Arkansas Trauma System Evidence-Based Guidelines for Treatment of Hemorrhagic Shock

Section Editor: Charles D. Mabry MD FACS

Introduction-

Hemorrhage is common in all forms of trauma, and once the blood lost reaches a critical amount, the patient then develops shock as a result of loss of blood and perfusion to tissues. Traumatic hemorrhage is the most common cause of mortality in the first hour of arrival to a trauma center, and the combination of exsanguination from hemorrhage and coagulopathy account for almost half of the deaths in the first 24 hours following an injury. Too often, we forget the lethal triad of trauma: **hypotension, coagulopathy, and acidosis** and become distracted with other, less important issues. Blood will not efficiently clot when the patient is cold, or the blood pH is acidotic. Coagulopathy develops early in these trauma patients with incidence on arrival of between 25-40% complicating the treatment of hemorrhage. [1]

Rapid detection and treatment of shock continues to be one of the key goals of pre-hospital and trauma center treatment for the trauma patient. Much has been learned about treatment of hemorrhagic shock on the battlefields of Afghanistan and Iraq, and in the major trauma centers of the world. [2] Treatments that were once considered standard-of-care are now known to be potentially deadly. Newer research and advances have significantly changed the modern treatment of patients in hemorrhagic shock; however those lessons have not filtered down into actions taken on the ground. [3] Thus, it is critical that all providers in our trauma system understand and identify shock as well as treating shock with the most modern tools and techniques available. As a trauma system, we are incorporating this new **evidence-based science** into our guidelines. The following is a summary of what is now known and accepted about hemorrhagic shock and how best to treat it:

What are the priorities that should be applied by EMS and trauma centers?

Evaluation of the patient for hemorrhagic shock: Always assure the ABC's of trauma: airway, breathing, and circulation with a rapid, but careful primary assessment.[4]

Questions to ask:

1. **What is the blood pressure and pulse? What is the Shock Index? Is the patient in shock &/or not perfusing adequately?**
2. **If the patient is in shock: does the patient have a patent and adequate airway?**
3. **If there is a good airway, is the patient breathing and ventilating adequately?**
4. **Are there any many signs of obvious external bleeding? Are there penetrating wounds that could be causing shock? Have we applied tourniquets and direct pressure to control bleeding?**
5. **Assess and reassess for the presence of shock with the Shock Index**: The best indicator of hemorrhagic shock is the **shock index = pulse / systolic blood pressure**. [5] Patients not in shock should have a shock index of < 1. As the patient begins to bleed, the pulse rate will increase as one compensatory mechanism. When shock compensation fails, the systolic pressure will fall. Thus, as the patient worsens, the shock index will go from 0.6 to > 1.0, indicating that the patient is getting into trouble that must be quickly treated.

Shock Index Examples		
Pulse	Systolic Blood Pressure	Shock Index
80	120	0.67
100	120	0.83
120	100	1.20
130	100	1.30
140	80	1.75

6. **EMS: Reporting the vital signs, including the shock index, enroute on a regular basis will help the receiving Trauma Center appropriately respond and prepare for the patient's arrival**.
7. **Trauma Center: Use of the shock index in the ED will help quickly identify those patients needing massive transfusion and surgical intervention, and also detect patients who were initially stable but now are going into shock.** [6] [7]

9. **Make the decision early: Where is the best place for this patient to be?**

   Patients that have hemorrhagic shock need to be quickly transported to a trauma center that has the capability for 1) giving blood transfusions, including plasma and platelets, and 2) surgical intervention that can be applied to stop the bleeding process. Thus— EMS should use ATCC to decide the best trauma center for the patient to go to, even if it is not the closest hospital. Trauma centers without blood transfusion capability and general surgery capability should immediately begin the transfer process to the closest appropriate trauma center with those capabilities. ***Do not waste time with tests that will only delay transfer or by taking these patients to a hospital that cannot properly care for them.***
10. **Choose the proper IV fluid and amount to administer.** Avoid giving crystalloid fluids until blood, blood products are available, and patient is in a trauma center where immediate surgery is available to stop the bleeding. Modern therapy involves using permissive hypotension, restricting crystalloid fluids, and giving blood as soon as it is available (see below).
11. **Avoid hypothermia and correct it if present.** Patients cannot clot effectively if they are cold, thus hypothermia leads to more bleedings and more shock. Measure the patient's temperature and takes steps to warm the patient and keep them warm in the ED, OR, and during transport.

