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Level of prehospital care and risk of mortality in patients with and without severe blunt head injury

Anna Lee [a,b,*], Alan Garner [b,1], Michael Fearnside [c], Ken Harrison [b,c]

[a] *Department of Anaesthesia and Intensive Care, Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, New Territories, Hong Kong, China*

[b] *NRMA CareFlight/NSW Medical Retrieval Service, P.O. Box 159, Westmead, 2145 NSW, Sydney, Australia*

[c] *Westmead Hospital, Sydney, Australia*

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Abstract

Objectives: To determine the association between mortality and the level of prehospital care in severely injured blunt trauma patients with or without severe head injury.

Method: Retrospective review of 2010 severe blunt trauma patients (injury severity score (ISS) >15) with or without severe head injury in a tiered trauma system involving ambulance officers (basic life support (BLS) and advanced life support (ALS)) and physicians, and a Level 1 trauma centre.

Results: After adjusting for age, type of head injury, glasgow coma scale score (GCS), systolic blood pressure, ISS and prehospital time, intensive care unit (ICU) admission modified the association between level of prehospital care and mortality. In those patients without ICU admission, patients in the paramedic and physician-staffed emergency services group were more likely to die than patients in the BLS ambulance group (odds ratio (OR) 2.18, 95% confidence intervals (CI): 1.05–4.55; 4.27, 95% CI: 1.46–12.45, respectively). Among patients who survived to ICU treatment, however, there was no association between level of prehospital care and risk of mortality. Presence or absence of a head injury did not modify the risk of mortality.

Conclusions: The level of prehospital care was associated with the risk of mortality. This was modified by whether the patient survived long enough to be admitted to the ICU.

1. Introduction

There is ongoing controversy regarding the benefits of advanced life support (ALS) versus basic life support (BLS) in the prehospital care of severely injured trauma patients. A systematic review of prehospital ALS versus BLS failed to show a benefit for onsite ALS and concluded that 'scoop and run' was the optimal strategy for trauma patients [12]. However, the sub-group of patients with severe head trauma has been suggested as a group that is particularly likely to benefit from on-scene stabilisation, as early correction of hypoxia and hypotension is critical for survival [6].

The objective of this study was to determine the association between mortality and the level of prehospital care in a population of severely injured blunt trauma patients with or without severe head injury. The study was approved by the Western Sydney Area Health Human Research Ethics Committee.

2. Patients and methods

We included patients who sustained severe blunt trauma with an injury severity score (ISS) >15 [5], with or without head injury, admitted to Westmead Hospital, western Sydney, Australia between July 1986 and December 2000. These patients were identified from the hospital trauma registry. Westmead Hospital is a tertiary referral hospital providing trauma services equivalent to an American College of Surgeons Level 1 trauma centre.

The Sydney prehospital trauma system is a tiered system involving both ambulance officers and physicians. Ambulance officers are trained to one of the three levels:

- *Level* 3: Basic life support minus external control of haemorrhage, splinting, non-invasive airway manoeuvres and bag-valve-mask ventilation.

* Corresponding author. Tel.: +852-2632-2735; fax: +852-2637-2422.
E-mail addresses: annalee@cuhk.edu.hk (A. Lee), alang@careflight.org (A. Garner).

[1] Tel.: +612-9891-6144; fax: +612-9891-1284.

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- *Level* 4: Basic life support plus intravenous cannulation and administration of intravenous fluids (crystalloid and colloid), in addition to a limited range of intravenous medications such as morphine and adrenaline, and needle thoracentesis.
- *Level* 5: Advanced life support. Paramedics are able to perform all the procedures of the other two categories plus oral endotracheal intubation. They also have access to a larger range of intravenous medications. Adjuvant neuromuscular blockade, anaesthetic or sedative agents to facilitate intubation are not included in paramedic protocols.

There is no on-line medical control in New South Wales, with all care delivered via a system of written protocols.

