Trauma, Emergency Medicine, And The Golden Hour

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The only way to reconstruct what happened in the emergency room is to know its trauma procedures.

WHAT DO A WORKER WHO FALLS from scaffolding, a child who breaks a bone, and a gunshot victim have in common? They all must seek emergency treatment for their trauma-related injuries.

Trauma-related injuries are the fourth leading cause of death in the United States and they are the primary source of death among individuals under the age of 45. Edward E. Cornwell III, *"Trauma," in Emergency Medicine — A Comprehensive Study Guide*, 1609 (Judith Tintinalli, Gabor Kelen & J. Stephan Stapczynski eds., McGraw-Hill 2000). Motor vehicle accidents are the major culprit of these types of fatalities, and in children under the age of 19, trauma is the leading cause of death above all other diseased conditions combined. Centers for Disease Control, http://www.cdc.gov/ncipc/

factsheets/CostBook/Cost_of_Injury. htm (last visited Jan. 2011). Surprisingly, the number of years of life lost before the age of 65 due to trauma exceeds those lost from heart disease and cancer put together. Cornwell, supra.

Trauma patients are among the most critically injured and require more sophisticated emergency room care than the garden-variety "walk-in" patients with colds or sprain and strains. In fact, many emergency rooms are staffed with trauma specialists and other personnel who have advanced training in trauma policies and procedures, with the ultimate goal of saving lives within the critical 60 minutes from when the trauma occurred — the golden hour. Candace Smith, *"Emergency Room Trauma Procedures,"* eHow, http://www.ehow.com/list_6789699_emergency-room-trauma-procedures.html (updated July 29, 2010).

Most attorneys are not aware of the nuances, procedures, and goals involved in the treatment of trauma patients. This type of insight, however, is crucial in any meaningful attempt to understand the medical records of these victims. This article will discuss how trauma impacts the body part injured as well as the other systems of the body. For instance, a chest wound from a gunshot will obviously cause bleeding and damage to the surrounding tissues. However, it can also affect the respiratory system because the bullet will cause a lung to collapse. If the person stops breathing, there will be no gaseous interchange in order for the circulatory system to distribute oxygen to the body. If the flow of oxygenated blood to the brain is interrupted, this vital part of the nervous system could die. So, a single injury can negatively influence and impact many other systems even if they are distant from the site of injury. With this in mind, the reader will be taken step-by-step through the trauma examination with an explanation as to why each body part is inspected.

TRAUMA • The word *trauma* is derived from the Greek word for wound so a simple definition is that trauma is a bodily injury resulting from the application of an external physical force. This force can be unintentional, such as a car accident, or it can be intentional, as in a physical assault. Trauma can also be divided into two categories: blunt and penetrating. Blunt trauma is exactly what its name implies; injury caused by some form of blunt force being applied to the body that does not penetrate the body cavities. This type of injury is most commonly seen in motor vehicle accidents or falls. Penetrating trauma on the other hand, is when the force penetrates into the body in some form or fashion. Bullet wounds, stabbings, or even stepping on a nail are good examples of this type of injury.

What Are The Goals Of Trauma Treatment?

Trauma may have a fairly simple definition but when it comes to treatment of trauma patients, there is nothing uniform or standard about it. Trauma places great demands on hospitals to maintain emergency room departments staffed with physicians who specialize in this field of practice. However, trauma is not a recognized board specialty. The American Board of Emergency Medicine is the ABMS-approved specialty for emergency physicians. Emergency Medicine physicians are not surgeons and this board is not trauma-specific. James Bartimus and Anthony DeWitt, *Making the Trauma Negligence Case,* 44 Trial 22, May 2008. Nevertheless, the ultimate goal of trauma treatment is to minimize the morbidity and mortality associated with the insult.

Studies have established a trimodal distribution of death as a result of trauma. R. Shayn Martin and J. Wayne Meredith, *Introduction to Trauma Care,* in The Trauma Manual: Trauma and Acute Care Surgery (Andrew B. Peitzman et al. eds., Lippincott Williams & Wilkins, 3d ed. 2008). Almost half of the deaths occur immediately at the time of the injury and are usually due to massive bleeding or severe neurological injuries. *Id.* The second peak time of death is in the minutes and hours immediately following the injury and is usually due to severe head or thorax trauma. Cornwell, supra. This second period accounts for 30 percent of the mortalities associated with trauma. R. Shayn Martin and J. Wayne Meredith, supra. The final peak period in the distribution occurs several weeks after the injury with deaths that are usually secondary to severe infection (sepsis) or the failure of multiple organ systems of the body. *Id.* The deaths in this third period are thought to be due to organ damage sustained either in the accident or in the hours shortly afterward due to a lack of an adequate blood flow. Cornwell, supra.

The goal of trauma care is to reduce the deaths associated with the second peak period which occurs in the hours shortly after the injury. This is accomplished by establishing and implementing a systematic approach toward the trauma patient that allows for rapid assessment and stabilization of the victim. These established protocols allow physicians to evaluate the patient in a logical, algorithmic manner and treat injuries in the order that has the greatest chance to prolong life and minimize long-term consequences from the injury. By focusing on the immediate period following injury, doctors believe they can also limit organ damage and infections that claim victim's lives in the third peak period; thus ultimately reducing the late stage mortality. The most prevalent trauma protocol in the United States is the Advanced Trauma Life Support Protocol (ATLS) established by the American College of Surgeons. *See,* American College of Surgeons, *ATLS Overview,* at http://www.facs.org/trauma/atls/index.html (last visited Jan 2011).

