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Impact of body mass index on outcomes after thoracic trauma—A matched-triplet analysis of the TraumaRegister DGU®

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ABSTRACT

Introduction: Chest trauma and obesity are both associated with increased risks for respiratory complications (e.g. hypoxia, hypercarbia, pneumonia), which are frequent causes of posttraumatic morbidity and mortality. However, as there is only limited and inconsistent evidence, the aim of our study was to analyse the effect of body mass index (BMI) on patient outcomes after thoracic trauma.
Patients and Methods: We screened 50.519 patients entered in TraumaRegister DGU®, between 2004–2009, when the BMI was part of the standardized dataset. After matching for injury patterns and severity of trauma we performed a matched tripled analysis with regard to the BMI (group 1: <25.0 kg/m^2; group 2: 25.0–29.9 kg/m^2; group 3: >30.0 kg/m^2). Data are shown as percentages and mean values with standard deviation.
Results: The matching process yielded a cohort of 828 patients with serious blunt thoracic trauma, evenly distributed over the 3 BMI groups (276 triplets). BMI did not have an impact on the need for prehospital or emergency department interventions. There was a trend towards more liberal use of whole-body-CT scanning with increasing BMI (group 1: 68.8%; group 2: 73.2%; group 3: 75.0%). Additional abdominal injuries were more common in normal weight patients (Group 1: 28.3%; Group 2: 14.9%; Group 3: 17.8%). Obesity (BMI > 30.0 kg/m^2) had a significant impact on the duration of mechanical ventilation (in days; group 1: 6.5 (9.4); group 2: 6.4 (8.9); group 3: 9.1 (14.4); p = 0.002), ICU days (in days; group 1: 11.5 (11.5); group 2: 10.9 (9.6); group 3: 14.1 (16.7); p = 0.005) and hospital length of stay (in days; group 1: 27.8 (19.3); group 2: 27.4 (19.2); group 3: 32.2 (25.9); p = 0.009). There were no significant differences regarding overall mortality (group 1: 3.6%; group 2: 1.8%; group 3: 4.0%; p = 0.26).
Conclusions: Obesity has a negative impact on outcomes after blunt chest trauma, as it is associated with prolonged duration of mechanical ventilation, ICU and hospital length of stay. Mortality did not seem to be affected, yet, further research is required to confirm these results in a larger cohort.

Introduction

Considering the rising prevalence of obesity in the Western world and the fact that obesity is associated with a higher risk for sustaining thoracic injuries in motor-vehicle collisions, the proportion of obese patients with thoracic trauma is likely to increase [1]. Investigating the impact of body mass index (BMI) on outcomes after thoracic injuries is of special interest, as chest trauma and obesity are both associated with increased risks for respiratory complications (e.g. hypoxia, hypercarbia, pneumonia), which are frequent causes of posttraumatic morbidity and mortality. Results of previous studies are controversial. Although obesity increases the incidence of posttraumatic pneumonia [2], data are inconsistent regarding its impact on the incidence of infectious complications in general and sepsis [3,4], as well as overall mortality. Furthermore, there are contradictory reports of both, beneficial and harmful effects on patient outcomes [3,5,6]. Further investigations within a cohort of comparable patients are

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required, to enable clinicians to validly assess posttraumatic risks of overweight and obese patients with thoracic injuries. The aim of our study was to analyse the effect of BMI on patient outcomes after thoracic trauma.

Patients and methods

We accessed the TraumaRegisterDGU® (TR-DGU), to identify cases of thoracic trauma with documented BMI.

The TraumaRegister DGU® of the German Trauma Society was founded in 1993. The aim of this multi-centre database is a pseudonymised and standardized documentation of severely injured patients.

Data are collected prospectively in consecutive time phases from the site of the accident until discharge from hospital. The documentation includes detailed information on demographics, injury pattern, comorbidities, pre- and in-hospital management, course on intensive care unit and outcome of each patient. Trauma patients that are admitted via the emergency room with subsequent ICU/ICM care or reach the hospital with vital signs and die before admission to ICU are included.

