Advanced Trauma Life Support® (ATLS®) Update: What Every Anesthesiologist Should Know

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Learning Objectives:
As a result of completing this activity, the participant will be able to
- Describe the content changes in the most recent edition of Advanced Trauma Life Support®
- Explain the role of the anesthesiologist in treating traumatic injury
- Describe the goals of care and appropriate interventions for the most critically injured patients

Author Disclosure Information:
Dr. McCunn has disclosed that she has no financial interests in or significant relationship with any commercial companies pertaining to this educational activity.

THE BURDEN OF INJURY

Trauma is the third leading cause of death in the United States and the leading cause of death in patients under the age of 44 years. One person dies from injury every 3 minutes (Supplemental Digital Content 1, http://links.lww.com/ASA/A489). The Centers for Disease Control and Prevention reports that falls are now the leading cause of all traumatic injury, because of the aging population, followed by motor vehicle collisions and penetrating trauma. Violent trauma, including assaults firearm injuries, and suicides, are increasing. Deaths due to homicide from gun violence are rising, specifically in African American men and in metropolitan areas.

The risk of death after injury is significantly lower when patients are treated at trauma centers compared with nontrauma hospitals. This is in part due to the 24/7 staffing of experts in the field of trauma care. Anesthesiologists are key partners in the resuscitation, operative management, and intensive care of the injured.

THE BURDEN OF INJURY

Many patients require multiple trauma-related operative procedures during their initial resuscitation that are performed by the trauma service (e.g., “damage control” with multiple returns to the operating room [OR] for staged abdominal closure). Other patients undergo multiple procedures by different services, all related to their initial surgery (i.e., decompressive craniotomy or spinal stabilization, ocular repair for globe rupture, fasciotomy, fracture fixation, tracheostomy/percutaneous gastrostomy...
tube, skin grafts). Expertise in acute and chronic pain management, including provision of regional anesthesia, has unique and clearly beneficial effects for patients after trauma. After their initial injury, many other trauma patients are readmitted for further procedures when swelling has decreased in the surgical field (i.e., repair of pilon fracture of the ankle or facial fracture repair). Anesthesiologists who do not work at major trauma centers may also care for these patients at later stages of recurrent hospitalizations and surgical procedures.

A 2010 survey by the American Society of Anesthesiologists (ASA) asked practitioners to describe their trauma care practices. Approximately 2,000 US anesthesiologists replied that they care for trauma patients. Demographics of participants in this study are presented in Table 1. The sample was representative of all regions of the United States and from levels I, II, and III trauma centers.

**BACKGROUND**

*History of Advanced Trauma Life Support*®

In 1976, orthopedic surgeon Dr. James Styner and his family crashed in their plane in rural Nebraska. His wife was killed instantly, three of their children sustained critical injuries, and he sustained serious injuries. The medical care that he and his family subsequently received was deemed inadequate by the day’s standards. Recognizing how ineffectual their treatment had been, Dr. Styner stated: “When I can provide better care in the field with limited resources than what my children and I received at the primary care facility, there is something wrong with the system and the system has to be changed.” This identified need for training in trauma care led to the creation of Advanced Trauma Life Support® (ATLS®): a new approach to the provision of care for individuals who suffer major, life-threatening injury. The first course was introduced in 1978.®

**Approach to the Patient**

In direct contrast to the approach to illness that is traditionally taught in medical school (extensive history taking, complete physical examination, differential diagnosis, and confirmatory tests), ATLS espouses three underlying concepts:

- Treat the greatest threat to life first.
- The lack of a definitive diagnosis should never impede the application of an indicated treatment.
- A detailed history is not essential to begin the evaluation and treatment of a patient with acute injuries.

These concepts were difficult for clinicians to accept; the result was the development of the “ABCDE” approach to the evaluation and treatment of injured patients. The mnemonic defines the specific, ordered evaluations and interventions that should be followed in all injured patients:

- Airway with cervical spine protection.
- Breathing.
- Circulation with hemorrhage control.
- Disability or neurological status.
- Exposure (undress) and Environment (temperature control).