"The golden hour" is a term often used by physicians or rescue personnel when referring to victims of trauma. The idea is that the time frame immediately following the injury is the crucial period in which to initiate life-sustaining care. The starting of medical treatment in this window provides the victim with the greatest chance of surviving the injury and minimizing subsequent complications that could result in death. Despite the first 60 minutes following trauma being dubbed the "golden hour," there are no studies that prove that post-accident survival rates actually drop off after this initial time period. *See* E. Brooke Lerner, M.S. and Ronald M. Moscati, M.D., *The Golden Hour: Scientific Fact or Medical "Urban Legend?"*, 8 Academic Emergency Medicine 758 (2001). Instead, the phrase represents the core concept that the greatest chance of survival for a trauma victim is rapid treatment in an appropriate facility that can manage his or her injuries.

What Is A Trauma Center?

In 1976, a physician was taking his family on a trip by private plane when the aircraft crashed. The family members sustained severe injuries and were taken to a local hospital where they received sub-standard care. *See* James K. Styner, M.D., *The Birth of Advanced Trauma Life Support,* 13 J. Trauma Nursing 41-(Apr.-June 2006).This prompted the doctor to seek the help of colleagues to correct the problem. These physicians ascertained that taking severely injured people to the closest, rather than the best staffed and best equipped hospital, could result in death. This started the movement to establish specialized trauma units and to change protocols so that paramedics would take the most severely injured people to those trauma centers. *Id.* at 44. Today, it is customary to transport accident victims directly to the appropriate level trauma center and not to the most convenient hospital. Robert Steinbuch, *Preventing Under-Equipped Medical Facilities from Killing Heart Attack Patients: Correcting Inefficiencies in the Current Regularity Paradigm for Providing Critical Health Care Services to Patients with Acute Coronary Syndrome,* 17 Health Matrix 17 (Winter, 2007).

Trauma care in our current environment is thought of as a system which comprises the overall treatment of the trauma victim from the initial evaluation through definitive care. The process of sending the injured party to an appropriate treatment facility is a vital part of this system approach. The treatment of a trauma patient begins the instant the patient is evaluated by any type of emergency medical personnel; from EMS to physician. One of the first steps is to determine the level of care that is needed. If the injury is minor, then any hospital or emergency room will suffice. If the patient is seriously injured or suffers from multiple problems, then the individual requires treatment at a specialized trauma facility.

Not all hospitals and emergency rooms, however, are created equal; they come in different sizes and have different capabilities. Hospitals can range from small rural facilities consisting of a few inpatient beds to large, metropolitan medical centers with multiple buildings and hundreds of inpatient beds. The sophistication of the attached emergency room tends to be directly proportional to the overall size of the hospital. Larger, more modern heath care centers have a greater ability to care for more severely injured patients than would a small hospital. This is because larger hospitals have more equipment and personnel available to treat a wider array of ailments. These bigger tertiary hospitals have many different types of physicians and specialists available in-house at all times; such as neurosurgeons or hand surgeons. ("In-house" means that a physician representing the particular medical specialty is physically in the hospital 24 hours per day or else is available to be at the hospital within minutes.) On the other hand, smaller hospitals may be staffed by a minimal number of in-house physicians with the majority of doctors being available on an on-call basis. These smaller facilities may also be manned by general practitioners with no specialist physicians on staff.

Some facilities receive the important designation of a trauma center. This title does not refer to a specialized part of an emergency room but is a label applied to a medical facility whose staff possesses specialized training, a surgical group, the finest equipment for emergency care, and be accredited to treat the most critically injured patients. A trauma center operates on a "team approach" whose staff includes emergency room physicians, neurosurgeons, anesthesiologists, and orthopedic surgeons who are experts in treating trauma victims. Typically, these physicians must be within a close proximity of the hospital, and be available any hour of the day or night. *NC Trauma Centers,* http://www.nctraumacenters.org (last visited Jan. 2011).

Trauma centers earn a "level" designation, as determined by the American College of Surgeons, based on the facility's ability to treat trauma. Centers for Disease Control, *Access to Trauma Care,* http://www.cdc.gov/traumacare/access_trauma.html (updated on Aug. 24, 2010). These designations range from a Level I facility to a Level V facility. A Level I facility provides the highest level of care and is capable of offering definitive treatment for any type of injury. Level I facilities must have 24-hour availability of all surgical subspecialties and advanced imaging capabilities. These requirements have demonstrated that severely injured patients brought to a Level I trauma center have better outcomes than lower-level facilities in treating patients with specific injuries associated with high mortality and poor functional outcomes. Demetrios Demetriades, et al., *The Effect of Trauma Center Designation and Trauma Volume on Outcome in Specific Severe Injuries,* 242 Anals of Surgery 512 (Oct. 2005) http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1402347/ (last visited Jan. 2011). On the other end of the spectrum are the Level V facilities. These hospitals generally lack the equipment or specialist availability needed in the evaluation and treatment of all trauma-related cases. Instead, they focus only on the immediate stabilization of the patient with the goal of rapid transfer to a more suitable facility for treatment. This may mean transfer to a Level II facility for the moderately injured patient or to a Level I facility in the face of severe trauma. (Many trauma centers are given some type of indirect subsidy to operate.)

