OTOLARYNGOLOGY/HEAD AND NECK SURGERY COMBAT CASUALTY CARE IN OPERATION IRAQI FREEDOM AND OPERATION ENDURING FREEDOM

Section IV: Emergency Management of Head and Neck Trauma

Ambulance-helicopter, Bagram Air Base, Afghanistan (2009).

Photograph: Courtesy of Colonel Joseph A. Brennan.

Chapter 11

PRIMARY AND SECONDARY TRAUMA ASSESSMENT

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INTRODUCTION

During the year between April 2011 and April 2012, Craig Joint Theater Hospital (CJTH) at Bagram Airfield and Task Force MED–East cared for and treated over 8,300 battle and non-battle wounded casualties during some of the most kinetic, violent operations tempo seen during Operation Enduring Freedom. During this period, CJTH and Task Force MED–East also trained and rotated 5,800 triservice medical staff including trauma, general and specialty surgeons, critical and noncritical cared trained physicians, support staff, technicians, nurses, physician assistants, paramedics, para-rescue jumpers, and critical care air transport teams.

The CJTH and TF-MED East staff represented experience from every size of military and civilian community hospital, clinic, teaching facility, and military training platform from both active duty and reserve components. Because of on-going rotations and variability of staff experiences in the deployed environment, a standardized trauma assessment survey is critical in the care of the combat casualty. The multi-team approach has proved to be invaluable in quickly assessing and treating injuries in today's combat environment. This standardized approach can be taught at every level of combat care and is used by the forward surgical team (Role 2) and hospital (Role 3) levels.

The combat care tent facility or deployed emergency department team is usually led by general surgeon "trauma czar." The size, location, and tactical situation of the deployed treatment facility determines the medical support footprint. Each casualty is assessed and managed according to prehospital Tactical Combat Casualty Care (TCCC) standardization protocols.[1] In smaller forward operating bases, the treatment staff may be composed of 10- to 12-person teams, each with surgeons (1 or 2), an orthopedist, nurses (2–4), surgical technicians (2–3), and administrative support personnel. At larger, fixed facilities such as CJTH, the teams are supported by medical, surgical, and ancillary clinical staff; pharmacists and pharmacy technicians; laboratory officers and technicians; radiologists and radiology technicians; patient administration staff; respiratory therapists; logistics staff; security personnel; and nursing, medical and surgical technicians.

Each trauma bay bed is assigned a physician (or physician extender) trained in Advanced Trauma Lifesaving (ATLS), a nurse, and technicians. Each casualty is assessed according to prehospital Tactical Combat Casualty Care (TCCC), approved Joint Theater Trauma System Clinical Practice Guidelines, ATLS protocols, and conventional trauma imaging protocols supplemented by selective computed tomography (CT) and magnetic resonance imaging (MRI) scanning, as indicated, and if available. Overlooked injuries and delayed diagnoses are still common occurrences in the tactical treatment of polytrauma combat casualties, but the use of a standardized, team approach to care of the combat casualty has proven to lessen these risks, improving quality of care and outcomes. This chapter will provide recommendations for a standardized, multidisciplinary team approach to assess and treat casualties in a combat environment based on CJTH and Task Force MED–East experiences between April 2011 and April 2012.

THE TEAM APPROACH

Trauma patients are commonly received at surgical-capable facilities by a team of providers with various roles. This team may include surgeons, anesthesiologists, emergency physicians, and technicians of various backgrounds. It is paramount that the team be prepared prior to receiving casualties. Communication is critical during the assessment and care of the combat casualty. A team leader is always pre-appointed, with duties and responsibilities assigned to each member. This preplanning is crucial and will minimize redundancy, promote cohesion, expedite evaluation, and optimize outcomes (Figure 11-1). Although the initial airway, breathing, and circulation evaluation and interventions are commonly undertaken simultaneously, this chapter will discuss these tasks separately.

PRIMARY ASSESSMENT

The initial evaluation of a trauma patient in the combat environment represents the most critical phase of care. Efficiently conducted primary and secondary evaluations facilitate rapid diagnosis and treatment of the most immediate life-threatening injuries, as well as optimizing triage protocols. It is crucial, therefore, that providers and staff who treat combat trauma casualties in the tactical environment conduct the initial evaluations in a systematic, thorough, and comprehensive manner.

Casualties may arrive at a facility capable of surgical intervention either directly from the point of injury or from a forward role of care within the trauma system.

Figure 11-1. A dedicated team conducting the initial evaluation of a trauma victim at a combat surgical hospital. Note that each team member is working in a concerted effort to achieve timely completion of rapid yet effective assessment.

Regardless of casualties' origin, it is important for receiving providers to understand and appreciate the principles of care employed at the point of injury. Prehospital care in the combat environment is dictated by the principles promoted in the TCCC guidelines. These guidelines are presently managed by a multidisciplinary TCCC committee housed at the US Army's Joint Trauma System/Institute for Surgical Research. The TCCC committee conducts continuous quality improvement efforts with the TCCC prehospital practices to maximize the delivery of survivors to surgical-capable facilities. Although the objectives of TCCC and in-hospital practices are the same—optimizing survival of the combat casualty—the methodology employed in these two environments differs in necessary ways. This is most notably apparent in initial care on the battlefield, where the "ABCs" (airway-breathing-circulation prioritization) employed as a routine element of initial in-hospital care is inverted. For a variety of important reasons, TCCC utilizes a "CAB" (circulation-airway-breathing) approach to initial care priorities in the field. Although a comprehensive review of TCCC guidelines in support of these priorities is beyond the scope of this discussion, a working knowledge of TCCC is useful for all providers who will assume care of these patients at a surgical-capable facility.

In addition to understanding TCCC guidelines, providers should also make use of what history may be available prior to patient arrival. Casualties arriving from forward medical facilities will often be accompanied by a limited amount of information. In today's combat care, telecommunications capabilities in a more advanced Role 2 facility often make it possible to review the initial documentation and basic radiographic images. However, even those casualties transferred and received directly from the field should have the elements of a basic "9-line" transport request available.