**Course Content**

ATLS® incorporates didactic teaching with skills stations in an intensive 2-day course. The content includes: initial assessment and management, airway and ventilatory management, shock, thoracic trauma, abdominal and

<table>
<thead>
<tr>
<th>Categories</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide anesthetic care for mildly, moderately, or severely injured trauma patients</td>
<td>2,058</td>
</tr>
<tr>
<td>Work in a designated trauma hospital (%)</td>
<td>Level I</td>
</tr>
<tr>
<td></td>
<td>Level II</td>
</tr>
<tr>
<td></td>
<td>Level III</td>
</tr>
<tr>
<td>Type of practice (%)</td>
<td>Academic</td>
</tr>
<tr>
<td></td>
<td>Government</td>
</tr>
<tr>
<td></td>
<td>Military</td>
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<tr>
<td></td>
<td>Private</td>
</tr>
<tr>
<td></td>
<td>University</td>
</tr>
<tr>
<td>Location of hospital (%)</td>
<td>Urban</td>
</tr>
<tr>
<td></td>
<td>Suburban</td>
</tr>
<tr>
<td></td>
<td>Rural</td>
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<tr>
<td>Region of the United States (%)</td>
<td>Northeast</td>
</tr>
<tr>
<td></td>
<td>Northwest</td>
</tr>
<tr>
<td></td>
<td>Southeast</td>
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<tr>
<td></td>
<td>Southwest</td>
</tr>
<tr>
<td></td>
<td>Central USA</td>
</tr>
<tr>
<td>ED response of anesthesiologist (%)</td>
<td>All ED trauma admissions</td>
</tr>
<tr>
<td></td>
<td>Only the most severely injured</td>
</tr>
<tr>
<td></td>
<td>Not at all</td>
</tr>
</tbody>
</table>

*ASA trauma care survey, 2010. ATLS® = Advanced Trauma Life Support®; ED = emergency department. From McCunn et al.® by permission of the Association of University Anesthesiologists.
pelvic trauma, head trauma, spinal cord trauma, musculoskeletal trauma, thermal injuries, pediatric trauma, geriatric trauma, trauma in pregnancy and intimate partner violence, and transfer to definitive care.

Table 2 lists the new content included in the most recent edition of ATLS® (9th edition, 2012). Greater detail on specific content updated from the previous edition is summarized in Table 3. This chapter focuses on the “ABCDE” concept and what the anesthesiologist needs to know to optimally care for the injured patient coming to the OR.

Although ATLS® is designed for the initial resuscitation and management of patients before coming to the OR, anesthesiology recommendations and strategies for intraoperative management will be presented in addition to the ATLS® course updates. ATLS® is a 2-day course approximately 20 hours long, and only the key principles to guide anesthetic care will be highlighted.

**ATLS® is designed for the initial resuscitation and management of patients before coming to the OR.**

**Table 2. Content Changes in the Most Updated Version (2012) of ATLS®**

<table>
<thead>
<tr>
<th>Chapters</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Initial assessment and management</td>
<td>New initial assessment scenarios</td>
</tr>
<tr>
<td>2. Airway and ventilatory management</td>
<td>Use of more advanced airway techniques for the difficult airway</td>
</tr>
<tr>
<td>3. Shock</td>
<td>The concept of balanced resuscitation</td>
</tr>
<tr>
<td>4. Abdominal and pelvic trauma</td>
<td>Emphasis on the pelvis as a source of blood loss</td>
</tr>
<tr>
<td>5. Thermal injuries</td>
<td>Optional expanded content on heat injury</td>
</tr>
<tr>
<td>Skills stations</td>
<td>New FAST skills station</td>
</tr>
<tr>
<td>Just-in-time videos</td>
<td>Optional DPL and pericardiocentesis</td>
</tr>
</tbody>
</table>

ATLS® = Advanced Trauma Life Support®; DPL = diagnostic peritoneal lavage; FAST = Focused Assessment Sonography for Trauma.

