ORIGINAL RESEARCH

Prehospital Management and Fluid Resuscitation in Hypotensive Trauma Patients Admitted to Karolinska University Hospital in Stockholm

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Abbreviations:
ED = emergency department
EMS = emergency medical services
HSD = hypertonic saline/dextran
ISS = Injury Severity Score
KUH = Karolinska University Hospital
PHTLS = prehospital trauma life support
OR = odds ratio
SBP = systolic blood pressure

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Abstract

Introduction: Few previous studies have been conducted on the prehospital management of hypotensive trauma patients in Stockholm County. The aim of this study was to describe the prehospital management of hypotensive trauma patients admitted to the largest trauma center in Sweden, and to assess whether prehospital trauma life support (PHTLS) guidelines have been implemented regarding prehospital time intervals and fluid therapy. In addition, the effects of the age, type of injury, injury severity, prehospital time interval, blood pressure, and fluid therapy on outcome were investigated.

Methods: This is a retrospective, descriptive study on consecutive, hypotensive trauma patients (systolic blood pressure ≤90 mmHg on the scene of injury) admitted to Karolinska University Hospital in Stockholm, Sweden, during 2001–2003. The reported values are medians with interquartile ranges. Basic demographics, prehospital time intervals and interventions, injury severity scores (ISS), type and volumes of prehospital fluid resuscitation, and 30-day mortality were abstracted. The effects of the patient's age, gender, prehospital time interval, type of injury, injury severity, on-scene and emergency department blood pressure, and resuscitation fluid volumes on mortality were analyzed using the exact logistic regression model.

Results: In 102 (71 male) adult patients (age ≥15 years) recruited, the median age was 35.5 years (range: 27–55 years) and 77 patients (75%) had suffered blunt injury. The predominant trauma mechanisms were falls between levels (24%) and motor vehicle crashes (22%) with an ISS of 28.5 (range: 16–50). The on-scene time interval was 19 minutes (range: 12–24 minutes). Fluid therapy was initiated at the scene of injury in the majority of patients (73%) regardless of the type of injury (77 blunt [75%] / 25 penetrating [25%]) or injury severity (ISS: 0–20; 21–40; 41–75). Age (odds ratio (OR) = 1.04), male gender (OR = 3.2), ISS 21–40 (OR = 13.6), and ISS >40 (OR = 43.6) were the significant factors affecting outcome in the exact logistic regression analysis.

Conclusion: The time interval at the scene of injury exceeded PHTLS guidelines. The vast majority of the hypotensive trauma patients were fluid-resuscitated on-scene regardless of the type, mechanism, or severity of injury. A predefined fluid resuscitation regimen is not employed in hypotensive trauma victims with different types of injuries. The outcome was worsened by male gender, progressive age, and ISS >20 in the exact multiple regression analysis.

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Introduction

Since uncontrolled hemorrhage is one of the leading causes of early death after trauma,[1,2] the treatment of these casualties at the site of the injury or during transportation to the hospital remains an important issue. This is particularly true when the bleeding source cannot be controlled without surgery or interventional radiology.

In order to improve the standard of prehospital care, numerous countries have introduced the prehospital trauma life support (PHTLS) protocol, which has reduced the mortality and morbidity of severely traumatized

- Rapid initial assessment of the patient's systemic condition. Evaluate airway, breathing, and circulation, while looking for possible spine injury. Focus on ventilation, shock, hemorrhage control, and spinal immobilization.
- Provide intervention for these life-threatening problems as they are found.
- Reassess vital functions to evaluate the effectiveness of the interventions.
- Reassess the head, chest, and abdomen to locate potentially life-threatening conditions. Rapidly provide needed interventions for any conditions that are found.
- Immobilize the patient and expedite transport to the closest appropriate facility.
- Field time should not exceed 10 minutes.
- Perform rapid secondary survey.
- Provide additional management (establishing large-bore intravenous lines, initiation of volume replacement) while en route to the hospital.

Table 1—Prehospital trauma life support guidelines for initial management of the injured patient

patients.[3–5] The PHTLS protocol sets the appropriate assessment and resuscitative priorities on the grounds of evidence-based medicine.[6] The PHTLS guidelines suggest that on-scene time should not exceed 10 minutes, and intravenous fluid replacement should be initiated en route to the hospital (Table 1).[7] Since 1998, the PHTLS protocol has become the prehospital standard of care in Sweden. There are a limited number of studies reviewing the prehospital management of hypotensive trauma patients, and no studies have been conducted to assess whether PHTLS guidelines are implemented in Stockholm County, Sweden. Therefore, the study was aimed at describing the prehospital management of hypotensive trauma patients admitted to the largest trauma center in Sweden and to assess whether PHTLS guidelines have been implemented regarding prehospital time intervals and fluid therapy. In addition, the effects of the type of injury, blood pressure, fluid therapy, injury severity, and prehospital time intervals on outcome were investigated.

