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Title: Ambulance management of patients with penetrating truncal trauma and hypotension in Melbourne, Australia

Running Title: Ambulance management of penetrating truncal trauma

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KS and SB conceived the study. KS, SB, MF, AC and GB provided advice on the study design. SC extracted and linked the data. ER cleaned, coded and analysed the data. SC assisted with data analysis. ER drafted the article. All authors contributed substantially to the article revision and approved of the final version.

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ABSTRACT

Objective: Penetrating truncal trauma with hypotension is uncommon in Australia. Current prehospital clinical practice guidelines based on overseas studies recommend expedited transport to definitive trauma care and that intravenous fluid should only be administered to maintain palpable blood pressure.

Methods: A retrospective review included all adult patients with penetrating truncal trauma and hypotension (systolic blood pressure <90mmHg) attended by emergency medical services in Victoria between January 2006 and December 2018. Patient prehospital characteristics and hospital outcomes are described using descriptive statistics. Predictors of fluid resuscitation and mortality were examined using logistic regression analyses.

Results: Between 2006 and 2018 there were 101 hypotensive, penetrating truncal injury major trauma patients in Melbourne, Victoria transported by road ambulance to a major trauma service. The median age of these patients was 38 years (IQR: 27-50) and 85% were male. Median scene time was 16.6 minutes (IQR: 12-26) and median prehospital time was 53.0 minutes (IQR 38-66). IV fluid resuscitation was given in 54.5% of cases. The mechanism of injury was stabbing in 91.1% and gunshot wound in 8.9%. Urgent surgery was required in 72.3% of cases, 32.7% of patients were admitted to ICU and there were eight deaths (8.3%).

Conclusions: Penetrating truncal trauma with hypotension is rare in Melbourne, Australia with most patients having the injury caused by stabbing rather than shooting. Compared with outcomes reported in the USA and Europe, the mortality rate is low.

Keywords: ambulance, emergency medical service, fluid resuscitation, hypotension, penetrating truncal trauma

INTRODUCTION

Each year over five million people die from injury worldwide.[1] In Australia, injury is the leading cause of death for people aged less than 45 years, where annually it is estimated that injury is the direct cause of approximately half a million hospitalisations and 12,000 deaths.[2] In Australia, penetrating trauma is uncommon, accounting for less than 5% of all major trauma and less than 1% of major trauma deaths.[3, 4,5]

Paramedic management emphasises rapid transport to hospital for penetrating trauma patients. Intravenous (IV) fluid resuscitation therapy is generally not recommended unless there is profound hypotension or cardiac arrest.[6, 7] The administration of IV fluid to elevate blood pressure in these patients runs the risk of increased bleeding, hypothermia, anaemia and coagulopathy.[6, 7,8] Data from one large, randomised, controlled trial suggested improved outcomes in penetrating truncal trauma if IV fluid was restricted.[9] Instead, the emphasis should be on timely transport to an appropriate hospital for surgical intervention.[4, 8]
In Melbourne, Australia, patients with penetrating truncal trauma and hypotension are transported to one of two adult major trauma services that are both near the centre of the city. There may be prolonged transport times for patients in outer metropolitan areas and recommendations for maintenance of hypotension in these patients may be associated with prolonged shock and potentially poorer outcomes.

The objective of the current study is to describe the epidemiology, injury patterns, treatment, scene times, transport times and outcomes for patients with penetrating truncal trauma and hypotension in a large Australian city.

METHODS

Study design

A retrospective review of pre-hospital patient care records and hospital medical records was conducted for patients identified between 1 January 2006 and 31 December 2018.