**PRIORITIES IN THE MANAGEMENT OF PATIENTS AFTER TRAUMATIC INJURY: “ABCDE”**

**Airway With Cervical Spine Protection**

Standard practice dictates that all blunt trauma victims be assumed to have an unstable cervical spine until this condition is ruled out.7 The airway management of these patients receives much attention from anesthesiologists because mask ventilation and direct laryngoscopy cause cervical motion8,9 with the potential to exacerbate spinal cord injury. For this reason, ATLS® recommends manual inline stabilization during airway management with chin lift and jaw thrust “if needed”; however, in a cadaver study of patients with C5-6 injury, significant cervical spine movement occurred during chin lift and jaw thrust.10 Cervical spine injuries occur in 1.5 to 6% of all major traumas.11 One should assume there is cervical spine injury if a patient has blunt, multisystem trauma, any altered level of consciousness, injury above the clavicle, or maxillofacial or head trauma.5

ATLS® teaches that all trauma patients should receive supplemental oxygen. For those requiring rapid-sequence induction and intubation, the recommendation is to pre-oxygenate, apply cricoid pressure, and administer succinylcholine after the induction agent. Some of these recommendations challenge current scientific understanding. Cricoid pressure may worsen the laryngoscopic grade of view in up to 30% of patients without effectively preventing aspiration. Discontinuing cricoid pressure facilitates intubation in most cases without worsening the grade of laryngoscopic view.12–14 If intubation is not possible, ATLS® suggests to “bag-mask until paralysis resolves.” Except for emergency cases with patients in extremis, this is not always possible. The ASA algorithm for management of difficult airways, modified for trauma, is a useful reference for the approach to patients when there is no option to awaken them or to postpone the case.15 When there is clear inability to intubate, ATLS® suggests an alternative airway plan such as laryngeal mask airway, intubating laryngeal mask airway, or a surgical airway.

Emergency awake fiberoptic intubation is generally difficult because of vomitus, blood, a patient’s inability to cooperate, and time constraints. Indirect videolaryngoscopy with systems such as the Bullard laryngoscope or GlideScope® potentially offers the best of both worlds: an anesthetized patient and decreased cervical motion. Ultimately, the technique that is most comfortable to the anesthesiologist and achieves the timeliest control of the airway should be used. In emergent situations when the patient is hemodynamically unstable and needs urgent operative or angiographic intervention, rapid sequence induction is the recommended approach, despite the current practice of many anesthesiologists (Supplemental Digital Content 2, http://links.lww.com/ASA/A490). Comparisons among direct laryngoscopy, videolaryngoscopy, fiberoptic intubation, blind nasal intubation, and cricothyrotomy in patients with known cervical cord or spine injuries show no difference in neurological deterioration with the technique used, and no clear evidence that direct laryngoscopy worsens outcome.16–20

**Breathing**

ATLS® identifies eight life-threatening chest injuries:

- Tension pneumothorax (PTX).
- Open PTX.
- Pulmonary contusion.
Table 3. ATLS, 9th Edition (2012) —Compendium of Changes

