Facilitator Guide  
Module 4: Pediatric Trauma

**Objectives of the module**

Section I - Response to a disaster

- Establish the preparedness needed for the management of patients with trauma in an emergency setting: personnel, equipment, communication, personnel protection, decontamination.
- Emphasize the importance of safety and transportation of the wounded.
- Review the patient classification process according to the severity of the trauma and the available resources.

Section II - Pediatric trauma assessment

- Recognize the distinctive features of the management of the child with trauma.
- Assess children with trauma according to specific priorities.
- Recognize the most common traumatic injuries among children.

Section III - Disaster-specific traumatic injuries

- Establish specific care procedures for victims of fires and burns.
- Emphasize the characteristics of lesions caused by bombs or blasts and its initial treatment.
- Characterize the crush syndrome, its consequences and treatment.
  - Recognize compartment syndrome
- Recognize mass hemorrhage situations and be able to establish initial therapy.

Problem based learning exercise objectives

- Understand how to manage traumatic injuries in mass casualty events.
- Discuss the features and the approach to pediatric patients with:
  - Blast injuries, focusing on head, chest and abdominal trauma
  - Crush lesions
  - Burns
  - Hemorrhaging
  - Basic fracture care
- Review techniques for:
  - Ventilation with bag-valve-mask (BVM)
  - Jaw-thrust maneuver
- Endotracheal tube placement
- Needle thoracostomy (pneumothorax decompression)
- Intraosseous vascular access
- Immobilization and placement of splints.
- Apply a pressure bandage
- Be able to place a tourniquet

• Discuss:
  - Triage and primary and secondary surveys
  - Decontamination
  - Pediatric Glasgow coma scale
  - Identification and treatment of disorders of cardiac rate and rhythm
  - Identification and treatment of crush syndrome
  - Identification and treatment of compartment syndrome
  - Fluid administrations in burn patients
  - Identification and treatment of complications in burn patients (focusing on airway management, electrolyte disorders, and compartment syndrome)
  - Discuss how to approach patients with traumatic hemorrhage
  - Discuss how to assess for a major vasculature extremity injury

**Presentation format**
Skill station (hands-on practice) in which students will practice decision-making, techniques and skills related to the station objectives, in simulated clinical cases with manikins and/or volunteers.

**Duration**
Two hours divided in 4 simultaneous work stations, of 25 minutes each, with a maximum of 5 minutes for reviewing questions and rotating to the next station:
  • 5 minutes for case presentation and team organization
  • 20 minutes for interactive discussion and practice

**Material**
• Practice areas that allow the distribution of participants in 4 groups of 8 to 10 maximum
• Scenario/clinical case(s) for each facilitator
• 1 lubricant for intubation head
• *Burn station*
- Working table or stretcher
- Manikin/made-up actor
- Bag-valve-mask (BVM) with adequate size for manikin or actor
- Intubation head
- Laryngoscope with straight blade number 0 and extra batteries
- Endotracheal tubes 2.5 or 3.0
- Suction catheter
- Kit for vascular access simulation and solutions
- Burn surface area estimation chart

• **Trauma station (blast)**
  - Working table or stretcher
  - Manikin/made-up actor
  - Bag-valve-mask with adequate size for manikin or actor
  - Intubation head
  - Laryngoscope with straight blade number 0 and extra batteries (1 per 2 students)
  - Endotracheal tubes 2.5 or 3.0 (1 per 2 students)
  - Suction catheter
  - Kit for vascular access simulation and solutions; kit for intraosseous access (needle)
  - Immobilization backboard
  - Cervical collar
  - Equipment to simulate mini-seal and water seal
  - Labeled syringes to simulate medication (lidocaine, sedatives, relaxation agents, etc.)
  - Needle thoracentesis: 14-20 ga catheter needle, 3-way stopcock, syringe (20-50ml)

• **Crush station (simple fracture care can be included)**
  - Working table or stretcher
  - Manikin/made-up actor
  - Bag-valve-mask with adequate size for manikin or actor
  - Intubation head
  - Laryngoscope with straight blade number 0 and extra batteries
  - Endotracheal tubes 2.5 or 3.0
  - Suction catheter
- Kit for vascular access simulation and solutions; kit for intraosseous access (needle)
- Monitor and rhythm simulator or cards with cardiac rhythms (hyperkalemia in different stages up to ventricular tachycardia)
- Immobilization backboard
- Cervical collar
- Labeled syringes to simulate medication (insulin, bicarbonate, calcium)
- Equipment to simulate immobilization (bandages, splints, plaster, cotton padding for Jones bandages, tape)

- Hemorrhage trauma station
  - Working table or stretcher
  - Manikin / made-up actor
  - Tourniquets
  - Kit for vascular access simulation and solutions; kit for intraosseous access (needle)
  - BP cuffs x2 to calculate ABI (ankle brachial index) and API (arterial pressure index)
  - Pressure dressing materials: packing gauze and wrap gauze
  - If available, hemostatic gauze
  - Consider using a prop, such as a chicken or beef part, place a deep cut into the tissue, for participants to practice wound packing and pressure bandage placement. You may also choose to simulate active hemorrhage by placing tubing into this simulated wound with red colored fluid bumped into the wound site.