Are the patient's injuries critical enough for transport to a Trauma Center?

1. **Use the Arkansas Field Triage to determine the severity of injury.** Any patient with major trauma should be transported quickly to the most appropriate trauma center, and EMS providers should **contact ATCC for the location of the most appropriate (not closest) trauma center**:[8]
2. **The Shock Index > 1 is a good predictor that the patient is critically injured and will need blood transfusions and surgery.**
3. **It does the patient no good to waste time at a hospital that can't adequately care for them**. Hemorrhagic shock mortality increases for each minute that there is a delay in reaching blood transfusion and surgical capability. [7, 10] Transport of a patient to a hospital without a blood bank and general surgeons can be lethal to patients that are critically injured. Use ATCC to help get the patient to the closest appropriate hospital that can care for the patient.

Permissive Hypotension is appropriate treatment for patients in hemorrhagic shock before they arrive at a trauma center with general surgery and massive transfusion capability. It is part of Damage Control Resuscitation.

Multiple studies have shown that patients have better survival and need less blood transfusions if moderate hypotension is allowed rather than raising the pressure by giving crystalloid IV solutions. [1] [9] [10] [11] **Permissive hypotension is generally defined as maintaining a systolic blood pressure of around 90 mm. If a blood pressure cannot be measured (ex- battlefield or austere environments) then a good substitute is administering enough fluids to maintain a weak radial pulse and consciousness of the patient.**

"***Current tactical combat casualty care guidelines are straight forward and target on a systolic blood pressure of 90 mm Hg or even lower, as long as the victim is still awake during casualty evacuation care."***[12]

What about patients with Traumatic Brain Injury (TBI) and Permissive Hypotension?

Patients with traumatic brain injury (TBI) are an exception to the rule above, in that the blood pressure is allowed to rise to 90-100 mm systolic or 65 mean arterial pressure, to maintain cerebral perfusion status. In austere environments with no blood pressure cuff, for patients with TBI, resuscitate until the radial pulse is felt (as opposed to weakly felt for non-TBI patients)[2]

Damage control resuscitation [13] [14] combines permissive hypotension, restriction of IV crystalloid solutions with quick transport to the operating room to achieve control of hemorrhage. Avoiding hypothermia and acidosis are also key components of Damage Control Resuscitation to avoid worsening hypocoagulation. [1, 5, 15]

Principles of Damage-Control Resuscitation

Avoid or correct hypothermia
Apply direct pressure or a tourniquet proximal to sites of hemorrhage in the extremities; pack junctional wounds with hemostatic dressings
Delay fluid administration until the time of definitive hemostasis in selected patients (those with penetrating trauma to the torso and short prehospital transport times)
Minimize crystalloid infusions (<3 liters in the first 6 hr)
Use a massive-transfusion protocol to ensure that sufficient blood products are rapidly available
Avoid delays in definitive surgical, endoscopic, or angiographic hemostasis
Minimize imbalances in plasma, platelet, and red-cell transfusions in order to optimize hemostasis
Obtain functional laboratory measures of coagulation (e.g., by means of thromboelastography or rotational thromboelastometry) to guide the transition from empirical transfusions to targeted therapy-
Selectively administer pharmacologic adjuncts to reverse any anticoagulant medications and to address persistent coagulopathy medications and to address persistent coagulopathy

From Cannon, Jeremy W. "Hemorrhagic shock." New England Journal of Medicine 378, no. 4 (2018): 370-379. And--

Cannon, Jeremy W., Mansoor A. Khan, Ali S. Raja, Mitchell J. Cohen, John J. Como, Bryan A. Cotton, Joseph J. Dubose 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 and Acute Care Surgery 82, no. 3 (2017): 605-617

What do we now know about the proper use of crystalloid IV fluids (Ringer's Lactate, Normal Saline, etc.)?

