

EMERGENCY MEDICINE

Dr. D. Cass, Dr. I. Dubinsky and Dr. M. Thompson
Mark Freedman and Michael Klompas, editors
Dana McKay, associate editor

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APPROACH

- patients are triaged as
 - emergent
 - urgent
 - non-urgent

PRIORITIZED PLAN

1. Rapid Primary Survey (RPS)
2. Resuscitation (often occurs at same time as RPS)
3. Detailed Secondary Survey
4. Definitive Care

RAPID PRIMARY SURVEY

- Airway maintenance with C-spine control
- Breathing and ventilation
- Circulation (pulses, hemorrhage control)
- Disability: neurologic status
- Exposure (complete) and environment (temperature control)
- restart sequence from beginning if patient deteriorates

AIRWAY

- secure airway is first priority
- assume a C-spine injury in every trauma patient --> immobilize with collar and sand bags

Causes of Airway Obstruction

- think of three areas
 - airway lumen: foreign body, vomit
 - airway wall: edema, fractures
 - external to wall: lax muscles (tongue), direct trauma, expanding hematoma

Airway Assessment

- consider ability to breathe and speak to assess air entry
- noisy breathing is obstructed breathing until proven otherwise
- signs of obstruction
 - apnea
 - respiratory distress
 - failure to speak
 - dysphonia
 - adventitious sounds
 - cyanosis
 - conduct (agitation, confusion, "universal choking sign")
- think about immediate patency and ability to maintain patency in future (decreasing LOC, increasing edema)
- always need to reassess, can change rapidly

Airway Management

- goals
 - achieve a reliably patent airway
 - prevent aspiration
 - permit adequate oxygenation and ventilation
 - facilitate ongoing patient management
 - give drugs via endotracheal tube
 - "NAVEL": naran, atropine, ventolin, epinephrine, lidocaine
- start with basic management techniques then progress to advanced

Basic Management

- protect the C-spine in the injured patient
- chin lift or jaw thrust to open the airway
- sweep and suction to clear mouth of foreign material
- oral/nasopharyngeal airway

Advanced Management

- ❑ endotracheal intubation (see Figure 1)
 - orotracheal +/- Rapid Sequence Intubation (RSI)
 - nasotracheal - may be better tolerated in conscious patient
 - does not provide 100% protection against aspiration
- ❑ indications for intubation
 - unable to protect airway
 - inadequate spontaneous ventilation
 - oxygen saturation < 90% with 100% oxygen
 - profound shock
 - GCS < or = 8
- ❑ surgical airway (if unable to intubate using oral/nasal route)
 - needle (requires jet ventilator)
 - cricothyroidotomy
 - tracheotomy

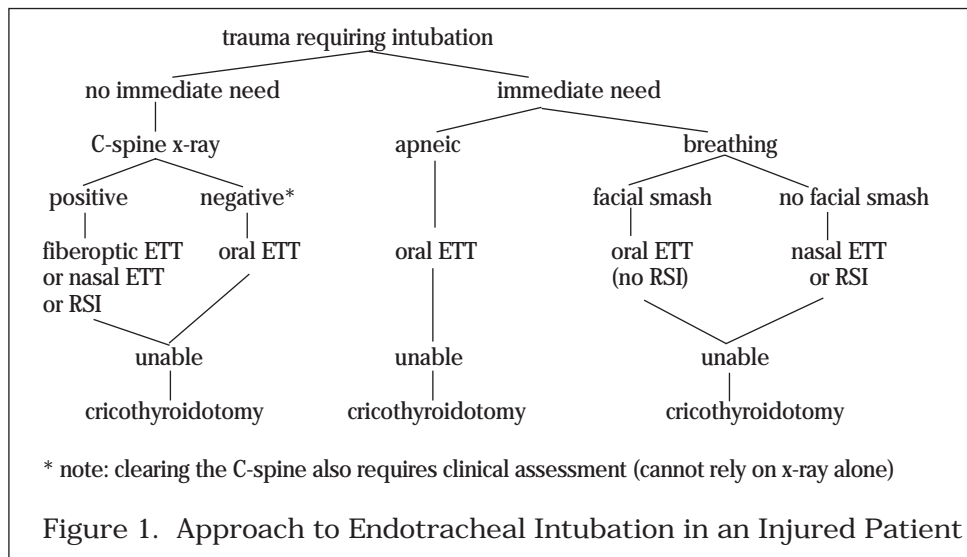


Figure 1. Approach to Endotracheal Intubation in an Injured Patient

BREATHING

LOOK for mental status, chest movement, respiratory rate/effort, patient's colour

LISTEN for air escaping during exhalation, sounds of obstruction (e.g. stridor), auscultate for breath sounds and symmetry of air entry

FEEL for the flow of air, chest wall for crepitus, flail segments and sucking chest wounds

ASSESS tracheal position, neck veins, respiratory distress, auscultation of all lung fields

Oxygenation and Ventilation

- ❑ measurement of respiratory function: rate, pulse oximetry, ABG's
- ❑ treatment modalities
 - nasal prongs --> simple face mask --> oxygen reservoir --> CPAP/BiPAP to increase oxygen delivery
 - venturi mask: used to precisely control oxygen delivery
 - Bag-Valve mask and CPAP: to supplement ventilation

CIRCULATION (see Shock Section)

- ❑ check level of consciousness, skin colour, temperature, capillary refill
- ❑ check the pulse for rate and rhythm
 - patient may be unable to increase heart rate (e.g. use of β -blockers, head injury, etc...)

Table 1. Estimated Systolic Blood Pressure Based on Position of Palpable Pulse

	Radial	Femoral	Carotid
SBP	> 80	> 70	> 60

- stop major external bleeding
 - apply direct pressure
 - elevate profusely bleeding extremities if no obvious unstable fracture
 - consider pressure points (brachial, axillary, femoral)
 - do not remove impaled objects as they tamponade bleeding
 - use tourniquet as last resort

DISABILITY

- assess level of consciousness by AVPU method (quick, rudimentary assessment)
 - A - ALERT
 - V - responds to VERBAL stimuli
 - P - responds to PAINFUL stimuli
 - U - UNRESPONSIVE
- size and reactivity of pupils
- movement of upper and lower extremities

EXPOSURE / ENVIRONMENT

- undress patient completely
- essential to assess all areas for possible injury
- keep patient warm with a blanket; avoid hypothermia

RESUSCITATION

- restoration of ABCs, oxygenation, ventilation, vital signs
- often done simultaneously with primary survey
- oxygen
- O₂ saturation monitor
- gain IV access
 - two large bore peripheral IV's for shock (14-16 gauge)
 - bolus with RL or NS (2 litres) and then blood as indicated for hypovolemic shock
 - inotropes for cardiogenic shock
 - vasopressors for septic shock
- vital signs - q 5-15 minutes
- ECG and BP monitors
- Foley and NG tube if indicated
 - Foley contraindicated if blood from urethral meatus or other signs of urethral tear (see Traumatology section)
 - NG tube contraindicated if significant mid-face trauma or basal skull fracture
- order appropriate tests and investigations: may include CBC, lytes, BUN, Cr, glucose, amylase, PT/PTT, β-hCG, toxic screen (EtOH), Cross + Type

DETAILED SECONDARY SURVEY

- done after Rapid Primary Survey problems have been corrected
- designed to identify major injuries or areas of concern
- involves
 - history
 - focused neurological exam
 - head to toe physical exam
 - X-rays (c-spine, chest, pelvis required in blunt trauma)

History

- "AMPLE": Allergies, Medications, Past medical history, Last meal, Events related to injury

Neurological Examination

- use GCS to detect changes in status (see Coma section)
- breathing patterns
 - alterations of rate and rhythm are signs of structural or metabolic abnormalities

- progressive deterioration of breathing pattern implies a failing CNS
- pupils
 - assess equality, size, symmetry, reactivity to light
 - inequality suggests local eye problem or lateralizing CNS lesion
 - reactivity/level of consciousness (LOC)
 - reactive pupils + decreased LOC --> metabolic or structural cause
 - non-reactive pupils + decreased LOC--> structural cause
 - extra ocular movements and nystagmus
 - fundoscopy (papilledema, hemorrhages)
- cranial nerve exam (including reflexes)
- assessment of spinal cord integrity
 - conscious patient
 - assess distal sensation and motor ability
 - unconscious patient
 - response to painful or noxious stimulus applied to extremities
- signs of increased ICP
 - deteriorating LOC (hallmark of increasing ICP)
 - deteriorating respiratory pattern
 - Cushing reflex (high BP, slow heart rate)
 - lateralizing CNS signs (e.g. cranial nerve palsies, hemiparesis)
 - seizures
 - papilledema (occurs late)

Head To Toe Physical Exam

- "tubes and fingers in every orifice" in injured patient
- remember "Medic-Alert" tags, necklaces, bracelets, wallet card
- look for specific toxidromes (see Toxicology Section)
- head and neck
 - examine for signs of trauma
 - inspect for C-spine injuries (assume injury in head, face, and neck trauma)
- complete examination of chest, abdomen, pelvis, perineum, and all four extremities
- log roll for T and L spine exam in injured patient

DEFINITIVE CARE

1. continue therapy
2. continue patient evaluations (special investigations)
3. specialty consultations including O.R.
4. disposition: home, admission, or another setting

PRE-HOSPITAL CARE

LEVEL OF PROVIDERS

- note: levels of providers not standard in every community
- first responders usually non-medical (i.e. firefighters, police)
 - administer CPR, O₂, first aid, ± automatic defibrillation
- basic Emergency Medical Attendant (EMA)
 - basic airway management, O₂ by mask or cannula, CPR, semi-automatic external defibrillation, basic trauma care
- Level I Paramedic
 - have "symptom relief package": blood sugar levels, IM glucagon, and some drugs (nitro, Salbutamol, epinephrine, ASA)
- Level II Paramedic
 - start intravenous lines, blood sugar levels, interpret ECGs, manual defibrillation
- Level III Paramedic
 - advanced airway management, cardioversion and defibrillation, emergency drugs, ACLS, needle thoracostomy
- base hospital physicians
 - provide medical control and verbal orders for Paramedics through line patch
 - ultimately responsible for delegated medical act and pronouncement of death in the field

