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Research Article

Intensive Care Paramedic Skills in the Management of Major Trauma – Effect on Mortality in an Informal, Two-Tiered, Decentralised State-Wide Trauma System

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Abstract

Background: A number of studies have attempted to determine the value of pre-hospital Advanced Life Support (ALS) interventions in trauma patients. Few of these studies provide enough detail of the scope of advanced skills performed, the education/training arrangements in which these skills have been learned, the pre-ALS educational platform training, or the organizational arrangements in which paramedics respond to enable comparison of like with like services. Combined, these factors provide a significant challenge to interpretation of the findings and the utility of extrapolating the results to other operational settings. In many published reports, survival to discharge is the outcome of interest and rarely are there analyses of the effectiveness of ALS interventions on survival benefit across the patients entire care pathway.

We sought to examine whether or not the training of Intensive Care Paramedics in Queensland had resulted in improved survival, at any point in the care trajectory, for major trauma patients.

Method: Retrospective linked analysis of routinely collected emergency prehospital clinical records, inpatient records and death registry data was conducted for all-age, all-cause major trauma for the four-year period 1998-2001. The key outcomes of interest were survival to hospital, survival to discharge or 30 days post discharge; and survival overall. Binomial logistic regression, controlled for GCS less than 9, age, sex and the presence or absence of co-morbidities, was employed to determine the relationship between advanced life support interventions performed by Intensive Care Paramedics and survival from major trauma.

Results: Between 1998 and 2001, Intensive Care Paramedics in Queensland attended approximately one quarter (24.4%; n=5, 481) of major trauma cases (N= 22, 463). Patients experiencing a major trauma and who are attended by Intensive Care Paramedics had a statistically significant higher pre-hospital survival probability at all times (OR 1.16; 95%CI 1.02-1.39) but were more likely to die in hospital (OR 0.69; 95% CI 0.58-0.80). Overall mortality however, when controlled for GCS <9, age, sex and co-morbidities, was not significantly reduced by the presence of Intensive Care Paramedics (OR 1.05; 95%CI 0.95-1.16).

Conclusion: The standard of advanced skill training in Queensland provides a pre-hospital survival benefit to major trauma patients in the State; however this effect is not sustained across the care continuum. We were not able to determine from this data whether this was a consequence of the resuscitation of patients who would inevitably die from catastrophic injuries or who succumbed later in their patient career as a result of end-organ damage and/or systemic infection.

Keywords: Major Trauma; Advanced life support; Care paramedics

Background

In the emergency pre-hospital setting, Advanced Life Support skills (ALS) are generally understood to constitute a level of skill beyond base qualifications. These advanced skills frequently include, but are not necessarily restricted to, intubation, cannulation and the administration of Intravenous (IV) fluids, management of major haemorrhage, decompression of tension pneumothoraxes, treatment of rhabdomyolysis (crush syndrome) and use of a wider range of cardio active, sedative and pain management drugs. In most Australian ambulance services, Basic Life Support (BLS) skills include less intrusive airway control and management techniques, fracture splinting and haemorrhage control, oxygen administration, defibrillation and the management of cardiac arrest with minimal

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cardio-active pharmaceutical support e.g. adrenaline, glycerol tri-nitrate.

There are a number of studies that have attempted to determine the value of pre-hospital ALS interventions in trauma patients [1-7]. These studies have typically compared:

• Rapid transportation from the scene ("scoop and run") versus field stabilization ("stay and play") [1,2,5];

• Pre- and post-ALS patient outcomes [7]; or

• The survival benefit of specific interventions [3,8-14].

Few of these studies provide significant detail of the scope of advanced skills performed, the education/training arrangements in which these skills have been learned, the pre-ALS educational platform training, or the organizational arrangements in which paramedics or Emergency Medical Technicians respond. Combined, these factors provide a significant challenge to interpretation of the findings and the utility of extrapolating the results to other operational settings.