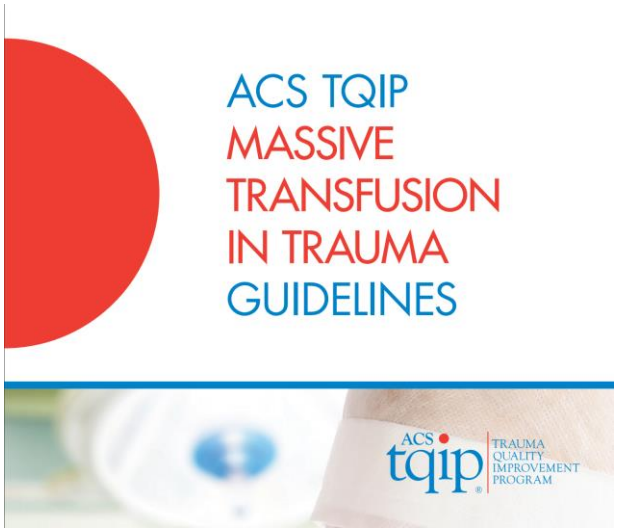
Research going from the 1990s began to question the use of crystalloids in the initial treatment of hemorrhagic shock. [16] Continued research since that time has supported the concept that the patient with hemorrhagic shock is best treated with Hypotensive Resuscitation techniques until they are at a trauma center that has the capability of 1) massive transfusion protocol; AND 2) capability to surgically explore the chest, abdomen, or extremities. **Raising the blood pressure before the patient is where bleeding can be actively stopped increases the mortality of patients with hemorrhagic shock.** Additionally, large doses of crystalloid solutions have been

shown to increase complications and increase coagulopathy in the bleeding patient. In 2014 the Committee on Tactical Combat Casualty Care dropped saline from the recommended fluid list for hemorrhagic shock resuscitation. [12]

Thus, large volumes of normal saline or Ringer's Lactate should be avoided. [17] [18] [19] [20] This means that buffered crystalloid solutions (Plasmalyte, etc.) should be used in small amounts (<500 ml) given to maintain the systolic blood pressure of ≤ 90 mm (see above for Permissive Hypotension).

Massive Transfusion Protocol (MTP) is the planning and preparation of a trauma center to administer blood products in a 1:1:1 ratio of PRBC, fresh frozen or liquid plasma, and platelets to replace blood lost to hemorrhage.

The ACS has recently published the TQIP Massive Transfusion in Trauma Guidelines [21] and the reader is directed to that excellent resource for trauma center based MTP protocols and guidelines.



https://www.facs.org/-/media/files/quality-programs/trauma/tqip/transfusion_guildelines.ashx

Use the Assessment of Blood Consumption (ABC) score to predict which patients are likely to need MTP

The ABC score was first introduced by Nunez and then later validated at three Level I academic trauma centers by Cotton. [22], [23] It predicts the need for 10 or more units of blood being given in the first 24 hours with a relatively high degree of accuracy. The ABC score performed as well other more complex scoring mechanisms and physician judgement as to which patients will need MTP. [24] And- the good news: both the ABC score and Shock Index were equal in being able to predict the need for massive transfusion and surgery. [25]

The ABC score is composed of four variables:

History of penetrating injury to the torso (chest or abdomen) = 1 point

Systolic BP ≤ 90 mm = 1 point

Heart Rate ≥ 120 = 1 point

Positive FAST exam = 1 point

A score of 2 or more = need for Massive Transfusion Protocol
Shock Index > 1 = need for Massive Transfusion Protocol

Use of Vasopressin in Hemorrhagic Shock

It is generally not advised to use vasopressors (Dopamine, Epinephrine, Levophed, etc.) for treatment of hemorrhagic shock. [26] [27]

However, recent research has shown promising benefits of using **Vasopressin** as an adjunct to Massive Transfusion Protocol blood products and prompt surgery to stop the bleeding. [28] Vasopressin acts differently than other vasopressors and is felt to help the body's compensation mechanisms for hemorrhagic and other forms of shock. Vasopressin has been shown to help support blood pressure and reduce the number of units of PRBCs for patients in hemorrhagic shock, and has been used in the pre-hospital as well as trauma center arena. Vasopressin is released by the pituitary in shock, but can be lost in the shed blood and diluted with transfusion products. Thus, replacement of normal levels of vasopressin will help the body achieve hemostasis and reverse hypotension in severe hemorrhagic shock. [29] [30]

Vasopressin dosage in hemorrhagic shock = 4 units arginine vasopressin IV followed by ≤ 0.04 u/ minute infusion, titrated to keep mean arterial pressure of 65 or greater.

