PRACTICE MANAGEMENT GUIDELINES FOR PREHOSPITAL FLUID RESUSCITATION IN THE INJURED PATIENT

EAST Practice Parameter Workgroup for Pre-hospital Fluid Resuscitation

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I. STATEMENT OF THE PROBLEM

Over the past several decades, the scope of practice for emergency medical personnel has rapidly expanded. [1] Along with this, a dramatic increase in the number of pre-hospital procedures (especially intubation and central venous access) has been noted.[2, 3] However, this dramatic change in the pre-hospital approach to the injured patient has occurred in the absence of data to support its adoption. Investigators from Los Angeles have noted no difference in survival when injured patients are transported by private vehicle or emergency medical services (EMS) transport. [4, 5] Liberman and colleagues recently evaluated Canadian cities with level 1 trauma centers and demonstrated no difference in outcomes between basic life support delivered by EMS providers and pre-hospital advanced life support delivered by either paramedics or physicians. [6]

Despite a lack of evidence demonstrating a benefit to pre-hospital fluid resuscitation, this practice is considered to be standard of care. As well, the type of fluid, the appropriate rate of administration, and the resuscitations themselves remain unguided and unsupervised. Recently, the largest pre-hospital organization in the United Kingdom issued a consensus statement calling for more “restrained” and “cautious” use of crystalloids in pre-hospital settings.[7] The authors argue that several pre-hospital hemorrhage models have demonstrated that limiting the initial resuscitation volume, before definitive care, leads to a reduction in hemorrhage.[8, 9] Unfortunately, clinical extrapolation of deliberate hypotension has, for the most part, been confined to a single prospective trial by Bickell and colleagues. [10] The investigators noted a decreased length of stay and lower mortality in patients with delayed resuscitation.

While the need and benefit of pre-hospital interventions has been controversial for quite some time, an increasing amount of evidence has stirred both sides into more frequent debate. Proponents of the traditional "scoop-and-run" technique argue that this approach allows a more timely transfer to definitive care facilities and limits unnecessary (and potentially harmful) procedures. Advocates of the "stay-and-play" method, however, point to improvement in survival to reach the hospital and better neurological outcomes following brain injury. Given the lack of consensus, the Eastern Association for the Surgery of Trauma convened a Practice Management Guideline (PMG) committee to answer the following questions regarding pre-hospital resuscitation: (1) should injured patients have vascular access attempted in the prehospital setting, (2) if so, what location is preferred for access, (3) if access is achieved, should intravenous fluids be administered, (4) if fluids are to be administered, which solution is preferred, and (5) if fluids are to be administered, what volume and rate should be infused.

II. PROCESS

A. Identification of references

A primary computerized search of the National Library of Medicine and the National Institute of Health MEDLINE database was undertaken using the PubMed Entrez interface. This search was undertaken by a Masters of Library Sciences Faculty member at Vanderbilt University School of Medicine. All English language citations between 1982-2007 focusing on pre-hospital vascular access and fluid resuscitation of trauma patients were reviewed. This primary search query retrieved 3300 citations:

[1] fluid AND pre-hospital, OR out of hospital, OR field, AND resuscitation, AND injury

[2] access OR vascular OR intra-venous OR cannulation AND pre-hospital OR field OR out of hospital AND injury

[3] pre-hospital AND injury AND dextrans/ or Sodium Chloride/ or Saline Solution, Hypertonic/ or saline OR blood substitute OR fluids

[4] intra-osseous AND access

Review articles, letters to the editor, case reports, and editorials were excluded. Basic science and animal studies, as well as items limited to pediatric patients and non-injured patients were also excluded. Excluding studies with the above stated populations limited this literature query to 79 articles.

A secondary query was carried out by PMG study group members (BAC, BRC) using the OVID database version of MEDLINE with the same search terms, exclusion, and date range. The secondary search criteria yielded 92 citations after above stated exclusions. There were 12 citations that were missed on the primary that were detected on the secondary. Searches merged and the removal of articles that did not strictly apply to the study questions and population of interest yielded 58 articles. A total of 16 articles were reviewed by the committee and determined by the members to be technical studies (flow rates for catheters and/or delivery systems) or mixed populations of patients (medical and surgical not purely trauma). Exclusion of these left 42 total articles that formed our evidence-based review and populated Tables 1-5.

B. Quality of the references

The references were classified using methodology established by the Agency for Health Care Policy and Research (AHCPR) of the U.S. Department of Health and Human Services (add reference). [11] Additional criteria and specifications were used for classification of articles from a tool described by Oxman and colleagues. [12] Thus, the classifications were:

Class I: Prospective, randomized controlled trials. A total of ten (10) Class I articles were reviewed.

Class II: Clinical studies prospectively collected data and retrospective analyses which were based on clearly reliable data. Fourteen (14) articles met criteria for Class II articles and were reviewed.

Class III: Studies based on retrospectively collected data; includes clinical series, database or registry reviews, large series of case reviews, and expert opinion. Eighteen (18) articles were identified as class III and underwent review.

Each of the above articles was reviewed and scored by a minimum of two (2) PMG committee members. After collection of all reviews, the Pre-hospital Fluid Resuscitation PMG Committee convened and developed recommendations based on the following definitions:

Level 1: The recommendation is convincingly justifiable based on the available scientific information alone. One (1) Level 1 guideline was supported by the literature.

Level 2: The recommendation is reasonably justifiable by available scientific evidence and strongly supported by expert opinion. A total of eight (8) Level 2 guidelines were established by the literature.

Level 3: The recommendation is supported by available data but adequate scientific evidence is lacking. Seven (7) Level 3 guidelines were developed.

III. RECOMMENDATIONS

Should vascular access be obtained in the pre-hospital setting? (Table 1)

A. Level 1

No level one recommendation can be made. There is insufficient data to support a level 1 recommendation for placing vascular access in the pre-hospital setting.

B. Level 2

Placement of vascular access at the scene of injury should not be performed as it delays patient transport to definitive care and demonstration of benefit is lacking noted.

C. Level 3

Placement of vascular access during transport is feasible and does not delay transport to definitive care.

If vascular access is obtained, where and how should it be placed? (Table 2)

A. Level 1

No level 1 recommendation can be made. There is insufficient data to support specifically where and through which approach vascular access should be obtained in the pre-hospital setting of trauma.

B. Level 2:

(a) If central access is necessary, the percutaneous "Seldinger" technique is recommended over traditional "cut-down" procedures as there is evidence that percutaneous techniques are quicker and have equivalent success rates.

(b) The use of intra-osseous access in trauma patients requiring vascular access in which intra-venous access is unobtainable or has failed two (2) attempts is recommended.

C. Level 3:

Attempts at peripheral intra-venous access should be limited to two (2) attempts during pre-hospital transport after which, alternative methods (intra-osseous, central access) should be attempted if equipment and trained personnel are available.

<u>If vascular access is obtained, should intra-venous fluids be given?</u> (Table 3)

A. Level 1:

No level one recommendation can be made. There is insufficient data to show that trauma patients benefit from pre-hospital fluid resuscitation.

B. Level 2:

(a) Intravenous fluids should be withheld in the pre-hospital setting in patients with penetrating torso injuries.

(b) An I.V. placed to "saline-lock" is equivalent in patency and function to a continuous infusion.

