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Damage Control Resuscitation

COL John B. Holcomb, MD, FACS

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While the vast majority of bleeding trauma patients who arrive in emergency departments are either hypercoagulable or only slightly injured with normal coagulation parameters, a small segment of trauma patients (~10%) are hypocoagulable. This small segment of severely injured patients comprises the majority of in-hospital trauma deaths. They are frequently hypothermic with acidosis and hypothermia-induced coagulation factor and platelet dysfunction, combined with coagulation factor consumption, and culminating in a profound coagulopathy. The most severely injured are more coagulopathic. Though it has long been recognized that the lethal triad of hypothermia, acidosis and coagulopathy is associated with a significant increase in mortality,[1] coagulopathy has been viewed as a byproduct of resuscitation, hemodilution and hypothermia. We know now that coagulopathy is in fact present on admission.

Current resuscitation practice focuses primarily on rapid reversal of acidosis and prevention of hypothermia while concurrent surgical interventions focus on controlling hemorrhage and contamination. Thus, early treatment of coagulopathy has been relatively ignored. Standard resuscitation methods are an appropriate policy for the ~90% of trauma patients who are not in shock and are hypercoagulable after injury.[2,3] However, for the 10% of patients who constitute the most seriously injured, are in shock, and coagulopathic, *liquid plasma* has been identified as the best resuscitation fluid.[4–8] Unfortunately, clinicians are still being taught to never use plasma as a resuscitation fluid.[9]

Recent studies have shown that 1) the coagulopathy of trauma is present at a very early stage after injury,[5,6,10–12] 2) Ringer's lactate and normal saline increase reperfusion injury and leukocyte adhesion,[13–17] 3) increased transfusion is associated with increased risks,[18–20] and 4) massive transfusion in military and civilian casualties are associated with an increased risk of death.[21–23] Taken together, these observations suggest that the most severely injured patients will likely benefit from a new resuscitation strategy focused on optimal timing and modulation of the metabolic, inflammation and coagulation pathways.

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Over the last 4 years I have served as a consultant and surgeon in military surgical facilities in Iraq. Based on 1) previous civilian clinical studies, 2) the recommendations of an international consensus conference on early massive transfusion for trauma,[24] and 3) the cumulative experience of medical experts in the current war, we now believe it is possible to rapidly identify patients at high risk for coagulopathy at admission and promptly, aggressively and simultaneously treat hypothermia, acidosis and coagulopathy. The technique to achieve this, developed by clinicians in theater and known as "damage control resuscitation," addresses the entire lethal triad immediately upon admission in concert with aggressive hemostatic interventions. Damage control resuscitation as a structured intervention currently begins immediately after rapid initial assessment in the emergency department and progresses through the OR into the ICU. By repeated point of care testing, commercial warming devices and the use of multiple blood products and FDA-approved drugs readily available in theater, (albeit in new ratios and amounts), all efforts are directed toward normalizing the INR, base deficit and temperature. Compared with civilian damage control surgery patients, resuscitation efforts are largely completed in the OR, with little resuscitation required in the ICU. Achieving this goal quickly in the OR may ultimately allow a shift from limited damage control surgery to earlier aggressive surgical interventions, including sophisticated limb salvage techniques and improved outcomes.

Damage control resuscitation consists of two parts and is initiated within minutes of arrival in the emergency department. First, resuscitation is limited to keep blood pressure at ~90 mm Hg, preventing renewed bleeding from recently clotted vessels.[16,17,25–31] Second, intravascular volume restoration is accomplished by using thawed plasma as a primary resuscitation fluid in at least a 1:1 ratio with PRBCs.[32–34] Recombinant FVIIa is used along with the very first units of red cells and plasma and as required throughout the resuscitation.[35] For casualties who will require continued resuscitation, the blood bank is notified to activate the massive transfusion protocol. This protocol results in the delivery of 6 units of plasma, 6 units of PRBCs, 6 packs of platelets and 10 units of cryoprecipitate stored in individual coolers.[33] Finally, for the most severely injured, fresh warm whole blood from the walking blood bank is used as a primary resuscitative fluid.[36,37] Crystalloid use is significantly limited and serves mainly as a carrier to keep lines open between the units of blood products.[38]

Progress in trauma care requires continuous improvement in everyday patient management, based on good clinical studies. Many of our most basic trauma care principles (the ABCs) are founded on tradition rather than evidenced-based best practice, leading us to frequently question the status quo. Current resuscitation practices of severely injured patients fall into this category. As in past wars, observation, discussion, analysis and recommendations from experienced military medics, nurses, physicians and scientists together with our civilian trauma colleagues will provide the basis for new medical practice, grounded in appropriate and relevant pre-clinical and human studies. Further experience, research and development will generate new information and ongoing modifications.[39,40]

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