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ORIGINAL ARTICLE

ADDITION OF PHYSICIANS TO PARAMEDIC HELICOPTER SERVICES DECREASES BLUNT TRAUMA MORTALITY

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Background: The authors hypothesized that the addition of critical care physicians to the flight crew of paramedic helicopter services would decrease mortality in blunt trauma, and that this would be due to the greater procedural capability and clinical judgement of the physician.

Methods: Retrospective comparison was undertaken of patients flown directly from the accident scene over a 28-month period by the paramedic-staffed Westpac Hunter region helicopter to John Hunter Hospital, and the physician-staffed NRMA CareFlight helicopter to Westmead or Nepean Hospitals. Inclusion criteria were blunt trauma and an Injury Severity Score of ≥ 10. Mortality was compared by trauma score–injury severity score (TRISS) methodology.

Results: There were 140 patients in the paramedic treatment group and 67 in the physician group. There were no significant differences between the groups in age, mechanism of injury, distance transported, response, scene or transport times. Physicians intubated a greater proportion of patients (51 *vs* 10%; $P < 0.001$) including all patients with a Glasgow Coma Score of < 9. Physicians gave significantly greater volumes of fluids to hypotensive patients (median: 5035 *vs* 1475 mL; $P < 0.001$) and performed thoracic decompressions on a larger proportion of patients (12 *vs* 1%; $P < 0.01$). The Z statistic for the physician treatment group was 2.72 ($P < 0.01$) compared with −1.16 ($P = 0.25$) in the paramedic group. The adjusted W statistic was 13.44 (95% CI: 7.80–19.08) suggesting that there would be between eight and 19 extra survivors per 100 patients treated in the physician group compared with the paramedic group.

Conclusions: Physicians perform a greater number of procedures at accident scenes without increasing scene time. This results in significantly lower mortality. Critical care physicians should be added to paramedic helicopter services for scene response to blunt trauma.

Key words: helicopter emergency medical services, paramedics, physicians, trauma, TRISS.

INTRODUCTION

The role of physicians in pre-hospital trauma care is controversial. In the Franco-German model, pre-hospital trauma care is routinely by physicians, often because legislation limits advanced life support (ALS) procedures to this group. In contrast, the Anglo-American model typically provides this care by 'physician extenders' such as paramedics and nurses.[1] In Australia there is a mixture of these models, particularly on helicopter emergency medical services (HEMS) with physician–paramedic, physician–nurse, and single or dual paramedic staffing configurations in use in various parts of the country. Staffing on some services varies depending on whether the mission is an interhospital transport or a response to an accident scene.

There are no previously published Australian data on the optimum staffing of HEMS for scene response. However, one study suggested a decrease in mortality in blunt trauma for patients treated by physician-staffed HEMS compared with ground paramedics.[2] Comparison with overseas services, mainly from North America, is difficult. United States (US) flight programmes usually use flight nurses and paramedics with extended skills beyond that of Australian paramedics. Additionally, US flight physicians are usually junior when compared with the physicians who staff services operating in several Australian capital cities.

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The NRMA CareFlight/NSW Medical Retrieval Service is based at Westmead in western Sydney. The flight crews for all missions consist of a physician and paramedic. The physician flight crew are specialists or advanced trainees in anaesthesia, emergency or intensive care medicine. The paramedics are seconded from the Ambulance Service of New South Wales (ASNSW), and have extended training in high angle and remote area rescue. The helicopter is always staffed for immediate dispatch, with medical crew members on site within the hanger.

The Hunter region Westpac helicopter service is based in Newcastle, north of Sydney. It is staffed for scene responses by two ASNSW paramedics, who are located at an ambulance station approximately 1.5 km from the helicopter base.

Both services use Bell 412 helicopters as their principal aircraft. These two services are similar except for crew composition. We hypothesized that the addition of a critical care physician to the flight crew of a paramedic-staffed HEMS would decrease mortality in blunt trauma. Furthermore, we hypothesized that this difference would be due to the greater procedural capability and clinical judgement provided by the physician.

