Hemostatic Resuscitation

by Louis Alarcon, MD

Trauma resuscitation practices have changed substantially over the last two decades. In the past, the goal was to normalize blood pressure as quickly as possible. Starting in the field and continuing in the trauma bay, clinicians infused large volumes of crystalloids before surgical hemostasis had been achieved. Transfusion of blood products was started relatively late, while plasma and platelets were administered even later. Dilutional anemia and coagulopathy were relatively common. Patients with large-volume blood loss often died from what was termed “the bloody vicious cycle” of hypothermia, acidosis, and coagulopathy. Excessive administration of crystalloids also led to the development of acute lung injury and compartment syndromes, in addition to worsening acidosis and coagulopathy.

Experience and research from civilian trauma centers and the military have changed this paradigm. Surgical techniques of damage control were described and incorporated into clinical practice. Damage control surgery is defined as abbreviated initial surgery to control life-threatening bleeding and contamination, followed by correction of physiologic abnormalities and subsequent definitive surgical management. In addition, the use of permissive hypotension until surgical control of hemorrhage was proved to be an effective strategy in two randomized control trials. This is now widely practiced in many trauma systems, particularly in patients who do not have associated brain or spinal cord injuries.

The concept of hemostatic resuscitation also has been studied extensively. The notion of approximating whole blood by giving plasma, platelets, and packed red blood cells (PRBCs) early in the course of treating massively bleeding trauma patients makes sense intuitively. Data from the military certainly supports this concept. A number of recent retrospective civilian studies support the efficacy of hemostatic resuscitation. Holcomb et al., reported a multicenter trial in 16 Level 1 trauma centers. Patients who received high plasma and high platelet transfusion ratios had significantly increased survival rates. In addition, those who died were significantly less likely to die from truncal hemorrhage.

At UPMC, our massive transfusion protocol addresses these issues. In addition to advocating the early surgical control of hemorrhage, minimizing infusion of crystalloids, and preventing hypothermia, we advocate starting with a 1:1:1 plasma:platelets:PRBC transfusion ratio in trauma patients expected to require massive transfusion (defined as (Continued on Page 5)
Historically, open fracture was considered both a limb- and life-threatening condition. During the American Civil War, a staggering mortality rate of 30 percent was reported after open fracture was sustained. Death was typically linked to sepsis. Fortunately, in the modern era, advancements in emergency medical services, critical care medicine, antibiotic therapy, and surgical technique have made limb-salvage surgery a distinct possibility even in the sickest patient with a mangled limb. Nevertheless, complications, both systemic and local, continue to be associated with these severe orthopaedic injuries.

Open fracture is characterized as a break in the bone that communicates with an overlying skin defect. Frequently, there is significant tissue death, including skin, subcutaneous tissue, muscle, and bone within the zone of injury (Figure 1). A vast majority of open fracture cases are the result of high-energy trauma. Associated injuries to the head, chest, abdomen, and musculoskeletal systems are commonplace.

Considering the limb- and potentially life-threatening nature of open fracture, a multidisciplinary approach to care is necessary to optimize outcomes. Communication between the medical professionals involved is essential to provide efficient and effective care.

In 1984, Gustillo and Anderson devised the most widely utilized classification system for open fractures. Both the severity of

Figure 1: High-energy open tibia fracture (Grade 3B) with massive bone defect and extensive trauma to adjacent soft tissue envelope.

Figure 2: Successful limb salvage for open tibia fracture, which required free flap coverage.
fracture and associated insult to the musculoskeletal envelope are taken into consideration. Fractures are classified with a scale of 1 through 3. For example, simple cuts over broken bone are defined as Grade 1, while severe open fractures that will require muscle transfer are assigned Grade 3B (Figure 2). Open fracture with vascular injury is considered a Grade 3C lesion.

Optimal care of the patient with open fracture starts in the field. Emergent care should consist of resuscitation of vasomotor instability, protection of the wound, and immobilization of the fractured extremity. The wound should be covered with a sterile, moist pressure dressing. The dressing should provide complete coverage of the wound to prevent further contamination of the fracture site, and to provide some compression to limit associated bleeding. A tourniquet should not be applied unless life-threatening bleeding is present, because it will significantly worsen ischemia to the injured limb and threaten its ultimate viability. Immobilization of the fractured extremity is a must. Fracture stabilization will stop the cycle of injury to the already traumatized limb, limit bleeding, and protect vital neurovascular structures.

The next step is expeditious transfer to a trauma center for definitive care. High-grade open fractures should receive operative debridement and bony stabilization within six hours of the time of injury. Unnecessary delays increase the rate of complications, such as infection, osteomyelitis, nonunion, and necessity of amputation.

Once the patient has arrived at the trauma center, the emergency medicine and trauma surgery services will perform primary and secondary assessments while resuscitating the patient in anticipation of orthopaedic intervention. Essential emergency room treatment should consist of antibiotic therapy and tetanus prophylaxis. Parenteral antibiotics as an adjunct to operative debridement have been proved to decrease the subsequent risk of infection. In general, Grade 1 and 2 injuries require a first-generation cephalosporin, while Grade 3 open fractures require the addition of an aminoglycoside, such as gentamicin. Severely contaminated farm wounds require penicillin in addition.

Focused evaluation of the injured extremity includes mechanism of injury, understanding pre-existing medical comorbidities, and physical and radiographic exams. Specifically, the extremity should be evaluated for concomitant compartment syndrome and neurovascular injury. Optimal radiographic examination includes the joints above and below the open fracture. If the fracture involves a joint, consideration is given to obtain a preoperative CT scan. If compartment syndrome is suspected, pressure measurements can be used to supplement the physical exam, especially in the obtunded patient. Occult vascular injury can be diagnosed with an ankle brachial index exam.