Research has shown that trauma center care not only saves lives, but it is also a cost-effective way of treating major trauma victims. Even though the treatment is more expensive, the number of lives saved and quality of life-years gained surpass the costs. *Trauma center care cost-effective,* http://www.physorg.com/news201265663.html (last visited Jan. 2011).

An effective trauma system requires extensive coordination between EMS crews and the trauma centers. While medical protocols are designed to address the most common situations that EMS personnel encounter in the field, it can't address all of them. When there is a question about whether to follow the protocol or deviate from it, EMS crews generally contact the local Level I trauma center for guidance. The trauma center serves as a base-station for the direction and control of ambulances in the area. If a unique situation arises, or EMS feels that a certain medication is needed that is not on the protocol, they contact the physicians at the trauma center and receive guidance or authorization for the desired act.

Pre-Hospital Determination Of Care

One of the key decisions in the initial treatment of trauma patients in the field is the decision of where to take the patient for treatment. This is a very important decision since the successful treatment of trauma patients requires an overall approach involving every aspect of patient care from initial evaluation in the field to the rendering of definitive treatment. A mistake in where to send the patient results in unnecessary delays at best and death at worst. To prevent this problem, many states have enacted medical protocols used by EMS crews to determine what level of care the patient needs. *See e.g.,* Maryland Institute for Emergency Medical Services Systems, *Maryland Medical Protocols for Emergency Medical Services Providers,* at 132 (2010), http://www.miemss.org/home/LinkClick.aspx?fileticket=WKeNmPDJ9w%3D&tabid=106&mid=534 (last visited Jan. 2011). These algorithms are based on multiple factors such as the physiologic state of the patient, the mechanism of injury, and the apparent degree of the injuries sustained (or potentially sustained).

These medical evaluation protocols are designed to ensure that patients who have been in accidents likely to result in serious, life-threatening injuries are taken to the appropriate-level trauma center. Take for example a roll-over car accident. When EMS crews arrive on the scene, the patient appears to have only minor injuries and is walking around — apparently unscathed. An initial reaction might be that the patient doesn't need to be evaluated at a Level I trauma center since she is walking, talking, and appears to be essentially uninjured. The story might change however if we learn that a passenger in the same vehicle was killed in the crash, or that the patient was actually ejected from the vehicle, is intoxicated, or has abnormal vital signs. All of these findings suggest that the mechanism of injury was severe *and* that circumstances exist suggesting that the patient sustained serious injuries that are masked by his or her current intoxicated condition. A well-designed medical protocol would mandate that this patient be taken to a Level I trauma center to be evaluated for such injuries since the manifestation of internal injuries can be delayed from minutes to hours after the initial insult.

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is not on the protocol, then they contact the physicians at the trauma center and receive guidance or authorization for the desired act.

THE EVALUATION AND TREATMENT OF TRAUMA • The modern approach to the evaluation and treatment of trauma patients is very much an algorithmic one. The assessment consists of an initial primary survey followed by a later secondary survey. The primary survey consists of a rapid initial evaluation of the patient coupled with rapid resuscitation. This basic method is a systems approach designed to rapidly identify and treat the immediate threats to life. After this initial survey, and with the patient in a somewhat more stable situation, a more detailed secondary survey is undertaken. This secondary approach is a more in-depth examination for less life-threatening injuries than those identified in the primary survey. Following this evaluation, the patient undergoes any needed diagnostic studies including lab work and imaging. Once these test results have been analyzed, the patient is given the appropriate dispositions based on future treatment needs.

The Primary Survey

The primary survey is the initial rapid assessment and stabilization of the injured trauma patient. The goal is to identify and subsequently treat the immediate threats to life. An organized approach is important especially when there is a patient with multiple injuries. Some injuries may appear to be horrific but actually present very little immediate threat to life, such as a deformed wrist fracture or significant laceration. Other injuries may appear benign but actually present an immediate life-threat such as vomiting in an unconscious patient or a few drops of blood behind the eardrum. (Vomit can obstruct the airway, leading rapidly to death. Blood behind the eardrum signifies a possible skull fracture.) A systematic approach prevents the physician from being distracted by, and focusing on, what may be a gruesome but nonlife-threatening injury at the expense of treating an immediately life-threatening one. These major risks are broken down into the categories of airway, breathing, and circulation. This is often referred to as the "ABC's" of trauma resuscitation. By following the ABC's, the physician proceeds down an algorithm that addresses the problem most likely to kill the patient the quickest. Once this injury is stabilized, then the physician proceeds to look for and treat (if necessary) the next most life-threatening injury and so on.

As already noted, the most important systems involved in this initial step of life saving measures are the airway, breathing (the lungs), and circulation (the heart as a pump and blood as the liquid). Since oxygen is crucial to sustaining life, this algorithm essentially follows oxygen on its path from the outside world, through the airway, into the lungs where it crosses into the blood, and then the blood being pumped throughout the body in order to deliver the oxygen to organs and tissues. If simplification helps, think of this important algorithm as a way to make sure that air goes in and out, and that blood goes around and around.

