Traffic accident victims and polytrauma patients: injury patterns, outcome and their influencing factors

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Injury pattern, hospital triage, and mortality of 1250 patients with severe traumatic brain injury caused by road traffic accidents.

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ABSTRACT

Background

This epidemiological study analysed the incidence, risk factors, hospital triage and outcome of patients with severe traumatic brain injuries (sTBI) caused by road traffic accidents (RTA) admitted to hospitals in the Trauma Center West-Netherlands (TCWN) region.

Methods

Trauma registry data were used to identify TBI in all RTA victims admitted to hospitals in the mid-West region of the Netherlands from 2003 to 2011. Type of head injury and severity were classified using the Abbreviated Injury Scale (AIS). Head injuries with AIS severity scores ≥ 3 were considered sTBI.

Results

Ten percent of all 12,503 hospital admitted RTA victims sustained sTBI, ranging from 5.4% in motorcyclists, 7.4% in motorists, 9.6% in cyclists and 12.7% in moped riders to 15.1% in pedestrians ($p<0.0001$). Amongst RTA victims admitted to hospital, sTBI was most prevalent in pedestrians (OR 2.25; 95% CI 1.78-2.86) and moped riders (OR 1.86; 95% CI 1.51-2.30). Injury patterns differed between road user groups. The incidence of contusion ranged from 46.6% in cyclists to 74.2% in motorcyclists, whereas basilar and open skull fractures were least common in motorcyclists (22.6%) and most common in moped riders (51.5%). Haemorrhage incidence ranged from 44.9% (motorists) to 63.6% (pedestrians). Subdural and subarachnoid bleedings were most frequent. Age, Glasgow Coma Scale, and type of haemorrhage were independent prognostic factors for in-hospital mortality after sTBI. In-hospital mortality ranged from 4.2% in moped riders to 14.1% in motorists.

Pedestrians have the highest risk to sustain sTBI and more specifically intracranial haemorrhage. Haemorrhage and contusion both occur in over 50% of the patients with sTBI.

Conclusions

Specific brain injury patterns can be distinguished for specific road user groups and independent prognostic risk factors for sTBI were identified. This knowledge may be used to improve the vigilance for particular injuries in specific patient groups and stimulate development of focussed diagnostic strategies.

INTRODUCTION

Road traffic accidents (RTA) contribute to morbidity and mortality in developing and industrialized countries around the world.[1] The World Health Organization estimated that each year more than 1.2 million people die and another 50 million people are injured as a result of RTAs worldwide.[2] Traumatic brain injury (TBI) due to RTAs is a global public health problem, and the incidence of both TBI and severe TBI (sTBI) is rising sharply, mainly due to RTAs.[3] The high mortality rates, disability and long-term loss of function pose a great burden on national health systems[1] and present a challenge for road safety programs. During the period 2003 – 2007, approximately 290,000 RTA victims in the Netherlands needed medical attention each year, of whom 21,000 were admitted to hospitals across the country. Although 20% of the admitted RTA victims sustained TBI, little is known about the epidemiology and risk factors for TBI after RTAs.[4]

In the Netherlands, traffic safety laws and extensive preventive governmental programs have gradually resulted in a decrease in RTA fatalities.[5] Simultaneously with these extensive governmental safety programs, the pre-hospital and in-hospital care for trauma patients changed dramatically during the 1990s. The Advanced Trauma Life Support (ATLS®) program provided a national guideline for the structured and systematic approach to the primary treatment of trauma.[6] This was followed in 1997 by the implementation of 11 regional trauma systems in the Netherlands, each of which contains a level I trauma center that provides the highest level of surgical care to trauma patients. Level II trauma hospitals work in collaboration with a level I trauma center to provide 24/7 comprehensive trauma care supplementing the clinical expertise of a Level I institution. Level III trauma hospitals do not have the full availability of specialists, but they have resources for emergency resuscitation, surgery, and intensive care for most trauma patients. Pre-hospital patient triage is performed by emergency services based on the injury type and severity and the subsequent required level of trauma care. Because sTBI patients mostly need advanced neurologic care, adequate pre-hospital triage is of major importance for TBI patients.

