

# Air medical scene response to blunt trauma: effect on early survival

Robert A Bartolacci, Blair J Munford, Anna Lee and Patricia A McDougall

## Abstract

**Objective:** To assess the impact of on-scene treatment by an experienced critical care physician on prehospital resuscitation, the initial hospital phase and early survival of patients with major blunt trauma.

**Design, setting and participants:** (i) Historical cohort of patients with trauma treated on scene by a helicopter emergency medical service (HEMS), 1986–1994, comparing medical and paramedical treatment and outcomes.

(ii) Comparison of a subgroup of 77 patients (injury severity score [ISS]  $\geq 15$ ) treated by the air medical team (AMT) with (a) an ISS-matched group of 308 patients treated by ground paramedics (GPMs) and (b) the Major Trauma Outcome Study cohort.

**Main outcome measures:** Procedural requirements assessed by the Therapeutic Intervention Scoring System (TISS), comparing resuscitation by medical and ambulance personnel; and observed versus expected mortality.

**Results:** (i) Of 445 patients treated on scene, 270 (61%) had sustained trauma, and 215 of these received early management by the AMT. Problems with ventilation or with volume resuscitation were encountered by general duties ambulance personnel (40%) and paramedics (60%) before arrival of the AMT. (ii) Matched patients treated by GPMs required significantly more emergency department interventions on arrival at hospital ( $P < 0.01$ ), and were possibly more likely to die in the first 48 hours (relative risk of death, 1.43; 95% confidence interval, 0.74–2.78) than patients treated by the AMT. Comparing the AMT-treated patients with the Major Trauma Outcome Study cohort, 9 deaths occurred of the 18 that were predicted — a 50% reduction in predicted deaths ( $Z = 3.38$ ;  $P < 0.001$ ) — and there were 11 unexpected survivors and one unexpected death. The adjusted “W” statistic was 12.18 (ie, there were 12 more survivors per 100 patients than the Major Trauma Outcome Study prediction, after adjustment for casemix).

**Conclusions:** As part of the air medical team for response to major blunt trauma, a physician can provide significantly improved prehospital stabilisation, especially in airway and ventilatory control. Our results suggest improvement in mortality in AMT-treated patients, probably due to the enhanced procedural capabilities of physicians, despite longer prehospital times.

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For editorial comment, see page 610

NRMA CareFlight, Westmead Hospital, Westmead, NSW.

Robert A Bartolacci, MB BS, Provisional Fellow in Anaesthesia.

Blair J Munford, MB ChB, FANZCA, Specialist Anaesthetist.

Anna Lee, MPH, Honorary Epidemiologist.

Department of Surgery, Westmead Hospital, Westmead, NSW.

Patricia A McDougall, RN, CNC, Trauma Nurse Coordinator.

Reprints: Dr B J Munford, NRMA CareFlight/NSW Medical Retrieval Service, PO Box 159, Westmead, NSW 2145.

Email: bmunford@ozemail.com.au

Helicopter emergency medical services (HEMS) in Australia perform a variety of missions, including search and rescue, scene (or “primary”) response to trauma or medical emergencies, and interhospital transport. Critical care physicians are included in the interhospital critical care transport teams, in accordance with specialist medical college policy,<sup>1</sup> but staffing for scene responses varies. Some Australian HEMS use only ambulance officers (usually with paramedic certification),<sup>2</sup> while others have scene response teams which include an emergency or critical care physician. The value of a physician for scene response is controversial.<sup>3-9</sup>

CareFlight is a medically staffed helicopter service operating from Westmead Hospital, near the demographic centre of Sydney. The air medical team (AMT) comprises a specialist or registrar in anaesthesia, emergency medicine or intensive care, as well as a paramedic and/or aircrewman medical assistant. Since its inception in July 1986, the service has been available for both scene response and interhospital transport. Dispatch for scene response is at the discretion of the New South Wales Ambulance Service and is based on injury severity, entrapment, remote location, or difficult access (including the need for rescue hoist extrication).