"A" Is For Airway

"A" stands for airway and cervical spine control. If air can't pass freely through the airway and proceed towards the lungs, then the patient will likely die within seconds to minutes. This makes the evaluation and stabilization of the airway the most immediate and foremost goal in trauma resuscitation. During this phase of the primary survey, the physician looks for any injury or obstruction which could compromise the patency of the airway. Commonly, injuries to the midface or maxilla result in significant bleeding which can obstruct the airway or cause physical obstruction of the air passages. Stephen Colucciello, *Maxillofacial Trauma,* in Emergency Medicine — A Comprehensive Study Guide 1661 (Judith Tintinalli, Gabor Kelen & J. Stephan Stapczynski eds., McGraw-Hill 2000). A mandible that is fractured on both sides results in the lower jaw collapsing the airway in the throat. Even food particles or loose teeth can become caught in this passageway preventing the free flow or air.

If significant injury or airway compromise occurs, the airway must be secured by mechanical means. The most common technique is endotracheal intubation. This consists of passing a tube through the nose or mouth, vocal cords and into the distal trachea in order to maintain a free flowing airway. Air is then mechanically pumped into the tube by a ventilator machine or a Bag-Valve-Mask bag (BVM). (The BVM is a hand-held plastic bag that connects directly to the endotracheal tube and when squeezed introduces oxygen into the tube. The mechanical ventilator is a freestanding machine that performs the work of breathing for the patient and is used for long-term ventilation.) Carbon dioxide exits through the tube as well. This tube essentially provides a secure route for air to pass through the upper airway into the lower airway. Sometimes there is such severe trauma to the face, mouth, or upper airway that placing an endotracheal tube through the mouth is impossible. In such situations, another approach is taken. The airway is still secured with a tube but instead of being placed through the mouth and into the throat, it is placed directly through the exterior of the neck and into the trachea. These approaches are accomplished by means of a cricothyrotomy or a tracheotomy depending on which part of the neck is cut to allow the tube to pass. In a cricothyrotomy, a incision in made in the part of the anterior neck known as the cricothyroid membrane. With a tracheotomy, an incision is made in the portion of the neck that overlays the trachea between the Adam's apple and top of the breastbone. A tracheotomy tube is then inserted into the opening which acts like a windpipe and allows the person to breathe. *Tracheotomy,* Encyclopedia of Surgery, http://www.surgeryencyclopedia.com/St-Wr/Tracheotomy. html (last visited Jan. 2011).

Endotracheal intubation is mandated when there is a compromise of the airway unrelated to a direct physical blockage. In these cases, the patients must still be able to maintain their airway and clear secretions which could obstruct the passage. This procedure requires the insertion of a flexible plastic tube through the mouth and down into the trachea. Many times the doctor inserts the endotracheal tube with the assistance of a device known as a laryngoscope, which allows the doctor to visualize the upper portion of the trachea, just below the vocal cords. As the tube is inserted, the laryngoscope is utilized to push the tongue aside. It is also vital that the head be positioned in such a manner to allow for proper visualization. Pressure is often applied to the Adam's apple to assist with visualization and to prevent aspiration of the contents of the stomach. *Endotracheal Intubation,* MedicineNet.com, http://www.medicinenet.com/endotracheal_intubation/article.htm. This pressure is known as Sellick's maneuver.

Conditions that cause a decreased level of consciousness result in a diminished ability of the patient to protect his or her airway. This is often seen with intoxication or brain injuries which result in a decreased level of consciousness or a diminished gag reflex, both of which can lead to a lowered or absent ability to protect the airway. The untimely deaths of several rock stars after choking on their own vomit is a testament to the importance of securing the airway in such intoxicated or head-injured patients.

Another important point to the airway assessment is stabilization of the cervical spine. In an awake and alert patient, a physical exam of the cervical spine can be performed which can "clear" the patient from a cervical spine injury in many situations. If this is the case, then the patient likely doesn't need a cervical collar and can move his or her neck freely. A problem occurs in unconscious patients or critically injured patients with a mechanism of injury that could conceivably have caused trauma to the cervical spinal area. A good example would be an unrestrained person in a MVA. In this situation, until proven otherwise, the patient is treated as if he or she actually has a c-spine injury. This treatment consists of taking "c-spine precautions." The patient's neck is immobilized with a rigid cervical collar (often applied by the EMS at the scene of the accident). If the patient is moved, then his or her spine is kept in alignment using a "log-roll" technique and a rigid backboard. All of this is done to prevent movement of the bones in a spinal fracture which could physically injure the spinal cord.

The area of the spine with the greatest mobility is the cervical spine and, therefore, it requires extra steps to immobilize. The technique used in conjunction with log-roll is the use of "in-line traction" of the cervical spine. This consists of one team member supporting the patient's head and neck while providing gentle traction in the direction of the top of the victim's head (in line with the axis of the spinal column). This provides a requisite amount of stabilization to enable the patient to safely be turned or rolled during the resuscitation phase. In-line traction is especially crucial during oral intubation since there can be significant movement of the neck during this procedure if the neck is not immobilized.