Experience in Australia

A 1980's Australian study compared the outcome of 472 trauma patients who required ambulance attention and who received pre-hospital ALS with a similar group of 589 patients who received only BLS [7]. The study reported that:

• Non-trapped, critically injured ALS patients were treated for an average of 13 minutes on scene, compared to 17 minutes for BLS cases ($p<.05$); and

• Improved 24-hour survival was associated with ALS care although overall case fatality rate was similar in both groups: 36% of ALS deaths occurred within 24 hours of injury compared with 73% of BLS fatalities ($p<.05$).

This study demonstrated that any real benefits of ALS appear to occur mainly in the clinical course of the patient during the first 24 hours after injury. The authors also note that many ALS interventions were performed en-route to hospital and often procedures that were indicated were not performed due to time constraints. The authors noted however that the study may not have had sufficient sample size to detect mortality outcomes. In Australia, sudden deterioration of trauma patients in the care of paramedics has been reported to be uncommon [15].

Paramedic training in Queensland

Between 1998 and 2001, a two-tiered emergency response operational system was in place in Queensland comprised of:

• Advanced Care Paramedics (ACP's); and

• Intensive Care Paramedics (ICP's).

ACP's were trained in the vocational education system over a three-year period and graduated at the Diploma level. The ACP training provided for three, six-week periods of block face-to-face training in classroom settings complemented by the remainder of the training experience provided in the field in operational vehicles. The clinical practice guidelines at this level included the establishment of IV access, airway adjuncts to the level of laryngeal mask airway, oxygen delivery including the use of nebulized agents such as salbutamol and access to a range of drugs including methoxyflurane, glycerol tri-nitrate, and adrenaline for the emergency treatment of anaphylaxis. ACP's were trained in application of splinting and extrication devices (Donway splints; Kendrick Extrication Device's) and performed cervical spine stabilization using collar and board where necessary.

In 1997, the Service began its Intensive Care Paramedic (ICP) training program delivered through the vocational education system. Intensive care training required applicants to have completed a minimum of five-years' service (including the three years initial training) before applying for course entry. Training at this level was completed over an intensive twelve-month period that included both classroom and on-road supervised intensive care practice with qualified mentors. By the end of the period of interest for this study, approximately 120 ICP's were in practice in the field, equivalent to around 7% of the total operationally active paramedic workforce. ICP's provide the highest level of pre-hospital intervention which includes the performance of endo-tracheal intubation, IV and Intra-Osseous (IO) access and the use of morphine, adrenaline, and midazolam, for example. ICPs operated in the main from single officer response vehicles and provided clinical support to other paramedics to facilitate the care of the most critically ill and injured patients [16].

System arrangements

By area, Queensland is the second largest by area of eight Australian States and Territories and covers 1.7 million square kilometers. Between 1998 and 2001, the State's population grew from 3.4 million to 4.1 million. The population is dispersed with the largest population densities concentrated on the eastern seaboard and south east corner of the State. Approximately a quarter of the population resides in the capital city, Brisbane. Queensland Ambulance Service (QAS) is the sole emergency pre-hospital provider and provides state-wide coverage. Over the study period, the Service was staffed by approximately 1,800 clinically active paramedics, approximately 10% of which were qualified as ICP's. Between 1998 and 2001, Queensland Ambulance Service responded on average to 443, 230 cases per annum. Major trauma cases accounted for only a small proportion of the overall workload (1.3%) but 4.5% of the average annual Code 1 (life threatening/resuscitation, lights and sirens response) and Code 2 (immediate response) presentations. Wherever possible, Intensive Care Paramedics are dispatched to support ACP crews for all major trauma cases. During this same period, ICPs attended around 25% of calls for major trauma.

International experience with advanced skill training

The Scottish Trauma Audit Study [5], prompted by reports that at least 39% of pre-hospital deaths from major injury were preventable [6], sought to evaluate the influence of paramedic skill sets compared to less extensively trained ambulance technicians, on outcomes for trauma patients. Paramedics trained in the additional skills of orotracheal intubation, peripheral percutaneous intravenous cannulation and the administration of fluids. The study involved 1,090 patients who met the study inclusion criteria and who were brought to hospital by ambulance. The results showed that paramedics spend longer at the scene than ambulance technicians; however there was no significant difference in total pre-hospital times between the groups. Paramedics were noted to direct a significantly higher proportion of patients to the resuscitation room and significantly more of those patients went to theatre, intensive care or the mortuary. No reduction in mortality or length of stay in intensive care were reported for the paramedic group and the authors concluded that paramedics delivered an "improved process of care compared to ambulance technicians but that their interventions did not significantly reduce mortality or length of stay in intensive care" [5;p9].

