

# ATLS Algorithms

## First Things First (assess & treat for the following)

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- Trauma is a consequence of harmful behavior that is planned or unplanned. Injury prevention starts with addressing these behaviors.
- Goals of trauma patient management
  - Identify and treat threats to life, then limb, and then eyesight.
  - Prevent exacerbation of existing injuries or occurrence of additional injuries.
  - Return patient to a level of function as close to pre-injury as possible.
- Outcomes for trauma patients are improved with a systematic, multispecialty, and interdisciplinary approach to pre-hospital, hospital, and rehabilitative care.
- Principles of trauma patient management
  - Treat the greatest threat to life first.
  - Definitive diagnosis is not immediately important.
  - Time matters (“golden hour” emphasizes urgency).
  - Do no further harm.
  - Assess, intervene, reassess
    - Did the intervention work?
    - Is the patient’s physiology returning to or staying normal?
- Preparation
  - Training by discipline and as a team
  - Capabilities defined by established and integrated pre-hospital and hospital care protocols
  - Equipment maintained and ready for rapid use
  - Appropriate supplies available
  - Universal precautions enforced
  - Referral resources and transfer policies clearly defined
- Field triage to a trauma center in four steps (from the Centers for Disease Control & Prevention expert panel with support from the National Highway Traffic Safety Administration, 2006)
  - Assess basic physiology.
    - Systolic blood pressure < 90
    - Respiratory rate < 10 or >29
    - Glasgow Coma Scale < 14

- Assess anatomy of injury.
  - Penetrating injury to head, neck, torso, and extremities proximal to elbow and knee
  - Flail chest
  - >1 proximal long bone fracture
  - Crushed, degloved, or mangled extremity
  - Amputation proximal to wrist and ankle
  - Pelvic fractures
  - Open or depressed skull fracture
  - Paralysis
- Assess mechanism of injury and evidence of high-energy impact.
  - Falls >20 feet (6 meters) in adults and >10 feet (3 meters) or 2-3 times height in children
  - High-risk auto crash
    - Intrusion >12 inches occupant site or 18 inches any site
    - Ejection (partial or complete) from vehicle
    - Death in same passenger compartment
    - Vehicle telemetry data consistent with high risk of injury
  - Auto vs. pedestrian/bicyclist thrown, run over, or with significant (>20 mph) impact
- Assess special patient or system considerations.
  - Age: older adults and children
  - Anticoagulation and bleeding disorders
  - Burns
  - Time-sensitive extremity injury (open fractures, vascular compromise)
  - End-stage renal disease requiring dialysis
  - Pregnancy >20 weeks
  - EMS provider judgment
- Initial assessment
  - Primary survey
  - Resuscitation
  - Adjuncts to primary survey
  - Secondary survey
  - Adjuncts to secondary survey
  - Ongoing post-resuscitation monitoring & reevaluation
  - Definitive care

- o Tertiary survey

## History & Physical (assess for the following)

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- Reordered in trauma to address first life-threatening physiology and then to identify and correct the anatomic injuries
- These guidelines are adapted from the American College of Surgeons Advanced Trauma Life Support® program.
- Primary survey and resuscitation: life-threatening conditions are identified rapidly & managed in sequence by priority

### A team can manage priorities in parallel.

- Brief history: age, gender, mechanism of injury (what led to the injury)
- Airway with cervical spine control
  - o Upper airway (above vocal cords) managed adjunctively with chin lift/jaw thrust, suctioning, oral airway, nasopharyngeal airway, and laryngeal mask airway. The most common cause of airway obstruction in the unconscious patient is the tongue.
  - o Lower airway managed definitively with a cuffed tube in the trachea (orotracheal intubation, nasotracheal intubation, or surgical airway—cricothyrotomy)
  - o Assume cervical spine injury in patients sustaining any blunt injury or penetrating injury above the chest.
  - o Intubation is indicated for airway protection (GCS < 9; severe maxillofacial fractures; laryngeal or tracheal injury; evolving airway loss with neck hematoma or inhalation injury) and as a conduit for ventilation (apnea, respiratory distress--tachypnea >30, hypoxia/hypercarbia).
- Breathing
  - o Ensure adequate oxygenation (pulse oximetry) & ventilation.
  - o Provide supplemental oxygen.
  - o Assess breath sounds, chest percussion, chest wall excursion, and jugular venous distention.
  - o Re-expand alveolar volume:
    - Tension pneumothorax (pneumothorax with hypotension) with needle decompression (second intercostal space, mid-clavicular line), followed by 32-36 French anterior chest tube
    - Simple pneumothorax with 32-36 French anterior chest tube
    - Open pneumothorax with occlusive chest wall dressing and 36 French anterior chest tube