Immobilization of the spine is crucial to prevent spinal cord injury in the presence of a spinal fracture. If a spinal cord injury compromises the spinal cord above the C5 level, there will be impairment of nerves vital to breathing. (C3-5 innervates the diaphragm and injury at this level can immediately compromise the ability of the diaphragm to move up and down. Without the diaphragmatic contraction, breathing ceases and the patient will require ventilatory support.) In this sense, the stabilization of the c-spine is as imperative as the stabilization of the airway; without the movement of the diaphragm breathing ceases. It is also crucial to establish early immobilization of the c-spine to prevent unwanted manipulation or movement during the rest of the resuscitative phase.

"B" Is For Breathing

Once the upper airway is secured then the primary survey moves to the next step which is "B" for breathing and ventilation. Theoretically, the oxygen is now making its way to the lungs and the goal is to make sure that the act of breathing is allowing the oxygen to enter the lungs, diffuse across the alveolar membrane, and enter the blood stream.

The first step in this process is to examine the neck and chest for any injury or evidence of underlying trauma. This is accomplished through direct visual inspection, palpation, and listening to the lungs (auscultation) with a stethoscope. In many cases, a simple physical examination reveals underlying chest trauma. A visual examination of the neck and chest can reveal if there is any deviation of the trachea from the midline. If the contents of the neck appear pushed to one side or the other, there could be a tension pneumothorax which represents an accumulation of air under pressure in the pleural space. H. Scott Bjerke, *Tension Pneumothorax,* eMedicine, http://emedicine.medscape.com/article/432979-overview (last visited Jan. 2011). Visual inspection of the chest can also detect if a part of the chest wall is deformed or not moving in unison with the rest of the chest; this is suspicious for a flail chest, a chest condition evidenced by multiple rib fractures. Simple observation also detects mechanical disruption of the chest such as a sucking chest wound or an otherwise large gaping hole in the chest.

The most common obstructions to breathing can be treated with tube thoracostomy; commonly called a "chest tube." If a pneumothorax occurs, then the treatment is to re-establish negative pressure in the thoracic cavity to allow re-expansion of the lung. A pneumothorax represents a collection of air in the space around the lungs. This buildup of air puts pressure on the lung, preventing the lung from inflating as much as it normally would when a person takes a breath. *Collapsed Lung*, Medline Plus, National Institutes of Health, http://www.nlm.nih.gov/medlineplus/ency/article/000087.htm (last visited Jan. 2011). This emergency medical problem is fixed by making an incision in the external chest wall and inserting a flexible tube into the pleural space (between the chest wall and the lung) around the level of the nipple. The tube allows for the egress of blood and air. The tube is then attached to a device that uses water to create a suction force in the tube. This constant gentle suction allows the lung to re-expand and function properly. The tube is maintained for several days until the original source of the air leak has healed. Eventually, the tube is removed and the hole is sewn shut to prevent further entry of air.

If the patient is suspected of having a tension pneumothorax, the goal is to relieve the pressure and convert the tension pneumothorax to a regular pneumothorax. This condition represents an accumulation of air in the pleural space that develops when injured tissue forms a one-way valve, allowing outside air to enter the pleural space but preventing the air from escaping naturally. Bjerke, supra. The tension is relieved by introducing a large bore needle into the pleural space at the apex of the rib cage. A sudden rush of air alerts the physician to the presence (and simultaneous treatment) of a tension pneumothorax. The patient is left with a regular pneumothorax which is then treated with a chest tube.

As has been noted, one of the most common threats to breathing is a pneumothorax. This is commonly referred to in laymen's terms as a collapsed lung. The lungs are usually kept inflated by a vacuum-like seal which uses negative pressure as a means of keeping the lungs expanded. A pneumothorax occurs when there is a hole in the chest wall or air is allowed to leak into the space between the lungs and the chest wall. This introduces air into the negative pressure seal and breaks the suction. As a result, the lung cannot maintain expansion and collapses. Common traumatic causes of pneumothorax include blunt force injury from a MVA which can rupture a lung thus allowing air into the pleural space. In penetrating trauma, such as a knife wound or gunshot, air from an external source enters the pleural space thus collapsing the lung. The tension pneumothorax is much more serious. When this occurs, air enters the chest cavity but can't escape. This causes severe compression of vital structures within the chest which can result in rapid death.

"C" Is For Circulation

The third stop on the trauma algorithm is "C" for circulatory system. By now, the oxygen should be making its way through the airway to the lung. The oxygen in the lung crosses the alveolar membrane and is absorbed into the small blood vessels providing a constant supply of oxygen as the heart pumps the blood throughout the body. Ventilation is occurring which is the exchange of fresh oxygen into the blood for carbon dioxide which is moving from the old venous blood into the lungs for exhalation. But in order for the oxygen-rich blood to do any good it has to be circulated throughout the body to supply oxygen to vital organs and tissues. This is the "blood goes around and around" part. If the organs and tissues don't get enough oxygen they become hypoxic and soon start to suffer injury.

In order for the blood to circulate it needs two things: a pump, and some tubing of sorts to allow circulation. Obviously, the pump is the heart. It provides constant pressure to propel the blood forward through the vascular system. The vascular system is the tubing that allows the blood to travel in an organized manner to the vital organs. The vascular system consists of arteries which carry freshly oxygenated blood away from the lungs toward the organs, and veins, which return the oxygen-poor blood to the heart for exchange in the lungs.