Setting

The Greater Melbourne Area in Australia has a population of approximately 5 million people[10] and covers an area 9,990 square kilometres.[11] Ambulance Victoria (AV) provides a two-tiered prehospital emergency medical response, with advanced life support paramedics able to insert IV cannula and administer IV fluid and mobile intensive care ambulance (MICA) paramedics able to perform needle thoracostomy for tension pneumothorax and rapid sequence intubation in unconscious trauma patients. [12, 13]

The Victorian state adult prehospital trauma triage criteria have been described previously.[14-18] Current (2019) adult criteria consist of physiological, anatomical (specific injury), mechanistic and logistical criteria. When a trauma patient meets one or more of these criteria and ambulance transport time is less than 45 minutes from scene to hospital destination, the clinical practice guidelines recommend transport to a major trauma service (MTS). Thus, almost all patients in Melbourne are transported by road ambulance to an adult MTS. [19] [20]

Study population and case selection

The study population consisted of: age ≥ 18 years, hypotension (systolic BP < 90mmHg) on first paramedic measurement of blood pressure, one or more penetrating injuries to the truncal region, ambulance road transport from scene to any of two MTS and included in the Victorian State Trauma Registry (VSTR)[5] between 1 January 2006 and 31 December 2018.

Patients were excluded from the study if they had chest compressions commenced prior to paramedic arrival on scene. Patients were also excluded if there was penetrating head trauma in addition to truncal trauma.

Intervention

The 2018 AV Clinical Practice Guidelines recommend the following care objectives for patients with penetrating trauma and hypotension: supplemental oxygen, compression of external bleeding, request for attendance of a mobile intensive care ambulance (MICA) skill set, insertion of IV, and analgesia.[21] In addition, rapid loading of the patient and transport to a MTS is required. IV fluid (normal saline 250mL, repeated as required) is administered when SBP is less than 70mmHg.

Data capture

Pre-hospital data was sourced from the VACIS, an in-field electronic patient care record that is linked to AV's integrated Data Warehouse.[22] Pre-hospital data included patient demographics, prehospital cases times (i.e. response time, scene time and transport time), trauma aetiology, vital signs, injuries, treatment and management information. Cases were identified as potential inclusions if the paramedic patient care record reported a 'case nature' of 'stabbing', 'shooting', 'penetrating trauma' or 'major/minor penetrating. Following initial case identification, electronic data filters were created to identify key data elements pertaining to the specified inclusion and exclusion criteria.
Hospital data were sourced electronically from the VSTR and included patient demographics, injury type and outcome information including in-hospital death, ISS, ICU admission, urgent surgery and hospital length of stay. Pre-hospital and hospital data were matched electronically via probabilistic linkage. Record linkage was manually reviewed to ensure accuracy.

Statistical analyses

Statistical analyses were performed using SPSS Version 25.0 for Windows.[23] Analyses were evaluated using a 2-sided significance level set at $p < 0.05$. Baseline descriptive statistics are presented as frequencies and proportions, means (standard deviation) or medians (interquartile range) as appropriate. For univariate analyses, Chi square tests were used to compare categorical variables, while Mann-Whitney tests were used to compare continuous variables. To examine factors associated with fluid resuscitation and mortality, odds ratios and 95% confidence intervals (CIs) were calculated using logistic regression. Based on previous literature,[6, 7, 24] current Clinical Practice Guidelines[21] and clinical experience the following patient level factors were included in the logistic regression analyses: age, gender, trauma mechanism, response time, scene time, transport time, initial systolic blood pressure (SBP), initial pulse rate, initial GCS score, initial oxygen saturation, MICA, fluid administration, fluid volume, Injury Severity Score (ISS), , Abbreviated Injury Score (AIS) thoracic score and AIS abdominal score. Univariate logistic regression analyses were preformed to identify significant predictors of fluid resuscitation and mortality. Predictors that were significant at a univariate level were included in multivariable logistic regression analyses.

Ethics Approval

The study was approved by the Monash University Human Research Ethics Committee (MUHREC). Linkage with hospital data was covered by ethics approval from all participating institutions in the Victorian State Trauma System (VSTS) as part of the function of the VSTR.

RESULTS

Between 1 January 2006 and 31 December 2018, there were 101 adult, hypotensive, penetrating truncal injury major trauma patients attended and transported by road ambulance to a major trauma service by Ambulance Victoria.

