Trauma Evaluation And Management

Program for Medical Students

STUDENT BOOKLET

American College of Surgeons Committee on Trauma
1999

Overview of the Trauma Evaluation And Management (TEAM) Program for Medical Students

Program Goals:

This Trauma Evaluation And Management (TEAM) Program for Medical Students provides the medical student with an overview of the purpose and concepts of immediate management of the injured patient and a basic understanding of the principles of trauma care, including:

1. Rapid, accurate, and physiologic assessment of the patient's condition.
2. Resuscitation, stabilization, and monitoring of the patient, according to priority.
3. Preparation for the patient's interhospital transfer, if the patient's needs exceed the facility's capabilities.

Program Objectives:

Upon completion of this overview, the medical student will be able to describe the principles of emergency medical care in the multiply injured patient. Specifically, the medical student will be able to:

1. Identify the correct sequence of priorities used in assessing the multiply injured patient.
2. Describe guidelines and techniques used in the initial resuscitation and definitive-care phases when treating the multiply injured patient.
3. Identify how the patient's medical history and the mechanism of injury contribute to the identification of injuries.

Introduction

The purpose of this TEAM Program is to orient medical students to the initial assessment and early management of the trauma patient. In general, the concepts presented in these materials are derived from the *Advanced Trauma Life Support® (ATLS®) Course forDoctors,* sponsored by the American College of Surgeons (ACS) Committee on Trauma. The ATLS Student Course provides further education in the essential information and skills the first responding doctor should apply to the identification and treatment of life-threatening or potentially life-threatening injuries. Medical students are permitted to take the ATLS Student Course in their final year of medical school and receive a document attesting to their successful completion upon graduation from medical school.

The Need

The first edition of the *ATLS® Student Manual* appeared in 1980. Since that time many dramatic and significant changes have taken place in the care of the injured patient. The sixth edition of the ATLS® *Student Manual,* upon which this TEAM Program is based, appeared in 1997. Nevertheless, trauma remains the leading cause of death in the first four decades of life (ages 1 through 44 years), surpassed only by cancer and atherosclerosis as the major causes of death in all age groups. As great as the death rate from injury is, about 150,000 deaths annually in the United States, permanent disability from injury dwarfs the mortality by three to one. The societal cost is staggering, as is the amount of human suffering. The need for improved methods of caring for injured patients is vitally important.

Six people will be killed, approximately 1,000 will have a disabling injury (at least 24 hours off work), and approximately $24,000,000 will be spent on the unintentionally-injured patient in the United States during the 30 minutes the student spends reading this Overview. Approximately 60 million injuries occur annually in the United States. Approximately 30 million (50%) of these injuries require medical care, and 3.6 million (12% of 30 million) require hospitalization. Nearly nine million of these injuries are disabling 300,000 permanently and 8.7 million temporarily.

Trauma-related dollar costs exceed $400 billion annually. This cost is accounted for by lost wages, medical expenses, insurance administration costs, property damage, fire loss, employer costs, and indirect loss from work-related injuries. Yet with these staggering costs, less than four cents of each federal research dollar is expended on trauma research. As monumental as these data are, the true cost to society can be measured only when it is realized that trauma strikes down its youngest and potentially most productive members. As tragic as is any "accidental" death, the loss of life in the early years is the most tragic of all. Research dollars spent on communicable diseases, for example, polio and diphtheria, have nearly eliminated the incidence of these diseases in the United States. Amazingly, the disease of trauma has not captured the public attention in the same way.

Methods and modalities are available to prevent most injuries. Unfortunately, public awareness has not translated into public utilization and acceptance, for example, seat belts and helmets. Therefore and until the public utilizes these preventative methods and modalities, training in trauma evaluation and management is even more necessary.

Trimodal Death Distribution

Death due to injury occurs in one of three time periods. The first peak of death is within seconds to minutes from injury. During this early period, deaths generally result from lacerations of the brain, brain stem, high spinal cord, heart, aorta, and other large blood vessels. Very few of these patients can be salvaged due to the severity of their injuries. Salvage after injury during this peak can be achieved only in certain large urban areas where rapid prehospital care and transport are available. Only prevention can significantly reduce this peak of traumatic deaths.

The second peak occurs within minutes to several hours following injury. The TEAM Program focuses primarily on this peak. Deaths occurring during this period are usually due to subdural and epidural hematomas, hemopneumothorax, ruptured spleen, lacerations of the liver, pelvic fractures, and/or other multiple injuries associated with significant blood loss. The "first hour" of care after injury is characterized by the need for rapid assessment and resuscitation which are the fundamental principles of trauma evaluation and management. The concept of the "golden hour" emphasizes the urgency necessary for successful management to maximize outcome of the injured patient and is not intended to imply a "fixed" time period of 60 minutes.

The third death peak, occurring several days to weeks after the initial injury, is most often due to sepsis and multiple organ system failure. Care provided during each of the preceding time periods impact on outcome during this stage. Thus, the first and every subsequent individual to care for the injured patient have a direct effect on long-term outcome.

The Concept

The concept behind trauma evaluation and management is simple. The approach to the injured patient is not the same as that for a patient with a previously undiagnosed medical condition, that is, an extensive history including past medical history, a physical examination starting at the top of the head and progressing down the body, and finally the development of a differential diagnosis and a list of adjuncts to confirm a diagnosis. This approach is quite adequate for a patient with diabetes mellitus or even many acute surgical illnesses. However, it does not satisfy the needs of the patient suffering life threatening injury.

There are five underlying precepts of trauma evaluation and management. The most important of these precepts is to treat the greatest threat to life first. Second, the lack of a definitive diagnosis should never impede the application of an indicated treatment, and a detailed history is not essential to begin the evaluation of an acutely injured patient. Third is the need for a physiologic approach to the evaluation and treatment of the injured. The fourth is that injury kills in certain reproducible time frames. Thus, time is of the essence. The fifth is to do no further harm.

Physiologic Approach

The physiologic approach to the evaluation and treatment of the injured patient is based on the fact that the airway, breathing, and circulation are an integrated system of organ function designed to carry oxygen to the body's cells. Core organs (for example, brain) require a continuous supply of oxygen and nutrients for optimal function. Because of the sequential nature of oxygen delivery, a patent airway and adequate breathing are necessary before the circulation can deliver oxygen. Therefore, the loss of an airway or ability to breathe kills more quickly than does diminished circulating blood volume. The presence of neurologic disability or altered mental status, particularly if caused by an expanding intracranial mass lesion, is the next most lethal problem.

The mnemonic "ABCDE" defines the specific, ordered, evaluations and interventions that should be followed in all injured patients:

A. Airway maintenance with cervical-spine protection
B. Breathing and ventilation with life-threatening chest injury management
C. Circulation with control of hemorrhage
D. Disability or neurologic status with intracranial mass lesion recognition
E. Exposure (undress) and Environment with maintenance of body temperature

Assessment and Management Sequence

Initial assessment and management are optimally performed in a set sequence. The primary survey, conducted simultaneously with resuscitation, consists of a rapid, systematic evaluation of the airway, breathing, circulation, disability, and exposure/environment, treating life-threatening conditions as they are discovered. Adjuncts, such as urinary and gastric catheters, vital signs, monitoring devices, and chest and pelvic x-rays facilitate the process of discovery.

The secondary survey consists of a focused injury history and detailed physical examination designed to pinpoint the exact nature of the injuries. Adjuncts, for example, laboratory tests and special x-ray and/or diagnostic studies, help to establish a definitive diagnosis.

The primary and secondary surveys should be repeated frequently to identify any deterioration in the patient's status, and any necessary treatment that should be initiated at the time an adverse change is identified. Continuous reevaluation and optimal stabilization complete the initial assessment and management process even while preparing the patient for transfer to the operating room, the intensive care unit, or another facility, as needed.

This sequence is presented as an overview of a longitudinal progression of events. In the actual clinical situation, many of these activities occur in parallel or simultaneously. The linear or longitudinal progression allows the doctor an opportunity to mentally review the progress of an actual trauma resuscitation.

Preparation

Preparation for the trauma patient occurs in two different clinical settings. First, during the prehospital phase, all events must be coordinated with the doctors at the receiving hospital. Second, during the inhospital phase, preparations must be made to rapidly facilitate the resuscitation of the trauma patient.

A. Prehospital Phase

Coordination with the prehospital agency and personnel can greatly expedite the treatment in the field. The prehospital system should be set up such that the receiving hospital is notified before the prehospital personnel transport the patient from the scene. This allows mobilization of the hospital's "Trauma Team" members so that all necessary personnel and resources are present in the emergency department at the time of the patient's arrival. Emphasis in the prehospital phase should be placed on airway maintenance, support of breathing, control of external bleeding and shock, immobilization of the patient, and immediate transport to the closest, appropriate facility, preferably a verified trauma center. Every effort should be made to minimize scene time. (See Appendix 2, Prehospital Triage Decision Scheme.) Emphasis also should be placed on obtaining and reporting information needed for triage at the hospital, for example, time of injury, events related to the injury, and patient history. The mechanisms of injury may suggest the degree of injury as well as specific injuries for which the patient must be evaluated.

The use of prehospital care protocols and online medical direction can facilitate and improve care initiated in the field. Periodic multidisciplinary review of the care provided through quality assurance/ improvement activities is essential.