The following pieces of information are pivotal to success in preparing for casualties: the number of casualties expected, the casualty's present physiologic state, and any specific needs that may be anticipated based upon the field triage care. This information can often be provided by down-range personnel and facilitates the marshaling of critical resources (logistics and personnel) prior to patient arrival. In particular, additional providers or unique skillsets can be made available without delay. Blood products and other critical resources may be collected and delivered expeditiously. These preparations, or failure to make them, have the potential to drastically alter combat injury outcomes.

Ultimately, it is paramount that each casualty be evaluated upon arrival in a standardized, expeditious, and comprehensive manner. At the next level of care, regardless of the information transmitted about the arriving casualty or the report given by the transporting team, no detail should be taken for granted. Each evaluation must be reaccomplished in a standardized fashion and with the utmost attention to detail to avoid a previously missed injury or a delay in addressing a new life-threatening diagnosis.

The principles of initial evaluation of the combat casualty are taught in a variety of predeployment training environments. The American College of Surgeons' ATLS course provides one of the most comprehensive and time-tested training courses presently utilized by both civilian and military trauma providers.[2] This 2-day course emphasizes a comprehensive approach to the initial and secondary evaluation of a trauma patient. The principles espoused are as applicable to a major civilian trauma system as they are to the austere combat hospital environment.

Airway

According to the ABC pneumonic utilized in ATLS and other settings, airway evaluation and preservation is the first consideration of initial trauma care. The patency of the airway must be established. The simplest maneuver in this assessment is to ask the patient "What is your name?" and "Can you tell me what happened?" Although a simple step, the ability of patients to respond appropriately provides a tremendous amount of information. If they are able to answer in an unlabored fashion, their airway and breathing are not in emergent danger. The ability to answer coherently also signifies that perfusion to the brain is adequate for processing thought and communication, implying that the patient is not in the advanced stages of shock and has no devastating head injury.

The ability of a patient to preserve his or her airway must then be assessed. If the injury's circumstance raises the suspicion of inhalational injury, the integrity of the airway must be further evaluated. Clues that should raise the index of suspicion for inhalational injury include a burning mechanism; singed facial or nares hairs; coughing up of black, carbonaceous sputum; an inflamed oropharynx; or voice changes. The presence of any of these findings combined with the history of a burning mechanism should mandate the strongest possible consideration for early intubation to protect the airway. If this intervention is not undertaken, particularly in the setting of large volume resuscitation, airway edema may lead to emergent airway loss.

Other findings that warrant strong consideration for endotracheal intubation include significant facial or neck trauma that may threaten airway patency and diminished sensorium (Figure 11-2). The latter is commonly assessed with the Glasgow Coma Scale (GCS) score (see below). A GCS score of less than 8 is a criterion for intubation; lower GCS scores are associated with the inability to clear secretions or independently protect the airway. In rare circumstances, endotracheal intubation will not be possible. Severe facial or neck trauma and evolving airway edema are examples of findings that may confound the ability to secure the airway orally. In these settings, emergent surgical airway via cricothyroidotomy may be life preserving.

Adjunctive medications will commonly be utilized to facilitate endotracheal intubation or to establish a surgical airway. Note that these classes of medications may have both sedative and paralytic effects and will compromise or affect the neurologic exam for some time after administration. For this reason, if time permits it is useful to obtain at least a basic neurologic exam prior to intubation. This will not, however, be possible in every circumstance.

Figure 11-2. Right neck wound. If associated with hematoma or air moving through the wound, this wound may represent impending airway compromise.

Breathing

Once the airway has been preserved, attention must be turned to assessment of breathing. During the primary survey, the most useful assessment tools are observation and auscultation. The chest should be examined for symmetric rise and fall. The adequacy of the respiratory rate and depth of respiration should be noted. Auscultation should then be undertaken. Both lung fields should be examined and the symmetry of their sounds noted.

Abnormalities during the initial breathing evaluation may highlight the need for emergent intervention. Decreased breath sounds unilaterally in the setting of hypotension represent a tension pneumothorax, and immediate decompression of the affected side of the chest should be undertaken. This can be accomplished rapidly by needle decompression of the chest, placing a large-bore needle just above the second rib at a position even with the midpoint of the clavicle. Decompression must be followed by placement of a thoracostomy tube. Whether hypotension is absent or altered breathing mechanics are present, a plain chest radiograph should be ordered to further evaluate the etiology. A hemothorax or pneumothorax commonly requires evacuation with a thoracostomy tube. If etiology is not clear, a thoracostomy tube should be placed.

Other abnormalities of the initial breathing exam may also trigger critical interventions. The presence of a chest wound with opening to the thoracic cavity, with or without visible lung, should mandate thoracostomy tube placement away from the wound (if possible) and covering of the thoracic wound. Rib fractures at multiple levels may present with the finding of "flail chest," in which the unstable segment of the chest wall moves paradoxically to the surrounding thorax with respiration. Such a finding may have a significant impact on pulmonary mechanics, resulting in precipitous pulmonary deterioration that can only be overcome with endotracheal intubation and mechanical ventilation until the defect can be surgically addressed. For this reason, early intubation in the presence of flail chest is advised.

Circulation

The initial assessment of circulation requires the determination of perfusion. Adequate mentation of the patient, determined by an appropriate response to basic questions designed to determine orientation, provides good evidence that circulation is adequate to maintain perfusion to the brain. Palpation of pulses provides additional evidence to assess perfusion. A palpable and slow radial pulse typically corresponds to a systolic blood pressure of at least 80 mm Hg. Moving more centrally, palpable carotid and femoral pulses are most commonly associated with a systolic blood pressure of at least 60 mm Hg. Pulse rate also provides an early clue to perfusion; a rapid pulse may indicate hypovolemia due to hemorrhage, and finding the potential source is crucial.

A more subtle clue to the quality of perfusion can be found by determining the capillary refill time distally. Released pressure from the fingers or toes should be followed by normal "refill" and return of perfused coloration of the indented area in less than 2 seconds. Refill times of over 2 seconds may indicate systemic alterations in perfusion due to hemorrhage. However, capillary refill may be extended in the presence of hypothermia.