The purpose of this region-wide study is to analyze the incidence, risk factors, hospital triage and outcome of patients with severe traumatic brain injuries (sTBI) for different types of road users.

MATERIALS AND METHODS

Study Design

The regional Trauma Center West-Netherlands (TCWN) is one of the 11 Dutch trauma centers and includes three level I trauma center hospital locations and 9 level II and III trauma hospital locations in the Mid-Western part of the Netherlands. The TCWN region covers an urban area with approximately 2.5 million inhabitants. All trauma patients presenting to the Emergency Departments of the TCWN hospitals are assessed and treated according to ATLS® principles. [6]

Data for this retrospective study were obtained from the TCWN trauma registry. An analysis of all RTA victims admitted to the TCWN hospitals from 1-1-2003 to 1-1-2011 was performed. Patients who were deceased upon arrival to the Emergency Department were included in the registry, whereas patients who were deceased at the scene of the accident and patients who were not admitted to the hospital were not included in the registry. Patients without data on the means of transport were excluded from the analysis. The use of the anonymous data in the regional trauma registry is exempt from ethics review board approval.

Data and definitions

The trauma registry dataset includes the Major Trauma Outcome Study (MTOS)[7] variables completed with pre-hospital data to create the MTOS+ dataset. The TCWN audits the dataset to monitor the data validity so the registry measures up to the international standards of Good Clinical Data Management Practice.

The analyzed data included age, sex, type of road user, inter-hospital transfers, discharge data, injury data coded according to the Abbreviated Injury Scale (AIS) update 1998[8], injury severity coded according to the Injury Severity Score (ISS)[9], Glasgow Coma Score (GCS)[10], and mortality. The AIS codes consist of 7 numbers; the first 6 numbers specify the type of injury, whereas the last number of the AIS code represents the severity of the injury. TBI was defined as all AIS codes for intracranial injury and skeletal injury of the cranium, and sTBI included all of these injuries with AIS severity code ≥ 3. For the analyses, the continuous variables were categorized using clinically relevant cut-off points for age (<25 years, 25-55 years and >55 years), GCS (GCS <8 and GCS 8-12 vs. GCS>12) and ISS (<16 vs. ≥ 16). The ISS is an anatomical scoring system that provides an overall score for patients with multiple injuries. Severe trauma was defined as ISS ≥16. Severe trauma was calculated using AIS scores ≥ 3 in one or more body systems (including intracranial injury and skeletal injury of the cranium). If a single injury is assigned AIS score of 6 (fatal injury), the ISS score is automatically assigned to 75.

Five road user groups were defined: motorists (cars and trucks with permitted maximum speed of respectively 130 km/h and 80 km/h), motorcyclists (permitted maximum speed 130 km/h), moped riders (permitted maximum speed 45 km/h), cyclists and pedestrians. Data on helmet use and driving speed were not available. Because the use of helmets by motorcyclists is obligatory by law, it was estimated that virtually 100% in this group were wearing a helmet while driving the vehicle.[11] The moped group defined in the registry consists of both moped and light-moped riders. Helmet use is mandatory for moped riders but not for light-moped riders. The proportion of light-moped users in this group is estimated to be 14% based on previous results.[12] The helmet use in the entire moped group is estimated to be approximately 85%. In the Netherlands, cyclists are not obligated to wear helmets. Helmet use in this group is currently still very rare. We did not differentiate between drivers and passengers for all vehicles, nor did we classify the accidents by the level of energy of the impact.

Statistical analysis

The risk of sTBI was assessed for the specific road user groups after correction for age and sex in a multivariate logistic regression analysis. Road user groups with sTBI were compared with respect to demographic and clinical characteristics using the Chi-square test for categorical data and one-way ANOVA for continuous data. Within the group with sTBI, the anatomical locations and types of the injuries were analyzed per road user group, using the injury description according to the AIS. The outcome after sTBI (length of hospital stay and in-hospital mortality) was compared between road user groups using Kruskal-Wallis and Chi-square tests. The predictive value for in-hospital mortality of road user group and clinically relevant characteristics (age, ISS, GCS and type of hemorrhage) was univariately assessed using the Chi-square test and multivariately assessed with logistic regression analysis. The level of the primary referral hospital per RTA victim over time was described.