Notes for the instructor
1) Emphasize primary (ABC) and secondary (ABCDE) surveys.
2) The goal is hands-on teaching based on the development of the case, with progressive complications in the clinical condition.
3) Ensure that the students rotate so that all can participate in the solution of hypothetic situations and in the practice of techniques and skills.

Station 1: Blast injury
A 2 year old is brought in by ambulance from political convention in which a bomb went off in an enclosed building. The patient was found moaning on the ground in respiratory distress with a large parietal scalp hematoma and bloody fluid draining from
the right ear canal. The patient is immobilized on a backboard with a non-rebreather mask 100% oxygen mask.

Key teaching points: Blast injuries

• Patients who are close to an explosion will suffer from significant blast injuries due to the expansive wave. The associated over-pressurization can result in blast lung, as well as people being thrown in the air, causing traumatic brain injury (TBI). Blast lung commonly causes pulmonary contusion, as well as pneumothorax. The TBI associated with blast mechanism is commonly intracranial bleeding, such as a subdural hemorrhage. Administration of positive pressure ventilation can lead to pneumothorax or cause an arterial air emboli after a blast injury (air emboli can seed the heart or brain leading to either stroke or sudden death). Use the minimal amount of positive pressure needed.

• Identify severe TBI and its management: Ask the participants to assess the Glasgow Coma Scale (GCS). Severe TBI results in a Glasgow Coma Scale (GCS) of 8 or below, and may be associated to evident physical signs of head injury (skull deformity, seizures, unequal pupils, focal neurologic deficits). Cushing triad consists of bradycardia, hypertension, and irregular respiration, and implies impending brain herniation. Once the primary brain injury has occurred, medical management of severe TBI focuses on prevention of secondary injury. This includes maintaining adequate oxygen delivery and adequate ventilation. PCO2 should only be mildly decreased 30-35 mm Hg. Lower PCO2 can cause reactive vasoconstriction and reduce cerebral blood flow, with the resulting tissue ischemia. Establishing an airway with RSI intubation is recommended for both her low GCS of 7 and for the presumed pulmonary contusion due to her blast exposure and rapid breathing. In addition to oxygenation and ventilation, avoiding hypotension is a significant management goal. Since cerebral perfusion pressure is defined as the difference between the mean blood pressure and the intracerebral pressure; therefore maintaining appropriate cerebral perfusion requires an adequate arterial pressure. Once intravascular volume resuscitation has occurred, vasopressors should be administered to normovolemic hypotensive patients. Other management options include hyperosmolar therapy with mannitol 0.5-1 gram/kg or hypertonic saline, elevation of the head of the bed to 30 degrees, increased sedation or barbiturate coma. Hypothermia is not recommended. Anticonvulsants may be needed if seizure activity occurs. Currently there is limited data on the utility of prophylactic anticonvulsant medications in the setting of pediatric head injury.
1) What initial information do you need?
Response:
• Current vital signs: Pulse: 180 bpm, respiratory rate: 50 rpm, blood pressure: 60/40 mm/Hg, temperature: 36.5°C.

Primary survey:
• Airway: patent, moderate secretions in mouth.
• Breathing: respiratory distress, moderate retractions, decreased breath sounds on the left.
• Circulation: pale, delayed capillary refill: 3-4 seconds.
• Disability: altered mental status (only responds with groans to painful stimuli), flexion of extremities with stimulation, pupils 5 mm equal, with sluggish response to light. (Students should estimate with these data a GCS of 7).
• Monitors show a pulse oximetry of 75%.

2) What is your initial assessment of this patient?
Response:
This patient suffered a blast injury and presents with altered mental status, respiratory distress and shock.

3) What interventions are needed at this time?
Response:
Airway
• Clear oral secretions with suctioning and prepare for rapid sequence intubation.
• Place cervical collar or maintain cervical spine in-line immobilization.

Breathing:
• BMV with 100% oxygen using cricoid pressure until intubated.
• Needle thoracostomy on the side with decreased breath sounds, will need chest tube eventually.
• Mild hyperventilation to keep the PCO2 30-35 mm Hg only if signs of increase ICP.

