Primary care and preanesthetic assessment of the severely traumatized patient

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This review describes the clinical management of the severely traumatized patient. The organization of, and rationale for, comprehensive trauma programs are reviewed. The initial assessment, resuscitation, and immediate management of the severely traumatized patient are discussed, emphasizing the anesthetist's role in airway management and resuscitation with fluids. Diagnostic tests and preoperative considerations for emergency surgery for trauma are also discussed.

Trauma is the leading cause of death in persons under 38 years of age. Currently, accidents are the third most common cause of death in the United States, cardiovascular disease and cancer being first and second. It has been estimated that 30-50% of trauma-related deaths would be preventable if optimal trauma care were linked in an operational system.

A comprehensive trauma program would include: (1) emergency medical services (EMS) and regional trauma centers; (2) integrated medical/surgical care (for example, categorizing injury in the field and rapidly transporting patients to the appropriate facility); (3) program administration and evaluation; (4) research on trauma; and (5) public education about trauma and its prevention. Prevention includes handgun control and legislation to lessen the incidence of drunk driving and to require the use of seat belts and motorcycle helmets.

When trauma-related deaths are plotted against time after injury, a trimodal distribution occurs. Approximately 50% of trauma deaths occur soon after injury ("immediate") and result from laceration of the brain, the brain stem, spinal cord, heart, or a major blood vessel. Because only a small percentage of these patients could be salvaged, even under ideal conditions, only preventive measures would reduce mortality for this classification of trauma-related deaths. Approximately 30% of trauma deaths occur within the first few hours of injury ("early deaths") and are usually caused by epidural or subdural hematoma, hemopneumothorax, pelvic and/or long bone fractures, and abdominal injuries. Most of these injuries are treatable, and survival can be expected if the interval between injury and definitive treatment is minimized. Approximately 20% of trauma deaths occur within days to weeks of an injury ("late deaths") and are usually due to sepsis or multiple-organ failure.

The Committee on Trauma of the American College of Surgeons has published guidelines for the optimal care of trauma patients. The guidelines define three levels of trauma centers, the principal difference being the availability of staff specialists. To be a level I or II facility, a trauma center must provide 24-hour, in-house, general
surgery and anesthesiology care for trauma patients. In a level I facility, a neurosurgeon should also be in-house. Although a level III facility is usually a small institution that lacks level I and II capability, in-house anesthesia coverage is imperative.

Approximately 5% to 10% of trauma-related injuries require the specialized care of a level I or II center. Therefore, plans for the triage of trauma patients are essential in getting the right patient to the right hospital.

An important and controversial question in setting up regional trauma centers is whether it is more efficient for ambulances to go to designated trauma centers or to go to the nearest hospital and then transfer triaged patients to those designated centers. A prime consideration is the "golden period," which varies in length and occurs immediately after an injury. The "golden period" is the time during which resuscitation and stabilization are most beneficial.

West, Trunkey, and Lim compared victims of motor-vehicle trauma who died after arrival at hospitals in San Francisco and Orange Counties. In San Francisco County, a geographically small area, all trauma victims were brought to a single trauma center. In Orange County, a geographically large area, patients were transported to the nearest receiving hospital. In Orange County, approximately two-thirds of the deaths not related to the central nervous system (CNS) and one-third of those related to the CNS were judged potentially preventable. Only one death in San Francisco County was judged preventable. Examples of non-CNS-related deaths include exsanguination from ruptured spleen or lacerated liver. Examples of potentially preventable CNS-related deaths include undiagnosed subdural or epidural hematomas. Furthermore, trauma victims in Orange County were younger and their injuries of a lesser magnitude than those of San Francisco County.

Subsequently, Orange County developed and implemented a system using regional trauma centers. A subsequent investigation studied selected time periods before and after regional trauma centers were instituted. The percentage of potentially salvageable patients dying from traumatic injury not related to the CNS was markedly reduced to 9%. Prior to regionalization, only 20% of the patients received an appropriate operative intervention. After regionalization, this value increased to 89% for patients treated at a trauma center. Also, the average time before arrival at the hospital had not increased significantly.