To assess the value of an experienced critical care physician as a member of scene response teams, we studied a retrospective cohort of patients treated on scene by CareFlight. Our aims were:

- To analyse the requirement, if any, for resuscitation of major trauma patients on scene and during transport by medically staffed HEMS;
- To use the Therapeutic Intervention Scoring System (TISS) (Box 1) to compare the hospital interventions required by patients with major blunt trauma after on-scene treatment by either an AMT or by ground ambulance paramedics (GPMs); and
- To use the Trauma Score – Injury Severity Score (TRISS) to compare early mortality of patients with major blunt trauma treated by an AMT with a matched group of patients treated by GPMs only, as well as with the cohort of the Major Trauma Outcome Study (Box 1).

TRISS has been used to evaluate an Australian paramedic-staffed helicopter ambulance,<sup>2</sup> but no previous Australasian study has done this for a medically staffed HEMS.

## Methods

Our historical cohort of patients treated on scene by CareFlight was from the period July 1986 – June 1994. A number of groups were analysed (Box 2).

## CareFlight data

Data were collected from CareFlight’s clinical database and the Westmead Trauma Registry by one of us (RAB). Mission details from CareFlight’s database included dates, patient

**1: Study instruments**

**Therapeutic Intervention Scoring System (TISS)**<sup>10,11</sup> — a method of estimating the stability of a patient's condition and the need for critical care from the interventions required. It has also been adapted for use in HEMS.<sup>12,13</sup>

**Injury severity score (ISS)**<sup>14</sup> — an anatomical summary scoring system whereby injured patients are assigned values of 1 to 75 based on the sum of squared scores of 1 (minor injury) to 5 (critical injury) for the (up to) three most severely injured regions. Three regions with a score of 5 gives the maximum total score of 75. An ISS of 16 (which corresponds to an average mortality rate of 10%) or more is taken as defining major trauma.<sup>15</sup>

**Trauma Score – Injury Severity Score (TRISS)** — a method of predicting the prognosis of trauma patients<sup>16</sup> which has become an accepted tool internationally for determining the impact of HEMS on trauma mortality.<sup>6-9,17</sup> It combines a physiological scoring system, the revised trauma score (RTS),<sup>18,19</sup> with the injury severity score (ISS).<sup>14</sup>

**Major Trauma Outcome Study (MTOS)**<sup>15,20</sup> — a study in which TRISS scoring, age and mechanism of injury were used to calculate norms for survival in a regression analysis of 80 000 patients with trauma in 139 North American hospitals. The norms were updated in 1990.<sup>20</sup> Patients with a survival probability (Ps) of 0.5 or less are expected to die and those with a Ps greater than 0.5 are expected to live.<sup>17</sup> The Major Trauma Outcome Study cohort has been widely used as a benchmark for comparing outcomes in patients with trauma using the TRISS methodology. It can be used to identify unexpected outcomes in populations and in individual patients.

demographics, nature of the accident, response, turnaround and transport times, injuries, staff on scene, assessment at scene, treatment before the arrival of the AMT, and treatment on scene/in transit by them. This information was supplied by the attending doctor at the completion of the mission. The treatment given by the AMT was in accordance with the principles of early management of severe trauma (EMST).<sup>21</sup>

**On-scene procedures**

TISS scoring was done by one of us (RAB), and three groups of patients were compared for their resuscitation requirements when (1) AMT first on scene; (2) general duties ambulance officers already on scene; and (3) GPM ambulance officers already on scene. TISS scoring was done for the period from first intervention until arrival at hospital.

**Patients with major blunt trauma**

All patients who were transported to Westmead Hospital by the AMT who had major blunt trauma (injury severity score [ISS]  $\geq 15$ ) were identified from the Westmead Trauma Registry. Each of these 77 AMT-treated patients were matched with four randomly chosen patients with equivalent ISS ( $\pm 5$ ) treated and transported by GPMs in the same year. Patients who had been treated by GPMs only and who were pronounced dead on arrival at hospital were excluded from this analysis. Other data collected included observations and procedures on arrival in the Emergency Department. TISS scoring was done for procedures performed in the Emergency Department.