Characteristics of all penetrating trauma patients

The median age of these patients was 38 years (IQR: 27-50) and 85.1% were male. The age ranges were 44.6% between 18 and 34 years, 30.7% aged 35 to 50 years, 17.8% aged 51 to 64 years and 6.9% were aged 65 years or over. The mechanism of injury was stabbing in 91.1% and gunshot wound (GSW) in 8.9% and these were the only two mechanisms of injury recorded. A MICA attended 85.1% of penetrating trauma patients. Clinical procedures included IV access (74.3%), oxygen therapy (43.6%) and wound dressing (28.7%). Analgesia was provided in 63.8%. The median scene time was 16.6 minutes and median transport time to the MTS was 24.5 minutes.

Major trauma characteristics

Overall, the median ISS was 16 (out of 75) (IQR: 9.3-25.0) and 64.6% of penetrating trauma patients recorded an ISS > 12. Seventy-two percent of patients required urgent surgery and 32.7% were admitted to ICU and required mechanical ventilation for longer than 24 hours. Eight patients (8.3%) did not survive to hospital discharge (compared to 46 prehospital deaths). The median AIS scores for both the chest and abdominal body regions were 3. For 64.6% of patients, discharge destination was directly home, while 12.5% were discharged to a rehabilitation facility.

Fluid resuscitation

There was IV fluid therapy administered for 54.5% (n = 55) of penetrating trauma patients. Of the 46 (45.5%) patients who did not receive fluid replacement, IV access was gained in 43.5% of cases. There was no significant difference in age, trauma mechanism, initial vital signs or destination hospital between patients who received fluid replacement and those that did not receive fluid (Table 1).

The response time was significantly faster for patients that received fluid (9 minutes vs. 12 minutes, p = 0.010), but there was no difference in scene time and transport time between these patient groups. Figure 1 shows the fluid administration compared with scene time and indicates that the volume of fluid administration is associated with an increase in scene time. Compared with patients who received IV fluid, a higher proportion of patients that did not receive any IV fluid required urgent surgery (84.4% vs. 68.6%, p = 0.034) and ICU admission with mechanical ventilation for more than 24 hours (46.7% vs. 23.5%, p = 0.011). Hospital length of stay (7.2 days vs. 6.7 days) and mortality (11.8% vs. 4.4%) were higher for patients that received fluid, but these differences did not reach statistical significance.

Predictors of fluid resuscitation

The following variables were examined for association with IV fluid administration: age, gender, trauma mechanism, ISS, initial systolic blood pressure, initial pulse, initial GCS, initial oxygen saturation, response time, AIS thoracic score and AIS abdominal score. The only variable that was significant at a univariate level was 'gender' (p = 0.026) with males receiving more IV fluid.

Predictors of mortality

The following variables were examined for their association with mortality: age, gender, trauma mechanism, ISS, MICA, response time, scene time, transport time, initial systolic blood pressure, initial pulse, initial GCS, initial oxygen saturation, fluid administration, fluid volume > 500 ml, AIS thoracic score and AIS abdominal score. There were five variables that were predictive of mortality at a univariate level: ISS ($p = 0.001$), initial pulse ($p = 0.024$), initial GCS ($p = 0.006$), AIS thoracic score ($p = 0.025$) and hospital length of stay ($p = 0.007$). These variables were selected for inclusion in a multivariable logistic regression model for the odds of mortality (in-hospital death) for penetrating trauma patients. The results of the regression analyses are presented in figure 2. The odds of mortality were increased for patients with a higher injury severity score (OR, 1.07; 95% CI, 1.02-1.12) and initial pulse rate (OR, 1.05; 95% CI, 1.01-1.09). For patients with a higher initial GCS score, the odds of mortality were 23% lower compared to patients with a low initial GCS score.

Discussion

This study has provided a detailed profile of the epidemiology, injury patterns, prehospital treatment and outcomes of hypotensive penetrating truncal trauma patients in the Greater Melbourne Area, Australia.

This study has a number of important findings. First, penetrating truncal injury with an initial SBP < 90 mmHg on presentation is rare in Victoria with only 101 cases over 13 years. Secondly, the median scene time for these patients was 16.6 minutes. Finally, the mortality rate was low, with only 8.3% of patients dying of their injuries.