Rapid transport of victims of severe trauma to a definitive care facility is becoming more routine within large cities. The process begins when authorities are notified and an ambulance team promptly responds. The team consists of trained emergency medical technicians (EMTs) who assess injury, establish an adequate airway, start intravenous lines for administration of fluids and/or drugs, and immobilize the patient properly to prevent further injury. If necessary, the team also applies military anti-shock trousers (MAST), controls external bleeding, or starts cardiopulmonary resuscitation (CPR).

The EMTs communicate with the trauma service center to obtain instructions on treatment and triage, and to give an estimated time of arrival. The extent of stabilization and resuscitation of the patient in the field can be much debated and depends on the injury and required transport time to the trauma center. For example, in patients having penetrating cardiac wounds, the survival rate was significantly greater when only minimal stabilization in the field was attempted ("scoop-and-run" technique) than when extensive in-field treatment was given, because transport time was only 10 minutes for the former and 25 minutes for the latter.

**Initial assessment and resuscitation**

In assessing and resuscitating the severely traumatized patient, many tasks are performed simultaneously. If CPR has been started, the trauma team takes over its administration and intubates the trachea. Any esophageal obturator inserted by paramedics should be left in place until the trachea is intubated.

Upon arrival at the emergency room, the patient is stripped of clothing and rapidly examined while vital signs are measured. Chest wall motion, the pattern of breathing, and breath sounds are evaluated. The condition of the mouth and anterior neck, the position of the trachea, the carotid pulse, and neck veins are evaluated. An extremity is checked for peripheral perfusion. At the same

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**Table I**

<table>
<thead>
<tr>
<th>Priorities in the management of the severely traumatized patient</th>
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<tr>
<td>1. Establish an airway and ensure adequate ventilation.</td>
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<td>2. Control external bleeding.</td>
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<td>3. Restore cardiac output.</td>
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<tr>
<td>4. Evaluate neurologic function.</td>
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<tr>
<td>5. Apply splints to fractures.</td>
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<td>6. Perform diagnostic studies.</td>
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time, other members of the trauma team are attending to the priorities listed in Table I.11

Patients having massive trauma may initially be categorized into one of three groups. The "lifeless" patient manifests no detectable signs of life. The second group has systemic hypotension or shock. The third group has severe injuries but is not hypotensive or severely hypovolemic. For the lifeless or near-lifeless patient, immediate treatment includes tracheal intubation, ventilation with 100% oxygen, rapid intravenous administration of fluids, chest drainage where appropriate, left anterolateral thoracotomy, and cross-clamping of the descending aorta. The patient is then transported to the operating room. Indications for emergency room thoracotomy when systemic blood pressure is unobtainable include pericardial tamponade, hypovolemic cardiac arrest, and systemic air embolism.12

Baker et al.12 reviewed 168 patients with multiple-organ injuries in whom emergency room thoracotomy was performed because of cardiac arrest occurring in the ambulance or emergency room. Overall, 19% survived to leave the hospital. When penetrating trauma was the mechanism of injury, the overall survival rate was 30%. Ten of 111 patients who presented to the emergency room with no vital signs or with attempted respiration (with or without thready pulse but no palpable blood pressure) were long-term survivors. No patients survived cardiac arrest resulting from primary brain injury. In this clinical setting, fixed, dilated pupils would not be accurate indicators of irreversible CNS damage and would not contraindicate aggressive management.13,14

If severe hypotension does not respond to rapid fluid administration or chest drainage, immediate transfer to the OR is indicated. After initial resuscitation, most patients will have stable vital signs, even though they are actually ill; therefore, diagnosing injury may be difficult. Close observation for abrupt changes in clinical condition is imperative.