B. Inhospital Phase

Advanced planning for the trauma patient's arrival is essential. Ideally, a resuscitation area should be available for trauma patients. Proper airway equipment (laryngoscopes, endotracheal tubes, and so on) should be organized, tested, and placed where it is immediately accessible. Warmed intravenous crystalloid solutions (for example, Ringer's lactate) should be available and be ready to infuse when the patient arrives. Appropriate monitoring capabilities should be immediately available. A method to summon extra medical assistance should be in place. A means to assure prompt response by laboratory and radiology personnel is necessary. Transfer agreements with a verified trauma center should be preestablished and operational. Periodic review of the care through the quality improvement process is an essential component of the hospital's trauma program.

All personnel who have contact with the patient must be protected from communicable diseases. Most prominent among these diseases are hepatitis and human immunodeficiency virus (HIV) infection. The Centers for Disease Control and Prevention (CDC) and other health agencies strongly recommend the use of standard precautions (for example, cap, face mask, eye protection, water-impervious gown/apron, leggings, and gloves) when coming in contact with body fluids. The ACS Committee on Trauma considers these to be minimum precautions and protection of all health care providers. This also is an Occupational Safety and Health Administration (OSHA) requirement in the United States.

Triage

Triage is the sorting of patients based on the need for treatment and the available resources to provide that treatment. Treatment is rendered based on the ABC priorities (Airway with cervical spine protection, Breathing with life-threatening chest injury management, and Circulation with hemorrhage control) as outlined later in this document.

Triage also pertains to the sorting of patients in the field and the medical facility to which they are to be transported. It is the responsibility of the prehospital personnel and their medical director to see that the appropriate patients arrive at the appropriate hospital. It is inappropriate for prehospital personnel to deliver a severely traumatized patient to a nontrauma center hospital if a trauma center is available. (See Appendix 2, Prehospital Triage Decision Scheme.) Prehospital trauma scoring is helpful in identifying those severely injured patients who should be transported to a trauma center. (See Appendix 3, Trauma Scores: Revised and Pediatric.) Two types of triage situations usually exist.

A. Multiple Casualties

The number of patients and the severity of their injuries do not exceed the ability of the facility to render care. In this situation, patients with life-threatening problems and those sustaining multiple system injuries are treated first.

B. Mass Casualties

The number of patients and the severity of their injuries exceed the capability of the facility and staff. In this situation, those patients with the greatest chance of survival, and requiring the least expenditure of time, equipment, supplies, and personnel, are managed first.

Primary Survey

Patients are assessed and their treatment priorities established based on their injuries, their vital signs, and the injury mechanism. These priorities are the same for all injured patients, including the adult, pediatric, and pregnant patients. In the severely injured patient, logical sequential treatment priorities must be established based on overall patient assessment. The patient's vital functions must be assessed quickly and efficiently. Patient management must consist of a rapid primary evaluation, resuscitation of vital functions, a more detailed secondary assessment, and finally, the initiation of definitive care. This process constitutes the ABCDEs of trauma care and identifies life-threatening conditions by adhering to this sequence:

A. Airway maintenance with cervical spine protection
B. Breathing with management of life-threatening chest injuries
C. Circulation with hemorrhage control
D. Disability: Brief neurologic examination with intracranial mass lesion recognition
E. Exposure/Environmental Control: Completely undress the patient and maintain normal body temperature

During the primary survey, life-threatening conditions are identified and management instituted simultaneously. The prioritized assessment and management procedures reviewed in this chapter are identified as sequential steps in order of importance and for the purpose of clarity. However, these steps are frequently accomplished simultaneously.

Trauma is the leading cause of death in the pediatric patient. Anatomic and physiologic differences from the adult include a vigorous compensatory response to major trauma which is relatively short=lived due to limited compensatory reserves. However, priorities for the care of the pediatric patient are the same as for adults. Although the quantities of blood, fluids, and medications; the size of the child; degree and rapidity of heat loss; and injury patterns may differ, assessment and management priorities are identical. Outcome depends on early aggressive care.

Priorities for the care of the pregnant woman are similar to those for the nonpregnant patient, but the anatomic and physiologic changes of pregnancy may modify the patient's response to injury. Early recognition of pregnancy, by palpation of the abdomen for a gravid uterus and laboratory testing (HCG), and early fetal assessment are important for maternal and fetal survival. However, the first priority is maternal resuscitation.

Trauma is the fifth most common cause of death in the geriatric patient. With increasing age, cardiovascular disease and cancer overtake injury as the leading causes of death. Interestingly, the risk of death for any given injury at the lower and moderate injury severity score (ISS) levels is greater for the elderly man than for the woman. Resuscitation of this group necessitates special attention. The aging process diminishes the physiologic reserve of the elderly trauma patient. Chronic cardiac, respiratory, and metabolic disease may reduce the ability of the patient to respond to injury in the same manner that younger patients are able to compensate for the physiologic stress imposed by injury. Comorbidities, such as diabetes, congestive heart failure, coronary artery disease, restrictive and obstructive pulmonary disease, coagulopathy, liver disease and peripheral vascular disease are more common and adversely affect outcome following injury to the older patient. The chronic use of medications may alter the usual physiologic response to injury. The narrow therapeutic window frequently leads to over or under resuscitation in this patient population and early invasive monitoring is frequently a valuable adjunct to management. Despite these facts, the majority of elderly trauma patients will recover and return to their preinjury level of independent activity if appropriately managed. Prompt aggressive resuscitation and the early recognition of preexisting medical conditions and medication use can improve the survival of this group.

A. Airway Maintenance with Cervical Spine Protection

Every effort should be made to promptly identify airway compromise and secure a definitive airway. Upon initial evaluation of the trauma patient, the airway should be assessed first to ascertain patency. This rapid assessment for signs of airway obstruction should include inspection for foreign bodies and facial, mandibular, or tracheal/laryngeal fractures that may result in airway obstruction.

1. Airway maintenance

Airway obstruction is identified and managed during the primary survey. Airway obstruction must be immediately recognized and promptly corrected. Gurgling, stridor, hoarseness, and rocking chest wall motions are indicative of airway obstruction. Equally important is the recognition of the potential for progressive airway loss. Frequent reevaluation of airway security is essential to identify the patient who is losing the ability to maintain an adequate airway.

Measures to establish a patent airway should be instituted while protecting the cervical spine. Initially, the chin lift or modified jaw thrust maneuver is recommended to achieve this task. Airway suctioning is then performed as necessary to clear excessive secretions, using a large-caliber suction catheter. Particulate matter is removed, if present, using a finger-sweep or forceps. Airway adjuncts (for example, oropharyngeal airway) may be necessary to maintain airway patency in patients who are unconscious and have lost their gag reflex.

If the patient is able to communicate verbally, the airway is not likely to be in immediate jeopardy; however, repeated assessment of airway patency is prudent, especially in patients with respiratory compromise or maxillofacial injury. Additionally, severe head-injury patients with an altered level of consciousness or a Glasgow Coma Scale (GCS) Score of 8 or less, usually require the placement of a definitive airway. The finding of nonpurposeful motor responses strongly suggests the need for definitive airway management. Management of the pediatric airway requires a knowledge of the unique anatomic features of the position and size of the larynx in children, as well as special equipment.

2. Cervical spine protection

While assessing and managing the patient's airway, great care should be taken to prevent excessive movement of the cervical spine. The patient's head and neck should not be hyperextended, hyperflexed, or rotated to establish and maintain the airway. Based on the history of the trauma incident, the loss of stability of the cervical spine should be suspected. Neurologic examination alone does not exclude a cervical spine injury. Protection of the patient's spinal cord with manual, inline immobilization followed by the application of appropriate immobilization devices should be accomplished. If immobilizing devices must be removed temporarily, the neutral position of the patient's head and neck should be reinstituted with manual, inline immobilization by one member of the trauma team. Immobilization devices, used to protect the patient's spinal cord, should be left in place until cervical spine injury is excluded. Protection of the spine and spinal cord is the important management principle. Cervical spine x-rays may be obtained to confirm or exclude injury once immediate or potentially life-threatening conditions have been addressed. Remember: Assume a cervical spine injury in any patient with multisystem trauma, especially with an altered level of consciousness or a blunt injury above the clavicle.

B. Breathing with Life-threatening Chest Injury Management

The initial step in managing respiratory failure in the injured patient is to recognize its presence. No laboratory tests diagnose respiratory failure. The initial diagnosis is based on clinical appreciation of the presence of inadequate or ineffective ventilation and oxygenation.

1. Respiratory mechanics and gas exchange

Airway patency alone does not assure adequate ventilation. Adequate gas exchange is required to maximize oxygenation and carbon dioxide elimination. Ventilation requires adequate function of the lungs, chest wall, and diaphragm. Each component must be examined and evaluated rapidly.

The patient's chest should be exposed to adequately assess chest wall excursions. Auscultation should be performed to assure gas flow in the lungs. Adequacy of ventilation should be assessed through observation of chest wall mechanics, that is, accessory muscle use and ventilatory rate. Percussion may demonstrate the presence of air or blood in the chest. Visual inspection and palpation may detect injuries to the chest wall that may compromise ventilation.

2. Immediately life-threatening chest injuries

Immediately life-threatening chest injuries must be recognized and managed during the primary survey. Injuries that may acutely impair ventilation are tension pneumothorax, flail chest with pulmonary contusion, massive hemothorax, and open pneumothorax. These injuries should be identified in the primary survey. Simple pneumo- or hemothorax, fractured ribs, and pulmonary contusion may compromise ventilation to a lesser degree and are usually identified in the secondary survey.