The participating hospitals are primarily located in Germany (90%), but a rising number of hospitals of other countries contribute data as well. Currently, approx. 40.000 cases from more than 600 hospitals are entered into the database per year.

Participation in TraumaRegister DGU® is voluntary. For hospitals associated with TraumaNetzwerk DGU®, however, the entry of at least a basic data set is obligatory for reasons of quality assurance.

The present study is in line with the publication guidelines of the TraumaRegister DGU® and registered as TR-DGU project ID 2017-029.

The BMI was part of the TR-DGU dataset for 6 years, between 2004 and 2009. During that period 50.519 cases were entered into the database. We included adult patients (≥18 years of age) with thoracic trauma (abbreviated injury scale $(AIS)_{Thorax} \geq 3$) that were primarily admitted to participating trauma centres in Germany (Fig. 1). Patients that were secondary admissions or later transferred to other hospitals, as well as patients that had severe head trauma ($AIS_{Head} \geq 5$) or unsurvivable thoracic trauma ($AIS_{Thorax} = 6$) were excluded. Furthermore, we excluded cases that had only the mandatory minimal/basic dataset entered or had

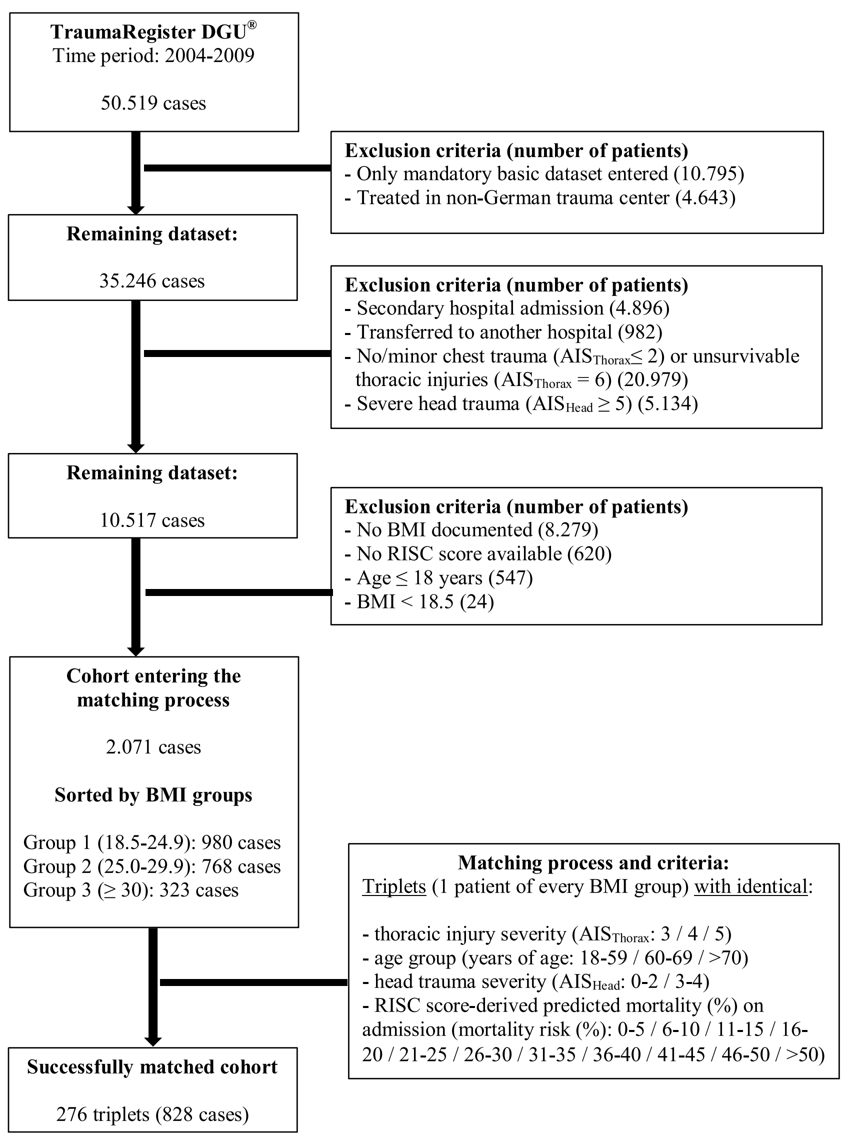

Fig. 1. Flow chart outlining the registry case selection and matching process. Multiple exclusion criteria may have applied to excluded patients.

missing values for BMI or RISC-score. Additionally, given the small number (n = 24) of underweight patients (BMI: < 18.5), this BMI group was excluded from further statistical analysis.

