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Effects of time of hospital admission on outcomes after severe traumatic brain injury in Austria

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Summary

Background The goal of this study was to compare outcomes of patients with severe traumatic brain injury (TBI) who had been admitted either during workdays from 7 a.m. to 7 p.m. ("regular service") or during any other time ("on-call service").

Material and methods Between March 2002 and April 2012, 17 Austrian centers enrolled TBI patients into two observational studies that focused on effects of guideline compliance ($n=400$) and on prehospital and early hospital management ($n=777$), respectively. Data on trauma severity, clinical status, treatment, and outcomes were collected prospectively. All patients with severe TBI (Glasgow Coma Scale score <9) were selected for this analysis. Secondary transfers and patients with unsurvivable injuries were excluded. The International Mission for Prognosis and Analysis of Clinical Trials in TBI core model was used to estimate probabilities of hospital death and unfavorable long-term outcome (Glasgow Outcome Scale score <4). Based on time of arrival, patients were assigned to groups "regular service" or "on-call service."

Results Data from 852 patients were analyzed (413 "regular," 439 "on-call service"). "On-call" patients were younger (45 vs. 51 years, $P<0.001$) and had a higher rate of alcohol intoxication (41 vs. 11 %, $P<0.001$). Trauma severity was comparable; the probabilities of death and unfavorable outcome were identical. There were no differences regarding computed tomography findings or treatment. Hospital mortality (24 vs. 28 %, $P=0.191$) and rate of patients with unfavorable outcome at 6 months (43 vs. 48 %, $P=0.143$) were comparable.

Conclusions In Austria, the time of hospital admission has no influence on outcomes after severe TBI.

Keywords Traumatic brain injury · Severe · Time of hospital admission · Day vs. night · Outcome

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Effekt des Zeitpunkts der Aufnahme im Krankenhaus auf das Behandlungsergebnis nach schwerem Schädelhirntrauma in Österreich

Zusammenfassung

Grundlagen Das Ziel dieser Studie war, die Behandlungsergebnisse von Patienten mit schwerem Schädelhirntrauma (SHT) zu vergleichen, die entweder an Werktagen zwischen 07.00 und 19.00 Uhr ("regulärer Dienst";

„RD“) oder zu irgendeiner anderen Zeit (“Bereitschaftsdienst“, „BD“) eingeliefert wurden.

Methodik Zwischen 3/2002 und 4/2012 rekrutierten 17 österreichische Zentren Patienten mit SHT für 2 Beobachtungsstudien, die den Effekt einer Richtlinien-konformen Behandlung ($n=400$) bzw. die Ergebnisse einer besseren Erstversorgung ($n=777$) untersuchten. Angaben zu Verletzungsschwere, klinischem Status, Therapie und Behandlungsergebnis wurden prospektiv erhoben. Alle Patienten mit schwerem SHT (Glasgow Coma Scale score <9) wurden für diese Analyse ausgewählt. Sekundäre Transferierungen und Patienten mit nicht überlebbaren Verletzungen wurden exkludiert. Das IMPACT Core Model wurde verwendet, um die Wahrscheinlichkeit von Tod im Krankenhaus und von ungünstigem Langzeitergebnis (definiert als Glasgow Outcome Scale score <4 nach 6 Monaten) abzuschätzen. Je nach Zeitpunkt der Einlieferung wurden die Patienten der Gruppe „RD“ oder „BD“ zugeteilt. Demografische Daten, Verletzungsschwere, Therapie und Behandlungsergebnisse wurden mittels Chi^2-Test, T-Test, und logistischer Regression verglichen.

Ergebnisse 852 Datensätze waren verfügbar (413 “RD”, 439 “BD”). “BD”-Patienten waren jünger (45 vs. 51 Jahre, $P<0.001$) und waren häufiger alkoholisiert (41 vs. 11 %, $P<0.001$). Die Verletzungsschwere war vergleichbar, die Wahrscheinlichkeiten von Tod und von ungünstigem Behandlungsergebnis waren identisch. Es fanden sich keine Unterschiede hinsichtlich CT-Diagnosen und Behandlung. Spitalsmortalität (24 vs. 28 %, $P=0.191$) und Prozentsatz der Patienten mit ungünstigem Langzeitergebnis (43 vs. 48 %, $P=0.143$) waren vergleichbar.

