

Fluid Resuscitation in the Management of Hemorrhagic Shock: Which Fluid to Give?

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Abstract

Hemorrhagic shock remains a leading cause of morbidity and mortality worldwide. Resuscitation strategies for patients with ongoing hemorrhage and early haemorrhagic shock are in constant change. Recognition of the major mechanisms of shock and hemostasis paved the way to advances in trauma resuscitation. Aggressive crystalloid resuscitation in hemorrhagic shock results in many different complications and enhances patient morbidity and mortality.

Timely transfusion will reduce the total amount of blood product use. The choice of fluids to be transfused should be tailored to each patient, taking into account the clinical status, the real amount of fluid lost, the physiologic reserves of the patient, comorbidities, operations and/or other interventions planned to pursue in the course of the victim.

Keywords: Fluid Resuscitation; Management; Hemorrhagic Shock; Trauma; Crystalloid

Introduction

Day by day, 21st century witnesses more mass casualties than ever, mostly due to transportation, disasters of various sizes, terrorism etc. Most trauma victims with hemorrhagic shock (HS) result from mass casualties and individual accidents. Hemorrhagic shock is still a leading cause of death and morbidity throughout world.

Shock can be described as inadequate blood flow to meet the metabolic demands of tissues. This state can be caused by many different kinds of insults, and those are classified into hypovolemic, septic, cardiac, or neurologic conditions. 'Distributive' shock usually encompasses anaphylactic, septic and neurogenic subtypes of shock, whereas 'obstructive' shock defines the low-perfusion states such as tension pneumothorax, cardiac tamponade, and pulmonary embolism. HS is the most widespread cause of death in trauma cases [1,2]. Figure 1 depicts that trauma encompasses both local and systemic processes together. Direct damage to tissue triggers tissue injury associated with pain. Disruption of blood vessels and solid organ parenchyma causes haemorrhage and a decline of cardiac output [3]. Table 1 lists signs, symptoms and findings encountered in patients with shock.

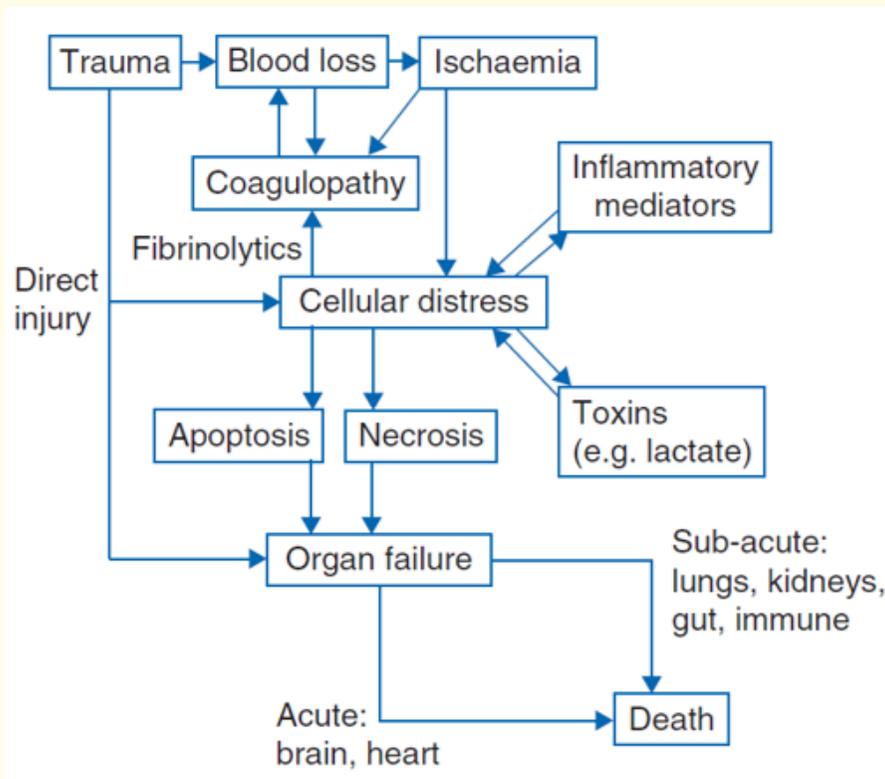


Figure 1: The pathophysiology of hemorrhagic shock.