The proper flow of blood can only be maintained if both the heart and the vascular system are intact. The heart and blood vessels work together to maintain a certain level of pressure within the system. This pressure ensures the proper flow and timing of blood throughout the body. This pressure (greatly simplified) is what is being measured as blood pressure. This is possible because the circulatory system is normally a closed circuit; blood doesn't usually leak out. There is a limited ability for the two parts of the system to compensate for each other if the other half is not functioning properly. If the blood vessels can't maintain proper tone, then blood pressure drops. The heart compensates by beating faster and stronger in an attempt to provide a boost to the sagging pressure in the vessels. Similarly, if the heart is beating too slowly, then the blood vessels constrict in an attempt to increase the overall blood pressure.

If the pressure in the system drops to a level at which proper blood flow is not maintained this is called hypotension or low blood pressure. Generally, blood pressure below 90/60 is considered low. Hypotension results in vital organs not receiving enough blood, which in turn leads to organ damage. This lack of sufficient blood flow is called hypoperfusion. Different organs and tissues tolerate different levels of hypoperfusion before they stop working and begin to die. The brain is one organ that does not tolerate hypoperfusion very well. If the blood pressure drops suddenly or below about 90 systolic, then patients begin to feel light-headed, as if they will pass out. If the blood pressure drops much below this point, then they do actually pass out because the brain is not receiving enough oxygenated blood to function properly. Conversely, the blood supply to an extremity can be completely occluded and the tissue takes several hours to begin to die.

When blood enters organs and tissues it is called "perfusion." A certain level of blood pressure is required to provide the force for perfusion. Perfusion is vital because it not only brings fresh oxygenated blood to tissues but also because it carries away waste products as well. If the blood pressure stays low, then organs are hypoperfused. *See, Hyperfusion*, The Free Dictionary by Farlex, http://medical-dictionary.thefreedictionary.com/hypoperfusion (last visited Jan. 2011). The damage from hypoperfusion is due to both a lack of oxygen in the tissues and the accumulation of injurious waste products. This hypoperfusion is commonly known as shock. Shock is bad because it increases the risk of immediate death as well as death from complications days to weeks later.

The most immediate threats to life in the "C" section are profuse bleeding or a problem with the heart's pumping action. During the primary survey, any obvious sources of bleeding should be addressed with direct pressure to control the bleeding. The first step in this process is to essentially keep the blood from leaving the body. The second step is helping provide pressure to the system if the patient can't maintain an adequate blood pressure. This assistance comes in the form of fluids. It is a simple physiologic principle that if fluid leaves a closed system, the pressure within that system drops. Giving the patient intravenous (IV) fluids seeks to reinstitute fluid back into the system in an attempt to increase the pressure. This is why the fluids are given directly into the circulatory system. Proper pressure is essential for adequate delivery of oxygenated blood. But the ability to give a patient fluid is limited due to a dilutional effect. IV fluids don't carry oxygen. If the patient's blood becomes too diluted then there is a serious lowering of the amount of oxygenated blood passing through the system. If the patient requires more than about four liters of fluids then the patient must also be given blood to compensate for this loss.

Evaluation of the circulatory system's function is done by monitoring vital signs. During a trauma evaluation, it is essential to check the patient's blood pressure and pulse. Evaluation of the blood pressure in conjunction with the pulse or heart rate lets the physician know how effectively the circulatory system is working. Many trauma patients lose a significant amount of blood because of the injury. It is impossible to quantify how much blood was lost or how much the patient may still be bleeding in the emergency room. The solution to this dilemma is provided by monitoring the patient's vital signs.

Emergency medicine recognizes four levels of shock, with level I being the least dramatic and level IV being the most severe. Cornwell, supra, 1609. Surprisingly, a patient can lose up to 15 percent of his or her blood volume and still have normal vital signs. The pulse rate becomes abnormally high (>100 bpm) only after the patient loses 750 to 1500 mL of blood; this represents about 15 to 30 percent of the total blood volume. By the time the blood pressure begins to drop, the patient is in stage III shock and has lost over 30 percent of the total blood volume. Monitoring the vital signs allows physicians to obtain an estimate of how effective the fluid resuscitation is progressing as well as whether there still may be ongoing hemorrhaging.

It is standard protocol that trauma patients have adequate intravenous access since most require fluid resuscitation. This access comes in the form of two large bore, peripheral IV's. Large bore means an 18 gauge needle or larger (a lower number means a larger needle diameter). The IV's must be placed on different sides of the body if possible. In this way, a large volume of fluids can rapidly be infused if required.

Ongoing hemorrhaging is a major threat to life so it is imperative to identify and stop significant sources of bleeding during the primary survey. Visual inspection is adequate for external sources of bleeding but how does the physician identify internal injuries? During the primary survey stage, the answer is ultrasound. Modern trauma protocol uses ultrasonography to assess for blood in the abdominal cavity. This type of internal bleeding is almost impossible to identify without some form of invasive procedure or diagnostic imaging. In the treatment of trauma patients, ultrasound provides the perfect balance between the ability to detect fluid in the abdomen and the need to perform the test rapidly and safely. The ultrasound is called the focused assessment with sonography for trauma, or the "FAST" scan. FAST has become routine because it can be performed rapidly at the bedside of the patient (as opposed to taking an unstable patient to a different portion of the hospital for imaging that can take a long time such as an MRI). FAST is used to look for fluid in the abdominal cavity which in the face of trauma signals an accumulation of blood. This is important since significant intra-abdominal bleeding requires immediate surgical intervention to stop the source of the blood loss.