GLASGOW COMA SCALE (GCS)

- designed for use on trauma patients with decreased LOC; good indicator of severity of injury
- often used for metabolic causes as well, but less meaningful
- most useful if repeated
 - changes in GCS with time is more relevant than the absolute number
 - patient with deteriorating GCS needs immediate attention

Eyes Open

- spontaneously 4
- on command 3
- to pain 2
- no response 1

Best Verbal Response

- answers questions appropriately 5
- confused, disoriented 4
- inappropriate words 3
- incomprehensible noise 2
- no verbal response 1

Best Motor Response

- obeys commands 6
- localizes pain 5
- withdraws to pain 4
- decorticate (abnormal flexion) 3
- decerebrate (abnormal extension) 2
- no response 1

- best reported as a 3 part score: Eyes + Verbal + Motor = total
- provides indication of degree of injury
 - 13-15 = mild injury
 - 9-12 = moderate injury
 - less than or equal to 8 = severe injury
- anyone with a severe injury needs an ETT
- if patient intubated reported out of 10 + T
(T= tubed, i.e. no verbal component)

CAUSES OF COMA

Definitions

- Coma - a sleep-like state, unarousable to consciousness
- Stupor - unresponsiveness from which the patient can be aroused
- Lethargy - state of decreased awareness and mental status (patient may appear wakeful)

Mechanisms

- Structural Causes - 1/3
 - brainstem lesions that affect the RAS
 - compression (e.g. supra/infratentorial tumour or subdural/epidural hematoma)
 - direct damage (e.g. brainstem infarct, hemorrhage)
 - cerebral
 - diffuse cerebral cortical lesion
 - diffuse trauma or ischemia
- Metabolic/Toxic Causes - 2/3
 - M - major organ failure
 - E - electrolyte/endocrine abnormalities
 - T - toxins (e.g. alcohol, drugs, poisons)
 - A - acid disorders
 - B - base disorders
 - O - decreased oxygen level
 - L - lactate
 - I - insulin (diabetes), ischemia, infection
 - C - hypercalcemia

MANAGEMENT OF THE COMATOSE PATIENT

- ABC's
- airway management should take into account
 - probability of C-spine injury, high if:
 - head or face trauma
 - history of fall or collapse
 - likelihood of aspiration
 - adequacy of ventilation
 - correct hypoxia and hypercarbia
 - reversibility of the cause of the coma
 - hypoglycemia or narcotic OD rapidly reversible therefore ETT may not be needed (controversial)
 - need for maximizing oxygenation
 - CO poisoning
 - raised ICP (usually requires ETT)

Resuscitation Should Include

- IV access
- rapid blood sugar (finger prick)
- glucose, CBC, lytes, Cr and BUN, LFT, and serum osmolality
- ECG
- arterial blood gases
- universal antidotes
 - thiamine 100 mg IM before glucose (if cachectic, alcoholic, malnourished)
 - glucose 50 cc of 50% (D50W) if glucose < 4 mmol/L or rapid measurement not available
 - naloxone 0.4-2.0 mg IV (opiate antagonist) if narcotic toxidrome present (risk of withdrawal reaction in chronic opiate users)
- drug levels of specific toxins if indicated
- rapid assessment and correction of abnormalities essential to prevent brain injury

Secondary Survey and Definitive Care

- focused history (from family, friends, police, EMA, etc...)
 - aim to identify
 - acute or insidious onset
 - trauma or seizure activity
 - medications, alcohol, or drugs
 - past medical history (e.g. IDDM, depression)
- physical examination (vital signs essential) with selected laboratory and imaging studies (x-ray and CT)

Five N's for inspection

- Noggin – e.g. Raccoon eyes, Battle's sign
- Neck – C-spine, neurogenic shock, nuchal rigidity
- eNt – otorrhea, rhinorrhea, tongue biting, odor on breath, and hemotympanum
- Needles – track marks of IV drug abuse
- Neurological – full examination essential but concentrate on
 - GCS - follow over time
 - respirations (rate and pattern)
 - apneustic or ataxic (brainstem)
 - Cheyne-Stokes (cortical)
 - pupils - reactivity and symmetry (CN II, III)
 - corneal reflex (CN V, VII)
 - gag reflex (CN IX, X)
 - oculocephalic reflex (after C-spine clearance)
 - oculocaloric reflex (rule out tympanic perforation first)
 - deep tendon reflexes and tone
 - plantar reflex ("positive Babinski" if upgoing)
- LP after normal CT to rule out meningitis, SAH

Diagnosis

- findings suggesting a toxic-metabolic cause
 - dysfunction at lower levels of the brainstem (e.g. caloric unresponsiveness)
 - respiratory depression in association with an intact upper brainstem (e.g. reactive pupils)
 - see Tables 2 and 3

Table 2. Structural vs. Metabolic Coma

	Structural	Toxic-Metabolic
pupillary reaction	asymmetric or absent	pupils equal, round, regular reaction to light (see Table 3)
extraocular movements	asymmetric or absent	symmetric or absent
motor findings	asymmetric or absent	symmetric or absent

Table 3. Toxic - Metabolic Causes of Fixed Pupils

Cause	Pupils	Characteristics	Treatment
anoxia	dilated	antecedent history of shock, cardiac or respiratory arrest, etc...	100% O ₂ , expectant management
anticholinergic agents (e.g. atropine, TCA's)	dilated	tachycardia, warm, dry skin	physostigmine (for Atropine) sodium bicarbonate (for TCA)
cholinergic agents (e.g. organo-phosphates)	small, barely perceptible reflex	diaphoresis, vomiting, incontinence, increased secretions	atropine
opiates (e.g. heroin)	pinpoint, barely perceptible reflex (exception: meperidine)	needle marks	naloxone
hypothermia	normal or dilated	history of exposure temperature < 35°C	warm patient (e.g. warm IV solutions, blankets)
barbiturates	midsized to dilated	history of exposure positive serum levels confusion, drowsiness, ataxia shallow respirations and pulse	ABC's no specific antidote
methanol (rare)	dilated	optic neuritis increased osmolal gap metabolic acidosis	ethanol ± dialysis

- it is essential to re-examine comatose patients frequently - can change rapidly
- diagnosis may only become apparent with the passage of time
 - delayed deficit after head trauma suggestive of epidural hematoma

Herniation Syndromes (see Neurosurgery Notes)

BASIC TREATMENT OF HERNIATION SYNDROMES

- ABCs
- intubate and hyperventilate to a PCO₂ of 30-35 mmHg
- ± mannitol (0.25-1 g/kg of 20% solution over 30 minutes)
- ± surgical decompression (where appropriate)

TRAUMATOLOGY

EPIDEMIOLOGY

- trauma is the leading cause of death in patients < 44 years
- trimodal distribution of death
 - minutes - lethal injuries - death usually at the scene
 - golden hour - death within 4-6 hours - decreased mortality with trauma care
 - days-weeks - death from multiple organ dysfunction, sepsis, etc...
- injuries generally fall into two categories
 - blunt - most common, due to MVC, falls, assault, sports, etc...
 - penetrating - increasing in incidence - often due to gunshots, stabbings, impalements

DOCUMENTATION OF TRAUMATIC INJURIES

- to anticipate and suspect traumatic injuries it is important to know the mechanism of injury
- always look for an underlying cause (seizure, suicide, medical problem)

Motor Vehicle Collisions (MVC)

- type of collision? velocity?
- where was patient sitting? driver or passenger? other passenger injuries/fatalities?
- passenger compartment intact? windshield? steering wheel?
- seatbelt? airbag?
- any loss of consciousness? how long? amnesia?
- head injury? vomiting? headache? seizure?
- use of alcohol? drugs?

Falls

- how far fell? how did patient land?
- what surface did patient land on (dirt, cement)?

SHOCK (see Anesthesia Notes)

Definition: Inadequate Organ and Tissue Perfusion

- think of perfusion to brain, kidney, extremities
- look for depression in mental status, pallor, cool extremities, weak pulse
- Classification
 - S - Spinal (Neurogenic) and Septic
 - H - Hypovolemic and Hemorrhagic
 - O - Obstructive
 - C - Cardiogenic
 - K - Anaphylactic "K"

- hemorrhagic shock (classic) - see Table 4
 - shock in the trauma patient is hemorrhagic until proven otherwise

Table 4. Classification of Hemorrhagic Shock (for a 70kg male)

Class	Blood loss (mL)	BP	Pulse	Resp rate	Urine output
I	< 15% (< 750)	normal	<100	14-20	> 30 mL/hour
II	15-30% (750-1500)	normal	>100	20-30	0-30 mL/hour
III	30-40% (1500-2000)	↓	>120	30-40	5-15 mL/hour
IV	>40% (>2000)	↓↓	>140	> 35	0 mL/hour

- cardiogenic shock
 - myocardial contusion
- obstructive shock (impaired venous return)
 - tension pneumothorax, cardiac tamonade, pulmonary embolism
- spinal/neurogenic shock (“warm shock”)
 - spinal cord injuries (isolated head injuries do not cause shock)
- septic shock
 - suspect in febrile patient who arrives several hours after trauma
 - look for bacteremia or nidus of infection
- anaphylactic (see Anaphylaxis Section)

Evaluation of Severity of Shock

- vital signs
- CNS status
- skin perfusion
- urine output
- central venous pressure (CVP) line

Blood Replacement if Needed

- packed RBC's
- cross-matched (ideal but takes time)
- type specific
- O-negative (children and women of child-bearing age) or O-positive (everyone else) if no time for cross and match
- consider complications with massive transfusions

Unproven or Harmful Treatments

- Trendelenberg position
- steroids (used only in spinal cord injury)
- MAST garments - efficacy unknown
- vasopressors during hemorrhagic shock

CHEST TRAUMA

- trauma to the chest accounts for, or contributes to 50% of trauma deaths
- two types
 - immediately life-threatening
 - potentially life-threatening

IMMEDIATELY LIFE-THREATENING CHEST INJURIES

- identified and managed during the primary survey
 - airway obstruction
 - flail chest
 - cardiac tamponade
 - hemothorax
 - pneumothorax (open, tension)
- 80% of all chest injuries can be managed by non-surgeons with simple measures such as intubation, chest tubes, and pain control

