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Effect of pre-hospital advanced life support with rapid sequence intubation on outcome of severe traumatic brain injury

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Background: The role of pre-hospital trauma care and the effect of pre-hospital rapid sequence intubation (RSI) on patient outcome are still not clear. This study evaluated the impact of pre-hospital trauma care by emergency physicians (EP) on mortality from severe traumatic brain injury (TBI) and a 180-day Glasgow Outcome Scale (GOS).

Methods: A 48-month parallel non-controlled cohort study compared a group of 64 patients with severe TBI [Glasgow Coma Scale (GCS) < 9; Injury Severity Score (ISS) > 15] who received pre-hospital advanced life support (ALS) with RSI and were transported to the hospital by EPs (EP group), with a group of 60 patients who did not receive pre-hospital ALS with RSI [emergency medical technicians (EMT) group].

Results: There were no significant statistical differences between the groups in age ($P = 0.79$), mechanism of injury ($P = 0.68$), gender ($P = 0.82$), initial GCS ($P = 0.63$), initial SaO_2 in the field ($P = 0.63$), initial systolic blood pressure in the field ($P = 0.47$) and on-scene time ($P = 0.41$). In the EP group, there was significantly better first hour survival (97% vs. 79%, $P = 0.02$), first day survival (90% vs. 72%, $P = 0.02$), better functional outcome (GOS 4–5: 53% vs. 33%, $P < 0.01$; GOS 2–3: 8% vs. 20%, $P < 0.01$) and shortened hospitalization time in intensive care unit (ICU) ($P = 0.03$) and other departments ($P = 0.04$). In total hospital mortality, we detected no differences between both groups [EP group: 40% (95% CI: 34–45%) vs.EMT group 42% (95% CI: 36–47%, $P = 0.76$], except in a subgroup of patients with GCS 6–8 where there was significantly lower total hospital mortality in the EP group (24% vs. 78%, $P < 0.01$).

Conclusion: After starting the trauma care system with emergency physicians in our region, there was a decrease in the number of deaths on hospital admission, a reduction in hospital mortality in the GCS group 6–8, a change in the temporal distribution of deaths, an improvement in functional neurological outcome and shortened hospitalization time.

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Key words: emergency medical system; pre-hospital trauma care; rapid sequence intubation; severe traumatic brain injury; outcome.

PRE-HOSPITAL advanced life support (ALS) in trauma patients is a subject of increasing importance (1–3), although the benefits of pre-hospital ALS for major trauma patients still remain controversial (4). At least for severely injured patients, the dilemma between a 'scoop and run' and 'stay and play' decision should not exist (1,5). Among all ALS procedures, rapid sequence intubation (RSI) is the most important – airway and respiratory problems are the quickest killers in patients with multiple injuries. Recent studies have confirmed that a pre-hospital care provider must not only be able to intubate with the use of neuromuscular blockers and anaesthesia induction agents, but also to ensure correct tube placement and perform controlled ventilation during transport (2,6–8). In trauma patients with TBI, hypoxemia should be corrected immediately after injury (4,9).

The aim of this study was to evaluate the impact of pre-hospital trauma care with ALS and RSI on the outcome in patients with severe traumatic brain injury (TBI). We wanted to answer the following questions: (i) does pre-hospital ALS with RSI, performed by emergency physicians (EP), have an effect on mortality from severe TBI, (ii) on neurological outcome from severe TBI and (iii) on the duration of hospitalization.

Methods

This parallel non-controlled cohort study was performed in the Center for Emergency Medicine in Maribor, the second largest city in Slovenia with a

population of approximately 200,000 spread over an area of approximately 780 km^2. Since August 1999, we have had two pre-hospital emergency teams (PET) and two basic life support teams (BLST) equipped with a defibrillator 24 h a day, 7 days a week. In the period of April to October, we have also had a motorcycle rescuer (MR) for basic life support with defibrillation capability (12 h a day). A PET is an ALS unit manned by an emergency physician and two register nurses or medical technicians. A BLST is manned by two register nurses or medical technicians. A PET is primarily routinely dispatched to the field in emergency situations (in case of presumed cardiac arrest, heart attack, respiratory distress, cerebrovascular incident, trauma, delivery, poisoning and so on).