Data analysis was performed with SPSS version 20.0. P-values <0.05 were considered statistically significant.

RESULTS

Risk of sTBI

A total of 13,427 road traffic accident (RTA) victims admitted to hospitals in the region of the TCWN between 2003 and 2011 were selected from the trauma registry. 924 were excluded from the analysis mainly because type of road user was not specified or because they had been incorrectly coded as RTA victim. The remaining group of 12,503 patients included 1,020 pedestrians, 6,701 cyclists, 2,106 moped riders, 571 motorcyclists and 2,015 motorists. Of these, 1,250 patients were admitted to hospitals with sTBI, the majority being cyclists (51.2%). The incidence of sTBI was highest in the oldest age group (>55 years; p=0.02, Table 1) and was similar for men and women (p=0.20). Amongst all hospital admitted RTA victims in the region of the TCWN, sTBI was most prevalent in pedestrians and moped riders. These findings were confirmed in the multivariate analysis (Table 1).

Characteristics of sTBI patients by road user group

Table 2 presents demographic and clinical characteristics of the hospitalized RTA victims with sTBI by road user group. Patients with sTBI were predominantly male (61.2%), especially in the motorcyclist group (93.5%). The mean age of the studied population with sTBI was 45.2 years (SD 23.2). The age distribution differed between road user groups with sTBI. Pedestrians and cyclists had the highest ages. The percentage of young patients (aged <25 yrs) with sTBI was highest in moped riders; the majority of hospitalized motorcyclists and motorists were between 25-55 years. The overall percentage of young patients (<25 yrs) with sTBI in the total group of hospitalized RTA victims declined over the years from 36.2% to 28.7%, and the percentage of elderly RTA victims (>55 yrs) with sTBI increased from 30.9% to 37.6% during the study period.

The majority of the sTBI patients (58.8%) were severe trauma patients (ISS ≥16). Data on Glasgow Coma Scale (GCS) scores were not available in 23.8% of all patients with sTBI (Table 1). A total of 14.3% had a GCS<8 in the Emergency Department, most frequently in motorists and pedestrians.

Table 1. Patient characteristics and their predictive value for severe traumatic brain injury (AIS ≥ 3) in 12,503 hospitalized victims of road traffic accidents.

	sTBI (N=1,250)	No sTBI (N=11,253)	Risk of sTBI	
	N (%)	N (%)	Crude OR (95% CI)*	Adjusted OR (95% CI)*
Age				
<25 yrs	341 (9.0)	3464 (91.0)	1	1
25-55 yrs	423 (10.0)	3804 (90.0)	1.13 (0.97-1.31)	1.26 (1.08-1.47)
>55 yrs	486 (10.9)	3985 (89.1)	1.24 (1.07-1.43)	1.32 (1.14-1.54)
Sex				
Female	488 (9.6)	4604 (90.4)	1	1
Male	762 (10.3)	6649 (89.7)	1.08 (0.96-1.22)	1.11 (0.98-1.26)
Road user group				
Motorists	156 (7.4)	1949 (92.6)	1	1
Motorcyclist	31 (5.4)	540 (94.6)	0.72 (0.48-1.07)	0.68 (0.46-1.02)
Moped riders	268 (12.7)	1838 (87.3)	1.82 (1.48-2.24)	1.86 (1.51-2.30)
Cyclists	641 (9.6)	6060 (90.4)	1.32 (1.10-1.59)	1.31 (1.09-1.57)
Pedestrians	154 (15.1)	866 (84.9)	2.22 (1.75-2.82)	2.25 (1.78-2.86)

* Odds ratio with corresponding 95% confidence interval

Table 2. Demographic and clinical characteristics of 1,250 hospitalized road traffic accident victims with severe TBI per road user group.