Tension Pneumothorax

- a clinical diagnosis
- one-way valve causes accumulation of air in the pleural space

- ❑ decreased venous return (torsion/compression of large venous vessels) + impaired function of good lung = HYPOXIA
- ❑ inspection: respiratory distress, tachycardia, distended neck veins, cyanosis, asymmetry of chest wall motion
- ❑ palpation: tracheal deviation away from pneumothorax
- ❑ percussion: hyperresonance
- ❑ auscultation: unilateral absence of breath sounds, hypotension
- ❑ management
 - large bore needle, 2nd intercostal space, mid-clavicular line
 - followed by chest tube in 5th intercostal space, anterior axillary line

Open Pneumothorax

- ❑ gunshot or open wound to chest, if hole is $> 2/3$ tracheal diameter air will preferentially enter chest from wound rather than trachea
- ❑ lung collapse \rightarrow ineffective ventilation \rightarrow HYPOXIA
- ❑ check posterior wall for exit wound
- ❑ management
 - cover wound with air-tight dressing sealed on 3 sides
 - insert chest tube
 - definitive care (surgery)

Massive Hemothorax

- ❑ > 1500 mL blood loss in chest cavity
- ❑ inspection: pallor, flat neck veins, shock
- ❑ percussion: unilateral dullness
- ❑ auscultation: absent breath sounds, hypotension
- ❑ management
 - restore blood volume (rapid crystalloid infusion)
 - decompress with chest tube
 - indications for thoracotomy
 - > 1500 cc total blood drained from chest tube
 - > 200 cc/hour continued drainage

Flail Chest

- ❑ free-floating segment of chest wall
- ❑ multiple rib fractures (> 4), each fractured at two sites
- ❑ underlying lung contusion causes most of the problem, not fractures
- ❑ lung injury (poor compliance \rightarrow V/Q mismatch \rightarrow HYPOXIA)
- ❑ increased work of breathing \rightarrow FATIGUE
- ❑ inspection: respiratory distress, cyanosis, paradoxical movement of flail segment
- ❑ palpation: crepitus of ribs
- ❑ auscultation: decreased air entry on affected side
- ❑ ABG's: decreased pO_2 , increased pCO_2
- ❑ CXR: rib fractures, lung contusion
- ❑ management
 - O_2 + fluid therapy + pain control
 - positive pressure ventilation
 - intubation and ventilation may be necessary

Cardiac Tamponade

- ❑ usually from penetrating injury
- ❑ 15-20 μ cc of blood in pericardium sufficient to interfere with cardiac activity
- ❑ Beck's classic triad
 - hypotension (with pulsus paradoxus)
 - distended neck veins
 - muffled heart sounds (with tachycardia)
- ❑ investigation: Echo
- ❑ management
 - IV fluids
 - pericardiocentesis
 - open thoracotomy

POTENTIALLY LIFE-THREATENING CHEST INJURIES

- ❑ identified in secondary survey (CXR)
 - C - Contusion: pulmonary, myocardial, aortic
 - H - Hernia: traumatic diaphragmatic
 - ES - ESophageal perforation
 - T - Tracheobronchial disruption/Tear (aortic)
- ❑ with these injuries - need to have high index of suspicion, usually dependent on mechanism of injury

Pulmonary Contusion

- ❑ history: blunt trauma to chest
- ❑ interstitial edema impairs compliance and gas exchange
- ❑ CXR: areas of opacification of lung within 6 hours of trauma
- ❑ management
 - maintain adequate ventilation
 - monitor with ABG, pulse oximeter and ECG
 - chest physiotherapy
 - positive pressure ventilation if severe

Myocardial Contusion

- ❑ history: blunt trauma to chest (usually in setting of multi-system trauma and therefore difficult to diagnose)
- ❑ physical examination: overlying injury, i.e. fractures, chest wall contusion
- ❑ investigations
 - ECG: arrhythmias, ST changes
 - serial CK-MB
 - cardiac output monitoring
 - 2D ECHO
 - radionuclide (MUGA) scan
- ❑ management
 - oxygen
 - antiarrhythmic agents
 - analgesia

Ruptured Diaphragm

- ❑ more often diagnosed on left side since liver conceals defect on right
- ❑ history: blunt trauma to chest or abdomen (high lap belt in MVC)
- ❑ investigations
 - CXR - abnormality of diaphragm/lower lung fields/NG tube placement
- ❑ management
 - laparotomy because of associated intra-abdominal injuries

Esophageal Injury

- ❑ history: penetrating trauma
- ❑ investigations
 - CXR: mediastinal air (not always)
 - esophagram (Gastrograffin)
 - flexible esophagoscopy
- ❑ management
 - repair (if in first 24 hours)

Tracheobronchial Injuries

- ❑ larynx
 - history: strangulation, clothes line, direct blow, blunt trauma, any penetrating injury involving platysma
 - triad of
 - hoarseness
 - subcutaneous emphysema
 - palpable fracture, crepitus
 - other symptoms: hemoptysis, dyspnea

- investigations
 - CXR
 - CT scan
 - arteriography (if penetrating)
- management
 - airway - manage early because of edema
 - C-spine: may also be injured, consider mechanism of injury
 - surgical
 - tracheotomy versus repair
 - surgical exploration if deep to platysma (penetrating)
- DON'T
 - clamp structures (can damage nerves)
 - probe
 - insert NG tube (leads to bleeding)
 - remove weapon/impaled object
- trachea/bronchus
 - frequently missed
 - history: deceleration, penetration, increased intra-thoracic pressure
 - complaints of dyspnea, hemoptysis
 - examination: subcutaneous air, Hamman's sign (crunching sound synchronous with heart beat)
 - CXR: mediastinal air, persistent pneumothorax
 - management
 - surgical repair if > 1/3 circumference

Aortic Tear

- 90% tear at subclavian, most die at scene
- salvageable if diagnosis made rapidly in ED
- history
 - sudden high speed deceleration (e.g. MVC, falls, airplane crash)
 - complaints of chest pain, dyspnea, hoarseness
- physical examination: decreased femoral pulses, differential arm BP (arch tear)
- investigations: CXR, aortogram, CT scan
- x-ray features include
 - wide mediastinum (most consistent)
 - pleural cap
 - massive left hemothorax
 - indistinct aortic knuckle
 - tracheal deviation to right side
 - depressed left mainstem bronchus
 - esophagus (NG tube) deviated to right side
- management
 - thoracotomy (may treat other severe injuries first)

Late Causes of Death in Chest Trauma

- respiratory failure
- sepsis (adult respiratory distress syndrome)

ABDOMINAL TRAUMA

- two mechanisms
 - blunt trauma - usually causes solid organ injury
 - penetrating trauma - usually causes hollow organ injury

Blunt Trauma

- two types
 - intra-abdominal bleed
 - retroperitoneal bleed
- high clinical suspicion in multi-system trauma
- physical exam unreliable in multi-system trauma
 - slow blood loss not immediately apparent
 - other injuries may mask symptoms
 - serial examinations are required
- inspection: contusions, abrasions, distension, guarding
- palpation: tenderness, point of maximal tenderness, rebound tenderness, rigidity

- ❑ diagnostic tests are indicated in patients with
 - unexplained shock
 - equivocal signs of abdominal injury
 - unreliable physical exam (paraplegia, head injury, substance use)
 - high likelihood of injury (pelvic/lumbar fracture, etc...)
 - impending periods of non-observation (e.g. surgery)
- ❑ diagnostic tests include
 - flat plate for retroperitoneal air or blood (psoas shadow obliterated)
 - CXR
 - free air under diaphragm
 - diaphragmatic herniation
 - ultrasound: pelvis, spleen, liver
 - CT scan
 - IVP
 - diagnostic peritoneal lavage (DPL)
 - tests for intra-peritoneal bleed
 - cannot test for
 - retroperitoneal bleed
 - discerning lethal from trivial bleed
 - diaphragmatic rupture
 - criteria for positive lavage:
 - > 10 cc gross blood
 - bile, bacteria, foreign material
 - RBC count > 100 000 x 10⁶/L,
 - WBC > 500 x 10⁶/L, amylase > 175 IU
- ❑ management
 - general: fluid resuscitation and stabilization
 - surgical: watchful wait versus laparotomy
- ❑ note: seatbelt injuries may have
 - retroperitoneal duodenal trauma
 - intraperitoneal bowel transection
 - mesenteric injury
 - L-spine injury

Penetrating Trauma

- ❑ high risk of GI perforation and sepsis
- ❑ history: size of blade, calibre/distance from gun, route of entry
- ❑ local wound exploration with the following exceptions:
 - thoracoabdominal region (may cause pneumothorax)
 - back or flanks (muscles too thick)
- ❑ management
 - gunshot wounds --> always require laparotomy
 - stab wounds - "Rule of thirds"
 - 1/3 do not penetrate peritoneal cavity
 - 1/3 penetrate but are harmless
 - 1/3 cause injury requiring surgery
 - mandatory laparotomy if
 - shock
 - peritonitis
 - evisceration
 - free air in abdomen
 - blood in NG tube, Foley catheter or on rectal exam

GENITOURINARY TRACT INJURIES

- ❑ diagnosis based on mechanism of injury, hematuria (gross or microscopic, but may be absent), and appropriate radiological studies

Renal Trauma

- ❑ etiology
 - blunt trauma
 - contusions (parenchymal ecchymosis with intact renal capsule)
 - parenchymal tears
 - non-communicating (hematoma)
 - communicating (urine extravasation, hematuria)

- penetrating injuries
- renal pedicle injury due to acceleration/deceleration
- ☐ history: mechanism of injury, hematuria, flank pain
- ☐ physical exam: CVA tenderness, upper quadrant mass, shock
- ☐ investigations
 - CT scan (study of choice if hemodynamically stable)
 - IVP (during laparotomy)
 - renal arteriography (if renal artery injury suspected)
- ☐ management
 - 90% conservative (bedrest, analgesia, antibiotics)
 - 10% surgical for
 - hemodynamically unstable or continuing to bleed > 48 hours
 - major urine extravasation
 - renal pedicle injury
 - all penetrating wounds
 - major lacerations
 - renal artery thrombosis
 - infection