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Open Fracture (Continued from Page 3)

Open fracture constitutes a surgical urgency. The paradigm of orthopaedic care consists of irrigation and excisional debridement, followed by skeletal stabilization. All devascularized tissues within the zone of injury — including skin, subcutaneous tissue, muscle, and bone — are excised. Failure to remove dead tissue is the leading cause of treatment failure, resulting in eventual infection, osteomyelitis, and limb loss. Fasciotomy is of critical benefit when compartment syndrome is diagnosed.

Fracture stabilization is dependent on anatomic location and break pattern, but in general, internal or external fixation is performed (Figures 3 and 4). The type of closure rendered for the traumatic wound depends on the level of energy imparted to the limb from the initial injury. Grade 3B injuries with soft tissue defect will require plastic surgery coverage, typically after interval negative pressure wound therapy. Grade 1 and 2 injuries may be closed primarily if debridement is adequate.

Patients who achieve limb salvage after open fracture are typically grateful for the heroic effort. However, complications are not uncommon despite proper treatment. In the most severe open fractures, nonunion and deep infection rates are reportedly as high as 18 and 25 percent, respectively.

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References

Figure 4: Innovative definitive management of open talus fracture with custom internal metal prosthesis.
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the requirement of 10 or more units of PRBCs in the first 24 hours after injury). However, we do not wait to reach the 10th unit of PRBC to begin infusing plasma and platelets. Instead, we employ the Assessment of Blood Consumption (ABC) score to predict the need for massive transfusion in trauma patients.6 The massive transfusion protocol is then activated and blood products given in a 1:1:1 ratio if the patient meets two or more of the ABC criteria: penetrating mechanism, positive focus abdominal sonography for trauma (FAST), SBP < 90 mm Hg, or heart rate > 120 bpm.

In addition, a recent, large randomized control trial of trauma patients deemed to be at risk of significant bleeding demonstrated that all-cause mortality was reduced in patients who received tranexamic acid (TXA, an antifibrinolytic agent) compared with controls.7 Based on this data, we administer TXA to all trauma patients with SBP < 90 mm Hg, heart rate > 110 bpm, or both; and who require at least one unit of PRBC. The dose of TXA is a 1 g bolus over 10 minutes, followed by an infusion of 1 g over eight hours. TXA administration should begin within three hours of injury. Future investigation may indicate whether TXA should be carried by EMS crews and administered in the field or en route to a trauma center for injured patients deemed to be at risk of bleeding.

The use of other products (such as cryoprecipitate or calcium) is at the discretion of the resuscitation team and as indicated by clinical hemostasis indicators and laboratory data. We use thromboelastography (TEG) and other conventional coagulation parameters during resuscitation and in the operating room as endpoints of hemostatic resuscitation. The advantage of TEG is that it is a global measurement of the entire clotting and coagulation systems, and the results are available in minutes (unlike prothrombin time, international normalize ratio, and partial thromboplastin time, which can take 45 minutes or longer to acquire).

Furthermore, based on the CONTROL trial,8 we no longer routinely use activated factor VIIa in bleeding trauma patients. In the non-head-injured patient, there is now little evidence to support the routine use of factor VIIa to treat or prevent coagulopathy after trauma.

There is little question that hemostatic resuscitation has changed the way that many trauma centers practice. Ongoing research is exploring the use of freeze-dried plasma products or purified protein concentrates that contain variable amounts of coagulation factors. These products are potentially safer than plasma from an infectious perspective, can correct clotting factor deficiency faster than plasma without inducing volume overload, and are logistically appealing, given they do not require refrigerator for storage and can be reconstituted and administered quickly in the ED, OR, ICU, and even perhaps in the prehospital setting.

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References
The 20-Second Shout-Out for Trauma

by Adam Z. Tobias, MD, MPH

Comprehensive care for trauma patients begins at the scene of the accident. As the first medical responders to make contact with the patient, EMS providers possess unique information about the scene, the mechanism of injury, and the patient’s medical condition and history. Transmission of this information to the trauma team in the hospital is critical for patient care. At the same time, the trauma team often must balance a desire to rapidly receive this crucial information with a need to continue patient resuscitation in a timely manner.

Adapting a model used in the Israeli trauma system, UPMC emergency physicians, trauma surgeons, and the Division of Prehospital Care have collaborated to develop the 20-Second Shout-Out for Trauma. The purpose of this model is to allow for the rapid transmission of critical information from EMS providers to the trauma team, while at the same time allowing the team to continue patient resuscitation efforts begun in the field.

In addition to applying a structured format to standardize verbal EMS reports, the initiative creates a specific framework for the transition of care between EMS and trauma. The Shout-Out report consists of:

1. Age, gender, mechanism of injury, time of event
2. Prehospital vital signs: heart rate, blood pressure, O₂ sat
3. Injuries
4. Prehospital interventions
5. Changes in patient status: any LOC, hypotension?
6. Past medical history, allergies, meds, blood thinners

Upon arrival in the trauma bay, the trauma team leader performs a primary survey (ABCs) with the patient still on the EMS stretcher. The EMS crew chief then gives the verbal Shout-Out while the patient is transferred to the hospital bed. This allows the essential aspects of the report to be given without interruption by members of the trauma team.

The 20-Second Shout-Out has been successfully implemented at each adult UPMC Trauma Center. An educational program has been undertaken by UPMC Prehospital Care and UPMC emergency physicians at regional lectures, and by trauma physicians for the trauma surgeons and house staff. This collaborative effort underscores the importance of continuity of care between the field and hospital providers, and the UPMC trauma system’s dedication to continually improving the care of trauma patients.

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