	Total	Pedestrians	Cyclists	Moped Riders	Motorcyclists	Motorists
	N=1250	**N=154**	**N=641**	**N=268**	**N=31**	**N=156**
Sex, n (%)						
Male	776 (61.2)	86 (55.8)	348 (54.3)	191 (71.3)	29 (93.5)	108 (69.2)
Age,						
Mean (SD)	45.2 (23.2)	47.8 (27.2)	49.7 (23.5)	38.0 (19.7)	37.5 (15.6)	38.2 (19.3)
By category, n (%)						
<25 yrs	341 (27.3)	45 (29.2)	139 (21.7)	104 (38.8)	5 (16.1)	48 (30.8)
25-55 yrs	423 (33.8)	41 (26.6)	185 (28.9)	93 (34.7)	23 (74.2)	81 (51.9)
>55 yrs	486 (38.9)	68 (44.2)	317 (49.5)	71 (26.5)	3 (9.7)	27 (17.3)
Injury Severity Score						
Mean (SD)	18.3 (9.2)	21.0 (10.6)	16.7 (7.5)	18.3 (8.6)	23.0 (11.5)	21.4 (12.6)
By category, n (%)						
Missing	4 (0.3)	0 (0)	2 (0.3)	1 (0.4)	0 (0)	1 (0,6)
ISS <16	511 (40.9)	47 (30.5)	285 (44.5)	109 (40.7)	11 (35.5)	59 (37.8)
ISS ≥16	735 (58.8)	107 (69.5)	354 (55.2)	158 (59.0)	20 (64.5)	96 (61.5)
Neurological Scale, n (%)						
Missing	297 (23.8)	33 (21.4)	162 (25.3)	67 (25.0)	7 (22.6)	28 (17.9)
GCS <8	179 (14.3)	32 (20.8)	64 (10.0)	34 (12.7)	5 (16.1)	44 (28.2)
GCS 8-12	145 (11.6)	26 (16.9)	77 (12.0)	30 (11.2)	4 (12.9)	8 (5.1)
GCS >12	629 (50.3)	63 (40.9)	338 (52.7)	137 (51.1)	15 (48.4)	76 (48.7)
Length of Hospitalization In days, Median (range)						
	5 (0-102)	9 (0-83)	4 (0-102)	4 (0-96)	6 (0-61)	5 (0-93)
In-hospital Mortality						
N (%)	101 (8.1)	20 (13.1)	46 (7.2)	11 (4.2)	2 (6.5)	22 (14.1)

Location and type of sTBI

The types of sTBI and their anatomical locations are presented in Table 3. Most patients with sTBI sustained injuries of the cerebrum (86.2%), with up to 100% in motorcyclists. Injuries of the brainstem or cerebellum were uncommon. Most patients suffered from combined injuries, and the injury pattern differed between road user groups. Motorcyclists had the highest incidence of contusions, whereas skull fractures were least common in motorcyclists and motorists. Skull fractures were diagnosed in 43.8% of all admitted sTBI crash victims and were most frequently diagnosed in moped riders. Respectively, 25.0% and 23.9% of the sTBI patients sustained a skull base or skull vault fracture (Table 3).

Table 3. Anatomical location and type of severe traumatic brain injury (AIS ≥ 3) in 1,250 hospital admitted RTA victims per road user group. Results are presented as numbers (%) of patients with that specific injury. Patients may have multiple TBI locations or types.

	Total N = 1,250	Pedestrians N = 154	Cyclists N = 641	Moped riders N = 266	Motorcyclists N = 31	Motorists N = 156
Brainstem	15 (1.2)	2 (1.3)	6 (0.9)	3 (1.1)	0	4 (2.6)
Cerebellum	88 (7.0)	14 (9.1)	56 (8.7)	9 (3.4)	1 (3.2)	8 (5.1)
Cerebrum	1077 (86.2)	137 (89.0)	540 (84.2)	227 (84.7)	31 (100)	142 (91.0)
- Contusion	648 (51.8)	86 (55.8)	299 (46.6)	151 (56.3)	23 (74.2)	89 (57.1)
- Hemorrhage	684 (54.7)	98 (63.6)	362 (56.5)	138 (51.5)	16 (51.6)	70 (44.9)
Skull fracture	547 (43.8)	71 (46.1)	285 (44.5)	138 (51.5)	7 (22.6)	46 (29.5)
- Skull base fracture	312 (25.0)	43 (27.9)	153 (23.9)	91 (34.0)	3 (9.7)	22 (14.1)
- Skull vault fracture	299 (23.9)	35 (22.7)	163 (25.4)	69 (25.7)	5 (16.1)	27 (17.3)

Hemorrhage, especially subdural and subarachnoid bleedings, was the most common head injury in sTBI patients. It was diagnosed in more than 50% of all RTA victims with sTBI, ranging from 44.9% in motorists to 63.6% in pedestrians. Motorcyclists had the highest incidence of subarachnoid hemorrhage and the lowest incidence of subdural bleeding compared to the other road user groups (Figure 1).