Ureter

- ☐ etiology
 - blunt (rare) at uretero-pelvic junction
 - penetrating (rare)
 - iatrogenic (most common)
- ☐ history: mechanism of injury, hematuria
- ☐ physical exam: findings related to intra-abdominal injuries
- ☐ investigations: retrograde ureterogram
- ☐ management: uretero-uretostomy

Bladder

- ☐ etiology
 - blunt trauma
 - extraperitoneal rupture from pelvic fracture fragments
 - intraperitoneal rupture from trauma + full bladder
 - penetrating trauma
- ☐ history: gross hematuria, dysuria, urinary retention, abdominal pain
- ☐ physical exam
 - extraperitoneal rupture: pelvic instability, suprapubic tenderness from mass of urine or extravasated blood
 - intraperitoneal rupture: acute abdomen
- ☐ investigations: urinalysis, plain abdominal film, CT scan, urethrogram, +/- retrograde cystography
- ☐ management
 - extraperitoneal: minor rupture --> Foley drainage, major rupture --> surgical repair
 - intraperitoneal: drain abdomen and surgical repair

Urethral

- ☐ etiology
 - usually blunt trauma in men
 - anterior (bulbous) urethra damage with straddle injuries
 - posterior (bulbo-membranous) urethra with pelvic fractures
- ☐ history/physical
 - anterior: blood at meatus, perineal/scrotal hematoma, blood and urine extending from penile shaft and perineum to abdominal wall
 - posterior: inability to void, blood at meatus, suprapubic tenderness, pelvic instability, superior displacement of prostate, pelvic hematoma on rectal exam
- ☐ investigation: retrograde urethrography
- ☐ management
 - anterior: if Foley does not pass, requires suprapubic drain
 - posterior: suprapubic drainage, avoid catheterization

HEAD TRAUMA

- 60% of trauma admissions have head injuries
- 60% of MVC-related deaths are due to head injury
- first physician who sees patient has greatest impact on the outcome
- alteration of consciousness is the hallmark of brain injury

Assessment of Brain Injury

- history
 - pre-hospital state, mechanism of injury
- vital signs
 - shock
 - Cushing's response to increasing ICP (bradycardia with hypertension)
 - hyperthermia
- level of consciousness
 - Glasgow Coma Scale
- pupils: pathology = anisocoria > 1 mm (in patient with altered LOC)
- neurological exam: lateralizing signs - motor/sensory

Severe Head Injury

- GCS < or = 8
- deteriorating GCS
- unequal pupils
- lateralizing signs

Investigations

- CT scan
- skull x-rays
 - little value in the early management of obvious blunt head injury
 - for diagnosis of calvarium fractures (not brain injury)
 - clinical diagnosis superior for basal skull fractures (i.e. raccoon eyes, Battle's Sign, hemotympanum, CSF otorrhea / rhinorrhea)
 - may help localize foreign body after penetrating head injury

Specific Injuries

- skull fractures
 - linear, non-depressed
 - linear, depressed
 - open
 - basal skull
- diffuse brain injury
 - concussion (brief LOC then normal)
 - diffuse axonal injury
- focal injuries
 - contusions
 - intracranial hemorrhage
 - epidural
 - acute subdural
 - intracerebral

Management

- general
 - ABC's
 - treat other injuries i.e. shock, hypoxia, spinal
- medical
 - seizure treatment/prophylaxis
 - steroids are of NO proven value
 - diazepam, phenytoin, phenobarbital
 - treat suspected raised ICP
 - 100% O₂
 - intubate and hyperventilate to a pCO₂ of 30-35 mmHg
 - mannitol 1 g/kg infused as rapidly as possible
 - raise head of stretcher 20 degrees if patient hemodynamically stable
 - consider paralyzing meds if agitated/high airway pressures
- surgical
 - neurosurgical consultation

SPINE AND SPINAL CORD TRAUMA

- spinal immobilization (cervical collar, spine board) must be maintained until spinal injury has been ruled out
- vertebral injuries may be present without spinal cord injury, therefore normal neurologic exam does not exclude spinal injury
- if a fracture is found, be suspicious, look for another fracture
- spine may be unstable despite normal C-spine x-ray
- collar everyone except those that meet ALL the following criteria
 - no pain
 - no tenderness
 - no neurological symptoms or findings
 - no significant distracting injuries
 - no head injury
 - no intoxication
- note: patients with penetrating trauma (especially gunshot and knife wounds) can also have spinal cord injury

X-Rays

- full spine series for trauma
 - AP, lateral, odontoid
- lateral C-Spine
 - must be obtained on all blunt trauma patients (except those meeting above criteria)
 - must visualize C7-T1 junction (Swimmer's view often required)
- thoracolumbar
 - AP and lateral views
 - indicated in
 - patients with C-spine injury
 - unconscious patients
 - patients with symptoms or neurological findings

Management of Cord Injury

- immobilize the entire spine with the patient in the supine position (collar, sand bags, padded board, straps)
- if patient must be moved, use a "log roll" technique with assistance
- if cervical cord lesion, watch for respiratory insufficiency
 - low cervical transection (C5-T1) produces abdominal breathing (phrenic innervation of diaphragm still intact)
 - high cervical cord injury --> no breathing --> intubation
- hypotension (neurogenic shock)
 - treatment: warm blanket, Trendelenberg position (occasionally), volume infusion, consider vasopressors
- methylprednisolone within 8 hours of injury (30 mg/kg initially followed by 5.4 mg/kg per hour for 23 hours)

APPROACH TO PATIENT WITH SUSPECTED C-SPINE INJURY

Clearing the C-Spine

- negative clinical exam
- normal x-rays

Indications for X-rays

- altered mental status
- history
 - midline neck pain: recheck for pain on movement after palpation
 - past history of spinal mobility disorder (ankylosing spondylitis, rheumatoid arthritis, osteoarthritis, vertebral fusion)
- physical exam
 - posterior neck tenderness, spasm, or crepitus
 - any neurologic signs of deficits: tone, power, reflexes, sensation, autonomic dysfunction (rectal tone, priapism)
 - other painful distracting injuries
- x-ray all unconscious trauma patients

C-Spine X-Rays

- The 3-view C-spine series is the screening modality of choice
 - AP
 - lateral C1-T1 (\pm swimmer's view) - T2 not involved with neck movements
 - odontoid (open mouth or oblique submental view)
- supine obliques can detect some injuries not seen on 3-views
 - better visualization of posterior element fractures (lamina, pedicle, facet joint)
 - can be used to visualize the cervicothoracic junction

Lateral View: The ABCS

A - Alignment and Adequacy

- Must see C1 to C7-T1 junction - if not - downward traction of shoulders, swimmer's view, bilateral supine obliques, or CT scan
- lines of contour (see Figure 2)
 - (NB in children < 8 years of age: physiologic subluxation of C2 on C3, and C3 on C4, but the spinolaminar line is maintained)
- widening of interspinous space (fanning of spinous processes) suggests posterior ligamentous disruption
- widening of facet joints
- check atlanto-occipital joint:
 - line extended inferiorly from clivus should transect odontoid
- atlanto-axial articulation - widening of predental space (> 3 mm in adults, > 5 mm in children)

B - Bones

- height, width and shape of each vertebral body
- pedicles, facets, and laminae should appear as one - doubling suggests rotation

C - Cartilages

- intervertebral disc spaces - widening anteriorly or posteriorly suggests vertebral compression

S - Soft Tissues

- widening of retropharyngeal (> 7 mm at C1-4, may be wide in children less than 2yo on expiration) or retrotracheal spaces (> 22 mm at C6-T1, > 14 mm in children < 15 years of age)
- prevertebral soft tissue swelling: only 49% sensitive for injury

Odontoid View

- rule out rotation and fracture
- odontoid should be centred between C1 lateral masses
- lateral masses of C1 and C2 should be perfectly aligned laterally
- lateral masses should be symmetrical (equal size)

Anteroposterior View

- alignment of spinous processes in the midline
- spacing of spinous processes should be equal
- check vertebral bodies

Indications for CT Scan

- inadequate plain film survey
- suspicious plain film findings
- to better delineate injuries seen on plain films
- any clinical suspicion of atlanto-occipital dislocation
- high clinical suspicion of injury despite normal plain films
- include C1-C3 when head CT is indicated in head trauma cases

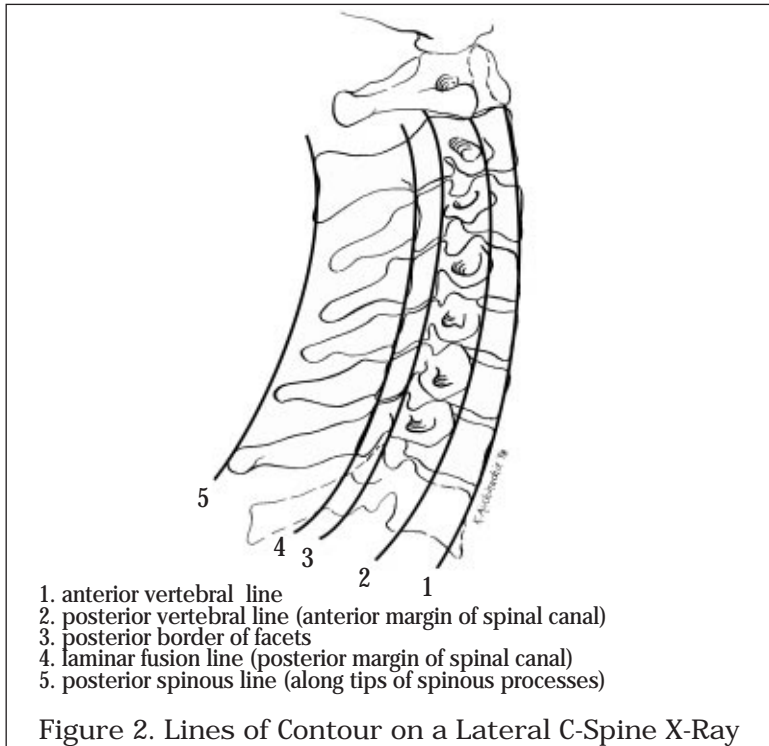


Figure 2. Lines of Contour on a Lateral C-Spine X-Ray

Drawing by Kim Auchinachie

Management Considerations

- immobilize C-spine with collar and sand bags (collar alone is not enough)
- injuries above C4 may need ventilation
- continually reassess high cord injuries - edema can travel up cord
- beware of neurogenic shock
- administer methylprednisolone within 8 hours of C-spine injury
- turn patient q2h to prevent decubitus ulcers
- clear C-spine and remove from board ASAP to prevent ulcers
- before O.R. ensure thoracic and lumbar x-rays are normal, since 20% of patients with C-spine fractures have other spinal fractures