Circulation
• Attempt intravenous access, if unable to obtain in 60 seconds then proceed to intraosseous (IO) access.
• Isotonic fluids 20 cc/kg bolus (normal saline or Ringer lactate), and then as needed to maintain adequate blood pressure and cerebral perfusion.
• Monitor blood pressure and pulse.
• Obtain hematocrit and transfuse emergently O negative blood if needed after initial isotonic fluids.
Disability
• Intubate using lidocaine to protect spike in the ICP.
• Hyperventilate as above.
• Mannitol for signs of increased intracranial pressure (0.5-1 gram/kg IV).
• Obtain head CT when stable.
• Neurosurgical consultation as available.

4) What complications may this patient develop?
Response:
• Vomiting, particularly if no cricoid pressure is done, with potential for aspiration.
• Unable to visualize the vocal cords when intubating when the secretions are not properly suctioned, as well as not utilizing the proper jaw-thrust technique. May have to remove the cervical collar and maintain manual in-line cervical immobilization while intubating.
• Failure to ventilate due to pulmonary contusion and lack of adequate PEEP (positive end expiratory pressure).
• Perfusion inadequate despite 40 ml/kg isotonic solution infusion. Packed RBC’s or colloid administration is recommended. If continued inadequate perfusion then there is a need for pressor pharmacological support (i.e. Dopamine).
• If seizure occurs, may need anticonvulsant therapy.

Case progression:
After the initial management, current vital signs are: Pulse: 70 bpm, blood pressure: 130/80 mm/Hg, respiratory rate: bagged at 40 times per minute with a PEEP of 6. Pulse oximetry now is 92%, breathing oxygen 100%. Physical exam reveals a sedated patient; right pupil 5mm non-reactive, with lateral deviation, and left pupil 2 mm and reactive.

5) What is the current status of the patient?
Response:
• The patient is showing signs of Cushing triad and cerebral herniation, i.e. bradycardia and hypertension, with unequal pupils. Asymmetric pupils imply uncal herniation and impingement of the third cranial nerve.

6) What additional interventions can be performed?
Response:
• Check PCO2 to see if mild hyperventilation is adequate.
• Ensure adequate sedation.
• Repeat the mannitol.
• Head of bed elevated 30 degrees.
• Needs emergent neurosurgical intervention, such as drainage of large intracranial hemorrhage, ICP monitoring, etc.

Station 2: Crush Injury
You are working in a front-line clinic/ emergency room after a recent earthquake that leads to a collapsed building. You are overwhelmed with patients and have two portable ventilators, a portable x-ray machine, and limited lab capabilities that include an EKG, urine dipstick, and a centrifuge to determine a hematocrit. A moaning 6 yo child arrives on a stretcher wearing an oxygen mask. You are told she was found trapped under a cement staircase with her chest partially exposed. The time since the earthquake is 30 hours. You notice that she has shallow respirations, and diminished breath sounds of the right chest. Pulse oximetry reveals a room air O2 saturation of 90%, her RR is 26 breaths per minute, and heart rate is 120 beats per minute. You also notice swelling of her right leg to the mid-thigh with obvious tissue maceration. She is unable to move her right thigh, but can wiggle her toes. Her pulses still remain strong centrally and peripherally in both extremities. Her abdomen is soft and non-distended and she cooperates with your exam. She appears very fatigued and at times does not respond to questions. An IV was placed prior to extraction with an initial 20cc/kg bolus of IV lactated ringers. A foley catheter is placed with noted dark urinary output.

Key teaching points
• Causes of shock in trauma injuries; pulmonary contusion, crush injuries, fracture care.
• Hidden blood loss can occur in the abdomen, pelvis or retroperitoneum. Spinal shock can also occur when the spinal cord is injured and there is loss of sympathetic tone. These patients usually present with hypotension and paradoxical bradycardia. Treatment is the same for all these conditions.
• Review the potential complications that may occur from a crush injury, particularly when extraction is delayed: highly severe hypovolemic shock, hyperkalemia, hypokalemia, metabolic acidosis and acute myoglobinuric renal failure. Also, compartment syndrome can occur. Compartment syndrome occurs when there is an increase in intracompartment pressure. This can lead to ischemia, with eventual muscle necrosis and nerve palsies/damage. The anterior compartment of lower leg is the most common site as it includes 4 susceptible compartments in a commonly injured region. In the physical exam, look for pain, especially with passive extension. Other
findings include lack of pulse, paresthesia, pallor, and paralysis/paresis. Elevated intracompartmental pressures may be confirmed by direct measurement of the intracompartment pressure.