C. Level 3:

(a) Intra-venous fluid resuscitation should be withheld until active bleeding/hemorrhage is addressed.

(b) Intravenous fluid administration in the pre-hospital setting (regardless of mechanism or transport time) should be titrated for palpable radial pulse using small boluses of fluid (250 mL) rather than fixed volumes or continuous administration.

<u>If fluid is given, which type of fluid should be chosen?</u> (Table 4)

A. Level 1:

(a) There is insufficient data to recommend one solution or type of fluid over other options in the pre-hospital setting.

(b) Small volume boluses (250 mL) of 3% and 7.5% hypertonic saline (HTS) are equivalent, with respect to vascular expansion and hemodynamic changes, to large volume boluses (one liter) of standard solutions such as lactated Ringer's (LR) or 0.9% normal saline (NS).

B. Level 2:

There is insufficient data to support any recommendation at this level.

C. Level 3:

There administration of blood in the pre-hospital setting is safe and feasible.

<u>If fluid is given, how much and how fast should it be administered?</u> (Table 5)

A. Level 1:

No level one recommendation can be made. There is insufficient data to recommend specific rates or volumes of fluids to be administered in the pre-hospital setting.

B. Level 2:

Fluids run at "keep vein open" (K.V.O.) rates are adequate for transporting injured patients.

C. Level 3:

Rapid infusion systems and/or pressurized systems (to deliver fluids more rapidly) should not be used in the pre-hospital setting.

IV. Scientific Foundation

A. General

On the heels of an ever expanding Pre-hospital Trauma Life Support (PHTLS) curriculum, we have seen not only an expansion in the procedural skills set of EMS providers, but also a dramatic increase in the number of procedures performed. While there is evidence to suggest potential benefit of pre-hospital procedures in rural blunt

trauma patients with prolonged transportation time, there is little (if any) data to justify these procedures in patients with penetrating injuries or those with short transport times (less than 30 minutes). [10, 13, 14]Advanced Trauma Life Support (ATLS) guidelines for administering (up to two liters) crystalloid to hypotensive trauma patients in the emergency room setting have been adopted into the pre-hospital environment without clear benefit. In addition, recent data has shown that the performance of pre-hospital procedures in urban and penetrating settings have a negative impact on survival. [15] In light of the expanding data calling into to question the "stay and play" method of pre-hospital care, the EAST PMG committee conducted a review of the currently available literature on pre-hospital vascular access and fluid resuscitation.

B. Should vascular access be obtained in the pre-hospital setting?

The first issue examined was whether or not vascular access should even be attempted in the pre-hospital setting. Several investigators have evaluated the success rate for pre-hospital venous access and noted scene placement times of these lines range from a mean of 2.2 minutes to 6.3 minutes. [14, 16-19] "Time to placement" of these lines was similar in patients with normal blood pressure and primary injuries confined to the extremities.[20-22] However, when patients were hypotensive or had primarily torso injuries, placement at the scene tended to be longer than that of en route intra-venous line placement. [14, 23, 24] Jones and colleagues noted a 91% success rate at the scene and a 94% success rate en route.[17] Additionally, Slovis and colleagues demonstrated an en route success rate for intra-venous line placement of 92%, regardless of hemodynamic status. [24] Delaying transport to place venous access also appears to be associated with increased overall time

to hospital, in some cases exceeding that of the actual transport itself. [14, 25, 26] Should the decision be made to obtain scene access, drawing blood for laboratory samples (e.g. - type and screen, etc) adds unnecessary time and should not be performed.[19]

Whether the committee felt it was able to recommend placement of access in the pre-hospital setting was predicated on demonstrating any benefit from access placement. Though several studies evaluating pre-hospital venous access have recommended their placement (simply because they could technically be placed), none of the investigators was able to demonstrate any benefit from their placement. [16, 18, 19] To the contrary, scene access placement has been associated with increased risk of death.[14, 25, 27] Seamon and colleagues evaluated 180 patients who underwent ED thoracotomy over a 6 year period.[26] The authors stratified according to method of transport (emergency medical services, EMS, or private vehicle/police, POV). They found that mortality in patients arriving by EMS was double that of patients transported by POV (17% vs. 8.0%). More importantly, each prehospital procedure performed reduced the odds of survival by 62% (O.R. - 0.38, 95% C.I. 0.18–0.79, p=0.009). Sampalis et al examined the association between on-site venous access and fluid replacement and mortality in critically injured patients. [25] The authors found that on-site access was associated with an increase in mortality (23% IV group versus 6% no IV group) and that this association was stronger as time to hospital arrival increased (O.R.-8.4, C.I. 1.27-54.69, p=0.03 for time to arrival >60 minutes). These outcomes (as well as time to placement of access and scene times) do not appear to differ whether the patient is transported by basic life support (BLS) or advanced life support ambulance crews.

In light of increasing experience in management of military injuries (both penetrating and blunt), a UK consensus group was recently convened to reconcile differences in practice with respect to pre-hospital fluid resuscitation.[28] The expert panel formulated an algorithm to assist in the early resuscitation of critically injured patients that consisted of the following: (1) access should not be obtained for superficial wounds, (2) if the patient's mental status is appropriate and a radial pulse is present, pre-hospital personnel may place venous access but fluids should be held, (3) venous access should be obtained and fluids initiated if no radial pulse or mental status is incoherent, (4) a 500 mL bolus of hetastarch should be given if no radial pulse or mental status is incoherent, (5) fluids should be discontinued if pulse and mental status return, and (6) if no response, repeat 500 ml of colloid (hetastarch). [28]

C. If access is obtained, where should it be placed?

In asking where to place venous access, it is important not only to determine where anatomically should this access be obtained, but also what approach should be used (percutaneous, cut-down) and what size catheter should be placed. As well, it is critical to evaluate whether there are alternatives to traditional intravenous catheter access (intraosseous lines). No clinical trials were found to suggest superiority of one anatomic location for venous access versus another. Peripheral access has been the standard location for placement in the pre-hospital setting; most commonly being placed in the upper extremity in the forearm and antecubital area. An animal study by Rosa et al examined the efficacy of intravenous access site on delivery of a bolus injection to the

heart during shock and resuscitation.[29] The authors noted that femoral access significantly prolongs bolus transit time when compared with central or brachial access regardless of intra-vascular status (euvolemic, hypovolemic, or aggressively resuscitated). Brachial access was advocated as the preferred route for bolus injection delivery in the emergency setting as it provides expedient bolus delivery equal to central access and is superior to femoral access.

A few authors have evaluated the time-to-placement and efficiency of traditional peripheral access, cut-down placement, and percutaneous (Seldinger) approaches in the pre-hospital setting.[30-32] Westfall and colleagues conducted a prospective, randomized, multi-centered trial to compare the speed of IV access and the rate of infusion for saphenous vein cut-down and percutaneous femoral catheterization.[32] Seventy-eight trauma patients were randomized to either saphenous cut-down or percutaneous femoral line placement, followed by passive infusion of 1.0 L of crystalloid. Mean procedure time for the cut-down group was 5.6 ± 2.6 minutes compared with 3.2 ± 1.2 minutes for the femoral line group ($P < 0.001$). The mean infusion time for the cut-down group was 6.6 ± 4.3 minutes compared with 4.6 ± 2.5 minutes for the femoral line group ($P = 0.03$). As the rate of flow increases with larger diameter and shorter length of the catheter (Poiseuille's law), several investigators have examined the impact of placing larger bore lines in the pre-hospital setting. Benumof et al measured the infusion pressure-flow characteristics of the side ports of 8.0 and 8.5 Fr introducer catheters against equivalent pressure-flow relationship through standard 22- to 14-gauge peripheral venous catheters.[30] While the 8.5 Fr introducers were superior to the 8.0 Fr catheters, neither was superior to 14- and

16-gauge standard peripherally placed catheters. Other authors evaluated the ability to place extremely large bore peripheral lines (10 and 12 gauge catheters) and to rapidly exchange smaller peripheral lines out to large introducer catheters (over a wire).[31, 33] However, none demonstrated superiority to standard large bore (14-18 gauge) peripheral lines.