<table>
<thead>
<tr>
<th>Chapters</th>
<th>Subject</th>
<th>8th Edition</th>
<th>9th Edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial assessment</td>
<td>Team training</td>
<td>New information</td>
<td>In many centers, trauma patients are assessed by a team, the size and composition of which varies from institution to institution. To perform effectively, one team member should assume the role of team leader. The team leader supervises preparations for the patient’s arrival and the assessment, treatment, and transfer of the patient.</td>
</tr>
<tr>
<td>Airway</td>
<td>Cuffed pediatric tubes</td>
<td></td>
<td>Previous concerns about cuffed endotracheal tubes causing tracheal necrosis are no longer relevant because of improvements in the design of the cuffs. Ideally, cuff pressure should be measured as soon as is feasible; 30 mm Hg is considered safe.</td>
</tr>
<tr>
<td></td>
<td>Use of videolaryngoscopy</td>
<td></td>
<td>Alternative intubation devices have been developed over the years with the integration of video and optic imaging techniques. Their use in trauma patients may be beneficial in specific cases by experienced providers. Careful assessment of the situation, equipment, and available personnel is mandatory, and rescue plans must be available.</td>
</tr>
<tr>
<td>Shock</td>
<td>Crystalloid</td>
<td>Warmed isotonic electrolyte solutions (e.g., lactated Ringer’s or normal saline) are used for initial resuscitation. This type of fluid provides transient intravascular expansion and further stabilizes the vascular volume by replacing accompanying fluid losses into the interstitial and intracellular spaces. An alternative initial fluid is hypertonic saline, although the current literature does not demonstrate any survival advantage.</td>
<td>Hypertonic saline has no benefit over standard crystalloid resuscitation.</td>
</tr>
<tr>
<td></td>
<td>Fluid resuscitation</td>
<td>The goal of resuscitation is to restore organ perfusion. This is accomplished by the use of resuscitation fluids to replace lost intravascular volume and has been guided by the goal of restoring normal blood pressure. The authors emphasized that increased bleeding may occur if blood pressure is raised rapidly before the hemorrhage has been definitively controlled. This may be seen in the small subset of patients in the transient or nonresponder categories. Persistent infusion of large volumes of fluids in an attempt to achieve a normal blood pressure is not a substitute for definitive control of bleeding. Fluid resuscitation and avoidance of hypotension are important principles in the initial management of blunt trauma patients, particularly those with TBI. In penetrating trauma with hemorrhage, delaying aggressive fluid resuscitation until definitive control may prevent additional bleeding. Although complications associated with resuscitation injury are undesirable, the alternative of exsanguination is even less so. A careful, balanced approach with frequent reevaluation is required. Balancing the goal of organ perfusion with the risks of rebleeding by accepting a lower than normal blood pressure has been called “controlled resuscitation,” “balanced resuscitation,” “hypotensive resuscitation,” and “permissive hypotension.” The goal is the balance, not the hypotension. Such a resuscitation strategy may be a bridge to but is also not a substitute for definitive surgical control of bleeding.</td>
<td>The concept of balanced resuscitation is further emphasized and the term “aggressive resuscitation” has been eliminated. The standard use of 2 L crystalloid resuscitation as the starting point for all resuscitation has been modified to initiation of 1 L crystalloid. Early use of blood and blood products for patients in shock is also emphasized without mandating or suggesting any specific ratio of plasma and platelets.</td>
</tr>
<tr>
<td>Abdomen and pelvis</td>
<td></td>
<td></td>
<td>The title “Abdomen and Pelvis” is reemphasized to delineate the pelvis as an underrecognized source of hemorrhagic shock.</td>
</tr>
<tr>
<td>Musculoskeletal and extremity</td>
<td></td>
<td></td>
<td>All pelvic content has been moved to the “Abdomen and Pelvis” chapter.</td>
</tr>
<tr>
<td>Trauma in women</td>
<td></td>
<td></td>
<td>Retitled “Trauma in Pregnancy and Intimate Partner Violence.”</td>
</tr>
<tr>
<td>Pediatric trauma</td>
<td>Cuffed endotracheal tubes</td>
<td>Uncuffed tubes of appropriate size should be used to avoid subglottic edema, ulceration, and disruption of the infant’s or child’s fragile airway.</td>
<td>Previous concerns about cuffed endotracheal tubes causing tracheal necrosis are no longer relevant because of improvements in the design of the cuffs. Ideally, cuff pressure should be measured as soon as is feasible; 30 mm Hg is considered safe.</td>
</tr>
<tr>
<td>Skill stations</td>
<td>DPL</td>
<td>Mandatory</td>
<td>Optional</td>
</tr>
<tr>
<td></td>
<td>FAST</td>
<td></td>
<td>New content*</td>
</tr>
<tr>
<td></td>
<td>Pelvic binder</td>
<td>Musculoskeletal</td>
<td>Moved to “Surgical Skills” to emphasize source of hemorrhagic shock.</td>
</tr>
<tr>
<td></td>
<td>Pericardiocentesis</td>
<td>Mandatory</td>
<td>Optional</td>
</tr>
<tr>
<td>ATLS app</td>
<td></td>
<td></td>
<td>New to 9th edition. Contains interactive algorithms, calculators, animations, just-in-time videos demonstrating key skills, and an interactive PDF version of the Student Manual.</td>
</tr>
</tbody>
</table>

*Either DPL or FAST must be taught during the Surgical Skills station as a method of evaluating the abdomen as a source of hemorrhagic shock.
ATLS® = Advanced Trauma Life Support®; DPL = diagnostic peritoneal lavage; FAST = Focused Assessment Sonography for Trauma; TBI = traumatic brain injury.
• Tracheobronchial disruption.
• Blunt cardiac injury.
• Aortic disruption.
• Esophageal rupture.
• Massive hemothorax.