Tension and open pneumothorax are identified and controlled in the primary survey. A tension pneumothorax compromises ventilation and circulation dramatically and acutely, and if suspected, needle decompression should be accomplished immediately. An open pneumothorax also compromises ventilation dramatically and acutely, and if suspected, the chest wall defect should be treated immediately with an occlusive dressing. (See Appendix 1, Glossary of Frequently Confused Terms.)

C. Circulation with Hemorrhage Control

Hemorrhage is the most common cause of shock in the injured patient and is the predominant cause of postinjury deaths that are preventable by rapid treatment in the hospital setting. It must be stopped as soon as possible. External bleeding is controlled by direct pressure. Internal hemorrhage is controlled by operative intervention.

The initial step in managing shock in the injured patient is to recognize its presence. No laboratory test can definitively diagnose shock. The initial diagnosis is based on clinical appreciation of the presence of inadequate organ perfusion and tissue oxygenation instead of the presence of hypotension. Although the patient may initially present with hypotension, the definition of shock as an abnormality of the circulatory system that results in inadequate organ perfusion and tissue oxygenation, becomes an operative tool for diagnosis and treatment. (See Appendix 1, Glossary of Frequently Confused Terms.) The severity of signs and symptoms of shock closely parallel the degree of hemorrhage. (See Table 1, Estimated Fluid and Blood Losses Based on Patient's Initial Presentation.)

	Class I	**Class 11**	**Class 111**	**Class IV**
Blood loss (mL)	Up to 750	750-1500	1500-2000	>2000
Blood loss (% blood volume)	Up to 15%	15%-30%	30%-40%	>40%
Pulse rate	<100	>100	>120	> 140
Blood pressure	Normal or increased	Decreased	Decreased	Decreased
Pulse pressure (mm Hg)	14-20	20-30	30-40	>35
Urine output (ml/hour)	>30	20-30	5-15	Negligible
CNS/Mental status	Slightly anxious	Mildly anxious	Anxious, confused	Confused, lethargic
Fluid replacement (3:1 Rule)	Crystalloid	Crystalloid	Crystalloid and blood	Crystalloid and blood

TABLE 1 ESTIMATED FLUID AND BLOOD LOSSES' Based on Patient's Initial Presentation

The guidelines in Table 1 are based on the "3-for-1" rule. This rule derives from the empiric observation that most patients in hemorrhagic shock require as much as 300 mL of electrolyte solution for each 100 mL of blood loss. Applied blindly, these guidelines can result in excessive or inadequate fluid administration. For example, a patient with a crush injury to the extremity may have hypotension out of proportion to his or her blood loss and requires fluids in excess of the 3:1 guidelines. In contrast, a patient whose continuing blood loss is being replaced by blood transfusion requires less than 3:1. The use of bolus therapy with careful monitoring of the patient's response can moderate these extremes.

1. Blood volume and cardiac output

   Hypotension following injury must be considered to be hypovolemic in origin until proved otherwise. Rapid and accurate assessment of the injured patient's hemodynamic status is therefore essential. The elements of clinical observation that yield key information within seconds are level of consciousness, skin color, and pulse. In assessing organ perfusion, signs accompanying decreased blood flow resulting from a decrease in cardiac output should be sought, for example, tachycardia, cool extremities from vasoconstriction, narrowed pulse pressure and, in the later phases, a fall in mean arterial blood pressure. Ideally, the diagnosis of shock should be made prior to the development of obvious hypotension.

   a. Level of consciousness

      When circulating blood volume is reduced, cerebral perfusion may be critically impaired, resulting in altered levels of consciousness. However, a conscious patient also may have lost a significant amount of blood.

   b. Skin color

      Skin color can be helpful in evaluating the hypovolemic, injured patient. A patient with pink skin, especially in the face and extremities, is rarely critically hypovolemic after injury. Conversely, the ashen, gray skin of the face and the white skin of the exsanguinated extremities are ominous signs of hypovolemia.

   c. Pulse

      Pulses, usually an easily accessible central pulse (femoral or carotid), should be assessed bilaterally for quality, rate, and regularity. Full, slow, and regular peripheral pulses are usually signs of relative normovolemia in a patient who has not been taking beta-adrenergic blocking medications. A rapid, thready pulse is usually a sign of hypovolemia, but may have other causes as well. A normal pulse rate does not assure that the patient is normovolemic. An irregular pulse usually is a warning of potential cardiac dysfunction. Absent central pulses, not attributable to local factors, signify the need for immediate resuscitative action to restore depleted blood volume and effective cardiac output if death is to be avoided.

2. Special considerations

   Children, the elderly, athletes, pregnant women, and others with chronic medical conditions do not respond to volume loss in similar or even in a "normal" manner. Thus, anticipation and an attitude of skepticism regarding the patient's "normal" hemodynamic status are appropriate.

   a. Children usually have abundant physiologic reserve and often demonstrate few signs of hypovolemia even after severe volume depletion. When deterioration does occur, it is precipitous and catastrophic.
   b. Elderly patients, at the other extreme, have a limited ability to increase their heart rate in response to blood loss, obscuring one of the earliest signs of volume depletion, tachycardia. Blood pressure has little correlation with cardiac output in the older patient group.
   c. The well-trained athlete also has rigorous compensatory mechanisms, is normally relatively bradycardic, and does not demonstrate the usual level of tachycardia with blood loss.
   d. Pregnant women also have an altered response to volume loss. Due to the physiologic hypervolemia of pregnancy and catecholamine stimulated vasoconstriction in the placental circulation, significant volume loss may occur before signs of hypovolemia become apparent.
   e. It also is common that the `AMPLE" history, described subsequently in this chapter, is not possible to obtain, and the health care team is not aware of the patient's use of medications for chronic conditions.

3. Bleeding

   External hemorrhage is identified and controlled during the primary survey.

Rapid, external blood loss is managed by direct manual pressure on the wound. Pneumatic splinting devices also may help control hemorrhage. These devices should be transparent to allow monitoring of underlying bleeding. Tourniquets should not be used because they crush tissues and cause distal ischemia, except in unusual circumstances such as a traumatic amputation of an extremity. The use of hemostats is time-consuming, and surrounding structures, such as nerves and veins, can be injured. Hemorrhage into the thoracic or abdominal cavities, soft tissues surrounding a major long bone fracture, the retroperitoneal space from a pelvic fracture, or as a result of a penetrating torso injury are the major sources of occult blood loss.

4. Life-threatening chest injuries causing shock

A patient with injuries above the diaphragm may demonstrate evidence of inadequate organ perfusion due to poor cardiac performance from blunt or penetrating myocardial injury, a tension pneumothorax that produces inadequate venous return, or massive bleeding into the chest cavity. (See Appendix 1, Glossary of Frequently Confused Terms.)

a. Tension pneumothorax

Tension pneumothorax is a true surgical emergency that requires immediate diagnosis and treatment. Tension pneumothorax develops when air enters the pleural space but a flap-valve mechanism prevents its escape. Intrapleural pressure rises, causing total lung collapse and a shift of the mediastinum to the opposite side with subsequent impairment of venous return and fall in cardiac output. Tension pneumothorax initially causes chest pain and acute respiratory distress. It also may cause hypotension as torsion of the superior and/or inferior vena cavae, at the upper and lower thoracic inlets, decreases venous return. Tension pneumothorax is a clinical diagnosis and treatment should not be delayed by waiting for radiologic confirmation. It requires immediate needle decompression, followed by tube thoracostomy.

b. Massive hemothorax

Massive hemothorax may acutely impair ventilation when more than 1500 mL of blood rapidly accumulates in the chest cavity. However, it more dramatically presents as hypotension and shock. Massive hemothorax is initially managed by the simultaneous restoration of blood volume and decompression of the chest cavity by means of tube thoracostomy. If 1500 mL of blood is immediately evacuated, it is highly likely that the patient will require an early thoracotomy for control of hemorrhage.

c. Cardiac tamponade

Cardiac tamponade may be caused by bleeding into the pericardium from the heart, great vessels, or pericardial vessels. Only a relatively small amount of blood is required to restrict cardiac activity and interfere with cardiac filling. Prompt evacuation of pericardial blood (pericardiocentesis) is indicated for patients who do not respond to the usual measures of resuscitation for hemorrhagic shock and who have the potential for cardiac tamponade. The simplest method of evacuating the pericardial sac is by performing pericardiocentesis, which should not be delayed for any diagnostic adjunct. Removal of small amounts of blood or fluid, often as little as 15 to 20 mL, may result in immediate hemodynamic improvement if cardiac tamponade exists. However, this procedure must be followed by direct operative repair of the bleeding source.

D. Disability (Neurologic Status)

After circulatory assessment and management, a rapid neurologic evaluation is performed. This neurologic evaluation establishes the patient's level of consciousness as well as pupillary size and reaction. A simple mnemonic to describe the level of consciousness is the AVPU method.

A - Alert
V - Responds to Vocal stimuli
P - Responds only to Painful stimuli
U - Unresponsive to all stimuli

The Glasgow Coma Scale (GCS) is a more detailed neurologic evaluation that also is quick, simple, and is predictive of patient outcome. This evaluation can be done in lieu of the AVPU. If not determined in the primary survey, the GCS should be performed as part of the more detailed, quantitative neurologic examination in the secondary survey. (See Appendix 3, Trauma Scores: Revised and Pediatric.)