Methods

Study design and ethical approval

This is a retrospective, descriptive study on hypotensive trauma patients admitted to Karolinska University Hospital (KUH) in Stockholm. The Central Ethical Review Board of the Swedish Research Council in Stockholm approved the study design.

Study setting, population and period

On average, KUH admits 1,200 trauma patients annually from Stockholm County, which has a ground surface area of 6,490 square kilometers, and contains 1.86 million inhabitants.

A KUH trauma alert activates the multidisciplinary trauma team consisting of a surgeon, radiologist, anesthesiologist, orthopedic surgeon, and nursing personnel in the designated trauma area. The trauma area comprises a resuscitation room with a computed tomography scanner and an operating room. The multidisciplinary trauma system includes all the emergency medical specialties on request. Physicians caring for trauma patients work in accordance with Advanced Trauma Life Support principles.[8] The emergency medical services (EMS) transport patients either by ground or by helicopter with transportation times usually taking no longer than 15 minutes. All EMS helicopters carry an anesthesiologist and a registered nurse with special training in ambulance care. All EMS ground ambulances are staffed either with two registered nurses with special training in ambulance care, or with two assistant nurses with supplementary ambulance care training. The study period was 2001–2003.

- Age
- Gender
- Type of injury
- Mechanism of injury
- Anatomical site of injury
- Injury severity score (ISS)
- Systolic blood pressure, on-scene
- Systolic blood pressure, emergency department
- Prehospital interventions
- On-scene time
- Transportation time
- Prehospital fluid therapy
- 30-day mortality

Table 2—Data points extracted

Study protocol

Criteria for inclusion were adult trauma patients (age ≥15 years) admitted directly to the KUH with a measured hypotension, systolic blood pressure (SBP) ≤90 mmHg on the scene of injury. No acute or chronic clinical conditions excluded patients from the study. Patients who died prior to arrival at the emergency department (ED) were excluded. The Trauma Registry identified all the consecutive trauma patients with post-traumatic hypotension on the scene of the injury. Data points were abtracted retrospectively from EMS and hospital records (Table 2). The SBP was measured by auscultation on the scene of injury and by electronic methods in the ED. The time interval at the scene of injury (time between arrival of the vehicle and its departure from the location), transport time (time between the departure from the scene and arrival at the ED), and the types and volumes of intravenous fluids were retrieved from the Stockholm County EMS data registry. The Injury Severity Score (ISS) is derived mathematically from the Abbreviated Injury Scale range from 1 (minor injury) to 75 (generally a fatal injury).[9] Mortality was defined as death within 30 days of the injury and was retrieved from hospital records. The Utstein Style Template was used for terms and definitions.[10]

Measurements and data analysis

Continuous variables are expressed as medians with interquartile ranges. In order to determine the effects of variables on outcome, an exact logistic regression analysis was employed. Variables tested in the analysis were age as a continuous variable, gender, the type of injury (blunt;

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Gender	n (%)	Type of Injury	n (%)	Anatomical Site of Injury	n (%)
Female	31 (30)	Penetrating	25 (25)	Chest	58 (57)
				Extremities	38 (37)
				Head	34 (33)
Male	71 (70)	Blunt	77 (75)	Abdomen	30 (29)
				Pelvis	25 (25)
				Spine	21 (21)

Table 3—Gender, type, and site of injury in the population

penetrating), on-scene time (<19 min; ≥19 min), on-scene SBP (<70 mmHg; ≥70 mmHg), emergency department SBP (<70 mm Hg; ≥70 mmHg), categories of ISS (0–20; 21–40; 41–75), fluid volumes infused (no fluid infused; 1–500 ml infused; >500 ml infused; hypertonic saline/dextran (HSD [7.5% normal saline/ dextran 70]) 250 ml with or without crystalloid). Stepwise selection was performed by combining forward and backward moves, resulting in exclusion of type of injury, on-scene time, and emergency department SBP from the model due to there being no effect on outcome (5% level). The subset selection eventually included age, gender, on-scene SBP, categories of ISS, and fluid volumes infused in the reduced exact logistic regression model. Odds ratios (ORs) were calculated with the respective 95% confidence intervals.