Neither general anesthesia nor positive pressure ventilation should be administered in a patient with a PTX until a chest tube is inserted. The concern is that a small PTX may transition to tension physiology without adequate decompression. Although the surgeon should communicate the presence of a PTX to the anesthesiologist, occult or small PTXs, particularly in pediatric patients, can be managed without a chest tube if the entire care team is vigilant.21,22

Pulmonary contusions are commonly associated with severe chest and thoracic injuries and should be suspected in patients with rib fractures (particularly flail segments), sternal fractures, or spinal column injury.23 Severe pulmonary contusions may lead to shunting, which will lead to hypoxemia. This syndrome may progress rapidly in the hours and days after injury. An initially clear chest radiograph does not exclude the possibility of a pulmonary contusion; close observation is warranted if signs of significant chest wall trauma are present. There is no specific therapy for a pulmonary contusion, and therapy is directed at treating the associated injuries or resultant hypoxemia. Early and aggressive implementation of lung protective strategies with mechanical ventilation is crucial in the treatment of patients with significant pulmonary contusion to minimize progression to acute respiratory distress syndrome or concomitant ventilator-associated lung injury.24,25

Blunt cardiac injury (BCI) is a rare and poorly understood phenomenon that must be considered in any patient who has sustained a frontal impact to the chest. Bruising or edema of the myocardium is functionally indistinguishable from myocardial ischemia and may be causally related in that the pathophysiology of cardiac contusion may involve forcible dislodgement of unstable atherosclerotic plaque. If the patient is hemodynamically stable and the electrocardiogram does not demonstrate conduction disturbances or tachyarrhythmias, BCI can be safely excluded.26 Electrocardiography alone is not sufficient to rule out BCI. On the basis of four studies showing that the addition of troponin I to the electrocardiogram improved the negative predictive value to 100%, an admission electrocardiogram and troponin I should be obtained in patients in whom BCI is suspected. BCI can be ruled out only if both the Electrocardiography result and troponin I level are normal—a significant change from the previous guideline. Patients with new electrocardiographic changes or elevated troponin I should be admitted for monitoring. Electrocardiography is not beneficial as a screening tool for BCI and should be reserved for patients with hypotension, arrhythmias, or both.27

If either a new tachyarrhythmia or conduction disturbance subsequently develops or the patient has explained hypotension, other causes (hypovolemia, renal failure) should be ruled out first. If the workup is negative, transthoracic echocardiography should be performed. Right ventricular dysfunction resulting in hypotension may be overlooked while more common causes of hypotension in the trauma patient are being evaluated. Once diagnosed, BCI should be managed in the same way as ischemic cardiac injury, with completion of resuscitation and then careful control of fluid volumes, administration of coronary vasodilators, appropriate monitoring, and symptomatic treatment of rhythm disturbances.

Traumatic aortic injury should be ruled out in any patient suffering a high-energy injury, such as from a motor vehicle crash or fall from a height. Aortic injury occurs most commonly just distal to the left subclavian artery and is the result of shear forces between the mobile heart and aortic arch and the immobile descending thoracic aorta. Traumatic aortic injury is manifested as a continuum of injury, from a small intimal flap to free transection contained by the surrounding mediastinum and pleura. The diagnosis is made by screening chest radiography followed by definitive angiography, computed tomography, or transesophageal echocardiography. Surgical or endovascular repair is indicated for most patients with traumatic aortic injury because of the high risk of rupture in the hours and days after injury.28 Various techniques have been described for this surgery, which is associated with high morbidity. The best results occur with partial bypass techniques using inflow from the left atrium, a centrifugal pump, and outflow to the descending aorta.29 The recent literature contains reports of selective nonoperative management of high-risk patients with traumatic aortic injury.30,31 Treatment is similar to that in patients with uncomplicated type B aortic dissections and consists of β-blockade to minimize the cardiac rate–pressure product. Endovascular repair is becoming more common at centers with experience in this technique and is likely to become the standard practice as stent-grafting hardware continues to improve.