The Ontario Prehospital Advanced Life Support (OPALS) Study [9] represents the largest pre-hospital study conducted to date. The study was established in 1994 and ran for an eight-year period to 2002. The sample size for the study was determined by the number of available cases and was set at 3,180 cases for each of the 36-month study periods and provided 80% power to detect a 3% absolute survival difference in before and after measures. The OPALS study was specifically designed to assess the incremental cost-effectiveness of community pre-hospital ALS programs.

The study applied a rigorous controlled methodology and captured a large sample (N=25,000 cardiac arrest, trauma and critical care patients). The primary outcome measure was survival to hospital discharge defined as the patient leaving hospital alive or transferred to an alternative level of care (i.e. long term care). Advanced life support skills included advanced airway management such as endo-tracheal intubation and IV fluid replacement. All paramedics undertaking this training had previously completed a 10-month community college program and had several years' on-road experience. ALS paramedics were trained in endo-tracheal intubation and IV skills over a 6-month period (6 weeks didactic training; 6 weeks clinical instruction; and a 12-week preceptorship in the field) to the Canadian Medical Association's Emergency Medical Technician Level III standard.

The subsequent pre- and post-training controlled analyses of outcomes in major trauma, demonstrated that among patients with a Glasgow Coma Scale (GCS) <9, survival was lower among those in the ALS group (50.9% v. 60.0%; p=0.02). However, the adjusted odds of death in the ALS versus BLS groups were non-significant (1.2, 95% CI 0.9-1.7; p=0.16). The authors interpreted this to indicate that system-wide implementation of ALS programs would not decrease mortality from major trauma patients.

Our study sought to examine whether or not the training of ICPs in Queensland had resulted in improved survival for major trauma patients. This study was conducted in the light of our previous work that demonstrated a significant survival benefit to patients experiencing an out-of-hospital cardiac arrest when attended by ICPs [17].

Method

The sample for this study was set by the number of available cases of major trauma attended by the Queensland Ambulance Service between 1998 and 2001. The study population was all age, all cause major trauma. Retrospective analysis of routinely collected emergency pre-hospital clinical records was conducted for the four-year period and linked to admitted in-patient data sets and deaths registration information using patient name, date of birth, sex and Medicare number.

Following linkage, the sample of major trauma patients was selected using the following inclusion criteria:

- Length of stay more than or equal to 24 hours for a 'serious' injury as determined by (a) physiological parameters (systolic blood pressure <90mmHg or respiratory rate less than 10 or more than 29 per minute or GCS <13) or (b) QAS patient status/triage code (life-threatening, resuscitation or urgent);
- Admission to an intensive care unit;
- In-patient death;
- Death post-separation but within 30 days of the injury; and
- Prehospital death [18].

Patients were excluded from the final sample if they were admitted for more than 24 hours for other medical, psychiatric or social reasons or if they had been admitted for more than 24 hours as a consequence of elective surgery, for complications from minor trauma, pathological fractures or spontaneous joint dislocations.

Outcome measures

The primary outcomes of interest were survival to hospital, survival to discharge or up to 30 days post, and survival overall. Survival to hospital was defined by the presence of respiration and circulation at the point of admission to the Emergency Department. Patients who did not survive to admission (n=3,599) were excluded from in-hospital and post-discharge analyses but included for overall mortality analyses.

Survival to discharge was defined as the patient leaving hospital alive regardless of their final destination (e.g. home, rehabilitation, or other care facility).