Over the last several years, intraosseous lines have been met with increasing enthusiasm and favor in the pre-hospital resuscitation of trauma patients. However, this enthusiasm is based on increasing provider "experiences" and not on any clinical trials. These studies are, for the most part, are limited to "how I do it" or device comparisons, using historical flow rates of intravenous catheters as reference values.[34] Others are pharmacokinetic drug studies or trials conducted in non-trauma patients. Frascone et al studied provider performance for obtaining intraosseous access with two FDA-approved intraosseous devices in two sequential field trials.[35] They evaluated 178 insertions in adult trauma patients, with success rates of 72% to 87%. Time to insertion was similar to that of historical data on intravenous access. The site most often used for adult intraosseous access is the proximal tibia (medial and inferior to the tibial tuberosity) and the sternum and humeral head.[34] While the pharmacokinetic delivery of drugs appears equal to that of the intravenous route, infusion volume-rates are only that of a 21-gauge catheter in the absence of a high-pressure infusion system.[34, 36]

D. If access is obtained, should fluid be administered in the pre-hospital setting?

Once access is established, another controversy arises in whether or not to initiate fluid therapy.[37] While many providers see the subsequent administration of fluids to be standard of care, the literature would not support this approach. At a minimum, pre-hospital fluid administration does not appear to improve outcomes in either penetrating or blunt trauma patients. [14, 38, 39] In a study of 235 trauma patients (blunt and penetrating), Dalton and colleagues evaluated the benefit of pre-hospital venous access and fluid administration.[38] The authors noted that 80% patients receive less than 600 mL of fluid in the pre-hospital setting, regardless of mechanism, scene entrapment, or hypotension en route. They were unable to identify benefit from such therapy and recommended withholding fluid administration. Kaweski et al conducted a retrospective study of almost 7000 trauma patients and noted that mortality rates were similar in those patients who received fluids and those who did not (23% vs. 22%, p=NS).[39] Comparison of groups with similar, injury severity (ISS), probability of survival (TRISS), and hypotension on arrival also failed to show an influence of fluid administration on survival. Other authors have also demonstrated that pre-hospital fluid therapy confers no survival benefit and delays transport of critically injured patients. [40, 41]

While numerous animal studies have demonstrated an increased rate of hemorrhage an increased mortality with “pre-hospital” fluid resuscitation, clinical extrapolation of this concept has, for the most part, been confined to a single prospective randomized controlled trial by Bickell and colleagues in the early 1990s.[10] Hypotensive patients with penetrating torso injuries were randomized in the field to receive either standard intravenous fluid resuscitation or no fluids, and the regimen was continued until the

patient reached the operating theater. Despite the lack of pre-hospital fluid resuscitation, the mean blood pressure between the groups was similar while intra-operative blood loss was significantly less in the delayed resuscitation group. Additionally, the length of stay was shorter and the mortality rate lower in the delayed resuscitation group. Another randomized controlled trial by Turner and colleagues in the UK involved 1309 patients, half of which were randomized to standard fluid protocols or no pre-hospital fluids.[42] Unfortunately, not much can be derived from this study to make any recommendations as there was extremely poor protocol compliance. Only 31% of standard protocol patients (who were supposed to receive fluids) received prehospital fluids and only 80% of the "no-fluid" patients had fluids withheld. There was no significant difference in mortality between the groups. Despite the studies significant limitations, the authors concluded that pre-hospital fluid resuscitation does no harm.

Several groups and authors have developed consensus statements aimed directly at the question of whether to place venous access in the pre-hospital setting and whether to administer fluids prior to hospital arrival (and definitive hemorrhage control).[28, 43, 44] In summary, the consensus recommendations are quite similar: (1) Patients with only superficial wounds (even in combat settings) do not require immediate intravenous access or fluid resuscitation, (2) If the patient is coherent and has a palpable radial pulse, place the venous access to "saline lock," (3) If incoherent or no radial pulse, obtain venous access and start 500 mL hetastarch, (4) repeat bolus if no response, saline lock I.V. if response noted, (5) In patients with suspected head injuries, fluids should be

titrated for SBP >90 mmHg. These recommendations reflect that of the groups' evaluations of blunt and penetrating patients in both military and civilian settings.[45]

With respect to maintaining venous access patency, several authors have evaluated whether continuous intravenous infusion is necessary.[46, 47] Boyle and colleagues evaluated 100 patients requiring intravenous access placement.[46] The use of a saline lock was found to be a cost-effective means of maintaining patency of intravenous lines during transport. Carducci et al demonstrated that a saline lock device was as effective at maintaining pre-hospital access as were traditional continuous infusions.[47] Additionally, paramedics found that the saline lock devices were easier to use, less time-consuming to initiate, and facilitated patient transportation.

E. If fluid is administered, which solution should be given?

While "standard" fluid on pre-hospital vehicles is typically normal saline (0.9% sodium chloride NS) or lactated Ringer's (LR) solution, neither has been well studied in the pre-hospital resuscitation of trauma and neither has been shown to be superior to other available solutions. However, their cost and provider familiarity with these solutions has likely been responsible for their "standard solution" status. Studies comparing various iso-oncotic solutions (hetastarch, dextran) and hypertonic saline (3% or 7.5% sodium chloride) to NS or LR have shown mixed results.[48-56]

Cooper et al recently compared LR and 7.5% sodium chloride in a randomized trial of trauma patients with either brain injury or hypotension.[57] The authors found no

significant difference between the groups with respect to favorable neurological outcomes at 6-months. Survival to discharge and 6-month survival were higher in the 7.5% sodium chloride group (55% versus 50% and 55% versus 47%, respectively), but this did not reach statistical significance (study powered to detect difference in neurological outcomes). In a trial of patients undergoing air medical transport after injury, Vassar and colleagues compared 7.5% sodium chloride (with and without dextran) with LR solution in a randomized fashion.[54, 58] The authors found that patients who received the hypertonic saline solutions had less fluid requirements in the pre-hospital setting and arrived to the trauma center with a higher systolic blood pressure. While overall survival was not different between the hypertonic saline and LR groups, patients with severe head injury who received hypertonic saline had a higher survival than that observed with the LR groups (32% versus 16%, $p=0.044$). The same group evaluated 0.9% sodium chloride (NS) with several hypertonic saline solutions in hypotensive patients transported by ground ambulance.[55] In this randomized, controlled and pre-hospital blinded trial, the authors found no difference in survival between patients who received 0.9% or 7.5% sodium chloride. However, the groups were poorly matched with significantly higher injury severity scores and predicted mortality in the 7.5% groups compared to the 0.9% group (both $p<0.05$). In addition, the study was severely underpowered with an estimated sample size calculation required of almost 700 patients (study had 258 patients).