Our data differs from the patients with penetrating trauma and hypotension enrolled in a study by Bickell et al. in Houston, Texas. That study setting was also a centralized system of pre-hospital emergency care but with a single major trauma receiving hospital. In their prospective, randomised trial, patients with penetrating truncal trauma and hypotension (SBP$\leq$90mmHg) were allocated to either immediate IV fluid resuscitation or no IV fluid resuscitation until they reached the operating room. Of 598 eligible adults, 289 received delayed fluid resuscitation and, of these 203 (70%) survived and were discharged alive from the hospital, compared with 193 of the 309 patients (62%) who received immediate fluid resuscitation ($p=0.04$). The marked difference in mortality rates between our patients and the Bickell et al study may be explained by the difference in mechanism of the penetrating trauma, with 66% of patients in their study having suffered gunshot wounds compared with only 8.9% in our setting. Of note, the scene times for our patients (14+/- 6 minutes) were longer than those reported by Bickell et al (7+/-6 minutes). Given the difference in mechanism of penetrating trauma, the findings of improved outcome with no IV fluid in the Bickell et al study may not be applicable in our setting.

Also, the value of IV fluid therapy is uncertain. Although our system uses a SBP <70mmHg for fluid therapy, this may only occur just prior to cardiac arrest.[25, 26] Also, if a palpable pulse is used to trigger the administration of IV fluid, this may be inaccurate since palpation of a carotid pulse may be difficult in the prehospital environment.[27]

The average volume of fluid infused for our patients was 1500ml, with three patients receiving more than 4,000mL. This differed from those reported in the Bickell *et al*. study where the immediate resuscitation group received an average of 867 ml (SD: 667 ml) and the delayed resuscitation group received an average of 92 ml (SD: 309 ml).[6] The average fluid volume may be so large given a small number of patients went into cardiac arrest whilst in paramedic care, at which point IV fluid volumes are targeted at traumatic hypovolaemia management. Our data may suggest the need for clearer guidelines, perhaps with the inclusion of a maximum infusion volume in penetrating truncal trauma.

Limitations and implications for future research

This is a single centre observational study with relatively few patients in comparison to studies from some other overseas cities. This small number in our cohort limits the power of the regression analyses. Also, the mechanism of penetrating injury differs from the other large published study. Finally, patients that died on-scene or enroute to hospital were excluded from the study. It should also be acknowledged that there are limited treatment options available to the paramedic under current clinical practice guidelines. Future research should investigate other interventions likely to impact on mortality, such as warming fluids, targeted blood products, tranexamic acid and early trauma team involvement.

Conclusions

Penetrating truncal trauma with hypotension on paramedic arrival is rare in Melbourne, Australia. We found that scene times are relatively short and mortality is much lower than compared with a comparable US city that has reported outcomes in this patient cohort. Many of our patients received significant volumes of IV crystalloid without demonstrable difference in mortality, thus clinical value of IV fluid for this patient group remains uncertain. However, short scene times and transport to a major trauma service with bypass of other hospitals appears to be associated with a very low mortality rate in our trauma system. This study has raised a number of important issues for ambulance services. Firstly, close monitoring of scene times is required to ensure that patient extrication and transport occurs immediately after the scene is made safe. Second, IV fluid should only be administered if there is loss of a radial pulse, or a systolic blood pressure less than 70mmHg.

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Conflict of interest

None to declare

Sources of funding

None to declare

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Table 1. Characteristics of patients with penetrating truncal trauma

