



Efficacy of prehospital critical care teams for severe blunt head injury in the Australian setting

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Abstract

Objective: To determine whether prehospital critical care teams (CCT) would result in improved functional outcomes for road trauma related severe head injury in the Australian setting, when compared with standard advanced life support measures provided by paramedics.

Methods: Retrospective review of 250 patients treated by paramedics and 46 patients treated by CCT transported directly from the accident scene, with a prehospital Glasgow coma scale (GCS) ≤ 8 .

Results: CCT-treated patients had longer median prehospital times (113 versus 45 min, $P < 0.001$), and a higher prehospital intubation rate (100% versus 36%, $P < 0.001$) than paramedic-treated patients. On multivariate analysis, revised trauma score ≥ 4.45 (odds ratio [OR] 2.31, 95% CI: 1.15–4.65), lower injury severity score (OR 1.04, 95% CI: 1.02–1.06), age ≤ 25 years (OR 1.76, 95% CI: 1.13–2.75), absence of an acute subdural haematoma (OR 3.36, 95% CI: 1.89–5.95) and prehospital treatment by a CCT (OR 2.70, 95% CI: 1.48–4.95) independently predicted better outcome.

Conclusion: The range of advanced interventions provided by the CCT were associated with improved functional outcome. Further studies are required to determine the individual factors responsible. © 2001 Elsevier Science Ltd. All rights reserved.

1. Introduction

Previous studies from North America have found an improvement in the outcome of patients with severe blunt head injury who received prehospital care by critical care teams (CCT), when directly compared with patients treated by paramedic services [1–3]. CCT typically have an expanded scope of practice when compared with paramedics and are helicopter-based, allowing a single team to cover a large geographical area. Additional interventions include further airway management options such as cricothyroidotomy or use of neuromuscular blocking agents to facilitate intubation, and drugs such as mannitol, sedatives, and barbiturates. CCT in these studies have consisted of nurses paired with other nurses, physicians or paramedics.

Physician-based CCT teams are used in some areas of Australia and New Zealand for scene response to

trauma patients [4,5]. As in North America, these teams are generally attached to helicopter services. There are no previous studies examining the efficacy of these teams in the management of severe blunt head injury in comparison with road-based paramedic services in an Australasian setting.

The aim of this study was to determine if prehospital management of patients with severe blunt head injury by an Australian CCT was also associated with an improvement in outcome.

2. Material and methods

2.1. Hospital catchment

Patients who were transported to Westmead Hospital in western Sydney, Australia by paramedic ambulance were identified from the trauma registry of Westmead Hospital. Patients who were transported to Westmead or Nepean Hospital (also in western Sydney) by the CCT were identified from the medical database of

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NRMA CareFlight/NSW Medical Retrieval Service. Westmead Hospital is a trauma service hospital providing tertiary trauma services, equivalent to an American College of Surgeons (ACS) Level 1 trauma centre, to a large area of western Sydney with a catchment population of approximately 654 000 people. Nepean Hospital provides trauma services equivalent to ACS Level 2 trauma centre to a catchment population of approximately 350 000 people. Nepean provides neurosurgical and thoracic surgical services, but it does not provide cardiac surgery services, which are available at Westmead. Neurosurgical services at Nepean Hospital are provided by a neurosurgeon with a conjoint appointment at Westmead Hospital.

2.2. CCT and paramedic services

NRMA CareFlight/NSW Medical Retrieval Service provided the CCT. This service responds to accident scenes by road ambulance or helicopter from a base within the grounds of Westmead Hospital. Medical staffing is by physicians with specialist qualifications in anaesthesia, emergency medicine or intensive care medicine or advanced trainees (minimum seventh post-graduate year), who have completed the Early Management of Severe Trauma (EMST) course of the Royal Australasian College of Surgeons [6]. Since 1989, a paramedic ambulance officer has been seconded from the Ambulance Service of NSW (ASNSW) to the service. No formal patient treatment protocols are used with physicians free to exercise their clinical judgement in each case. All tasking to accident scenes is via the ASNSW. Dispatch of the CCT to road accident scenes is at the discretion of the dispatch centre supervisor and is considered in cases where the patient is more than 30 min from a trauma centre due to distance, access difficulty or entrapment.