- Discuss the need for splinting fractures to prevent continued soft tissue, neurologic and vascular injury, decrease bleeding and control pain. Unless trained in fracture management, avoid trying to manipulate or reduce fractures. This may be unavoidable if the extremity is in a position that makes splinting impossible. Move fractured extremities with care due to potentially increase neurovascular injury.
- Be familiar with the various methods for splinting and stabilizing fractures. Discuss the methods used to place long arm/leg, sugar tong, volar, thumb spica and ulnar gutter splints. Be sure to splint one joint above and one joint below the injury. When wrapping the splint allow for monitoring of neurovascular status.
- Splinting material can be metal, plaster, fiberglass or, if far from a medical facility, any other stiff object. Ties or wraps can be made from any cloth or tape to secure the injured extremity.
- Discuss fractures and injured extremities monitoring. Review the risk factors for compartment syndrome: long bone injury, high energy trauma, penetrating injuries (which may cause arterial injuries), venous injuries (palpable pulses may give a false sense of adequate perfusion), crush injuries and burn injuries. Monitor for the 6 P’s: 6Ps – lack of pulse, pallor, poikilothermia, pain (extreme), paresthesias, and paresis. Emphasize that compartment syndrome can exist even in the absence of these signs.

1) What additional initial information would you want?

Response:
- When receiving this patient obtain information on any treatment given already including fluids and pain medications. If there is family present obtaining a quick brief medical information can be useful. This may include allergies, medications, past medical/surgical history, last meal, Environment surrounding the injury.
- Current vital signs: Pulse: 120 bpm, respiratory rate: 26, blood pressure: 80/45 mm/Hg, temperature: 38.5 ºC.

2) What is your initial assessment of this patient?

Response:
- Airway: patent moving air freely, stable
- Breathing: diminished breath sounds on right with rales, symmetric chest wall movement and oxygen saturation low on oxygen (90%), trachea midline
- Circulation: heart rate elevated at 120 but strong peripheral pulses
• **Disability:** sleepy, opens eyes to speech, responds to vocal stimuli appropriately, GCS = 14
• **Exposure:** when clothes removed you notice a swollen right thigh (unable to move) and an obvious deformity of the left forearm

3) **What is your initial workup of this patient?**
   Response:
   - CXR reveals a diffuse hazy appearance of the right lung.
   - EKG reveals normal sinus rhythm with no signs of ST segment elevations/depressions
   - Compartment pressures of the right thigh is 15 (pressures >30mm Hg usually require surgical decompression). Oftentimes, you will not have the resources to measure compartment pressures, therefore you will need to make a clinical assessment of his risk for compartment syndrome based on pain/paresthesias/pallor/paralysis/pulselessness.
   - This patient is most at risk for impending respiratory failure. She has two severe injuries, namely pulmonary contusion and CRUSH INJURY, which has not yet progressed to CRUSH SYNDROME.

4) **What interventions are needed at this time? Prioritize them.**
   Response:
   - **Airway/Breathing:** Your patient is in impending respiratory failure both due to splinting/increased dead space ventilation and pulmonary contusions.
     - Position the airway.
     - 100% oxygen with a non-rebreather mask
     - If continues with respiratory distress consider PPV or consider Intubation if able to transport to a more stable environment where longer-term ventilation is possible.
   - **Circulation:** Your patient has signs of decreased cerebral perfusion, seen by her waxing/waning mental status. Her perfusion remains good, and her blood pressure is still adequate, but you are concerned about decreased intravascular volume.
     - Obtain additional access: one IV is in place but patient is in shock and additional access is recommended. Ongoing fluid support is needed. Start a second bolus of isotonic fluids 20 ml/kg bolus (normal saline or Ringer lactate), and eventually a third bolus as needed to correct the shock and to flush myoglobin out of the kidney caused by the crush injury. Plan to run a solution of D5 1/2NS with 40meq bicarb at 20ml/kg/hour to ensure urine output at least 2ml/kg/hour. If urine output drops off, give mannitol
   - **Disability/Secondary Survey:** Your patient has crush injury of the right leg that is evolving into crush syndrome - shock and signs of acidosis and oliguria/acute renal failure (ARF). She does not have any EKG changes to suggest hyperkalemia and impending arrhythmia/arrest. She does have significant limb
swelling and dyskinesia, but does not have any signs of compartment syndrome - pain, pallor, paralysis, paresthesias, and pulselessness or compartment pressure >30, which would indicate the need for fasciotomy.

- Your priority should be to optimize the circulating blood volume and promote diuresis to prevent renal failure.
- Infuse 0.9 % NaCl r +40meqNaHCO3/L at 20ml/kg/hour. If urine output <2cc/kg/hr and patient is hemodynamically stable, consider giving mannitol to increase the elimination of myoglobin by the kidney. Alkalination of fluids avoids precipitation of toxic myoglobin metabolites in nephrons, improves acidosis, and limits hyperkalemia.