Numerous investigators have examined the different hypertonic solutions available, including 3% and 7.5% sodium chloride and solutions with and without added colloids

(6% and 12% dextran).[48-52, 54, 55, 57-61] With respect to 3% versus 7.5% sodium chloride, there are few, if any, animal studies comparing the solutions and no clinical trials of pre-hospital resuscitation of trauma. In a porcine model of uncontrolled hemorrhage, Watters et al recently evaluated the effect of 3% versus 7.5% sodium chloride.[59] The authors noted that a single bolus of 3% solution produced an adequate and sustained rise in blood pressure and tissue oxygenation while 7.5% sodium chloride failed to produce a sustained improvement in these variables. As well, the 7.5% sodium chloride solution resulted in a significant dilutional anemia and relative hypofibrinogenemia. Pre-hospital clinical trials have utilized 7.5% sodium chloride (with and without dextran) almost exclusively, thus preventing a critical comparison of and evidenced-based recommendation by the committee for one over the other.[49-51, 54, 55, 58, 62] As to the benefit of adding colloid to hypertonic saline, solutions of 7.5% sodium chloride with 6% or 15% dextran added do not appear superior to those without dextran.[54, 55, 58] Vassar et al noted that the use of 7.5% sodium chloride was superior to LR in reducing the amount of pre-hospital fluid requirements and improving admission/ED blood pressure, with no additional benefit seen with the dextran solutions.[54] Glasgow outcome scores were higher in the 7.5% group compared to lactated Ringer's, but no further effect was observed with the dextran solutions.

Clinical trials evaluating blood and blood substitutes in the pre-hospital setting are also scarce and prevented the committee from making any significant recommendation on the subject. Barkana and colleagues evaluated 40 patients who had received pre-hospital blood transfusions.[63] Prolonged extrication and delayed transport were the primary

indications for transfusion and the mean volume of crystalloid infused by hospital arrival was almost 4.5 liters. During the study period, only 4% of blood reserved for pre-hospital patients was actually used (versus 90% during that period for in-hospital use). While the authors found it safe and feasible to transfuse blood in the pre-hospital setting, there was a tremendous amount of product wastage. Sumida et al performed a chart review of patients receiving pre-hospital resuscitation with blood products and found no difference in mortality.[64] The authors noted that the crystalloid only group, however, had shorter transport times and more "normal" vital signs in the field. As to blood substitutes, data regarding use in trauma patients is extremely limited while that for pre-hospital resuscitation is essentially non-existent.[65, 66] Gould et al conducted a prospective, randomized, open label trial of a human polymerized hemoglobin substitute.[65] Forty-four in-hospital trauma patients were randomized to receive red cells or up to six units of the blood substitute as their initial blood replacement after trauma and during emergent operations. The total number of allogeneic red cell transfusions for the control and experimental groups was not significantly different through study day 3 (11.3 ± 4.1 units vs. 7.8 ± 4.2 units ($p = 0.06$).

F. If fluid is administered, how much should be given and how fast should it be infused? Even more poorly understood and more under-studied than the above controversies is that of "how much" and "how fast." Basic trauma guidelines recommend an initial rapid infusion of fluid (1.0-2.0 liters) in hypotensive trauma patients as a diagnostic procedure to aid treatment decisions. While this has been interpreted (or misinterpreted) to mean that patients in the prehospital setting should receive 2.0 liters of crystalloid (often

regardless of hemodynamic status), this practice is not supported by the literature. Currently, there are no clinical trials to support a recommendation for rate or volume of fluid administration to trauma patients in the pre-hospital setting.

Animal studies have been performed that suggest higher volumes and more rapid infusions of crystalloid in the pre-hospital setting result in higher mortality. Using a murine model of uncontrolled hemorrhage, Krausz et al compared bolus and continuous infusion administration of lactated Ringer's and hypertonic saline, combined with splenectomy.[67] Continuous infusion of LR solution resulted in significantly less bleeding than bolus infusion and improved survival time, while there was no difference in continuous or bolus infusion of hypertonic saline. Bickell et al demonstrated that patients with penetrating torso injury who received small volumes of resuscitation (<250 mL) in the pre-hospital setting had significantly higher survival to hospital discharge than those who received standard pre-hospital resuscitation (750 mL-1000 mL in less than 30 minutes).[10] Vassar and colleagues noted that hypertonic saline boluses (on the order of 250 mL volumes) appear to be associated with improved survival.[54, 58]

In-patient clinical trials suggest that “lowering expectations” of resuscitation end-points may improve survival and decrease hemorrhage volume. Dutton and colleagues evaluated the concept of “hypotensive resuscitation” and noted that titration of initial fluid therapy to a lower than normal SBP (≥70 mmHg instead of >100 mmHg) during active hemorrhage did not affect mortality.[9] Several years earlier, this same group of investigators evaluated the delivery of crystalloid and blood products through a rapid

infusion system to critically injured patients in hemorrhagic shock. Contrary to beliefs and biases at the time, the investigators noted an almost 5-fold increase in mortality in patients resuscitated with a rapid infusion system.[68] This higher mortality remained even after matching for age, injury severity scores, and Glasgow coma scale (53% vs. 61%, $p< 0.001$). Even more surprising, was that the mortality difference was greatest not in penetrating patients but in the blunt trauma population (48.8% vs. 63.0%, $P < 0.001$).

CONCLUSION

Despite the widely held belief that pre-hospital venous access placement and fluid resuscitation is standard of care, there is little data to support this practice. In fact, an increasing amount of data suggests that it may be quite harmful to a significant number of critically injured patients. The EAST PMG committee has found that placement of venous access at the scene delays transport and placement of access en route should be considered. In those patients in whom intra-venous access has failed, intra-osseous may be attempted if equipment and trained personnel are available. There is insufficient data to suggest that blunt or penetrating trauma patients benefit from pre-hospital fluid resuscitation. In patients with penetrating injuries and short transport times (less than 30 minutes), fluids should be withheld in the pre-hospital setting in patients who are alert or have a palpable radial pulse. Fluids (in the form of small boluses, i.e. - 250 mL) should be given to return the patient to a coherent mental status or palpable radial pulse. In the setting of traumatic brain injury, however, fluids should be titrated to maintain systolic blood pressure greater than 90 mmHg (or mean pressure greater than 60 mmHg). Hypertonic saline boluses of 250 mL appear equivalent in efficacy to 1000 mL boluses of

standard solutions (lactated Ringer's, 0.9% sodium chloride). There is insufficient evidence to show that injured patients with short transport times benefit from pre-hospital blood transfusions. Finally, rapid infusion systems and or pressurized devices (to deliver fluids more rapidly) should not be used in the pre-hospital setting.

Table1. Should vascular access be obtained?