The paramedic treatment group was transported by road ambulance to Westmead Hospital. Treatment was according to written ASNSW medical protocols. These include oral endotracheal intubation, and volume replacement in shocked patients with crystalloid or colloid solutions. Protocols exclude the use of muscle relaxant, anaesthetic or sedative drugs to facilitate intubation. Mannitol or the use of blood and blood products are also not authorised. There is no on-line medical control of paramedics by emergency medical service physicians in NSW.

2.3. Patient selection

Patients were included in the study if they met the following criteria:

- Sustained blunt injury as the result of a road traffic accident;

- Were transported directly to the trauma centre from the accident scene;
- Survived initial resuscitation;
- Had an initial Glasgow Coma Scale (GCS) ≤ 8 and remained unconscious, or had an initial GCS ≥ 9 and subsequent deterioration to a GCS ≤ 8 prior to trauma centre arrival;
- Injury occurred between July 1986 and April 1998.

3. Study and confounding (predictor) variables

Data on prehospital intubation, treating team (CCT or paramedic), prehospital times and the first recorded GCS, systolic blood pressure and respiratory rate were collected from the case-sheet. Revised trauma scores (RTS) were calculated from the first recorded prehospital data to ensure consistency of timing of data collection in both treating team groups and to exclude the impact of differences in prehospital management on subsequent changes to the RTS [5]. ISS were calculated for each patient by trained nurse researchers using case notes and autopsy records. Probability of survival by trauma score-injury severity score (TRISS) methodology were calculated using coefficients derived from the multiple trauma outcome study [7] (MTOS) using the 1990 abbreviated injury scale [8]. Type of lesion on initial CT scan, age and sex were recorded from hospital records. The time after injury of the Glasgow outcome score [9] (GOS) assessment were also collected.

3.1. Outcome measures

Morbidity was determined by use of the GOS [9] assigned at last documented contact. GOS were categorised as: (1) recovery, (2) partial disability, (3) severe disability, (4) persistent vegetative state and (5) dead. Follow-up was by one of two methods. The Westmead Head Injury Project [10] enrolled patients with severe blunt head injury transported to Westmead Hospital over a 2-year period; data on 42 of these patients are included in the present study. Outcome data on patients who were not part of this study were obtained from the Westmead Brain Injury Rehabilitation Unit. This unit operates within Westmead Hospital and routinely performs patient follow-up at 6 months, 2 years and 5 years. Patients requiring inpatient rehabilitation from Nepean Hospital are transferred to this unit. Mortality was defined as death due to the original injury or complication of that injury.

3.2. Statistical analysis

The distribution of predictor variables between the two treating team groups were analysed by χ^2 or Fish-

er's exact test for categorical variables as appropriate, and Students 't' test or the Mann-Whitney *U* test for continuous variables as appropriate. The association between the predictor variables and the outcome variable (GOS) was analysed by polytomous regression performed using SAS Version 6.12 (SAS Corp). Cumulative logits model [11] was used for all regressions and the assumption of proportional odds confirmed from the SAS output. Univariate and multivariate models were developed using methods described by Hosmer and Lemeshow [12]. To eliminate zero cells in cross tabulations, GOS was recoded to (1) recovery, (2) partial disability, (3) severe disability and (4) persistent vegetative state or death as there were no vegetative survivors in the physician group and only four in the paramedic group. Age and RTS were found to be non-linearly related to the log odds and were dichotomised (age ≤ 25 , > 25 ; RTS < 4.45 , ≥ 4.45). Backward elimination was performed until all variables had $P < 0.05$. Eliminated variables were tested in the final model for confounding effect (change of odds ratio $> 10\%$). Effect modification between the treating team and the other predictor variables was examined with interaction terms. None were found to be significant.

