Prognostic impact of prehospital management in traumatic brain injury

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ABSTRACT

Background: Traumatic brain injury remains a major global health concern, with prehospital management playing a decisive role in both survival and neurological recovery. The actions performed at the accident scene can prevent or exacerbate secondary brain injury, particularly through their impact on oxygenation, perfusion, and the quality of immobilization. **Objective:** To assess the prognostic and functional impact of prehospital management among patients with traumatic brain injury admitted to the intensive care unit.

Methods: A retrospective, descriptive, and analytical study was conducted over six months (January–June 2025) in the medical intensive care unit. We included all patients over 16 years old admitted for TBI with documented prehospital care. Functional outcomes were categorized using the Glasgow Outcome Scale.

Results: Twenty-seven patients were included (median age 33 years; 74.1% male). Road traffic accidents accounted for 96.3% of cases. The median of prehospital Glasgow Coma Scale score was 10. Prehospital care was provided mainly by the Mobile Emergency and Resuscitation Service (59.5%). Treatment included oxygen therapy (25.9%), intubation (25.9%), and cervical immobilization (100%). The median delay between trauma and hospital arrival was 30 minutes. Mortality reached 18.5%. Pupillary abnormalities at both prehospital and admission stages were significantly associated with mortality ($p = 0.02$). Longer Intensive care unit and in-hospital stays were significantly associated with poor functional outcomes ($p = 0.034$ and $p = 0.04$, respectively).

Conclusion: The outcomes of TBI patients depend not only on injury severity but also on the quality and timeliness of prehospital management. Rapid prehospital Mobile Emergency and Resuscitation Service medical team, continuous monitoring, and safe transport significantly reduce mortality and functional disability.

Keywords: Traumatic brain injury, prehospital care, prognosis, intensive care, functional outcome, mortality.

Introduction

Traumatic brain injury (TBI) remains a major global public health issue (1). Initial management, particularly during the prehospital phase, plays a crucial role in determining both vital and functional prognosis (2–4). The period between the trauma and hospital admission is critical: actions performed at the accident scene can either prevent or worsen secondary brain injuries. Inadequate cerebral oxygenation and perfusion, delayed transfer, or insufficient immobilization can compromise survival and neurological recovery (5).

Prehospital emergency systems differ from one country to another (6). In Tunisia, prehospital management of trauma victims involves several actors: the Mobile Emergency and Resuscitation Service (MERS), the Civil Protection teams, and private ambulances.

The objective of this study was to evaluate the prognostic and functional impact of prehospital management among patients with traumatic brain injury admitted to the intensive care unit.

Methods

This was a retrospective, descriptive, and analytical study conducted over six months (January–June 2025) involving patients admitted for traumatic brain injury to the emergency room of Habib Bourguiba University Hospital in Sfax. We included all patients aged over 16 years admitted for TBI, regardless of severity, who had documented prehospital management. We excluded patients secondarily transferred from another hospital and those with incomplete records. Data were collected from medical files and prehospital care forms. Functional outcomes were categorized as poor (GOS 2–3) or good (GOS 4–5). Data analysis was performed using SPSS software (version 25.0).

Results

A total of 27 patients were included. The median age was 33 years (range 16–72), with a male predominance (n = 20; 74.1%). Road traffic accidents were the main cause (n = 26; 96.3%). The median prehospital Glasgow Coma Scale (GCS) score was 10; eight patients (29.6%) had a GCS $\leq$ 8. Pupillary examination showed normal pupils in 23 cases (85.2%), unilateral mydriasis in 2 (7.4%), and bilateral mydriasis in 2 (7.4%). Vital distress signs were observed as circulatory distress (n = 2; 7.4%), respiratory distress (n = 7; 25.9%), and neurological distress (n = 22; 81.5%). Vomiting occurred in five patients (18.5%). The median delay between trauma and the arrival of emergency services was 15 minutes (5–30 minutes). Prehospital care was provided by SMUR in 16 patients (59.5%), by Civil Protection in 3 (11.1%), and by type B ambulances in 1 (3.7%). Prehospital interventions included oxygen therapy (n = 7; 25.9%), intubation (n = 7; 25.9%), hemodynamic stabilization by using fluid filling (n=4;14.8%) and catecholamines (n = 4; 14.8%), spine immobilization in all patients (100%), sedation (n = 7; 25.9%), and continuous monitoring (n = 7; 25.9%). On arrival to the emergency room, the median time from trauma to hospital arrival was 30 minutes (5–60 minutes). The median GCS score was 13 (mean 10.05 ±