Schlussfolgerungen In Österreich hat der Zeitpunkt der Einlieferung ins Krankenhaus keinen signifikanten Einfluss auf die Behandlungsergebnisse von Patienten mit schwerem SHT.

Schlüsselwörter Schädelhirntrauma · Schwer · Zeitpunkt der Spitalsaufnahme · Tag vs. Nacht · Behandlungsergebnis

Background

Traumatic brain injury (TBI) is a major cause of morbidity and mortality, and is the leading cause of death in people aged 15–45 years [1]. Tagliaferri et al. [2] reported that TBI accounted for the majority of trauma deaths in Europe. It is generally agreed that patients with TBI should be treated without unnecessary delay to avoid secondary brain insults. Some studies have shown that trauma patients admitted during the night shift or on weekends have worse outcomes than those admitted during the day shift or on weekdays: Egol et al. [3] reported that patients admitted between midnight and 6 a.m. had a significantly higher risk for in-hospital mortality, and another study showed that TBI patients admitted at night had a significantly longer interval between hospital admission and surgery [4]. Other studies, however, found no significant effect of time of admission [5, 6], and one study reported lower mortality of trauma patients admitted on weekends [7].

There are two key factors that may influence outcomes of patients who are admitted during the night or on holidays: due to reduced staffing, fewer physicians, nurses, and technicians may be available, which might cause some delay of treatment, and fatigue may become a problem, as almost all physicians work 24-h shifts. The goal of this study was to analyze the effects of the time of hospital admission on outcomes in a sample of patients with severe TBI that had been collected prospectively over the past 10 years. Our hypothesis was that patients who were admitted during the night shift or on holidays/weekends would have higher rates of hospital death and unfavorable long-term outcome compared with patients who arrived on weekdays.

Patients and methods

Between 2001 and 2012, the International Neurotrauma Research Organization (INRO, a nongovernmental research organization, founded in 1999; based in Vienna, Austria) coordinated two projects that focused on Austrian patients with TBI. Both projects were purely observational and enrolled pediatric as well as geriatric patients, TBI patients with multiple trauma, and patients with low Glasgow Coma Scale (GCS) scores. The first project analyzed epidemiology and hospital treatment of patients with severe TBI as well as the effects of guideline-based treatment [8]. This project started in March 2002; five centers enrolled 400 patients until June 2005. The second project focused on prehospital and early hospital management of patients with moderate and severe TBI. It started in March 2009; 16 centers enrolled 777 patients until April 2012. Both projects were done with approval of the local ethical committees. Due to the purely observational design of the projects, informed consent of the patients was not mandatory; however, all patients who recovered sufficiently to consent gave written permission to use their data for scientific purposes.

The data were collected in 17 Austrian centers. Of these centers, 13 were “high-volume” centers: 4 free-standing trauma hospitals, 2 University departments of Traumatology, and 7 large trauma departments in tertiary hospitals. The four remaining centers were “low-volume” centers; they included three trauma departments in regional hospitals and one smaller trauma hospital. All centers were able to provide state-of-the-art patient management. The number of patients enrolled by these centers (median: 50, interquartile range (IQR): 29-101, range: 12–163) varied considerably, as 4 “high volume” centers participated in both projects, and some centers joined the second project with just few months remaining for patient inclusion. Using the prognostic International Mission for Prognosis and Analysis of Clinical Trials in TBI (IMPACT) core model [9], the observed vs. expected mortality ratio was <1 for 16 of 17 centers (median: 0.85, IQR: 0.67–0.95, range: 0.59–1.09)—this confirms that the centers provided high-quality treatment.

Treatment in the field was provided by emergency physicians. All patients had rapid examination including documentation of vital signs (GCS score, pupillary status, blood pressure, heart rate, and oxygen saturation). Rapid sequence intubation facilitated by hypnotics and relaxants, ventilation, treatment of hemorrhage, and fluid resuscitation were done as appropriate. After admission, each patient was examined by a trauma team (anesthesiologists, trauma surgeons, and/or neurosurgeons, radiologists, nurses), and a computed tomography (CT) scan was done. The patients then underwent surgery as appropriate and/or were admitted to the intensive care unit (ICU). Neurosurgery was provided by neurosurgeons (6 centers) or by trauma surgeons (11 centers) who had the option of consulting neurosurgeons for more difficult cases. In a previous study, we have shown that the specialty of the surgeon had no impact on outcomes of the patients [10]. Intensive care was provided by anesthesiologists in cooperation with neurosurgeons or trauma surgeons.