METHODS

Patients who were transported by the paramedic-staffed Hunter region Westpac helicopter service were retrospectively identified from the trauma registry of John Hunter Hospital, Newcastle. The physician treatment group consisted of patients identified from the medical database of NRMA CareFlight/NSW Medical Retrieval Service, who were transported to Westmead or Nepean

hospitals in Sydney. The John Hunter and Westmead hospitals are both level 6 trauma services with on-site neurosurgical and cardiothoracic surgical services. Nepean Hospital is a level 5 service with on-site neurosurgical and thoracic services, but without cardiac surgery. None of the three hospitals have dedicated spinal or burns units.

Patients qualified for inclusion in the study if the following were met: (i) they had an Injury Severity Score (ISS) ≥ 10 as a result of blunt trauma; (ii) they were transported directly from the incident scene; and (iii) the incident occurred between January 1996 and April 1998. Interhospital transfers were excluded. Pre-hospital case sheets were examined to determine physiological variables to allow the calculation of a Revised Trauma Score (RTS).[3] Other data collected included patient demographics, mechanism of injury, response, scene and transport times, entrapment at the scene, requirement for winch extrication, fluids administered and procedures performed either at the scene or in transit to the trauma centre.

Outcomes were compared by trauma score–injury severity score (TRISS) methodology with coefficients derived from the Multiple Trauma Outcome Study (MTOS)[3] using the 1990 Abbreviated Injury Scale.[4] First recorded data on the pre-hospital case sheets was used to calculate the RTS. The ISS was calculated by trained nurse researchers from the trauma registry of each hospital using case notes and autopsy reports. The comparison between observed and predicted mortality was made at hospital discharge.

Statistical analysis was by χ^2 or Fisher's exact test for categorical variables as appropriate, and the Mann–Whitney *U*-test for continuous variables. Comparisons between predicted and observed mortality were made using 'Z', 'W' and 'M' statistics. An adjusted W statistic by the method outlined by Younge *et al.*[5] was used when the M statistic indicated a poor match of probabilities of survival with the MTOS cohort. An adjusted W statistic was also calculated by this method to directly compare the outcomes in the paramedic and physician-treated groups.

To ensure that no significant differences in outcomes existed between the three trauma centres, all blunt trauma patients with complete data who were treated over the same time period by paramedic ambulance officers, transported to these hospitals by road and with ISS ≥ 10 were also compared by TRISS methodology.

RESULTS

Demographics and interventions

Over the study period the paramedic team transported 147 patients who met the inclusion criteria. Case sheets were available for examination in 140 cases. There were 67 patients transported by the physician team and case sheets were available in all cases.

Demographic details, mechanism of injury, distance transported and time intervals are compared in Table 1. There was no significant difference in the proportion of patients trapped at the scene between the paramedic (49/140) and the physician groups (32/67; $P = 0.08$). There was a significantly greater proportion of patients requiring extrication by rescue winch in the physician group (8/67) than the paramedic group (2/140; $P < 0.01$). Two of the eight patients in the physician group were intubated prior to winch extrication, one with a Glasgow Coma Score (GCS) of 8 and the other with a GCS of 9 and combative behaviour.

Procedures performed at the scene and during transport are compared in Table 2. Of patients who were hypotensive (systolic blood pressure of < 90 mmHg) at first contact by the treating team, 4/19 (21%) in the physician group were still hypotensive on arrival at the trauma centre, compared with 20/34 (59%) in the paramedic group ($P = 0.01$). There was one unrecognized oesophageal intubation in the paramedic group compared with zero in the physician group.