A decrease in the level of consciousness may indicate decreased cerebral oxygenation and/or perfusion, or it may be due to direct brain injury. An altered level of consciousness indicates the need for

immediate reevaluation of the patient's oxygenation, ventilation, and perfusion status. Alcohol and/ or other drugs also may alter the patient's level of consciousness. However, if hypoxia and hypovolemia are excluded, changes in the level of consciousness should be considered to be of traumatic central nervous system origin until proven otherwise.

A unilaterally dilated pupil is an ominous sign that indicates the presence of a mass lesion, usually an expanding intracranial hematoma. Immediate consultation with the neurosurgeon is necessary. Failure to recognize and manage an intracranial hemorrhage can lead to transtentorial herniation and death.

Despite proper attention to all aspects of managing the patient with a closed head injury, neurologic deterioration can occur, often rapidly. The lucid interval commonly associated with acute epidural hematoma is an example of a situation where the patient will "talk and die." Frequent neurologic reevaluation can minimize this problem by allowing early detection of changes. It may be necessary to return to the primary survey and to confirm that the patient has a secure airway, adequate ventilation and oxygenation, and adequate cerebral perfusion. Emergent consultation with the neurosurgeon also is necessary to guide additional management efforts.

E. Exposure/Environmental Control

The patient should be completely undressed, usually by cutting off the garments to facilitate thorough examination and assessment. Sporting gear (for example, football helmets and shoulder pads) also should be removed at this time while observing appropriate spine precautions. After the patient's clothing is removed and assessment is completed, it is imperative to cover the patient with warm blankets or an external warming device to prevent hypothermia in the emergency department. Intravenous fluids should be warmed before infusion, and a warm environment should be maintained. It is the patient's body temperature which is most important, not the comfort of the health care providers.

Injured patients may arrive in the emergency department hypothermic, and some of those who require massive transfusions and crystalloid resuscitation become hypothermic despite aggressive efforts to maintain body temperature. The problem is best minimized by early control of hemorrhage. This may require operative intervention or the application of an external device to reduce the pelvic volume for certain types of pelvic fractures. Efforts to rewarm the patient and to prevent hypothermia should be considered as important as any other component of the primary survey or resuscitation phase!

Resuscitation

The resuscitation phase is conducted simultaneously with the primary survey. Aggressive resuscitation and the management of life-threatening injuries, as they are identified, are essential to maximize patient survival.

A. Airway

The airway should be protected in all patients and secured when the potential for airway compromise exists. The jaw thrust or chin lift maneuver may suffice. A nasopharyngeal airway may initially establish and maintain airway patency in the conscious patient. If the patient is unconscious and has no gag reflex, an oropharyngeal airway may be helpful temporarily. However, a definitive airway should be established if there is any doubt about the patient's ability to maintain airway integrity.

Definitive control of the airway in patients who have compromised airways due to mechanical factors, who have ventilatory problems, or who are unconscious is achieved by endotracheal intubation, either nasally or orally. This procedure should be accomplished with continuous protection of the cervical spine. A surgical airway (cricothyroidotomy) should be performed if oro- or nasotracheal intubation is contraindicated or cannot be accomplished.

B. Breathing/Ventilation/Oxygenation

Every injured patient should receive supplemental oxygen to achieve optimal oxygenation. If not intubated and if the patient is breathing spontaneously, the patient should have oxygen administered by a nonrebreathing mask to achieve optimal oxygenation. If intubated, the patient should have oxygen delivered by and ventilations assisted with a bag-valve reservoir device. The use of the pulse oximeter is valuable in monitoring adequate hemoglobin saturation.

Tube thoracostomy is required in the definitive control of the following, immediately life-threatening chest injuries.

1. Tension pneumothorax, after needle decompression
2. Open pneumothorax, after placement of an occlusive dressing over the wound
3. Massive hemothorax with simultaneous restoration of blood volume
4. Circulation

The first, most critical step in shock management is to stop the bleeding. Control bleeding by direct pressure or operative intervention. With few exceptions, patients who are hypotensive on admission require urgent surgical management.

The second vitally important step in shock management, after hemorrhage is controlled, is to restore circulating blood volume. A minimum of two large-caliber *intravenous* catheters (IVs) should be established. The maximum rate of fluid administration is determined by the internal diameter of the catheter and inversely by its length, not by the size of the vein in which the catheter is placed. Establishment of upper extremity peripheral intravenous access is preferred. Other peripheral lines, cutdowns, and central venous lines should be utilized as necessary in accordance with the skill level of the doctor caring for the patient. When establishing the intravenous lines, blood should be drawn for type and crossmatch and for baseline hematologic studies, including a pregnancy test for all females of childbearing age.

Intravenous fluid therapy with a balanced salt solution should be initiated. Ringer's lactate solution is preferred as the initial crystalloid solution and should be administered rapidly. Such bolus intravenous therapy may require the administration of two to three liters of solution to achieve an appropriate patient response in the adult patient. All intravenous solutions should be warmed either by storage in a warm environment (37 to 40°C or 98.6 to 104°F) or by fluid warming devices.

The shock state associated with trauma is most often hypovolemic in origin. Patients with minimal blood loss (less than 20% blood loss) respond rapidly to bolus intravenous therapy. However, if the patient responds only transiently to fluid replacement or remains unresponsive to bolus intravenous therapy, type-specific blood may be administered as necessary. If type-specific blood is not available, low titer type O or 0-negative blood is considered as a substitute. For life-threatening blood loss, the use of unmatched, type-specific blood is preferred over type O blood unless multiple, unidentified casualties are being treated simultaneously. Hypovolemic shock should not be treated by vasopressors, steroids, or sodium bicarbonate, or continued crystalloid/blood infusion. If blood loss continues this should be controlled by operative intervention. The process of operative resuscitation provides the surgeon the opportunity to stop the bleeding in addition to the maintenance and restoration of intravascular volume. If shock persists despite seemingly adequate volume resuscitation, consider other causes of shock, for example, tension pneumothorax, cardiac tamponade, blunt cardiac injury.

Hypothermia may be present when the patient arrives or it may develop quickly in the emergency department in the uncovered patient and by rapid administration of room temperature fluids or refrigerated blood. Hypothermia is a potentially lethal complication in the injured patient and aggressive measures should be taken to prevent the loss of body heat and to restore body temperature to normal. The temperature of the resuscitation area should be increased to minimize the loss of body heat. The use of a high-flow fluid warmer or microwave oven to heat crystalloid fluids to 39°C (102.2°F) is recommended. Blood products should not be warmed in a microwave oven.

Use of the pneumatic antishock garment (PASG) is not recognized as appropriate treatment for most forms of hypovolemic shock. However, it may be indicated for hypotension associated with unstable pelvic fractures.

Adjuncts to Primary Survey and Resuscitation

A. Urinary and Gastric Catheters

The placement of urinary and gastric catheters should be considered as part of the resuscitation phase.

1. Urinary catheters

   Urinary output is a sensitive indicator of the volume status of the patient and reflects renal perfusion. Monitoring of urinary output is best accomplished by the insertion of an indwelling bladder catheter. Transurethral bladder catheterization is contraindicated in patients in whom urethral transection is suspected. Urethral injury should be suspected if there is (1) blood at the penile meatus, (2) perineal ecchymosis, (3) scrotal hematoma, (4) a high-riding or nonpalpable prostate, or (5) a pelvic fracture. Accordingly, the urinary catheter should not be inserted before an examination of the rectum and genitalia. If urethral injury is suspected, urethral integrity should be confirmed by a retrograde urethrogram before the catheter is inserted.

   A urine specimen should be submitted for routine laboratory analysis whenever a urinary catheter is inserted.

2. Gastric catheters

   A gastric tube is indicated to reduce stomach distention and decrease the risk of aspiration. Decompression of the stomach reduces the risk of aspiration, but does not prevent it entirely. Thick or semisolid gastric contents will not return through the tube, and actual passage of the tube may induce vomiting. For the tube to be effective, it must be positioned properly, attached to appropriate suction, and be functioning. Blood in the gastric aspirate may represent oropharyngeal (swallowed) blood, traumatic insertion, or actual injury to the upper digestive tract. If a cribriform plate fracture, basilar skull fracture, or massive maxillofacial trauma is suspected or present, the gastric tube should be inserted orally to prevent intracranial passage. In this situation, any nasopharyngeal instrumentation is potentially dangerous.

B. Monitoring

Adequate resuscitation is best assessed by improvement in physiologic parameters, that is, pulse rate, blood pressure, pulse pressure, ventilatory rate, arterial blood gas analysis, body temperature, and urinary output, rather than the qualitative assessment done in the primary survey. Actual values for these parameters should be obtained as soon as practical after completing the primary survey. Periodic reevaluation is prudent.