**Scenario continued:**

*Fluid support is continued and vital signs are showing some improvement. Pulse 165 bpm, blood pressure 90/50 mm/Hg, respiration rate 35 rpm. Then, the patient suddenly deteriorates; becomes increasingly pale, with diminished peripheral pulses, heart rate > 190 bpm, and decreased blood pressure. Cardiac monitoring shows a wide complex tachydysrrythmia.*

Facilitator note: you can show the ECG (included in the appendix) of ventricular tachycardia secondary to hyperkalemia

5) **What may be causing this clinical picture?**
   
   Response:
   - Shock
   - Cardiac rhythm disorders
   - Chest complications (cardiac or pulmonary contusion, tension pneumothorax, pericardial tamponade)
   - Choose ventricular tachydysrrythmia if a rhythm simulator is available; if not, show the image once requested.

6) **What is the current status of the patient?**

   Response:
   - The patient has ventricular tachycardia with pulse.

7) **What additional interventions can be performed?**

   Response:
   - Treat ventricular tachycardia according PALS guidelines (if stable, lidocaine; if in shock with a pulse, then ventricular cardioversion; if without a pulse treat as ventricular fibrillation and defibrillate)
   - Suspect and treat hyperkalemia: look for peaked T-waves, and widening of the QRS complex on the electrocardiogram (ECG). Symptomatic hyperkalemia or hyperkalemia with ECG changes should be treated with calcium chloride 10% (0.2ml/kg IV) or calcium gluconate 10% (0.5-1ml/kg IV). This will stabilize the cell membrane. In addition, shifting of potassium into the intracellular space will
occur with: 1) alkalinization (sodium bicarbonate 1mEq/kg IV); 2) glucose (0.5-1g/kg D25W) plus insulin (0.1units/kg IV); 3) albuterol nebulization. Kayexalate (sodium polystyrene sulfonate) at (1 gm/kg PO/PR), will help to clear potassium suppressing intestinal reabsorption.

Case progression 2:
You restore a normal cardiac rhythm. Your patient has not urinated in response to fluid bolus. Your patient complains of extreme pain in his right leg. You notice increasing limb swelling. The limb appears warm and pink, pulses are strong, however, you are concerned about the limb swelling.

8) What may be causing the clinical picture?
Response:
• Compartment Syndrome-hyperkalemia and limb pain are indicative of this
• Potential renal failure

9) What should you do to evaluate the limb?
Response:
• Surgical consult or measure limb pressures with stryker. Discuss the need to be able to make a clinical determination of need for fasciotomy based on pain/paresthesias/pallor/paralysis/pulselessness. All these features may not be present.
• If limb pressures exceed >30, perfusion is compromised. This is an indication for fasciotomy.

10) What do you want to do to evaluate the reason for decreased urine output? Are there any interventions you want to implement?
Response:
  a. Check serum creatinine, set of electrolytes. K is still elevated at 6.5.
  b. Either give fluid bolus challenge or mannitol to promote diuresis.
  c. Alkalinize fluids to avoid precipitation of myoglobin in nephrons: Start NS or LR, add bicarbonate if able (40meq/l) and run at 20cc/kg/hour with goal urine output >2cc/kg/hr.

11) What should be the disposition of this patient?
Response:
• Your patient should be transferred whenever possible to a hospital capable of managing this critical patient, continue monitoring for renal failure (BUN, Cr, and
K if possible), and closely follow the need for fasciotomy/broad spectrum antibiotics, and even dialysis.

Station 3: Hemorrhage

You are the doctor in charge when you receive news of a violent attack in a local village including both gunshot and knife wound injuries. Your first patient is an 8 year old boy who arrives with a large knife laceration of the right thigh and a gunshot wound to the abdomen. He is awake but appears pale, sweaty, with rapid and weak pulses. Bleeding is active from the right thigh injury.

Key teaching points

- Violence is common and can lead to trauma with significant hemorrhage. Being able to stabilize a patient with active bleeding, being able to identify occult hemorrhage and identify when a major vascular injury has occurred is important. Hemorrhagic shock 15-20 % blood volume may initially only be noted to have mild tachycardia. When 30-40% blood volume loss occurs then the tachycardia becomes more significant and hypotension is noted. CNS changes are also noted at that level with anxiety, confusion and then lethargy. If shock is present then initiate treatment by giving 20ml/kg of crystalloid, if no response then give another 20ml/kg of crystalloid or 10ml/kg of packed red blood cells. If still no response to this resuscitation then the patient will likely need operative intervention. A useful guide to resuscitation effectiveness is the improvement of the vital signs as well as adequate urine output (1ml/kg/hr).