Physician group

Interventions performed by the physician team which exceeded paramedic protocol included transfusion with packed red blood cells in 28/67 (42%) patients. The median number of units transfused was 3 (range: 1–12). The patient who received 12 units also received 3 units of fresh frozen plasma and has been reported elsewhere.[6] Muscle relaxant drugs were used in 28 of the 34 patients intubated, and there was one cricothyroidotomy. Of the 11 patients with initial GCS > 8 who were intubated before reaching hospital, six were intubated to facilitate safe, controlled extrication from motor vehicle entrapments or by rescue winch in agitated, combative patients. Four were intubated for oxygen saturations of < 90% despite high flow mask oxygen and/or large-bore tube thoracostomy. One patient whose initial GCS was > 8 was intubated after their GCS rapidly fell

Table 1. Demographic details, mechanism of injury, distance transported and time intervals

	Paramedic team (n = 140)	Physician team (n = 67)	Significance level
Median age in years (range)	33 (2–89)	31 (13–70)	$P = 0.58$
Mechanism of injury			
Motor vehicle occupant	88 (63%)	42 (63%)	
Motor bike rider	16 (11%)	6 (9%)	
Pedal cyclist or pedestrian	7 (5%)	2 (3%)	
Falls	9 (6%)	7 (10%)	
Other	20 (14%)	10 (15%)	$P = 0.80$
Median transport distance in nautical miles (range)	19 (3–170)	14 (2–89)	$P = 0.08$
Median time intervals in minutes (range)			
From call to arrival at scene	26 (3–121)	29 (9–70)	$P = 0.11$
Scene time (excluding trapped and winched patients)	34 (5–74)	33 (14–91)	$P = 0.95$
Transport time to hospital	12 (2–50)	15 (5–54)	$P = 0.08$
Total pre-hospital time	82 (25–192)	86 (24–225)	$P = 0.10$

to 4. One patient received a regional nerve block. An arterial line was placed by a physician in one trapped patient.

Two patients in the physician group were documented to be in cardiorespiratory arrest at the time of the team's arrival on the scene. There was return of spontaneous circulation in both patients, but both suffered further arrests from which they could not be resuscitated after arrival in the receiving trauma centre. There were no patients documented to be in arrest when the paramedic team arrived on the scene, though one patient arrested during transport and was pronounced dead on arriving at the trauma centre.

Mortality

Characteristics, outcomes and survival probabilities of the patients on whom pre-hospital case sheets were available, are compared in Table 3. All of the seven patients in the paramedic group on whom case sheets were unavailable, died. The difference between the observed and predicted number of deaths was significant in the physician group ($Z = 2.72$; $P < 0.01$), but not in the paramedic group ($Z = -1.16$; $P = 0.25$). M statistics for both groups (physician = 0.62, paramedic = 0.68) indicate poor matches with the MTOS patient cohort. The adjusted W was 9.48 (95% CI: 3.84 to 15.12) in the physician group, and −2.37 (95% CI: −6.81 to 2.07) in the paramedic group. An adjusted W directly comparing the physician and paramedic treatment groups was 13.44 (95% CI: 7.80 to 19.08), suggesting that there would be 13 extra survivors per 100 patients treated in the physician group compared with the paramedic group.

The adjusted W statistic for blunt trauma patients transported by paramedic road ambulance to either Westmead and Nepean or John Hunter hospitals with ISS ≥ 10 was 2.11 (95% CI: −0.34 to 4.56) which was not statistically significant. This suggests that there was no difference in mortality between the receiving trauma centres for patients who received the same level of pre-hospital care.

DISCUSSION

Direct comparison of the physician to the paramedic treatment group showed that there was a substantial difference in mortality. We estimated that there were between eight and 19 extra survivors per 100 treated in the physician group. This difference may be related to staffing of the service and numbers and type of interventions performed.