A database developed by INRO was used to collect data. Basic demographic data of the patient, cause and location of trauma, prehospital status and treatment, mechanism and severity of trauma (Abbreviated Injury Score [AIS], Injury Severity Score [ISS]), results of CT scans, results of laboratory testing, and data on surgical procedures and outcomes were recorded prospectively. Prehospital data were documented by paramedics, and were then transferred into the databases. CT scans were interpreted by neurosurgeons, trauma surgeons, and radiologists, and the summarized findings were entered into the CT page of the database. This CT page collected detailed data on basal cisterns, midline shift, and main findings. Data on duration of various treatments, complications, and outcomes were collected at discharge from the ICU and at hospital discharge. Information on status and location was recorded at 6 months after injury. This was done by phone calls to the patients and/or their relatives; in some cases, the Glasgow Outcome Scale (GOS) score was recorded at patients' follow-up visits to the centers. In all centers, data were collected by local investigators; data quality was monitored by the INRO project manager (Alexandra Brazinova). Missing or implausible data were reported to local investigators who then submitted missing or corrected values. Personal data protection was observed, and the identifiers were kept separately from the data.

All patients who had severe TBI (defined as AIS "head" >2 and/or enrollment GCS score <9) were selected for this analysis. Patients with unsurvivable injuries (AIS "head" = 6) and those who had been transferred from another hospital were excluded. Data on trauma mechanism, trauma severity, CT findings, treatment, and outcomes were retrieved for each patient. The IMPACT core model [9] was used to estimate the probabilities of hospital death and unfavorable long-term outcome. This model has been validated for our patient sample. To describe long-term outcomes, the GOS [11] was used. "Favorable outcome" was defined as a GOS score of 5 or 4; "unfavorable outcome" was defined as a GOS score of 3 or less at 6 months after trauma.

Based on the time of arrival at the center, patients were assigned to group "regular service" (arrival at workdays from 7 a.m. to 7 p.m.) or to group "on-call service" (arrival at any other time). In the centers that participated in the TBI projects, minimum in-house staffing during "on-call service" included two surgeons, one anesthesiologist, one radiologist, two surgical nurses, one anesthesia nurse, one radiology technician, and one to two paramedic assistants. Depending on the size of the center, other surgical specialists would be available either from in-house departments, or from other hospitals. During "regular service," the teams could be considerably larger. Physicians usually worked 24-h shifts, and all others worked 12-h shifts.

Demographic data, clinical status, treatment, and outcomes of these two groups were compared. In addition, demographic and treatment data were analyzed, and rates of mortality and unfavorable outcomes were calculated for the following groups:

- admission between midnight and 6 a.m. vs. admission between 6 a.m. and midnight,
- admission on workdays vs. admission on holidays/weekends (including the nights),
- admission between 7 a.m. and 7 p.m. (day) vs. admission between 7 p.m. and 7 a.m. (night),
- admission during the night (7 p.m. to 7 a.m.) vs. admission on workdays (7 a.m. to 7 p.m.) vs. admission on holidays/weekends (7 a.m. to 7 p.m.).

Statistical analysis

Our sample was large enough (power = 0.83) to detect a small effect (d = 0.2) at a significance level of 0.05. Two-tailed *t*-test (for comparisons of mean values), Fisher's exact test, and chi-square test (for analysis of 2 × N contingency tables) were done as appropriate to identify differences between the groups. To check for associations with outcomes, we constructed logistic regression models for hospital death and unfavorable long-term outcome, where the effects of time of admission on outcomes were corrected for age, GCS scores, and ISS. Data are presented as means with standard deviations, or as proportions. A *P*-value of <0.05 was considered statistically significant.