Survival time was estimated using QAS call out time, response time, arrival at hospital time and patient status information (Code Q). Survival time for patients who were dead when QAS arrived was estimated as the interval from call out to QAS arrival divided by 2. Patients who were alive when QAS arrived but who did not survive to be transported had a survival interval equal to response interval plus half of their on-scene interval. Similarly, patients who died during transport had a survival interval equal to response interval plus on-scene interval plus half of the interval from scene to arrival at hospital.

Statistical analysis

Linkage and analyses were conducted using SAS software. For descriptive analyses age was broken into categories as suggested by the Utstein convention [19] (0-12 months, 1-4 years, 5-14 years, 15-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75-84 years and 85 years and older).

A series of multiple logistic regression models were developed to determine whether there was any differential survival benefit for major trauma patients attended by ICP's compared to ACP's. Associations between independent variables and mortality were examined using binomial logistic regression adjusting for age, sex and GCS <9. In-hospital mortality ratios were also adjusted for patient co-morbidities. Analyses were first conducted on the whole trauma data set then subsequently for the most predominant causes of injury (traffic accidents and falls) to establish whether or not the presence of an advanced trauma life support skills differed as a function of injury type.

Table 1: Distribution of trauma by vector of injury, age and sex.

Vector	Frequency	%	Sex Distribution (n)		Age-related peak incidence
			M	F	
Transport accidents	6507	28.1	4425	1910	15 - 44
Falls	6288	27.2	3165	3080	65+
Asphyxia	430	1.9	282	144	1 - 4
Assault	838	3.6	666	172	15 - 44
Self-Harm	2758	11.9	1452	1236	15 - 54
Other	6261	27.1	*	*	N/A
Total	23,082*	100.00	*	*	

Note: * patients may have more than one vector of injury identified

Table 2: Injury severity measures – mean Revised Trauma Score and Initial Glasgow Coma Score for trauma dataset, transport accidents and falls.

	TOTAL TRAUMA SET		
Variable	**N**	**Mean**	**95% CI**
RTS	9344	7.33	1.74 - 7.80
Initial GCS	16219	12.67	12.61 - 12.73
	TRANSPORT ACCIDENTS		
Variable	**N**	**Mean**	**95% CI**
RTS	3005	7.40	7.37 - 7.43
Initial GCS	5079	12.98	12.88 - 13.08
	FALLS		
Variable	**N**	**Mean**	**95% CI**
RTS	3005	7.5	7.48 - 7.53
Initial GCS	5079	13.95	13.87 -14.03

These analyses were complemented by survival analyses of the complete major trauma data set examining the effect of skill set over time.

Results

Between 1998 and 2001, a total of 22, 463 individuals of all ages suffered a major injury and were attended by paramedics. The number of trauma cases per 100 000 population for both males and females was calculated for each year and for each age group and is described elsewhere [19,20]. Age standardization was performed using census counts for 2001 and demonstrated peak rates between the ages of 15 and 44 years of age increasing again in the over 75 age group.

Patients aged 15 to 34 and over 65 years were over represented by comparison to population distribution. Males demonstrated a higher injury rate than females. Males also made up a higher proportion in the trauma dataset than in the Queensland population. A closer examination of the age distribution of males demonstrates peaks in the 15 to 44 year old age groups and again among older males (65 years plus). Among women, there is a significant leap in the age distribution among women aged 65 years and older. When both sexes were compared higher ratios were observed for males aged 15 to 24 years and females aged over 65.

Blunt force trauma predominated (90%; n=20, 324) the study population. Three and a half percent (3.5%) of the study population experienced an injury by penetrating forces (n=810) and a further 1.51% (n=349) suffered major burns.

The most common causes of major injury were transport accidents (n=6507), falls (n=6288) and self-harm (n=2758) (Table 1).

The mean time to scene for this population was 13.84 minutes (95% CI 13.45-14.23) and the mean on-scene interval was 22.48 minutes (95% CI 21.91-23.05). Excluding those patients who died in the pre-hospital phase of care, the mean time to definitive care was 3.92 hours (95% CI 3.88-3.96).