Sequelae of C-spine Fracture

- decreased descending sympathetic tone (neurogenic / spinal shock) responsible for most sequelae
- cardiac
 - no autoregulation, falling BP, decreasing HR, vasodilation
 - GIVE IV FLUIDS ± pressors
- respiratory
 - no cough reflex (risk of aspiration pneumonia)
 - no intercostal muscles +/- diaphragm
 - intubate and maintain vital capacity
- GI
 - ileus, vasodilation, bile and pancreatic secretion continues (> 1L/day), risk of aspiration, GI stress ulcers
 - NG tube may be required for suctioning, feeding, etc...
- renal
 - hypoperfusion --> IV fluids
 - kidney still producing urine (bladder can rupture if patient not urinating)
 - Foley catheter may be required (measure urine output/perfusion)
- skin
 - vasodilation, heat loss, no thermoregulation, atrophy (risk of skin ulcers)
- muscle
 - flaccidity, atrophy, decreased venous return
- penis
 - priapism

PELVIC AND EXTREMITY INJURIES

- rarely life threatening, often limb threatening
- evaluation carried out in secondary survey
- patient must be completely undressed for evaluation

Physical Exam

- Look: deformity, swelling, bleeding, bruising, spasm, colour
- Feel: pulse, warmth, tenderness, crepitation, sensation, capillary refill
- Movement: ROM assessed actively (beware passive ROM testing)

Life Threatening Injuries

- major pelvic fractures
- traumatic amputations
- massive long bone fractures (e.g. femoral)
- vascular injuries proximal to knee/elbow

Limb Threatening Injuries

- fracture/dislocation of ankle
- crush injuries
- compartment syndrome
- dislocations of knee/hip
- fractures with vascular/nerve injury
- open fractures
- fractures above the elbow or knee

Blood Loss

- may be major in
 - pelvic fractures (up to 3.0 litres blood lost)
 - femur fractures (up to 2.0 litres blood lost per femur)
 - open fractures (double blood loss of a closed fracture)

Assessment of Neurovascular Injury

- assess pulses before and after immobilization
- diminished pulses should not be attributed to "spasm"
- angiography is definitive if diagnosis in doubt

Vascular Injuries Suggested by 5 P's

- pulse discrepancies
- pallor
- paresthesia/hypoesthesia (loss of sensation first sign of ischemia)
- paresis
- pain (especially when refractory to usual doses of analgesics)

Treatment of Vascular Compromise

- realign limb/apply traction
- recheck pulses (Dopplers)
- surgical consult
- consider measuring compartment pressures
- angiography

Compartment Syndrome

- rise in interstitial pressure above that of capillary bed (30-40 mmHg)
- usually in leg or forearm
- often associated with crush injuries (extensive soft tissue damage)
- diagnosed by measurement of compartment pressures
- suspect when you find
 - excessive pain with passive stretching of involved muscles
 - decreased sensation of nerves in that compartment
 - tense swelling
 - weakness, paralysis
- pulse may still be present until very late

Management of Extremity Injuries

- fractures
 - immobilize/traction
- open wounds
 - remove gross contamination, irrigate
 - cover with sterile dressing
 - definitive care within 6-8 hours
 - control bleeding with pressure (no clamping)
 - splint fracture
 - antibiotics - cefazolin (+/- gentamicin/metronidazole in extensive/dirty injury)
 - tetanus prophylaxis
- joint injuries
 - orthopedic consultation
 - reduce dislocations after x-ray
 - immobilize
- compartment syndrome
 - remove constrictive dressings/casts
 - prompt fasciotomy

SOFT TISSUE INJURIES

Bruises

- tender swelling (hematoma) following blunt trauma
- is patient on anticoagulants? coagulopathy?
- acute treatment
 - R - rest
 - I - ice
 - C - compression
 - E - elevation

Abrasions

- partial to full thickness break in skin
- management
 - clean thoroughly (under local anesthetic if necessary) with brush to prevent foreign body impregnation (tattooing)
 - antiseptic ointment (Polysporin) or vaseline for 7 days for facial and complex abrasions

Lacerations

- always consider every structure deep to a laceration severed until proven otherwise
- never test function against resistance
- physical exam
 - think about underlying anatomy
 - examine tendon function and neurovascular status distally
 - x-ray wounds if a foreign body is suspected (e.g. shattered glass) and not found when exploring wound
 - clean and explore under local anesthetic
- management
 - irrigate copiously with normal saline
 - evacuate hematomas, debride non-viable tissue, and remove foreign bodies
 - secure hemostasis
 - suture (Steristrip, glue, or staple for selected wounds) unless delayed presentation, a puncture wound, or animal bite
 - in general, facial sutures are removed in 5 days, those over joints in 10 days, and everywhere else in 7 days
 - in children, topical anesthetics such as TAC (tetracaine, adrenaline and cocaine) and in selected cases a short acting benzodiazepine (midazolam) for sedation and amnesia are useful
 - DO NOT use local anesthetic with epinephrine on fingers, toes, penis, ears, nose
 - maximum dose of lidocaine
 - 7 mg /kg with epinephrine
 - 5 mg /kg without epinephrine

Mammalian Bites

- ❑ important points on history:
 - time and circumstances of bite
 - symptoms
 - comorbid conditions
 - allergies
 - tetanus
 - rabies risks
- ❑ on examination
 - assess type of wound: abrasion, laceration, puncture, crush injury
 - assess for direct tissue damage - skin, bone, tendon, neurovascular
- ❑ x-rays
 - if bony injury or infection suspected check for gas in tissue
 - ALWAYS get skull films in children with scalp bite wounds, +/- CT to rule out cranial perforation
- ❑ treatment
 - wound cleansing and copious irrigation as soon as possible
 - irrigate/debride puncture wounds if feasible, but not if sealed or very small openings - avoid hydrodissection along tissue planes
 - debridement is important in crush injuries to reduce infection and optimize cosmetic and functional repair
 - culture wound if signs of infection (erythema, necrosis or pus) - anaerobic cultures if foul smelling, necrotizing, or abscess
 - notify lab that sample is from bite wound
- ❑ most common complication of mammalian bites is infection (2 to 50%)
 - types of infections resulting from bites: cellulitis, lymphangitis, abscesses, tenosynovitis, osteomyelitis, septic arthritis, sepsis, endocarditis, meningitis
 - early wound irrigation and debridement are the most important factors in decreasing infection
- ❑ to suture or not to suture?
 - the risk of wound infection is related to vascularity of tissue
 - vascular structures (i.e. face and scalp) are less likely to get infected, therefore suture
 - avascular structures (i.e. pretibial regions, hands and feet) by secondary repair
- ❑ high risk factors for infection
 - puncture wounds
 - crush injuries
 - wounds greater than 12 hours old
 - hand or foot wounds, wounds near joints
 - immunocompromised patient
 - patient age greater than 50 years
 - prosthetic joints or valves

Tetanus Prophylaxis

- ❑ clean wounds
 - management
 - tetanus status unknown or never vaccinated --> full course tetanus toxoid
 - last tetanus > 10 years --> booster
 - last tetanus < 10 years --> nothing
- ❑ dirty wounds
 - management
 - tetanus status unknown or never vaccinated: --> tetanus Ig (human) + full course tetanus toxoid
 - last tetanus > 10 years --> booster
 - last tetanus < 10 years --> nothing

Prophylactic antibiotics

- ❑ widely recommended for all bite wounds to the hand
- ❑ should be strongly considered for all other high-risk bite wounds
- ❑ 3-5 days is usually recommended for prophylactic therapy
- ❑ dog and cat bites (pathogens: *Pasteurella multocida*, *S. aureus*, *S. viridans*)
 - 1st line: Clavulin
 - 2nd line: tetracycline or doxycycline
 - 3rd line: erythromycin, clarithromycin, azithromycin

- human bites (pathogens: *Eikenella carrodens*, *S. aureus*, *S. viridans*, oral anaerobes)
 - 1st line: Clavulin
 - 2nd line: erythromycin, clarithromycin, azithromycin
 - 3rd line: clindamycin

ENVIRONMENTAL INJURIES

Burns (see Plastic Surgery Notes)

- immediate management
 - remove noxious agent
 - resuscitation
 - Ringer's lactate: 4cc/kg/%BSA burned (not including 1st degree) according to Parkland formula (1/2 in first 8 hours, 1/2 in second 16 hours)
 - at 8 hours, fresh frozen plasma or 5% albumin: if > 25% BSA give 3-4 U/day for 48 hours
 - second 8 hours, 2/3-1/3 at 2cc/kg/%BSA
 - urine output should be 40-50 cc/hr or 0.5 cc/kg/hr
 - avoid diuretics
 - continuous morphine infusion at 2 mg/hr with rescue bolus
 - burn wound care
 - escharotomy or fasciotomy for circumferential burns (chest, extremities)
 - cover gently with sterile dressings
 - systemic antibiotics infrequently indicated
 - topical - silver sulfadiazene; face - polysporin; ears - sulfomyalon
- guidelines for hospitalization
 - 10-50 years old with 2nd degree burns to > 15% TBSA or 3rd degree to greater than 5% TBSA
 - less than 10 years old or > 50 years old with 2nd degree to > 10% TBSA or 3rd degree to > 3% TBSA
 - 2nd or 3rd degree on face, hands, feet, perineum or across major joints
 - electrical or chemical burns
 - burns with inhalation injury
 - burn victims with underlying medical problems or immunosuppressed patients (e.g. DM, cancer, AIDS, alcoholism)

