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The impact of body mass index on the development of systemic inflammatory response syndrome and sepsis in patients with polytrauma

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ABSTRACT

Purpose: Obesity is a growing problem in industrial nations. Our aim was to examine how overweight patients coped with systemic inflammatory response syndrome (SIRS) after polytrauma.
Methods: A total of 651 patients were included in this retrospective study, with an ISS $\geq$ 16 and age $\geq$ 16 years. The sample was subdivided into three groups: body mass index (BMI; all in kg/m^2) $<$ 25, BMI 25–30 and BMI $>$ 30, or low, intermediate and high BMI. The SIRS score was measured over 31 days after admission together with measurements of C-reactive protein (CRP), interleukin-6 (IL-6) and procalcitonin (PCT). Data are given as the mean $\pm$ SEM if not otherwise indicated. Kruskal–Wallis and χ^2 tests were used for statistical analysis and the significance level was set at $p < .05$.
Results: The maximum SIRS score was reached in the low BMI-group at 3.4 $\pm$ 0.4, vs. 2.3 $\pm$ 0.1 and 2.5 $\pm$ 0.2 in the intermediate BMI-group and high BMI-group, respectively ($p < .0001$). However, the maximum SIRS score was reached earlier in the BMI 25–30 group at 1.8 $\pm$ 0.2 days, vs. 3.4 $\pm$ 0.4 and 2.5 $\pm$ 0.2 days in the BMI $<$ 25 and BMI $>$ 30 groups, respectively ($p < .0001$). The incidence of sepsis was significantly higher in the low BMI group at 46.1%, vs. 0.2% and 0% in the BMI 25–30 and BMI $>$ 30 groups, respectively ($p < .0001$). No significant differences in the CRP, IL-6 or PCT levels were found between groups.
Conclusions: A higher BMI seemed to be protective for these patients with polytrauma-associated inflammatory problems.

Introduction

Varying results have been reported regarding the association of body mass index (BMI) with polytrauma.[1,2] Most of these studies focused on obesity and its comorbidities to predict the mortality rate in obese patients with polytrauma. The BMI is an anthropometric index of the weight-to-height relationship defined as the individual's weight in kilograms divided by the square of the height in metres (kg/m^2). Individuals of normal weight have a BMI of 18.5–24.9 kg/m^2; overweight is defined as a BMI $\geq$ 25 kg/m^2 and obesity as a BMI $\geq$ 30 kg/m^2. BMI values are age and sex independent.[3] In industrialised nations, obesity is one of the most significant risk factors for developing diseases such as cancer, heart disease and diabetes mellitus.[4] To date, the association between chronic diseases and obesity seems to be clear but the impact on patients' immunity in critical care settings after suffering a polytrauma remains unclear.[2,5] Obesity not only impairs nursing procedures but also negatively affects airway management, makes surgical exposure more difficult and makes radiographic imaging less reliable.[6] However, one report claimed that overweight, obese and severely obese patients in critical care showed some decreased mortality and improved functional status after discharge from hospital.[7] This seems to contradict data from population-based and disease-based studies, and from the critical care literature.[8–12] Those studies showed that severely obese victims of blunt trauma deteriorate rapidly and are less responsive to interventions. Furthermore, obesity has been recognised as an independent predictor of mortality in such patients, who are reported to have an increased risk of multi-organ failure.[2,13] BMI was reported as a predictor of injury pattern, in that a BMI of >31 kg/m^2 was a significant factor for patients to develop pulmonary problems and rib and pelvic fractures after a blunt trauma.[14] There are few data about systemic inflammatory response syndrome (SIRS) and sepsis as a major burden in patients with polytrauma under intensive care settings. The aim of this study was to analyse the development of SIRS in obese and non-obese patients after polytrauma.

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Patients and methods

Patients

Six hundred and fifty-one patients with polytrauma admitted to the emergency room of the University Hospital of Zürich during 1996–2008 were included in this study. Inclusion criteria were an ISS $\geq$ 16 points, age $\geq$ 16 years and an admission time within at least 24 h of suffering a polytrauma (ISS $\geq$ 16). The patients received ICU treatment and damage control surgery where necessary. The BMI was calculated from the anamnestically obtained pre-trauma height and weight of the included patients, a reliable source was house doctor's documentation. The population was subdivided into three groups (Table 1): BMI $<$ 25 kg/m^2, BMI 25–30 kg/m^2 and BMI $>$ 30 kg/m^2, respectively low BMI-group, intermediate BMI-group and high BMI-group. The lowest BMI accepted for analysis in this series was 18.5 kg/m^2. All patient data were collected retrospectively from patient records, as approved by the local institutional review board (IRB) according to the University of Zürich IRB guidelines. The study was conducted according to our guidelines of good clinical practice ("*Retrospektive Analysen in der Chirurgischen Intensivmedizin*" Nr. StV 01-2008).

Diagnostic protocol

All haemodynamically stable patients admitted to the trauma bay underwent an immediate whole-body CT scan. Unstable patients underwent resuscitative procedures according to Advanced Trauma Life Support® (ATLS®) standards with consecutive whole-body CT scans.