- Massive hemothorax with 36 French posterior chest tubes en route to operating room
  - Simple hemothorax with 36 French posterior chest tube
  - Flail chest/severe pulmonary contusion with intubation and mechanical ventilation
- Circulation: Hemorrhagic shock is the most common form of shock in trauma.
    - Assess for and stop external hemorrhage.
      - Direct manual pressure.
      - For traumatic amputation/severe mangled extremity, application of a tourniquet
    - Assess for tissue perfusion.
      - Cardiovascular: blood pressure, pulse, pulse pressure
      - Pulmonary: oxygen saturation via pulse oximetry, respiratory rate
      - Skin: color, temperature, capillary refill
      - CNS: mental status
      - Renal: urine output (normal 0.5 cc/kg/hr in adults, 1.0 cc/kg/hr in children, 2.0 cc/kg/hr in neonates)
    - Gain vascular access.
      - Two < 16-gauge peripheral intravenous catheters
      - >9 French central (subclavian, femoral, or internal jugular) introducer catheters
      - Intraosseous catheter
      - Saphenous vein cutdown
    - Administer initial volume.
      - 2 L lactated Ringer's
      - If penetrating torso trauma, controlled resuscitation with minimal fluids until bleeding is controlled
    - Assess for response.
      - Responder: bleeding < 20%
      - Transient responder: bleeding 20-40%, needs blood
      - Non-responder: >40%, needs blood and intervention to stop internal bleeding
    - Consider and intervene to stop hidden sources of bleeding.
      - Chest: chest tube
      - Abdomen
      - Pelvis: pelvic binder
      - Long bone fracture: reduce and splint
      - Posterior scalp laceration: whipstitch closure

- Maxillofacial trauma with swallowed blood: anterior/posterior nasal packing
- Blood left at the scene
- Consider non-hemorrhagic sources of shock
  - Tension pneumothorax
  - Cardiac tamponade
  - Neurogenic shock (relative hypovolemia due to vasodilatation)
- No role for vasopressor agents in the initial management of traumatic shock
- Disability
  - Brief neurologic exam
    - Level of consciousness: Glasgow Coma Scale
    - Pupil symmetry and reaction to light
    - Lateralizing signs
  - Maintain airway, breathing, and circulation to prevent secondary brain injury.
  - Temporize for evidence of increased intracranial pressure.
    - Elevate head of bed.
    - Mild hyperventilation to  $\text{paCO}_2 = 35$
    - Mannitol (1 gm/kg)
    - Neurosurgical consultation
- Exposure/environmental
  - Assess temperature.
  - Remove all clothing to facilitate access and examination.
  - Maintain normothermia/prevent hypothermia: warm room, warm fluids, warm blankets.
- Adjuncts to primary survey and resuscitation
  - Foley placement to monitor urinary output; withhold for evidence of urethral injury (blood at the urethral meatus, perineal hematoma, high-riding prostate)
  - Gastric tube placement to prevent gastric dilatation; no nasal placement in setting of facial fractures
  - Hemodynamic monitoring for blood pressure, heart rate, and cardiac rhythm
  - Respiratory monitoring with pulse oximetry, capnography, and respiratory rate monitoring
  - Arterial blood gas (pH, base deficit) and lactate monitoring