<p>Vital signs</p> <ul style="list-style-type: none"> • Tachycardia/brady asystole • Tachypnea/dyspnea • Confusion and/or altered mental status • Hypotension > 30 min duration • Narrowed pulse pressure
<p>Adjunctive physical findings</p> <ul style="list-style-type: none"> • Pallor on the skin • Cold sweating, perspirations • Decreased urine output (below 0.5 mL/kg/h in adults) • Angor animi/sense of impending doom

Table 1: Signs and physical findings that can be sought to monitor shock state and the effectiveness of resuscitation.

Evaluation and management of hemorrhagic shock

Although increased heart rate and reduced blood pressure (BP) are viewed as the hallmarks of deterioration of the patient into HS, clinical assessment must also include capillary refill, skin temperature and color, mental status, and urine output [4]. Inadequacy of blood flow to tissues and organs is not limited by the actual blood loss the patient experienced via the trauma itself. Trauma-induced coagulopathy is frequent in injured patients at the time of hospital presentation.

The physician should search for the source of hemorrhage while infusion of necessary volume to the central circulation is on the way. A minimum of two 16-gauge intravenous catheters should be established in adults [4]. Intraosseous route must be employed instead of venous cut-down in most situations. In the last decades, the initial resuscitation of trauma victims has undergone only minor modifications. Prehospital algorithms written in '80's recommended early IV access with 2 large-bore cannulas and aggressive administration of crystalloid, regardless of patient physiology. The patient's response to the initial volume replacement would guide the continuation of the treatment; that is, if the first response is rapid and satisfactory, one can say that the injury was not very severe and blood loss was relatively small. In these cases an infusion of a balanced saline solution can be sufficient treatment.

After evaluation of the response to the fluid replacement are fulfilled and interpreted as unsatisfactory, adjunctive therapies to fluid resuscitation, such as catecholamines to augment cardiac contraction and venous return, can be considered early as a mode of circulatory support [5].

In the last decades, trauma resuscitation typically comprised bolus infusion of lactated ringer's or 0.9% saline solutions as it was emphasized in ATLS and for easy availability. On the other hand, aggressive crystalloid infusion exacerbates the "mortal triad" via hemodilution, decreased oxygen carrying capacity, diminished oxygen delivery, and other hazardous effects (pulmonary edema, brain edema, adult respiratory distress syndrome, metabolic acidosis, inflammation, electrolyte abnormalities, etc).

With the advances in biomedical technology, thromboelastography (TEG) provides users with a holistic overview of coagulation through the analysis of platelet function, clotting strength and fibrinolysis. TEG can measure the function of the entire coagulation cascade including platelets, hence guiding further management [6,7]. Expediency and ability to simultaneously measure discrete aspects of coagulation cascade provide important advantages over standard laboratory analyses.

There is a dysfunction of the microcirculation in target organs and the clinician can view the integrity of the patient's microcirculation as a predictor of patient's deterioration. Some studies disclosed that 'classical' vital signs had poor correlation with the severity of microcirculatory hypoperfusion [8,9]. Thus, reliance on normalizing of these vital signs as an indicator for restoration of microperfusion was not shown to be accurate [10]. Studies in humans have shown that a vast majority of trauma patients resuscitated to "normalized" vital parameters (heart rate, blood pressure) remained in a state of microcirculatory shock [9,11].

Which fluid to infuse?

Physiological and clinical status together with clinician experience determine the preferences of resuscitation fluids. Efficacy in certain clinical scenarios, ease of use, safety issues, cost and availability are some of the factors which would affect use of a product in the long run.

Tremblay, *et al.* pointed out that the "ideal fluid" would combine the volume expansion and oxygen carrying capacity of blood, without the need for cross-matching or the risk of disease transmission [12]. It would also restore and maintain the normal distribution of body fluid compartments, while being durable, portable, and cheap. As can be seen, none of the options comes close to this ideal. Table 2 tabulates different types of fluids and their characteristics in their clinical uses and table 3 summarizes fluid resuscitation principles in trauma victims with HS.