Outcome after sTBI

The median hospitalization duration of the sTBI patients was 5 days (range 0-102 days; Table 2). Pedestrians were hospitalized longest (median 9 days). Of the 1,250 admitted sTBI patients, 101 (8.1%) died during their stay in the hospital. In-hospital mortality was highest in the motorists (14.1%) and pedestrians (13.1%) (Table 2). In the univariate analysis, GCS<12, ISS≥16, subdural, subarachnoid and intra-cerebral hemorrhage were also associated with increased in-hospital mortality (Table 4). In the multivariate analysis, age, GCS and ISS were independent prognostic factors for in-hospital mortality in RTA victims with sTBI (Table 4). The strongest predictor of in-hospital mortality was the GCS; patients with sTBI with a GCS<8 were the most at risk to die in the hospital

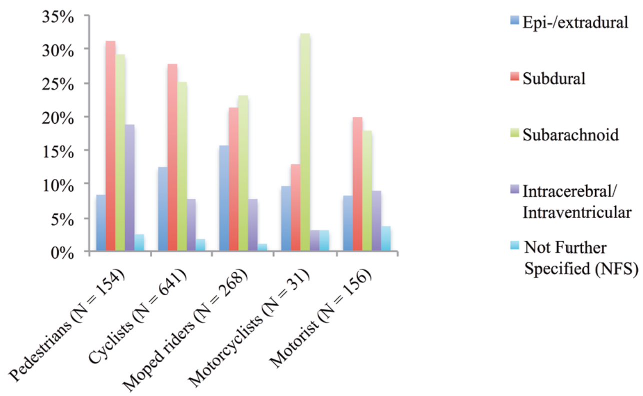

Figure 1. Distribution of haemorrhage type in road traffic accident victims with severe traumatic brain injury, according to the AIS classification per road user group.

Table 4. Clinical characteristics and their predictive value for in-hospital mortality in 1,147 victims of road traffic accidents with severe traumatic brain injury.*

	Deceased (N=101)	Survived (N=1,146)	Risk of in-hospital mortality	
	N (%)	N (%)	Crude OR (95% CI)**	Adjusted OR (95% CI)**
Age, n (%)				
<25 year	23 (6.8)	317 (93.2)	1	1
25-55 year	29 (6.9)	393 (93.1)	1.02 (0.58-1.79)	0.89 (0.47-1.70)
>55 year	49 (10.1)	436 (89.9)	1.55 (0.93-2.60)	1.91 (1.01-3.59)
ISS, n (%)				
<16	3 (0.6)	506 (99.4)	1	1
≥16	98 (13.4)	636 (86.6)	25.99 (8.19-82.47)	12.58 (3.71-42.67)
GCS, n (%)				
>12	10 (1.6)	617 (98.4)	1	1
8-12	12 (8.3)	133 (91.7)	5.57 (2.36-13.15)	3.89 (1.61-9.40)
<8	56 (31.1)	123 (68.7)	28.09 (13.95-56.58)	19.24 (9.11-40.62)
Unknown	23 (7.8)	273 (92.2)	5.20 (2.44-11.07)	4.46 (2.05-9.68)
Hemorrhage, n (%)				
No hemorrhage	17 (3.0)	547 (97.0)	1	1
Epi- or extradural	3 (3.3)	89 (96.7)	1.09 (0.31-3.78)	0.47 (0.13-1.78)
Subdural, -arachnoidal, or intracerebral	79 (13.8)	494 (86.2)	5.15 (3.01-8.81)	1.60 (0.85-3.01)
Not further specified type	2 (11.1)	16 (88.9)	4.02 (0.86-18.90)	1.81 (0.34-9.61)
Road user group, n (%)				
Motorists	22 (14.1)	134 (85.9)	1	1
Motorcyclists	2 (6.5)	29 (93.5)	0.42 (0.09-1.89)	0.59 (0.12-3.00)
Moped riders	11 (4.1)	256 (95.9)	0.26 (0.12-0.56)	0.30 (0.13-0.71)
Cyclists	46 (7.2)	594 (92.8)	0.47 (0.27-0.81)	0.61 (0.31-1.18)
Pedestrians	20 (13.1)	133 (86.9)	0.92 (0.48-1.76)	0.76 (0.35-1.65)