Airway management

The goals of active control of any patient's airway are to relieve anatomic obstruction, to prevent the aspiration of gastric contents, and to promote adequate gas exchange. (Table II.) All severely traumatized patients should receive oxygen. General considerations regarding airway management in the traumatized patient include the following: (1) all patients should be considered to have a full stomach and be at risk for aspiration; and (2) patients may require difficult or complicated airway management because of variations in normal upper airway anatomy or injuries to the upper or lower airway, adjacent structures, or cervical spine.

Options for controlling the airway in the severely traumatized patient are listed in Table III. Temporarily overcoming upper airway obstruction and restoring ventilation and oxygenation can be achieved by either anterior mandibular subluxation (chin lift or jaw thrust), placement of an oropharyngeal or nasopharyngeal airway, and/or, in extreme cases, anterior displacement of the tongue with a towel clamp. The upper airway should be cleared of secretions or foreign material with a tonsil suction or by the examiner's finger.

If tracheal intubation is indicated and the airway is judged normal, a rapid-sequence technique may be performed. This would include preoxygenation, blockade of succinylcholine-induced fasciculations with a small dose of a nondepolarizing muscle relaxant,16 an appropriate dose (none to normal, according to hemodynamic status or level of consciousness) of anesthetic agent, succinylcholine (1.5 mg/kg IV), and application of cricoid pressure until tracheal intubation is confirmed and the cuff is inflated.14 Administration of positive-pressure ventilation by mask is avoided unless tracheal intubation is not accomplished during the attempted laryngoscopy. Cricoid pressure is maintained throughout, until either the patient has been successfully intubated or is allowed to recover from the muscle relaxant and anesthetic agent.

If tracheal intubation is difficult or airway management is complicated (see the preceding paragraphs), alternative techniques for tracheal intubation may be used (Table III). Awake intubation, either orally or nasally, under direct vision with topicalization of nose and pharynx may be preferred. Awake intubation is contraindicated for patients having a perforation of the eyeball, and often in patients having penetrating injuries of the neck not compromising the airway.

A fiberoptic bronchoscope may facilitate placement of the tracheal tube when airway man-

<table>
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<th>Table II</th>
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<tr>
<td>Rationale for airway management in the traumatized patient</td>
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<tr>
<td>1. Relieve anatomic obstruction.</td>
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<tr>
<td>2. Prevent the aspiration of gastric contents.</td>
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<tr>
<td>3. Promote adequate blood-gas exchange.</td>
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management is complicated; however, lack of familiarity and poor visualization from excessive blood in the airway make this option less attractive. Blind nasotracheal intubation may be acceptable under certain circumstances, such as a cervical spine injury. However, when a cervical spine injury causes acute quadriplegia, blind nasotracheal intubation should be used cautiously, as the patient lacks a forceful cough and ability to protect the airway should regurgitation or vomiting occur. If orotracheal or nasotracheal intubation is not feasible and the patient cannot be ventilated with a mask, emergency cricothyroidotomy is indicated.

Emergency surgical cricothyroidotomy is performed by using a No. 11 blade to make a short transverse incision through the skin, subcutaneous tissue, and cricothyroid membrane. The handle of the scalpel is then used to hold the membrane open by turning it to enlarge the tracheal opening. A No. 5 cuffed endotracheal tube is then placed into the trachea. The single contraindication to cricothyroidotomy is complete laryngeal-tracheal separation.

When airway management may be complicated and success of oral tracheal intubation is considered very likely, a rapid-sequence technique is usually performed, however, in such a case the surgeon must be prepared for emergency cricothyroidotomy.

For the pediatric patient in whom intravenous access has not been established, an acceptable technique would consist of induction with an inhalation anesthetic, spontaneous ventilation, and application of cricoid pressure, followed by tracheal intubation. Alternatively, intramuscular ketamine (4-8 mg/kg) and succinylcholine (3-4 mg/kg) after preoxygenation and application of cricoid pressure may also be an acceptable technique to secure tracheal intubation.