Hemothoraces, irrespective of size, should be considered for drainage. The primary indication for surgical intervention should be patient physiology, rather than absolute numbers of initial or persistent output as suggested by the quantitative volumes of massive hemothorax (more than 1,500 mL or 200 mL/h for more than 2 hours).32 Bleeding of 1,500 mL via a chest tube in any 24-hour period, irrespective of mechanism, should prompt consideration for surgical exploration.33 Patients with a small hemothorax and hemodynamic stability may not come to the OR urgently, in contrast to the patient with exsanguination from a thoracic injury, who will require massive resuscitation and transfusion interventions.

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**Hemothoraces, irrespective of size, should be considered for drainage.**
Circulation With Hemorrhage Control

Once an airway and adequate oxygenation have been established, the single most important aspect of resuscitation from hemorrhagic shock is control of hemorrhage. The art of resuscitation during acute traumatic hemorrhage has changed drastically over the past several years with advances in understanding the science of coagulopathy. The concept of “hypotensive resuscitation”—that is, maintaining blood pressure at a minimum mean arterial pressure until hemorrhage is definitively controlled—has been accepted by ATLS® and is likely beneficial in patients with penetrating trauma and possibly in those with blunt trauma. The exclusions to this treatment are patients with known or suspected central nervous system injury or cardiac disease.

According to ATLS®, traditional fluid management for patients in hemorrhagic shock consisted of a rapid bolus of 2 L of warmed lactated Ringer’s solution followed by reassessment of hemodynamic parameters. Patients with signs of ongoing hemorrhage require ongoing resuscitation, but the use of crystalloids has decreased significantly as we now understand the acute coagulopathy of trauma (Supplemental Digital Content 3, http://links.lww.com/ASA/A491). Without intrinsic clotting factors or the administration of extrinsic factors—either through dilution with intravenous fluids or loss due to ongoing bleeding—stable clots are unlikely to form. Multiple studies, in both the military and in civilian trauma centers, have demonstrated improved outcomes with the early use of blood products, including plasma, platelets, and cryoprecipitate.

With an average hematocrit of 50 to 60%, a unit of erythrocytes will predictably restore oxygen carrying capacity and expand intravascular volume to the same extent as any colloid solution. Cross-matching is desirable when time allows (typically about 1 hour from the time a sample reaches the blood bank until the erythrocytes reach the patient), but the type-specific blood requires less time for delivery (about 30 minutes) and may be an appropriate alternative. Type O blood—the “universal donor” type—can be given to patients of any blood type with little risk of a major reaction.24 This is the preferred approach for patients who arrive at the emergency department in hemorrhagic shock. The introduction of massive transfusion protocols that deliver specified ratios of erythrocytes to plasma to platelets for administration has significantly decreased mortality in severe hemorrhagic shock.35–37 An additional benefit is lower utilization of total blood products.38 If O-positive blood is given to a Rhesus-negative woman who survives, prophylactic administration of anti-Rh0 antibody is indicated.

Although plasma requires only blood typing and not cross-matching, the need to thaw frozen units before they can be administered delays the availability of plasma. Busy trauma hospitals often maintain a supply of prethawed plasma (thawed plasma as opposed to fresh frozen plasma) that can be issued quickly in response to an emergency need. Platelet transfusion is normally reserved for clinically coagulopathic patients with a documented thrombocytopenia (more than 50,000 per high-power field). When the patient is in shock, however, and blood loss is likely to be substantial, platelets, which have a very short serum half-life, should be empirically administered in proportion to erythrocytes and plasma. Platelets should not be administered through filters, warmers, or rapid infusion systems because they will bond to the inner surfaces of these devices, thereby reducing the quantity of platelets actually reaching the circulation. The optimal ratio of erythrocytes to plasma to platelets is still in debate, but a “1:1:1” strategy is a useful reminder to administer plasma and platelets in ratios that approximate the composition of whole blood.39 Viscoelastic monitoring (TEG® or ROTEM®) is useful for detecting clinically relevant hemostatic abnormalities in trauma and surgical patients with massive bleeding and diffuse coagulopathy and should be used to guide component therapy for transfusion when available.40,41