Author(s)	Year	Title	Class	Comments and Consensus
O'Gorman M[23]	1989	Zero-time pre-hospital I.V. J Trauma. 1989 Jan;29(1):84-6.	II	Prospective observational-evaluated whether pre-transport venous access was more successful than in-transport attempts. 350 patients. No statistical difference in ability to place IV prior to or during transport in non-hypotensive patient. In hypotensive patients placement in ambulance is more successful
Jones SE[17]	1989	Pre-hospital intravenous line placement: a prospective study. Ann Emerg Med. 1989 Mar;18(3):244-6.	II	Prospective observational study. 97 patients; 12 patients were hypotensive or in cardiac arrest. Success rate for trauma patients was 96%. On scene success rate 91%. En-route success 94%. Hypotensive 86% success rate. Average time to placement (single attempt) 2.8 minutes; with failed attempts, 6.3 minutes. En-route placement recommended.
Minville V[18]	2006	Pre-hospital intravenous line placement assessment in the French emergency system: a prospective study. Eur J Anaesthesiol. 2006 Jul;23(7):594-7.	II	Prospective observational study. 388 patients (83% medical). Results: 76% success for first attempt. Average time to IV was 4.4 minutes with a 99.7% success rate. 71% of the patients received therapy through the line pre-hospital.
Honigman B[16]	1990	Pre-hospital advanced trauma life support for penetrating cardiac wounds. Ann Emerg Med. 1990; 19(2):145-50.	II	Retrospective. 70 consecutive patients with penetrating cardiac injuries (31 GSW, 39 stab wounds). Results: 10.7 minutes on scene, 93% had IV access gained. 30% survival. No correlation between on scene time and IV access gained. No statistical difference noted. Recommendations: Well trained paramedics can perform procedures with short scene times and high rate of survival.
Pace SA[22]	1999	Paramedic decisions with placement of out-of-hospital intravenous lines. Am J Emerg Med. 1999 Oct;17(6):544-7.	II	Prospective observational cohort. 290 patients. Results: 57% of patients received out-of-hospital intravenous catheters with an over-treatment rate of 29% ± 5%, and an under-treatment rate of 2.4% ± 1.8%. 89% overall successful placement rate Conclusions: Lines are frequently started and not used. Paramedics exercise reasonable judgment and appropriate decision-making when deciding to start an IV. 29% nonuse rate may represent acceptable trade off to achieve under-treatment rate of 2.4%.
Barrett B[20]	2000	How long does it take to perform procedures on scene? Pre-hospital Immed Care 2000; 4(1):25-29.	II	Prospective observational study. 365 patients. Results: Median time successful cannulation 3.2 min. 86% scene cannulation attempts successful. Conclusions and Recommendations: Paramedic training should ensure personnel can perform procedures quickly and that they are efficient in their use of on scene time.
Pons PT[19]	1988	Pre-hospital venous access in an urban paramedic system--a prospective on-scene analysis. J Trauma. 1988	II	Prospective observational study of timing of obtaining venous access. 125 patients. Results: Mean time to obtain access and sample blood was 2.2 ± 0.2.Blood draws add >60 seconds to

		Oct;28(10):1460-3.		venous access placement. First attempt success 90% and 100% of patients were able to get access. Statistical Methods: descriptive data only. Conclusions/Recommendations: Patients should get access placed.
Gausche M[21]	1998	Out-of-hospital intravenous access: unnecessary procedures and excessive cost. Acad Emerg Med. 1998 Sep;5(9):878-82.	II	Retrospective study of 452 consecutive patients admitted to an urban hospital. 84% received an IV (IV line or saline lock); 7% received fluid resuscitation in the field. 37% received "appropriate" treatment; 56% received an IV line when saline lock was indicated; 7% received saline lock when IV line needed. Conclusions/Recommendations: Paramedics and base hospital personnel often provide discordant over-treatment of patients by placement of an IV when a saline lock or no IV would suffice, resulting in unnecessary costs for EMS systems.
Sampalis JS[25]	1997	Ineffectiveness of on-site intravenous lines: is pre-hospital time the culprit? J Trauma. 1997;43(4):608-15.	II	Observational study. 434 patients. Methods: 217 patients (IV group) compared with 217 patients (no IV) matched by Prehospital Index Score. Results: Mortality rates for the IV and no-IV groups were 23% and 6% ($p< 0.001$). Logistic regression analysis demonstrated on-site fluid replacement associated with significant increase in risk of mortality (adjusted OR=2.3; 95% CI=1.02-5.28; p=0.04). Recommendations: Use of on-site IV fluid replacement is associated with an increase in mortality risk; association is exacerbated by increased pre-hospital time.
Smith JP[14]	1985	Pre-hospital stabilization of critically injured patients	III	Retrospective review of 52 patients divided into three groups. No SBP, SBP<70, SBP 70-100 mmHg. In all groups, time to obtain access greater than transport time. No more than 450 mL of fluid received. No change in vital signs during transport with this intervention. Conclusion: Minimize field maneuvers, "scoop and run."
Seamon MJ[26]	2007	Pre-hospital Procedures Before Emergency Department Thoracotomy: "Scoop and Run" Saves Lives. *J Trauma.* 2007;63:113–120.	III	Retrospective chart review. 180 consecutive penetrating trauma patients (2000–2005) who underwent ED thoracotomy. Patients divided into two groups by mode of transportation. Results: 88 patients arrived by emergency medical services (EMS), 92 by police or private vehicle (POV). Groups similar with respect to demographics. 8.0% EMS patients survived until hospital discharge vs. 17.4% of POV patients. Pre-hospital procedures performed in 88.6% EMS patients. Multivariate analyses identified pre-hospital procedures as the sole independent predictor of mortality. For each procedure, patients were 2.63 times more likely to die before hospital discharge (O.R. 0.38).
Slovis CM [24]	1990	Success rates for initiation of intravenous therapy en route by pre-hospital care providers. Am	III	Retrospective evaluation of the ability to start venous access in the back of a rolling motor vehicle. 641patients. Results: At least one IV

		J Emerg Med. 1990; 8(4):305-7.		line was started in 92% of trauma patients, regardless of blood pressure. In hypotensive patients, success rates for at least one IV was 95%. Average on scene time for all calls was 14.9 minutes (SD ± 10.1), while the average on scene time for hypotensive patients was 11.6 minutes (SD ± 6.2). Statistical Methods: Descriptive. Conclusions/Recommendations: Venous access can be secured with a high degree of success en route. Prompt transport of unstable patients should not be delayed solely to obtain IV access.
Spaite DW[69]	1991	The impact of injury severity and pre-hospital procedures on scene time in victims of major trauma. Ann Emerg Med. 1991 Dec;20(12):1299-305.	III	Prospective, observational study. Methods: Compared time on scene and evaluation for differences caused by severity of injury and procedures performed. 98 patients. Results: More severely injured patients had more procedures. Number of procedures did not increase scene time. Conclusions: In a highly developed trauma system, pre-hospital ALS procedures do not increase time to ED arrival.
Henderson RA[70]	1998	Unnecessary intravenous access in the emergency setting. Prehosp Emerg Care. 1998 Oct-Dec;2(4):312-6.LinkOut	III	Retrospective chart review. 940 patients. Methods: Patients presenting to ED by EMS or private vehicle. 62% patients who had access placed by EMS did not have any benefit. 58% of ED placed lines went unused (in EMS patient) 52% of ED placed lines for private vehicle patients went unused. Conclusions: Many routinely placed lines are unnecessary and protocols should be studied to reduce this rate.
Cayten CG[27]	1993	Basic life support versus advanced life support for injured patients with an injury severity score of 10 or more. J Trauma. 1993 Sep;35(3):460-6; discussion 466-7.	III	Retrospective, multi-institutional study. 781 patients. Methods: Consecutive trauma patients with ISS ≥ 10. Subset analysis of 219 hypotensive patients. Results: 434 patients transported by ALS ambulance, 347 by BLS. No significant differences between ALS and BLS with regard to age or ISS. Observed survival in penetrating injury compared more favorably with MTOS predicted survival in BLS patients. Among hypotensive patients, observed survival also compared more favorably with MTOS predicted survival in BLS. Total pre-hospital times were not different between BLS and ALS. No benefit of ALS for trauma patients with total pre-hospital times of <35 minutes.
Hedges JR[71]	1988	Factors contributing to paramedic on scene time during evaluation and management of blunt trauma. Am J Emerg Med. 1988 Sep;6(5):443-8.	III	Retrospective cohort. 109 patients. Methods: Divided into high and low trauma score (TS) groups. Step-wise linear regression used to identify factors having effect on scene time. Results: Mean on-scene time did not differ between high (>13) and low (≤13) TS groups. Higher number of procedures performed in the high TS patient groups. Patient groups with low TS showed no improvement in score with increasing on scene time. Conclusions: Paramedics tend to spend more time on scene