We investigated 64 patients with TBI (Glasgow Coma Scale (GCS) < 9; Injury Severity Scoring > 15; Abrreviated Injury Severity Scoring for Head > 3) who received pre-hospital ALS and RSI by emergency physicians in the period between January 2000 and January 2004 [emergency physicians (EP) group]. This group was compared with 60 patients who were injured in the period between January 1998 and January 2004 and did not receive pre-hospital ALS and RSI in the field [emergency medical technicians (EMT) group]. Patients from both groups were admitted to the Teaching Hospital Maribor and were treated at the Department of Anaesthesiology and Intensive Care Medicine on the same principle.

Pre-hospital RSI was performed with induction agents (midazolam, thiopental, ketamine, etomidate, fentanyl) in recommended doses followed by the administration of a rapid-acting neuromuscular blocking agent (succinycholine 1–1.5 mg/kg). EPs confirmed endotracheal tube placement with auscultation and capnometry/capnography. Hyperventilation and the use of mannitol were reserved for patients with clinical deterioration and signs of cerebral herniation (bradycardia, hypertension, loss of pupillary reflex) (10). The mechanism of injury was recorded and reported as a traffic accident, fall/jump accident, blow/assault and other rarely occurring causes.

The Glasgow Outcome Scale (GOS), measured at 6 months (180 days) after injury, was used for assessment of functional outcome. It was recorded on a scale of 1–5 (GOS 1 – dead, GOS 2 – persistent vegetative state, GOS 3 – severe disability, GOS 4 – moderate disability, GOS 5 – good recovery). For the purpose of analysis, patients who survived were grouped into the good outcome (GOS 4 or 5) or poor outcome (GOS 2–3) group.

Statistical analysis

Statistical analysis was performed using Wilcoxon's rank sum test for nominal variables and Fisher's exact test for categorical variables. Variability was expressed either as a median with range (or percentiles) for non-parametric data or mean with standard deviation for normally distributed data. Proportions were reported with a 95% confidence interval. Multivariate logistic regression analysis was done to examine the relationship between survival/functional outcome and pre-hospital intervention (RSI), controlling for age, gender, mechanism of injury, GCS, ISS, initial SaO_2 and systolic blood pressure (11).

Statistical analysis was done with the programmes Statistica 5.0 Software (Statsoft, Inc., Tulsa, OK) and Systat Software (Systat Inc., Evanston, IL).

Results

There were no significant statistical differences between the groups in age, mechanism of injury, gender, initial GCS, initial SaO_2, initial systolic blood pressure and on-scene time (Table 1). In the EP group, there was a significantly higher rate of intubations in the field (all intubations, including intubations without RSI methods), a significantly higher rate of RSI in the field and significantly better results of SaO_2 and systolic blood pressure on admission to the hospital ($P < 0.05$).

In the EP group, there was significantly better first hour survival, first day survival, better functional outcome and shortened hospitalization time in the ICU or other departments (Table 2).

When adjusting for dissimilarities in age, gender, mechanism of injury, GCS, ISS, initial SaO_2 and initial systolic blood pressure, the odds ratio for first hour survival after admission to the hospital among patients who were intubated compared with non-intubated was 2.24 (95% CI: 1.78–2.91; $P < 0.001$). When adjusting similarly for various differences, the odds ratio for first hour survival after admission among patients who received RSI compared with patients who did not receive RSI was 1.83 (95% CI: 1.12–2.76; $P = 0.002$).

Similarly, the odds ratio for first 24-h survival after admission among patients who were intubated compared with non-intubated was 2.61 (95% CI: 1.83–3.85; $P < 0.001$) and the odds ratio for first 24-h survival after admission among patients who received RSI compared with patients who did not receive RSI was 2.04 (95% CI: 1.61–2.93; $P = 0.0012$).