Results

Of the 1,177 patients in the database, 202 patients had been transferred from another hospital, 74 had an unsurvivable injury (AIS "head" = 6), and 49 had only moderate TBI (AIS "head" <3 and GCS score >8 at enrollment). This left 852 patients with severe TBI for analysis. Of these, 413

Table 1 Demographics, prehospital status, and trauma severity

Variable	On-call service N = 439	Regular service N = 413	Total N = 852	P-value
Age (years; mean, SD)	44.8 (21.1)	50.6 (21.8)	47.6 (21.6)	< 0.001
Male sex (N, %)	331 (75 %)	301 (73 %)	632 (74 %)	0.446
Blood alcohol > 0.1 % (N, %; only 483 patients tested)	101 (41 %)	26 (11 %)	127 (26 %)	< 0.001
Injury mechanism (N, %)				
Fall < 3 m	107 (24 %)	113 (27 %)	220 (26 %)	< 0.001
MVA driver	55 (13 %)	45 (11 %)	100 (12 %)	
Fall > 3 m	41 (9 %)	62 (15 %)	103 (12 %)	
Motorcycle	50 (11 %)	28 (7 %)	78 (9 %)	
MVA pedestrian	41 (9 %)	28 (7 %)	69 (8 %)	
Bicycle	24 (5 %)	34 (8 %)	58 (7 %)	
Other	36 (8 %)	20 (5 %)	56 (7 %)	
Sports activity	20 (5 %)	30 (7 %)	50 (6 %)	
MVA passenger	30 (7 %)	16 (4 %)	46 (5 %)	
Work related	6 (1 %)	17 (4 %)	23 (3 %)	
Gunshot	5 (1 %)	4 (1 %)	9 (1 %)	
Assault (blunt)	7 (2 %)	3 (1 %)	10 (1 %)	
AIS "head" (N, %)				
3	63 (14 %)	66 (16 %)	129 (15 %)	0.249
4	269 (61 %)	230 (56 %)	499 (59 %)	
5	107 (24 %)	117 (28 %)	224 (26 %)	
ISS (mean, SD)	27.7 (12.4)	28.5 (12.7)	28.1 (12.5)	0.284
First GCS (mean, SD)	6.6 (3.7)	7 (4)	6.8 (3.8)	0.129
Spinal cord injury present (N, %)	23 (5 %)	28 (7 %)	51 (6 %)	0.415
Field hypotension present (N, %)	35 (8 %)	34 (8 %)	69 (8 %)	0.923
Field hypoxia present (N, %)	55 (13 %)	39 (9 %)	94 (11 %)	0.157
Prehospital pupils (N, %)				
Both reactive	304 (69 %)	311 (75 %)	615 (72 %)	0.176
One reactive	60 (14 %)	44 (11 %)	104 (12 %)	
None reactive	51 (12 %)	38 (9 %)	89 (10 %)	
Not assessable	5 (1 %)	1 (0 %)	6 (1 %)	
Probability of death at 6 months (mean, SD)	0.347 (0.079)	0.346 (0.084)	0.346 (0.041)	0.858
Probability of unfavorable outcome at 6 months (mean, SD)	0.562 (0.128)	0.565 (0.137)	0.563 (0.066)	0.841

MVA motor vehicle accident, *AIS* abbreviated injury scale, *ISS* Injury Severity Score, *GCS* Glasgow Outcome Scale, *SD* standard deviation

arrived on a workday between 7 a.m. and 7 p.m. ("regular service" group), and 439 arrived at another time (holiday, weekend, night; "on-call service" group).

Demographic data, data on status, and data on trauma severity are given in Table 1. "On-call" patients were significantly younger. Patients aged between 15 and 34 years were significantly more likely to be admitted during "on-call service" (Fig. 1); patients from all other age groups were more likely to be admitted during "regular service." "On-call" patients had a significantly higher rate of alcohol intoxication (Table 1) and had different trauma mechanisms (fewer falls, more motor vehicle accidents, and more motorbike accidents). Trauma severity was comparable; AIS "head," ISS, GCS score, rates of hypoxia and hypotension, and pupillary reactivity were not different. The probabilities of death and unfavorable outcome were almost identical.