				when long transport times are initiated.
Consensus Working Group on Pre-hospital Fluids[7]	2001	Fluid Resuscitation in Pre-Hospital Trauma Care: a consensus view. J R Army Med Corps. 2001; 147(2):147-52.	III	Study design: Consensus group. Methods: None. Results: 1. Control of bleeding is paramount. 2. No access for superficial wounds. 3. Utilize mental status and radial pulse as initial triage means (start IV but hold fluids if present). 4. Start IV and provide 500 ml of colloid if no radial pulse or mental status not coherent. 5. Stop fluids if pulse and mental status return. 6. If no response, repeat 500 ml of colloid (hetastarch). Conclusions: Algorithm base on expert experience and literature from other military conflicts.

Table 2. If access is obtained, where and how should it be placed?

Westfall MD[32]	1994	Intravenous access in the critically ill trauma patient: a multi-centered, prospective, randomized trial of saphenous cut-down and percutaneous femoral access. Ann Emerg Med. 1994 Mar;23(3):541-5.	I	Prospective, multi-center trial. Randomized, non-blinded, waiver of consent. 78 patients. Results: Percutaneous femoral vein cannulation faster than saphenous cut-down in patients with femoral pulse. Conclusions: Placement of an 8.5F percutaneous femoral line is an acceptable alternative to saphenous vein cut-down in unstable trauma patients
Guisto JA[31]	1990	The feasibility of 12-gauge intravenous catheter use in the pre-hospital setting. J Emerg Med. 1990 Mar-Apr;8(2):173-6.	II	Prospective observational. 38 patients. Methods: Patients evaluated over a 6-month period, for access attempts. Results: There were 43 attempts at 12-gauge intravenous catheter placement in 38 patients. Overall success rate was 84% with a success-per-attempt rate of 74%. Conclusions/Recommendations: 12-gauge catheters can be successfully used by paramedics.
Frascone RJ[35]	2007	Consecutive field trials using two different intra-osseous devices. Prehosp Emerg Care. 2007;11(2):164-71.	II	Observational study. 178 patients. Results: Evaluation of intra-osseous insertions (89 each of FAST 1TM and EZ-IO). Results: FAST 1TM - 64 of 89 successful initial attempts (this group had more initial IV attempts as well). EZ-IO – 78 of 89 successful initial attempts and were placed faster. Recommendations: If intra-osseous access utilized, EZ-IO has higher success rate of insertion.
Benumof JL[30]	1983	A large catheter sheath introducer with an increased side-port functional gauge. Crit Care Med. 1983 Aug;11(8):660-2.	III	Observational study. 17 patients. Methods: In vivo and in vitro experiments to judge flow rates of various catheters and introducers Results: High rates of infusion can be achieved with introducer catheters. Similarly, high rates of flow can be achieved via 14 gauge peripheral lines and through the side port of introducers as a 16-gauge line. Conclusions: Introducer side ports can function as volume lines even with indwelling pulmonary artery catheters (or slicks) in place.
Herron H[33]	1997	8.5 French peripheral intravenous access during air medical transport of the injured patient. Air Med J 1997; 16(1):7-10.	III	Retrospective review. 23 patients. Results: Evaluated injured patients who received a peripheral 8.5 Fr introducer during the study period. Initial small bore access achieved and this was exchanged over wire to larger catheter. Conclusions: Peripheral 8.5 Fr IV access via guide-wire exchange of an existing IV is a rapid and simple approach to large-bore IV access.

Table 3. If access is obtained, should fluid be administered in the pre-hospital setting?

Turner J[42]	2000	A randomized controlled trial of pre-hospital intravenous fluid replacement therapy in serious trauma. Health Technol Assess. 2000; 4(31):1-57.	I	Prospective randomized controlled study. 1309 patients. Methods: Randomization to (1) standard of care, (2) withholding fluids until arrival to hospital unless transport time was to be more than 1 hour. Results: 699 patients randomized to standard fluids according to existing protocols and 610 patients were cared for by paramedics randomized into giving no fluids. Extremely poor compliance with only 31% of patients who were supposed to receive fluids actually received fluids and 80% of patients who were supposed to have fluids withheld actually received them. Mortality was similar between the two groups. Longer transport time in the group randomized to give standard fluids. Conclusions: Authors concluded that protocols recommending pre-hospital fluid administration do no harm.
Bickell WH[10]	1994	Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. N Engl J Med. 1994 Oct 27;331(17):1105-9.	I	Prospective, randomized trial. 598 patients. Methods: Patient with penetrating torso injuries were randomized to delayed resuscitation (no fluids until O.R.) and standard of care fluid resuscitation for EMS. Results: Delayed resuscitation versus standard resuscitation, 70% versus 62% survival (p=0.04). Shorter length of stay and higher nadir hemoglobin. Conclusions: In patients with penetrating torso injury, delayed resuscitation is recommended in the pre-hospital setting.
Boyle MF[46]	1994	Saline locks in pre-hospital care. Prehosp Disaster Med. 1994 Jul-Sep;9(3):190-2.	II	Observational study. 110 patients. Methods: Evaluated the use of saline locks instead of traditional IV placement and continuous infusion. Results: All patients who required fluid resuscitation were appropriately given IVs. Those patients who required medications only appropriately received SL. Patency adequate. Conclusions: The use of a saline lock is an alternative to the use of traditional IV/infusion in the pre-hospital setting.
Carducci B[47]	1994	Intravenous maintenance with a saline lock intermittent infusion device in the pre-hospital environment. Prehosp Disaster	II	Prospective, non-blinded. 70 patients. Methods: Prospective evaluation to evaluate the effectiveness of saline