4. Results

Over the study period, 250 patients who met the study inclusion criteria were transported by paramedic teams and 46 by CCT. Demographic details, time intervals, date of injury, the prehospital intubation rate, GCS, predominant lesion on computerised tomography (CT) scan, RTS, ISS, probability of survival (P_s) by TRISS methodology and mechanism of assignment of GOS are compared in Table 1. All paramedic patients were transported by road ambulance. Four patients treated by CCT were transported by road ambulance and 42 by helicopter. Eight patients were transported by CCT from within the road ambulance catchment area of Westmead hospital, with the remainder transported from other suburban or rural areas. Five of the CCT-treated patients were transported to Nepean Hospital and the remaining 41 patients to Westmead Hospital.

Thirty-seven of the paramedic patients (14%) were hypotensive (systolic blood pressure < 90 mmHg) on first contact compared with 11 (24%) in the CCT group ($P = 0.10$). Oxygen saturations are not routinely determined by the ambulance service and it was therefore not possible to compare groups by hypoxia at the scene. There was a significantly higher intubation rate

Table 1
Demographics, severity, type of injuries and mechanism of assigning GOS^a

	Paramedic team, (n = 250)	CCT team (n = 46)	Significance
Mean age in years (S.D.)	27 (± 16)	27 (± 13)	$P = 0.82$
Male gender (%)	185 (74)	33 (71.7)	$P = 0.75$
Median total prehospital time in min (IQR)	45 (35-75)	113 (75-146)	$P < 0.001$
<i>Date of injury</i>			
July 1986 to December 1991	144	24	
January 1992 to April 1998	106	22	$P = 0.52$
<i>GCS</i>			
3	84	13	
4	24	6	
5	30	3	
6	37	5	
7	49	14	
8	26	5	$P = 0.49$
<i>Lesion on CT scan</i>			
Extradural haematoma	23	4	
Acute subdural haematoma	51	10	
Other focal lesion	120	18	
Diffuse injury	56	14	$P = 0.62$
Mean RTS at scene (S.D.)	4.70 (± 1.38)	4.54 (± 1.34)	$P = 0.51$
Mean ISS (S.D.)	33 (± 13)	32 (± 13)	$P = 0.86$
Mean P_s (S.D.)	0.60 (± 0.31)	0.58 (± 0.31)	$P = 0.76$
<i>Mechanism of assigning GOS</i>			
Westmead Head Injury Project	35	7	
Westmead Brain Injury Rehabilitation Unit	215	39	$P = 0.82$

^a CCT, critical care team; S.D., standard deviation; IQR, interquartile range; GCS, Glasgow coma scale; CT, computed tomography; GOS, Glasgow outcome score.

Table 2
Median time in months (interquartile range) from injury to assignment of GOS in survivors^a

GOS	Paramedic team (n = 172)	CCT team (n = 37)	Significance
1	24 [3-24]	18 [2-24]	
2	15 [4-24]	2 [1-27]	
3	15 [2-36]	8 [1-14]	
4	13 [1-65]	-	
All survivors	18 [4-24]	10 [1-24]	P = 0.06

^a GOS 1 = recovery; GOS 2 = partial disability; GOS 3 = severe disability; GOS 4 = persistent vegetative state; CCT, critical care team.

in the CCT treatment group (46/46) when compared with the paramedic group (89/250, $P < 0.001$). All patients that had not been intubated in the field by the paramedic teams were intubated after arrival at Westmead Hospital by the trauma team. Treatments administered by CCT at the scene, which are outside paramedic protocols included mannitol in five patients (median 50 g, interquartile range 28-63 g) and transfusion of O-negative packed red blood cells in 18 patients (median four packs, interquartile range 2-4).