Results

During the study period, 102 patients (71 males) were recruited. The median age was 35.5 years (27–55 years) and 77 patients (75%) had suffered blunt injury (Table 3). The predominant injury mechanisms were falls between levels (24%) and motor vehicle crashes (22%), followed by stabbing (16%); motorcycle crashes (8%); automobile vs. pedestrian (16%). Gunshots (7%) ranked next, and the remainder of causes comprised very small proportions of data (1–4%) (Table 3). The most frequently injured anatomical sites were the chest (57%), extremities (37%), and head (34%), followed by abdomen (29%), pelvis (25%), and spine (21%) (Table 4). Traumatic brain injury was present in 34 patients (33%), 31 (40%) and three (12%) from blunt trauma and penetrating trauma, respectively. The overall median ISS was 28.5 (range: 16–50): for patients with penetrating injuries 17 (range: 11–25), and 34 (range: 21–50) for those with blunt injuries.

Prehospital EMS provided supplemental oxygen in 96 patients (94%), and 36 patients (35%) were intubated endotracheally at the scene of the event. Intravenous cannulation for fluid therapy was established in 84 (82%) patients, whereas, in 74 patients (73%), the intravenous fluid therapy was initiated at the scene of the event (53 patients (69%) injured by blunt trauma and 21 (84%) patients injured by penetrating trauma). Five patients (24%) were infused with a combination of HSD and a crystalloid solution after penetrating injury. The time spent at the scene of the incident and the transport time were 19 min and 11 min, respectively.

Mechanism	n	(%)
Fall (between levels)	25	(24)
Motor vehicle crash	23	(22)
Stabbing	16	(16)
Motorcycle crash	8	(8)
Gunshot	7	(7)
Automobile vs. pedestrian	6	(6)
Train accident	4	(4)
Assault	4	(4)
Boat accident	2	(2)
Crush injury	1	(1)
Bicycle accident	1	(1)
Occupational injury	1	(1)
Combined injuries[a]	4	(4)
Total	**102**	**(100)**

Table 4—Mechanism of injury ([a]Combined injuries: stab + burn (1), assault + burn (1), assault + auto vs. pedestrian (1), assault + stab (1); n = number)

All interventions performed by prehospital EMS are listed in Table 5. Endotracheal intubation was performed in 15 (50%) and three (100%) brain-injured patients, after blunt and penetrating head injury, respectively. Ten brain-injured patients (23%) were resuscitated with HSD on-scene and during transport with a mortality of 45% (Table 6).

A considerably high mortality was recorded in patients with marked hypotension on the scene of the event (SBP <70 mmHg), amounting to 49% and 42%, after blunt and penetrating trauma, respectively. Markedly hypotensive patients in the ED, after blunt trauma, had an analogous mortality of 27% compared with less hypotensive patients (SBP ≥70 mmHg). Increasing injury severity correlated strongly with poorer survival as shown in Table 7. Fifty-five patients (54%) were hypotensive both on the scene of the event and in the ED.

The types of fluids used for on-scene intravenous fluid resuscitation for 74 (73%) patients were Ringer's acetate, normal saline, dextran 70, and HSD in 29%, 7%, 10%, and 25%, respectively. Hypertonic saline/dextran was administered to 19 patients (25%) suffering blunt trauma, and in seven of them (37%), an additional crystalloid also was infused (Table 8). Fifteen patients (60%) had suffered penetrating torso injuries and their fluid therapy is listed in Table 9. Most of these patients were infused with dextran 70 (31%), HSD (25%) in combination with Ringer's

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Interventions	Blunt n = 77 n (%)	Penetrating n = 25 n (%)	Total n = 102 n (%)
Oxygen	73 (95)	23 (92)	96 (94)
Endotracheal intubation	24 (31)	8 (32)	36 (35)
Cardiopulmonary resuscitation	1 (1)	-	1 (1)
Intravenous cannulation	62 (81)	22 (88)	84 (82)
Prehospital fluid therapy	53 (69)	21 (84)	74 (73)
Cervical collar	43 (56)	-	43 (42)
Spine board	11 (14)	-	11 (11)
Vacuum mattress	37 (48)	-	37 (36)
Pressure bandage	1 (1)	9 (36)	10 (10)
Fracture reposition	2 (2)	-	2 (2)
Chest tube insertion	1 (1)	-	1 (1)
Time interval, on scene (min)	19.5	14	19
Time interval, transport (min)	10	10.5	11.5

Table 5—Prehospital interventions and time intervals accordint to type of injury (n = number; min = minutes)