1. Ventilatory rate and arterial blood gases should be used to monitor the adequacy of the patient's airway and breathing. Endotracheal tubes can be dislodged whenever the patient is moved. A colorimetric carbon dioxide detector should be readily available in the emergency department. This device is capable of detecting carbon dioxide in exhaled gas and can rapidly detect the presence of carbon dioxide in exhaled gas. It is useful in confirming that the endotracheal tube is located somewhere in the airway of the ventilated patient and not in the esophagus. It does not confirm proper placement of the tube in the airway. Auscultation of the chest and epigastrium as well as a chest x-ray are more appropriate for determining tube position.
2. Pulse oximetry is a valuable adjunct for monitoring injured patients. The pulse oximeter measures the oxygen saturation of hemoglobin colorimetrically, but does not measure ventilation or the partial pressure of oxygen. A small sensor is placed on the finger, toe, earlobe, or some other convenient place. Most devices display pulse rate and oxygen saturation continuously.
3. The blood pressure should be measured, realizing that it may be a poor measure of actual tissue perfusion.
4. Electrocardiographic (ECG) monitoring of all trauma patients is required. Dysrhythmias, including unexplained tachycardia, atrial fibrillation, premature ventricular contractions, and ST segment changes, may indicate blunt cardiac injury. Pulseless electrical activity (PEA, formerly termed electromechanical dissociation) may indicate cardiac tamponade, tension pneumothorax, and/or profound hypovolemia. When bradycardia, aberrant conduction, and premature beats are present, hypoxia and hypoperfusion should be suspected immediately. Extreme hypothermia also produces these dysrhythmias.

C. X-rays and Diagnostic Studies

X-rays should be used judiciously and should not delay patient resuscitation. The anteroposterior (AP) chest film and an AP pelvis film may provide information which can guide resuscitation efforts of the patient with blunt trauma. Chest films may demonstrate potentially life-threatening injuries requiring treatment, and pelvic films may demonstrate fractures of the pelvis which indicate the need for early blood transfusion and the possibility of urethral or bladder injury. These films can be taken in the resuscitation area, usually with a portable x-ray unit, but should not interrupt the resuscitation process.

A lateral cervical spine x-ray should be obtained with a portable x-ray unit during the secondary survey on any patient who may have a cervical spine injury. A lateral cervical spine x-ray that demonstrates an injury is an important finding while a negative or inadequate film does not exclude cervical spine injury. During the secondary survey, complete cervical and thoracolumbar spine films also may be obtained if the patient's care is not compromised, and if the mechanism of injury suggests the possibility of spinal injury. Spinal cord protection should have been performed in the primary survey and maintained. Essential diagnostic x-rays should not be avoided in the pregnant patient.

Diagnostic peritoneal lavage (DPL) and focused abdominal sonography in trauma (FAST) are useful tools for the quick detection of occult intraabdominal bleeding. Their use depends on the skill and experience level of the doctor. Early identification of the source of occult intraabdominal blood loss may indicate the need for operative control of hemorrhage.

Consider the Need for Patient Transfer

During the primary survey and resuscitation phase, the evaluating doctor frequently has enough information to indicate the need for transfer of the patient to another facility. This transfer process may be initiated immediately by administrative personnel at the direction of the examining doctor, while additional evaluation and resuscitative measures are being performed. Transfer should be initiated when the treatment needs of the patient exceed the capabilities of the initial facility. The patient should be transferred to the closest appropriate facility, that is, one capable of satisfactorily meeting the patient's treatment needs, ideally a trauma center. Once the decision to transfer the patient has been made, referring doctor to receiving doctor communication is essential. Remember, life-saving measures are initiated when the problem is identified, rather than after the primary survey.

Secondary Survey

The secondary survey does not begin until the primary survey (ABCDEs) is completed, resuscitative efforts are well established, and the patient is demonstrating normalization of vital functions.

The secondary survey is a head-to-toe evaluation of the trauma patient, that is, a complete history and physical examination, including a reassessment of all vital signs. Each region of the body is completely examined. The potential for missing an injury or failure to appreciate the significance of an injury is great, especially in the unresponsive or unstable patient.

In this survey a complete neurologic examination is performed, including a GCS Score determination, if not done during the primary survey. During this evaluation, indicated x-rays (that is, x-rays pertinent to the sites of suspected injury), are obtained. Such examinations can be interspersed into the secondary survey at appropriate times.

Special procedures, for example, speck radiologic evaluations and laboratory studies, also are obtained during this time. Complete evaluation of the patient requires repeated physical examination. The secondary assessment might well be summarized as "tubes and fingers in every orifice."

A. History

Every complete medical assessment should include a history of the mechanism of injury. Many times such a history cannot be obtained from the patient. Prehospital personnel and family must be consulted to obtain information that may enhance an understanding of the patient's physiologic state. The AMPLE history is a useful mnemonic for this purpose.

A Allergies

M Medications currently used

P Past illnesses/Pregnancy

L Last meal

E Events/Environment related to the injury

The patient's condition is greatly influenced by the mechanism of injury. Prehospital personnel can provide valuable information on such mechanisms and should report pertinent data to the examining doctor. Some injuries can be predicted based on the direction and amount of energy force. (See Appendix 4, Mechanisms of Automotive Injury and Related, Suspected Injury Patterns.) Injury usually is classed into two broad categories, blunt and penetrating.

1. Blunt trauma

   Blunt trauma results from automobile collisions; falls; and other transportation-, recreation-, and occupation-related injuries.

   Important information to obtain about automobile collisions includes: seat belt usage, steering wheel deformation, direction of impact, damage to the automobile in terms of major deformation or intrusion into the passenger compartment, and ejection of the passenger from the vehicle. Ejection from the vehicle greatly increases the chance of major injury.

   Injury patterns may often be predicted by the mechanism of injury. Such injury patterns also are influenced by age groups and activities. (See Appendix 4, Mechanisms of Injury and Related, Suspected Injury Patterns.)

2. Penetrating trauma

   The incidence of penetrating trauma (injuries from firearms, stabbings, and impaling objects), has increased rapidly in recent years. Factors determining the type and extent of injury and subsequent management include the region of the body injured, the organs in proximity to the path of the penetrating object, and the velocity of the missile. Therefore, the velocity, caliber and presumed path of the bullet, and the distance from weapon to wounded may provide important clues to the extent of injury.

3. Injuries due to burns and cold

   Burns are another significant type of trauma that may occur alone or may be coupled with blunt and penetrating trauma resulting from a burning automobile, explosion, falling debris, the patient's attempt to escape the fire, or an assault with a firearm or knife. Inhalation injury and carbon monoxide poisoning often complicate burn injury. Therefore, it is important to know the circumstances of the burn injury. Specifically, knowledge of the environment in which the burn injury occurred (open or closed space), substances consumed by the flames (plastics, chemicals, and so on), and possible associated injuries sustained is critical in the treatment of the patient.

   Patients sustaining body surface chemical burns require removal of dry chemicals and/or profuse irrigation of the affected area.

   Acute or chronic hypothermia without adequate protection against heat loss produces either local or generalized cold injuries. Significant heat loss may occur at moderate temperatures (15 to 20°C or 59 to 68°F) if wet clothes, decreased activity, and/or vasodilatation caused by alcohol or drugs compromise the patient's ability to conserve heat. Such historical information can be obtained from prehospital personnel.

4. Hazardous environment

   History of exposure to chemicals, toxins, and radiation are important to obtain for two reasons. First, these agents can produce a variety of pulmonary, cardiac, or internal organ dysfunction in the injured patient Second, these same agents also present a hazard to health care providers. Frequently, the doctor's only means of preparation is to understand the general principles of management of such conditions and establish immediate contact with the Regional Poison Control Center.

B. Physical Examination

1. Head

   The secondary survey begins with evaluating the head and identifying all related and significant injuries. The entire scalp and head should be examined for lacerations, contusions, and evidence of fractures.

Because edema around the eyes may later preclude an in-depth examination, the eyes should be reevaluated for:

a. Visual acuity
b. Pupillary size
c. Hemorrhages of the conjunctiva and fundi
d. Penetrating injury
e. Contact lenses (remove before edema occurs)
f. Dislocation of the lens
g. Ocular entrapment

A quick visual acuity examination of both eyes can be performed by having the patient read printed material, for example, a hand-held Snelling Chart, words on an intravenous container, or a 4 x 4 dressing package. Ocular mobility should be evaluated to exclude entrapment of extraocular muscles due to orbital fractures. These procedures frequently identify optic injuries not otherwise apparent.

Facial edema in patients with massive facial injury or patients in coma can preclude a complete eye examination. Such difficulties should not deter the doctor from performing those components of the ocular examination that are possible.

2. Maxillofacial

Maxillofacial trauma, not associated with airway obstruction or major bleeding, should be treated only after the patient is stabilized completely and life-threatening injuries have been managed. Definitive management may be safely delayed without compromising care at the discretion of appropriate specialists.

Patients with fractures of the midface may have a fracture of the cribriform plate. For these patients, gastric intubation should be performed via the oral route.

Some maxillofacial fractures, for example, nasal fracture, nondisplaced zygomatic fractures, and orbital rim fractures, may be difficult to identify early in the evaluation process. Therefore, frequent reassessment is crucial.

3. Cervical spine and neck

Patients with maxillofacial or .head trauma should be presumed to have an unstable cervical spine injury (fracture and/or ligamentous injury), and the neck should be immobilized until all aspects of the cervical spine have been adequately studied, injury excluded, and the patient is clinically asymptomatic. The absence of neurologic deficit does not exclude injury to the cervical spine, and such injury should be presumed until a complete cervical spine radiographic series is reviewed by a doctor experienced in detecting cervical spine fractures radiographically.