- Controlling active bleeding can be achieved with direct pressure, pressure bandage or use of hemostatic agents. If bleeding continues despite these efforts then a major vascular injury is suggested and the use of a tourniquet can be life and limb saving procedure. Proper technique in hemorrhage control and tourniquet use should be emphasized.

- Penetrating trauma is more common in adults then in pediatric patients but this type of trauma is increasing overall. In general, complications of penetrating extremity wounds include retained foreign bodies (such as bullet fragments), development of infection, bone fractures and damage to nerves, blood vessels or tendons. Vascular injuries are considered the most critical. Timely diagnosis and treatment (usually less then 6-12 hours) will prevent ischemic injury. After stabilization, a careful inspection of the extremity is needed to look for evidence of vascular injury. Suggestive findings include: bleeding (pulsatile and/or bright red suggests arterial, non-pulsatile or darker
red suggests venous), expanding hematoma, absent pulses, active hemorrhage and signs of distal ischemia (including cyanosis and a cold extremity). Further evaluation of a possible vascular injury may include the determination of the ankle brachial index (ABI) – a ratio comparing the BP on the same side of the body; or the arterial pressure index (API) – a ratio comparing the BP of adjacent limbs i.e. either arms or legs. In either ABI or API, a value < 0.9 is suggestive of a vascular injury. Using clinical findings and these indices are simple fast ways to determine a vascular injury without the need for angiography etc.

1) What initial information do you need?

Response:

Current vital signs:
- Pulse: 160 bpm, respiratory rate: 25 rpm, blood pressure 78/45 mm/Hg, temperature: 37.5°C.

Primary Survey:
- Airway: Anxiously speaking without difficulty.
- Breathing: Breath sounds are clear and equal bilaterally.
- Circulation: Uninjured extremities have palpable pulses and are warm.
- Disability: GCS 15

Gunshot wound noted to the abdomen just to right of the umbilicus, no exit wound noted. There is also an obviously injured right lower extremity. Right thigh has a 10cm laceration to the thigh with active pulsatile bright red bleeding.

2) What is your initial assessment of this patient?

Response:

- The patient is in hemorrhagic shock. He has both a penetrating torso injury and a large laceration with active bleeding (likely arterial).

3) What is your approach for this patient?

Response:

- Hemorrhage control should start with wound packing and direct pressure. Once hemorrhage is controlled, a pressure bandage should be applied to the large laceration to replace manual pressure (review technique pressure bandage application).
- Obtain intravenous or IO access for administration of IVF’s, analgesia.
- Carefully monitor response to IVF’s (using vital and physical signs) and use O negative blood or PRBC’s as needed.
- When hemodynamically stable reassess the lower extremity for vascular injury.
Scenario continued:

After pressure bandage application and the initiation of intravenous fluids, the patient’s pulse is 150, BP 80/40. He is moaning and will follow commands. There is ongoing bleeding from the leg laceration that is bright red around the gauze.

4) What is your assessment now?
   Response:
   • This patient is in ongoing hemorrhagic shock although he is slightly improved with interventions. He is at risk for progressive hemorrhagic shock if further treatment is not performed.

5) What is your treatment plan now for this patient?
   Response:
   • Additional efforts at hemorrhage control are needed. Additional fluid and blood products can be used to support this patient.
   • Application of tourniquet just proximal to the active bleeding should occur.
   • Review technique.

6) How do you determine if there is a vascular injury?
   Response:
   • Clinical signs include expanding hematoma, pulsatile bleeding, lack of distal pulse, and calculation of ABI or API ratio (less than 0.9 = likely vascular injury). Review technique for ABI or API calculation (ABI: compare ankle brachial blood pressures on same side of the body; API: compare blood pressures of both arms or both legs dependent on location of injury). What are the options if no vascular surgeon is available? (inter-hospital transfer, additional pressure/ tourniquet. There is potential for loss of limb if ischemia is not reversed).

Scenario continued:

You are able to stop the bleeding with a tourniquet. The vitals after 40ml/kg of crystalloids and 10ml/kg of PRBCs shows a HR of 140, BP of 92/34. He now also complains of increasing abdominal pain and has a firm and extremely painful abdomen.

7) What is the current status of the patient?
   Response:
   • Improvement in vital signs but still wide pulse pressure and tachycardia suggestive of compensated shock.
8) What additional injuries are you concerned about?
Response:
• Visible bleeding source (extremity) is now controlled, attention should focus on the silent bleeding occurring in the torso.

9) What interventions should be implemented?
Response:
• Treatment for ongoing hemorrhage should include blood products after crystalloids. This can initially be red blood cells. After 50% of estimated total blood loss, this patient will be at risk for coagulopathy. If available, in addition to packed red blood cells, the patient should also receive platelets and fresh frozen plasma. Receiving these 3 products in a trauma resuscitation is referred to as a “massive transfusion protocol” in the USA.