Whenever consciousness is markedly impaired (as from head injury, drugs, or severe hypotension), the airway must be protected. Intubation overcomes airway obstruction, prevents aspiration, and facilitates hyperventilation should intracranial pressure increase. Patients having serious head, neck, or deceleration injuries should be assumed to have a fracture of the cervical vertebrae. The neck should be maintained in a neutral position and the head taped to a padded spine board. Placing sandbags on each side of the head also adds stability.

Roentgenograms of the neck should show all seven cervical vertebrae. If the cervical vertebrae are unstable, some form of traction (such as Gardner-Wells tongs, Crutchfield traction tongs, or a halo-traction) provides stability and reduces movement. Traction should be established before any airway manipulations are performed. If the

| Table III |
| Options for airway control in the severely traumatized patient |
| I. Temporary measures |
| A. Anterior mandibular subluxation |
| B. Placement of an oropharyngeal or nasopharyngeal airway |
| C. Anterior displacement of tongue with towel clamp |
| II. Tracheal intubation |
| A. Normal airway management |
| 1. Rapid-sequence induction |
| a. Preoxygenation |
| b. Blockade of succinylcholine-induced fasciculations |
| c. Appropriate dose (none to normal, according to hemodynamic status) of anesthetic agent |
| d. Succinylcholine (1.5 mg/kg IV) |
| e. Application of cricoid pressure |
| B. Complicated airway management |
| 1. Tracheal intubation of awake patient |
| a. Orotracheal or nasotracheal intubation under direct vision |
| b. Intubation over fiberoptic laryngoscope |
| c. Blind nasotracheal intubation |
| d. Awake cricothyroidotomy, or tracheostomy under local anesthesia |
| 2. Rapid-sequence induction (as in II.A.), with surgeons prepared for emergency cricothyroidotomy |
| 3. Inhalation induction with spontaneous ventilation and application of cricoid pressure |
airway is compromised but instability of the cervical vertebrae has not been ruled out, anterior mandibular subluxation may clear the airway pending confirmation by roentgenogram. If the jaw thrust is not successful and/or definitive airway control is necessary, awake orotracheal or nasotracheal intubation under topical anesthesia is preferred.

If orotracheal intubation is expected to be technically straightforward, administration of muscle relaxants and application of cricoid pressure after preoxygenation are acceptable procedures. When airway manipulation is necessary before application of traction, the senior surgeon holds the head, and axial traction limits excessive movement. If tracheal intubation cannot be accomplished without undue extension or flexion, cricothyroidotomy is the preferred method. Awake blind nasotracheal intubation after topical anesthesia of nose and pharynx is usually easy to perform in less urgent situations.

When fractures of the face or upper airway have occurred, blind insertion of an endotracheal tube may result in intubating the cranial vault, sinuses, or retropharyngeal space, or may push foreign material toward the glottis, causing airway obstruction. Generally, most patients having facial fractures do not require immediate tracheal intubation, although early intubation may be indicated if edema and swelling occlude the airway or preclude safe oral access to the trachea.

Management of open neck injuries depends on the structures damaged and the anatomic level of injury. A cut above the hyoid bone entering the oropharynx may release the support muscles of the tongue, thereby causing respiratory obstruction, severe arterial hemorrhage, and injury to the superior laryngeal nerve. The last event produces anesthesia of the upper larynx. Open neck injuries at the level of the larynx may sever the epiglottis, thus producing positional airway obstruction. A cut at the level of the thyroid cartilage may result in severe bleeding from various neck vessels with rapid expansion of hematoma and airway compression. In addition, the recurrent laryngeal nerve may be severed, although stridor occurs with bilateral recurrent laryngeal nerve injury. Open neck injuries below the cricothyroid membrane may cause tracheal injuries and partial or total airway obstruction.

In all these instances, airway manipulations should be performed with the patient awake. Often the patient can maintain some gas exchange with spontaneous ventilation, and this should never be abolished. Direct laryngoscopy is satisfactory for injuries above the thyroid cartilage. For injuries below the thyroid cartilage that involve the airway, the preferred method is awake intubation using a flexible or rigid bronchoscope and placement of a tracheal tube (under direct vision) beyond the injury to avoid creating a passage outside the trachea. In some open tracheal injuries, placement of a small tracheal tube through the wound into the trachea can be done for initial airway control.