With regard to treatment (Table 2), the rate of helicopter transport was significantly lower in "on-call" patients because Austrian rescue helicopters usually do not fly missions after dark. All other treatment variables were not different. The intervals between admission and CT scan and between admission and start of neurosurgery (if required) were comparable. There were no differences regarding CT scan findings (Table 2). The causes of death (Table 2) were not different. Hospital mortality and rate of patients with unfavorable outcome at 6 months were

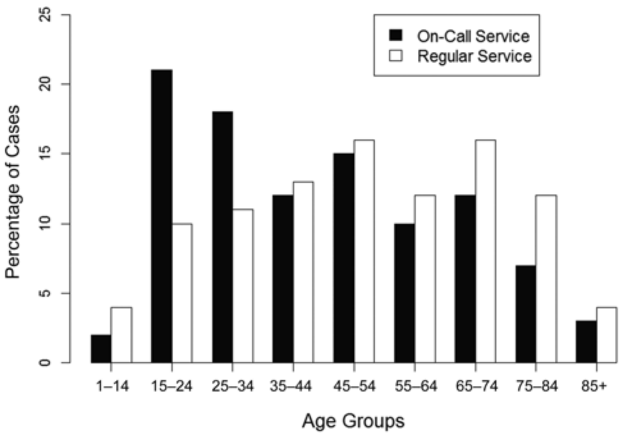

Fig. 1 Percentages of cases admitted during "regular service" and "on-call service" vs. age groups (years)

lower in the "on-call" group, but this difference was not significant.

Table 3 gives an overview of the rates of hospital deaths and unfavorable outcome at 6 months for groups with different admission times. Patients who arrived between midnight and 6 a.m. had lower hospital mortality, and had a significantly lower rate of unfavorable outcome. The same pattern was found for patients who arrived during the night shift vs. during the day shift. No significant differences were found for all other comparisons. For all comparisons, patients who arrived during the night shift or during holidays/weekends were significantly younger, were more likely to test positive for blood alcohol, and had different trauma mechanisms.

The multivariate analysis (Table 4) showed that only age, ISS, and first GCS score were significantly associated with outcomes; after correction for these factors, alcohol intoxication had no significant effect.

Discussion

This study presents an analysis of the effects of the time of hospital admission for Austrian patients with severe TBI who had direct transport to the participating centers and had survivable injuries. We choose to compare "on-call service" to "regular service" in detail because the influence of both reduced staffing and fatigue was expected to be found in the "on-call" patients. However, we found that "on-call" service was adequate because the time of admission had no significant effect on hospital mortality and on the rate of unfavorable outcome at 6 months after trauma. The guidelines of the Austrian Society of Traumatology state that all departments admitting severe trauma cases must have at least one full trauma team available 24/7 to care for these patients. Thus, limitation of service during "on-call" times does not affect treatment of severe cases (but may affect patients with minor injuries, e.g., by longer intervals between admission and treatment). This study also found no effects of fatigue. Our hypothesis has been proven wrong.

This study confirms previous findings from Guly et al. [6]: this British group used data from Trauma Audit and Research Network (3 years, 40,866 cases) and reported that 31.1 % of trauma patients with an ISS > 15 who were admitted "out of hours" died, compared with 33.5 % of patients who were admitted inside "working hours." Similar results have been reported by Carmody et al. [5]: this group from California reviewed 8,015 consecutive trauma admissions (3 years) and found that mortality of trauma patients admitted at night was significantly lower than that of patients admitted during the day (10.1 vs. 13.1 %). They performed different comparisons (e.g., morning vs. night for all patients, for blunt trauma, for penetrating trauma, weekday vs. weekend, and weeknight vs. weekend night) and found no significant differences in ISS-matched mortality rates. A recent study by Carr et al. [7] used data from the Pennsylvania trauma system (5 years, 90,461 cases) and reported that patients who arrived on weeknights were more likely to die than patients who arrived on weekdays (unadjusted mortality: 7.5 vs. 6.6 %). In the adjusted analysis, there was no significant difference in mortality between weekday and weeknight admissions, and patients who arrived on weekends were less likely to die than those who arrived on weekdays (odds ratio (OR): 0.89; 95 % confidence interval (CI): 0.81–0.97). None of these three articles reported data on staffing.

Other authors reported different results. Egol et al. [3] used 2002–2006 data from the US National Trauma Data Bank and analyzed outcomes of 601,388 patients aged > 18 years. They found that cases admitted between midnight and 6 a.m. were significantly more likely to die (OR: 1.18; 95 % CI: 1.12–1.25, adjusted analysis). This pattern was found in all trauma centers, but was weakest at level 1 trauma centers and strongest at level 3 and 4 trauma centers. This article did not report data on staffing.