Coagulopathy after trauma involves a complex interplay of dilution of coagulation factors, acidosis, hypothermia, hyperfibrinolysis, inflammation, and possibly genetics42,43 (Supplemental Digital Content 4, http://links.lww.com/ASA/A492). As a general rule, vasoactive agents have no role during acute shock resuscitation unless a patient has concomitant blunt cardiac dysfunction. The role of vasopressin in “replacement” doses after hemorrhage is currently being investigated.44

Disability or Neurological Status

Patients with major traumatic brain injuries (TBI) are particularly prone to coagulation abnormalities; the reported incidence has ranged from 15 to 100%.45 Anesthesiologists can play a major role in determining the outcome of patients with severe TBI. Despite invasive advanced monitoring techniques for intracranial pressure, cerebral blood flow, and cerebral oxygenation, the avoidance of hypotension and hypoxemia is still considered to be the key determinant of neurological outcome in the severely brain-injured.46

Central nervous system injury accounts for almost half of all trauma deaths after admission to a trauma center.47 The most challenging of all trauma patients are those with severe TBI and coexisting hemorrhagic shock. A single episode of hypotension, defined as systolic blood pressure less than 90 mm Hg, is associated with an increase in morbidity and doubled mortality after severe TBI.48 Hypotension together with hypoxia is associated with a three-fold increase in mortality. In contrast to past practice, current recommendations are to maintain a
patient with severe TBI in a euvoletic state (Supplemental Digital Content 5, http://links.lww.com/ASA/A493). Therefore, fluid resuscitation is the mainstay of therapy, followed by vasoactive infusions as needed.\textsuperscript{46}

Hyperventilation therapy (e.g., at a PaCO\textsubscript{2} of 25 mm Hg), previously used “prophylactically” to prevent elevations in intracranial pressure, is no longer recommended. Current guidelines suggest a range of PaCO\textsubscript{2} between 30 and 35 mm Hg, with hyperventilation to 30 mm Hg only when episodes of increased intracranial pressure cannot be controlled with sedatives, drainage of cerebrospinal fluid, neuromuscular blockade, osmotic agents, decompressive craniectomy, or barbiturate coma.\textsuperscript{49,50}

Hyperventilation therapy, previously used “prophylactically” to prevent elevations in intracranial pressure, is no longer recommended.

Most spinal cord injuries are found in the lower cervical spine, just above the thorax, or in the upper lumbar region, just below the thorax. Blunt injury usually occurs in the regions of the cord that are most flexible, especially at the junctions between flexible and inflexible segments. Injury at midthoracic levels is less common because of the rotational instability of the spinal column. Injury at the thoracolumbar junctions between flexible and inflexible segments is less common because of the rotational instability of the spinal column. Injury at the thoracolumbar junctions between flexible and inflexible segments. Injury at the thoracolumbar junctions between flexible and inflexible segments.

Exposure (Undress) and Environment (Temperature Control)

Hypothermia is inevitable after trauma. Patients are undressed in the emergency department, lose body heat through multiple mechanisms, and often receive massive resuscitation in cold environments (OR or angiography suite) despite efforts to warm fluids and the environment. Because hypothermia can exacerbate coagulopathy, can impair wound healing, and is associated with an increased incidence of infection, all measures to avoid hypothermia and actively warm the patient should be undertaken.

**Summary**

ATLS\textsuperscript{R} is designed for the management of patients before admission to the OR or intensive care unit. Understanding the principles of early diagnosis and resuscitation after traumatic injury may improve outcomes in these patients. Anesthesiologists are key partners in the care of trauma patients and are likely to encounter them irrespective of the type of practice in which they work.

**References**