Fluid / solution type	Characteristics	Pluses	Minuses
Albumin %4	Osmolarity = 250 Na = 148 mEq/L	Safe, recipient-friendly	May cause hypoosmolar state, expensive
Plasma	Glucose 535 mg/dl, sodium 172 mEq/L, chloride 73 mEq/L, potassium 3.5 mEq/L, bicarbonate 15 mEq/L, protein 5.5 g/dl (60% albumin)	Can be stored safely for longer than RBCs, standard cure for exsanguination-associated coagulopathy	Disease transmission risks, hypochloremia, hypernatremia, hyperglycemia
Hydroxyethyl starch (HES) 6% (130/0.4)	Osmolarity = 308 Na = 154 mEq/L Cl = 154 mEq/L pH = 3.5 - 7.0	Easier to use when compared to blood products	May cause electrolyte abnormalities; hypernatremia, coagulation problems, hypocalcemia, hypokalemia
Normal saline	Osmolarity = 308 Na = 154 mEq/L Cl = 154 mEq/L	Not allergic, safe, cheap; alternative for Lactated Ringer's	May cause electrolyte abnormalities; hypernatremia, hyperchloremic acidosis. Does not provide free water or calories.
Lactated Ringer's	Osmolarity = 280 Na = 131 mEq/L K = 4 mEq/L Ca = 2.0 mEq/L Cl = 110 mEq/L Lactate = 28 mEq/L	Not allergic, safe, stable in storage, cheap; fluid choice for initial resuscitation. More closely resembles the electrolyte composition of normal blood serum.	May cause electrolyte abnormalities; hypochloremia. Does not provide calories.

Table 2: Different types of fluids and their characteristics in their clinical uses.

- Serum sodium, osmolarity, and acid–base status should be taken into account to decide on the correct fluid to be replaced.
- Body weight and insensible losses should also be thought for the dose of resuscitation fluid.
- Catecholamine use should be considered concurrent with fluid replacement.
- The use of a fluid challenge can be evaluated in the early phase of resuscitation.
- After hemorrhage is controlled, transfusion with red cells and blood components is commenced.
- Most acutely ill victims of trauma would improve with isotonic, balanced salt solutions for initial resuscitation should the bleeding is ceased.
- As normal saline causes hyperchloremic acidosis, patients with hypovolemia and alkalosis deserve this fluid to prevent further deterioration.
- Albumin can be used in patients with severe sepsis instead of other fluid types.
- Victims with traumatic brain injury must be treated with isotonic crystalloids.
- Hydroxyethyl starch is not indicated in patients with sepsis or those at risk for acute kidney injury.
- Semisynthetic colloids is not recommended, for safety issues.
- Fluids are intravenous drugs, thus caution should be exercised in usage. The type of the fluid, dose, indications, drawbacks, toxicity, availability and prices should be taken into account before use.
- When possible, replace only the fluid lost in proper volumes.

Table 3: Fluid resuscitation principles in trauma victims with HS.

Standard trauma resuscitation as defined by the ATLS course includes infusion of ringer lactate solution, which is a racemic mixture containing two stereo-isomers of lactate D-lactate and L-lactate [13]. Crystalloids with a chemical composition that approximates extracellular fluid have been termed “balanced” or “physiologic” solutions and are derivatives of the original Hartmann’s and Ringer’s solutions. Interestingly, these solutions have not been proved to be really balanced or physiologic so far [14]. Normal saline is also frequently used with lactated ringer for resuscitation in hemorrhagic shock, but it has been associated with hyperchloremic acidosis, when given in large volumes [15].

RBCs: In case of ongoing hemorrhage or a critically low hemoglobin level (usually set at 7 g/dL), PRBC transfusion is recommended (1 - 2 units in adults) to be undertaken.

Fresh Frozen Plasma (FFP) serves as a potent volume expander by leading to a significant increase in osmotic pressure. It increases IV volume via direct and indirect mechanisms by drawing interstitial and intracellular volume into circulation [16]. The use of FFP has become an integral part of massive transfusion protocols in most trauma centers, especially with the aim of overcoming consumption coagulopathy associated with most trauma deaths. Hardships related to availability, high cost, transfusion-related adverse events, ABO incompatibility, transfusion reactions, and transmission of infections have all contributed to its low consumption throughout the world. Via component separation, RBCs can be safely stored at 2 to 6°C for 40 days, and FFP (plasma that has been frozen within 8 hours of collection) can be stored at -80°C for years [17]. The product is administered 20 mL/kg for the victim. In 1986, Ewalenko, *et al.* used a sample of 35 FFP units and highlighted the characteristics of the product [18] (Table 2).

Radwan, *et al.* demonstrated that having plasma available in any form in the ED led to fewer transfusions of RBC, plasma, and platelets in the early phase of trauma and predicted a lower short-term mortality in this population [19]. Meanwhile, prospectively collected data failed to verify a promising effect of aggressively transfused FFP in patients with hemorrhagic shock following trauma [20].

The use of hydroxyethylstarch (HES) is associated with alterations in coagulation, and the clinical outcomes associated with its use and effects in specific circumstances, are yet to be determined [21].