* Data on in-hospital mortality was missing for 3 patients with sTBI.
** odds ratio with corresponding 95% confidence interval

(OR 19.24, 95% CI 9.11-40.62). ISS ≥16 also proved to be a strong predictor for mortality after hospitalization (OR 12.58, 95% CI 3.71-42.67) (Table 4). After correction for the clinically relevant factors, there was no statistically significant difference in mortality between the road user groups (p=0.08).

Hospital triage

A total of 77% of RTA victims with sTBI were admitted in a level I trauma care hospital. This percentage was fairly stable over time (Figure 2). The percentage of sTBI patients admitted to a level II trauma hospital almost doubled from 11.7% in 2003 to 21.3% in 2011, whereas the percentage of sTBI patients who were admitted to a level III trauma hospital decreased from 9.7% to 5.7%.

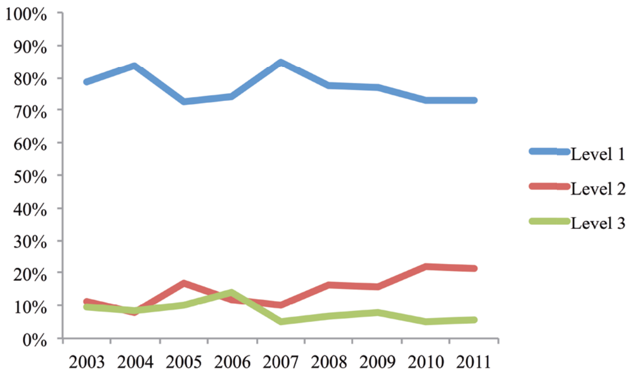

Figure 2. Distribution of admissions to level I, II or III trauma centres of road traffic accident victims with severe traumatic brain injury in the TCWN region during the study period.

DISCUSSION

This region-wide study aimed to determine the incidence, risk factors, hospital triage and outcome of severe traumatic brain injuries (sTBI) for different types of road users involved in RTAs. The study included 12,503 RTA victims who were admitted to hospitals in the regional trauma network of TCWN during a 9-year period (2003–2011).

Incidence and injury distribution.

In the study group, 10% of all RTA victims sustained sTBI, which is comparable with data from a Finnish study.[13] A comparison of our study with other international literature is difficult because of the absence of a clear clinical description of (severe) TBI. Differences in the definitions of TBI may result in divergent estimates of (severe) TBI incidence. The most widely used classification for scoring the severity of TBI is the GCS, but others used the AIS or ICD-9 (International Classification Disease – Ninth Edition) to classify TBI.[14-19]

Most hospital admitted RTA victims were cyclists. This is not surprising because 84% of Dutch citizens own a bicycle, and cycling is a very common mode of transportation in the Netherlands.[20] The WHO and a recent European Union summary of the most recent injury statistics classified cyclists as a vulnerable group of road users, along with pedestrians and motorcyclists(2). Due to their high risk of head injury, helmet laws for cyclists have been introduced in many countries. The preventive effect is still a topic of debate.[21,22] In the Netherlands, no obligatory helmet law for cyclists exists, and wearing a helmet when riding a bicycle is still very rare.[23] Our current findings may be helpful to set policy concerning the legislation of helmet usage in cyclists.

The majority of the sTBI patients were trauma patients with an ISS of 16 or higher. The explanation for this finding is two-fold. On the one hand, sTBI is often caused by high-energy trauma, which is likely to result simultaneously in severe traumatic brain injury and injury to other anatomical regions. The other explanation concerns the documentation and AIS classification. Within the current AIS coding manual, most cranial hemorrhages score a 4 in severity, which means that if cranial hemorrhage is the only diagnosis, the patient automatically has an ISS of 16 and is considered a severe trauma patient. An updated AIS scoring version will correct for this phenomenon in the future.