		Med. 1994 Jan-Mar;9(1):67-70.		lock to maintain access. Conclusions: Saline lock is an effective, rapid, reliable method of maintaining intravenous access during trauma transport. Continuous infusion is unnecessary.
Dula DJ[40]	2002	Use of pre-hospital fluids in hypotensive blunt trauma patients. Prehosp Emerg Care. 2002 Oct-Dec; 6(4):417-20.	II	Retrospective. 150 patients Methods: Matched pairs, case-control study of hypotensive patients (initial SBP<90 mm Hg). SBP higher in fluid group. No difference in outcome in patients who received ≥ 500 or < 500 mL fluid. Time to ED was lower in no fluid group (45 vs. 54 min., p= 0.02). Conclusions: Control of airway, breathing, immobilization of fractures, and control of external bleeding should have priority over I.V. fluid administration in pre-hospital setting.
Eckstein M[37]	2000	Effect of pre-hospital advanced life support on outcomes of major trauma patients. J Trauma. 2000 Apr;48(4):643-8.	III	Retrospective. 496 patients. Methods: All major trauma patients transported by paramedics to a Level I Trauma Center. Results: Survival among patients who received I.V. fluids was not significantly greater than for those who did not receive fluids. Average on-scene times for patients who received fluids was not significantly longer than those who did not receive fluids. Conclusions: ALS procedures performed by paramedics on major trauma patients do not prolong scene time, but do not improve survival.
Holcomb JB[44]	2003	Fluid resuscitation in modern combat casualty care: lessons learned from Somalia. J Trauma. 2003 May;54(5 Suppl):S46-51.	III	Expert opinion/consensus statement. Algorithm provided base on expert experience and literature from other military conflicts. (1) Superficial wounds do not require immediate IV access or fluid resuscitation, (2) If the soldier is coherent and has a palpable radial pulse, place a saline lock I.V., (3) If incoherent or no radial pulse, obtain IV access and start 500 mL hetastarch, (4) repeat bolus if no response, saline lock I.V. if response noted, (5) In patients with suspected head injuries, fluids should be titrated for SBP >90 mmHg.
Consensus Working Group on Pre-hospital Fluids[28]	2001	Fluid Resuscitation in Pre-Hospital Trauma Care: a consensus view. J R Army Med Corps. 2001; 147(2):147-52.	III	Study design: Consensus group. Methods: None. Results: 1. Control of bleeding is paramount. 2. No access for superficial wounds. 3. Utilize mental status and radial pulse

				as initial triage means (start IV but hold fluids if present). 4. Start IV and provide 500 ml of colloid if no radial pulse or mental status not coherent. 5. Stop fluids if pulse and mental status return. 6. If no response, repeat 500 ml of colloid (hetastarch). Conclusions: Algorithm base on expert experience and literature from other military conflicts.
Revell M[45]	2002	Fluid resuscitation in pre-hospital trauma care: a consensus view. Emerg Med J. 2002 Nov;19(6):494-8.	III	Consensus Group statement. Recommendations: (1) Cannulation should take place en route where possible, (2) Only two attempts at cannulation should be made, (3) Transfer should not be delayed by attempts to obtain intravenous access, (4) Entrapped patients require cannulation at the scene, (5) Normal saline is recommended as a suitable fluid for administration to trauma patients, (6) Boluses of 250 ml fluid may be titrated against the presence or absence of a radial pulse (caveats; penetrating torso injury, head injury, infants)
Talving P[41]	2005	Pre-hospital management and fluid resuscitation in hypotensive trauma patients admitted to Karolinska University Hospital in Stockholm. Prehospital Disaster Med. 2005 Jul-Aug;20(4):228-34.	III	Retrospective. 102 patients. Methods: A retrospective, descriptive study on consecutive, hypotensive trauma patients. Results: 75% blunt. On-scene time 19 min. Fluid therapy initiated at the scene in 73%, regardless of mechanism or injury severity. Conclusions: Time interval at the scene of injury exceeded PHTLS guidelines. Majority of hypotensive patients were fluid-resuscitated on-scene regardless of the mechanism or injury severity.
Dalton AM[38]	1995	Pre-hospital intravenous fluid replacement in trauma: an outmoded concept? J R Soc Med. 1995 Apr;88(4):213P-216P.	III	Observational study. 235 patients. Methods: Injured patients admitted to trauma center (72% penetrating) who received pre-hospital I.V. placement. Results: Mean infusion time 17 minutes. 92% patients received volumes < 1000 mL, 80% received less than < 600 mL. Hypotensive patients had mean infusion time of 16 minutes, receiving mean 573 mL. Conclusions: Given the uncertain benefits and potential complications, intravenous cannulation and fluid replacement may not be appropriate where expected pre-hospital time is likely to be less than 30min.

Smith JP[14]	1985	Pre-hospital stabilization of critically injured patients	III	Retrospective review of 52 patients divided into three groups. No SBP, SBP<70, SBP 70-100 mmHg. In all groups, time to obtain access greater than transport time. No more than 450 mL of fluid received. No change in vital signs during transport with this intervention. Conclusion: Minimize field maneuvers, "scoop and run."
Kaweski SM[39]	1990	The effect of pre-hospital fluids on survival in trauma patients. J Trauma. 1990 Oct;30(10):1215-8.	III	Retrospective. 6855 patients. Methods: Evaluation of a cohort of patients from a trauma registry. Results: 56 % of patients received fluids, penetrating got fluid more often. Longer transport time in patients receiving I.V. and fluids. No difference in receiving fluids and mortality by ISS, TRISS, or hypotension on arrival. Conclusions: Pre-hospital fluids do not effect outcome but initiating fluids does delay transport.

Table 4. If fluid is administered, which solution should be given?

Vassar MJ[58]	1991	7.5% sodium chloride/dextran for resuscitation of trauma patients undergoing helicopter transport. Arch Surg. 1991 Sep;126(9):1065-72.	I	Randomized, double blind multi-center trial. 166 patients. Methods: Waiver of consent obtained. Study compared 250 mL boluses of LR and 7.5% + 6% Dextran. Remainder of resuscitation with standard solutions. Results: No significant difference in initial SBP, mortality, use of blood products overall. In patients with GCS <8 hypertonic saline groups had had higher survival. Mean change in SBP was higher in hypertonic groups. Conclusions: Pre-hospital use of hypertonic saline is feasible in air medical transported patients and is associated with improved survival in those patients with head injury.
Vassar MJ[54]	1993	A multi-center trial for resuscitation of injured patients with 7.5% sodium chloride. The effect of added dextran 70. The Multi-center Group for the Study of Hypertonic Saline in Trauma Patients. Arch Surg. 1993;128(9):1003-11; discussion 1011-3.	I	Randomized, double blind multi-center trial. 194 patients. Methods: Waiver of consent obtained. Critically injured patients transported by air medical ambulance. Compared 250 mL bolus of LR, 7.5% sodium chloride, 7.5% + 6% Dextran, or 7.5% + 12% Dextran. Remainder of resuscitation with standard solutions. Results: Hypertonic saline associated with improved admission SBP compared to LR. No differences noted with the addition of Dextran. Brain injury patients seem to benefit the most with 7.5% saline. Conclusions: Use of hypertonic saline, with or without Dextran, reduces mortality in trauma patients.
Vassar MJ[55]	1993	Pre-hospital resuscitation of hypotensive trauma patients with 7.5% NaCl versus 7.5% NaCl with added dextran: a controlled trial. J Trauma. 1993 May;34(5):622-32.	I	Randomized, provider blinded trial. 258 patients. Methods: Single center trial of all patient transported by ground ambulance with SBP<90 en route. Received 0.9% sodium chloride, 7.5% sodium chloride, and 7.5% with Dextran. Results: ISS higher in 7.5% groups. 7.5% group had more unexpected survivors than 0.9% group but the overall mortality was not significantly different. No benefit to dextran. Conclusions: Infusion of small bolus of 7.5% saline may improve survival in severely injured patients.
Maningas PA[52]	1989	Hypertonic saline-dextran solutions for the pre-hospital management of traumatic hypotension.	I	Randomized, double-blinded controlled trial. 48 patients. Methods: All patients with penetrating injury