Table 2. Procedures performed at the scene

	Paramedic team (n = 140)	Physician team (n = 67)	Significance level
Number of patients who received > 50 mL intravenous fluids	104	53	$P = 0.45$
Median volume of fluid (mL) infused in patients who received > 50 mL (range)	825 (100–4500)	2500 (200–14 380)	$P < 0.001$
Median volume of fluid (mL) infused in patients with initial hypotension* (range)	1475 (0–4500)	5035 (1000–14 380)	$P < 0.001$
Number of patients intubated	14	34†	$P < 0.001$
Proportion of patients with Glasgow Coma Score < 9 intubated	14/36	23/23	$P < 0.001$
Thoracic decompressions	2 (both needle)	8 (6 tube, 2 needle)	$P < 0.01$

*Hypotension defined as systolic pressure of < 90 mmHg.
†One cricothyroidotomy.

Table 3. Patient characteristics, outcomes and survival probabilities

	Paramedic team (n = 140)	Physician team (n = 67)	Significance level
Median RTS (range)	7.55 (0.58–7.84)	6.90 (0.00–7.84)	$P = 0.21$
Median GCS (range)	14 (3–15)	13 (3–15)	$P = 0.05$
Median ISS (range)	18 (10–66)	25 (10–59)	$P = 0.05$
Outcomes by TRISS methodology			
Predicted to die and died	16	5	
Predicted to die and lived	4	9	
Predicted to live and died	11	5	
Predicted deaths	23	16	
Observed deaths	27	10	
Comparison of survival probabilities (Ps) stratified by M statistic bands (fractions of patients within each range)			
0.96–1.00	0.51	0.45	
0.91–0.95	0.17	0.13	
0.76–0.90	0.11	0.10	
0.51–0.75	0.06	0.10	
0.26–0.50	0.09	0.09	
0.00–0.25	0.06	0.12	M = 0.89

RTS, revised trauma score; GCS, Glasgow coma score; ISS, injury severity score; TRISS, trauma score–injury severity score.

Baxt and Moody have published the only randomized prospective trial comparing paramedic- and physician-staffed HEMS.[7] This study compared physician–flight nurse teams with paramedic–flight nurse teams. The physicians were faculty level (consultant or specialist) emergency physicians. The paramedic–flight nurse teams were trained to perform all the procedures that the physician was capable of performing, including oral and nasal endotracheal intubation, tube thoracostomy, central line placement, pericardiocentesis, and cricothyroidotomy. There was significantly lower mortality as determined by TRISS methodology in the physician–flight nurse group. This was attributed to a higher likelihood of successful completion of indicated interventional procedures.

Unlike Baxt and Moody's study, there are considerable differences in the procedural capabilities of the two teams reported in the present study. It is noteworthy, however, that even where both teams were capable of performing a procedure such as volume replacement, it was performed more aggressively by the physicians. This suggests that training to perform a procedure does not necessarily impart judgement on when to perform the procedure or to what degree. Although it is possible that further training may correct these problems, it is not clear that this judgement can be effectively taught.[7] In many US flight programmes this problem has been partly addressed by provision of direct radio control by a physician. Physician freedom to exercise clinical judgement may be an important factor resulting in improved outcome. No difference in mortality was found between physician and non-physician teams when both were bound by essentially the same patient care protocols.[8]

In the Australian setting, the outcome from a Victorian paramedic-staffed HEMS was not significantly different from that predicted by TRISS methodology.[9] Patient demographics, scene times and total pre-hospital times are similar to those reported for the two services in the present study. The overall intubation rate, the intubation rate in patients with GCS < 9 and the volume of fluids given were also similar to our paramedic group, but vary considerably from our physician group. The low intubation rates for severe head injury patients in both paramedic-staffed HEMS is a matter of concern because there is evidence that pre-hospital intubation improves outcome.[10] The differences in intubation rate and fluid volumes infused between these two Australian paramedic services and the physician service parallel the reported differences in a comparison of US paramedic and German physician-staffed services.[11] Despite the subsequent introduction of a high-dose sedation intubation protocol for use by paramedics in Victoria, episodes of failure to intubate, delayed intubation and unrecognized oesophageal intubation continue to occur.[12] Excessive sedation contributes to death in some patients. Inadequate fluid resuscitation has also been identified as an ongoing problem.