The most reliable and reproducible assessment of circulation quality and perfusion is direct measurement. In the field and early hospitalization phases of assessment, this is most commonly achieved with a pneumatic blood pressure cuff, or sphygmomanometer. Serial blood pressure measurements should be obtained throughout the initial evaluation and resuscitation phase; changes in blood pressure must be recognized and treated early to optimize outcome. Abnormalities in blood pressure is indicative of the need for aggressive resuscitation, and direct catheter transduced measurement of blood pressure may prove very useful. Although this technique requires arterial access, it provides real-time assessment that improves upon the monitoring intervals afforded by intermittent pneumatic measurement.

Another key element of the ABC circulation phase involves establishing adequate intravenous access for resuscitation and administering adjunctive medications. Large-bore peripheral access, ideally using 18-gauge or larger catheters, should be established. If significant resuscitation is anticipated based upon the clinical picture, central venous access is indicated at either subclavian or femoral venous access sites. Field or emergency department placement of intraosseous access devices provides additional options for administering life-saving fluids and blood.

With the establishment of access, blood can be drawn for initial laboratory evaluation and initiation of resuscitation. The most important lab values to be obtained in a severely injured patient is blood type and cross-match, so that lifesaving blood products can be administered. Additional labs that should be prioritized, as possible, include arterial or venous blood gases and lactate levels, which are useful in guiding subsequent resuscitation efforts.

Crystalloid, specifically lactated Ringer's solution or normal saline, continue to be the most common initial resuscitation fluids. Modern combat casualty research supports the utilization of the colloid Hextend (Hospira Inc, Lake Forest, IL) in the earliest phases after injury. Specific guidelines for using these and other adjuncts, including hypertonic saline, exist and should be reviewed for current guidance.

In the patient with obvious signs and symptoms of hemorrhage, the initial resuscitation with crystalloid or colloid should be followed with immediate blood product administration. Current guidelines for utilization of uncross-matched, emergency-release blood products exist for most civilian trauma centers and in military protocols. Providers should be familiar with these guidelines and implement them accordingly.

Other important elements of restoring circulation include both control of obvious hemorrhage sources and early splinting of extremities with deformities that are amenable to such interventions. Direct pressure and tourniquet utilization provide the most useful initial adjuncts for controlling bleeding sites in either the field or early hospital phases. Paramount to assessing circulation is the understanding that this evaluation is a dynamic and a continual process. Constant reevaluation and monitoring is required to document response to therapy, guide triage, and prevent unrecognized deterioration of the casualty. Current guidelines for the use of a tourniquet, and the administration of resuscitative fluids and blood products, are available through both the TCCC course and the Joint Trauma System's Clinical Practice Guidelines.

Disability

The disability assessment of the ABCs provides useful information on brain or spinal cord injury. If the patient requires early endotracheal intubation, a rapid GCS assessment should be obtained, if possible, before administering any medications to facilitate airway establishment, because such medications will limit the ability to assess neurologic status for a period of time. The pupillary exam should also be conducted. Unilateral dilation and unresponsiveness to direct exposure to light are common harbingers of severe brain injury with herniation. This exam should be conducted at initial evaluation and repeated after any signs of neurologic deterioration.

Exposure

The exposure phase of the ABCs involves fully exposing the casualty to completely assess all external clues of injury. All articles of clothing and other items that may obscure a comprehensive external exam must be removed. The patient should be "log-rolled" in a coordinated fashion to maintain in-line spinal immobilization while allowing full posterior examination and direct palpation of the entire spine. Such a maneuver will determine any localized tenderness in the awake patient or reveal any evidence of step-off deformity of the cervical, thoracic, or lumbar spine (Figure 11-3). All external wounds should be assessed for active hemorrhage and documented. Any contusion or hematoma should also be documented, because these findings may provide evidence of significant internal injury.

The full external exam should be rapidly completed, and the patient should then be covered with a warm blanket to avoid hypothermia. Failure to prevent is a well-known complication of trauma and should be avoided throughout the continuum of care. Recognizing hypothermia upon admission is extremely important because it may contribute to coagulopathy and adverse outcomes after trauma.

Figure 11-3. Multiple penetrating wounds to the back. This patient was profoundly hypotensive with no obvious injuries anteriorly. Full exposure and a log-roll with spine immobilization was necessary to fully document these wounds.

Adjuncts to the Primary Survey

Several important adjuncts to the initial assessment are key tools of trauma evaluation and triage. These include basic radiographic investigations, initial laboratory evaluation, and gastric and bladder decompression. The mainstays of initial trauma radiographic investigation include the Focused Abdominal Sonography for Trauma (FAST) exam and plain radiography of the chest and pelvis. The FAST exam is useful in identifying intraabdominal hemorrhage sources. The plain film of the chest will identify pneumothorax or hemothorax, and document the adequate position of invasive devices such as endotracheal tubes or central venous catheters placed at subclavian or jugular locations. Pelvic plain radiography will identify fracture patterns suspicious for possible associated retroperitoneal hemorrhage.

Gastric decompression mitigates the risk of aspiration of gastric contents and facilitates the administration of enteric contrast for subsequent CT evaluation when indicated. If a basal skull fracture is suspected, the gastric tube should be placed orally as opposed to nasally. In the awake patient, however, oral placement will result in gagging and possible vomiting. If there is no blood at the urinary meatus, bladder catheterization is safe and should be done. Blood within the delivered urine raises the suspicion for possible urinary tract injury.

SECONDARY ASSESSMENT

The secondary assessment is best described as a methodical head-to-toe examination of the trauma patient. While the ABCs of the primary survey are designed to provide for rapid identification of the most common immediately life-threatening injuries, the secondary exam affords a repeated and more thorough evaluation of each section of the body to identify more subtle clues of trauma or more definitively address previously documented issues. It is paramount to keep in mind, however, that any acute deterioration of the casualty should result in immediate discontinuation of the secondary survey and a repeat of the steps of the primary survey to ensure that no new immediately actionable changes in condition have evolved.