Characteristic	Overall	Fluid	No Fluid	p-value[†]
Patients, n (%)	101	55 (54.5)	46 (45.5)	-
Age (years), median (IQR)	38 (27-50)	37 (24-50)	39 (29-52)	0.501
Age category, n (%)				
18 to 34 years	45 (44.6)	27 (49.1)	18 (39.1)	0.316
35 to 50 years	31 (30.7)	15 (27.3)	16 (34.8)	0.415
51 to 64 years	18 (17.8)	9 (16.4)	9 (19.6)	0.675
65 + years	7 (6.9)	4 (7.3)	3 (6.5)	0.882
Gender (male), n (%)	86 (85.1)	51 (92.7)	35 (76.1)	0.019
Trauma mechanism, n (%)				
Stabbing	92 (91.1)	49 (90.9)	42 (91.3)	0.711
Shooting	9 (8.9)	5 (9.1)	4 (8.7)	0.945
Final Primary Assessment, n (%)				
Wound or puncture	58 (57.4)	30 (54.5)	28 (60.9)	0.522
Laceration	17 (16.8)	12 (21.8)	5 (10.9)	0.143
Open Wound	8 (7.9)	3 (5.5)	5 (10.9)	0.315
Hypotension	5 (5.0)	1 (1.8)	4 (8.7)	0.113
Pneumothorax	3 (3.0)	2 (3.6)	1 (2.2)	0.667
Cardiac Arrest	2 (2.0)	2 (3.6)	0	-
Tension Pneumothorax	2 (2.0)	1 (1.8)	1 (2.2)	0.898
Avulsion	1 (1.0)	1 (1.8)	0	-
Soft Tissue Injury	1 (1.0)	1 (1.8)	0	-
Other	4 (4.0)	2 (3.6)	2 (4.3)	0.855
MICA attendance, n (%)	80 (85.1)	43 (87.8)	37 (82.2)	0.781
Response Time (minutes), median (IQR)	11.0 (8.0-14.2)	9 (7-12)	12 (8.0-15.5)	0.010
Scene Time (minutes), median (IQR)	16.6 (12.0-26.0)	18 (13-28)	16 (10.9-22.0)	0.132
Transport Time (minutes), median (IQR)	24.5 (13.2-34.0)	26 (15-34)	23 (10-32)	0.132
Prehospital Time (minutes, median (IQR)	53.0 (38.0-66.0)	55.5 (42.7-69.2)	51.0 (31.0-60.5)	0.359
Response Time < 15 minutes, n (%)	77 (76.2)	45 (81.8)	32 (69.6)	0.149
Scene Time < 20 minutes, n (%)	59 (58.4)	29 (52.7)	30 (65.2)	0.205
Transport Time < 45 minutes, n (%)	92 (91.1)	50 (90.9)	42 (91.3)	0.945
Initial Vital Signs, median (IQR)				
Systolic blood pressure	80 (70-85)	80 (70-85)	80 (70-84)	0.893
Pulse rate	96 (80-120)	92 (78-112)	100 (80-120)	0.141
GCS	15 (13-15)	15 (14-15)	14 (13-15)	0.269

Characteristic	Overall	Fluid	No Fluid	p-value†
Oxygen Saturation	98 (93-99)	97 (93-99)	98 (92-99)	0.471
Final Vital Signs, median (IQR)				
Systolic blood pressure	95 (80-110)	100 (81-115)	90 (80-107)	0.102
Pulse rate	92 (80-110)	90 (80-110)	92 (80-116)	0.821
GCS	15 (14-15)	15 (14-15)	14 (13-15)	0.166
Oxygen Saturation	99 (98-100)	99 (98-100)	99 (99-100)	0.713
Clinical procedures performed‡, n (%)	58 (57.4)	38 (69.1)	20 (43.5)	0.009
Median procedures performed‡ (IQR)	3 (2-4)	3 (2-4)	3 (1-4)	0.739
Clinical Procedures, n (%)				
IV access	75 (74.3)	55 (100.0)	20 (43.5)	0.001
Oxygen therapy	44 (43.6)	31 (56.4)	13 (28.3)	0.005
Dressing or wound cover	29 (28.7)	20 (36.4)	9 (19.6)	0.063
Cardiac monitor	22 (21.8)	16 (29.1)	6 (13.0)	0.052
Haemorrhage control	12 (11.9)	10 (18.2)	2 (4.3)	0.032
Thoracostomy	6 (5.9)	4 (7.3)	2 (4.3)	0.536
Tension pneumothorax decompression or needle test	5 (5.0)	4 (7.3)	1 (2.2)	0.239
CPR	4 (4.0)	4 (7.3)	0	-
Spinal immobilisation	4 (4.0)	3 (5.5)	1 (2.2)	0.399
Chest Tube Insertion	3 (3.0)	2 (3.6)	1 (2.2)	0.667
Autoinfusion	2 (2.0)	0	2 (4.3)	-
Defibrillation	2 (2.0)	1 (1.8)	1 (2.2)	0.898
Oropharyngeal airway	2 (2.0)	1 (1.8)	1 (2.2)	0.898
LMA	1 (1.0)	1 (1.8)	0	-
Laryngoscopy	1 (1.0)	1 (1.8)	0	-
Medications administered, n (%)				
Fluids	55 (54.5)	55 (100.0)	0	-
Analgesia	60 (63.8)	36 (73.5)	24 (53.3)	0.176
Antiemetic	18 (19.1)	15 (30.6)	3 (6.7)	0.007
Ceftriaxone	6 (5.9)	5 (9.1)	1 (2.2)	0.143
Adrenaline	3 (3.0)	3 (5.5)	0	-

