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Childhood obesity: a risk factor for injuries observed at a level-1 trauma center

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Abstract

Purpose—Obesity is an independent risk factor in trauma-related morbidity in adults. The purpose of this study was to investigate the effect of obesity in the pediatric trauma population.

Methods—All patients (6-20 years) between January 2004 and July 2007 were retrospectively reviewed and defined as non-obese (body mass index [BMI] <95th percentile for age) or obese (BMI ≥95th percentile for age). Groups were compared for differences in demographics, initial vital signs, mechanisms of injury, length of stay, intensive care unit stay, ventilator days, Injury Severity Score, operative procedures, and clinical outcomes.

Results—Of 1314 patients analyzed, there were 1020 (77%) nonobese patients (mean BMI = 18.8 kg/m^2) and 294 (23%) obese patients (mean BMI = 29.7 kg/m^2). There was no significant difference in sex, heart rate, length of stay, intensive care unit days, ventilator days, Injury Severity Score, and mortality between the groups. The obese children were significantly younger than the nonobese children (10.9 ± 3.3 vs 11.5 ± 3.5 years; $P = .008$) and had a higher systolic blood pressure during initial evaluation (128 ± 17 vs 124 ± 16 mm Hg, $P < .001$). In addition, the obese group had a higher incidence of extremity fractures (55% vs 40%; $P < .001$) and orthopedic surgical intervention (42% vs 30%; $P < .001$) but a lower incidence of closed head injury (12% vs 18%; $P = .013$) and intraabdominal injuries (6% vs 11%; $P = .023$). Evaluation of complications showed a higher incidence of decubitus ulcers ($P = .043$) and deep vein thrombosis ($P = .008$) in the obese group.

Conclusion—In pediatric trauma patients, obesity may be a risk factor for sustaining an extremity fracture requiring operative intervention and having a higher risk for certain complications (ie, deep venous thrombosis [DVT] and decubitus ulcers) despite having a lower incidence of intracranial and intraabdominal injuries. Results are similar to reports examining the effect(s) of obesity on the adult population.

Keywords

Childhood obesity; Trauma; Outcomes

Recent population-based data have shown that 61% of adults in the United States are obese, as defined by a body mass index (BMI) greater than or equal to 30 kg/m^2, with an associated

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rise in the age-adjusted prevalence of 22.9% in 1980 to 30.5% in 2000. These data correspond to an increasing rate of obesity of approximately 1% annually [1]. As demonstrated by recent data from the National Health and Nutrition Examination Survey (NHANES 2003-2004), there has been a nearly 4-fold rise in the prevalence of the pediatric age group from approximately 4% in the mid 1960s to 17% in 2004 among children and adolescents between the ages of 2 and 19 years in the United States. These data make the pediatric age group the fastest growing subpopulation of obese individuals in the this country [2]. In addition to the wide-ranging impact of obesity on society and the health care delivery system, recent data have highlighted the adverse effects of obesity on critically ill adult trauma victims [3-6]. Despite an increasing body of literature examining the effects of obesity on the adult population, there remains a paucity of data examining the potential obesity-related effects on the management and outcomes in children and adolescents with traumatic injury. Therefore, the purpose of this study is to examine the relationship between obesity and mechanisms of injury as well as clinical outcomes for patients cared for at a regional pediatric level-1 trauma center.

1. Methods

After obtaining approval from the Institutional Review Board at Nationwide Children's Hospital, Columbus, OH, a retrospective analysis of the patient medical records as well as the institutional electronic trauma database was performed to evaluate all admitted trauma patients between the ages of 6 and 20 years from January 2004 to July 2007. Individual admission height (cm) and weight (kg) were used to calculate the BMI for each subject. Charts of patients with BMI values greater than or equal to 8 standard deviations from the mean underwent repeat review to verify accurate height and weight measurements. Patients were subsequently stratified by BMI as either nonobese (BMI <95th percentile for age) or obese (BMI ≥95th percentile for age). The groups were compared according to age, sex, BMI, admission vital signs, Glasgow Coma Scale (GCS), Injury Severity Score (ISS), mechanism of injury (ie, blunt, penetrating or burn), specific type of injury, Abbreviated Injury Score (AIS) for each body region, length of stay (LOS) in hospital, days in the intensive care unit (ICU), ventilator days, complications, and type of surgical intervention (craniotomy, laparotomy, thoracotomy, or orthopedic procedure). Complications reviewed included pneumonia, deep venous thrombosis, pulmonary embolism, bacteremia, acute renal failure, decubitus ulcers, wound infection, and intestinal fistula.