Head and Neck Examination

Scalp

The entire scalp and head should be examined for lacerations, contusions, and fractures. The scalp can be a significant source of blood loss, and excessive bleeding should be addressed prior to transfer. Scalp

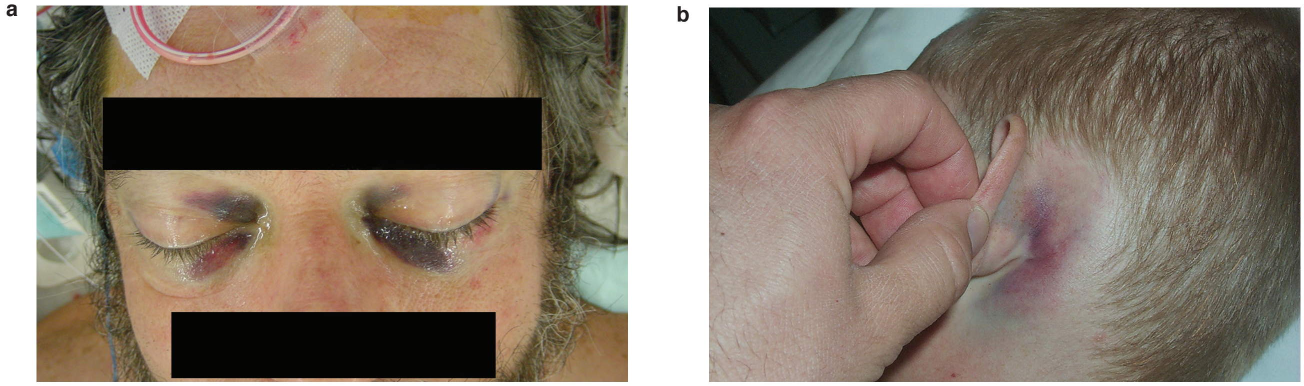

Figure 11-4 (a). "Raccoon eyes" as a sign of a basilar skull fracture. **(b)** Battle sign as a sign of a basilar skull fracture.

wounds should be cleaned and the skull examined prior to closure with sutures, clips, or staples. In many cases of low velocity penetrating injuries, this will be the only treatment necessary.[3] A subgaleal hematoma can feel like a skull fracture and should be evaluated by CT scan or plain radiograph.

Skull Fractures

Skull fractures can be linear, stellate, open, or closed. They should be considered a significant finding because it takes considerable force to fracture the skull. Linear fractures, for example, increase the likelihood of an underlying intracranial hematoma. Basilar skull fractures are best identified via a CT scan of the skull; however, some signs of a basilar fracture may be picked up on secondary survey, including periorbital ecchymosis ("raccoon eyes," Figure 11-4a); mastoid bruising (Battle sign, Figure 4b); cerebral spinal fluid (CSF) leakage from the nose (rhinorrhea) or ear (otorrhea); and seventh and eighth nerve dysfunction (facial paralysis and hearing loss). Basilar skull fractures that traverse the carotid canals may require a cerebral arteriography. Generally, a skull fracture with a depression greater than the thickness of the skull requires surgical decompression.[2]

Penetrating Brain Injuries

Penetrating injuries should be evaluated with CT imaging, plain films, and in cases of injuries near the venous sinuses, orbit, or skull base, CT angiography is the recommended adjuvant scan. Angiography should also be used with subarachnoid hemorrhages or delayed hematoma. MRI can be helpful when injuries are caused by wood or other nonmetallic objects.[4] Penetrating injuries with large contusions, hematomas, or intraventricular hemorrhage are associated with increased mortality, especially when bilateral.[5] Objects that are partially exteriorized should be left in place and secured until vascular imaging can be performed and definitive neurosurgical consultation is completed (Figure 11-5). Premature removal can have devastating consequences.

Figure 11-5. Penetrating intracranial foreign object.

Intracranial Bleeding

Brain trauma and bleeding involve four major areas of concern:

1. **Epidural hematomas** occur in 0.5% of all patients with brain injuries and in 9% of traumatic brain injury patients who are comatose.[2] These hematomas are formed from a bleed between the dura and the skull, which often results from rupture of the meningeal arteries or dural sinuses, and are associated with a skull fracture. Most commonly, the middle meningeal artery ruptures from trauma to the temple region. This can cause an uncal herniation when the medial part of the temporal lobe (the uncus) is pushed medially, compressing the parasympathetic nerve fibers of the third cranial nerve, leading to ipsilateral pupil dilation and contralateral hemiparesis. The hemiparesis is contralateral as the corticospinal tracts cross the midbrain to the opposite side. Epidural hematomas are classically described as biconvex or lenticular in shape on CT scan and are characterized by a lucid interval followed by neurological deterioration (Figure 11-6).
2. **Subdural hematomas** occur in 30% of brain injury patients and result from rupture of bridging veins between the dural and arachnoid layers of the brain. Subdural hematomas appear to conform to the contours of the brain on CT scan (Figure 11-7), and may or may not require surgical drainage. Because of the nature of mechanical injury, these types of hematomas are usually associated with a higher incidence of parenchymal damage than are epidural hematomas.
3. **Subarachnoid hemorrhages** usually occur with brain contusions, trauma to the base of the brain, or skull base fractures.
4. **Contusions and intracerebral hematomas** occur in approximately 20% to 30% of severe brain injuries, with the majority occurring in the frontal and temporal lobes. Twenty percent of contusions will progress to significant hematomas requiring immediate surgical evacuation, so these injuries are routinely followed closely by serial CT scans.[6] The ventricular system may occlude with intracranial bleeding or injury, causing dangerous rises in intracranial pressures.

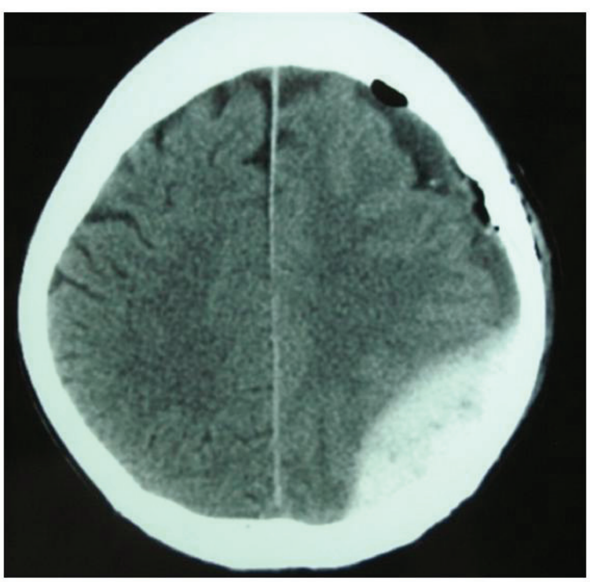

Figure 11-6. Epidural hematoma.