- CBC, electrolytes, glucose, creatinine (relevant for contrast administration), INR (relevant to detect antecedent anticoagulation), type and screen vs. crossmatch
- Assessment for intraperitoneal injury
  - Focused Assessment by Sonography in Trauma (FAST)
    - Looks for fluid in 4 areas (hepatorenal, splenorenal, pelvic, and pericardial spaces)
    - Assumes that fluid represents blood and can detect 200 cc or more
    - Can be rapidly repeated for follow-up
    - Not designed to find injuries unassociated with mild to moderate intraperitoneal fluid loss
  - Diagnostic peritoneal lavage (DPL)
    - Invasive test to find and assess the character of intraperitoneal fluid
    - Begins with peritoneal aspiration to find gross blood or enteric contents
    - Overly sensitive: finds evidence of injury that does not require surgical intervention
    - Not designed to find injuries unassociated with intraperitoneal fluid loss
- Radiographs
  - AP chest, to assess for tube and line placements, as well as subclinical hemopneumothoraces
  - Pelvis, to assess for pelvic fracture as a source of hidden bleeding
  - Cervical spine, to assess for source of neurogenic shock. As long as the cervical spine is protected with immobilization, this radiologic evaluation can be moved to the secondary survey. CT imaging of the cervical spine has replaced plain film imaging (lateral, AP, and open-mouth odontoid) in facilities with this capability.

## Secondary survey

- Complete, head-to-toe physical examination to identify all anatomic injuries
  - Begins after primary survey & resuscitation have been completed and patient is sustaining satisfactory physiology
  - History
    - Allergies
    - Medications, particularly cardiac, anticoagulation, and diabetic medications

- Past medical history/pregnancy
- Last meal eaten
- Events/environmental (more detailed mechanism of injury, helps to define injury patterns)
  - Blunt
    - Motor vehicle
    - Pedestrian
    - Fall
    - Crush
  - Penetrating
    - Gunshot
    - Shotgun
    - Stab
  - Environmental
    - Burn
    - Cold
    - Chemical, radiological, biological
  - Primary pressure wave (blast)
  - Explosions combine all four mechanisms of injury and produce multi-dimensional injuries.
- Physical exam
  - Head
    - Mental status: GCS
    - Scalp
      - Lacerations and avulsions
      - Open skull fractures
    - Eyes
      - Visual acuity: the vital sign of the eye
      - Pupil size & reactivity
      - Globe integrity & foreign body assessment
      - Extraocular muscle movement
    - Ears
      - Pinna
      - External auditory canal
      - Hemotympanum and tympanic membrane rupture
  - Face
    - Nose

- Epistaxis
- Septal hematoma
- Fracture
- Mouth
  - Mid-face stability
  - Malocclusion
  - Dental fractures
  - Mandibular fractures
  - Tongue lacerations
- Neck: maintain in-line stabilization as anterior and posterior collar sections are temporarily removed for neck exam
  - Anterior
    - Laryngeal deformity
    - Subcutaneous emphysema
    - Hematoma
    - Bruit
  - Posterior
    - Cervical spine tenderness
    - Paravertebral swelling
- Chest
  - Breath sounds
  - Hyper-resonance or dullness to percussion
  - Rib, sternal, and clavicular fractures
  - Subcutaneous emphysema
- Abdomen
  - Scars and open wounds
  - Distention
  - Tenderness
  - Peritoneal signs
- Pelvis
  - Bony tenderness and stability
  - Perineum/genitalia: stigmata of urethral injury and pelvic fracture
    - Hematoma/bruising
    - Blood at urethral meatus
    - Vaginal lacerations
    - Scrotal hematoma

- Anorectum
  - Anal tone, voluntary contraction (sacral sparing with cord injury)
  - Rectum: high-riding prostate, lacerations
- Extremities: use symmetry to advantage
  - Deformity and limb length: fracture and dislocation
  - Swelling: fracture, soft tissue (crush) and joint injury
  - Skin integrity: open fracture
  - Neuromuscular function
    - Axillary: shoulder abduction
    - Musculocutaneous: elbow flexion
    - Ulnar: little finger sensation
    - Median: thumb opposition
    - Radial: wrist extension
    - Femoral: knee extension
    - Posterior tibial: ankle plantarflexion
    - Deep peroneal: great toe dorsiflexion
  - Circulation
    - Upper: brachial and radial
    - Lower: femoral, posterior tibial, dorsalis pedis
- Back: logroll essential (50% of body surface area)
  - Tenderness
  - Deformity
  - Torso neurologic level
    - Shoulder abduction: C5
    - Elbow flexion: C6
    - Elbow extension: C7
    - Grip: C8
    - Finger spread: T1
    - Nipple level sensation: T4
    - Umbilical level sensation: T10
    - Hip flexion: L2
    - Knee extension: L3,4
    - Big toe dorsiflexion: L5
    - Ankle plantarflexion: S1