In addition to the ambulance service, there are two physician-staffed emergency medical services (EMS) which respond to accident scenes by either road ambulance or helicopter. All tasking is through the Ambulance Service of New South Wales (ASNSW). Physicians are specialists in anaesthesia, emergency or intensive care medicine or advanced trainees (minimum of seventh postgraduate year). Paramedics from the ASNSW are also secondary to the services. Physicians do not work under a protocol system and are free to exercise their clinical judgement in each case. Interventions include oral and nasal endotracheal intubation, adjuvant neuromuscular blockade, sedation and anaesthesia, surgical vascular access and airways, tube thoracostomy, and transfusion with packed red blood cells.

Data were retrospectively extracted from case records from the hospital trauma registry. We collected demographic details, details of the circumstances of the incident (e.g. falls, assault, type of road traffic accident), level of prehospital care (non-EMS transport, Levels 3–5 ambulance, physician-staffed EMS), time from notification of the treating prehospital team to arrival at hospital (prehospital time), length of stay in the intensive care unit (ICU), length of stay in hospital and survival status on hospital discharge. Glasgow coma scale score (GCS), blood pressure and respiratory rate recorded on the scene were used to calculate the revised trauma score (RTS), a score ranging from 0 to 7.84, with higher score indicating less severe physiological derangement [4]. Details of injuries were coded by using the abbreviated injury scale (AIS) [2]. AIS scores were used to calculate ISS [5], ranging from 0 to 75, with the higher score indicating a greater injury severity. The ISS was calculated by trained nurse researchers from the hospital trauma registry using case notes and autopsy reports.

3. Statistical analysis

Analysis of variance (ANOVA) was used to compare the mean ISS between the various levels of prehospital care. Factors associated with mortality were examined by using logistic regression. The predictor variables included in the initial model were: level of prehospital care, time from injury to arrival in hospital, type of injury, mechanism of injury, age, sex, ISS, GCS and systolic blood pressure. The level of prehospital care was categorised into three groups: BLS (Levels 3 and 4 ambulance), paramedic (Level 5 ambulance) and physician EMS (non-EMS transport group was excluded from this analysis). The type of injury was categorised into three groups:

1. *Isolated severe head injury*: AIS for head region ≥ 3 and GCS <9, but no injury to chest or abdomen with AIS >3.
2. *Severe head injury in combination with severe chest/abdominal injury*: AIS for head region ≥ 3 and GCS <9, and AIS for chest and/or abdomen >3.
3. *Severe injury without severe head injury*: AIS for head region <3 and/or GCS ≥ 9 in a patient with ISS >15.

The mechanism of injury was broadly classified as falls, assaults, road traffic accident and others. Age was entered as an ordinal variable (<30, 30–64, ≥ 65). ISS was categorised into three groups (16–24, 25–40, 41–75). The following variables were dichotomised: GCS (<9, ≥ 9), systolic blood pressure (<90 mmHg, ≥ 90 mmHg) and prehospital time (<60 min, ≥ 60 min). Another model was used, substituting RTS (continuous variable) for GCS and systolic blood pressure which yielded similar results (not shown). We chose to report the model without RTS, as respiratory rate is not highly sensitive or specific to predict outcome [9]. Additionally, the respiratory rate had not been recorded in many intubated patients. Effect of modification between the level of prehospital care and other predictor variables was examined with interaction terms.

The model's calibration was assessed by the Hosmer–Lemeshow goodness-of-fit χ^2-test and its predictive accuracy was assessed by the area under the receiver operating characteristic curve (*c*-index in logistic regression) [11]. An area of 0.5 indicates no predictive discrimination and an area of 1.0 indicates perfect separation of patients with different outcomes. The bootstrap technique was used to validate the model [11]. The amount of "over-optimism" in the initial logistic model derived was quantified by measuring the decrease in the *c*-index. All data analysis was performed using STATA Statistical software version 7.0 (StataCorp, College Statition, TX). The level of significance was set at $P < 0.05$.

4. Results

4.1. Population

Out of 2010 patients with severe blunt injury, most were males (76%). The median age was 30 years (interquartile range 21–49 years). The most common cause was road traffic accident (1355 (67%)), falls (271 (13%)) and assault (104 (5%)). There were 713 (36%) patients with no head injury, 1047 (52%) with isolated head injury and 250 (12%) with head injury with abdominal/chest injuries.