4.68). Pupils were normal in 22 cases (81.5%), unilaterally dilated in 4 (14.8%), and bilaterally dilated in 1 (3.7%). Vital distress signs were present in 16 patients (59.3%). Associated injuries included polytrauma (n = 21; 77.8%), thoracic trauma (n = 18; 66.7%), abdominal trauma (n = 13; 48.1%), and bone fractures (n = 24; 88.9%). All patients were admitted to the Intensive Care Unit (ICU). Neurosurgery was required in 5 patients (18.5%). The median ICU stay was 18 days (5–72), and the median total in-hospital stay was 21 days (6–72). Complications included infections (n = 21; 77.8%) and seizures (n = 9; 33.3%). Tracheostomy was performed in 12 patients (44.4%). The Glasgow Outcome Scale (GOS) at discharge was: death (GOS 1) = 5 (18.5%), vegetative state (GOS 2) = 1 (3.7%), severe disability (GOS 3) = 2 (7.4%), moderate disability (GOS 4) = 5 (18.5%), and good recovery (GOS 5) = 14 (51.9%). Table 1 shows that prehospital bilateral mydriasis admission and myosis or normal light reflex at admission were the only factors significantly associated with mortality (*p* = 0.02 for both). Table 2 shows that ICU stay duration and total hospital stay were the only factors significantly associated with poor functional outcome (GOS 2–3) (p = 0.034 and p = 0.04, respectively).

Discussion

Traumatic brain injury remains one of the leading causes of mortality and acquired disability worldwide. In developing countries, where road traffic accidents are frequent and prehospital resources are limited, prehospital care is a major

Table 1: Factors Associated with Mortality

Variables	Survivor (n=22)	Dead (n=5)	p
Median age (years)	36	20	0.8
Sex (M); n(%)	15 (68.18)	5 (100)	0.2
Pre-hospital Glasgow Coma Scale (median)	10	10	0.6
Pupil status (pre-hospital)			
– Myosis or normal light reflex; n(%)	18 (81.81)	3 (60)	0.08
– Unilateral mydriasis; n(%)	2 (9.09)	0	0.4
– Bilateral mydriasis; n(%)	0	2 (40)	0.02
Pre-hospital vital distress signs			
– Circulatory distress; n(%)	18 (81.81)	5 (100)	0.3
– Respiratory distress; n(%)	16 (72.72)	4 (80)	0.6
– Neurological distress; n(%)	17 (77.27)	5 (100)	0.4
– Vomiting; n(%)	4 (18.18)	1 (20)	0.6
Median delay between trauma and first aid arrival (min)	15	20	0.3
Pre-hospital medical team			
– MERS; n(%)	13 (59.09)	3 (60)	0.9
– Civil protection; n(%)	3 (13.63)	0	0.5
– Type B ambulance; n(%)	1 (4.54)	0	0.6
Pre-hospital resuscitation measures			
– Oxygen therapy; n(%)	6 (27.27)	1 (20)	0.6
– Intubation; n(%)	5 (22.72)	2 (40)	0.5
– Catecholamines; n(%)	3 (13.63)	1 (20)	0.6
– Fluid filling	3 (13.63)	1 (20)	0.6
– Sedation; n(%)	5 (22.72)	2 (40)	0.5
– Continuous monitoring (monitor, oximeter); n(%)	4 (18.18)	1 (20)	0.7
Hospital admission data			
– Median delay between first aid and hospital arrival (min)	30	30	0.7
– Median Glasgow Coma Scale at admission	11	6	0.3
Pupil status at admission			
– Myosis or normal light reflex; n(%)	20 (90.9)	2 (40)	0.02
– Unilateral mydriasis; n(%)	2 (9.09)	2 (40)	0.1
– Bilateral mydriasis; n(%)	0	1 (20)	0.2
Vital distress at admission; n(%)	12 (54.54)	4 (80)	0.3
Associated injuries			
– Polytrauma; n(%)	17 (77.27)	4 (80)	0.6
– Thoracic trauma; n(%)	15 (68.18)	3 (60)	0.5
– Abdominal trauma; n(%)	11 (50)	2 (40)	0.5
– Bone fractures; n(%)	20 (90.9)	4 (80)	0.4
– Neurosurgical procedure; n(%)	3 (13.63)	1 (20)	0.5
Evolution data			
– Median ICU stay (days)	16	10	0.2
– Median total hospital stay (days)	21	12	0.1
Complications			
– Infection; n(%)	18 (81.81)	3 (60)	0.3
– Seizures; n(%)	7 (31.81)	2 (40)	0.5
– Tracheostomy; n(%)	11 (50)	1 (20)	0.2