The predicted mortality of these 77 AMT patients was determined using TRISS and the coefficients derived from the Major Trauma Outcome Study<sup>16</sup> (using the 1990 Abbreviated Injury Scale).<sup>15,20</sup> The revised trauma score (RTS)<sup>19</sup> and the ISS<sup>14</sup> were calculated from information on injuries sustained recorded in the case notes or the autopsy reports. To calculate the RTS, the Glasgow Coma Scale (GCS) and respiratory rate were obtained from CareFlight's records. The predicted mortality could not be calculated for the ISS-matched GPM group as these data are not recorded by the ambulance service.

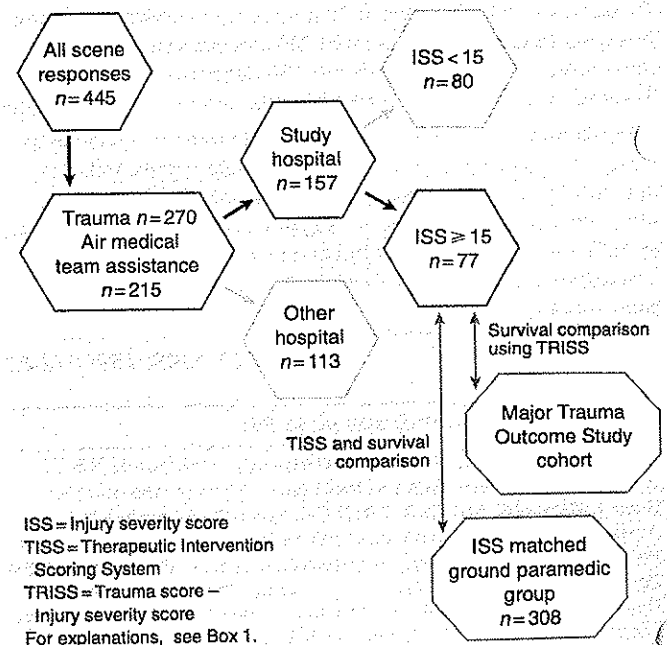
The comparison between predicted and observed mortality of AMT patients was made at 48 hours after hospital admission. Survival intervals as short as 6–12 hours have been used previously<sup>9,22</sup> to measure efficacy of prehospital care, while 48 hours was recommended by Baxt and Moody, who found that all deaths related to prehospital factors occurred within this time.<sup>6</sup>

**Statistical analysis**

**On-scene procedures**

Kruskal–Wallis ANOVA was used to compare the resuscitation requirements of the three groups with different staff first on scene, as evaluated by TISS.

**2: Study population.**



**3: Procedures performed by general duties and paramedic ambulance officers first on scene and supplementary treatment by air medical team (AMT)**

Procedure	General duties ambulance		Paramedic ambulance	
	No. of patients (n=50)	AMT	No. of patients (n=125)	AMT
Intubation	np	13 (26%)	18 (15%)	35 (28%)
Controlled ventilation	2 (4%)	13 (26%)	17 (14%)	51 (41%)
Intravenous line placement	18 (36%)	33 (66%)	101 (81%)	54 (43%)
Volume replacement	11 (22%)	25 (50%)	81 (65%)	63 (50%)
Blood transfusion*	np	7 (14%)	np	35 (28%)
Chest drainage	np	4 (8%)	1 (needle) (1%)	13 (tube) (13%)
Mast suit application	3 (6%)	4 (8%)	24 (19%)	19 (15%)
<b>Problems before AMT intervention</b>				
Ventilation	3 (6%)		20 (16%)	
Volume resuscitation	17 (34%)		55 (44%)	

np = not in protocol. \*Mean volume administered, 2.7 units (430 mL/pack).

**4: Patients with blunt trauma: comparison of procedures required in the emergency department**

	Air medical team on scene	Paramedics only on scene
<b>Patients</b>	n=77	n=308
Median age (years)	26 (4-77)	25 (1-85)
Sex ratio (M:F)	56:21	239:69
Mean injury severity score (SD)	32 (13)	31 (13)
Median Glasgow Coma Scale (range)	13 (3-15)	12 (3-15)
<b>Emergency department procedures</b>		
Intravenous line placement	10 (13%)	80 (26%)*
Endotracheal intubation	8 (10%)	114 (37%)*
Mechanical ventilation	8 (10%)	102 (33%)*
Intercostal catheter placement	12 (16%)	59 (19%)

Significant differences: \*P = 0.01; †P < 0.001.