Examination of the neck includes inspection, palpation, and auscultation. Cervical spine tenderness, subcutaneous emphysema, tracheal deviation, and laryngeal fracture may be discovered on a detailed examination. The carotid arteries should be palpated and auscultated for bruits. Evidence of blunt injury over these vessels should be noted and, if present, should arouse a high index of suspicion for carotid artery injury. Occlusion or dissection of the carotid artery may occur hours or days after the injury without antecedent signs or symptoms. Angiography or duplex ultrasonography may be required to exclude the possibility of major cervical vascular injury when the mechanism of injury suggests that possibility. Most major cervical vascular injuries are the result of penetrating injury. However, blunt force to the neck, or a traction injury from a shoulder harness restraint can result in intimal disruption, dissection, and thrombosis.

Protection of a potentially unstable cervical spine injury is imperative for patients wearing any type of protective helmet. Extreme care must be taken when removing the helmet.

Penetrating injuries to the neck have the potential of injuring several organ systems. Wounds that extend through the platysma should not be explored manually or probed with instruments in the emergency department or by individuals in the emergency department who are not trained to deal with such injuries. The emergency department usually is not equipped to deal with problems which may be encountered unexpectedly. These injuries require evaluation by a surgeon, either operatively, or with specialized diagnostic procedures under direct supervision by the surgeon. The finding of active arterial bleeding, an expanding hematoma, arterial bruit, or airway compromise usually requires surgical operative evaluation. Unexplained or isolated paralysis of an upper extremity should raise the suspicion of a cervical nerve root injury and be accurately documented.

Blunt injury to the neck may produce injuries in which clinical signs and symptoms develop late and may not be present during the initial examination. Injury to the intima of the carotid arteries is an example.

The identification of cervical nerve root or brachial plexus injury may not be possible in the comatose patient. Consideration of the mechanism of injury may be the only clue available to the doctor.

In some patients, a decubitus ulcer may develop quickly over the sacrum or other areas from immobilization on a rigid spine board and the cervical collar. Efforts to exclude the possibility of spinal injury should be initiated as soon as practical and these devices removed. However, resuscitation and efforts to identify life-threatening or potentially life-threatening injuries should not be compromised.

4. Chest

   Visual evaluation of the chest, both anterior and posterior, identifies such conditions as open pneumothorax and large flail segments. A complete evaluation of the chest wall requires palpation of the entire chest cage, including the clavicle, ribs, and sternum. Sternal pressure may be painful if the sternum is fractured or costochondral separations exist. Contusions and hematomas of the chest wall should alert the doctor to the possibility of occult injury.

   Significant chest injury may be manifested by pain, dyspnea, or hypoxia. Evaluation includes auscultation of the chest and a chest x-ray. Breath sounds are auscultated high on the anterior chest wall for pneumothorax and at the posterior bases for hemothorax. Auscultatory findings may be difficult to evaluate in a noisy environment, but may be extremely helpful. Distant heart sounds and narrow pulse pressure may indicate cardiac tamponade. Cardiac tamponade or tension pneumothorax may be suggested by the presence of distended neck veins, although associated hypovolemia may minimize this finding or eliminate it altogether. Decreased breath sounds, hyperresonance to percussion, and shock may be the only indications of tension pneumothorax and the need for immediate chest decompression.

   The chest x-ray confirms the presence of a hemothorax or simple pneumothorax. Rib fractures may be present, but they may not be visible on the x-ray. A widened mediastinum or deviation of the gastric tube to the right may suggest an aortic rupture.

   Significant injury to the intrathoracic structures, especially the lungs, occurs frequently in children without evidence of thoracic skeletal trauma on physical examination. A high index of suspicion is essential.

   Elderly patients may not be tolerant of even relatively minor chest injuries. Progression to acute respiratory insufficiency must be anticipated and support instituted before collapse occurs.

5. Abdomen

   Abdominal injuries must be identified and treated aggressively. The specific diagnosis is not as important as the recognition that an injury exists and surgical intervention may be necessary. A normal initial examination of the abdomen does not exclude a significant intraabdominal injury. Close observation and frequent reevaluation of the abdomen, preferably by the same observer, is important in managing blunt abdominal trauma. Over time, the patient's abdominal findings may change. Early involvement by a surgeon is essential.

   Patients with unexplained hypotension, neurologic injury, impaired sensorium secondary to alcohol and/or other drugs, and equivocal abdominal findings should be considered as candidates for peritoneal lavage, abdominal ultrasonography, or if hemodynamically normal, computed tomography of the abdomen with intravenous and intragastric contrast. Fractures of the pelvis or the lower rib cage also may hinder accurate diagnostic examination of the abdomen, because pain from these areas may be elicited when palpating the abdomen.

   Excessive manipulation of the pelvis should be avoided. The AP pelvic x-ray, performed as an adjunct to the primary survey and resuscitation, should be used as the guide to the identification of pelvic fractures which have the potential of being associated with significant blood loss.

Injury to the retroperitoneal organs may be difficult to identify, even with the use of computed tomography. Hollow viscus and pancreatic injury are classic examples.

Knowledge of injury mechanism, associated injuries which can be identified, and a high index of suspicion are required. Despite the doctor's appropriate diligence, some of these injuries are not diagnosed initially.

6. Perineum/rectum/vagina

The perineum should be examined for contusions, hematomas, lacerations, and urethral bleeding.

A rectal examination should be performed before placing a urinary catheter. Specifically, the doctor should assess for the presence of blood within the bowel lumen, a high-riding prostate, the presence of pelvic fractures, the integrity of the rectal wall, and the quality of the sphincter tone.

For the female patient, a vaginal examination also is an essential part of the secondary survey. The doctor should assess for the presence of blood in the vaginal vault and vaginal lacerations. Additionally, pregnancy tests should be performed on all women of childbearing age. Inability to identify pregnancy very early in gestation remains problematic.

Female urethral injury, while uncommon, does occur in association with pelvic fractures and straddle injuries. When present, they are difficult to detect.

7. Musculoskeletal

The extremities should be inspected for open wounds, contusions, or deformities. Palpation of the bones and examining for tenderness or abnormal movement, aids in the identification of occult fractures. Additionally, assessment of peripheral pulses aid in the identification of vascular injuries.

Pelvic fractures can be suspected by the identification of ecchymosis over the iliac wings, pubis, labia or scrotum. Other clues include an increase in the width of the pubic symphysis and leg length inequality. Pain on palpation of the pelvic ring is an important finding in the alert patient. Mobility of the pelvis in response to gentle anterior to posterior pressure with the heels of the hands on both anterior iliac spines and the symphysis pubis can suggest pelvic ring disruption in the unconscious patient.

Blood loss from pelvic fractures which increased pelvic volume can be difficult to detect and control, and fatal hemorrhage may result. A sense of urgency should accompany the management of these injuries.

Thoracic and lumbar spinal fractures and/or neurologic injuries must be considered based on physical findings and mechanism of injury. Other injuries may mask the physical findings of spinal injuries, which may go unsuspected unless the doctor obtains the appropriate x-rays.

The doctor must remember that the musculoskeletal examination is not complete without an examination of the patient's back. Unless the patient is carefully log-rolled so the patient's back can be examined, significant injuries may be missed.

Significant extremity injuries may exist without fractures being evident on examination or x-rays. Ligament ruptures produce joint instability. Muscle-tendon unit injuries interfere with active motion of the affected structures. Impaired sensation and/or loss of voluntary muscle contraction strength may be due to nerve injury or to ischemia, including that due to compartment syndrome.

Fractures involving the bones of the hands, wrists, and feet are often not diagnosed in the secondary survey performed in the emergency department. It may be only after the patient has regained consciousness or other major injuries are resolved that the patient complains of pain or dysfunction in the area of an occult injury.

Compartment syndrome may be present in patients with ischemic or crush injuries to the distal lower extremities. This complication must be suspected in any patient who presents with such injuries, particularly if the patient is hypotensive or has an altered level of consciousness.

Injuries to the soft tissues around joints are frequently diagnosed after the patient begins to recover. Therefore, frequent reevaluation is essential.

8. Neurologic

A comprehensive neurologic examination includes not only motor and sensory evaluation of the extremities, but also reevaluation of the patient's level of consciousness and pupillary size and response. The GCS Score facilitates detection of early changes and trends in the neurologic status. (See Appendix 3, Trauma Scores: Revised and Pediatric.)

Early consultation with a neurosurgeon is required for patients with neurologic injury. The patient should be monitored frequently for deterioration in the level of consciousness or changes in the neurologic examination as these findings may reflect progression of the intracranial injury. Non-contrast computed tomography (CT) of the head should be performed in any patient for whom there is suspicion of traumatic brain injury. If a patient with a head injury deteriorates neurologically, oxygenation and perfusion of the brain and the adequacy of ventilation (ABCDEs) must be reassessed, and a CT scan obtained if not already performed. Measures to reduce intracranial pressure, including intracranial surgical intervention, may be necessary. The neurosurgeon must determine whether such conditions as epidural and subdural hematomas require evacuation or depressed skull fractures need operative intervention.

Any increase in intracranial pressure can reduce cerebral perfusion pressure and lead to secondary brain injury. Secondary brain injury is caused by hypotension and hypoxia. Hypotension increases mortality. Most of the diagnostic and therapeutic maneuvers necessary for the evaluation and care of the brain-injured patient increase intracranial pressure. Tracheal intubation is a typical example, and in the patient with brain injury, it should be performed expeditiously and as smoothly as possible. Rapid neurologic deterioration of the brain injured patient can occur despite the application of all measures to control intracranial pressure and maintain appropriate support of the central nervous system.