		Am J Surg. 1989 May;157(5):528-33; discussion 533-4.		and a SBP<90. Randomized in the field to 7.5% sodium chloride + 6% dextran or crystalloid (plasmalyte) based on an alternate-day protocol. Results: Trends toward improved SBP response and less blood transfusion with the study group yet neither reached statistical significance. Conclusions: It is feasible to give low volume solution in a pre-hospital setting. There were trends toward improvements in clinically significant outcomes in patients receiving 7.5% sodium chloride.
Mattox KL[62]	1991	Pre-hospital hypertonic saline/dextran infusion for post-traumatic hypotension. The U.S.A. Multicenter Trial. Ann Surg. 1991 May;213(5):482-91.	I	Multi-center, randomized double-blinded trial. 359 patients. Methods: Waiver of consent, intention to treat trial. Randomized in the field to 7.5% sodium chloride + 6% dextran or crystalloid. Results: Non-statistically significant trend to higher overall survival in treatment arm. However, significantly better survival was observed in patients requiring operative intervention (p=0.02) and in those with penetrating injuries (p=0.01). Conclusions: Hypertonic saline as safe and effective as standard resuscitation. This solution may improve survival in patients who require early operative intervention or in those who sustain penetrating injuries.
Cooper DJ[57]	2004	Pre-hospital hypertonic saline resuscitation of patients with hypotension and severe traumatic brain injury: a randomized controlled trial. JAMA. 2004 Mar 17; 291(11):1350-7.	I	Prospective, randomized, double blind trial. 262 patients. Methods: Community waiver of consent. Evaluated patients with either head injury or hypotension. Randomized to 7.5% sodium chloride or Ringer's lactate. Results: No difference in overall mortality or 6 month neurological outcome. Lower mean ICP on admission in 7.5% group. Conclusions: Hypertonic saline is not associated with improved neurological outcomes at 6-months.
Holcroft JW[49]	1987	3% NaCl and 7.5% NaCl/dextran 70 in the resuscitation of severely injured patients. Ann Surg. 1987 Sep;206(3):279	I	Randomized, provider blinded trial. 258 patients. Methods: Single center trial of all patient transported by ground ambulance with SBP<90 en route. Received lactated Ringer's or 7.5% sodium chloride with dextran. Results: Overall survival was 40% in hypertonic group versus 30% in the LR group (not significant). The LR

				arm required more fluids to maintain SBP en route and in ED. 7.5% group had a greater increase in SBP from baseline (49 mmHg versus 19 mmHg, p<0.005). Conclusions: Pre-hospital use of 7.5% sodium chloride with dextran improves SBP more than LR and may improve survival.
Barkana Y[63]	1999	Pre-hospital blood transfusion in prolonged evacuation. J Trauma. 1999 Jan;46(1):176-80.	III	Retrospective chart review. 40 patients. Methods: Evaluated all cases of trauma patients in who received prehospital blood transfusions during a 30 month period.. Results: 40 pts received 60 units of blood. Mean pre-hospital crystalloid 4.4L. Over the 30 month period, less than 4% of blood units that were "on standby" for pre-hospital situations were actually used (90% used in hospital). Conclusions: Pre-hospital blood transfusion is feasible and safe. However, a large amount of wasted blood occurs utilizing pre-hospital blood.
Sumida MP[64]	2000	Pre-hospital blood transfusion versus crystalloid alone in the air medical transport of trauma patients. Air Med J. 2000 Oct-Dec;19(4):140-3.	III	Retrospective chart review. 48 patients. Methods: One year review of air medical transported patients. Control group made up of those patients receiving no blood but >2.0L crystalloid en route. Study group made up of patients who received in-flight transfusions. Results: 31 patients received crystalloid only; 17 received blood and crystalloid. No demographic differences between the groups. However, the crystalloid only group had higher initial blood pressure and heart rate and the blood group had longer transport times. In addition, the blood group had lower pH and HCO3 on admission. No difference in mortality. Conclusions: The impact of blood products in outcomes could not be assessed because of significant differences in transport times.

Table 5. If fluid is administered, how much should be given and how fast should it be infused?

Vassar MJ[58]	1991	7.5% sodium chloride/dextran for resuscitation of trauma patients undergoing helicopter transport. Arch Surg. 1991 Sep;126(9):1065-72.	I	Randomized, double blind multi-center trial. 166 patients. Methods: Waiver of consent obtained. Study compared 250 mL boluses of LR and 7.5% + 6% Dextran. Remainder of resuscitation with standard solutions. Results: No significant difference in initial SBP, mortality, use of blood products overall. In patients with GCS <8 hypertonic saline groups had had higher survival. Mean change in SBP was higher in hypertonic groups. Conclusions: Pre-hospital use of hypertonic saline is feasible in air medical transported patients and is associated with improved survival in those patients with head injury.
Vassar MJ[54]	1993	A multi-center trial for resuscitation of injured patients with 7.5% sodium chloride. The effect of added dextran 70. The Multi-center Group for the Study of Hypertonic Saline in Trauma Patients. Arch Surg. 1993;128(9):1003-11; discussion 1011-3.	I	Randomized, double blind multi-center trial. 194 patients. Methods: Waiver of consent obtained. Critically injured patients transported by air medical ambulance. Compared 250 mL bolus of LR, 7.5% sodium chloride, 7.5% + 6% Dextran, or 7.5% + 12% Dextran. Remainder of resuscitation with standard solutions. Results: Hypertonic saline associated with improved admission SBP compared to LR. No differences noted with the addition of Dextran. Brain injury patients seem to benefit the most with 7.5% saline. Conclusions: Use of hypertonic saline, with or without Dextran, reduces mortality in trauma patients.
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				actually received them. Mortality was similar between the two groups. Longer transport time in the group randomized to give standard fluids. Conclusions: Authors concluded that protocols recommending pre-hospital fluid administration do no harm.
Bickell WH[10]	1994	Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. N Engl J Med. 1994 Oct 27;331(17):1105-9.	I	Prospective, randomized trial. 598 patients. Methods: Patient with penetrating torso injuries were randomized to delayed resuscitation (no fluids until O.R.) and standard of care fluid resuscitation for EMS. Results: Delayed resuscitation versus standard resuscitation, 70% versus 62% survival (p=0.04). Shorter length of stay and higher nadir hemoglobin. Conclusions: In patients with penetrating torso injury, delayed resuscitation is recommended in the pre-hospital setting.
Kaweski SM[39]	1990	The effect of pre-hospital fluids on survival in trauma patients. J Trauma. 1990 Oct;30(10):1215-8.	III	Retrospective. 6855 patients. Methods: Evaluation of a cohort of patients from a trauma registry. Results: 56 % of patients received fluids, penetrating got fluid more often. Longer transport time in patients receiving I.V. and fluids. No difference in receiving fluids and mortality by ISS, TRISS, or hypotension on arrival. Conclusions: Pre-hospital fluids do not effect outcome but initiating fluids does delay transport.

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