After applying inclusion and exclusion criteria, 2.071 patients entered the matching process. We identified matching triplets, that had comparable age, thoracic injury severity, injury patterns (i.e. prevalence of head trauma) and overall injury severity, as indicated by predicted mortality (RISC score) at hospital admission. Triplets were distinguished by BMI (group 1: normal-weight (BMI: 18.5–24.9); group 2: overweight patients (BMI: 25.0–29.9); group 3: obese patients (BMI: ≥ 30)) (Fig. 1).

Besides describing basic patient characteristics, patterns and mechanism of injury, the need for prehospital interventions, emergency department diagnostics and treatment, the statistical analysis focused on patient outcomes during and after ICU care.

We also described the impact of BMI on patient outcomes in separate subgroups with varying degrees of thoracic injury severity. As the number of patients with AIS_{Thorax} of 5 was relatively small (8,3% of patients), we combined more severely injured AIS_{Thorax} groups 4 and 5.

Differences in patient outcomes between the three groups were evaluated with the Cochrane's Q-test in case of categorical variables, and 2-way-ANOVA in case of continuous measurements. To account for the matching nature of the data, these tests were fitted for two fixed effects (triplet ID and BMI group). A significant ($p < 0.05$) test result means that the hypothesis of identical values in all three groups is unlikely.

Statistical analysis was performed with SPSS Statistics® (IBM Corp., Armonk, USA).

Results

Patients

The matching process yielded a cohort of 828 patients with thoracic trauma, evenly distributed over the 3 BMI groups (276 triplets). Basic patient characteristics are displayed in Table 1. The study groups were identical with respect to the prevalence of serious ($AIS_{Thorax} = 3$; 62.0%), severe ($AIS_{Thorax} = 4$; 29.7%) and critical ($AIS_{Thorax} = 5$; 8.3%) thoracic injuries, as indicated by the AIS classification (Table 1). Across all groups, 22.1% of cases had serious or severe head trauma (AIS_{Head}: 3 or 4). All groups were comparable in age, ISS, initial GCS and predicted mortality at hospital admission (RISC-score) (Table 1). There were fewer male patients in the normal body weight group (Group 1: 76.4%; Group 2: 86.6%; Group 3: 80.4%). Although all study groups were well matched regarding the prevalence and severity of thoracic, head and extremity injuries, abdominal injuries ($AIS_{Abdomen} \geq 3$) were more common in normal weight patients (Group 1: 28.3%; Group 2: 14.9%; Group 3: 17.8%) (Table 1).

Prehospital care

With increasing BMI, road traffic accidents became the most common mechanism of injury (Group 1: 54.7%; Group 2: 60.9%, Group 3: 72.1%). Overall, the need for emergency prehospital interventions, such as chest tube placement or endotracheal intubation was comparable in all study groups (Table 1). The BMI did not influence the duration of prehospital care (accident to

Table 1
Basic characteristics and initial prehospital/emergency department care of the matched study groups (n = 828 patients).