Inhalation Injury

- CO poisoning
 - closed environment
 - cherry red skin/blood (usually a post-mortem finding)
 - headache, nausea, confusion
 - pO₂ normal but O₂ sat low
 - measure carboxyhemoglobin levels
 - treatment: 100% O₂ +/- hyperbaric O₂
- thermal airway injury
 - etiology: injury to endothelial cells and bronchial cilia due to fire in enclosed space
 - symptoms and signs: facial burns, intraoral burns, singed nasal hairs, soot in mouth/nose, hoarseness, carbonaceous sputum, wheezing
 - investigations: CXR +/- bronchoscopy
 - treatment: humidified oxygen, early intubation, pulmonary toilet, bronchodilators

Hypothermia

- predisposing factors: old age, lack of housing, drug overdose, EtOH ingestion, trauma (incapacitating), cold water immersion, outdoor sports
- diagnosis: mental confusion, impaired gait, lethargy, combativeness, shivering
- treatment on scene
 - remove wet clothing; blankets + hot water bottles; heated O₂, warmed IV fluids
 - no EtOH due to peripheral vasodilating effect

- vitals (take for > 1 minute)
- cardiac monitoring; no chest compressions until certain patient pulseless > 1 minute, since can precipitate ventricular fibrillation
- NS IV since patient is hypovolemic and dehydrated secondary to cold water diuresis and fluid shifts
- note: if body temperature < 32.2°C, you may see decreased heart rate, respiratory rate, and muscle tone, dilated + fixed pupils (i.e. patient appears "dead")
- due to decreased O₂ demands, patient may recover without sequelae
- ❑ treatment in hospital
 - patient hypovolemic and acidotic
 - rewarm slowly with warm top + bottom blankets (risk of "afterdrop" if cold acidotic blood of periphery recirculated into core)
 - at body temperature < 30°C risk of ventricular fibrillation therefore warm via peritoneal/hemodialysis or cardiopulmonary bypass
- ❑ PATIENT IS NOT DEAD UNTIL THEY ARE WARM AND DEAD!

Frostbite

- ❑ classified according to depth - similar to burns (1st to 3rd degree)
- ❑ 1st degree
 - symptoms: initial paresthesia, pruritis
 - signs: erythema, edema, hyperemia, NO blisters
- ❑ 2nd degree
 - symptoms: numbness
 - signs: blistering, erythema, edema
- ❑ 3rd degree
 - symptoms: pain, burning, throbbing (on thawing)
 - signs: hemorrhagic blisters, skin necrosis, edema, decreased range of motion
- ❑ management
 - remove wet and constrictive clothing
 - immerse in 40-42°C water for 10-30 minutes
 - elevate, wrap individual appendages in dry gauze
 - tetanus prophylaxis
 - ASA
 - local anti-infective
 - prophylactic IV antibiotics for deep frostbite
 - surgical
 - amputation/debridement in 3-6 weeks if no recovery
 - never allow a thawed area to re-freeze

PEDIATRIC TRAUMA CONSIDERATIONS

- ❑ priorities remain the same

Airway

- ❑ "sniffing position"
- ❑ short trachea (5 cm in infants, 7.5 cm at 18 months)
- ❑ orotracheal tube diameter = age/4 + 4
- ❑ uncuffed ETT under age 8
- ❑ surgical cricothyroidotomy NOT indicated
- ❑ needle cricothyroidotomy with jet ventilation if unable to intubate

Breathing

- ❑ stethoscope not as useful for diagnosing problems - noting tachypnea is important

Circulation

- ❑ normal blood volume = 80 ml/kg
- ❑ fluid resuscitation
 - bolus crystalloid 20 ml/kg
 - repeat x 1 if necessary
 - blood replacement if no response to 2nd bolus of crystalloid

- venous access
 - intraosseous infusion if unable to establish IV access in < 30 seconds
 - venous cutdown (medial cephalic, external jugular, great saphenous)

Thermoregulation

- children prone to hypothermia
- blankets/external warming/cover scalp

	P	sBP	RR
infant	< 160	80	40
preschool	< 140	90	30
adolescent	< 120	100	20

TRAUMA IN PREGNANCY

- treatment priorities the same
- the best treatment for the fetus is to treat the mother

Hemodynamic Considerations

- near term, inferior vena caval compression in the supine position can decrease cardiac output by 30-40%
 - use left lateral decubitus positioning to alleviate compression and increase blood return
- BP drops 5-15 systolic in 2nd trimester, increases to normal by term
- HR increases 15-20 beats by 3rd trimester

Blood Considerations

- physiologic macrocytic anemia of pregnancy (Hb 100-120)
- WBC increases to high of 20 000

Shock

- pregnant patients may lose 35% of blood volume without usual signs of shock (tachycardia, hypotension)
- however, the fetus may be in "shock" due to contraction of the uteroplacental circulation

Management Differences

- place bolster under right hip to stop inferior vena cava compression
- fetal monitoring (Doppler)
- early obstetrical involvement
- don't avoid x-rays (C-spine, CXR, pelvis)

ANALGESIA

Table 6. Analgesics Indicated for Specific Presentations (Adults)

Injury	Drug	Dose	Route	Notes
severe trauma, burns, visceral pain, perforation, myocardial infarction, biliary/renal colic, pancreatitis	morphine* demerol	2-10 mg 12.5-25 mg	IV IV	titrate doses to effect
renal colic	indomethacin	100 mg	PR	may decrease narcotic need
gout	indomethacin	25-100 mg TID	PO	start high dose and taper over 5-7 days
soft tissue injuries, dysmenorrhea	NSAID		PO	
earache/sore throat	acetaminophen	10-15 mg/kg q4h	PO	antipyretic/ analgesic
dental	codeine and/or	1 mg/kg	PO	NSAID
herpes zoster, trigeminal neuralgia	codeine and/or carbamazepine	1 mg/kg 100 mg BID	PO PO	titrate up

*may need Gravol 25-50 mg IV for nausea when using opioid analgesics

HEADACHE

- key principles
 - brain is anesthetic (most headaches arise from surrounding structures such as blood vessels, periosteum, muscle)
 - every headache is serious until proven otherwise
- serious causes
 - increased ICP due to mass lesions (abscess, subdural, brain tumour)
 - intracranial bleeding from subarachnoid or intracerebral hemorrhage
 - meningitis (bacterial or viral)
 - temporal arteritis and other vasculitides
- common types
 - common migraine (no aura)
 - classic migraine (involves aura)
 - tension headache
 - cluster headache
- clinical danger signs
 - worst headache ever or change in quality of previous headache
 - sudden onset
 - decreased level of consciousness
 - history of trauma
 - new onset in person over age 50 or under age 10
 - persistent nausea / vomiting
 - symptoms persisting over days and weeks
 - meningeal irritation (Kernig's Sign, Brudzinski's Sign)
 - abnormal vital signs (including fever)
 - focal neurological signs
 - pupillary abnormality
- investigations
 - CT scan (low sensitivity for meningitis but 95% sensitive for subarachnoid bleeds)
 - LP to rule out bleed or meningitis if CT negative

CHEST PAIN (ATRAUMATIC)

Must Rule Out Life-Threatening Causes

- unstable angina/acute MI
- thoracic aortic dissection
- pulmonary embolism
- spontaneous pneumothorax (\pm tension)
- esophageal rupture
- pericarditis / cardiac tamponade

Additional Differential Diagnosis

- stable angina
- GI disorders: PUD, pancreatitis, cholecystitis, esophagitis, etc...
- pneumonia
- MSK
- psychogenic

History

- compare with previous episodes
- description of pain
- deep visceral vs. superficial somatic
- classic presentations (remember, presentations are seldom classic)
 - aortic dissection - sudden severe tearing pain, often radiating to back
 - pulmonary embolism - pleuritic chest pain (75%), dyspnea, anxiety
 - pericarditis - anterior precordial pain, pleuritic, relieved by sitting up and leaning forward
 - acute CAD - retrosternal squeezing/pressure pain, radiation to arm/neck, dyspnea, nausea/vomiting, syncope
- consider esophageal etiology with the following:
 - frequent heartburn
 - acid reflux
 - dysphagia
 - relief with antacids
- associated symptoms
- risk factors for CAD, PE
- more likely to be atypical in females, and people > 80-years-old

Physical Exam

- vitals
 - tachypnea (may be only sign of PE)
 - BP in BOTH arms \rightarrow > 20 mmHg difference suggests thoracic aortic dissection
- palpate chest wall for tender points but not a good discriminator since 25% of patients with acute MI have chest wall tenderness
 - accept only if fully reproduces pain symptoms, and more serious causes excluded
 - may result from pleural inflammation
- cardiac exam
 - friction rub
 - new murmurs
 - mitral regurgitation murmur in acute MI (papillary muscle dysfunction)
 - aortic insufficiency murmur in aortic dissection
- respiratory exam
 - percuss and auscultate all the lung fields
- peripheral vascular exam - abdomen, extremities

Investigations

- ECG
 - cardiac + non-cardiac causes (PE)
 - PE, acute MI may have NORMAL ECG!
 - always compare with previous

- ❑ CXR
 - pulmonary embolism
 - often completely NORMAL
 - atelectasis, elevated hemidiaphragm, Westermark's sign, Hampton's hump
 - aortic dissection
 - mediastinal widening, bulging aortic arch, pleural effusion, separation of intimal calcification from edge of aortic shadow
- ❑ ABGs - NORMAL in 20% of patients with PE
- ❑ serial cardiac enzymes (see Cardiology Section)
 - normal CK does NOT rule out MI
 - elevated CK is MI until proven otherwise
 - newer markers (e.g. troponin I) increase accuracy
- ❑ V/Q scan if suspicion of PE