Patients	Endotracheal Intubation (%)	Hypertonic Saline/Dextran (HSD) (%)	Mortality (%)
Blunt n = 31	15 (50)	10 (25)	14 (45)
Penetrating n = 3	3 (100)	0 (0)	3 (100)
Total n = 34	18 (53)	10 (23)	17 (50)

Table 6—Endotracheal intubation rate, HSD infusion and mortality among patients with traumatic brain injury (n = number)

Categorized Data	Blunt Injury mortality/n (%)	Penetrating Injury mortality/n (%)
Systolic blood pressure, on scene		
SBP 0–69	19/39 (49)	5/12 (42)
SBP >70	6/38 (16)	1/13 (8)
Missing Data	1	0
Systolic blood pressure, emergency department		
SBP 0–69	8/15 (27)	3/5 (60)
SBP >70	16/60 (27)	3/20 (15)
Missing Data	2	0
Injury Severity Score		
0–20	0/18 (0)	0/14 (0)
21–40	6/25 (24)	4/9 (44)
41–75	18/32 (56)	2/2 (100)
Missing Data	2	0

Table 7—Mortality according to systolic blood pressure, injury severity score, and type of injury (n = number)

acetate in some cases, or with Ringer's acetate exclusively in 19%. Fluid therapy on the incident was administered in similar frequencies of 78%, 78%, and 71% in the respective ISS subgroups 0–20, 21–40, and 41–75. No predefined fluid therapy regimen was found in patients sustaining different types of injuries (blunt, penetrating).

Thirty-one patients (30%) died. Patients in the blunt and penetrating injury groups had mortality rates of 32% and 24%, respectively.

In the reduced exact logistic regression analysis, the age, gender, and categories of ISS appeared as the significant variables affecting mortality. The age, as a continuous variable, worsened the outcome 0.04 times with each progressive year of age; male gender was associated with a 3.2 times worse outcome than was the female gender. The reference ISS category <20 was associated with a 13.6 times better survival than ISS category 21–40, whereas the ISS category of >40 was associated with a 43.6 times worse outcome compared with the reference category. Results of the reduced exact logistic regression analysis are given in Table 10. Complete sets of extracted data points were found for 92 patients (90%).

Discussion

Few surveys have been conducted among trauma patients in hemorrhagic shock in the prehospital setting in Stockholm County. Blunt trauma was the predominant mechanism of injury and may explain the standardized, current, prehospital treatment of hypotension after trauma. The most common mechanisms of injury were falls and motor vehicle crashes, although the incidence of penetrating injuries was high among the patients with hypotension.

The ISS for the study population was relatively high since blunt trauma with injuries to multiple body regions predominanted. Accordingly, penetrating trauma victims had lower ISSs. Categorization of patients by their ISS indicates that the EMS care provider's decision to initiate prehospital fluid resuscitation was not affected by the severity of the injury. However, the ISS was a significant risk factor on outcome, which is in accord with other studies.[11–13] The ISS was utilized instead of the Revised Trauma Score because of the frequent absence of the recording of some vital signs, mostly the ventilatory rate, in the EMS records, in severely injured patients.

The time spent at the scene by EMS for victims of

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Prehospital fluids and volumes (ml)	n (%)
No fluid administered	24 (24)
Ringer's acetate	
1–500	1 (1)
501–2,500	29 (28)
Normal saline	
500	5 (5)
1,000	2 (2)
Dextran 70	
500	10 (10)
Hypertonic saline/dextran 250 ±cyistalloids	26 (25)
Missing data	5 (5)

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Table 8—Prehospital fluids infused (n = number; ml = milliliters; ± = with or without)

Prehospital fluids and volumes (ml)	n (%)
No fluid administered	3 (19)
Ringer's acetate	
1–500	1 (6)
501–2,500	3 (19)
Dextran 70	
500	5 (31)
Hypertonic saline/dextran 250 ±crystalloids	4 (25)

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Table 9—Fluid therapy in patients with penetrating torso injuries (n = number; ml = milliliters; ± = with or without)

Risk Factor	Odds Ratio	95% CI
Age[a]	1.04	(1.0–1.1)
Gender		
Female	1.0	(Reference)
Male	3.2	(1.0–16.4)
Systolic Blood Pressure, on scene		
≥70 mmHg	1.0	(Reference)
<70 mmHg	2.7	(0.6–12.6)
Injury Severity Score Categories		
<20	1.0	(Reference)
21–40	13.6	(1.9–Infinity)
>40	43.6	(6.0–Infinity)
Fluid Administered, volume (ml)		
0	1.0	(Reference)
1–500	0.7	(0.07–5.9)
>500	0.2	(0.01–1.4)
HSD 250 ±cristalloids	1.2	(0.2–8.0)

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Table 10—Results of the reduced exact logistic regression analysis of risk factors on mortality ([a]Age was used as a continuous variable; CI = confidence interval; ml = milliliters; HSD = hypertonic saline/dextran; ± = with or without)

major trauma varies widely. Some authors report time intervals as short as 6.5 minutes,[14] while other investigators recorded intervals as long as 26 minutes.[15] The time interval of 19 minutes in the present series falls within the reported limits, but exceeds the PHTLS guidelines. This may be due to numerous factors.