	Group 1 normal weight	Group 2 overweight	Group 3 obese
Results presented as means (SD)			
BMI (kg/m^2)	23.0 (1.5)	27.1 (1.4)	34.7 (5.6)
Age (years)	47.3 (14.7)	47.0 (14.4)	48.0 (4.9)
RISC-score predicted mortality (%)	6.1 (10.3)	5.9 (10.8)	6.0 (10.5)
ISS	25.6 (10.1)	24.5 (9.7)	24.0 (9.6)
Initial GCS	13.2 (3.3)	13.2 (3.2)	13.2 (3.3)
Time: accident to ED admission (min)	69.0 (26.8)	68.6 (28.7)	69.2 (27.8)
Results presented numbers (%)			
Male gender	211 (76.4)	239 (86.6)	222 (80.4)
Injury pattern/ severity at hospital admission			
Road traffic accident	151 (54.7)	168 (60.9)	199 (72.1)
High fall (>3 meters)	59 (21.4)	63 (22.8)	49 (17.8)
Low fall (<3 meters)	19 (6.9)	12 (4.3)	10 (6.9)
Other mechanism of injury	47 (17.0)	33 (12.0)	18 (6.5)
ISS ≥ 16 (multiple trauma)	233 (84.4)	228 (82.6)	226 (81.9)
Systolic BP < 90 mmHg	22 (8.0)	19 (7.2)	28 (10.4)
Initial GCS ≤ 8	31 (11.7)	29 (10.7)	30 (11.1)
$AIS_{Thorax} = 3$[a]	171 (62.0)	171 (62.0)	171 (62.0)
$AIS_{Thorax} = 4$[a]	82 (29.7)	82 (29.7	82 (29.7)
$AIS_{Thorax} = 5$[a]	23 (8.3)	23 (8.3)	23 (8.3)
$AIS_{Abdomen} \geq 3$	78 (28.3)	41 (14.9)	49 (17.8)
$AIS_{Extremities} \geq 3$	110 (39.9)	105 (38.0)	103 (37.3)
$AIS_{Head} = 3$ / 4[a]	61 (22.1)	61 (22.1)	61 (22.1)
Prehospital and emergency department (ED) care			
Endotracheal intubation (prehospital)	60 (22.0)	55 (20.4)	57 (21.3)
Chest tube placement (prehospital)	27 (9.9)	34 (12.4)	28 (10.2)
Endotracheal intubation (ED)	125 (45.8)	129 (48.0)	115 (42.9)
Chest tube placement (ED)	102 (37.9)	82 (31.4)	83 (31.1)
Vasopressor support (ED)	69 (25.7)	57 (21.8)	75 (28.1)
Cardiopulmonary resuscitation (ED)	5 (1.9)	8 (3.1)	8 (3.1)
Chest X-ray	174 (63.0)	177 (64.1)	169 (61.2)
Multislice whole body CT	190 (68.8)	202 (73.2)	207 (75.0)
FAST ultrasound abdomen	238 (86.2)	234 (84.8)	231 (83.7)

AIS = abbreviated injury scale FAST = focused assessment with sonography for trauma.
[a] =matching criteria.

hospital arrival) (Table 1) or the choice of transportation vehicle (transport by air ambulance in %: group 1: 35.3; group 2: 42.1; group 3: 35.1).

Emergency room care

Across all groups, most patients (84.9%) were treated in level 1 trauma centres. Looking at diagnostic techniques (chest X-ray, FAST, CT), no differences were detected between the BMI groups, although there was a trend towards more liberal use of whole-body-CT scanning with increasing BMI (group 1: 68.8%; group 2: 73.2%; group 3: 75.0%) (Table 1).

The need for ED emergency interventions, such as endotracheal intubation, vasopressor support or cardiopulmonary resuscitation was comparable (Table 1). In normal weight patients the placement of chest tubes in the ED tended to be more common (group 1: 37.9%; group 2: 31.4%; group 3: 31.1%).

After initial ED care, most patients were transferred to the ICU (group 1: 50.2%; group 2: 57.0%; group 3: 46.7%) or taken to the operating room (group 1: 41.2%, group 2: 38.2%; group 3: 43.2%).

ICU and hospital course

Looking at ICU care, the BMI did not seem to influence transfusion requirements, the incidence of multiple organ failure or sepsis (Table 2). Obesity (BMI > 30.0 kg/m^2) had a negative impact on the duration of mechanical ventilation (in days; group 1: 6.5 (9.4); group 2: 6.4 (8.9); group 3: 9.1 (14.4); p = 0.002), ICU days (in days; group 1: 11.5 (11.5); group 2: 10.9 (9.6); group 3: 14.1 (16.7); p = 0.005) and hospital length of stay (in days; group 1: 27.8 (19.3); group 2: 27.4 (19.2); group 3: 32.2 (25.9); p = 0.009). There were no significant differences regarding overall hospital mortality (group 1: 3.6%; group 2: 1.8%; group 3: 4.0%; p = 0.26).