Closed injuries of the larynx and cervical trachea are usually the result of direct trauma, hyperextension of the neck, or shearing forces during a deceleration injury. Often a cervical spine injury has also occurred. Injuries to the larynx may rapidly obstruct the airway and require immediate cricothyroidotomy. In less urgent cases, patients are very hoarse and unable to make a high-pitched "e" sound, as this sound requires a mobile cricoarytenoid joint and functioning laryngeal neuromuscular mechanisms. Palpation of the neck is extremely painful, and the usual landmarks of the thyroid cartilage are indistinct.

In addition, neck palpation may also reveal subcutaneous emphysema, although the latter does not distinguish laryngeal from other tracheobronchial injuries. Indirect or direct laryngoscopy may also help evaluate suspected laryngeal fractures. If clinical status permits, computerized axial tomography of the larynx may confirm the diagnosis in uncertain cases, and may provide additional information regarding the feasibility of translaryngeal intubation. When the larynx has been fractured, airway control is usually obtained with a tracheostomy under local anesthesia, followed by surgical repair. Careful translaryngeal intubation seems to be a satisfactory alternative when the larynx can be easily visualized.

Intrathoracic tracheobronchial injuries should be suspected in victims of high-speed traffic accidents who sustain a deceleration injury. The injuries are commonly located within 2-3 cm of the carina. Patients having progressive subcutaneous emphysema and persistent pneumothorax despite tube thoracostomy should be suspected of having a tracheobronchial injury, for which bronchoscopy is the definitive diagnostic measure. For tracheal lacerations or avulsions, the tracheal tube should be placed beyond the injury under direct vision as described for open neck injuries. If bronchoscopy reveals a bronchial disruption, airway management requires placement of a double-lumen endobronchial tube, the endobronchial portion of which is inserted into the normal bronchus.

Patients with continued cardiovascular insta-
Cardiovascular management

Cardiovascular instability may result from pump failure or inadequate circulating blood volume. Pump failure should be suspected in any hypotensive patient who has cool and clammy extremities and distended neck veins. However, both pump failure and hypovolemia may occur simultaneously, and distension of the neck veins may not be present initially. Pump failure is caused by tension pneumothorax, pericardial tamponade, myocardial contusion or infarction, or coronary air embolization.

Tension pneumothorax interferes with preload by increasing intrathoracic pressure. In addition, myocardial failure is secondary to the associated severe hypoxemia. Tension pneumothorax is suspected when respiratory distress and shock are accompanied by abnormal breath sounds, distended neck veins, and contralateral shift of the trachea. In the unstable patient, treatment is instituted (before confirmation by chest roentgenogram) by inserting a 16-gauge catheter into the second intercostal space, in the midclavicular line of the involved side, followed by tube thoracotomy if the diagnosis is confirmed.

Pericardial tamponade that mimics tension pneumothorax may result from a penetrating or blunt chest injury. Also, cardiac arrest may occur suddenly. Although pericardiocentesis is often recommended as a time-gaining measure, false negative results often occur, and immediate transfer of the patient to the operating room and thoracotomy are indicated. Other useful, although temporary, measures include volume expansion (despite high central venous pressure) and avoidance of tracheal intubation and positive-pressure ventilation until just before surgery. If severe hypotension or cardiac arrest occurs, emergency thoracotomy and pericardiectomy should be performed.

Myocardial contusion is usually a result of blunt chest trauma and can cause serious arrhythmias and hypotension. Diagnosis is confirmed by the presence of abnormalities on ECG, arrhythmias, and serum creatine phosphokinase MB enzymes. All patients suspected of having a myocardial contusion should have continuous ECG monitoring. Also, unstable cardiovascular status warrants monitoring of hemodynamic variables via a pulmonary artery catheter. Inotropic or vasodilating therapy can be instituted as appropriate.