2. Statistical analysis

Statistical analysis was performed using SPSS Version 15 (Chicago, IL). Results are presented as mean ± standard deviation or raw percentage. Analysis variance and Pearson χ^2 analysis were used to compare groups when appropriate. Post hoc comparison was done with 2 keys adjustment for comparison and adjusting standard residual for frequency data. Statistical significance was assigned at $P < .05$.

3. Results

During the study period, there were 4853 pediatric trauma patients admitted to Nationwide Children's Hospital. A retrospective review of all associated patient records, as well as the institutional electronic trauma database, revealed that 73% of patients did not have a documented height and/or weight, making calculation of BMI impossible. A total of 1314 trauma patients had documented heights and weights enabling the calculation of BMI and inclusion into this study. There were 1020 (77%) nonobese patients with a mean BMI of 18.8 kg/m^2 and 294 (23%) obese patients with a mean BMI of 29.7 kg/m^2. The obese children were significantly younger than the nonobese children (10.9 vs 11.5 years; $P = .$

008). As seen in Table 1, comparison of the obese to nonobese cohorts failed to demonstrate significant differences in sex distribution, admission heart rate, GCS, ISS, or distribution of traumatic injury mechanism (ie, blunt, penetrating, or burn). Results did reveal a significantly higher systolic blood pressure at the time of admission among the obese patients in comparison to their nonobese counterparts (128 vs 124 mm Hg; $P < .001$).

Although both groups demonstrate similar ISS scores (8.2 vs 7.6), as well as similar AIS scores for various body regions, analysis of specific injury patterns showed several unique differences. As shown in Table 2, the obese subjects had a significantly higher incidence of extremity fractures compared to the nonobese group (55% vs 40%; $P < .001$), whereas the nonobese children had a significantly higher incidence of traumatic brain injuries (18% vs 12%; $P = .013$) and intraabdominal injuries (11% vs 6%; $P = .023$). In addition, there was a trend toward a higher incidence of thoracic injuries (ie, pneumothorax, hemothorax, pulmonary contusion, rib fractures, cardiac injury, and aortic injury) in the nonobese pediatric trauma patients (6% vs 3%; $P = .06$). All other injury types, including pelvic fractures, spine fractures, and burns, were similar between the groups.

Further analysis examining the specific types of surgical intervention performed (Table 3) showed similar frequencies with regard to craniotomy (1% vs. 2%), thoracotomy (0.5% vs 0%), and laparotomy (2% vs 2%). Interestingly however, comparison of treatment outcomes of all extremity fractures (obese and nonobese patients) demonstrates a significantly higher frequency of operative vs closed reduction in the obese subpopulation compared to the nonobese patients with extremity fractures (42% vs 30%; $P < .001$).

Finally, analysis of total hospitalization and associated complications showed no differences in total LOS (2.6 vs 2.9 days), ICU admission (0.4 vs 0.7 days), incidence of pneumonia, intraabdominal complications, wound infections, pulmonary embolism, and acute renal failure. Obese patients, however, were more likely to sustain a decubitus ulcer (1% vs 0.2%; $P = .04$) and deep vein thrombosis (0.7% vs 0%; $P = .008$). Mortality was equivalent in both groups, with one death in each.

4. Discussion

The prevalence of obesity continues to increase in the United States and is especially prevalent among children, adolescents, and men [2]. Although the overall impact of obesity with regard to trauma-related morbidity, mortality, and long term outcomes in the adult trauma literature remains uncertain, recent literature demonstrates unique patterns of injury and related complications [5-7]. In a recent review of 1179 adult trauma patients, Byrnes et al [8] demonstrated that mortality and posttraumatic complications were significantly more common in obese vs nonobese trauma patients. In addition, the obese group was shown to have a 50% higher incidence of complications and was 2.8 times more likely to die after having traumatic injury. No differences were observed in the distribution of the injury patterns (traumatic brain injury, chest injury, extremity fracture, and so forth) [8]. In an effort to characterize the physiologic effects of obesity on adult trauma victims, Belzberg et al [9] examined several hemodynamic and physiologic parameters (ie, cardiac index, mean arterial pressure, transcutaneous oxygen tension, transcutaneous carbon dioxide tension, and oxygen delivery) and concluded that obesity may be a risk factor for low tissue perfusion and low oxygenation during times of stress. Although no differences in mortality were observed in this series, the identification of potential obesity-related pathophysiological differences, as stated above, may begin to offer an explanation for the increased incidence of overall complications and a longer LOS that were reported. Similarly, Neville et al [3] in a recent case-control study of 242 obese and nonobese adult trauma patients admitted to the ICU, again, showed no significant differences regarding injury patterns and ISS; however,