Figure 11-7. Subdural hematoma.

It is recommended that a neurosurgeon perform all craniotomies for emergent bleeding. However, in the rare instance when an emergent craniotomy is necessary and a neurosurgeon is not available, such as in a combat environment or small community hospital, it is essential that the person performing the procedure have prior training and instruction by a neurosurgeon.[7] Burr holes are generally not effective for draining hematomas and can be misplaced, potentially causing additional parenchymal injury.

Glasgow Coma Scale Score

A GCS score can give a good initial assessment of the extent of brain injury (Table 11-1). Although normally performed during the initial survey, GCS should be reassessed during a secondary survey because the score may change frequently. Generally, a score of 8 or lower is indicative of a coma, while scores of 9 to 12 are considered moderate, and 13 to 15 are minimal. Complete brain death results in a score of 3.[2]

Traumatic brain injury. The primary goal of treatment for patients with suspected traumatic brain injury is to prevent secondary brain injury. Adequate oxygen levels and appropriate blood pressure levels are essential. Any patient with evidence of a mass effect on CT scan and deteriorating neurologic status as a result of intracranial hematoma or parenchymal injury should be taken to the operating room and cared for by a neurosurgeon. If neurosurgical capabilities are not available, transfer to an appropriate facility should take place without a CT scan rather than delay the transfer.

Minor brain injury (GCS: 13–15). The secondary survey is particularly important in these patients because 3% of them will deteriorate after some time has passed, leading to severe neurologic dysfunction. Attention should be paid to the mechanism of injury, length of loss of consciousness, retrograde and antegrade amnesia, seizure activity, and the present level of alertness. The GCS score should be continually reevaluated. A CT scan should be obtained in patients with open skull fractures, suspected basilar skull fractures, three or more episodes of vomiting, loss of consciousness for longer than 5 minutes, retrograde amnesia for longer than 30 minutes, a dangerous mechanism of injury, severe headaches, focal neurologic deficit, or age over 65 years.[8] Applying these parameters to patients with a GCS score of 13, 25% of patients will have evidence of brain injury on CT, and 1.3% of these will require neurosurgical intervention. For a GCS of 15, 10% of CT scans will reveal brain injury, and 0.5% of patients will require neurosurgical intervention.[9] Asymptomatic, fully awake patients can be discharged home with strict instructions after a few hours of observation, but they should be monitored by a companion for the next 24 hours. If the CT scan is positive or the GCS remains under 15, a repeat scan should be considered. These GCS criteria and neurosurgical intervention parameters must followed to minimize the risk to patients and avoid additional neurologic injury.

Moderate brain injury (GCS: 9–12). The secondary survey is also very important for patients in the moderate injury group. This group makes up about 15% of brain injury patients presenting to the emergency room, and 10% to 20% of them will deteriorate into a coma. Serial neurologic exams are crucial. Preparation for urgent intervention such as intubation should be made, and narcotics should be used sparingly. A CT scan must always be obtained and the neurosurgeon notified. However, obtaining a CT scan should not delay transfer. Generally, a herniation of 5 mm or greater is an indication for surgery. If a neurosurgeon is not available, the patient should be transferred to an appropriate facility immediately. After neurosurgical decompression, the patient should be observed in the intensive care unit for 12 to 24 hours, and a follow-up CT scan obtained in 12 to 18 hours.[10]

TABLE 11-1

GLASGOW COMA SCALE SCORING

Score	Eye Opening	Verbal Response	Motor Response
1	None	None	None
2	To painful stimuli	Incomprehensible sounds	Decerebrate
3	To verbal command	Confabulation	Decorticate
4	Spontaneously	Confused, disoriented	Generalized pain response
5	NA	Oriented and appropriate	Localizes painful stimuli
6	NA	NA	Follows commands

NA: not applicable

Severe brain injury (GCS: 3–8). Ten percent of brain injury patients presenting to the emergency room are in this category (Figure 11-8). This group has perhaps the fastest deterioration, requiring prompt diagnosis and treatment. These patients will be unable to follow simple commands even after cardiopulmonary stabilization. The secondary survey should include a thorough history and focal neurologic exam including pupil response, GCS reevaluation, and notation of any focal neurologic deficit. Therapeutic agents should be given in consultation with a neurosurgeon. These can include oxygen supplementation, intravenous fluids to avoid hypervolemia, mannitol or hypertonic saline to regulate intracranial pressure, moderate hyperventilation to keep P_{CO_2} between 32 and 35 mm Hg (avoiding a P_{CO_2} of less than 28). Barbiturates are often recommended for refractory increased intracranial pressure, and anticonvulsants in certain cases of posttraumatic

Figure 11-8. While on patrol in Afghanistan, this patient sustained a gunshot wound to the head with exposed intracranial contents. Secondary survey revealed a left globe injury, requiring enucleation, and significant cranial bone loss.

epilepsy. Muscle relaxants are not a treatment for seizures; they should be avoided because they can mask a seizure that is causing devastating neurological injury.[11,12]

Neurologic Examination

In all brain injury patients, it is important to consider mental status-altering drugs such as alcohol, narcotics, and intoxicants, as well as other injuries, to avoid missing a severe brain injury. It is crucial to obtain an accurate GCS score, pupil exam, and focal neurologic exam prior to administering any sedation or paralytics because subsequent exams will need to be compared to this baseline. The shortest acting agents should be used in cases when sedation is required to keep patients from injuring themselves, for intubation, or for obtaining diagnostic studies. The postictal state after a seizure can worsen a patient's response for minutes or hours, and the GCS should be reevaluated at that time. In a comatose patient, motor responses can be elicited by a trapezius pinch or nail-bed or supraorbital ridge pressure. Testing oculocephalic (doll's eye phenomenon) and oculovestibular responses (calorics, ice water in the ear canals) as well as corneal responses are best left to a neurosurgeon or neurologist. Doll's eye testing should never be done until the cervical spine is cleared.

Diagnosing Brain Death

Brain death is usually considered definite when all the following six criteria are met:

1. GCS: 3;
2. nonreactive pupils;
3. absent brainstem reflexes (eg, oculocephalic, corneal, doll's eyes, and gag reflex);
4. no spontaneous ventilatory effort on formal apnea testing;
5. no activity on electroencephalogram; and
6. cerebral blood flow studies (eg, isotope studies, Doppler studies, xenon cerebral blood flow studies) or cerebral angiography show no cerebral blood flow.