Coronary air embolization, although unusual, can occur after lung laceration and positive-pressure ventilation. Air is forced into the pulmonary venous circulation, causing cardiogenic shock and/or disturbances of the CNS. This condition is treated with emergency thoracotomy on the involved side and, if confirmed, occlusion of the lung...
hilum. Definitive treatment consists of lobectomy or pneumonectomy.

The initial step in restoring adequate circulatory blood volume is establishing vascular access. At least two large-bore cannulae are inserted, preferably in uninjured extremities. When hypotension accompanies massive trauma, at least one intravenous line should lie within the superior vena cava. When the first IV line is established, blood is obtained for determination of hematocrit, cross-matching of blood, and other laboratory tests (assessments of electrolytes, glucose, creatine, amylase, and toxicologic assay). In addition, a Foley catheter is inserted to monitor urine volume and to detect hematuria. In the emergency room, blood pressure should be monitored by an automated pressure measurement system. Later, in the operating room, an arterial line should be established if hemodynamic instability continues.

Shock is categorized as mild, moderate, or severe. Blood pressure and pulse are not always accurate indicators of normovolemia, particularly in healthy patients. In mild shock, blood loss is approximately 10% to 20% of blood volume, and blood pressure is usually normal. In moderate shock, blood loss is 20% to 40%, cardiac output is reduced proportionately, and cerebral and coronary blood flows are maintained. Also, intense vasoconstriction occurs and urinary output decreases. Severe shock occurs when blood loss exceeds 40%. Compensatory maintenance of normal coronary and cerebral blood flow no longer occurs, and mental state is altered.

Hypovolemic patients can tolerate rapid IV infusion of 2-3 L of crystalloid solution. Each liter of crystalloid should be clearly numbered and recorded. Red blood cells are transfused in order to keep hematocrit at 25% to 30%. Fluid administration should aim at increasing central venous pressure and urinary output, and at improving systemic blood pressure. If available, whole blood should be used to restore blood volume after hemorrhage.

Patients requiring blood transfusion either immediately or with only minimal delay can receive universal donor blood (O Rh-negative packed red cells) or type-specific blood (ABO-Rh). The risk of transfusion reaction with type-specific blood is less than 1%, and the reaction is usually not hemolytic. Universal donor blood is usually given if type-specific blood is not available. If more than four units of universal donor blood have been given and additional transfusions are required, universal donor blood should be given rather than type-specific blood. Before the recipient is given his hereditary blood group (A, B, or AB), declining levels of transfused anti-A and anti-B antibodies (from prior universal donor transfusion) should be confirmed so that transfusion of the hereditary blood group will not cause a hemolytic transfusion reaction. The Vietnam experience substantiates the safety of transfusions with universal donor blood. Over 100,000 such transfusions were given without one death being attributable to a transfusion reaction. In contrast, nine deaths were attributable to hemolytic transfusion reactions after extensive cross-match testing to confirm blood compatibility. These reactions were primarily due to errors in patient and/or blood sample identification.

A MAST suit is commonly used to treat hemorrhagic shock in the field, emergency room, or intensive care unit. It is more useful for hemorrhage resulting from injuries below the diaphragm, from a ruptured ectopic pregnancy, or from an aortic aneurysm. Inflating the MAST suit increases systemic blood pressure by decreasing the venous capacitance vessels and increasing systemic vascular resistance. In this way, coronary and cerebral blood flows are preserved. In addition, an inflated MAST suit may decrease bleeding by reducing the size of the injured vessels and the transmural pressure. The suit should be left inflated until normal intravascular volume is restored.

Induction of anesthesia in the operating room should proceed with the suit inflated, followed by gradual deflation of the abdominal component. The components for the lower extremities may be deflated after bleeding has been controlled. Complications and side effects have occurred after using an inflated MAST suit. The increase in intraabdominal pressure may cause respiratory distress or vomiting, and pulmonary edema may result because of excessive fluid volume replacement. Also, blood loss from injuries above the level of the garment may increase. Finally, long-term application of a MAST suit may predispose the compressed areas to vascular compromise and metabolic acidosis, and the patient to renal dysfunction. Other considerations in using a MAST suit are that covered areas are not available for examination, and that the measured CVP may not accurately reflect total intravascular volume.