All studies discussed so far included all trauma patients, while our study included only patients with severe TBI. There is only one study that also focused on TBI patients [4]; it showed that patients who arrived between 6 p.m. and 8 a.m. had significantly longer intervals between admission and start of neurosurgery; no data on staffing were given. In our study, however, there were no differences regarding the intervals admission to CT scan and admission to neurosurgery.

What are the possible reasons for the small outcome differences observed in our study? The differences in mortality and unfavorable outcome were most pronounced in all analyses that included periods after 7 p.m. No differences were observed for patients who were admitted during weekends or holidays between 7 a.m. and 7 p.m. There were no differences in treatment, and only age and rate of alcohol intoxication were significantly different. Age is one of the most important factors influencing outcomes after TBI as demonstrated in the large study done by Hukkelhoven et al. [12] and by a number of other studies. The significant effect of age has been confirmed by our results. In addition to the factor "age," it seems possible that "alcohol intoxication" may be responsible for

Table 2 Treatment, computed tomography scan findings, and outcomes

Variable	On-call service *N* = 439	Regular service *N* = 413	Total *N* = 852	*P*-value
Air transport (*N*, %)	146 (33 %)	207 (50 %)	353 (41 %)	< 0.001
Prehospital intubation done (*N*, %)	308 (70 %)	276 (67 %)	584 (69 %)	0.182
Capnography used (*N*, % Yes)	109 (35 %)	105 (38 %)	214 (37 %)	0.903
Infusion (ml; mean, SD)	858 (62 %)	810 (59 %)	835 (60 %)	0.249
Interval admission to CT scan (*N*, %)				
Within 30 min	189 (43 %)	185 (45 %)	374 (44 %)	0.886
Within 60 min	108 (25 %)	98 (24 %)	206 (24 %)	
Within 2 h	41 (9 %)	44 (11 %)	85 (10 %)	
Basal cisterns on first CT scan (*N*, %)				
Open	320 (73 %)	296 (72 %)	616 (72 %)	0.211
Compressed	81 (18 %)	67 (16 %)	148 (17 %)	
Closed	29 (7 %)	37 (9 %)	66 (8 %)	
Not documented	3 (1 %)	9 (2 %)	12 (1 %)	
Midline shift on first CT scan (*N*, %)				
No shift	288 (66 %)	274 (66 %)	562(66 %)	0.71
< 5 mm	49 (11 %)	41 (10 %)	90 (11 %)	
5–15 mm	74 (17 %)	61 (15 %)	135 (16 %)	
> 15 mm	13 (3 %)	19 (5 %)	32 (4 %)	
Predominant injury on first CT scan				
Subdural hematoma	146 (33 %)	143 (35 %)	289 (34 %)	0.388
Subarachnoid hemorrhage	58 (13 %)	61 (15 %)	119 (14 %)	
Contusions	63 (14 %)	60 (15 %)	123 (14 %)	
Epidural hematoma	56 (13 %)	47 (11 %)	103 (12 %)	
Diffuse edema	40 (9 %)	32 (8 %)	72 (8 %)	
Normal CT	33 (8 %)	31 (8 %)	64 (8 %)	
Intracerebral hematoma	16 (4 %)	26 (6 %)	42 (5 %)	
Intraventricular hemorrhage	22 (5 %)	10 (2 %)	32 (4 %)	
Not determined	5 (1 %)	3 (1 %)	8 (1 %)	
Any neurosurgery (*N*, %)	325 (74 %)	292 (71 %)	617 (72 %)	0.339
ICP monitoring (*N*, %)	280 (64 %)	248 (60 %)	528 (62 %)	0.313
Interval admission to surgery				
0–60 min	95 (33 %)	96 (36 %)	191 (34 %)	0.322
61–120 min	113 (39 %)	87 (33 %)	200 (36 %)	
> 120 min	83 (29 %)	83 (31 %)	166 (30 %)	
Cause of death (*N*, % of all deaths)				
Brain death	58 (55 %)	59 (50 %)	117 (53 %)	0.812
Cardiovascular failure	22 (21 %)	29 (25 %)	51 (23 %)	
Multiple organ failure	6 (6 %)	9 (8 %)	15 (7 %)	
Hemorrhage	4 (4 %)	3 (3 %)	7 (3 %)	
Pulmonary embolism	2 (2 %)	1 (1 %)	3 (1 %)	
Adult respiratory distress syndrome	0	2 (2 %)	2 (1 %)	
Other	5 (5 %)	7 (6 %)	12 (5 %)	
Not documented	9 (9 %)	7 (6 %)	16 (7 %)	
Hospital deaths (*N*, %)	106 (24 %)	117 (28 %)	223 (26 %)	0.191
Unfavorable outcome at 6 months (*N*, %)	188 (43 %)	198 (48 %)	386 (45 %)	0.143