**Major blunt trauma patients**

We compared patient demographics, hospital interventions and outcomes of patients treated by the AMT with these data for patients treated by GPMs using appropriate Student's *t* tests, Mann-Whitney *U* tests and  $\chi^2$  analysis. Early death was defined as death due to initial injuries or complications of those injuries within 48 hours of hospital admission. The relative risk (RR) of early death and 95% confidence intervals (CI) were estimated to compare outcomes of patients treated by the AMT and GPMs, respectively.

Comparisons between predicted and observed mortality of AMT patients were made using the "Z", "W" and "M" statistics.<sup>16</sup> Flora's "Z" statistic estimates the deviation of mortality in the study group compared with the Major Trauma Outcome Study benchmark.<sup>16</sup> The "W" statistic provides a clinical perspective on a statistically significant "Z" score,<sup>19</sup> and calculates the number of survivors more (or less) than the Major Trauma Outcome Study norm per 100 patients analysed.<sup>23</sup> The "M" statistic evaluates the match of injury severity between the study group and the entire Major Trauma Outcome Study cohort.<sup>16</sup> An adjusted "W" statistic was also estimated using the method of Younge et al,<sup>23</sup> which was developed to adjust for the more severely injured patients treated by HEMS.

**Results**

Over the study period, the AMT attended 445 patients in scene responses, of whom 270 had trauma (Box 2). This excluded minor injuries where the HEMS was required only for remote access or hoist extrication. Most patients were male (70%). Vehicle-related trauma occurred in 138 patients (51%); 19 patients (7%) were entrapped. The trauma cases included 61 (23%) with spinal injury only, 19 (7%) with head injury only, 81 (30%) with head plus other injuries, and 109 (40%) with other injuries. Only three cases (1%) had penetrating trauma.

The median response time for the ATM from initial call to arrival at the patient was 26 minutes (range, 6-624, includ-

ing several cases requiring prolonged secondary access). The median turnaround time (time from arrival at patient to departure from scene) was 33 minutes (range, 1-400, including entrapments and difficult access). Median transport time (time from scene departure to arrival at tertiary facility) was 18 minutes (range, 3-205).

**Comparison of on-scene treatment**

Of 270 patients with trauma, 215 required AMT assistance. The AMT was first on the scene for 31 of these patients (14%); general duties and paramedic ambulance officers were on the scene before the AMT's arrival for 50 (23%) and 125 (58%) patients, respectively. In the remaining nine patients (4%), other health professionals were on the scene. Of the 61 spinal injury patients, 26 (43%) did not require AMT assistance. Conversely, of the 209 remaining patients with head and/or other injuries, only 29 (14%) did not require AMT assistance. No patients died during transport, but 12 died at the scene. Eleven of these were already in traumatic cardiac arrest when the AMT arrived and one was an entrapped motor vehicle accident victim who exsanguinated during release.

The on-scene procedures performed by general duties ambulance officers and paramedics, the supplementary patient management by the AMT, and problems identified with treatment given by ambulance officers and paramedics are shown in Box 3. Of the 35 paramedic-treated patients with a low score on the Glasgow Coma Scale (<9), only 15 (43%) were correctly intubated at the time of the arrival of the AMT. Even in the 16 patients with a score on the Glasgow Coma Scale of 3 or 4, six (37%) were not intubated before AMT arrival. Of the 18 patients with endotracheal tubes placed by paramedics, there were problems in five (28%) cases, including three oesophageal intubations. Intubations by the AMT were all oral, with the aid of muscle relaxants, with no failed or oesophageal intubations. No patient with a low score on the Glasgow Coma Scale (<9) was transported unintubated.

There was a significant difference in median TRISS scores between the three patient groups — AMT first on scene, and general duties ambulance or paramedics first on scene ( $P=0.04$ ). There was a significantly higher number of interventions in the paramedic group (median TRISS score, 12) than in the AMT (median TRISS score, 7) ( $P=0.01$ ).