Autotransfusion can be a lifesaving measure. The simplest method consists of collecting blood from chest tubes draining hemotheraces, adding citrate as an anticoagulant, and then reinfusing the blood into the patient.

Measuring acid-base balance is crucial if nor-
mal hemodynamic status is not restored after initial volume replacement. Although restoration of intravascular volume is the usual treatment of metabolic (lactic acid) acidosis due to hypovolemic shock, if hypotension persists, the clearance of lactate is impeded and excess production continues. Under these circumstances, partial correction to a pH of 7.25 is facilitated by administering sodium bicarbonate.

The trauma patient is particularly vulnerable to hypothermia because of environmental conditions, administration of large volumes of crystalloid, and infusions of cold blood. Hypothermia decreases myocardial performance, and refractory ventricular fibrillation may occur when body temperature drops to 27°C to 29°C.

**Neurologic and orthopedic assessment**

Neurologic assessment of the patient with head injuries attempts to determine the level of consciousness and to detect signs of brain-stem dysfunction. For the former purpose, the Glasgow Coma Scale (Table IV), a sensitive and reproducible exam, is widely used. It records the best response from each category (eye opening, motor response, verbal response). A total score of 3 indicates deep coma, and a score of 15, full consciousness. A score of less than 7 indicates poor neurologic functioning. Patients having a score of 8 to 11 are expected to survive but with disability. Patients whose scores are 12 to 15 are expected to do well. Brain-stem compromise is evaluated by examination of cranial nerves II to XII.

Patients with head trauma who demonstrate brain-stem dysfunction, particularly signs of tentorial herniation (abnormal pupillary reflexes to light, depression of consciousness, and asymmetric motor signs) require immediate treatment: (1) tracheal intubation and hyperventilation to a PaCO$_2$ of 25 mmHg; (2) IV infusion of mannitol (1.0-1.5 gm/kg); (3) close monitoring of systemic arterial pressure and avoidance of hypotension; and (4) immediate transport to the operating room for burr holes (one in each quadrant), through which extracerebral mass lesions (e.g., epidural or subdural hematoma) will be searched for.

Patients with focal neurologic deficits but no signs of brain-stem compression, particularly those who have normal pupillary reflexes to light, are evaluated by CAT scanning. Some of these patients will require tracheal intubation and paralysis to facilitate CAT scanning. Patients who were not intubated initially must be closely observed.

Although barbiturates lower elevated intracranial pressure, their effectiveness in improving outcome in patients with head injuries has not been established. Because cardiovascular side effects from administering large doses of barbiturates can be substantial, widespread use of barbiturates is not recommended.

Suspected fractures or instability of cervical and/or thoracolumbar vertebrae should be ruled out by appropriate roentgenograms and neurologic assessment of spinal cord function. Splinting of major fractures prevents further neurovascular damage and reduces pain. When cardiovascular variables become stable, either after initial resuscitation or emergency surgery, roentgenograms of all suspected fractures should be obtained.

**Occult blood loss and definitive diagnosis**

The chest, abdomen, pelvis, retroperitoneum, and thigh are sites of significant occult blood loss in massive trauma. A hemothorax may contain up to 2 L of blood, and the obtaining of a chest roentgenogram is crucial in excluding or confirming the thorax as a source of bleeding. Peritoneal lavage should be performed if intraabdominal hemor-