Overall, there was no significant difference in time (months) from injury to assignment of GOS in survivors between CCT and paramedic groups (Table 2). Fig. 1 shows the distribution of GOS scores for the two treating teams. Univariate analysis of the association

Table 3
Significant predictors of better outcome from severe head injury by polytomous logistic regression (proportional odds model)^a

Predictors	Odds ratio (95% CI)
RTS ≥ 4.45	2.31 (1.15-4.65)
Lower ISS	1.04 (1.02-1.06)
Age ≤ 25 years	1.76 (1.13-2.75)
Absence of acute subdural haematoma on CT scan	3.36 (1.89-4.95)
Treatment by CCT	2.70 (1.48-4.95)

^a CI, confidence interval; RTS, revised trauma score; ISS, injury severity score; CT, computerised tomography; CCT, critical care team.

with GOS found treatment by a CCT to be associated with a better outcome (OR = 2.22, 95% CI: 1.25-3.94, $P = 0.0063$). Intubation was found to be associated with a poorer outcome. Intubated patients were 1.85 (95% CI: 1.22-2.78) times more likely to have a poorer outcome than non-intubated patients.

Multivariate analysis of the association between predictor variables and outcome (GOS) found prehospital treatment by a CCT to be significantly associated with a better functional outcome (OR = 2.70, 95% CI: 1.48-4.95, $P = 0.0013$). ISS, RTS, age and absence of an acute subdural haematoma were also independently associated with a better outcome on GOS (Table 3). Intubation was not found to be an independent predictor of outcome ($P = 0.84$).

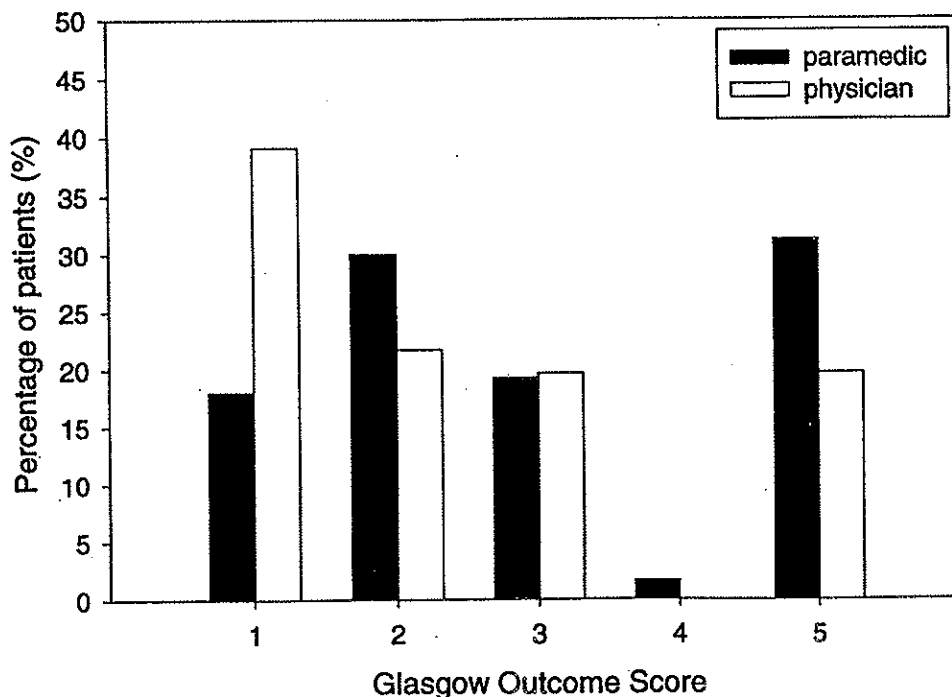


Fig. 1. Comparison of GOS between CCT ($n = 46$) and paramedic-treated patients ($n = 250$). GOS 1 = recovery, GOS 2 = partial disability, GOS 3 = total disability, GOS 4 = vegetative, GOS 5 = death.

5. Discussion

Comparison of the CCT treatment group with the paramedic treatment group showed a substantial difference in functional outcome as measured by GOS. Patients treated by the CCT were 2.7 times more likely to make a better outcome than those treated by paramedics, after controlling for age, RTS, ISS and type of lesion on CT scan. Other variables were not found to be significant independent predictors of outcome.

This is consistent with the findings of the three previous North American studies, all of which found an improvement in outcome associated with prehospital management by a CCT [1–3]. The reduction in mortality in the CCT-treated patients in the present study was not accompanied by an increase in morbidity, also similar to the previous studies. The specific factors associated with the improvement in outcome in the CCT groups is difficult to identify with certainty, as there are multiple differences between the treatments provided by the CCT and paramedics [3].