ANAPHYLAXIS

- ❑ anaphylactic: IgE mediated, requires sensitization, time lag, and reexposure (e.g. food, vaccines, antibiotics)
- ❑ anaphylactoid: non-IgE mediated, direct trigger, may occur with first exposure (e.g. radiocontrast dyes, ASA, NSAIDS)
- ❑ symptoms and signs
 - cardiovascular collapse (shock)
 - marked anxiety and apprehension
 - generalized urticaria, edema, erythema, light-headedness
 - choking sensation, cough, bronchospasm or laryngeal edema
 - abdominal pain, nausea, vomiting, diarrhea
- ❑ allergies and prior episodes important
- ❑ severe cases:
 - hypotension and loss of consciousness ± incontinence
 - sudden death
- ❑ treatment
 - stop the cause
 - secure airway and obtain IV access
 - on scene - "epi-pen" (injectable epinephrine) if available
 - if signs and symptoms are MODERATE (minimal airway edema, mild bronchospasm, cutaneous reactions) treat with
 - adult 0.3 -0.5 ml of 1:1000 solution IM or SC epinephrine
 - child 0.01 ml/kg/dose up to 0.4mL/dose 1:10 000 epinephrine
 - if signs and symptoms are SEVERE (laryngeal edema, severe bronchospasm and shock) then give:
 - epinephrine via IV or endotracheal tube starting at 1 ml of 1:10 000
 - diphenhydramine 50mg IM or IV (Benadryl)
 - methylprednisolone 50-100 mg IV dose depending on severity
 - salbutamol via nebulizer if bronchospasm present

ALCOHOLIC EMERGENCIES

- ❑ acute intoxication - slurred speech, CNS depression, disinhibited behavior, poor coordination
 - nystagmus, diplopia, dysarthria, ataxia --> coma
 - "blackouts"
 - frank hypotension (peripheral vasodilation)
- ❑ obtundation - may be due to alcohol intoxication, but must rule out:
 - associated head trauma
 - cerebral atrophy + repeated falls --> increased subdural risk
 - associated depressant/street drugs
 - synergistic with alcohol --> respiratory/cardiac depression
 - hypoglycemia: must screen with bedside glucometer

- hepatic encephalopathy
 - precipitating factors: GI bleed, infection, sedation, electrolyte abnormalities, protein meal
- Wernicke's encephalopathy
 - horizontal or vertical nystagmus, CN VI paresis, confusion, ataxia
 - ocular findings may be absent at time of presentation
 - give thiamine
- other neurological problems
 - e.g. post-ictal state following seizures induced by alcohol withdrawal
- ❑ syndromes of withdrawal (may occur before blood alcohol level reaches zero)
 - 1) Mild withdrawal
 - 6-8 hours after last intake
 - generalized tremor, anxiety, agitation but no delirium
 - autonomic hyperactivity, insomnia, nausea, vomiting
 - 2) Alcoholic hallucinosis
 - visual and auditory hallucinations
 - onset: 24-36 hours after stopping intake
 - vital signs often normal
 - 3) Alcohol withdrawal seizures
 - usually brief, generalized tonic-clonic seizures
 - focal findings or prolonged seizure --> do CT scan --> LP
 - 4) Delirium Tremens - (5% of untreated withdrawal patients)
 - high rate of mortality
 - 3-5 days after stopping alcohol
 - severe confusional state
 - agitation, insomnia, hallucinations/delusions, tremor, tachycardia
 - hyperpyrexia, diaphoresis
- ❑ treatment of alcohol withdrawal
 - many protocols
 - 10-20 mg diazepam(Valium) PO/IV q1h prn for agitation no upper limit
 - 100 mg thiamine IM then 100 mg PO x 3 days
 - patient with DT's must be admitted

Metabolic Abnormalities

- ❑ alcoholic ketoacidosis
 - history of chronic alcohol intake, malnourished, abdominal pain
 - lab findings of metabolic acidosis, positive nitroprusside test, glucose low and osmolality normal, ethanol level zero
 - treatment: dextrose, thiamine and normal saline
- ❑ abnormal alcohols
 - ethylene glycol --> CNS, CVS, renal findings
 - methanol
 - early: lethargy, confusion
 - late: headache, visual changes, N&V, abdo pain, tachypnea
 - both produce severe metabolic acidosis with anion gap and osmolal gap
 - ethanol co-ingestion is protective
 - treatment
 - IV 10% ethanol bolus and drip to achieve blood level of 20 mmol/L
 - alcohol loading may be done PO
 - fomepizole (4-mp) if available
 - urgent hemodialysis required
- ❑ "lesser" electrolyte abnormalities
 - hypomagnesemia
 - hypophosphatemia
 - hypocalcemia

GI Abnormalities

- gastritis
 - common cause of abdominal pain and GI bleed in chronic alcohol users
- pancreatitis
 - serum amylase very unreliable in patients with chronic pancreatitis
 - hemorrhagic form (15%) associated with increased mortality
- hepatitis
 - AST/ALT ratio > 2 suggests alcohol as the cause
- peritonitis
 - occasionally accompanies cirrhosis
 - leukocytosis, fever, generalized abdominal pain
 - paracentesis for diagnosis
- GI bleeds
 - most commonly gastritis or ulcers, even if patient known to have varices
 - must consider Mallory-Weiss tear
 - often complicated by underlying hematologic abnormalities

Miscellaneous Problems

- dysrhythmias ("holiday heart")
 - binge drinking precipitates arrhythmias
 - atrial fib, PAT, PVCs
 - treatment: abstinence ± medications depending on severity
- rhabdomyolysis
 - presents as acute weakness associated with muscle tenderness
 - usually occurs after prolonged immobilization
 - increased creatinine kinase, hyperkalemia
 - myoglobinuria - may lead to acute renal failure
 - treatment: IV fluids, forced diuresis (mannitol)
- fever
 - look for a source of fever
 - atypical pneumonias (Gram negatives, anaerobes, TB)
 - meningitis
 - peritonitis
 - hepatitis
 - not a benign finding in an alcoholic
 - alcoholics are slightly immunosuppressed

VIOLENT PATIENTS

- SAFETY FIRST - yourself, patient, staff, other patients
- always consider and rule out organic causes (as they can be fatal)
- leading organic causes are EtOH, drugs, and head injuries

Differential Diagnosis

- organic
 - drugs/toxins/withdrawal
 - metabolic (electrolyte abnormalities, hypoglycemia, hypoxia)
 - infections (sepsis, encephalitis, brain abscess etc...)
 - endocrine (Cushing's, thyrotoxicosis)
 - CNS (head injuries, tumour, seizure, delirium and dementia)
- functional/psychiatric
 - situational crisis
 - schizophrenia, bipolar disorder (manic), personality disorder

Prevention

- be aware and look for prodromal signs of violence
 - prior history of violence or criminal behavior
 - anxiety, restless
 - defensiveness, verbal attacks
- de-escalate the situation early - may not always work
 - address the patient's anger
 - empathize

Restraints

- physical
 - present option to patient in firm but non-hostile manner
 - demonstrate sufficient people to carry it out
 - restrain supine or on side
 - suction and airway support available in case of vomiting
- pharmacologic
 - often necessary - may mask clinical findings and impair exam
 - haloperidol 5-10 mg IM (be prepared for dystonic reactions, especially with multiple doses of neuroleptics over a short period) + lorazepam 2 mg IM
 - look for signs of anticholinergic OD first (see Toxicology Section)
- once restrained, search person/clothing for drugs and weapons

History

- antecedent and precipitating events and locale
- drugs
 - prescription
 - over-the-counter (antihistamines, anticholinergics, stimulants)
 - recreation/abuse/steroids
 - withdrawal reaction
- past medical history (especially diabetes mellitus)
- past psychiatric history and past legal history
- patient's insight
- ask family/friends what they think is wrong

Physical Exam

- vitals
 - temperature often increased in delirium or toxic psychosis
 - hypothermia may have altered mental status
- signs of trauma - especially head and neck
- neurologic exam, including brief mental status
- signs of drug toxicity and needle marks
- signs of hypoglycemia

Investigations

- screening bloodwork: CBC, lytes, glucose, creatinine, BUN, osmolality
- selective drug and toxin screen (see Toxicology Section)

SUICIDAL PATIENT (see Psychiatry Notes)

SEXUAL ASSAULT

- involve local/regional Sexual Assault Team

General Management Principles

- ABC's first
- ensure patient is not left alone and ongoing emotional support provided
- set aside adequate time for exam (usually 1 1/2 hours)
- obtain consent for:
 - medical exam and treatment
 - collection of evidence
 - disclosure to police --> notify police as soon as consent obtained
- use Sexual Assault Kit to ensure uniformity and completeness
- samples --> labelled immediately --> passed directly to police
- offer community crisis resources (e.g. shelter, hotline)

History

- who? how many? when?
- where did penetration occur?
- what happened? any weapons or physical assault?
- post-assault activities (urination, defecation, change of clothes, shower, douche, etc ...)

- gynecologic history
 - gravity, parity
 - last menstrual period
 - contraception
 - last voluntary intercourse (sperm motile 6-12 hours in vagina, 5 days in cervix)
 - allergies and past medical history

Physical Exam

- evidence collection is always secondary to treatment of serious injuries
- never retraumatize a patient with the examination
- general examination
 - mental status
 - sexual maturity
 - patient should remove clothes and place in paper bag
 - document abrasions, bruises, lacerations, torn frenulum/broken teeth (indicates oral penetration)
- pelvic exam and specimen collection
 - ideally before urination or defecation
 - examine for seminal stains, hymen, signs of trauma
 - collect moistened swabs of dried seminal stains
 - hair clippings with dried semen
 - pubic hair combings and cuttings
 - posterior fornx secretions if present or aspiration of saline irrigation
 - immediate wet smear for motile sperm
 - air-dried slides for immotile sperm, acid phosphatase, ABO group
 - Pap smear
 - endocervical culture for gonorrhea and chlamydia
 - speculum exam
 - lubricate with water only
 - vaginal lacerations, foreign bodies
- other specimens to be obtained
 - fingernail scrapings
 - anus/mouth cultures and smears if appropriate
 - saliva sample from victim
 - VDRL - repeat in 3 months if negative
 - serum β -HCG
 - blood for ABO group, Rh type
 - baseline serology (e.g. hepatitis, HIV)

Treatment

- medical
 - suture lacerations
 - tetanus prophylaxis
 - gynecology consult for foreign body, complex lacerations
 - treat as presumed positive for gonorrhea and chlamydia \pm trichomonas
 - may start prophylaxis for hepatitis B and HIV
 - pre and post counselling for HIV testing
- pregnancy prophylaxis offered
 - patient exposed midcycle is at highest risk
 - ethinyl estradiol 100mg and norgestrel 1mg or equivalent ("Morning after pills") stat with antiemetic prn
 - repeat in 12 hours
- psychological
 - high incidence of psychological sequelae
 - have victim change and shower after exam completed
 - follow-up with MD in rape crisis centre within 24 hours
 - best if patient does not leave ED on own