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**Table IV**

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<tr>
<th>Glasgow Coma Scale*</th>
<th>Best motor response</th>
<th>Best verbal response</th>
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<tbody>
<tr>
<td><strong>Eye opening</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Spontaneously</td>
<td>6 Follows commands</td>
<td>5 Oriented</td>
</tr>
<tr>
<td>3 To voice</td>
<td>5 Localized painful stimulus</td>
<td>4 Confused</td>
</tr>
<tr>
<td>2 To pain</td>
<td>4 Complex arm movement</td>
<td>3 Inappropriate words</td>
</tr>
<tr>
<td>1 None</td>
<td>3 Reflex flexor posturing</td>
<td>2 Incomprehensible sound</td>
</tr>
<tr>
<td></td>
<td>2 Reflex extensor posturing</td>
<td>1 None</td>
</tr>
<tr>
<td></td>
<td>1 Flaccid</td>
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*A total score of 3 = deep coma; 15 = full consciousness.*

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rhage is suspected in an unconscious patient who will undergo other emergency surgery. In the cardiovascularly stable patient, CAT scanning of the abdomen is useful for evaluating injuries to solid organs and the retroperitoneum. However, arteriography is still the best method of evaluating neck and chest injuries, pelvic fractures, and suspected vascular injuries in the extremities.

**Preanesthetic assessment**

Preanesthetic evaluation of the severely traumatized patient should include assessment of pre-existing medical diseases and prior drug use, anesthetic experiences, and allergic reactions. Assessing whether drug (psychotropic and/or alcohol) ingestion has occurred recently may alter anesthetic management. Although intoxication from alcohol may decrease anesthetic requirements, it does not predictably prevent recall of intraoperative events, should anesthetic agents be reduced. Also, because alcohol is a vasodilator and myocardial depressant, intoxication may predispose the patient to greater circulatory instability. Acute intoxication from amphetamines or phencyclidine may make the patient acutely psychotic and difficult to manage. Options include sedation with droperidol, physostigmine, and/or paralysis and intubation.

Physical assessment of the severely traumatized patient has been described previously, and attention to the adequacy of the airway, ventilation, blood-gas exchange, hemodynamic variables, volume status, fluid replacement, and neurologic status are mandatory. Preoperative check of the most recent hematocrit, blood availability, and roentgenogram of the chest or cervical spine should be performed before induction of anesthesia.

Preoperative medications should not be given routinely. For example, narcotics may cause vaso-dilation and increase hypotension in the hypovolemic patient. For the hemodynamically stable patient in extreme pain, titrated doses of narcotics may be administered intravenously or intramuscularly while drug effects are closely observed.

Preoperative measures to prevent pulmonary aspiration of gastric contents include delay of surgery, if appropriate, and changing the pH and volume of the gastric contents. Orally administered sodium citrate, a nonparticulate antacid, changes only pH, while intravenously administered cimetidine increases pH and can also reduce the volume of gastric contents. Metoclopramide will decrease gastric emptying time, but more importantly, it may increase lower esophageal sphincter tone. However, both effects are partially or completely antagonized by narcotic or anticholinergic agents. In addition, a nasogastric tube should be inserted before induction of anesthesia if intestinal obstruction, gastric perforation, or massive gastrointestinal bleeding occurs. The administration of antacid, cimetidine, and/or metoclopramide is not universally practiced.

Preanesthetic management of the severely traumatized patient should include prior preparation of the operating room: all equipment routinely used in anesthetic management (anesthesia machine, anesthesia circuit, ventilator, temperature monitor and probe, suction, and ECG) should be prechecked and readied. In addition, the following items should be checked and in place: (1) vascular pressure transducer should be assembled and connected to a continuous flushing system; (2) IV fluids should be connected through blood administration sets with pump and through blood warmers; (3) heated blanket should be placed on the operating room table and a device to deliver heated humidified gas should be connected on the inspiratory limb of the circuit; (4) laryngoscope and blades of various sizes and shapes, as well as tracheal tubes (of various sizes) with stylets should be available; (5) appropriate drugs (succinylcholine, pancuronium, ketamine, and thiopental) should be drawn up in syringes and labeled; and (6) a defibrillator having internal and external paddles, as well as appropriate CPR drugs, should be available.

**REFERENCES**

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