## General Management Principles

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- Recognize trouble.
  - Pre-hospital hypotension
  - Emergency room hypotension
  - Truncal gunshot wounds
  - Pelvic fractures
  - Acidemia and hypothermia, on the way to coagulopathy (triad of death)
- Consider transfer to higher level/facility of care if injuries exceed treatment capabilities.
- Do not delay indicated inter-facility transfer for diagnostic tests.
- Clinical clearance of cervical spine
  - Patient preconditions
    - Awake and alert
    - Neurologically normal
    - No alcohol or drug intoxication
    - No distracting injuries
  - Clinical exam
    - No neck pain
    - No midline neck tenderness
    - Full voluntary range of neck motion (flexion/extension, lateral bending) without pain
  - If all seven points are met, then cervical spine may be clinically cleared; when in doubt, leave the collar in place and proceed with radiological evaluation.
- Equivocal abdomen
  - Abdomen that defies clinical examination
    - Altered sensorium
      - Head injury
      - Spinal cord injury
      - Alcohol intoxication
      - Illicit drug use
    - Distracting injuries
      - Pelvic fracture
      - Lower rib fractures
      - Lumbar spine fracture
  - Requires further evaluation (FAST exam, DPL, CT scan)

- CT scans indicated in stable patients; consider CT angiogram (CTA) for vascular assessment
  - Head
    - Midline
    - Ventricular effacement
    - Bleeding (epidural, subdural, subarachnoid, intracerebral)
    - Edema
  - Facial: maxillofacial and mandibular fractures
  - Neck
    - C-spine
    - CTA carotid and vertebral arteries
  - Torso (chest, abdomen, pelvis)
    - Arterial phase
      - Blunt aortic injury
      - Solid organ arterial blush
      - Pelvic arterial blush
    - Venous phase
      - Solid organ injury (liver, spleen, kidney)
      - Bowel/mesenteric injury
    - Delayed phase: renal pelvis and ureter
    - CT cystogram: bladder
- Interventional radiology in definitive control of arterial hemorrhage
  - Liver & some spleen
  - Pelvic (15% of pelvic bleeding is arterial)
  - Glutea

## Specific Treatment

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- Cardiac tamponade
  - Consider with penetrating mechanism in cardiac cylinder (jugular notch to costal margins, circumferentially) and hypotension.
  - Classically described with Beck's triad (hypotension, jugular venous distention, and muffled heart sounds), seen in only 25%
  - Diagnosis
    - FAST exam with pericardial fluid
    - Pericardiocentesis
    - Subxiphoid pericardial window

- Management
  - Relatively stable
    - Volume to drive right-sided intracardiac pressures
    - Operating room for median sternotomy
  - Unstable: resuscitative thoracotomy
- Resuscitative thoracotomy by qualified surgeon
  - Penetrating torso trauma in extremis
    - Address airway and tension pneumothorax.
    - Assess for signs of life (pulse, blood pressure, cardiac electrical activity, cardiac wall motion on FAST).
    - If none, resuscitative thoracotomy not indicated
  - Blunt torso trauma: Patients arriving in cardiac arrest, to include pulseless with cardiac electrical activity, are not candidates for resuscitative thoracotomy.
- Indications for urgent thoracotomy by qualified surgeon
  - >1.5 L chest tube output upon tube insertion (within 1 hour of injury)
  - Ongoing chest tube output, >200 cc/hr, over 4 hours
- Indications for celiotomy (also known as laparotomy)
  - Blunt abdominal trauma and hypotension with suspected intraperitoneal source
  - Penetrating abdominal trauma with hypotension
  - Peritonitis
  - Evisceration
  - Free intraperitoneal air
  - Evidence of ruptured diaphragm
  - Evidence of ruptured gastrointestinal tract, intraperitoneal bladder, or pancreaticoduodenal complex
- Contrast urography for assessment of the lower urinary tract
  - Retrograde urethrogram to determine urethral injury
    - Insert 30 cc diluted water-soluble contrast into urethral meatus with Toomey syringe.
    - Hold penis at oblique angle and shoot film.
    - If extravasation is seen, consider urology consultation for suprapubic cystostomy.
    - If no extravasation, perform cystography.
  - Cystogram (may be performed by CT) to define bladder injury
    - Insert bladder catheter.

