Resuscitation for Hypovolemic Shock

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KEYWORDS

• Hemorrhagic shock • Trauma • Coagulopathy • Damage control resuscitation
• Massive transfusion • Visoelastic hemostatic assays

KEY POINTS

- Massive hemorrhage in trauma causes inadequate tissue perfusion and coagulopathy.
- Early transfusion with balanced ratios of blood products results in improved coagulation profiles, less product and transfusions improved outcomes in trauma patients requiring massive transfusion.
- Damage control resuscitation for patients in hemorrhagic shock results in decreased morbidity and improved survival.
- Monitoring coagulation and basing resuscitation on visoelastic hemostatic assays results in decreased transfusions and improved survival.

INTRODUCTION: HISTORY OF HEMORRHAGIC SHOCK RESUSCITATION

The term "shock" originates from "choc," which was coined by French surgeon Henri François Le Dran in the eighteenth century to describe the destructive impact of gunshot.[1] It subsequently evolved to signify the suddenly worsening condition that can ensue after major trauma. In modern medical literature, shock denotes a lack of end-organ perfusion, which can result from multiple etiologies, but hemorrhage is the cause of acute hypovolemic shock resulting from nonburn trauma.

The first recorded human blood transfusion occurred in 1819,[2] but its use did not become common until almost 100 years later when the discovery of blood types[3] and development of techniques to crossmatch blood[4] allowed for widespread use. Crystalloid became the standard resuscitation fluid used for hemorrhagic shock in the nineteenth and early twentieth centuries[5–7] because of its availability and safety. However, with the high volume of severely injured combatants encountered during

Disclosure Statement: Dr B.A. Cotton has served as a consultant for Haemonetics Corporation, Braintree, MA, makers of TEG thromboelastogram. Dr K.J. Kalkwarf has no disclosures or conflicts.

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Surg Clin N Am 97 (2017) 1307–1321
http://dx.doi.org/10.1016/j.suc.2017.07.011
0039-6109/17/Published by Elsevier Inc.

World War I (WWI), Allied physicians soon that realized crystalloid transfusions resulted in "unsatisfactory" results because of dilution.[8] They preferred using limited whole-blood transfusions to maintain a low blood pressure and rewarming the patient.[9] This became the standard of care for resuscitation for the last 8 months of the Great War.[10] WWII physicians described similar practices of giving enough whole blood to achieve a systolic blood pressure of 85 mm Hg, along with appropriate skin color and warmth, while working to quickly stop bleeding.[11,12] They also used transfusions of recently developed reconstituted dried plasma to maintain blood pressure while preparing whole blood.[13]

By the time of the Vietnam War, there was a renewed interest in crystalloid administration based on subsequently refuted basic science[14,15] and animal models[16–19] of hemorrhage shock that showed improved survival from infusing Ringer lactate (LR) before whole-blood transfusion. As a result, trauma patients began receiving increasing quantities of crystalloid. Simultaneously, new blood fractionation techniques were being developed that allowed for whole blood to be separated into units of red blood cells (RBCs), plasma, and platelets. The ability to treat multiple patients with one unit of whole blood and the risk of hepatitis[20,21] associated with plasma at that time prompted medical leaders and groups[22,23] to advocate for specific component blood therapy for all transfusions despite no rigorous studies demonstrating the effects of such therapy in massively bleeding patients.[24,25] Although some studies performed at that time suggested "noninferiority in elective surgical cases," not a single study showed hemostatic potential in bleeding patients. Blood bankers demonstrated that they could administer component therapy safely, not necessarily that they should.

Trends away from whole-blood transfusions and toward large-volume crystalloid and RBC resuscitation continued throughout the last three decades of the twentieth century as a result of studies that said LR and more than six units of RBCs could be used without causing coagulopathy,[26] and others saying it was not important to augment blood transfusions with plasma[27,28] or platelets[29] unless there was clinical or laboratory coagulopathy. Another study declaring that it was safe to administer 2 L of crystalloid while waiting for blood[30] was widely propagated when it was adopted by the Advanced Trauma Life Support course.[31] Often forgotten is that these studies were conducted in patients receiving whole blood rather than RBCs and LR, as had become the standard practice in some busy trauma centers as early as the mid-1970s.[32] Concerns about human immunodeficiency virus transmission[33,34] and goals of therapy targeting "supranormal" resuscitation[35–40] led to continued propagation of transfusing large volumes of only crystalloid and RBCs during the 1980s and 1990s despite new tests making blood transfusions safe and large multicenter trails that showed no survival advantage to supranormal resuscitation.[41,42]

When examined critically, large-volume transfusion strategies resulted in increased morbidity including decreased intestinal perfusion along with increased abdominal compartment syndrome, cardiopulmonary dysfunction, multiple organ dysfunction, and death.[43–45] At the same time, coagulopathy was being identified in severely injured patients, independent of resuscitation,[46–48] and was found to be associated with increased mortality.[47,49,50] As a result, military surgeons returned to resuscitation techniques attempting to replicate the whole blood used in previous wars by including high ratios of plasma and platelets to RBCs. Results from data collected during conflicts in Afghanistan and Iraq showed that patients who received high ratios of plasma to RBCs had improved survival compared with those who received lower ratios.[51] As a result, the military developed damage control resuscitation (DCR) to reduce blood loss and coagulopathy. DCR is focused on limiting crystalloids, delivering whole blood or