Mobile Emergency and Resuscitation Service (MERS), intensive care unit(ICU), NA: not applied

Table 2: Factors Associated with Functional Outcome

Variables	GOS 4–5 (n=19)	GOS 2–3 (n=3)	p
Median age (years)	24	21.5	0.4
Sex (M); n(%)	12 (63.15)	3 (100)	0.3
Pre-hospital Glasgow Coma Scale (median)	11	8.5	0.07
Pupil status (pre-hospital)			
– Myosis or normal light reflex; n(%)	15 (98.74)	3 (100)	0.5
– Unilateral mydriasis; n(%)	2 (10.52)	0	0.6
Pre-hospital vital distress signs			
– Circulatory distress; n(%)	4 (21.05)	0	0.5
– Respiratory distress; n(%)	4 (21.05)	2 (66.66)	0.2
– Neurological distress; n(%)	14 (73.68)	3 (100)	0.5
– Vomiting; n(%)	3 (15.78)	1 (33.33)	0.4
Median delay between trauma and first aid (min)	15	15	0.5
Pre-hospital medical team			
– MERS; n(%)	12 (63.15)	1 (33.33)	0.3
– Civil protection; n(%)	3 (15.78)	0	0.7
– Type B ambulance; n(%)	1 (5.26)	0	0.8
Pre-hospital resuscitation measures			
– Oxygen therapy; n(%)	5 (26.31)	1 (33.33)	0.6
– Intubation; n(%)	4 (21.05)	1 (33.33)	0.7
– Catecholamines; n(%)	2 (10.52)	1 (33.33)	0.6
– Fluid filling	2 (10.52)	1 (33.33)	0.6
– Sedation; n(%)	4 (21.05)	1 (33.33)	0.7
– Continuous monitoring (scope, oximeter); n(%)	3 (15.78)	1 (33.33)	0.7
Hospital admission data			
– Median delay between first aid and hospital arrival (min)	30	30	0.9
– Median Glasgow Coma Scale at admission	13	8	0.5
Pupil status at admission			
– Myosis or normal light reflex; n(%)	17 (89.47)	3 (100)	0.6
– Bilateral mydriasis; n(%)	2 (10.52)	0	0.7
Vital distress at admission; n(%)	9 (47.36)	3 (100)	0.1
Associated injuries			
– Polytrauma; n(%)	14 (73.68)	3 (100)	0.4
– Thoracic trauma; n(%)	15 (98.74)	3 (100)	0.3
– Abdominal trauma; n(%)	9 (47.36)	2 (66.66)	0.5
– Bone fractures; n(%)	17 (89.47)	3 (100)	0.7
– Neurosurgical procedure; n(%)	3 (15.78)	0	0.6
Evolution data			
– Median ICU stay (days)	13	40	0.034
– Median hospital stay (days)	17	41.5	0.04
Complications			
– Infection; n(%)	15 (98.74)	3	0.5
– Seizures; n(%)	6 (31.58)	1	0.7
– Tracheostomy; n(%)	8 (42.1)	3	0.1