- Instill 250-300 cc of dilute water-soluble contrast into bladder & clamp Foley.
- Obtain AP and oblique films with bladder distended to identify intraperitoneal injury.
- Obtain post-drainage films to identify extraperitoneal bladder rupture.
- CT or interventional diagnostic angiography
  - Penetrating zone I or III neck injuries
  - Concern for blunt carotid or vertebral artery injury
  - Evaluation for blunt aortic injury
  - Ankle/brachial index < 0.9 without apparent mechanism and antecedent peripheral vascular disease
  - Severe fractures
  - Knee dislocation (popliteal artery injury)
- Extremity trauma
  - Reduction and splinting control bleeding and reduce pain.
  - Assess pulses before and after reduction and splinting. If pulse is lost, release and reapply traction/splint.
  - Ankle/brachial index
    - As measured by Doppler, systolic blood pressure at ankle divided by systolic blood pressure in right arm (left arm is more subject to atherosclerotic disease)
    - < 0.9 indicates lower flow from injury or peripheral vascular disease.
  - Open fractures
    - Rapid washout with Betadine solution in ED
    - Reduce and splint.
    - As contaminated or dirty wound, needs treatment with intravenous antibiotics
    - Operative intervention within 6 hours improves outcome.
  - Crush syndrome = direct muscle injury + muscle ischemia
    - Leads to rhabdomyolysis
      - Fluid and electrolyte abnormalities
        - Hypovolemia
        - Acidemia
        - Hyperkalemia
        - Hyperphosphatemia and hypocalcemia
      - Disseminated intravascular coagulation
    - Manage with intravascular saline volume expansion to promote diuresis.

- Goal urine output 100 cc/hour
- Role of urinary alkalinization unproven
- Compartment syndrome = elevated pressure within osteofascial compartment that compromises perfusion
  - Risks
    - Tibial and forearm fractures
    - Crush injury
    - Ischemia/reperfusion injury
    - Tight dressings or casts
    - Circumferential burns
  - Diagnosis
    - Pain out of proportion to injury; tense compartment swelling
    - Neurological and vascular compromise are late (and often irreversible) findings.
  - Management:
    - Preemptive fasciotomy for risks 1-3
    - Remove/bivalve casts
    - Escharotomy for circumferential full-thickness burns
- Tetanus prophylaxis
  - Tetanus-prone wound: >6 hrs postinjury; stellate or avulsion; >1 cm deep, projectile or crush-type injury; devitalized, contaminated, or ischemic tissue
  - Unknown status in general or < 3 adsorbed tetanus toxoid doses or >5-10 years since last dose: administer tetanus toxoid 0.5 cc IM
  - With tetanus-prone wounds and above, administer tetanus immune globulin 250 units IM.

## Ongoing Assessment

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- Continue post-resuscitation monitoring & re-evaluation.
  - Continuous monitoring of vital signs and organ perfusion
  - Urinary output
  - ABG (pH, lactate, base deficit)
  - Pulse oximetry
  - End-tidal carbon dioxide
  - Mentation
  - Skin color, temperature, and capillary refill
- Assess for adequate analgesia and comfort.

- Short-acting narcotics administered IV
- Benzodiazepines for non-hypoxic anxiety
- Collect all clinical and radiological data to catalog all injuries.
- Repeat primary & secondary exams within 24 hours as a tertiary survey to prevent missed injuries and confirm satisfactory physiology.
  - Wrist and ankle films for falls
  - Skeletal survey in obese patients to find subclinical fractures
  - Complete spine films in patients with one spinal fracture or with calcaneal fractures
  - Skin survey to confirm wound status/closure
  - Confirmation of consultant engagement and patient movement to definitive care

## Complications

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- Failure to obtain airway
- Perseverance on unobtainable orotracheal intubation without movement to surgical airway
- Failure to diagnose and treat tension pneumothorax with needle decompression
- Failure to stop the bleeding (both external and internal)
- Missed intraperitoneal source of bleeding (most commonly the spleen)
- Use of hypotonic resuscitative fluids in traumatic brain injury
- Failure to maintain normothermia
- Failure to reassess clinical status of patient
- Obtaining CT scans in unstable patients
- Missed extremity fractures (most commonly hands and feet)
- Failure to perform tertiary exam after stabilization
- Inadequate transfer policies in place

## Author

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