they concluded that the obese group was more likely to experience multiple organ failure (13% vs 3%; $P = .02$) and related mortality (32% vs 16%; $P = .008$).

Despite an increasing body of literature examining the potential impact of obesity on trauma-related mechanisms and outcomes, there remains a relative paucity of data examining the effects of obesity on the pediatric trauma population [3-6,8,10]. In a recent retrospective analysis of 316 severely injured pediatric trauma patients requiring admission to the ICU, Brown et al [11] demonstrated a higher incidence of overall complications (41% vs 26%; $P = .006$) and longer ICU stays (8 ± 9 vs 6 ± 6 days; $P = .05$) among patients defined as obese despite similar ISS results. Although no significant differences in patterns of injury were identified, possibly because of the relatively small number of subjects reported in this series, the authors did report a trend toward fewer head injuries among the obese pediatric patients [11].

Unlike previous report, which reviewed the obesity-related outcomes among critically ill pediatric trauma patients requiring ICU admission, the present study sought to review the impact of obesity on all patients admitted to the pediatric trauma service at our institution. Furthermore, instead of using the conventional stratification methodology commonly reported in the current literature examining the adult trauma population (ie, BMI), we conducted this retrospective analysis using BMI percentile. This specific nomenclature was chosen as the best measure of childhood obesity because it utilizes the ease of calculation of the BMI using height and weight (2 readily measured variables) and then compares this to the Centers for Disease Control BMI-for-age growth charts (for males and females) to obtain a percentile ranking. The percentile ranking demonstrates the relative position of the child's BMI among children of the same age and sex. These variables are important when assessing childhood obesity because the amount of body fat predictably changes with age and differs between males and females. The percentile rank takes these variables into account and improves the reliability of the BMI measurement. When interpreting the BMI percentile, healthy weight is defined as 5th to <85th percentile, overweight is 85th to <95th percentile, and obese is >95% [12-16].

Results of the present study show no difference in hospital mortality, ICU admission, or LOS between the obese and nonobese groups. In addition, there was no difference in ISS, AIS, or GCS between the groups, which is similar to the adult literature [3,4]. Pediatric obesity was, however, found to be a risk factor for the development of decubitus ulcers and deep vein thrombosis. These findings support the data in the adult trauma literature describing obesity as a risk factor for complications [8,10]. Although both patient cohorts (obese and nonobese) had similar ISS and AIS scores, the higher incidence of extremity fractures and lower incidence of intracranial and intraabdominal injuries observed are similar to reports examining the adult trauma population. Specifically, Boulanger et al [17] conducted a prospective analysis of 6368 adult patients with 743 obese patients (BMI ≥30 kg/m^2), which reported that obese patients were more likely to have extremity fractures and less likely to have head injuries or liver injuries. Another study by Arbabi et al [18] examined the possibility of a "cushion effect" by analyzing the outcomes of adult and pediatric blunt trauma patients and found obesity to be an independent predictor of increased severity of an extremity injury. In addition, obesity was found to be an independent predictor of a fatal outcome after a motor vehicle crash [18].

Although a clear explanation for the association between obesity and the increased prevalence of extremity fractures remains uncertain, possible explanations include the potential effect of increased patient body mass on patterns of force and energy transfer, resulting in an increased propensity for extremity injuries as a result of blunt trauma [18]. In addition, it has been suggested that differences in energy transmission during blunt trauma

may also be the result of obesity-related alterations in the effectiveness of passive restrain mechanisms (ie, seat belts) resulting in less protection against injury [11].