Severity was assessed or ascribed only for those patients who were coded as being alive when QAS arrived. Where possible, a Revised Trauma Score (Table 2) was calculated however values used to calculate the Revised Trauma Score (RTS) were missing for over 50% of cases. Respiratory rate measurements or missing blood pressure measurements were most commonly missing from the clinical record. It is noteworthy that the mean initial GCS was quite high (12.7) in the study population (Table 2), although this is within the range (GCS < 13) recommended by the American College of Surgeons for consideration as 'major injury'. Since a high mean initial GCS may be indicative of over-triage in this group and that some less severe trauma cases may be included, Glasgow Coma Scores of less than 9 were applied in multivariable analyses as the marker of severity.

Analyses of the number of body regions included only those patients admitted to hospital to ensure full capture of all injury sites. Most injuries affected multiple body sites and lower limb, head and facial injuries were common as would be anticipated due to the most common vectors, transport accidents and falls.

Thirty-four per cent (n= 6, 661) of patients admitted to hospital

Table 3: Qualification level of ambulance officer for patients alive at QAS arrival.

	OVERALL	
Qualification level	**n**	**%**
Standard	14,229	68.4
ICP	4,608	22.2
Unable to determine	1,939	9.3
	TRAFFIC ACCIDENTS	
Qualification level	n	%
Standard	3,967	69.7
ICP	1,728	30.2
Unable to determine	812	12.4
	FALLS	
Qualification level	n	%
Standard	4,001	81.4
ICP	913	18.6
Unable to determine	1,374	21.8
	OTHER	
Qualification level	n	%
Standard	6,262	30.1
ICP	2,641	12.6
Unable to determine	1,384	13.4

Table 4: Association between skill level and mortality at point of care.

Qualification level of ambulance officer	Adjusted Odds Ratio	95% Confidence Interval
	OVERALL MORTALITY**	
ICP qualifications	1.00	(ref)
Standard	1.05	(0.95 - 1.16)
	PREHOSPITAL MORTALITY*	
ICP qualifications	1.00	(ref)
Standard	1.16	(1.02 - 1.31)
	INPATIENT MORTALITY**	
ICP qualifications	1.00	(ref)
Standard	0.69	(0.58 - 0.80)

* Adjusted for age, sex and GCS <9; **Adjusted for age, sex, co-morbidities and GCS <9.

for their injuries were identified as having a co-morbid condition. The most commonly reported co-morbidities were associated with cardiovascular disease and hypertension.

The principal outcome measure applied in this study was mortality. Of the 22, 463 patients in the study population, 30% (n=6, 793) died as a result of their injuries. Of these patients, 16% (n=3,599) died in the pre-hospital period including 1, 687 patients who were dead on arrival of ambulance services. Ten percent (n=2,322) of patients died during the inpatient period and nearly 4% (n=872) at some point in the period up to 30 days post discharge. Mortality was highest among patients who had experienced a fall (33.7% of all deaths) and these patients were most likely to die in hospital. By contrast, the majority of transport accident victims who died did so during the pre-hospital period of care.

The frequency of ICP attendance was determined for the overall sample and separately for falls and traffic accidents (Table 3).

The association between skill level and mortality was examined using logistic regression (Table 4) and survival analysis (Figure 1).

The survival interval for patients who were alive when they arrived at hospital was equal to their entire pre-hospital interval.

Patients who were treated by an ICP had higher pre-hospital survival probabilities at all times. However this survival benefit did not extend to analyses of inpatient mortality (OR 0.69; 95% CI 0.58-0.80). Similarly, analysis of the impact of ICP skill level on overall mortality demonstrated a slight, though non-significant trend toward a survival benefit for patients whose care had involved an ICP (OR 1.05; 95%CI 0.95-1.16).

The survival curve after 40 minute was notably erratic due to the small number of patients whose response interval exceeded 40 minutes.

Discussion

Hodgetts and Smith acknowledge that the "prehospital care of major trauma victims is a balance of timely delivery to definitive care and appropriate intervention to maximize the probability of survival" [21,22]. However, agreement about the level of pre-hospital intervention and skill level that constitutes "appropriate intervention" is difficult to secure. There have probably been as many studies which support aggressive pre-hospital resuscitation and stabilization of major trauma patients [7,23-26] as those that have refuted the efficacy of ALS interventions [27-30].