Vasopressin should be given with the start of MTP and continued as a drip during surgery, resuscitation, etc. until the patient is stable.

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[1] Cosgriff NM, E.E. Sauaia, A. Kenny-Moynihan, M. Burch, J.M. Galloway, B. Predicting life-threatening coagulopathy in the massively transfused trauma patient: hypothermia and acidoses revisited. J Trauma 1997;42(5)(May):857-61.

[2] Butler, Frank K., John B. Holcomb, Martin A. Schreiber, Russ S. Kotwal, Donald A. Jenkins, Howard R. Champion, F. Bowling, Andrew P. Cap, Joseph J. Dubose, and Warren C. Dorlac. Fluid resuscitation for hemorrhagic shock in tactical combat casualty care: TCCC guidelines change 14-01-2 June 2014. ARMY INST OF SURGICAL RESEARCH FORT SAM HOUSTON TX, 2014.

[3] Dadoo, Sahil, Joseph M. Grover, Lukas G. Keil, Kay S. Hwang, Jane H. Brice, and Timothy F. Platts-Mills. "Prehospital fluid administration in trauma patients: a survey of state protocols." Prehospital Emergency Care 21, no. 5 (2017): 605-609.

[4] Up to Date: Prehospital care of the adult trauma patient 2019

[5] Spahn, Donat R., Bertil Bouillon, Vladimir Cerny, Jacques Duranteau, Daniela Filipescu, Beverley J. Hunt, Radko Komadina et al. "The European guideline on management of major bleeding and coagulopathy following trauma." Critical care 23, no. 1 (2019): 98.

[6] DeMuro, Jonas P., Susan Simmons, Judy Jax, and Scott M. Gianelli. "Application of the Shock Index to the prediction of need for hemostasis intervention." The American journal of emergency medicine 31, no. 8 (2013): 1260-1263.

[7] Mutschler, Manuel, Ulrike Nienaber, Matthias Münzberg, Christoph Wölfl, Herbert Schoechl, Thomas Paffrath, Bertil Bouillon, Marc Maegele, and TraumaRegister DGU. "The Shock Index revisited–a fast guide to transfusion

