The Evolving Science of Trauma Resuscitation

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KEYWORDS

• Trauma resuscitation • Hypovolemia • Trauma-induced coagulopathy
• Viscoelastic hemostatic assays • Endothelial damage • Hemostasis

KEY POINTS

- Future research should inform clinicians on the role of permissive hypovolemia, for how long this should be maintained, and how/if this should be applied to patients with traumatic brain injury.
- Our understanding of trauma-induced coagulopathy (TIC) is evolving and may see targeted blood component therapy incorporated early in trauma shock resuscitation.
- The role of viscoelastic hemostatic assays in assessing TIC and directing blood component resuscitation requires further study.
- There is increasing understanding of endothelial damage as a driver of TIC, raising the possibility of targeting repair to improve hemostasis and reduce organ failure.
- More work is required to identify the most appropriate goals for posthemostasis resuscitation balancing the risks of fluid overload and underresuscitation.

INTRODUCTION

The 2 leading causes of death after trauma are blood loss and neurologic injury, which account for more than three-quarters of injury related mortality.[1] Fifty percent of early deaths (<24 hours from injury) are due to hemorrhage, with hemorrhagic shock an important driver for postresuscitation organ failure and late mortality.[1–3] There has been a considerable improvement in our understanding of trauma resuscitation over the past 30 years, particularly in hemorrhage control and trauma resuscitation, seeing outcomes steadily improve. However, blood loss remains a leading cause of preventable death in the initial 24 hours of hospital admission.[4]

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This review summarizes the evolution of trauma resuscitation, offering clinicians the knowledge base to enable the highest standards of clinical care. Trauma resuscitation has evolved from a one-size-fits-all approach to one tailored to patient physiology. The most dramatic change is in the management of patients who are actively bleeding, with a balanced blood product–based resuscitation approach (avoiding crystalloids) and surgery focused on hemorrhage control, not definitive care. The key components of this "damage control resuscitation (DCR)" approach are (1) hemorrhage control, (2) permissive hypotension/hypovolemia, and (3) the prevention and correction of trauma-induced coagulopathy (TIC). When hemostasis has been achieved, definitive resuscitation to restore organ perfusion is initiated. This DCR strategy prioritizes TIC, temporarily sacrificing perfusion for haemostasis.[5] This approach is associated with a decrease in mortality, reduced duration of stay in intensive care and hospital, improved coagulation profile, and reduced crystalloid/vasopressor use. There are many areas of trauma resuscitation that remain controversial and subject to ongoing research, such as patients with concomitant traumatic brain injury (TBI), environments with limited access to blood products, and the optimal diagnostic and therapeutic approaches to treating coagulopathy. In this article, we focus on the tools and methods used for trauma resuscitation in the acute phase of trauma care (**Box 1**).

HEMORRHAGE CONTROL

The most effective resuscitation fluid is our patients' own blood; thus, preserving circulating volume and minimizing blood loss is a key component of trauma resuscitation. Strategies include minimal handing, direct pressure on wounds, early and accurate fracture splinting, and rapid surgical or radiologic hemorrhage control.[16]

The management of bleeding patients has 2 aims—to arrest bleeding and to restore blood volume—and is recognized as the single most important step in the management of the severely injured patient.[17] Hemorrhage can be compressed by applying direct pressure to the site or using tourniquets, but there are certain anatomic regions (groin, axilla, neck) that prove difficult for standard tourniquet use. Junctional tourniquets (for injuries in the inguinal and axillary regions) and hemostatic dressings have been developed to control proximal bleeding, but there are few data on their effectiveness, with studies mainly from combat-related case series.[18] A number of different devices and interventions have been developed in an attempt to reduce the morbidity and mortality associated with noncompressible torso hemorrhage, with military campaigns driving forward innovation in this field. Devices such as tourniquets and splints are used alongside interventions, such as resuscitative endovascular balloon occlusion of the aorta to preserve circulating volume until definitive surgical treatment can be undertaken.

THE RECOGNITION OF SHOCK AND ACTIVE BLEEDING

All patients need to be resuscitated from shock and have normal organ perfusion restored. However, in trauma patients who are actively bleeding, attempts to restore

Box 1
Damage control resuscitation strategy

Permissive hypotension[6,7]

Early empiric use of red blood cells and clotting products[4,8–14]

Limited fluids that may dilute coagulation proteins[15]