The results of a descriptive analyses looking at separate subgroups with different degrees of thoracic injury severity are presented in Table 3 (supplementary material).

Discussion

As obesity and thoracic trauma both increase odds for posttraumatic complications, we investigated how these conditions interact and whether the BMI influences outcomes of patients with serious to critical blunt thoracic trauma. In our matched cohort of 828 patients, obesity (BMI > 30.0 kg/m^2) affected major outcome parameters.

Considering the implications of obesity and thoracic injuries on respiratory functions independently, the negative impact on the duration of mechanical ventilation, ICU and hospital length of stay are not unexpected in such a high-risk cohort.

The comparability of our findings to previous studies is limited by the fact that most trials analysing the impact of BMI on trauma outcomes, do not focus exclusively on patients with thoracic injuries and include patients with unselected injury patterns. Furthermore, not all BMI subgroups are present in all previous studies. We identified only 2 studies that analysed the impact of obesity on thoracic injuries [5,7]. These retrospective analyses state that obesity is associated with higher rates of endotracheal intubation [7], prolonged duration of mechanical ventilation [7] and increased hospital length of stay [5]. However, they did not match study groups for basic patient characteristics or injury severity and provide only very limited data on clinical outcomes of different BMI groups. Apart from reported differences in endotracheal intubation rates, these results are in accordance with our findings, yet, considering the different methodologic approaches, the comparability to our study may be limited.

In our trial, we found lower rates of abdominal injuries with increasing BMI values. Previous studies indicate that obesity has a significant impact on injury patterns, predisposing obese patients to chest and lower extremity injuries, while reducing the risk of head and abdominal injuries [8–13]. These differences are attributed to a protective cushioning effect of an obese abdomen and the fact that regular airbag and seat-belt safety systems are generally built and tested for occupants with a height of 175 cm and a BMI of 24.3 kg/m^{2,} [14]. Deviations from these parameters are associated with different injury pattern and higher fatality rates [14].

Given the lack of previous data on the impact of BMI on thoracic trauma, we also looked at trials investigating the role of BMI in multiple trauma patients with non-specified injury patterns.

In accordance with our findings, previous data from a large prospective study (n = 1435) suggests that obesity does not increase the need for emergency endotracheal intubation after trauma [15].

Despite heterogeneous evidence, increased BMI have been shown to be associated with prolonged mechanical ventilation [11,16], ICU [11,16–19] and hospital length of stay [11,20,21]. While these findings are comparable to the results of our study, a recent meta-analysis could only demonstrate a significant negative impact of obesity on ICU LOS and mortality [19].

We found the lowest mortality rate in the overweight patient group. Comparing our findings with other trials, however, is difficult, as study groups in previous analyses were rarely matched for initial injury severity, injury pattern or age. Furthermore, there is marked heterogeneity regarding overall trauma severity, patient selection and BMI ranges used throughout previous trials, making valid comparisons impossible. Hence, data of previous trials are inconsistent, demonstrating a negative [6,18–20,22,23], neutral/non-significant [9,11,16,17,24–28] or even beneficial [4] impact of increased BMI values on trauma mortality.

Table 2
Impact of BMI on patient outcomes after thoracic trauma.

	Group 1 $_{\text{normal weight}}$	Group 2 $_{\text{overweight}}$	Group 3 $_{\text{obese}}$	p
Results presented as numbers (%)				
Hospital mortality	10 (3.6)	5 (1.8)	11 (4.0)	0.26
Multiple organ failure	65 (23.6)	58 (21.0)	64 (23.2)	0.72
Sepsis	28 (10.1)	16 (5.8)	26 (9.4)	0.14
Results presented as means (SD)				
Days of mechanical ventilation	6.5 (9.4)	6.4 (8.9)	9.1 (14.4)	0.002
ICU length of stay	11.5 (11.5)	10.9 (9.6)	14.1 (16.7)	0.005
Hospital length of stay	27.8 (19.3)	27.4 (19.2)	32.2 (25.9)	0.009
PRBC units	2.3 (6.7)	1.5 (4.0)	2.1 (5.8)	0.16
FFP units	1.6 (4.7)	1.3 (4.3)	1.6 (4.6)	0.58

PRBC = packed red blood cells.
FFP = fresh frozen plasma.