requirement? A retrospective analysis on 21,853 patients derived from the TraumaRegister DGU®." Critical care 17, no. 4 (2013): R172.
[8] Arkansas Trauma Triage Protocol: https://www.healthy.arkansas.gov/images/uploads/FieldTriageDecisionScheme.pdf
[9] Cannon, Jeremy W. "Hemorrhagic shock." New England Journal of Medicine 378, no. 4 (2018): 370-379.
[10] Rossaint, Rolf, Bertil Bouillon, Vladimir Cerny, Timothy J. Coats, Jacques Duranteau, Enrique Fernández-Mondéjar, Daniela Filipescu et al. "The European guideline on management of major bleeding and coagulopathy following trauma." Critical care 20, no. 1 (2016): 100.
[11] Albreiki, Mohammed, and David Voegeli. "Permissive hypotensive resuscitation in adult patients with traumatic haemorrhagic shock: a systematic review." European Journal of Trauma and Emergency Surgery 44, no. 2 (2018): 191-202.
[12] Butler FK Jr, Holcomb JB, Giebner SD, McSwain NE, Bagian J. Tactical combat casualty care 2007: evolving concepts and battlefield experience. Mil Med. 2007;172:1–19.
13 Fisher, Andrew D., Ethan A. Miles, Andrew P. Cap, Geir Strandenes, and Shawn F. Kane. "Tactical damage control resuscitation." Military medicine 180, no. 8 (2015): 869-875.
[14] Cannon, Jeremy W., Mansoor A. Khan, Ali S. Raja, Mitchell J. Cohen, John J. Como, Bryan A. Cotton, Joseph J. Dubose 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 and Acute Care Surgery 82, no. 3 (2017): 605-617.
[15] Holcomb, John B., Erin E. Fox, Charles E. Wade, and PROMMTT Study Group. "The PRospective observational multicenter major trauma transfusion (PROMMTT) study." Journal of Trauma and Acute Care Surgery 75 (2013): S1-S2.
[16] Bickell, William H., Matthew J. Wall Jr, Paul E. Pepe, R. Russell Martin, Victoria F. Ginger, Mary K. Allen, and Kenneth L. Mattox. "Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries." New England Journal of Medicine 331, no. 17 (1994): 1105-1109.
[17] Bouglé, Adrien, Anatole Harrois, and Jacques Duranteau. "Resuscitative strategies in traumatic hemorrhagic shock." Annals of intensive care 3, no. 1 (2013): 1-9.
[18] Cherkas, David. "Traumatic hemorrhagic shock: advances in fluid management." Emerg Med Pract 13, no. 11 (2011): 1-19.
[19] Häske, David, Lance Stuke, Michael Bernhard, Axel R. Heller, Uwe Schweigkofler, Bernhard Gliwitzky, and Matthias Münzberg. "Comparison of the Prehospital Trauma Life Support recommendations and the German national guideline on treatment of patients with severe and multiple injuries." Journal of Trauma and Acute Care Surgery 81, no. 2 (2016): 388-393.
[20] Cotton, Bryan A., Rebecca Jerome, Bryan R. Collier, Suneel Khetarpal, Michelle Holevar, Brian Tucker, Stan Kurek et al. "Guidelines for prehospital fluid resuscitation in the injured patient." Journal of Trauma and Acute Care Surgery 67, no. 2 (2009): 389-402.
[21] https://www.facs.org/-/media/files/quality-programs/trauma/tqip/transfusion_guildelines.ashx
[22] Nunez TC, Voskrensensky IV, Dossett LA, Shinall R, Dutton WD, Cotton BA. Early Prediction of Massive Transfusion in Trauma: Simple as ABC (Assessment of Blood Consumption)? The Journal of Trauma: Injury, Infection, and Critical Care. 2009; 66: 366-352.
[23] Cotton BA, Dossett LA, Haut ER, Shafi S, Nunez TC, Au BK, Zaydfudi V, Johnston M, Arbogast P, Young PP. Multicenter Validation of a Simplified Score to Predict Massive Transfusion in Trauma. Journal of Trauma: Injury, Infection, and Critical Care. 2010; 69: S33-S39.
[24] Pommerening MJ, Goodman MD, Holcomb JB, Wade CE, Fox EE, del Junco DJ, Brasel KJ, Bulger EM, Cohen MJ, Alarcon LH, Schreiber MA, Myers JG, Phelan HA, Muskat P, Rahbar M, Cotton BA. Clinical gestalt and the prediction of massive transfusion after trauma. Injury. 2015; 46: 807-813.
[25] Schroll R, Swift D, Tatum D, Couch D, Heaney JB, Llado-Farrulla M, Zucker S, Gill F, Brown G, Buffin N. Shock index versus ABC score to predict need for massive transfusion in trauma patients. Injury. 2017; 49 (1): 15-19.
[26] Hylands, Mathieu, Augustin Toma, Nicolas Beaudoin, Anne Julie Frenette, Frédérick D'Aragon, Émilie Belley-Côté, Emmanuel Charbonney et al. "Early vasopressor use following traumatic injury: a systematic review." BMJ open 7, no. 11 (2017): e017559.

[27] Gauss, T., S. Hamada, F. X. Duchateau, M. Eurin, J. Mantz, and C. Paugam-Burtz. "Prehospital use of norepinephrine does not reduce total amount of prehospital fluid in hemorrhagic shock." In Intensive care medicine, vol. 37, pp. S151-S151. 233 SPRING ST, NEW YORK, NY 10013 USA: SPRINGER, 2011.

[28] Voelckel, Wolfgang G., Victor A. Convertino, Keith G. Lurie, Alois Karlbauer, Herbert Schöchl, Karl-Heinz Lindner, and Helmut Trimmel. "Vasopressin for hemorrhagic shock management: revisiting the potential value in civilian and combat casualty care." Journal of Trauma and Acute Care Surgery 69, no. 1 (2010): S69-S74.

[29] Martin, Matthew J. "Vasopressin as an Early Adjunct to Resuscitation in Hemorrhagic Shock: Crisis AVERTed?." JAMA surgery (2019).

[30] Sims, Carrie A., Daniel Holena, Patrick Kim, Jose Pascual, Brian Smith, Neils Martin, Mark Seamon et al. "Effect of low-dose supplementation of arginine vasopressin on need for blood product transfusions in patients with trauma and hemorrhagic shock: a randomized clinical trial." JAMA surgery (2019).