**Patients with major blunt trauma**

**Hospital interventions and outcome**  
 There were no significant differences in patient characteristics between the AMT-treated ( $n=77$ ) and matched GPM-treated ( $n=308$ ) groups transported to Westmead Hospital (Box 4). Patients in the GPM group required significantly more interventions in the Emergency Department (median TRISS score, 3) than those in the AMT group (median TRISS score, 2;  $P<0.01$ ). In comparing the various resuscitation procedures (Box 4), the AMT group required fewer intravenous line placements and endotracheal intubations and less mechanical ventilation than the GPM-treated group. Patients in the GPM group were 1.43 (95% CI, 0.74–2.78) times more likely to die in the first 48 hours compared with those in the AMT group.

**Comparison with the Major Trauma Outcome Study**

The outcomes for the patients in the AMT-treated group using TRISS (1990 coefficients<sup>20</sup>) are shown in Box 5. The predicted number of deaths for the group analysis was 18. Nine patients actually died within 48 hours, a 50% reduction in expected mortality. The difference in the observed and expected number of survivors was significant ( $Z=3.38$ ;  $P<0.001$ ). The W statistic was 11.88. The M statistic was 0.52, which is less than the 0.88 acceptable level<sup>16</sup> for comparing populations (ie, there was a higher proportion of patients with a low probability of survival in the AMT group compared with the Major Trauma Outcome Study cohort) (Box 6). This required calculation of an adjusted “W” statistic (using the method of Younge et al to compensate for casemix difference), which was 12.18 (95% CI, 5.29–19.07). This suggests that there are 12 more survivors per 100 patients with major blunt trauma than would be predicted by comparing with the Major Trauma Outcome Study, after adjusting for casemix differences but not for late deaths (> 48 hours).

**Discussion**

Our study shows the advantages of a medically staffed HEMS, compared with paramedics alone, for prehospital stabilisation of major trauma patients. Of note was the number of patients with low scores on the Glasgow Coma Scale (< 9) who were

**5: Patients treated by air medical team: characteristics and outcomes**

No. of patients	77
Mean revised trauma score (SD)	6.4 (1.7)
Mean injury severity score (SD)	31.6 (13.0)
Mean probability of survival (Ps)*	0.76
No. of patients expected to die who lived (mean Ps, 0.34)	11
No. of patients expected to live who died (mean Ps, 0.84)	1
No. of patients expected to die who died (mean Ps, 0.24)	8
Observed no. of deaths	9
Predicted no. of deaths	18

\* See Box 1.

**6: Comparison of survival probabilities (Ps)\* of the Major Trauma Outcome Study (MTOS) cohort and our study group**

Increment of Ps range	MTOS cohort†	Air medical team cohort†
0.96–1.00	0.83	0.35
0.91–0.95	0.06	0.20
0.76–0.90	0.03	0.14
0.51–0.75	0.02	0.07
0.26–0.50	0.02	0.14
0.00–0.25	0.04	0.10

\* See Box 1.

† Fraction of patients within each range.

not able to be intubated by paramedics, reflecting the difference between airway control in patients with cardiac arrest (unmodified oral intubation is usually possible) and those with trauma (likely require techniques incorporating sedative and muscle relaxants outside paramedic protocols).

Medically treated patients required significantly fewer interventions in their initial hospital phase compared with patients treated by GPMs. Because of hospital proximity, some patients in the paramedic group may have been rapidly transported, thus generating additional interventions and TRISS points. However, some interventions (eg, airway control) should be performed as soon as possible regardless of hospital proximity.

In AMT-treated patients with severe blunt trauma, there were significantly more early survivors than predicted by TRISS. There were also more survivors compared with the ISS-matched group of GPM-treated and GPM-transported patients, although the 95% confidence interval does not exclude a similar risk of death or even a better chance of survival in the GPM-treated group. The percentage improvement in both comparisons is very similar, suggesting a real improvement over the GPM-treated group. As this occurred despite longer prehospital time it is presumably due to the enhanced pre-hospital stabilisation by the AMT.