In obese patients, there are several factors that may complicate weaning from mechanical ventilation and increase the duration of mechanical ventilation, such as compression atelectasis, decreased chest wall and abdominal compliance or residual effects of accumulated sedatives and analgesics. Prolonged mechanical ventilation is associated with morbidity and mortality, as the risk for ventilator-associated complications such as pneumonia increases over time. Our study was probably underpowered to demonstrate a negative impact on mortality in obese patients, resulting from a mean difference in mechanical ventilation of 2.6–2.7 days. Nonetheless, the need for preventive measures, such as intensive physiotherapy, optimal patient positioning, early mobilization and weaning in this high-risk group should be emphasized.

As patients can hardly be randomized to different BMI categories upon hospital admission, study designs investigating the impact of BMI on posttraumatic outcomes are inherently limited to retrospective analyses and prospectively observational trials. This applies to our study as well, although we tried to minimize this impact by matching our study groups regarding injury severity, injury patterns, age and expected mortality.

Accessing registry data provides the advantage of using multi-centre, prospectively collected data of large samples, however, the analysis is restricted to the parameters collected in the registry's dataset. In the TR-DGU the BMI was only recorded in the years between 2004–2009, which restricted our study period and limited our sample size. The external validity of our findings to current clinical practice may be affected by changes in trauma care during the past decade. With regards to mortality, our study may have been underpowered to demonstrate significant differences. It is unclear whether this affects the validity of our findings, as larger trials and meta-analyses equally failed to consistently detect significant differences in mortality. A large-scale prospective multi-centre trial would be preferable to address these issues.

Conclusion

Obesity has a negative impact on outcomes after blunt chest trauma, as it is associated with prolonged duration of mechanical ventilation, ICU and hospital length of stay. Mortality did not seem to be affected, yet, further research is required to confirm these results in a larger cohort.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.injury.2018.09.051.

