Body Mass Index >35 as Independent Predictor of Mortality in Severe Traumatic Brain Injury

Patrick Czorlich[1], Marc Dreimann[2], Pedram Emami[1], Manfred Westphal[1], Rolf Lefering[3], Michael Hoffmann[4]

■ OBJECTIVE: **Severe traumatic brain injury (TBI) has a major influence on polytrauma outcome. The aim of this study was to evaluate the impact of body mass index (BMI) on mortality and early neurologic outcome in patients suffering from severe TBI with a special focus on obesity classes II and III (BMI ≥35).**

■ METHODS: **A retrospective cohort analysis of patients suffering from a leading, at least severe TBI and registered in the TraumaRegister DGU was conducted. Patients alive on admission with full status documentation on Glasgow Coma Scale, height, and weight were classified into 4 BMI subgroups. Early neurologic outcome was classified using the Glasgow Outcome Scale.**

■ RESULTS: **A total of 1634 patients met the inclusion criteria. Lowest mortality was documented for BMI group 1 (15.2%, BMI 25.0–29.9918.5). Highest mortality was found in BMI group 5 (25.6%, BMI ≥35). BMI ≥35 was an independent predictor of mortality with an odds ratio of 3.15 (95% confidence interval [1.06–9.36], $P = 0.039$). Further independent mortality predictors were >65 years of age, a Glasgow Coma Scale of ≤13, an Abbreviated Injury Scale$_{head}$ ≥5, prehospital cardiopulmonary resuscitation, and a prehospital blood pressure of <90 mm Hg. In terms of good early neurologic outcomes, no differences were recorded between the BMI groups (range 59.0%–62.6%, $P = 0.087$).**

■ CONCLUSIONS: **In this study a BMI ≥35 is an independent predictor of mortality and is associated with an inferior early functional neurologic outcome.**

INTRODUCTION

Traumatic brain injury (TBI) remains one of the major causes of disability and death after trauma, especially in younger patients.[1,2] Obesity is widely acknowledged to be a leading public health threat and is commonly associated with multiple comorbidities. The prevalence of obesity is increasing in not only high-income countries but also low- and middle-income countries.[3-7] Body mass index (BMI) is an anthropometric index of weight for height. It is defined as the weight in kilograms divided by the square of the height in meters (kg/m²) and represents a widely accepted grading system for obesity.[8]

The general impact of BMI on trauma is discussed controversially. Recent studies demonstrated that morbid obesity is associated with a higher mortality risk while Mica et al[9] demonstrated a lower mortality in polytrauma patients with a BMI ≥30. Finally, Majdan et al[9-12] found no association between

Key words
- Body mass index
- Mortality
- Obesity
- Outcome
- Traumatic brain injury

Abbreviations and Acronyms
AIS: Abbreviated Injury Scale
BMI: Body-mass-index
BP: Blood pressure
CI: Confidence interval
CPR: Cardiopulmonary resuscitation
DGU: Deutsche Gesellschaft für Unfallchirurgie (German Trauma Society)
GCS: Glasgow Coma Scale
GOS: Glasgow Outcome Scale
ICU: Intensive care unit
ISS: Injury Severity Score
OR: Odds ratio
RISC: Revised Injury Severity Classification, Sektion NIS Committee on Emergency Medicine, Intensive Care and Trauma Management of the German Trauma Society
SMR: Standardized Mortality Ratio
TBI: Traumatic brain injury
TR-DGU: TraumaRegister Deutsche Gesellschaft für Unfallchirurgie

From the [1]Department of Neurosurgery and [2]Division of Spine Surgery, University Medical Center Hamburg-Eppendorf, Hamburg; [3]Institute for Research in Operative Medicine, Witten/Herdecke University, Cologne; and [4]Department of Trauma, Hand and Reconstructive Surgery, University Medical Center Hamburg-Eppendorf, Hamburg, and Clinic for Orthopedics, Holstein, Germany

To whom correspondence should be addressed: Patrick Czorlich, M.D. [E-mail: p.czorlich@uke.de]
Patrick Czorlich and Marc Dreimann contributed equally as first authors.

Citation: World Neurosurg. (2017) 107:515-521.
http://dx.doi.org/10.1016/j.wneu.2017.08.010

*Journal homepage: **www.WORLDNEUROSURGERY.org***

*Available online: **www.sciencedirect.com***

BMI and outcome of TBI caused by low-level falls. Similarly to obesity, underweight was associated with a higher mortality rate in polytrauma patients.[10] The specific impact of BMI on mortality in patients suffering from TBI has not been clarified yet. Data investigating this issue are either limited or focus on specific trauma mechanisms or include varying grades of TBI.[11,13-15]

The aim of this study was to evaluate the impact of BMI on mortality and early neurologic outcome in patients suffering from severe TBI with a special focus on a BMI >35.