Table 1
Mean injury severity scores (ISS) between various levels of prehospital care

Level of prehospital care	Mean ISS (95% CI)
Non-EMS transport (n = 96)[a]	20 (19–21)
Level 3 ambulance (n = 452)	24 (23–25)
Level 4 ambulance (n = 45)	25 (22–27)
Paramedic (n = 1167)	31 (30–31)
Physician-staffed EMS (n = 224)	31 (30–33)

[a] Defined as transported by private transport.

Patients received various levels of prehospital care: non-EMS transport (5%), Level 3 ambulance (23%), Level 4 ambulance (2%), paramedic (59%) and physician-staffed EMS (11%). The median prehospital time was 53 min (interquartile range 40–80 min); the longest prehospital times of those receiving EMS transport were in the physician-staffed EMS group (median 114 min, interquartile range 85–160) compared to the shortest times in the paramedic group (median 50 min, interquartile range 40–66). The median ISS and RTS were 25 (interquartile range 18–34) and 7.55 (interquartile range 5.97–7.84), respectively. There was a significant difference in mean ISS between the various levels of prehospital care ($F_{4,1979} = 39.53$, $P < 0.001$) (Table 1). Nine hundred and fifty-five patients received intensive care treatment (50%) with the median length of stay of 5 days (interquartile range 2–10 days). The median length of hospital stay was 13 days (interquartile range 5–28 days).

4.2. Mortality

The overall mortality rate was 20% (95% CI, 18–22%). Table 2 shows the mortality rate by type of injury, mechanism of injury and level of prehospital care.

Table 2
Mortality rate by type of injury and level of prehospital care

	Mortality rate (%, 95% CI)
Type of injury	
No head injury (n = 713)	8.8 (7.0–11.1)
Isolated head injury (n = 1047)	18.1 (15.8–20.5)
Head injury with abdominal/chest injury (n = 250)	59.6 (53.4–65.5)
Mechanism of injury	
Road traffic accident (n = 1355)	21.9 (19.8–24.2)
Assaults (n = 104)	9.6 (5.3–16.8)
Falls (n = 271)	15.9 (12.0–20.7)
Others (n = 280)	18.2 (14.1–23.2)
Level of prehospital care	
Non-EMS transport (n = 96)[a]	2.1 (0.6–7.3)
Level 3 ambulance (n = 452)	12.2 (9.5–15.5)
Level 4 ambulance (n = 45)	13.3 (6.3–26.2)
Paramedic (n = 1167)	24.8 (22.4–27.3)
Physician-staffed EMS (n = 224)	19.6 (15.0–25.3)

[a] Defined as transported by private transport.

Table 3
Risk in odds ratio (95% CI) of mortality by level of prehospital care and intensive care unit (ICU) treatment

	Basic life support ambulance	Paramedic	Physician-staffed EMS
No ICU admission	1.00	2.18 (1.05–4.55)	4.27 (1.46–12.45)
ICU admission	1.00	0.79 (0.53–1.18)	0.63 (0.28–1.39)

Adjusted for prehospital time, Glasgow coma score, systolic blood pressure, injury severity score, type of injury and age.

4.3. Predictors of mortality

In the final logistic model, sex and mechanism of injury were not included, as these were not significant factors. The risk of mortality among patients with head injuries was similar to those without head injuries (isolated head injury odds ratio (OR) 1.16, 95% CI: 0.68–1.96; head injury with chest/abdominal injury OR 1.23, 95% CI: 0.67–2.24). There was no significant interaction between type of injury and level of prehospital care ($P = 0.36$). However, there was a significant interaction between ICU admission and level of prehospital care ($P = 0.02$). ICU admission modified the association between level of prehospital care and mortality (Table 3). In those patients without ICU admission, paramedic and physician-staffed EMS group patients were significantly more likely to die than BLS ambulance group patients. The majority of these deaths in the paramedic and physician groups occurred in the first 24 h indicating that these patients did not survive initial resuscitation (the proportion of patients dying within 24 h without being admitted to ICU in the paramedic group was 85/94 and physician-staffed EMS group was 12/13 compared to 6/19 in the BLS ambulance group). Among patients who survived long enough to be admitted to ICU however, there was no association between prehospital level of care and risk of mortality despite adjusting for important confounders.