Any evidence of loss of sensation, paralysis, or weakness suggests major injury to the spinal column or peripheral nervous system. X-rays of the entire spinal column are indicated under such circumstances. Neurologic deficits should be documented when identified, even when transfer to another facility or doctor for specialty care is necessary. Immobilization of the entire patient, using a long spine board, a semi-rigid cervical collar, and/or other cervical immobilization devices, must be maintained until spinal injury can be excluded. The common mistake of immobilizing the head and freeing the torso allows the cervical spine to flex with the body as a fulcrum. Protection of the spinal cord is required at all times until a spine injury is excluded, and especially when a patient is transferred.

Adjuncts to the Secondary Survey

Specialized diagnostic tests may be performed during the secondary survey to identify specific injuries. These include additional x-rays of the spine and extremities; computerized tomography of the head, chest, abdomen and spine; contrast urography; angiography; transesophageal ultrasound; bronchoscopy; esophagoscopy; and other diagnostic procedures. Often these procedures require transportation of the patient to other areas of the hospital where equipment and personnel to manage life-threatening contingencies are not immediately available. Therefore, these specialized tests should not be performed until the patient's hemodynamic status has been normalized and the patient has been carefully examined. If the studies are to be performed and if there is any potential for deterioration of the patient's condition, qualified members of the trauma team must accompany the patient to the diagnostic suite.

Reevaluation

The trauma patient must be reevaluated constantly to assure that occult or other injuries (not previously identified) are not overlooked, and to discover adverse changes from previously noted findings. As initial life-threatening injuries are managed, other equally life-threatening problems and less severe injuries may become apparent. Underlying medical problems that may severely affect the ultimate prognosis of the patient may become evident. A high index of suspicion facilitates early diagnosis and management.

Continuous monitoring of vital signs and urinary output is essential. For the adult patient, maintenance of urinary output of 0.5 mI/kg/hour is desirable. In the pediatric patient over one year of age, an output of 1 mL/kg/hour should be adequate. Arterial blood gas and cardiac monitoring devices should be employed. Pulse oximetry, for critically injured patients, and end-tidal carbon dioxide monitoring, for intubated patients, should be considered.

Pain Management

The relief of severe pain is an important part of the management of the trauma patient. Many injuries, especially musculoskeletal injuries, produce pain and anxiety in the conscious patient. Effective analgesia usually requires the use of intravenous opiates or anxiolytics. Intramuscular injections should be avoided. These agents should be administered judiciously and in small doses to achieve the desired level of patient comfort and relief of anxiety while avoiding respiratory depression, the masking of subtle injuries or changes in the patient's status. Careful reevaluation is essential to ensure that respiratory depression does not result in impaired ventilation and oxygenation.

Transfer to Definitive Care

Preestablished criteria for interhospital transfer, help determine the level, pace, and intensity of initial management of the multiple-injured patient. These criteria take into account the patient's physiologic status, obvious and anatomic injury, mechanisms of injury, concurrent diseases, and factors that may alter the patient's prognosis. Emergency department and surgical personnel should use these criteria to determine if the patient requires transfer to a trauma center or closest appropriate hospital capable of providing more specialized care. The closest appropriate hospital should be chosen based on its overall capabilities to care for the injured patient. (See Appendix 2, Prehospital Triage Decision Scheme.) Definitive care is initiated in accordance with the principles outlined herein.

The transfer process should be initiated as soon as the need is recognized. Patient transfer is not delayed to obtain definitive diagnostic tests. Instead, time before transfer focuses on patient evaluation and resuscitation, and direct doctor-to-doctor communication at the receiving hospital.

A. Airway and Breathing

1. Actual or impending airway obstruction should be suspected in all injured patients.
2. The cervical spine must be protected by inline immobilization when performing all airway maneuvers.
3. Clinical signs suggesting airway compromise should be managed by securing a patent airway and providing adequate oxygen-enriched ventilation.
4. Definitive control of the airway should be established by performing endotracheal intubation or cricothyroidotomy if there is any doubt on the part of the doctor as to the integrity of the patient's airway.
5. Definitive control of the airway should be established early after the patient has been ventilated with oxygen-enriched air. Prolonged periods of apnea must be avoided.
6. Airway management requires assessment and reassessment of airway patency, endotracheal tube position, and ventilatory effectiveness.
7. The selection of orotracheal or nasotracheal routes for intubation is based on the experience and skill level of the doctor.
8. A surgical airway is indicated whenever a definitive airway is needed and nonsurgical attempts at intubation are unsuccessful.

B. Hemorrhagic Shock

1. Hypovolemia is the cause of shock in most trauma patients.
2. Management of the patient in shock requires immediate hemorrhage control (stop the bleeding), and intravenous fluids and/or blood replacement.
3. Patients who fail to respond to these measures because of continued bleeding usually require operative control of the hemorrhage.
4. Other possible causes of the shock state must be considered in the transient responders or non-responders.
5. The patient's response to initial fluid therapy determines further therapeutic and diagnostic procedures.
6. All patients who manifest signs of hypovolemic shock are potential candidates for surgical exploration.
7. The goal of therapy is prompt restoration of organ perfusion with the delivery of oxygen and substrate to the cell for aerobic metabolism.
8. Vasopressors are contraindicated in the management of hypovolemic shock.

9. Central venous pressure measurement may be a valuable tool for confirming the volume status and monitoring the rate of fluid administration in selected patients.

C. Thoracic Trauma

1. Thoracic trauma is common in the multiple-injured patient and can be associated with life threatening problems.
2. Patients with thoracic injuries usually can be treated or their conditions temporarily improved or relieved by relatively simple measures such as intubation, ventilation, needle decompression, tube thoracostomy, and needle pericardiocentesis.
3. The ability to recognize life-threatening thoracic injuries and the skills to perform the necessary procedures can be life-saving.
4. An unrecognized tension pneumothorax remains a leading cause of preventable death in patients with thoracic trauma.

D. Abdominal Trauma

1. Early consultation with a surgeon is necessary whenever a patient with possible intraabdominal injuries is brought to the emergency department.
2. Once the patient's vital functions have been restored, evaluation and management varies depending on the mechanism of injury.
3. The hemodynamically abnormal patient with multiple blunt injuries is rapidly assessed for intraabdominal bleeding or contamination from the gastrointestinal tract by performing diagnostic peritoneal lavage (DPL) or focused assessment by sonography in trauma (FAST). The hemodynamically normal patient with signs suggestive of peritonitis is evaluated by contrastenhanced CT, with the decision to operate based on the speck organ involved, the magnitude of injury, and clinical judgment.
4. All patients with penetrating wounds in proximity to the abdomen and associated hypotension, peritonitis, or evisceration require emergent celiotomy. Patients with gunshot wounds that obviously traverse the peritoneal cavity or visceral/vascular area of the retroperitoneum on physical examination or routine x-rays also require emergency celiotomy. Asymptomatic patients with anterior abdominal stab wounds that penetrate the fascia or peritoneum on local wound exploration may be evaluated by serial physical examinations or DPL. Asymptomatic patients, with flank or back stab wounds that are not obviously superficial, are evaluated by serial physical examinations or contrast-enhanced CT, although it may be safer to perform a celiotomy in patients with gunshot wounds to the flank and back.

E. Head Trauma

1. Avoid secondary brain injury through vigorous support of the airway, breathing, and circulation.
2. In a comatose patient, secure and maintain the airway by endotracheal intubation.
3. Ventilate the comatose patient to reverse hypercarbia, maintaining the Pco_2 between 25 and 35 mm Hg (3.3 to 4.7 kPa). Aggressive hyperventilation can compromise cerebral perfusion and should be avoided unless there are signs of impending herniation or acute neurologic deterioration.
4. Shock should not be attributed to a head injury. Treat shock aggressively and look for its cause.
5. Resuscitate with normal saline, Ringer's lactate solution, or similar isotonic solutions without dextrose. Do not use hypotonic solutions.
6. Avoid both hypovolemia and overhydration. The goal in resuscitating the head-injured patient is to achieve a euvolemic state.
7. Perform a minineurologic examination after normalizing the blood pressure and before paralyzing the patient. Search for associated injuries.
8. Contact a neurosurgeon as early as possible-preferably even before the patient arrives in the emergency department. If a neurosurgeon is not available at your facility, transfer all moderately or severely head-injured patients to a facility with the resources and capabilities to manage these types of patients.
9. Frequently reassess the patient's neurologic status.
10. Exclude cervical spine injuries radiographically and clinically, and obtain other radiographs as needed.

F. Spine and Spinal Cord Trauma

1. Attend to life-threatening injuries, minimizing any movement of the spinal column.
2. Establish and maintain proper immobilization of the patient until vertebral fractures or spinal cord injuries have been excluded.
3. Obtain a lateral c-spine x-ray, when indicated, as soon as life-threatening injuries are controlled.
4. Document the patient's history and physical examination to establish a baseline for any changes in the patient's neurologic status.
5. Obtain early consultation with a neurosurgeon and/or orthopedic surgeon whenever a spinal injury is suspected or detected.
6. Transfer patients with vertebral fractures or spinal cord injury to a definitive-care facility.