MATERIALS AND METHODS

TraumaRegister Deutsche Gesellschaft für Unfallchirurgie

The TraumaRegister Deutsche Gesellschaft für Unfallchirurgie (TR-DGU) of the German Trauma Society was founded in 1993. This multicenter database serves to pseudonymize and standardize documentation of severely injured patients.

Data are collected prospectively in 4 consecutive time phases from the site of the accident until discharge from hospital: A) prehospital phase, B) emergency department and initial surgery, C) intensive care unit (ICU), and D) discharge. The documentation includes detailed information on demographics, injury pattern, comorbidities, prehospital and in-hospital management, a course on the ICU, and relevant laboratory findings including data on transfusion and outcome of each individual. The inclusion criterion is admission to hospital via emergency department with subsequent ICU/intermediate care unit or reaches the hospital with vital signs and dies before admission to ICU.

The infrastructure for documentation, data management, and data analysis is provided by the Academy for Trauma Surgery, a company affiliated with the German Trauma Society. The scientific leadership is provided by the Committee on Emergency Medicine, Intensive Care and Trauma Management (Sektion NIS) of the German Trauma Society. The participating hospitals submit their data pseudonymized into a central database via a web-based application. Scientific data analysis is approved according to a peer review procedure established by Sektion NIS.

The participating hospitals are primarily located in Germany (90%), but a rising number of hospitals of other countries contribute data as well (at present from Austria, Belgium, China, Finland, Luxembourg, Slovenia, Switzerland, The Netherlands, and the United Arab Emirates). Currently, approximately 25,000 cases from >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 publication guidelines of the TraumaRegister DGU and registered as TR-DGU project ID 2016-017.

Study Population and Inclusion Criteria

Although the TR-DGU database comprises a wide variety of information for each case, only patients with a leading, at least severe traumatic brain injury (TBI, Abbreviated Injury Scale $[AIS]_{head} \geq 3$ and AIS_{head} as the leading trauma) treated between 2005 and 2009 with a complete status documentation of height and weight (to calculate the BMI) and Glasgow Coma Scale (GCS) were included in this study.

Patients with a BMI <18.5 and age <16 years were excluded. Height and weight were documented in the TR-DGU database only in this given period and only in 30.5% of all cases. Patients with missing weight, height, or GCS data were excluded from this study. Patients documented in the TR-DGU from Germany and Austria qualified for this analysis if the injury severity score (ISS) was ≥9 and if the patient was admitted from the scene directly to the participating hospital (i.e., interhospital-transferred patients were excluded). To evaluate if the remaining patients represent the collective, we checked the ISS, which was 29 in patients with and without documented BMI.

DEFINITIONS

TBI was defined as an AIS_{head} score of ≥3. Severe injuries were defined from an AIS of 3 onwards for any body region. Patient collective was classified into 5 BMI subgroups according to the definition of the World Health Organization: group I: BMI 18.5–24.9 (normal range), group II: BMI 25–29.9 (overweight), group III: BMI 30–34.9 (obese class I), and group IV: BMI ≥35.[8]

TBI and alteration of consciousness were scored using the GCS, coded: motor, coded 1–6; verbal, coded 1–5; and eye, coded 1–4. Unconsciousness was defined as GCS ≤8. Mortality was defined as any patient not surviving to hospital discharge.

Early neurologic outcome was classified in 5 levels using the Glasgow Outcome Scale (GOS): 1, dead; 2, vegetative state (unable to interact with environment; unresponsive); 3, severe disability (able to follow commands; unable to live independently); 4, moderate disability (able to live independently; unable to return to work or school); and 5, good recovery (able to return to work or school). A GOS of 4 and 5 indicated good early neurologic outcome.

EXPECTED MORTALITY

As injury pattern and severity might vary within subgroups, observed outcome was compared with a prognostic estimate deriving from the Revised Injury Severity Classification (RISC) score.[16] This score was developed and validated on the basis of the TR-DGU dataset. Outcome prognosis is calculated using age, New Injury Severity Score, AIS_{head}, $AIS_{extremities}$, GCS, partial thromboplastin time, base excess, relevant bleeding signs, and cardiac arrest. The RISC prognosis reflects the average expected hospital mortality rate in the TR-DGU based on patients documented in the 1990s.[16] For the calculation of the RISC prognosis, datasets of 1607 patients were available (98.1%).

Statistical Analysis

Statistical analyses were performed using SPSS statistical software (SPSS Version 23.0, IBM Inc., Armonk, New York, USA). Data are presented as mean (±standard deviation) for continuous variables, as median for time to death and for ISS and GCS scores, and as percentages for categorical variables.

To assess the impact of BMI, age, GCS, injury pattern prehospital cardiopulmonary resuscitation (CPR) and blood pressure (BP), ISS and head injury on mortality, a multivariable logistic regression analysis was performed. Coefficients are presented together with the respective odds ratio (OR) and corresponding 95% confidence interval (CI).