†p-value: comparisons are between patients given fluid and patients who did not receive fluid.

Note: Where (n) values are < 5, p-values should be interpreted with caution.

‡ Procedures performed excludes 'IV access'.

Table 2. Major Trauma Characteristics

Characteristic	Overall	Fluid	No Fluid	p-value†
Patients, n	101	55	46	
Major trauma criteria				
In-hospital death, n (%)	8 (8.3)	6 (11.8)	2 (4.4)	0.224
ISS, median (IQR)	16 (9.3 -25)	16 (10-25)	16 (9-25.5)	0.594
ISS > 12, n (%)	62 (64.6)	33 (64.7)	29 (64.4)	0.754
ICU, n (%)	33 (32.7)	12 (23.5)	21 (46.7)	0.011
Urgent surgery, n (%)	73 (72.3)	35 (68.6)	38 (84.4)	0.034
AIS injury score, median (IQR)				
Chest region	3.0 (2.0-4.75)	3 (3-4)	4 (2-5)	0.276
Abdominal region	3.0 (2.0-3.0)	2 (2-3)	3 (2-3.5)	0.476
Hospital length of stay (days), median (IQR)	6.8 (5.6-11.6)	7.2 (5.5-9.6)	6.7 (5.7-14.9)	0.596
Discharge type, n (%)				
Home	62 (64.6)	31 (60.8)	31 (68.9)	0.257
Rehabilitation	12 (12.5)	9 (17.6)	3 (6.7)	0.128
Hospital for convalescence	6 (6.3)	3 (5.9)	3 (6.7)	0.821
Other	8 (8.3)	2 (3.9)	6 (13.3)	0.081
Death	8 (8.3)	6 (11.8)	2 (4.4)	0.224