Primary care

The treatment of all admitted patients followed the ATLS® guidelines and previously assessed trauma management protocol after appropriate indications.[15,16] Briefly, after airway intubation, ventilation and cardiovascular management, life-saving surgery took place with decompression of body cavities, control of any haemorrhages and identification of any contaminated tissue. The first surgical interventions were followed by stabilisation of major fractures and radical debridement of necrotic tissues. Cefazolin was used as the perioperative antibiotic. In all of these patients, enteral nutrition was established within 24 h after trauma to prevent spontaneous transmigration of the enteric microbial flora and peritoneal contamination.

Assessment of SIRS and Sepsis

The worst parameters of leucocyte count, respiratory rate, heart rate and temperature were taken to determine the SIRS score each day.[17] SIRS was measured during the first 31 days after admission or as long as the patients were hospitalised. Sepsis was defined as SIRS score $\geq$ 2 with an infectious focus.

Measurement of C-reactive protein, interleukin-6 and procalcitonin

C-reactive protein (CRP) was measured using the latex-enhanced turbidimetric method.[18] The interleukin-6 (IL-6) level was determined by a commercially available ELISA.[19] The procalcitonin (PCT) concentration was analysed using a chemiluminescent assay.[20] All parameters were analysed routinely by the Institute for Clinical Chemistry of the University Hospital of Zürich.

Trauma scoring systems

The ISS and NISS were used to define the severity of the trauma[21,22] based on AIS 2005.[23] The APACHE II score was used to evaluate the overall physiological impairment of the patient.[24]

Statistical analysis

Data are presented as the mean (standard deviation) (SD) for continuous variables and as percentages for categorical variables if not otherwise indicated. Data for the BMI groups were compared using the χ^2 test for categorical data and by Kruskal–Wallis test for

Table 1
Characteristics of the patient sample at admission.

Characteristics	Total	BMI[a] 18.5–25 kg/m^2	BMI 25–30 kg/m^2	BMI $>$ 30 kg/m^2	*p*
Patients (*n*)	651	378	224	49	
Age (years)	42.9 (18.4)	42.9 (18.4)	43.4 (18.9)	44.3 (16.3)	.632[*]
Sex: male/female (*n*)	495/156	264/114	191/33	40/9	<.0001[c]
Time to admission (h)	2.8 (6.8)	2.2 (2.7)	3.7 (10.8)	2.2 (2.2)	.720[b]
BMI (kg/m^2)	24.7 (3.7)	22.3 (2.1)	27.0 (1.3)	32.7 (3.9)	<.0001[b]
AIS: head	3.9 (1.1)	4.0 (1.1)	4.0 (1.2)	3.8 (1.4)	.968[b]
AIS: face	2.1 (0.8)	2.1 (0.8)	2.2 (0.7)	1.9 (0.8)	.581[b]
AIS: thorax	3.2 (0.9)	3.2 (0.9)	3.2 (0.8)	3.5 (0.9)	.067[b]
AIS: abdomen	4.1 (0.8)	4.1 (0.8)	4.1 (0.8)	4.3 (0.8)	.642[b]
AIS: spine	3.1 (1.2)	3.1 (1.1)	3.1 (1.3)	3.3 (1.1)	.836[b]
AIS: extremities	2.7 (0.9)	2.7 (0.9)	2.6 (0.9)	2.7 (0.8)	.704[b]
AIS: pelvis	2.8 (0.6)	2.8 (0.6)	2.7 (0.5)	2.5 (0.7)	.272[b]
AIS: skin	1.7 (0.9)	1.7 (0.9)	1.7 (0.9)	2.0 (0.9)	.366[b]
ISS	29.6 (13.4)	28.9 (13.1)	30.1 (14.2)	32.8 (12.0)	.057[b]
NISS	40.1 (16.0)	39.2 (17.7)	41.0 (16.4)	43.4 (15.5)	.156[b]
APACHE II	16.9 (8.8)	16.9 (8.7)	17.0 (9.2)	15.5 (8.1)	.669[b]
Haemoglobin (g/L)	10.6 (3.0)	10.8 (2.9)	10.7 (3.2)	9.4 (3.0)	.053[b]
Base excess (mmol/L)	−2.8 (4.9)	−2.3 (4.9)	−3.4 (4.6)	−4.1 (5.7)	.162[b]
Lactate (mmol/L)	3.5 (5.4)	3.5 (6.6)	3.5 (3.0)	3.5 (2.7)	.396[b]
Blood pH	7.3 (0.5)	7.2 (0.7)	7.3 (0.1)	7.3 (0.2)	.396[b]
Prothrombin time (%)	77.9 (22.1)	76.1 (22.8)	81.0 (20.3)	76.5 (22.9)	.104[b]
Platelet count (10^3/μL)	189.7 (86.0)	189.8 (86.2)	193.5 (89.0)	171.7 (68.0)	.297[b]

All BMI values are in kg/m^2. *Key*: AIS, abbreviated injury scale; ISS, injury severity score; NISS, new injury severity score; APACHE II, acute physiology and chronic health evaluation II.

[a] Fourteen patients that met the criteria for being underweight (BMI $<$ 18.5) were excluded. Data are given as the mean (SD).

[b] Kruskal–Wallis.

[c] χ^2 test.