FAST can also be used to evaluate the heart for a life threatening pericardial tamponade. Tamponade occurs when there is an injury to the heart and fluid accumulates in the membrane that surrounds the heart; the pericardial sac. If enough fluid (blood) accumulates in the space between the heart and the outside area of the sac then the heart becomes compressed. Significant compression impairs the ability of the heart to pump blood. A pericardial tamponade is fatal since the failure of the heart to pump causes the blood to stop flowing. Fortunately, FAST allows the physician to quickly look at the heart and assess for tamponade. If blood is found it is removed with a large needle to decompress the heart and restore pumping action.

"D" Is For Deficit

The next step in the algorithm is accomplished by performing a brief assessment of the neurologic status of the patient or "D" for deficit. The exam focuses on pupil size and reactivity, level of consciousness, and overall motor function of the extremities. This information gives the physician a gauge of overall neurologic function and provides a clue as to any immediately life-threatening abnormalities such as intracranial bleeding.

Pupil size is measured to assess for signs of traumatic brain injury (TBI), also commonly called a head injury. Unequal pupil size, or anisocoria, is a sign of a TBI with increased intracranial pressure. This increased pressure within the skull is due to swelling of the brain or bleeding within the closed confines of the skull. As the pressure increases, the brain will eventually be pushed out of the skull through the foramen magnum. This process is called a brain herniation and is rapidly fatal because it harms the area of the brain that controls respiration and heartbeat. Any difference in pupil size should alert the physician to this possibility and immediate measures must be implemented to prevent the herniation.

Sluggish or non-reactive pupils often indicate the presence of a traumatic brain injury. (Sluggish or non-reactive pupils are not always diagnostic of a TBI since the same effects can be caused by multiple medications.) The physician retracts the patient's eyelids and shines a light into each eye to assess the size of the pupils and the reaction of the pupil to light. Ordinarily, the pupil constricts in the presence of bright light. A failure of the pupils to react, or if they react very slowly, is usually an indication of a TBI.

The overall level of consciousness of the patient is assessed by using a test known as the Glasgow Coma Scale (GCS). This test accesses the patient's ability to open the eyes to command, communication skills, and overall ability to move the extremities on command. A score is assigned to each category based on the patient's responses.

The score on the GCS gives the physician a rough guide as to the patient's level of neurologic function. The test is useful as a screening tool for TBI. The Glasgow Coma Scale is also helpful when given in a serial fashion to allow for detection of improvement or worsening in the patient's condition. Much like the pupillary response, the GCS alerts physicians to the possibility and even the severity of a traumatic brain injury in the patient who has just presented to the emergency room.

The last rapid assessment during the "D" portion of the algorithm is to assess for the general ability to move the extremities. If the patient is spontaneously moving all extremities that is a rough gauge that there isn't any significant spinal cord impairment. A lack of movement, however, is not diagnostic of a spinal injury if the patient is unconscious or otherwise has an altered sensorium.

"E" Is For Exposure

The end of the primary assessment is "E" for exposure. During this last phase, the patient must be undressed and examined from head to toe for any sources of injury. Bruising, punctures, or deformities should be clues to underlying injuries not yet seen. It is essential that the patient's back be examined for trauma. Therefore, the patient is turned using the log-roll maneuver and cervical spine traction. The cervical, thoracic, and lumbar spine areas are inspected for any indication of injury or tenderness, which would alert the physician to the possibility of a spinal fracture. Even the perineal area must be checked. This is the diamond-shaped area of the body between the pubic arch and the anus. *Perineal,* The Free Dictionary, http://medical-dictionary.thefreedictionary.com/perineal. More than one gunshot wound between the gluteal cheeks has been missed because the physician failed to inspect this area.

"E" is also concerned with the environmental status of the patient. Trauma resuscitations generally result in the patient becoming very cold. This is due to a combination of factors such as a cold hospital room, the administration of cold IV fluids, and the patient's clothing being removed. Treatment protocol merely requires the patient to be covered with warm blankets or other similar coverings.

Modern trauma centers also store their intravenous resuscitation fluids in special warmers to prevent lowering of the patient's temperature. A lowered body temperature is undesirable because it can result in vasoconstriction and diminished blood flow to the extremities.

The Primary Survey Is Ongoing

If the patient's condition deteriorates at any point, the physician starts over at the beginning of the ABC algorithm. The doctor looks for any alterations that have occurred and reassess the patient beginning again with "A" and working forward. Just because the patient has been assessed for "B" issues, such as a pneumothorax, and the examination was negative, does not rule out the development of this complication at a later time. For instance, what was once a small hemothorax or pneumothorax that escaped detection may blossom into a massive, life-threatening one at any time. By constantly going back over the "ABC's," the physician continually reassesses the patient for immediate life threats that must be treated.