10) What management will this patient require?
Response:
• Most penetrating torso trauma will eventually need surgical management. Surgical treatment should be arranged. Until surgical exploration and repair occurs, plans for ongoing hemodynamic and blood product support need to be arranged. Continual reassessment of patients’ vitals and close observation for evidence of end organ perfusion (by physical exam and/or laboratory tests) will help guide therapy as bleeding may continue without being visible.

Station 4: Burns
A mother and her 5yo child were trapped in a house fire from the cooking stove. The mother has severe burns from pulling her child out, was separated from the child and is being seen by an adult emergency team. You are seeing the 5 year old male who has facial burns, nasal soot, and blisters to the back and both legs. He is awake and crying out both in pain and for his mother.

Key teaching points
Burns:
• Review the need for early airway intervention and the signs of inhalational injury (stridor, soot around the mouth or nose, singed facial hair, burns on the face and neck, and decreased mental status). Re-emphasize the risk for airway complications in burn patients, and the need for back-up methods and for compulsive monitoring of endotracheal tube placement.
• Review the estimation of total body surface area burned by the 3 methods (Lund-Browder chart, Rule of Nines, and Palmar estimation) and the methods to calculate fluid resuscitation. Discuss the option of oral rehydration if intravenous rehydration is not a possibility. Early fluid resuscitation is a key element in decreasing the morbidity and mortality of burn patients.

• Discuss the use of intravenous and inhaled beta-agonists, epinephrine and intravenous steroids for airway reactivity.

• Review the indications for escharotomy and the instructions for performing the procedure at bedside referring to the chart as a guide for the location of incisions.

• Discuss wound care. Initial management should include removing all clothing and jewelry, debriding loose tissue and covering the burns with either bacitracin or neosporin, and dressing with loose, clean gauze. Emphasize the importance of early surgical intervention for full thickness burns, and of tetanus prophylaxis. Treat for streptococcus infection if detected in the pharynx.

• Discuss the different interventions for electrical burns. The patient should be carefully removed from the electric current source. Like for thermal burns the injury would also require continuous electrocardiographic monitoring and close monitoring of electrolytes, as well as a high index of suspicion for internal injuries due to the electrical current passing through the body.

• Discuss the different interventions for chemical burns. The patient requires extensive decontamination and the wounds should be irrigated with several liters of isotonic saline. This type of injury requires careful monitoring of electrolytes. In addition, if the mouth is involved, consider aspiration pneumonitis, gastrointestinal injury, and difficult airway situations.

• Discuss the emotional support needed by this child. Is there another family member or staff member that can help provide this emotional support. If not, use volunteers or additional staff members and provide distraction for the child during what will be uncomfortable medical care and stress.

1) What initial information do you need?

Response:

Current vital signs: Pulse: 160 bpm, respiratory rate 42 rpm, blood pressure: 70/52 mm/Hg, temperature: 36.4° C, weight: 20 kilograms.

Primary survey:

• Airway: moderate stridor, but freely moving air.
• Breathing: breath sounds equal on both sides, but with shallow breath movements due to chest burns.
• Circulation: capillary refill 3-4 seconds, all 4 extremities warm distally.
• Disability: crying, mildly confused, GCS 14.

2) What are the immediate interventions for this patient?

Airway:
• Place cervical collar or maintain in-line cervical spine immobilization.
• Rapid sequence intubation, due to moderate stridor and extent of burns.
• 5 year-old child normally needs a 4-4.5 uncuffed endotracheal tube.
• Have 2.5, 3, 3.5 uncuffed endotracheal tubes as well as a laryngeal mask airway and a cricothyrotomy kit available in the event of extensive upper airway edema.

Breathing:
• 100% FIO2 with the idea that her confusion may be due to carbon monoxide exposure because of prolonged time in an enclosed burning room.

Circulation:
• Two large bore peripheral intravenous catheters placed.
• Placement of catheters through burned tissue is suboptimal but often necessary to begin resuscitation.
• Continuous reassessment of blood pressure and pulse.

Disability:
• Remove all clothing.
• Warm patient with warm blankets, heat lamps and prepare fluid warmer if available.
• Continue to monitor temperature.
• Use either Lund-Browder chart, the Rule of Nines or Palmar estimation to calculate the percentage of total body surface area burned.
• After calculation, the child had 40% total body surface area burns.
• Use warmed Ringer’s lactate 2-4ml/k/%burn/24hours (half in the first 8 hours).
• 1600 ml over the first 24 hours, 800 ml over the first 8 hours, 100 ml/hour.
• Attention to pain management and sedation.