Using logistic regression analysis to compare groups GOS 2–3 vs. GOS 4–5, the adjusted odds ratio among patients who were intubated compared with

Table 1

Comparison of the demographic and clinical characteristics of patients between emergency physicians and emergency medical technicians group.

	EMT group	EP group	*P*-value
Age	42.5 ± 21.3 (18–82)	44.8 ± 23.6 (18–86)	0.79
Mechanism of injury	Traffic incident 29 Fall/jump19 Blow/assault 6 Other 6	Traffic incident 34 Fall/jump 15 Blow/assault 8 Other 7	0.68
Gender (male/female)	49/11	49/15	0.82
GCS (median; percentile 25 and 75)	6 (4, 8)	5 (3, 8)	0.63
ISS (median, percentile 25 and 75)	23 (17, 25)	24 (16, 26)	0.81
Intubation in the field % (*n*)	3 (2)	100 (64)	<0.001
RSI in the field % (*n*)	0	86 (55)	<0.001
Time from call to arrival on the scene (min)	7 ± 3	8 ± 5	0.57
On-scene time (min)	27 ± 9	29 ± 8	0.41
Initial SaO_2 in the field (%)	86 ± 11	84 ± 10	0.63
SaO_2 on admission to the hospital (%)	89 ± 8	96 ± 3	0.04
Initial systolic blood pressure in the field (mmHg)	101 ± 38	104 ± 34	0.47
Systolic blood pressure on admission to the hospital (mmHg)	105 ± 35	132 ± 32	0.03

EP, emergency physicians; EMT, emergency medical technicians; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; RSI, rapid sequence intubation.

non-intubated was 2.01 (95% CI: 1.34–3.12, $P < 0.001$) and among patients who received RSI compared with patients without RSI it was 2.56 (95% CI: 1.36–3.75, $P = 0.002$).

In the subgroup of patients with GCS scores between 6 and 8, significantly more patients in the EP group (all patients were intubated with the RSI method) survived than in the EMT group (all patients were ventilated through bag-valve masks and were not intubated) (16/21 or 76% vs. 4/18 or 22%; $P < 0.01$). When adjusting for dissimilarities in age, gender, mechanism of injury, GCS, ISS, initial SaO_2 and systolic blood pressure, the odds ratio for discharge from hospital among patients who were intubated with RSI compared with non-intubated was 3.85 (95% CI: 1.84–6.38, $P < 0.001$).

Discussion

Our investigation strongly supports the role of prehospital intubation and RSI on outcome. In the EMT group, only two patients were intubated, both of them had GCS 3 and intubation was performed without RSI. In the EP group, all patients were intubated; RSI was performed in 86% (in the other 14% EPs used induction drugs without neuromuscular blockers).

Through multivariate logistic regression analysis, we confirmed a statistically significant better first hour and first day survival in the EP group. In our opinion, this is the result of better airway management (significantly higher values of SaO_2 on admission to the hospital) and volume resuscitation (significantly higher values of systolic blood pressure on admission to the hospital) in the EP group. We also confirmed a better functional outcome and shortened hospitalization time in the EP group.

But when we compared the entire hospital mortality, we detected no differences between the EP and EMT groups (40% vs. 42%; $P = 0.76$). These results may be explained by Stoccheti's hypothesis (12). He found that the quality of the trauma system affected

Table 2

Comparison of the outcome of patients between emergency physicians and emergency medical technicians group.

	EMT group	EP group	*P*-value
Survival (y/n) (%; 95% CI)	35/25 (58; 53–64)	39/25 (60; 56–66)	0.76
First hour survival	47/13 (78; 73–84)	62/2 (97; 95–99)	0.02
First day survival	45/15 (75; 73–82)	57/7 (90; 83–96)	0.02
GOS 4–5,% (n)	33 (21)	53 (34)	0.01
GOS 2–3,% (n)	25 (14)	7 (5)	0.01
ICU hospitalization (days)	19.7 ± 12.5	11.2 ± 6.5	0.01
Trauma hospitalization (days)	44.8 ± 20.2	33.1 ± 30.4	0.04