Hypothermia and barbiturate coma can mimic the effects of brain death and should be ruled out before making the diagnosis. Children have a remarkable ability to recover from devastating brain injury, and multiple serial neurologic exams should be performed hours apart to confirm the initial clinical impression.[13]

Eyes

The eyes should be evaluated for acuity (use a brief exam with a Snellen chart or words on a dressing package) and mobility to rule out entrapment. Pupil size, light response, penetrating injury, foreign bodies, prosthetic eyes, discoloration, hyphema, lacrimal duct injury, retinal hemorrhage or detachment, and lens dislocation should be assessed. Contact lenses should be removed if present. Note that significant orbit or periorbital edema can prevent a good visual exam. All attempts should be made to get as complete an exam as possible. Unilateral pupil dilation with loss of the light reflex can be caused by parasympathetic compression, as mentioned previously, but can also result from direct orbital trauma.

Face

Massive facial fractures and significant soft tissue injury can be signs of an impending airway compromise (Figure 11-9). The airway should be constantly reevaluated in these patients. If possible, facial nerve function should be documented in the awake patient because it will prove useful in subsequent management decisions. The maxillofacial exam includes palpating bony structures. Forehead compression is notable in a fracture of the anterior frontal sinus wall and is indicative of a high impact injury.

The naso-orbito-ethmoid complex should be assessed by visualization and palpation of the glabella region. Fractures in this area can also be indicative of underlying intracranial injury and in some cases will be associated with CSF rhinorrhea. There will be a lack of definition of the bony anatomy in the medial canthal

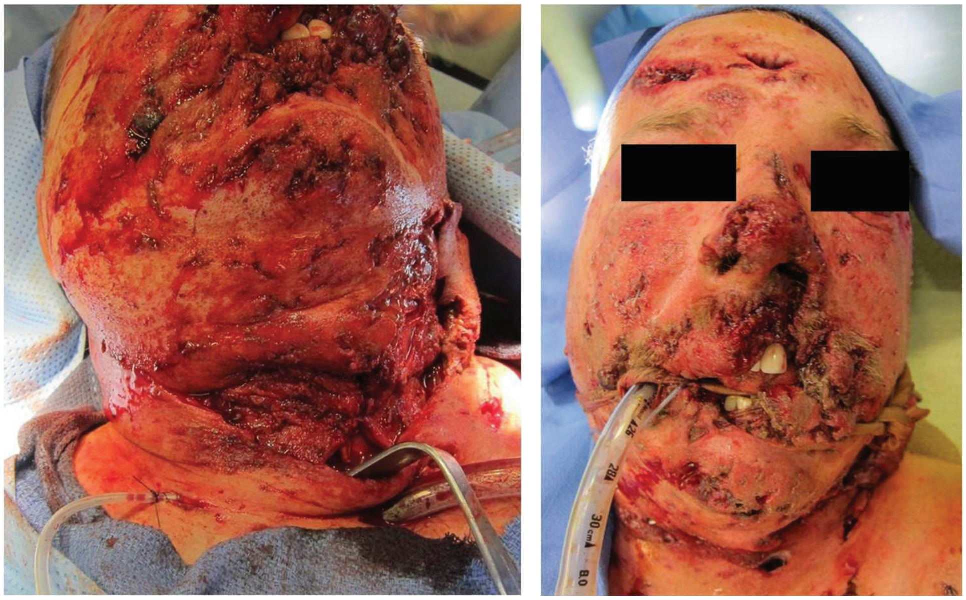

Figure 11-9. A patient injured by an improvised explosive device. Intubation was performed in the field and secured with tracheal ties for transport. Secondary survey revealed extensive mandible and facial fractures, soft tissue loss, and penetrating neck trauma.

area and possible lateral splaying of the medial canthus with increased intercanthal distance (the normal distance varies depending on the ethnic group; eg, in Caucasians, an intercanthal distance over 35 mm is considered abnormal). A thorough ophthalmological examination should be performed on all patients.

One simple test to evaluate the integrity of the medial canthal tendon is to grab the eyelid or use a forceps to grab the skin in the medial canthal area and pull it laterally (the "bow-string" test). The lid is pulled laterally while the tendon area is palpated to detect movement of fracture segments. A lack of resistance or movement of the underlying bone is indicative of a fracture. Orbital blowout fractures, zygomatic complex fractures, and mandibular fractures are usually diagnosed on the secondary survey, and at this time the bow-string test is recommended (Figure 11-10).

The nose and ears should be checked for foreign bodies, fluid, blood, and perforations. CSF leaks can be diagnosed clinically by persistent clear rhinorrhea or otorrhea. Tests to verify a CSF leak include a positive "halo" sign (Figure 11-11) or comparing the amount of glucose in the fluid to the patient's serum. Diagnosis must be verified by sending a fluid sample for beta-2 transferrin, which is specific to CSF only and is confirmatory.

Isolated nasal bone fractures do not require imaging. If there is nasal deformity or significant deviation, the nasal bones can be reduced in a closed fashion up to approximately 1 week. After a week, surgical repair may be warranted in the operating room. Septal hematoma is an emergency; these patients must be evacuated as soon as possible to prevent cartilage loss. Septal hematoma is diagnosed by using a proper headlight or illumination during an intranasal speculum

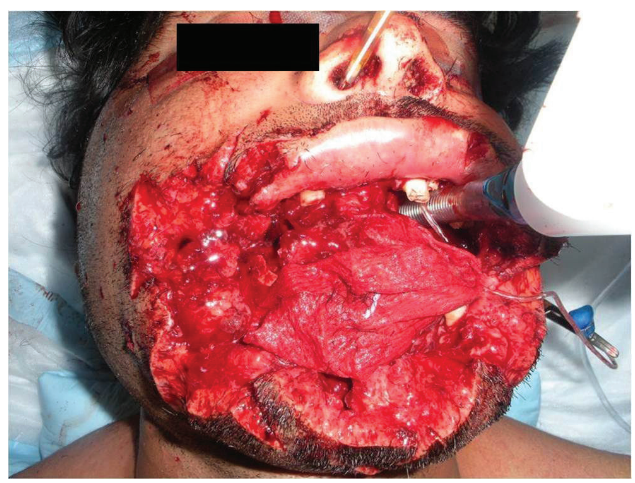

Figure 11-10. This patient sustained a gunshot wound to the face in Afghanistan. He was orally intubated in the field despite sustaining severely comminuted mandible fractures, loss of teeth, hard palate fractures, and soft tissue loss. Secondary survey revealed no orbital or brain injuries.