The fit of the model was adequate (Hosmer–Lemeshow goodness-of-fit test χ^2-value was 13.63, d.f. = 8, $P = 0.09$) and highly discriminative (c-index = 0.91). The jack-knife results showed that there was minimal bias in the predictive accuracy of the model (c-index = 0.91, 95%CI: 0.89–0.92).

5. Discussion

5.1. Main findings

The multivariate analysis suggests that there was no evidence that patients with severe head injuries were more likely to benefit from advanced prehospital interventions, than patients with severe injuries but who did not have severe head injury. The level of prehospital care was associated with the risk of mortality after adjusting for age, physiological derangement, severity of injury, type of injury and prehospital time. There was an increased risk of mortality in those patients receiving paramedic and physician-staffed EMS treatment who were not admitted to ICU, with almost all the patents dying within the first 24 h, indicating that this group of patients did not survive initial resuscitation. In contrast, patients who received paramedic or physician-staffed EMS care and who survived to ICU admission did not have a significant decrease risk of mortality.

5.2. Strengths and weaknesses of this study

Patient selection is a probable explanation for the apparent increased risk of early mortality in the paramedic and physician groups. The dispatch process is selective, with patients allocated to paramedic response if they were likely to have severe injuries. Physician teams are dispatched only where the patient is more than 30 min from a trauma centre due to distance or entrapment, or at request of paramedics at the scene, ensuring longer prehospital times, thereby also selecting a more severely injured patient sub-group. There was anecdotal evidence to suggest that paramedics called out the physician-staffed EMS when the patient's death was imminent, but there was inadequate data to show this.

First recorded systolic blood pressure and GCS were used instead of RTS for three reasons. First, most patients in the physician-treated group were intubated before reaching hospital and no GCS or respiratory rate would have been recorded on hospital arrival. Second, prehospital GCS and systolic blood pressure are sensitive and specific predictors of outcome [9]. Third, RTS is known to change with both time and treatment, so that more aggressive management in one group may result in greater changes in RTS before hospital arrival [10].

5.3. Relation to other studies

Difference in methods and structure of trauma systems make comparisons with previous work difficult. Previous studies suggest that higher prehospital intervention levels are associated with better outcomes in patients with severe blunt head injury [1,3,7,8]. A sub-cohort of patients from this study, followed up to 5 years after their head injury, showed that physician-staffed EMS was associated with better functional outcomes (glasgow outcome scale) compared with paramedics (OR 2.70, 95% CI: 1.48–4.95) after adjusting for RTS, ISS, age, and absence of acute subdural haematoma on computerised tomography scan [8]. This was thought to be due to better control of intracranial pressure from intubation facilitated by a combination of neuromuscular blocking agents, sedative or anaesthetic drugs, administration of mannitol and packed red blood cells, and correction of hypotension [8]. The current study assesses outcome in terms of mortality only, and does not exclude a possible benefit of advanced prehospital interventions in decreasing disability in head injury survivors.

5.4. Implications of study

This study was unable to demonstrate a benefit from advanced interventions specifically in patients with severe head injury relative to patients with other types of severe injury. Moreover, there was insufficient evidence to suggest that paramedic or physician led prehospital care decreased mortality in those who survived to ICU admission. Recent evidence has suggested that patients with minor injuries will survive, and patients with very severe injuries will die, regardless of prehospital treatment [13]. Further investigation should seek to confirm if our findings apply widely and evaluate interventions to improve mortality rates and reduce sequelae of severe blunt trauma patients with or without head injuries. Ideally, these studies should be randomised, to avoid the possibility of selection bias that exists in systems which use dispatch criteria to selectively task advanced intervention teams to patients likely to have high injury severity.

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