All procedures that can be performed in the emergency department can be successfully performed in the pre-hospital environment, including thoracotomies for penetrating chest trauma.[13,14] Patients treated by physicians prior to arrival in the emergency department may have shorter times to definitive management, because the focus in the emergency department switches from procedures to imaging and disposition.[15,16] Paramedic-treated patients require significantly more interventions after arrival in the emergency department than physician-treated patients.[2] Pre-hospital treatment by physicians is associated with substantially shorter times to cranial computed tomography scan and surgery for head-injured patients.[16] Because there are no significant differences in scene times or total pre-hospital times between critical care physicians and paramedics, shorter overall times from injury to surgery in those who require surgical haemostasis or evacuation of intracranial haematomas may result from physician involvement in pre-hospital management.

There were more winch extrications in the physician group, highlighting geographical differences in the catchment areas of the services. The NRMA CareFlight has primary responsibility for rescue in the Blue Mountains west of Sydney. Local geography may also account for the longer response and transport times in the physician group, despite the shorter distances transported. There may have been more instances of prolonged secondary access in the physician group; that is, the team having to walk or be conveyed by road from the helicopter landing site to the patient. This cannot be confirmed because these data are not routinely collected by either service.

The TRISS methodology is known to have limitations.[17] Additionally the Z statistics in the present study should be treated with caution when compared with the MTOS because the RTS is calculated from the first recorded pre-hospital data, rather than the data collected on emergency department arrival. The M statistics also indicate poor matches for severity of injury. First recorded pre-hospital data for RTS was used in the present study for two reasons. First, most patients in the physician-treated group were intubated before reaching hospital, and no GCS or respiratory rate could be recorded on hospital arrival. The last recorded data prior to intubation could have been substituted; however, collection of all data at first contact and prior to interventions allowed consistent timing of data collection in both groups. Second, RTS is known to change with both time and treatment. More aggressive management in one group may have resulted in greater changes in the RTS prior to hospital arrival. For example, significantly more patients in the physician group had hypotension corrected.

There were seven patients in the paramedic treatment group on whom no pre-hospital case sheet was available, and therefore they were excluded from the analysis. Because all seven died, this group contained no unexpected survivors but may have contained unexpected fatalities. Inclusion of these patients in the analysis would therefore have resulted in either no significant change or, possibly, an increase in the number of expected additional survivors in the physician group.

Selection bias is a potential limitation in the present retrospective study. Different ambulance coordination centres task the two helicopter services. Variations in dispatch practices cannot be excluded. There was a trend towards more severe injury in the physician-treated group, which may reflect greater availability of ground paramedics in the Sydney coordination area and selective dispatch of the helicopter to patients who were thought to require interventions exceeding paramedic protocols. The difference in the numbers of patients treated by the two services is surprising given the larger catchment population of the physician-staffed service. This suggests that the physician service is under-utilized. Apparent differences in outcome may have resulted from the paramedic and physician patient groups being treated in separate trauma centres; but we were unable to detect any significant differences in outcome by receiving hospital for patients who received the same level of pre-hospital care.

The key factor in improving survival is the interval between the accident and the arrival of the helicopter medical personnel at the scene or outlying hospital.[18] The speed with which the patient can be delivered to a trauma centre is of secondary importance,

because few patients are urgently in need of surgery.[15] When this is required, patients receiving pre-hospital treatment by physicians arrive in theatre more rapidly.[15,16] The regionalization of trauma services has shown a distinct benefit in trauma outcome by concentrating expertise in specific hospitals. Helicopter emergency medical services allow this same concentration of skilled, highly trained clinicians to occur in the pre-hospital environment, because a single service can cover a wide geographical area. They also allow bypass or early provision of senior clinical support to small or rural emergency departments. In these contexts, the enhanced procedural skill and clinical judgement of critical care physicians is of particular benefit in improving patient outcomes. Critical care physicians should be added to paramedic helicopter services, wherever practicable, for scene response to blunt trauma.

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