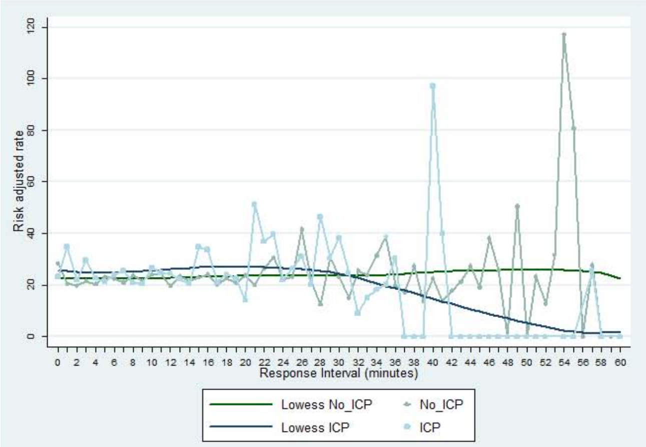

Figure 1: Risk adjusted mortality rate by response interval (effect of ICP) Queensland 1998-2001.

In Queensland, ACP's undertake three years training to achieve base qualifications. ICP's extend this training by a further year after a minimum of 5 years in-field practice (including the initial three year training period). By comparison to training periods reported elsewhere, 6 weeks in the United Kingdom, 22 weeks on South Africa, and in the case of the OPALS study, a 12 week ALS preceptorship in Canada [9,20], and Queensland paramedics would consequently appear to be extremely well qualified.

The geography and population distribution of Queensland present key challenges to the delivery of emergency pre-hospital services and arguably constitute significantly different circumstances too much of the published work on the emergency pre-hospital care of trauma patients. The considerable distances often involved in delivering patients to definitive care and the limitations of medical support available in rural and remote locations necessitates a well-qualified paramedic workforce. In environments where exposure to major trauma is relatively low and predominately defined by blunt force mechanisms this study indicates that a two-tiered system, in which the standard level of emergency pre-hospital care can be supported with high level of resuscitation skills, provides a benefit that ensures that these patients have the best possible pre-hospital survival opportunity.

Our results differ significantly from the OPALS study [7]. In Ontario, the investigators sought to train all paramedics to the same skill level in the study locations. Since comparison of the distribution of mechanism of injury between this study and ours is similar, i.e. predominant blunt force mechanisms, we posit that the level of exposure to major trauma in the OPALS study may have been too small to support a single tiered ALS workforce and as a consequence, skill degradation may have a part to play in explaining the results. It is well established that skill retention is a significant factor in maintaining high success rates for interventions such as endo-tracheal intubation.

However, our findings also suggest that interventions offered by ICP's may be delaying death for trauma patients whose survival likelihood is poor, rather than providing an overall protective effect, since patients who are treated by an ICP are more likely to die in hospital than patients treated by an ACP. We observed a survival advantage in-hospital for patients treated by an Advanced Care Paramedic. Information on time of death is not available in a precise enough format in hospital records to allow further analysis of this issue since inpatient times can be measured in days but not accurately in hours or minutes.

Conclusion

The standard of advanced skill training in Queensland provides a pre-hospital survival benefit to major trauma patients in the State; however this effect is not sustained across the care continuum. Further work is required to determine whether this was a consequence of the resuscitation of patients who would inevitably die from catastrophic injuries or who succumbed later in their patient career as a result of end-organ damage and/or systemic infection. However, we should not resile from our goal as emergency pre-hospital providers that the provision of pre-hospital intervention must add value and provide victims of major injury with the best possible chance of survival to definitive care.

Rather than continue to strive for universal agreement about the most appropriate level of emergency pre-hospital intervention, trauma system development should proceed on the basis that the qualifications of the emergency pre-hospital workforce, the transport and retrieval resources available and the capacity of receiving facilities match the need in the community.

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