References

[1] Cormier J.M.. The influence of body mass index on thoracic injuries in frontal impacts. Accid Anal Prev 2008;40:610–5.
[2] Mica L, Keller C, Vomela J, Trentz O, Plecko M, Keel MJ. Obesity and overweight as a risk factor for pneumonia in polytrauma patients: a retrospective cohort study. J Trauma Acute Care Surg 2013;75:693–8.
[3] Mica L, Vomela J, Keel M, Trentz O. The impact of body mass index on the development of systemic inflammatory response syndrome and sepsis in patients with polytrauma. Injury 2014;45:253–8.
[4] Mica L, Keller C, Vomela J, Trentz O, Plecko M, Keel MJ. The impact of body mass index and gender on the development of infectious complications in polytrauma patients. Eur J Trauma Emerg Surg 2014;40:573–9.
[5] Fatica F, Geraci G, Puzhlyakov V, Modica G, Cajozzo M. The effect of body mass index on chest trauma severity and prognosis. Ann Ital Chir 2017;6:389–91.
[6] Mica L, Keel M, Trentz O. The impact of body mass index on the physiology of patients with polytrauma. J Crit Care 2012;27:722–6.
[7] Reiff DA, Hipp G, McGwin [8_TD$DIFF]Jr. G, Modjarrad K, MacLennan PA, Rue [8_TD$DIFF]3rd LW. Body mass index affects the need for and the duration of mechanical ventilation after thoracic trauma. J Trauma 2007;62:1432–5.
[8] Arbabi S, Wahl WL, Hemmila MR, Kohoyda-Inglis C, Taheri PA, Wang SC. The cushion effect. J Trauma 2003;54:1090–3.
[9] Evans DC, Stawicki SP, Davido HT, Eiferman D. Obesity in trauma patients: correlations of body mass index with outcomes, injury patterns, and complications. Am Surg 2011;77:1003–8.
[10] Liu HT, Rau CS, Wu SC, Chen YC, Hsu SY, Hsieh HY, et al. Obese motorcycle riders have a different injury pattern and longer hospital length of stay than the normal-weight patients. Scand J Trauma Resusc Emerg Med 2016;24:50.
[11] Brown CV, Neville AL, Rhee P, Salim A, Velmahos GC, Demetriades D. The impact of obesity on the outcomes of 1,153 critically injured blunt trauma patients. J Trauma 2005;59:1048–51 discussion 51.
[12] Osborne Z, Rowitz B, Moore H, Oliphant U, Butler J, Olson M, et al. Obesity in trauma: outcomes and disposition trends. Am J Surg 2014;207:387–92 discussion 91-2.
[13] Boulanger BR, Milzman D, Mitchell K, Rodriguez A. Body habitus as a predictor of injury pattern after blunt trauma. J Trauma 1992;33:228–32.
[14] Carter PM, Flannagan CA, Reed MP, Cunningham RM, Rupp JD. Comparing the effects of age, BMI and gender on severe injury (AIS 3+) in motor-vehicle crashes. Accid Anal Prev 2014;72:146–60.
[15] Sifri ZC, Kim H, Lavery R, Mohr A, Livingston DH. The impact of obesity on the outcome of emergency intubation in trauma patients. J Trauma 2008;65:396–400.
[16] Childs BR, Nahm NJ, Dolenc AJ, Vallier HA. Obesity is associated with more complications and longer hospital stays after orthopaedic trauma. J Orthop Trauma 2015;29:504–9.
[17] Alban RF, Lyass S, Margulies DR, Shabot MM. Obesity does not affect mortality after trauma. Am Surg 2006;72:966–9.
[18] Ditillo M, Pandit V, Rhee P, Aziz H, Hadeed S, Bhattacharya B, et al. Morbid obesity predisposes trauma patients to worse outcomes: a National Trauma Data Bank analysis. J Trauma Acute Care Surg 2014;76:176–9.
[19] Liu T, Chen JJ, Bai XJ, Zheng GS, Gao W. The effect of obesity on outcomes in trauma patients: a meta-analysis. Injury 2013;44:1145–52.
[20] Christmas AB, Reynolds J, Wilson AK, Franklin GA, Miller FB, Richardson JD, et al. Morbid obesity impacts mortality in blunt trauma. Am Surg 2007;73:1122–5.
[21] Ciesla DJ, Moore EE, Johnson JL, Burch JM, Cothren CC, Sauaia A. Obesity increases risk of organ failure after severe trauma. J Am Coll Surg 2006;203:539–45.
[22] Bochicchio GV, Joshi M, Bochicchio K, Nehman S, Tracy JK, Scalea TM. Impact of obesity in the critically ill trauma patient: a prospective study. J Am Coll Surg 2006;203:533–8.
[23] Hoffmann M, Lefering R, Gruber-Rathmann M, Rueger JM, Lehmann W. The impact of BMI on polytrauma outcome. Injury 2012;43:184–8.
[24] Andruszkow H, Veh J, Mommsen P, Zeckey C, Hildebrand F, Frink M. Impact of the body mass on complications and outcome in multiple trauma patients: what does the weight weigh? Mediators Inflamm 2013;2013:345702.
[25] Diaz [8_TD$DIFF][1_TD$DIFF]Jr. JJ, Norris PR, Collier BR, Berkes MB, Ozdas A, May AK, et al. Morbid obesity is not a risk factor for mortality in critically ill trauma patients. J Trauma 2009;66:226–31.
[26] Duane TM, Dechert T, Aboutanos MB, Malhotra AK, Ivatury RR. Obesity and outcomes after blunt trauma. J Trauma 2006;61:1218–21.
[27] Newell MA, Bard MR, Goettler CE, Toschlog EA, Schenarts PJ, Sagraves SG, et al. Body mass index and outcomes in critically injured blunt trauma patients: weighing the impact. J Am Coll Surg 2007;204:1056–61 discussion 62-4.
[28] Dossett LA, Heffernan D, Lightfoot M, Collier B, Diaz JJ, Sawyer RG, et al. Obesity and pulmonary complications in critically injured adults. Chest 2008;134:974–80.