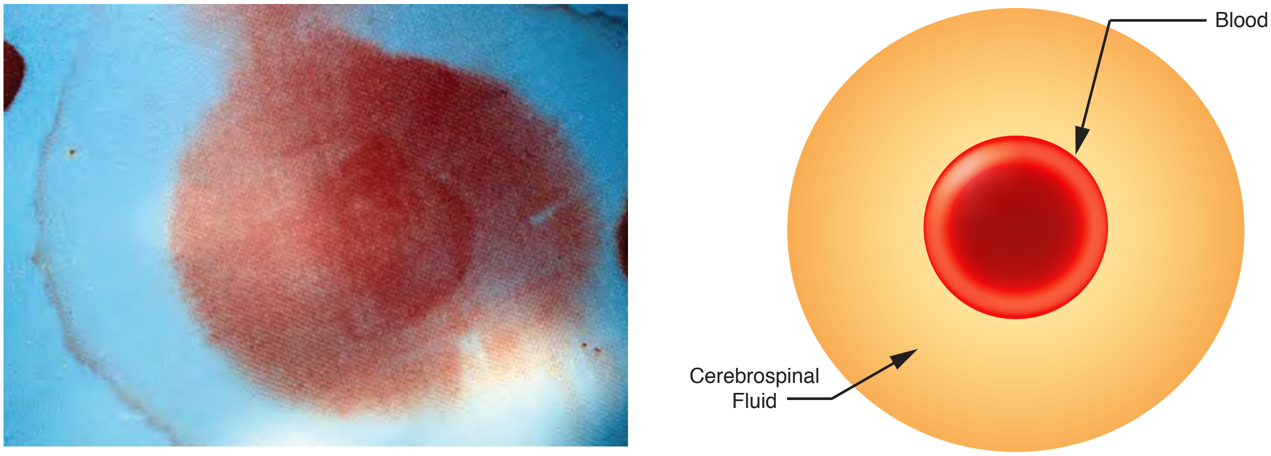

Figure 11-11. A halo sign is noted when placing cerebrospinal fluid on a white background. Blood is surrounded by a clear ring as the fluid separates.

exam. Once proven, the hematoma should be incised and drained. Auricular hematomas should also be drained in a timely fashion and usually require bolster placement to prevent recurrence. These procedures are usually performed by an otolaryngologist, plastic surgeon, or other qualified provider.

The oral exam includes assessing the type of maxillary-mandibular occlusion and asking patients (when awake) how their bite feels or if their teeth come together well. Check the mouth for potential airway obstructions (swelling, dentures, loose or avulsed teeth, vomitus, absent gag reflex) and odors, altered voice or speech patterns, and evidence of dehydration. Some fractures are difficult to assess initially and should be reassessed frequently as swelling decreases. Maxillofacial trauma not associated with an airway emergency or severe blood loss should be managed after the patient is completely stabilized. If a cribriform plate injury is suspected, gastric tubes should be placed orally.[14]

Cervical Spine Injuries

A cervical spine injury should always be suspected in head trauma patients. Immobilization is crucial until this injury can be ruled out. Neurologic deficits should be assessed, but their absence does not rule out a cervical spine injury. Isolated upper limb deficits are usually related to cervical nerve root injury but may be impossible to assess in a comatose patient. Cervical spine radiographs or CT scans should be reviewed by an experienced physician before removing immobilization.

If no cervical spine injury is present, immobilization devices should be removed as expeditiously as possible to avoid fast-forming decubitus ulcers. Removal of headgear should be done with extreme caution using a two-person procedure. While one person provides manual, in-line stabilization of the head and neck, the second person expands the helmet laterally. The second person then removes the helmet, with attention paid to the helmet clearing the nose and occiput. Once the helmet is removed, the first person supports the weight of the patient's head, and the second person takes over in-line stabilization. If attempts to remove the helmet result in pain and parenthesis or there is evidence of a cervical spine fracture, the helmet should be removed with a cast cutter, using a bicoronal cut.[15] Neurosurgical consultation should be obtained for these patients.

Neck

The neck should be palpated, visually inspected, and auscultated. Cervical spine tenderness, subcutaneous emphysema, use of neck muscles for respiration, tracheal deviation, jugular vein distention, laryngeal fractures, and medical information medallions should be sought. Blunt or penetrating trauma to the thyroid or cricoid cartilages can be a sign of laryngeal lacerations, fractures, and mucosal edema. If there is concern of an impending airway compromise, consultation with an airway specialist such as an otolaryngologist is warranted. These patients should be observed at a minimum in an intensive care setting because airway swelling may increase after 24 to 48 hours.[16] Intubation may be extremely difficult in these situations, and a tracheotomy or cricothyroidotomy may be necessary to establish a definitive airway.

Carotid artery bruits and blunt injury near the vessels should raise suspicion for arterial injury. A seatbelt mark is a worrisome sign for a carotid injury, and signs of an injury may present late in the process. Imaging such as angiography or duplex ultrasound may be useful to exclude injury to the great vessels of the neck. However, a carotid injury is present in only 0.76% of patients with a "seatbelt sign," and a carotid duplex may be unnecessary if this is the only suspicious sign of a great vessel injury.[17] Most major vascular injuries are the result of penetrating injury to the neck, but blunt trauma can cause dissection, thrombus formation, and occlusion. Injuries deep to the platysma should not be explored or probed in the emergency room. Expanding hematomas, carotid bruits, active arterial bleeding, and airway compromise are mostly managed in the operating room.