SD standard deviation, *CT* computed tomography, *ICP* intracranial pressure

Table 3 Comparison of rates of death and unfavorable outcome for different admission times

Admission	Hospital deaths (*N*, %)	*P*-value	Unfavorable outcome (*N*, %)	*P*-value
Regular vs. "on-call" service				
Regular: workdays 7 a.m. to 7 p.m. ($n=413$)	117 (28 %)	0.191	198 (48 %)	0.143
On-call: all other times ($n=439$)	106 (24 %)		188 (43 %)	
Late night vs. all other times				
Midnight to 6 a.m. ($n=94$)	18 (19 %)	0.100	32 (34 %)	0.020
6 a.m. to midnight ($n=758$)	205 (27 %)		354 (47 %)	
Workday vs. holiday/weekend (including the nights)				
Workday ($n=588$)	158 (27 %)	0.490	275 (47 %)	0.200
Holiday/weekend ($n=264$)	65 (25 %)		111 (42 %)	
Day vs. night				
Day: 7 a.m. to 7 p.m. ($n=575$)	160 (28 %)	0.114	274 (48 %)	0.047
Night: 7 p.m. to 7 a.m. ($n=277$)	63 (23 %)		112 (40 %)	
Workday vs. holiday/weekend vs. night				
Workday: 7 a.m. to 7 p.m. ($n=413$)	117 (28 %)	0.221	198 (48 %)	0.137
Holiday/weekend: 7 a.m. to 7 p.m. ($n=162$)	43 (27 %)		76 (47 %)	
Night: 7 p.m. to 7 a.m. ($n=277$)	63 (23 %)		112 (40 %)	

Table 4 Multivariate analysis

Predictors	Hospital outcome (death = 1)		Six-month outcome (unfavorable = 1)	
	OR (95 % CI)	*P*-value	OR (95 % CI)	*P*-value
Staffing				
Regular Service	Reference	–	Reference	–
On-call Service	0.99 (0.58–1.71)	0.98	1.06 (0.66–1.68)	0.798
Age	1.06 (1.04–1.07)	<0.001	1.05 (1.03–1.06)	<0.001
ISS	1.05 (1.02–1.06)	<0.001	1.04 (1.01–1.05)	<0.001
First GCS	0.84 (0.77–0.9)	<0.001	0.84 (0.79–0.89)	<0.001
Alcohol > 0.1 %				
No	Reference	–	Reference	–
Yes	0.95 (0.49–1.79)	0.869	0.89 (0.52–1.49)	0.649

ISS Injury Severity Score, *GCS* Glasgow Outcome Scale, *OR* odds ratio, *CI* confidence interval

the small difference in outcomes. There is evidence that alcohol intoxication may be beneficial for patients with moderate and severe TBI [13, 14]. Suggested mechanisms for this beneficial effect include a reduction of the neuroinflammatory response to TBI [15] and a decrease in pneumonia rate after TBI [16].

Conclusions

The study analyzed hospital mortality and long-term outcome of patients admitted either during workdays (regular service) or during holidays/weekends and nights ("on-call service"). "On-call" patients were younger and were more likely to have positive blood alcohol levels. There were no differences in trauma severity or treatment. Timing of hospital admission had no effect on outcomes, although mortality and rate of unfavorable outcomes were insignificantly lower in "on-call" patients.

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Conflicts of interest

The authors do not have any conflicts of interest. This study has not been presented anywhere.

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