G. Musculoskeletal Trauma

1. The goal of assessment and management of musculoskeletal trauma is to identify injuries that pose a threat to life and/or limb.
2. Although uncommon, life-threatening musculoskeletal injuries must be properly assessed and managed.
3. Most extremity injuries are appropriately diagnosed and managed during the secondary survey.
4. It is essential to recognize and manage in a timely manner pelvic fractures, arterial injuries, compartment syndrome, open fractures, crush injuries, and fracture-dislocations.
5. Early splinting of fractures and dislocations can prevent serious complications and late sequelae.
6. An awareness of the patient's tetanus status and appropriate treatment are essential and can prevent serious complications.

H. Injuries Due to Burns and Cold

1. Burn injury: Thermal, chemical, electrical
   a. Immediate life-saving measures for the burn patient include the recognition of inhalation injury and subsequent endotracheal intubation, and the rapid institution of intravenous fluid therapy.
   b. Rapidly remove all clothing
   c. Identify the extent and depth of the burn
   d. Administer fluids according to the patient's weight and body surface area burned
   e. Maintain peripheral circulation in circumferential burns by performing an escharotomy if necessary
   f. Identify which burn patients require transfer to a burn unit or center
2. Cold injuries
   a. Diagnose the cause and severity of cold injury by obtaining an adequate history and noting the physical findings as well as measuring the core temperature using a low-range thermometer (esophageal temperature probe preferred).
   b. Immediately remove the patient from the cold environment, and continuously monitor and support the patient's airway, breathing, and circulation.
   c. Apply rewarming techniques as soon as possible
   d. The patient with hypothermia should not be considered dead until rewarming has occurred.

I. Pediatric Trauma

1. The recognition and management of pediatric injuries require the same astute skills as those required for adults.
2. Unique features of the pediatric trauma patient require special attention to airway anatomy and management, fluid requirements, recognition of CNS injury as well as thoracic and abdominal injuries, diagnosis of extremity fractures, and the recognition of the battered, abused child.
3. Most pediatric trauma results from a blunt mechanism of injury involving the head, mandating an aggressive management approach to the airway and breathing.
4. The child with multiple injuries, including head injury, must be rapidly and appropriately resuscitated to avoid the untoward effects of hypovolemia and secondary brain injury.
5. Early involvement of a qualified surgeon is imperative in the management of the injured child.

6. Non-operative management of abdominal visceral injuries should be performed only by surgeons in facilities equipped to handle any contingencies in an expeditious manner.

J. Trauma in Pregnancy

1. Important and predictable anatomic and physiologic changes occur during pregnancy that may influence the evaluation and treatment of the injured pregnant patient. Because of the increased intravascular volume, the pregnant patient can lose a significant amount of her blood volume before tachycardia, hypotension, and other signs of hypovolemia occur. Thus the fetus may be "in shock" and deprived of vital perfusion, while the mother's condition and vital signs appear stable.
2. Vigorous fluid and blood replacement should be given to correct and prevent maternal as well as fetal hypovolemic shock.
3. A search should be made for conditions unique to the injured pregnant patient, such as blunt or penetrating uterine trauma, abruptio placentae, amniotic fluid embolism, isoimmunization, and premature rupture of membranes.
4. Attention also must be directed toward the fetus, the second patient of this unique duo, after its environment is stabilized.
5. The best prevention of fetal demise is early and aggressive maternal resuscitation.
6. A qualified surgeon and obstetrician should be consulted early in the evaluation of the pregnant trauma patient.

Summary

The TEAM Program for medical student presents an ABCDE-approach to trauma care. It introduces one, safe way to care for the trauma patient, and emphasizes the principles of "do no further harm" and "treat the greatest threat to life first."

The injured patient must be evaluated rapidly and thoroughly. The doctor must develop treatment priorities for the overall management of the patient, so no steps in the process are omitted. An adequate patient history and accounting of the incident are important in evaluating and managing the trauma patient.

Evaluation and care are divided into the following phases for the purposes of discussion and to provide clarity. In actual situations, assessment, resuscitation or treatment, reevaluation, and diagnosis may occur simultaneously, but priorities should not change.

A. Primary Survey Assessment of ABCDEs

1. Airway with cervical spine protection
2. Breathing with management of life-threatening chest injuries
3. Circulation with control of hemorrhage
4. Disability: Brief neurologic evaluation with intracranial mass lesion recognition
5. Exposure/Environment: Completely undress the patient, but prevent hypothermia

D. Resuscitation

1. Oxygenation and ventilation
2. Shock management, intravenous lines, Ringer's lactate
3. The management of life-threatening problems identified in the primary survey is continued C.

C. Adjuncts to Primary Survey and Resuscitation

1. Monitoring
   a. Arterial blood gas analysis and ventilatory rate
   b. Patient's exhaled CO_2 with an appropriate monitoring device
   c. Electrocardiograph
   d. Patient's hourly urinary output

    e. Pulse oximetry
    f. Blood pressure
2. Urinary and gastric catheters
3. X-rays and diagnostic studies
    a. Chest x-ray
    b. Pelvis x-ray
    c. C-spine x-ray
    d. DPL or abdominal ultrasonography

D. Reassess the Patient's ABCDEs and Consider Need for Transfer

E. Secondary Survey, Total Patient Evaluation: Physical Examination and History
1. Head and skull
2. Maxillofacial
3. Neck
4. Chest
5. Abdomen
6. Perineum/rectum/vagina
7. Musculoskeletal
8. Complete neurologic examination
9. Tubes and fingers in every orifice

F. Adjuncts to the Secondary Survey

Specialized diagnostic procedures which are utilized to confirm suspected injury should only be performed after the patient's life-threatening injuries have been identified and managed and the patient's hemodynamic and ventilation status returned to normal.

1. Computerized tomography
2. Contrast x-ray studies
3. Extremity x-rays
4. Endoscopy and ultrasonography

G. Patient Reevaluation

Reevaluate the patient, noting, reporting, and documenting any changes in the patient's condition and responses to resuscitative efforts. Judicious use of analgesics may be employed. Continuous monitoring of the patient's vital signs and urinary output is essential.

H. Transfer

If the patient's injuries exceed the institution's immediate treatment capabilities, the process of transferring the patient is initiated as soon as the need is identified. The referring doctor and receiving doctor should communicate directly. Transfer personnel should be adequately skilled to administer the required patient care en route. Delay in transferring the patient to a facility with a higher level of care may significantly increase the patient's risk of mortality.

I. Definitive Care

Definitive care begins after identifying the patient's injuries, managing life-threatening problems, and obtaining special studies. The principles of definitive care, associated with the major trauma entities, are described previously in this document.

Glossary of frequently confused terms

Term	Definition
Simple pneumothorax	Pneumothorax results from air entering the pleural space between the visceral and parietal pleura. Both penetrating and nonpenetrating trauma may cause this injury. Air in the pleural space collapses lung tissue, which causes a ventilation/perfusion defect because the blood perfusiog the nonventilated area is not oxygenated.
Tension pneumothorax	A tension pneumothorax develops when a "one-way-valve" air leak occurs either from the lung or through the chest wall. Air is forced into the thoracic cavity without any means of escape, completely collapsing the affected lung. The mediastinum is displaced to the side, decreasing venous return and compressing the opposite lung.
Open pneumothorax (Sucking chest wound)	When a large defect of the chest wall occurs and remains open, it results in an open pneumothorax or sucking chest wound. Equilibration between intrathoracic pressure and atmospheric pressure is immediate. If the opening in the chest wall is approximately two thirds the diameter of the trachea, air passes preferentially through the chest defect with each respiratory effort, because air tends to follow the path of least resistance through the large chest-wall defect. Effective ventilation is thereby impaired, leading to hypoxia and hypercarbia.
Massive hemothorax	Massive hemothorax results from a rapid accumulation of more than 1500 mL of blood in the chest cavity. It is most commonly caused by a penetrating wound that disrupts the systemic or hilar vessels, but it also may be the result of blunt trauma. Massive hemothorax can significantly compromise respiratory efforts by compressing the lung and preventing inadequate ventilation, but more dramatically presents as hypotension and shock
Flail chest	A flail chest occurs when a segment of the chest wall does not have bony continuity with the rest of the thoracic cage. This condition usually results from trauma associated with multiple rib fractures, that is, two or more ribs fractured in two or more places. The presence of a flail chest segment results in severe disruption of normal chest wall movement.
Cardiac tamponade	Cardiac tamponade occurs when blood from an injured heart, great vessel, or pericardial vessel fills the pericardial sac. The human pericardial sac is a fixed fibrous structure, and only a relatively small amount of blood is required to restrict cardiac activity and interfere with cardiac filling. Cardiac tamponade most commonly results from penetrating injuries, but blunt injuries also may cause this condition.
Shock	An abnormality of the circulatory system that results in inadequate organ perfusion and tissue oxygenation.
Neurogenic shock	Neurogenic shock occurs when the hemodynamic findings associated with spinal cord transection (that is, hypotension without tachycardia due to the loss of sympathetically mediated peripheral vasomotor tone and reflex tachycardia) are associated with disruption of sympathetic nerve fibers in the spinal cord.
Spinal shock	Neurogenic shock results from impairment of the descending sympathetic pathways in the spinal cord and causes the neurologic findings associated with spinal cord transection (that is, paradoxical flaccidity and arreflexia).