. 893-934.
21. Bochicchio GV, Joshi M, Bochicchio K, et al. Impact of obesity in the critically ill trauma patient: a prospective study. *J. Am. Coll. Surg.* 2006; 203(4):533–538. [PubMed: 17000398]
22. Maheshwari R, Mack CD, Kaufman RP, et al. Severity of injury and outcomes among obese trauma patients with fractures of the femur and tibia: a crash injury research and engineering network study. *J Orthop Trauma*. 2009; 23(9):634–639. [PubMed: 19897984]
23. Leet AI, Pichard CP, Ain MC. Surgical treatment of femoral fractures in obese children: does excessive body weight increase the rate of complications? *J Bone Joint Surg Am.* 2005; 87(12):2609–2613. [PubMed: 16322608]
24. Weiss JM, Choi P, Ghatan C, et al. Complications with flexible nailing of femur fractures more than double with child obesity and weight >50 kg. *J Child Orthop.* 2009; 3(1):53–58. [PubMed: 19308613]
25. Akinbami LJ, Ogden CL. Childhood overweight prevalence in the United States: the impact of parent-reported height and weight. *Obesity*. 2009; 17(8):1574–80. [PubMed: 19629061]
26. Pinhas-Hamiel O, et al. Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. *J. Pediatr.* 1996; 1996; 128:608–615. [PubMed: 8627431]

A

B

C

D

Figure 1. Femur fracture treatment selection. Pretreatment (*A, C*) and posttreatment (*B, D*) roentgenograms of two 5-year-old patients with similar femoral shaft fractures. The obese patient (*A, B*) was treated with intramedullary rods, whereas the nonobese patient (*C, D*) was managed with a spica cast. Note the distance from the bone to the surface of the soft tissue.

TABLE 1

Demographic and Mechanism of Injury Characteristics of Obese and Nonobese Pediatric Patients

	Obese (n = 78)	Nonobese (n = 278)	p
Age, mean (SD), y	9.9 (3.7)	8.8 (3.9)	0.0162
Race, n (%)			0.8132
White	41 (52.6)	143 (51.4)	
African American	33 (42.3)	115 (41.4)	
Other	5 (5.1)	20 (7.2)	
Sex, n (%)			0.9369
Male	52 (66.7)	184 (66.2)	
Female	26 (33.3)	94 (33.8)	
Mechanism of injury, n (%)			0.3921
Motor vehicle collision	41 (52.6)	118 (42.5)	
Pedestrian	18 (23.1)	85 (30.6)	
Transportation other	11 (14.1)	43 (15.5)	
Fall	1 (1.28)	11 (4.0)	
Other*	7 (9.0)	21 (7.6)	

* Additional E-code categories classified as Other include motor vehicle traffic motorcyclist, motor vehicle traffic other, pedal cyclist other, pedestrian other, other specified/not otherwise classifiable, nature/environment, and struck by/against.

TABLE 2

Obese and Nonobese Pediatric Patient Injuries

	Obese (n = 78)	Nonobese (n = 278)	p
ISS, mean (SD)	20.8 (13.4)	14.5 (10.8)	0.0002
AIS score 3, n (%)			
Head and neck	24 (30.8)	53 (19.1)	0.0265
Chest	29 (37.2)	53 (19.1)	0.0008
Abdomen	10 (12.8)	18 (6.5)	0.0658
Extremity	55 (70.5)	159 (57.2)	0.0338
Intra-abdominal solid organ injury, n (%)	19 (24.4)	37 (13.5)	0.0200
Intra-abdominal hollow viscus injury, n (%)	3 (3.9)	0 (0.0)	0.0105 *
Pelvic fracture, n (%)	12 (15.4)	19 (6.9)	0.0196
Spinal column, n (%)	10 (12.8)	18 (6.6)	0.0703
Femur fracture, n (%)	61 (78.2)	189 (68.0)	0.0811
Open	4 (6.6)	19 (10.1)	0.4115
Bilateral	9 (14.8)	14 (7.4)	0.0843
Multiple same bone	3 (3.9)	3 (1.1)	0.1220
Tibia fracture, n (%)	25 (32.1)	110 (39.6)	0.2266
Open	10 (40.0)	29 (26.4)	0.1745
Bilateral	2 (8.0)	0 (0.0)	0.0332 *
Multiple same bone	0 (0.0)	5 (4.6)	0.5837 *
Femur and tibia fracture, n (%)	9 (11.5)	22 (7.9)	0.3157

* Fisher's exact test.

TABLE 3**Obese and Nonobese Pediatric Patient Fracture Treatment**

Treated Fractures	Obese	Nonobese	<i>p</i>	Age-Adjusted <i>p</i>
Femur, * n (%)	69	201		
Operative	62 (89.9)	159 (79.1)	0.0456	0.0484
Tibia, † n (%)	26	111		
Operative	9 (34.6)	28 (25.2)	0.3317	0.6249
Total, n (%)	95	312		
Operative	71 (74.7)	187 (59.9)	0.0087	0.0220

* Eight femur fractures were excluded from the analysis because the patient died before treatment, and one femur fracture was excluded because the treatment was amputation

† Four tibia fractures were excluded from the analysis because the patient died before treatment, and one tibia fracture was excluded because the treatment data were not recorded.

TABLE 4

Hospitalization Characteristics of Obese and Nonobese Pediatric Patients

	Obese (n = 78)	Nonobese (n = 278)	<i>p</i>
Length of stay, mean (SD)	9.6 (8.8)	6.9 (8.8)	0.0410
ICU admission, n (%)	32 (41.6)	73 (26.3)	0.0092
Days, mean (SD)	4.2 (5.3)	5.1 (5.5)	0.4588
Ventilation, n (%)	18 (23.4)	45 (16.2)	0.1439
Days, mean (SD)	4.6 (5.2)	5.1 (5.4)	0.7367
Musculoskeletal complication, n (%)	4 (5.1)	8 (2.9)	0.3047 *
Compartment syndrome, n (%)	2 (2.6)	3 (1.1)	0.3019 *
Wound infection, n (%)	2 (2.6)	1 (0.4)	0.1222 *
Refracture/loss of reduction, n (%)	0 (0.0)	3 (1.1)	1.0000 *
Decubitus ulcer, n (%)	0 (0.0)	1 (0.4)	1.0000 *
Mortality, n (%)	6 (7.7)	7 (2.5)	0.0423 *

* Fisher's exact test.

TABLE 5

RRs and 95% CIs for ICU Admission, Mechanical Ventilation, and Mortality for Obese and Nonobese Pediatric Patients

	Unadjusted RR (95% CI)	Age-Adjusted RR (95% CI)	Age- and ISS-Adjusted RR (95% CI)
ICU admission	1.56 (1.03–2.37)	1.68 (1.10–2.55)	1.12 (0.72–1.75)
Ventilation	1.46 (0.83–2.46)	1.57 (0.90–2.73)	0.84 (0.46–1.54)
Mortality	3.06 (1.03–9.09)	3.45 (1.14–10.41)	1.54 (0.43–5.46)

TABLE 6

Mean ICU Length of Stay, Days on Mechanical Ventilation, and Hospital Length of Stay Adjusted for Age and ISS

	Mean Adjusted for Age			Mean Adjusted for Age and ISS		
	Obese	Nonobese	<i>p</i>	Obese	Nonobese	<i>p</i>
ICU length of stay, d	4.21	5.07	0.4613	3.83	5.24	0.2075
Ventilator, d	4.62	5.11	0.7495	4.34	5.22	0.5567
Length of stay, d	9.67	6.87	0.0188	7.55	7.47	0.9349