Injury patterns differed between road user groups. Pedestrians were the most vulnerable road user group in our study. They had the highest risk of sTBI, and skull fractures and intracranial hemorrhages were their most common injuries, which may account for this road user group having the longest hospitalization and the second highest mortality. These findings are in accordance with recent epidemiological studies conducted in several European countries, which demonstrated that pedestrians are vulnerable participants in daily traffic and have the most severe TBI with the worst outcome.[24-27] Both the high incidence of specific types of sTBI and the combination with severe trauma in pedestrians may be due to their unprotected traffic participation and relatively high age. The latter was confirmed in this study by a multivariate analysis. Moped riders sustained skull fractures more often than motorcyclists, whereas the incidences of other sTBI types were almost similar in both groups. The difference in the amount of skull fractures can most likely be ascribed to the protective effect of helmets[1,28-30] because helmet use is not mandatory for light-moped riders in the Netherlands.

Risk factors for in-hospital mortality

The study results indicate that a lower GCS was related to higher risks of in-hospital mortality after sTBI. The GCS is therefore a very relevant parameter that should be documented adequately in all ED admitted trauma patients. In our registry, 25% of GCS scores were missing for hospital admitted RTA victims. For future research and clinical strategy development, accurate documentation of all aspects (e.g., GCS, trauma scoring systems, vital parameters) of TBI by the initial trauma management teams is of major importance, not in the least for the purpose of early recognition of high-risk patients with head injury.

Other strong and independent prognostic factors for in-hospital mortality after sTBI were advancing age and severe trauma (ISS ≥16). No significant differences in the risks for in-hospital mortality between road user groups were found in our study after adjusting for clinical risk factors.

Hospital triage

The study period concerns an era in which centralization of trauma care was initiated and all-inclusive trauma systems in level I trauma centers became a standard of care. As part of this system, regional medical networks agreed on pre-hospital patient distribution to specific hospitals, depending on the level of care required for the patient. Following this principle, all severely injured patients (ISS≥16) should be brought to a center with at least level II facilities, but preferably to level I centers because direct transportation of these patients to a high-care facility reduces mortality and morbidity.[31] The results of our study show that the proposed centralization of trauma care was implemented gradually during the study period. The vast majority of patients with sTBI were transported directly to a level I trauma center, and this percentage remained stable (approximately 75% each year) during the studied period. The number of patients with sTBI presented directly to a level II trauma center almost doubled in the study period, whereas the number of sTBI patients presented to level III centers declined.

Limitations

We based our analyses on the data in the regional trauma registry, which includes data for trauma patients admitted to TCWN hospitals. Data for RTA victims who were deceased at the scene of the accident are absent in the registry. Based on figures on registered RTAs of the Dutch Ministry of Infrastructure and Environment, this concerned about 400 RTA victims in the study period in our region, who were not included in the initial study population of 13,427 hospital admitted RTA victims. Pre-hospital mortality in RTA is therefore estimated to be around 3% and represents about two third of all RTA related mortality. The causes of pre-hospital mortality remain however unknown.

The risks of sTBI and mortality presented in our study should be interpreted with care because they apply to a specific subgroup of RTA victims and do not reflect these risks in the entire population of RTA victims. Because we compared five different groups of road users, it is important to note that the groups differ from one another with respect to vulnerability and speed in daily traffic. It was impossible to control for speed, helmet usage and other protection because of the absence of these characteristics in the registry. Consequently, no conclusions can be drawn regarding the effect of speed and protection on the risks of sTBI and mortality within groups of traffic participants.

CONCLUSION

Severe traumatic brain injury patients represent 10% of all hospital admitted road traffic accident victims. Cyclists, moped riders and pedestrians have a high risk for sustaining sTBI in RTAs. Of all road traffic participants, pedestrians have the highest risk of sustaining sTBI and, more specifically, intracranial hemorrhage, whereas hemorrhage and contusion both occur in over 50% of the patients with sTBI after an RTA.

Awareness of these crash characteristics and risk factors will improve the vigilance for specific types of head injury in road user groups, will stimulate the development of focused diagnostic strategies and will consequently help to achieve better outcomes for the trauma patient with sTBI.

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