The requirement for an operation was also reviewed in this study. When compared to nonobese patients with extremity fractures, the obese patients with extremity fractures were more likely to require an “operative” intervention, as opposed to “nonoperative” or “closed” reduction, despite similar AIS results. This observation is similar to several reports in the current literature examining the adult population. Specifically, in a prospective analysis of adult trauma patients, Spaine and Bollen [19] found that the obese patients had a significantly higher incidence of displaced ankle fractures requiring an operation as compared with the nonobese group. In addition, Bostman [20,21] demonstrated obesity to be a predisposing risk factor for displaced ankle and elbow fractures in a cross sectional study of 4012 patients and, in addition, reported evidence predicting failure in closed orthopedic reduction technique as well as higher postoperative complication rate. The authors concluded that a higher BMI may result in the transfer of additional stress force on the extremity, leading to more severe injuries resulting in operative repair and an increased risk of associated morbidity. Although the obese patients reviewed in our study did not have more severe extremity fractures (AIS ≥3) compared to the non-obese subjects, obesity may have an impact on the severity of fractures sustained during trauma requiring an operative intervention.

In summary, this report represents one of the first studies to provide a comprehensive overview of the relationship between obesity, patterns of injury, and trauma-related outcomes in the pediatric population. The current study demonstrates that obesity does affect the outcome of pediatric trauma patients and is associated with an increased risk of sustaining extremity fractures requiring orthopedic intervention. In addition, obese patients are more likely to experience specific trauma-related complications (ie, decubitus ulcers and deep venous thrombosis). Recognition of these associated clinical trends may help to increase focused health care delivery efficiency and clinical outcomes at centers treating pediatric trauma victims. In addition, this analysis highlights the need to obtain accurate BMI on all patients. Study limitations include sample size and a possible selection bias because of the elimination of a large number of individuals without documented heights for calculation of BMI. The data are derived from a limited fraction of the trauma patients treated during the study period; however, this again shows the need for pediatric institutions to improve their system for recording height and weight because it may assist in addressing clinical outcomes as shown in this study.

As rates of obesity increase in the United States, this study serves as yet an additional “call to arms” with regard to directing medical efforts to reduce the incidence of pediatric obesity. Additional studies examining the relationship between obesity and trauma in the pediatric population, with specific focus on injury prevention, are needed to improve treatment outcomes among this challenging population of patients.

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Table 1

Admission characteristics

	Nonobese (n = 1020)	**Obese (n = 294)**	***P***
Sex, n (%)			
Male	671 (66)	206 (70)	.2
Female	349 (34)	88 (30)	
BMI (mean)	18.8	29.7	<.001
Heart rate (beat/min)	96 ± 20	98 ± 19	.1
Systolic blood pressure (mm Hg)	124 ± 16	128 ± 17	<.001
GCS	14.5 ± 1.5	14.7 ± 2.3	.1
ISS	8.2 ± 5.9	7.6 ± 6.2	.2
LOS (d)	2.6 ± 5	2.9 ± 10	.5
Trauma mechanism, n (%)			
Blunt	850 (83)	260 (88)	.9
Penetrating	100 (10)	20 (7)	
Burn	70 (7)	14 (5)	

Table 2

Analysis of injury patterns in nonobese and obese patients

Injury	Nonobese (n = 1020)	Obese (n = 294)	*P*
Head injury	180 (18)	34 (12)	.01
Head AIS≥3	90 (50)	16 (47)	.8
Chest injury	64 (6)	10 (3)	.06
Chest AIS ≥3	26 (41)	2 (20)	.2
Abdominal injury	112 (11)	19 (6)	.02
Abdominal AIS ≥3	70 (63)	11 (58)	.7
Pelvic fracture	34 (3)	9 (3)	.8
Extremity fracture	412 (40)	163 (55)	<.001
Extremity AIS ≥3	140 (34)	62 (38)	.4
Spine fractures	35 (3)	9 (3)	.8
Spine AIS ≥3	26 (74)	6 (67)	.4

Values are expressed as number (percentage).

Table 3

Comparison of operative intervention

	Nonobese, n (%)	Obese, n (%)	*P*
Craniotomy	13 (1)	6 (2)	.3
Thoracotomy	5 (0.5)	0 (0)	.2
Laparotomy	21 (2)	6 (2)	.98
Orthopedic reduction (extremity fracture)	309 (30)	124 (42)	<.001