As in the present study, all previous studies found a significantly higher intubation rate in the CCT group. This is an expected finding given that the CCT had access to an expanded range of options in airway management, particularly neuromuscular blocking agents. On univariate analysis, intubation was found to be associated with a poorer outcome. The majority of patients intubated in the present study were intubated by paramedics without the use of neuromuscular blocking agents. Only patients with a very low GCS could be expected to be intubated under these circumstances and their outcome is predictably poor. On multivariate analysis when both physiological and anatomical measures of injury severity (RTS and ISS) were controlled for, intubation was not significantly associated with functional outcome. Several studies have specifically examined the effect of prehospital intubation or the time from injury to intubation with conflicting conclusions [13–16]. Further studies are required to determine if higher prehospital intubation rates are a critical factor in the improved outcome demonstrated in both the present, and previous studies.

Intubation was not performed by the same technique in both treatment groups. All patients intubated prehospital in the paramedic group received no neuromuscular blocking agents, sedatives or anaesthetic drugs whereas patients in the CCT group received these drugs in combination. Better control of intracranial pressure may result from intubation facilitated by these agents. This difference in prehospital management may possibly account for the observed difference in outcome but there was insufficient data to test this hypothesis. Administration of mannitol and packed red blood cells by the CCT team may also have contributed to the outcome difference.

The duration of time before arrival at hospital was not found to be an independent predictor of outcome in the present study. The paramedic patients were injured in a suburban setting whereas the CCT patients were mostly transported from rural areas, remote from the trauma centres which resulted in longer prehospital times. Despite this, management by CCT was associated with better outcomes. The two previous studies which reported prehospital times also found better outcomes in the CCT group despite longer total prehospital times [2,3]. This suggests that the subgroup of trauma patients with severe blunt head injury may be particularly likely to benefit from on-scene stabilisation [17]. This has implications for the design of prehospital trauma systems in regions where severe blunt head injury is the major cause of trauma related mortality.

There were a number of important differences between the CCT and paramedic groups in this study. There was a trend to longer times to evaluation of GOS in the paramedic patients, which is a potential confounding variable. Patients with brain injuries typically slowly improve over time. Equal follow-up times in both groups may have produced a larger difference in outcome than found in the present study. GOS assignments from two different sources were used. A variation in interpretation of GOS between sources is possible. However, a similar proportion of the patients in each group had GOS assigned by each source making it unlikely this was responsible for the observed outcome difference. All paramedic-treated patients received their hospital management at Westmead hospital whereas five of the CCT patients were treated at Nepean hospital. Differences in management between the institutions may have favoured a better outcome in the CCT group but there was inadequate data to test this hypothesis. However, all neurosurgical care at Nepean was provided by a neurosurgeon who also treated patients at Westmead, and Nepean patients requiring inpatient rehabilitation were transferred to the Westmead Brain Injury Rehabilitation Unit.

Prehospital hypoxia and hypotension have been demonstrated to significantly affect outcome in head injury [18,19]. Pulse oximetry was only introduced by the ambulance service during the last several years of the study period and is inconsistently available. A difference in the rate of prehospital hypoxia between the groups cannot, therefore, be excluded. There was no significant difference in the proportion of patients who were hypotensive on first contact by the treating teams. However, a previous study comparing a physician-staffed helicopter service with a paramedic-staffed service in NSW [5] demonstrated significantly greater rates of correction of hypotension by physicians during prehospital management. Shorter duration of hypotension is another possible explanation for the observed outcome difference.

In conclusion, prehospital treatment by CCT of persons with severe head injuries resulting from road traffic accidents were associated with better outcomes than patients treated by paramedics using ASNSW written protocols. This may be due to the range of advanced interventions provided by the CCT. Further studies are required to determine the individual factors responsible. These findings support the conclusions of previously published North American studies and suggest that CCT should be used in the prehospital management of patients with severe blunt head injuries wherever practicable.

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