Albumin has long been viewed as the reference colloid solution, which is limited to some extent by its cost [22]. On the other hand, plasma was demonstrated to be a 50-fold better buffer than crystalloids and 5-fold better than albumin [23]. The ‘Saline versus Albumin Fluid Evaluation’ (SAFE) study, a blinded, randomized and controlled trial, investigated the use and safety of albumin in almost 7000 adults [24]. The study showed no significant difference between albumin and saline regarding death rate or de novo organ failure development. More studies are needed to highlight benefit from albumin in certain specific populations, e.g. severe sepsis.

The concept of “balanced resuscitation” in the management of shock

“Balanced resuscitation” (BR), employs using ratios of plasma, platelets, and red blood cells (RBCs) that approximate whole blood as early as possible in a patient’s care. Aggressive crystalloid resuscitation impairs coagulation cascade through dilution, leads to acidosis through pH alteration, and augments hypothermia via infusion of large volumes of cold solution. BR encompasses three main components to restore bodily functions: (1) minimization of crystalloids, (2) plasma, platelets, and RBCs in a 1:1:1 ratio, and finally, (3) permissive hypotension.

Acute lung injury after trauma is triggered by HS and crystalloid resuscitation. Plasma transfusion can be beneficial in this scenario. These findings led to the recent Eastern Association for the Surgery of Trauma’s (EAST) recommendation for transfusion of equal amounts of RBC, plasma, and platelets during the early, empiric phase of resuscitation [25].

In the military setting, the concept of controlled resuscitation strategy (BR, permissive hypotension and limited crystalloid use), has resulted in an early survival advantage. The strategy had previously been recommended by some researchers [26,27]. Most trauma surgeons advocate a policy of judicious fluid administration to maintain the MAP between 60 and 80 mmHg. Permissive hypotension is not proposed as a definitive therapy; in fact it can only be a temporizing measure before definitive control of blood loss is accomplished [28].

Most institutions initiate plasma and RBC transfusion based on the prehospital Assessment of Blood Consumption (ABC) score while some others takes into account the prehospital shock index to guide the usage of blood products [29,30]. For an effective BR, blood products, (e.g. plasma and platelets and RBCs), should be instantly ready to use in the ED or trauma bay.

Expedient institution of massive transfusion in the selected patient improves mortality rate, identifying those trauma patients early in their ED course is important [31]. The Assessment of Blood Consumption (ABC) score has been validated and is easy to use [30,32]. The score encompasses four parameters which are easily addressed on presentation.

- USG: FAST- Positive examination
- SBP \leq 90 mmHg
- Heart rate \geq 120 bpm
- Penetrating injury

A score of 2 or more predicts the need for massive transfusion with a sensitivity of 75 percent and a specificity of 86 percent.

In brief, BR with plasma, platelets, and RBC in a 1:1:1 ratio improves outcomes and should be initiated early, including prehospital, when possible. The strategy diminishes coagulopathy via restrictive crystalloid use, and high ratios of plasma and platelet to RBC transfusion.

Conclusion

Although still debated, clear fluids are to be avoided and of blood and blood products is generally recommended to be infused early. Timely transfusion will reduce the total amount of blood product use. The choice of fluids to be transfused should be tailored to each patient, taking into account the clinical status, the real amount of fluid lost, the physiologic reserves of the patient, comorbidities, operations and/or other interventions planned to pursue in the course of the victim.

Bibliography

1. Siegel JH. "The effect of associated injuries, blood loss, and oxygen debt on death and disability in blunt traumatic brain injury: the need for early physiologic predictors of severity". *Journal of Neurotrauma* 12.4 (1995): 579.
2. Colwell C., *et al.* "Initial management of moderate to severe hemorrhage in the adult trauma patient" (2017).
3. Dutton RP. "Haemostatic resuscitation". *British Journal of Anaesthesia* 109.S1 (2012): i39-i46.
4. American College of Surgeons, Committee on Trauma: ATLS Student Course Manual. Tenth Edition. Chicago, IL (2018).
5. Persichini R., *et al.* "Effects of norepinephrine on mean systemic pressure and venous return in human septic shock". *Critical Care Medicine* 40.12 (2012): 3146-3153.
6. Duchesne JC., *et al.* "Damage control resuscitation: the new face of damage control". *Journal of Trauma, Injury, Infection, and Critical Care* 69.4 (2010): 976-990.