Body Examination

Chest

Chest examination involves the mainstays of auscultation, inspection, and palpation. Both lung fields should be auscultated, both apically and at the bases. In the primary survey, any evidence of tension pneumothorax should have been addressed by decompression. Any evidence of unequal or diminished breath sounds in the repeat secondary exam should be correlated with radiography to determine if pneumothorax or hemothorax is present. The chest inspection should include comprehensive documentation of contusions or wounds that may provide clues of internal thoracic injury. Palpation can be used to identify any evidence of crepitance and determine chest stability.

Abdomen

The most useful elements of the secondary exam of the abdomen are inspection and palpation. Wounds and contusions should be identified and cataloged (Figure 11-12). Palpation is a key element in determining the absence of peritonitis or rebound. If the patient has pronounced pain with the release of deep palpation or any jarring of the bed, it is commonly indicative of peritoneal irritation from intraabdominal hemorrhage. Frank signs of peritonitis are a key indicator of the need for surgical exploration.

Spine

The initial palpation of the spine is conducted during the exposure phase of the primary survey. During the secondary exam, any noted abnormality should be further defined. In addition, distal sensation and motor function of the extremities should be comprehensively assessed. Any alteration in these neurologic functions may be indicative of an occult spinal cord injury. Until these injuries can be excluded by physical exam and radiography as indicated, full spine immobilization should be continued.

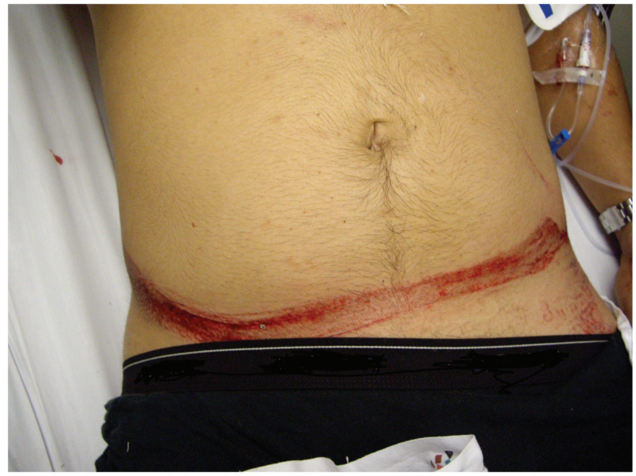

Figure 11-12. Abdominal "seat-belt" sign. This injury pattern is commonly associated with intraabdominal injury. Any contusion or bruising of the abdomen should raise the suspicion for intraperitoneal injury.

Pelvis

The basic pelvis exam is used to determine suspicion for pelvic instability (Figure 11-13). Suspicious mobility of the pelvic ring can often be diagnosed with a single palpation of the pelvis. Repeat exams are not advised because each manipulation of an injured pelvis is likely to promote additional hemorrhage due to the motion of bony fragments. The perineum should also be carefully examined because perineal hematoma is another documented potential indicator of pelvic hemorrhage. Finally, if not conducted during the primary survey log-roll, a rectal exam should be accomplished during the secondary survey to document intact rectal tone and the absence of rectal blood. The presence of blood raises the index of suspicion for possible rectal injury or open pelvic fracture. The absence of rectal tone suggests the presence of spinal cord injury.

Extremities

The extremities should be assessed for any evidence of wounds, deformities, or contusions (Figure 11-14). Hemorrhage sources should be controlled with either tourniquet or direct pressure. Deformities should be reduced with splinting, and radiographic assessment for fractures should be ordered. A comprehensive

Figure 11-13. A patient with a pelvic fracture and dislocation. Note the external rotation and shortening of the right lower extremity indicative of this pathology.

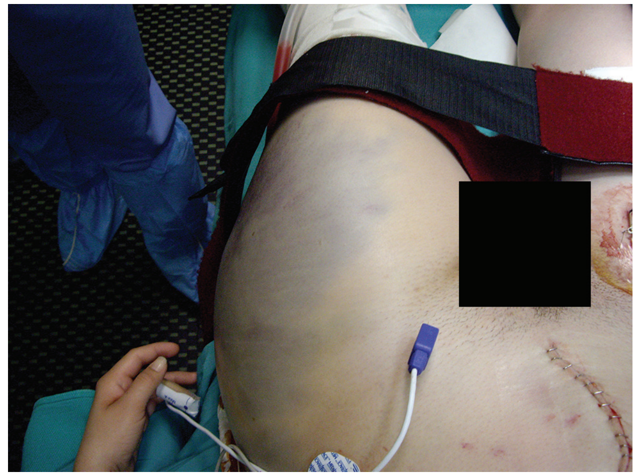

Figure 11-14. A large femoral hematoma associated with a femur fracture of the left lower extremity. Bleeding into the thigh at this location can contribute to significant hemorrhage.

neurovascular exam of each individual extremity should be documented. Any abnormality requires imaging evaluation. The extremities should be palpated over the muscular compartments to assess the potential for subtle compartment syndrome, particularly if vascular compromise or fracture of the extremity is documented or suspected. Any suspicion of compartment syndrome requires appropriate action to exclude the possibility of this potentially devastating process.

SUMMARY

The years of war in Afghanistan and Iraq have provided many lessons in the care of combat-wounded service members. Research, documented lessons learned, the Joint Theater Trauma Registry Clinical Practice Guidelines, and contributions by all specialties involved in the care of polytrauma combat casualties have resulted in improved outcomes. The standardized trauma assessment and well-rehearsed team approach as outlined in this chapter are critical in the care of the combat casualty. This approach has proven to be invaluable in rapidly assessing and treating battle injuries in today's and, likely, tomorrow's combat environment. Timely, well-documented, continuum of care protocols with nonpunitive approaches have proven to be vital. It is crucial that postincident forums continue to include all providers, from the smallest team such as point-of-injury, forward surgical teams (Role 2) to the most advanced level of combat care (Role 3), and continental US facilities. This ongoing, real-time dialogue allows clinicians, surgeons, nurses, and support staff involved in care of the combat casualty to openly discuss near-misses, relay clinically significant missed injuries, and share positive and negative contributing factors, ultimately resulting in improved outcomes. In addition, these types of dynamic forums have provided "closure" for some providers, helping address mental health issues that have arisen in staff who care for polytrauma casualties. The results of such open forums and subsequent publicized lessons will ensure the future development and implementation of process improvements that will better train medical staff, reduce morbidity, and improve the quality of trauma care for service members.

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