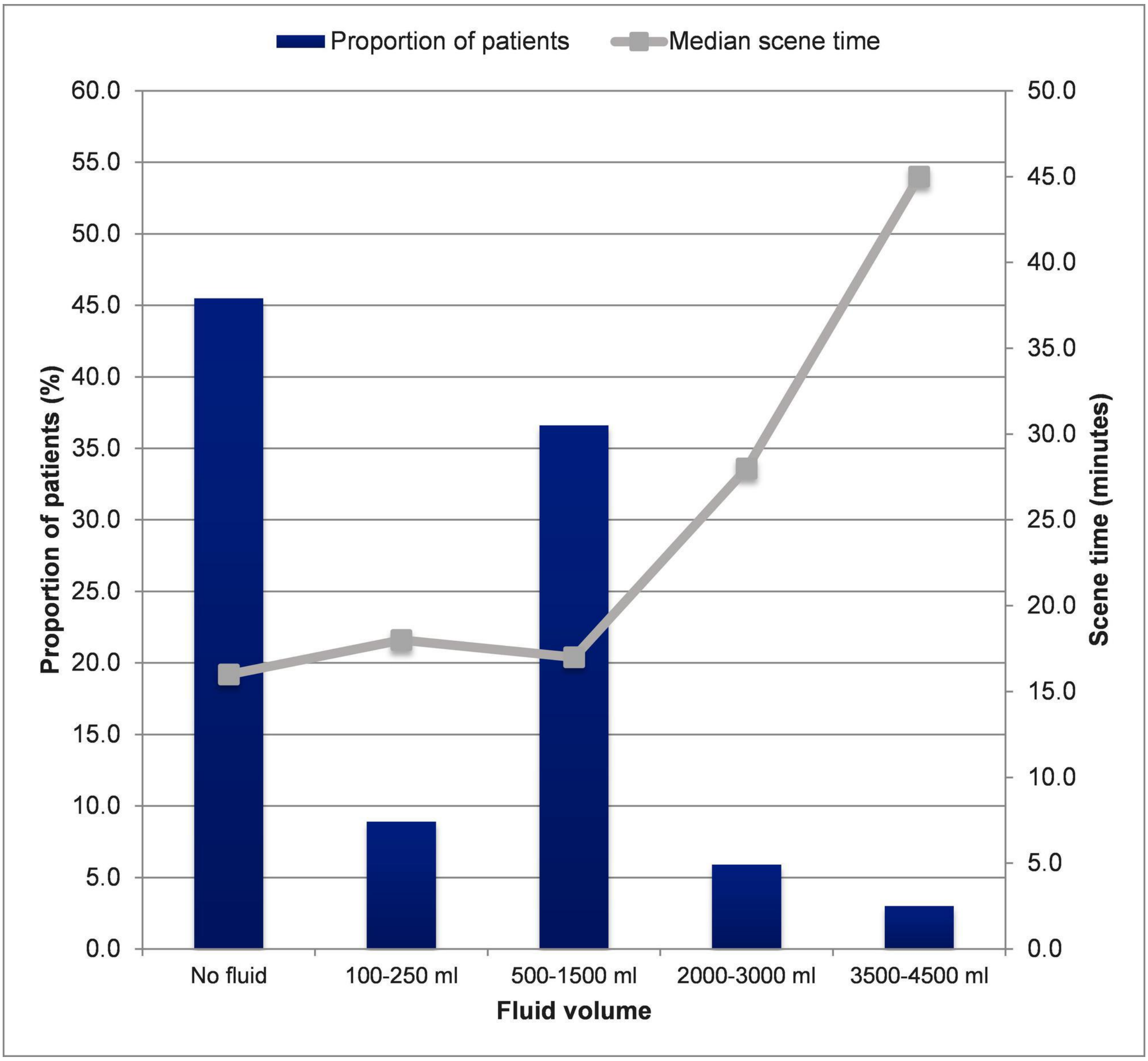
† p-value: comparisons are between patients given fluid and patients who did not receive fluid.

Note: Where (n) values are < 5, p-values should be interpreted with caution.

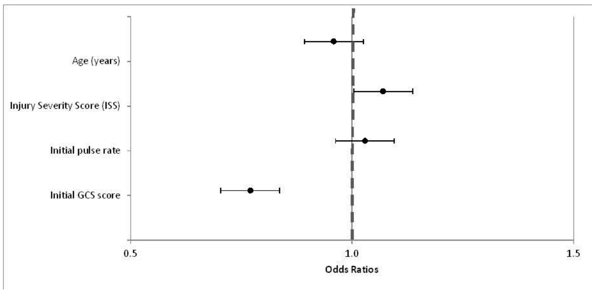
Figure Legends

Figure 1. Fluid administration and median scene time for penetrating trauma patients

Figure 2. Odds ratios and 95% confidence intervals for predictors of mortality (in-hospital death) for penetrating truncal trauma patients



EMM_13450_Figure 1_300dpi.jpg



EMM_13450_Figure 2_300dpi.jpg

Title: Ambulance management of patients with penetrating truncal trauma and hypotension in Melbourne, Australia

Running Title: Ambulance management of penetrating truncal trauma

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KS and SB conceived the study. KS, SB, MF, AC and GB provided advice on the study design. SC extracted and linked the data. ER cleaned, coded and analysed the data. SC assisted with data analysis. ER drafted the article. All authors contributed substantially to the article revision and approved of the final version.

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