Prolonged extrication times from car wrecks may cause considerable delays in the prehospital phase of care. However, new techniques for rapid extrication should shorten the time it takes to reach the hospital[16] and should change the indications for more advanced treatment at the site of the event. Additionally, despite the PHTLS guidelines and the results of recent clinical trials,[17,18] the EMS in Stockholm still prefers to establish intravenous access on the scene of injury. That may result in extension of the prehospital time although some data indicate that intravenous access may be established successfully en route to the hospital and shorten the on-scene time.[19,20]

Many different types of intravenous resuscitation fluids were used for unknown reasons. The data indicate that predefined fluid therapy regimens are not available or are not applied by the EMS providers in Stockholm County for hypotensive patients with different types of injuries.

The data also indicate relatively large volumes of fluid were administered during the on-scene management and subsequent transportation to the hospital. However, the precision of the volumes of infused intravenous fluid reported by the EMS providers may be limited since the EMS workers approximate the volumes given to the closest 500 ml. The fluids were infused through 18G catheters (1.3 mm inner diameter) by the majority of the EMS providers. These catheters allow flow rates by gravity of 103 ml/minute, according to the manufacturer (Becton Dickinson, Infusion Therapy AB, Helsingborg, Sweden). Consequently, early on-scene establishment of intravenous catheters for fluid administration and extended on-scene intervals plus the transportation time may explain the relatively large prehospital intravenous fluid volumes infused.

Traumatic brain injuries were common in the blunt trauma group. Since head injuries frequently may be associated with injuries to the cervical spine,[21–23] more time will be required for careful extrication, concomitant securing of the airway, and stabilization of the spine. As many as

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50% of the patients with brain injury after blunt trauma were intubated and ventilated, which could explain the need for intravenous access for drug administration and fluid infusion. Also, in conformity with some of the data,[24,25] hypertonic saline/dextran was used more often in this group in order to raise the blood pressure and enhance cerebral perfusion. However, data from an experimental study indicate that a limited period of hypotension may be well tolerated in certain cases of head injury.[26]

The aggressive fluid resuscitation in uncontrolled hemorrhage has had adverse effects in recent laboratory studies due to increases in the volume of bleeding.[27–31] In addition, a considerable body of evidence is beginning to support avoiding or restricting early fluid resuscitation in clinical practice.[32] Since the Houston study,[33] it has been suggested that prehospital fluid resuscitation should be restricted more in victims with penetrating trauma to the torso. In the present study, 81% of the patients with penetrating torso trauma received intravenous fluid resuscitation. The establishment of peripheral intravenous access may have resulted in the loss of valuable time as it usually is performed in difficult situations.[34,35] Nevertheless, in this small-scale study, the prolonged time had no significant effect on outcome. In addition, 24% of patients sustaining penetrating injuries were infused with more than one type of fluid, indicating that some additional time may have elapsed between the occurrence of the trauma and arrival at the hospital. The reason that patients in the penetrating injury group experienced a median on-scene time of 14 minutes still is not understood. This finding demonstrates the difficulties involved in implementing new therapeutic routines in clinical practice, and particularly in postponing active treatment as early as possible after injury. Due to the limited number of penetrating torso injuries in this study, statistical analysis to determine the effects of infused volumes on outcomes was not feasible.

Conclusions

In Stockholm County, the prehospital treatment of hypotensive trauma patients still must be improved regarding the on-scene time intervals provided in PHTLS guidelines. In the majority of hypotensive trauma patients, intravenous fluid therapy was initiated on the scene of injury, but not en route to the hospital. On-scene fluid resuscitation is initiated regardless of the type of injury or injury severity, which may extend the prehospital phase of care. Eighty-one percent of patients sustaining penetrating torso injury were fluid resuscitated contradicting recent laboratory and clinical studies. There is a need for a predefined fluid therapy regimen for hypotensive trauma patients. The effects of resuscitative fluid volumes and prehospital blood pressure on outcomes were not determined. The study is limited by a small number of patients.

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