Scenario continued:
Fluid resuscitation is continued and the systolic pressure is now 104 mm/Hg, with a pulse of 120 bpm and a RR of 35. The patient develops a prolonged expiratory phase, wheezing and increasing cough.
3) **What is the current status of the patient?**

   Response:
   • She has developed reactive airways from inhalation of small particles.

4) **What additional interventions can be performed?**

   Response:
   • In-line beta agonists, intravenous beta-agonists, low dose intravenous epinephrine and intravenous steroids.
   • Albuterol appears to improve her wheezing but you notice that she has very high peak airway pressures and minimal chest rise with the ventilator breaths. On further examination, you note that her chest burns are almost completely circumferential, as the burns in her right arm. As you examine her right arm, you note that despite elevating the extremity, her fingers are cool and cyanotic with increased capillary refill time, and poor radial pulse.

5) **What is the current status of the patient now?**

   Response:
   • She has now developed compartment syndrome of her right arm, and chest constriction, and now requires escharotomies to allow her to continue to ventilate and to improve the perfusion to her right arm.
   • Using the escharotomy site chart as a guide, you use coagulative electrocautery to make linear incisions through the eschar and cutaneous tissues of the right arm and chest.
   • The patient is now stable from a cardiopulmonary standpoint and you may now perform the secondary survey, and dress and clean her wounds.

6) **What should you do?**

   Response:
   • Incise and debride loose tissue, rinsing with saline. Dress with bacitracin ointment. All full thickness burns should be addressed by a surgeon and prepared for excision as soon as possible. Pain control is paramount. Tetanus prophylaxis should be administered.
Auxiliary material:

ECG: Hyperkalemia induced ventricular tachycardia

ECG changes based on degree of hyperkalemia

<table>
<thead>
<tr>
<th>Serum Potassium</th>
<th>Typical ECG Appearance</th>
<th>Possible ECG Abnormalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild (5.5-6.5 mEq/L)</td>
<td><img src="image" alt="Mild ECG" /></td>
<td>Peak T waves, Prolonged PR segment</td>
</tr>
<tr>
<td>Moderate (6.5-8.0 mEq/L)</td>
<td><img src="image" alt="Moderate ECG" /></td>
<td>Loss of P wave, Prolonged QRS complex, ST-segment elevation, Ectopic beats and escape rhythms</td>
</tr>
<tr>
<td>Severe (&gt;8.0 mEq/L)</td>
<td><img src="image" alt="Severe ECG" /></td>
<td>Progressive widening of QRS complex, Sinus wave, Ventricular fibrillation, Axis deviations, Bundle branch blocks, Fascicular blocks</td>
</tr>
</tbody>
</table>
CARVAJAL-GALVESTON FORMULA

- **First 24 hours:**
  
  \[ 5,000 \text{ mL} \times \text{BBSA (m2)}^* + 2,000 \text{ mL} \times \text{TBSA (m2)}^{**} \]
  
  - Ringer’s lactate (half in the first 8 hours and the rest in the following 16 hours) No colloid should be given.

- **Second 24 hours:**
  
  \[ 3,750 \text{ mL} \times \text{BBSA (m2)} + 1,500 \text{ mL} \times \text{TBSA (m2)} \] of dextrose solutions with electrolytes
  
  (based on patient’s electrolytic anomalies)

* BBSA (burned body surface area): Formula: TBSA × %/100
**TBSA (total body surface area): Formula: (W (kg) × H (cm))/3600

Notes:
- Colloids are recommended at least 12-24 hours after the burn, using albumin poor in salt 1 g/kg/day divided in 3 doses (this aims at maintaining albumin levels above 2.4 g/dL).
- If the patient develops myoglobinuria or hemoglobinuria (electrical burns, for example), take the following steps:
  - Increase fluids administered to achieve a urine output of 3-5 ml/kg/hour
  - Add bicarbonate to solutions
  - If urine output does not improve, add mannitol to therapy
FIGURE 6. JumpSTART

- Able to walk? YES
  - MILD
  - SECONDARY TRIAGE*

- Is he/she breathing? NO
  - AIRWAY POSITIONING
  - APNEIC
  - PALPABLE PULSE
  - YES
  - 5 ASSISTED RESPIRATIONS
  - APNEIC
  - DEAD

- Respiratory rate
  - 15 to 45
  - No
  - IMMEDIATE

- Palpable pulse
  - IMMEDIATE

- AVPN**
  - “D” (INADEQUATE)
  - DECELERATED or
  - DECORTICATED POSTURE or “N”
  - IMMEDIATE
  - “A”, “V” or “D” (ADEQUATE)
  - DELAYED

* Evaluate infants first through secondary triage using JumpSTART algorithm

** A: alert; P: voice responsive; V: pain responsive; N: non-responsive