7. Giannoudi M and Harwood P. "Damage control resuscitation: lessons learned". *European Journal of Trauma and Emergency Surgery* 42.3 (2016): 273-282.
8. Barbee RW, et al. "Assessing shock resuscitation strategies by oxygen debt repayment". *Shock* 33.2 (2010): 113-122.
9. Tisherman SA, et al. "Clinical practice guideline: endpoints of resuscitation". *Journal of Trauma* 57.4 (2004): 898-912.
10. Paladino L, et al. "The utility of base deficit and arterial lactate in differentiating major from minor injury in trauma patients with normal vital signs". *Resuscitation* 77.3 (2008): 363-368.
11. Scalea TM, et al. "Resuscitation of multiple trauma and head injury: role of crystalloid fluids and inotropes". *Critical Care Medicine* 22.10 (1994): 1610-1615.
12. Tremblay LN, et al. "Advances in fluid resuscitation of hemorrhagic shock". *Canadian Journal of Surgery* 44.3 (2001): 172-179.
13. Dutta R and Chaturvedi R. "Fluid therapy in trauma". *MAJFI* 66.4 (2010): 312-316.
14. Guidet B, et al. "A balanced view of balanced solutions". *Critical Care* 14.5 (2010): 325.
15. Cherkas D. "Traumatic hemorrhagic shock: Advances in fluid management". *Emergency Medicine Practice* 13.11 (2011): 1-20.
16. Pati S, et al. "Protective effects of fresh frozen plasma on vascular endothelial permeability, coagulation, and resuscitation after hemorrhagic shock are time dependent and diminish between days 0 and 5 after thaw". *Journal of Trauma* 69.S1 (2010): S55-S63.
17. Shabihkhani M, et al. "The procurement, storage, and quality assurance of frozen blood and tissue biospecimens in pathology, biorepository, and biobank settings". *Clinical Biochemistry* 47.4-5 (2014): 258-266.
18. Ewalenko P, et al. "Composition of fresh frozen plasma". *Critical Care Medicine* 14.2 (1986): 145-146.
19. Radwan ZA, et al. "An emergency department thawed plasma protocol for severely injured patients". *JAMA Surgery* 148.2 (2013): 170-175.
20. Scalea TM, et al. "Early aggressive use of fresh frozen plasma does not improve outcome in critically injured trauma patients". *Annals of Surgery* 248.4 (2008): 578-584.
21. Hartog CS, et al. "Influence of hydroxyethyl starch (HES) 130/0.4 on hemostasis as measured by viscoelastic device analysis: a systematic review". *Intensive Care Medicine* 37.11 (2011): 1725-1737.
22. Finfer SR and Vincent JL. "Resuscitation Fluids". *New England Journal of Medicine* 369 (2013): 1243-1251.
23. Traverso LW, et al. "The buffering capacity of crystalloid and colloid resuscitation solutions". *Resuscitation* 12.4 (1985): 265-270.
24. The SAFE Study Investigators. "A comparison of albumin and saline for fluid resuscitation in the intensive care unit". *New England Journal of Medicine* 350.22 (2004): 2247-2256.
25. Cannon JW, et al. "Damage control resuscitation in patients with severe traumatic hemorrhage: a practice management guideline from the Eastern Association for the Surgery of Trauma". *Journal of Trauma* 82.3 (2017): 605-617.
26. Beecher HK. "Preparation of battle casualties for surgery". *Annals of Surgery* 121.6 (1945): 769-792.

27. Beecher HK. "Resuscitation and anesthesia for wounded men". Springfield (IL): Banerstone House (1949).
28. Hai SA. "Permissive hypotensive resuscitation--an evolving concept in trauma". *Journal of the Pakistan Medical Association* 54.8 (2004): 434-436.
29. Goodman MD, *et al.* "Prehospital ABC score accurately triages patients who will require immediate resource utilization". Presented at the 72nd Annual Meeting of AAST and Clinical Congress of Acute Care Surgery. San Francisco, CA (2013).
30. Nunez TC, *et al.* "Early prediction of massive transfusion in trauma: simple as ABC (assessment of blood consumption)?" *Journal of Trauma* 66.2 (2009): 346-352.
31. Cantle PM and Cotton BA. "Balanced Resuscitation in Trauma Management". *Surgical Clinics of North America* 97.5 (2017): 999-1014.
32. Cotton BA, *et al.* "Multicenter validation of a simplified score to predict massive transfusion in trauma". *Journal of Trauma* 69.1 (2010): S33-S39.

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