EP, emergency physicians; EMT, emergency medical technicians; GOS, Glasgow Outcome Scale; ICU, intensive care unit.

the outcome because a better trauma system produced a lower rate of favourable outcomes. This paradox is owing to the fact that a more efficient pre-hospital trauma system brings even the most severe cases to hospital. Because of this, a larger number of patients who cannot be saved are admitted to the hospital and mortality is therefore higher. In contrast, when the system does not work properly most affected patients die before reaching hospital, so mortality among patients admitted to hospital may appear lower (in our investigation this was evident as a change in the temporal distribution of deaths and shorter total hospitalization period).

On the other hand, in the subgroup of patients with an initial GCS between 6 and 8, there was significantly better total survival in the EP group vs. the EMT group ($P < 0.001$). Similar findings were described by Schuttler et al. (13). This subgroup of patients best demonstrates the role of emergency physicians in pre-hospital management of TBI. In these patients, intubation without the support of anaesthetic drugs is difficult because airway protective reflexes are maintained. Therefore, the RSI method is essential to effectively inhibit these reflexes.

In the acute phase of TBI, it is important to start adequate resuscitation as early as possible to prevent hypotension and hypoxia, as these factors may initiate pathophysiological mechanisms leading to secondary brain injury (1,2,14,15).

Hussain and Redmond (16) found that airway problems are the main cause of mortality in patients with otherwise survivable injuries. The detrimental effect of hypoxemia on the outcome of patients with TBI has been demonstrated in several studies (17–20). Winchell (21), Lossius (22), Davis (23), Garner (24) and Bulger (25) showed that pre-hospital endotracheal intubation was associated with significantly improved survival. On the other hand, several recent studies (26–28) have shown that pre-hospital intubation does not improve survival. In these studies, endotracheal intubation was performed by paramedics and emergency medical technicians who did not use drugs to facilitate intubation attempts. Attempted intubation in trauma patients without the support of sedative and muscle relaxant drugs is often difficult and can lead to an increase in intracranial pressure. Rapid sequence intubation, which induces unconsciousness and motor paralysis, is associated with a decrease in intubation failures and complications (29). RSI is the gold standard for emergency intubation attempts in patients with severe TBI (30,31). The new guidelines therefore recommend pre-hospital RSI for patients with severe TBI (31,32).

Some authors compared pre-hospital RSI, performed by emergency physicians, with hospital RSI, performed by anaesthesiologists. They found that there were no differences in the success rate and the rate of complications between RSI in the field and RSI in the hospital. They concluded that pre-hospital intubation was safe (33,34).

Besides studies which investigated the role of pre-hospital management of TBI on survival, there are many studies that also studied the connection between pre-hospital management of TBI and neurological outcome in patients who survived. Rudehill et al. (14) noted that the introduction of effective pre-hospital care most likely contributed to the improved post-resuscitation neurological status and consequently to better outcome (GOS). Bulger et al. (15) reported that pre-hospital intubation in the management of TBI was associated with decreased mortality rate, but without significant differences in functional neurological status at discharge among survivors. In a similar investigation, Garner et al. (24) concluded that pre-hospital intubation independently predicted better outcome in severe blunt head injury.

Recent studies (28,35) have confirmed the association between hyperventilation and mortality. Continuous monitoring of $petCO_2$ is important for checking tracheal tube placement (7,8) and gives important information about circulation and respiration.

The results of our study demonstrate the importance of ALS and the role of emergency physicians in the pre-hospital treatment of TBI. Our study uses historic controls and has a small number of patients. Therefore our results should be confirmed in the future by larger multi-centre clinical trials.

Conclusion

After starting the pre-hospital trauma care system and RSI airway management with emergency physicians in our region, there was a decrease in the number of deaths on hospital admission, a decrease in total hospital mortality for patients with GCS 6–8, a change in the temporal distribution of deaths, an improvement in functional outcome and shortened hospitalization time in patients with severe TBI.

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