Mobile Emergency and Resuscitation Service (MERS), intensive care unit (ICU), NA: not applied

determinant of both vital and functional outcomes (5,7). In our series, most patients were young men with a median age of 33 years, consistent with international literature (8–10). The delay between the accident and the arrival of emergency services is a critical prognostic factor (11). In low- and middle-income countries, the average prehospital delay is around 217 minutes—much longer than in high-income settings (12). Moderate (10–60 min) and prolonged (≥61 min) delays are associated with higher mortality (OR ≈ 1.3) and increased 24-h mortality (OR ≈ 3.4–3.8) (13). Rogers et al. emphasized the "golden hour" of trauma care: every minute lost increases the risk of secondary neurological deterioration (14). Longer times from injury to hospital admission are also linked to poorer functional outcomes (15). Patients managed by a medical MERS team had significantly higher survival and better neurological recovery than those managed by non-medical teams (16). The advantage of such teams lies in early intubation and assisted ventilation, stable hemodynamic management, continuous monitoring, and coordination with the receiving hospital. These findings are consistent with studies by Baxt & Moody (17) and Sampalis et al. (18), which showed significantly lower mortality in severe TBI patients receiving full prehospital resuscitation. Transport by (MERS) reduces 30-day mortality compared to transport by Civil Protection (16). Management by paramedics is associated with higher mortality and severe disability (GOS ≤ 3) (16,19). Initial injury severity, particularly a low GCS score, remains a robust predictor of mortality and sequelae (20), as observed in our study. Pupillary abnormalities (unilateral or bilateral mydriasis) are major neurological signs of poor prognosis (20); they were more frequent among deceased patients in our series. Early oxygenation is one of the most critical interventions (3,21). A systematic review by Shafique et al. showed that prehospital intubation reduces morbidity and mortality compared with non-intubated TBI patients (22). Thirawattanasoot et al. found that a prehospital $SpO_2 \geq 94\%$ correlates with better outcomes in hypotensive TBI patients (23). Maintaining adequate cerebral perfusion depends on prompt correction of hypotension through fluid resuscitation and, if necessary, vasoactive drugs. Early stabilization limits secondary ischemic damage (3). A systematic review of moderate-to-severe TBI demonstrated that hypotension is significantly associated with higher mortality (24). A multicenter cohort study confirmed that prehospital hypotension, hypoxia, or hypocapnia each increases the risk of death or disability after TBI (25). Lack of immobilization exposes patients to potential spinal cord injuries, often with devastating consequences (26). Pain and agitation increase intracranial pressure; judicious use of analgesics and sedatives under monitoring improves hemodynamic and neurological stability (27,28). Prolonged ICU or hospital stays after TBI are often associated with worse outcomes, more complications, and higher functional disability at discharge (29). In our study, longer ICU and hospital stays were significantly associated with poor functional prognosis, in agreement with the literature.

Limitations: This study has several limitations. It was retrospective and relied on the quality of recorded data. The sample size was relatively small, and no long-term follow-up was performed (GOS was assessed only at discharge). Nevertheless, this study provides a realistic overview of current conditions and highlights the crucial importance of the prehospital chain in post-traumatic prognosis.

Conclusion

The prognosis of patients with traumatic brain injury depends not only on the initial severity of the injury but also on the speed and quality of prehospital management. Early Medical MERS team intervention, safe transport, and continuous monitoring are associated with a significant decrease in mortality and neurological sequelae.

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