Baxt and Moody were the first to use TRISS to assess the impact of HEMS scene response in trauma. They found a

52% reduction in predicted mortality from blunt trauma in an AMT-treated group versus a non-significant increase in a standard GPM-treated group, despite greater distances and pre-hospital time in the former.<sup>17</sup> Two other studies have found that physicians contributed judgement or procedural skill both, in 22%<sup>5</sup> to 25%<sup>24</sup> of missions.

A subsequent US multicentre study showed a 21% reduction in mortality, using the Major Trauma Outcome Study cohort as a benchmark.<sup>25</sup> Only four out of seven of these services included a physician in the medical crew. However, this study cannot be directly compared with ours as the non-physician crew were more highly trained and often worked under direct radio control of a critical care or emergency physician, while the physicians were more junior than their Australian equivalents.

In Australia, procedures performed by paramedics are limited and on-line medical control is not used. Our study found major differences in resuscitation compared with an earlier Australian HEMS study by Cameron et al with a paramedic crew,<sup>2</sup> in which 42% of patients with a low score on the Glasgow Coma Scale (< 9) were transported unintubated (compared with none in our study). This non-intubation rate was almost identical to that before AMT arrival in our study.

reflecting the shortcomings of current paramedic protocols as discussed above.

Limitations to our study include its small sample size, which may reflect underutilisation of the service, and the fact that it is retrospective. Selection bias cannot be ruled out, and this may have affected the results either way: the AMT may not have been called out for some older patients or those with a poor prognosis; and, conversely, anecdotal evidence suggests that the AMT may be called out by paramedics when a patient's death is imminent. However, we found no difference in demographics between AMT- and GPM-treated patients.

The main limitation was that data collection by the NSW Ambulance Service does not include all the variables necessary to calculate the RTS. Hence, TRISS could not be calculated for the matched GPM group, only the ISS. TRISS itself has limitations: the physiological component (RTS) varies with time and therapy. Thus, consistent timing of data collection is logistically impossible in any trauma population, whether this is done prehospital or at admission. Nevertheless, there is a need for better data collection and more outcome studies of all Australian trauma patients. Ideally, TRISS data should be available for all trauma patients to aid in evaluation of trauma care, with calculation of local norms for survival. Only then will it be possible to accurately assess the value of HEMS with and without advanced medical capability.

The significance of our study needs to be viewed in the light of the regionalised system of trauma centres, the benefit of which lies in the centralisation of experience and resources available to patients on reaching the trauma centre. The disadvantage is that some patients will now find themselves further from this destination. The need for pretransport stabilisation must be balanced against the need for rapid transport to definitive care. Rotary wing transport can shorten transport times, but may not decrease total prehospital time when used as a secondary response (ie, when called in by emergency services already at the scene). Helicopters, although two to three times faster than road ambulance, must travel twice as far (out and back), plus launch time and time on scene. Consequently, the value of HEMS is limited if the staff are unable to provide a higher level of clinical care on scene and in transit.

A study of paramedic-staffed urban HEMS showed no improvement in prehospital time or survival when called in by paramedics already on scene.<sup>22</sup> This is consistent with the findings of the Australian study by Cameron et al.<sup>2</sup> While care must be taken not to unnecessarily prolong scene times, our study showed almost identical scene times to those for Australian paramedics.<sup>2</sup> A study of rural HEMS also found that scene times are not prolonged by performance of advanced procedures by physicians.<sup>26</sup>

**Conclusions**

Our study suggests that an appropriate critical care doctor should be considered, if not routinely incorporated, as part of any air medical scene responses to major blunt trauma. Air medical transport is currently relevant only to those trauma patients who have significant injuries and, because of distance, entrapment, or difficult access, cannot be rapidly transported to an appropriate hospital by conventional ambulance. In these circumstances, prolongation of prehospital time is fre-

quently inevitable despite HEMS. Consequently, more advanced prehospital measures from a critical care medical team may be required aboard the HEMS. The use of HEMS allows an AMT to respond rapidly over a wide area.

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