The Secondary Survey

Once the primary survey is completed and immediate life threats have been identified and stabilized, the secondary survey begins. This is a rapid but much more detailed and thorough examination of the patient. The goal of this survey is to identify as many injuries as possible in order to establish a logical plan for the evaluation and management of these injuries. Cornwell, supra,1609. Unlike the primary survey, this examination proceeds in a more or less head-to-toe fashion instead of following the ABC pattern.

The process starts with an examination of the head for injuries. The skull is inspected for lacerations or facial fractures. The tympanic membranes (eardrums) are checked for signs of blood behind the drum (hemotympanum). The detection of a hemotympanum is a strong indicator of a skull fracture or traumatic brain injury. The orbits are checked for fractures. Extraocular movements are examined for signs of entrapment — a sign of an orbital floor fracture. The nasal cavity is inspected for a septal hematoma. This is a collection of blood under the mucosa overlying the cartilage in the midline of the nose or wall between left and right sides. While not life-threatening, an untreated septal hematoma can result in necrosis of the cartilage leading to a deformity of the nose.

The survey then proceeds down the body to the feet. The chest, rib cage, thoracic, and lumbar spine are checked more thoroughly for injuries such as rib fractures, sternal fractures, or bruising. The abdomen is palpated to check for tenderness. A visual inspection of the thorax and abdomen is carried out to look for signs of seat-belt injury or other pattern injuries consistent with the mechanism of trauma.

The bones and joints of the upper and lower extremities are checked for deformity or injury. The long bones are distracted; this means the physician applies pressure in contrasting directions to check for pain or instability which suggests a fracture. The joints, such as the knee and elbow, are palpated and placed through a range of motion to look for problems. This procedure is performed on the upper and lower extremities as well as over any areas of pain the patient may be experiencing.

Rectal and perineal examinations are performed. The rectum is checked for the presence of blood, which suggests an intra-abdominal injury. The ability of the rectum to maintain tone is also examined because such a loss is evidence of a spinal cord injury. The extremities are checked for pulses, an absence of which suggests a vascular injury in the affected limb such as a crush injury or nerve compression.

The secondary survey is also the point at which limited, initial diagnostic imaging occurs. In severe traumas from a car accident, or when the victim has been injured through a mechanism capable of causing severe injury such as a fall from a height, several plain x-ray films are usually obtained during the initial resuscitation. These films are taken because they don't take very long but yield an enormous amount of information about many life-threatening injuries. The films obtained are a lateral view of the c-spine, an AP chest, and an AP pelvis. ("AP" means anterior to posterior. It signifies that the x-ray beam moves from an anterior to posterior direction through the body before striking the x-ray film plate.)

These x-rays provide a wealth of information about multiple, life-threatening injuries that would otherwise be very difficult to detect on the basis of a physical exam alone. For instance, the lateral c-spine film reveals whether there is an obvious fracture of the crucial upper vertebrae. If a pneumothorax has occurred, air will be visible on the neck or chest films as a dark space. The films also reveal the presence of a hemothorax, rib fractures, or even an injury to the aorta. The pelvis film is critical in detecting a shattered pelvis or a broken femur which can cause a life-threatening hemorrhage with no external evidence of the injury. The imaging studies can also reveal the presence of projectiles or foreign bodies such as bullets or fragments of metal.

CONCLUSION • Trauma refers to a bodily injury resulting from the application of an external physical force. While the word may have a fairly simple and standard definition, when it comes to treatment of trauma patients, there is nothing uniform or standard about it. The insult can be unintentional, such as a car accident, or it can be intentional as in a physical assault. The trauma could be blunt or it could be penetrating.

Regardless of the cause or type of trauma, the ultimate goal of treatment is to minimize the morbidity and mortality associated with the insult. This is accomplished by establishing and implementing a systematic approach toward the trauma patient that allows for rapid assessment and stabilization of the victim. These established protocols allow physicians to evaluate the patient in a logical, algorithmic manner and treat injuries in the order that has the greatest chance to prolong life and minimize long term consequences from the insult.

Specialized trauma units have been created to achieve these goals and to require paramedics to take the most severely injured people to those trauma centers. Today, it is customary to transport accident victims directly to the appropriate level trauma center and not to the most convenient hospital. The treatment of a trauma patient begins the instant the patient is evaluated by any type of emergency medical personnel; from EMS to physician.

The modern approach to the evaluation and treatment of trauma patients is very much an algorithmic one. The assessment consists of an initial primary survey followed by a later secondary survey. The primary survey consists of a rapid initial assessment of the patient coupled with rapid resuscitation. This basic method is a systems approach designed to rapidly identify and treat the immediate threats to life. This secondary approach is a more in-depth examination for less life-threatening injuries.

This type of systematic approach prevents the physician from being distracted by, and focusing on, what may be a gruesome but nonlife-threatening injury at the expense of treating an immediately life-threatening one. These major risks are broken down into the categories of airway, breathing, and circulation. By following the ABC's, the physician proceeds down an algorithm that addresses the problem most likely to kill the patient the quickest. Once this injury is stabilized, then the physician proceeds to look for and treat (if necessary) the next most life-threatening injury and so on.

By understanding this algorithm, attorneys will gain a better appreciation for what is rapidly transpiring in the treatment of trauma patients and have an easier time making sense out of the medical records.