Male Victims

- approach is the same
- attention to mouth and rectum

APPROACH TO THE OVERDOSE PATIENT

Principles of Toxicology

- "All substances are poisons ... The right dose separates a poison from a remedy"
- 5 questions to consider with all ingestions
 - is this a toxic ingestion?
 - can the agent be removed?
 - what is alternate treatment?
 - would decontamination be dangerous?
 - what options are available?
- suspect overdose when
 - altered level of consciousness /coma
 - young patient with life-threatening arrhythmia
 - trauma patient
 - bizarre or puzzling clinical presentation

ABCs OF TOXICOLOGY

- basic axiom of care is symptomatic and supportive treatment
- can only address underlying problem once patient is stable
 - A Airway
 - B Breathing
 - C Circulation (consider stabilizing the C-spine)
 - D1 Drugs
 - ACLS as necessary to resuscitate the patient
 - universal antidotes
 - D2 Draw bloods
 - D3 Decontaminate (protect yourself!)
 - E Expose (look for specific toxidromes)/Examine the Patient
 - F Full vitals, ECG monitor, Foley, x-rays, etc...
 - G Give specific antidotes, treatments
- GO BACK!! Reassess

D1 - UNIVERSAL ANTIDOTES

- treatments which will never hurt any patient and which may be essential

Oxygen

- do not deprive a hypoxic patient of oxygen no matter what the antecedent medical history (i.e. even COPD and CO₂ retention)
- if depression of hypoxic drive --> intubate and ventilate
- only exception: paraquat or diquat exposure (inhalation or ingestion)

Thiamine (Vitamin B₁)

- give 100 mg IV/IM to all patients prior to IV/PO glucose
- a necessary cofactor for glucose metabolism, but do not delay glucose if thiamine unavailable
- purpose is to prevent Wernicke-Korsakoff syndrome
 - Wernicke's encephalopathy - ophthalmoplegia, ataxia, global confusion
 - untreated, may progress to Korsakoff's psychosis (disorder in learning and processing of new information)
 - treatment: high dose thiamine (1000 mg/day x 3 days)
 - most features usually irreversible
- populations at risk for thiamine deficiency
 - alcoholics
 - anorexics
 - hyperemesis of pregnancy
- in ED, must assume all undifferentiated comatose patients are at risk

Glucose

- give to any patient presenting with altered LOC
- do dextrostix prior to glucose administration (if time permits)
- 0.5-1.0 g/kg immediately (D50W in adults, D25W in children)

Naloxone

- antidote for opioids
- used in the setting of the undifferentiated comatose patient
- loading dose
 - adults
 - 2 mg initial bolus IV/IM/SL/SC or via ETT
 - 8-10 mg (0.1 mg/kg) if no response after 5 minutes and narcotic use still suspected
 - known chronic user, suspicious history, or evidence of tracks
 - 0.01 mg/kg (to prevent acute withdrawal)
 - child
 - 0.01 mg/kg initial bolus
 - 0.1 mg/kg if no response and still suspect narcotic
- maintenance dose
 - may be required because half-life of naloxone much shorter than many narcotics (half-life of naloxone is 30-80 minutes)
 - continuous infusion at 2/3 of original effective dose per hour, titrate to effect

D2 - DRAW BLOODS

- essential bloods
 - CBC, electrolytes, urea, creatinine
 - glucose (and dextrostix), PT/PTT
 - ABGs, measured O₂ sat
 - osmolality
 - ASA, acetaminophen levels
- potentially useful bloods
 - drug levels
 - Ca²⁺, Mg²⁺, PO₄³⁻
 - protein, albumin, lactate, ketones and liver tests

Serum Drug Levels

- treat the patient, not the drug level
- where the levels make a difference if in toxic range
 - methanol
 - ethylene glycol
 - carboxyhemoglobin
 - methemoglobin
 - iron
 - lithium
 - acetaminophen
 - ASA
 - theophylline
 - phenobarbital
 - digoxin
- available on most "general" serum screens
 - alcohols except ethylene glycol
 - sedative/hypnotics including barbiturates
 - ASA
 - acetaminophen
- specific requests
 - ethylene glycol
 - benzodiazepines (qualitative only)
 - bromide
 - ethchlorvynol (obsolete sleep drug)
- urine screens also available (qualitative only)

Important Concepts

- anion gap (AG)
 - Na⁺ - (Cl⁻ + HCO₃⁻), normal range ~10 ~14 mmol/L
 - unmeasured cations: Mg²⁺, Ca²⁺
 - unmeasured anions: proteins, organic acids, PO₄³⁻, sulfate

- metabolic acidosis
 - increased AG (differential of causes, toxic causes circled)
 - Alcoholic ketoacidosis
 - Methanol
 - Uremia
 - Diabetic ketoacidosis
 - Phenformin/paraldehyde
 - INH/iron
 - Lactate (any drug that causes seizures or shock)
 - Ethylene glycol
 - CO, CN⁻
 - ASA
 - Toluene
 - decreased AG
 - error
 - electrolyte imbalance (increased Na⁺/K⁺/Mg⁺⁺)
 - Li, Br elevation
 - increased serum protein (albumin, IgG, multiple myeloma)
 - normal AG
 - increased K⁺: pyelonephritis, obstructive nephropathy, RTA IV, TPN
 - decreased K⁺: small bowel losses, acetazolamide, RTA I, II
- osmolal gap
 - (measured - calculated) osmoles
 - normally about 10 mOsmol/L or less
 - calculated osmolality = $2 \text{ Na}^+ + \text{BUN} + \text{blood glucose (mmol/L)}$
 - increased osmolal gap
 - alcohols (ethanol, methanol, ethylene glycol)
 - glycerol, mannitol, sorbitol
 - acetone
 - others
- oxygen saturation gap
 - (measured - calculated) O₂ saturation
 - measured by absorption spectrophotometry
 - calculated from Hb/O₂ saturation curve
 - increased O₂ saturation gap
 - carboxyhemoglobin
 - methemoglobin
 - sulfhemoglobin

Test	Finding	Selected Causes
ABGs	hypoventilation (elevated P _{CO2}) hyperventilation	CNS depressants (opioids, sedative-hypnotic agents, phenothiazines, and EtOH) Salicylates, CO, other asphyxiants
electrolytes	anion-gap metabolic acidosis hyperkalemia hypokalemia	"A MUDPILE CAT" digitalis glycosides, fluoride, potassium theophylline, caffeine, beta-adrenergic agents, soluble barium salts, diuretics
glucose	hypoglycemia	oral hypoglycemic agents, insulin, EtOH
osmolality and osmolar gap	elevated osmolar gap	EtOH, methanol, ethylene glycol, isopropyl alcohol, acetone
ECG	wide QRS complex prolongation of QT interval atrioventricular block	TCAs, quinidine, other class Ia and Ic antiarrhythmic agents quinidine and related antiarrhythmics, terfenadine, astemizole calcium antagonists, digitalis glycosides, phenylpropanolamine
abdominal x-ray	radiopaque pills or objects	"CHIPES" Calcium, Chloral hydrate, CCl ₄ , Heavy metals, Iron, Potassium, Enteric coated, Salicylates, and some foreign bodies
serum acetaminophen	elevated level (>140 mg/l 4 hours after ingestion)	Acetaminophen (may be the only clue to a recent ingestion)

D3 - DECONTAMINATION

PROTECT YOURSELF FIRST

Ocular Decontamination

- saline irrigation to neutral pH
- alkali exposure requires ophthalmology consult

Dermal Decontamination

- remove clothing
- brush off toxic agents
- irrigate all external surfaces

Gastrointestinal Decontamination

- activated charcoal (AC)
 - absorption of drug/toxin to charcoal prevents availability and promotes fecal elimination
 - single dose will prevent significant absorption of many drugs and toxins
 - exceptions are acids, alkalis, cyanides, alcohols, Fe, Li
 - dose = 1 g/kg body weight or 10 g/g drug ingested
 - cathartics probably no longer have any clinical indication
 - multidose activated charcoal (MDAC) can increase drug elimination
 - without charcoal, gut continuously absorbs toxins; MDAC interrupts the enterohepatic circulation of some toxins and binds toxin diffusing back into enteral membrane from the circulation
 - dose
 - various regimes
 - continue until nontoxic or charcoal stool

- ❑ whole bowel irrigation
 - 500 cc (child) to 2000 cc (adult) of balanced electrolyte solution/hour by mouth until clear effluent per rectum
 - indications
 - awake, alert patient who can be nursed upright
 - delayed release product
 - drug/toxin not bound to charcoal
 - drug packages - if any evidence of breakage --> emergency surgery
 - contraindications
 - evidence of ileus, perforation, or obstruction
- ❑ endoscopic removal
 - indicated for drugs
 - that are toxic
 - that form concretions
 - that are not removed by conventional means
- ❑ gastric lavage: historical

E - EXAMINE THE PATIENT

- ❑ important to examine for : vital signs (including temperature), skin (needle tracks, colour), mucous membranes, odours and CNS
- ❑ head-to-toe survey, including
 - C-spine
 - signs of trauma
 - signs of seizures (incontinence, "tongue biting", etc...)
 - signs of infection (meningismus)
 - signs of chronic alcohol abuse
 - signs of drug abuse (track marks, nasal septum erosion)
 - mental status

SPECIFIC TOXIDROMES

Narcotics, Sedatives/Hypnotics, Alcohol Overdose

- ❑ signs and symptoms
 - hypothermia
 - bradycardia
 - hypotension
 - respiratory depression
 - dilated/constricted pupils
 - CNS depression

Sympathomimetics

- ❑ signs and symptoms
 - increased temperature
 - tachycardia
 - hypertension
 - dilated pupils
 - ❑ drugs
 - amphetamines
 - cocaine
 - LSD
 - theophylline
 - ASA toxicity looks like sympathomimetic overdose
 - sedative/hypnotic withdrawal (including alcohol) also similar
- CNS excitation (including seizures)
 - nausea and vomiting
 - diaphoresis

Drug / Substance Withdrawal

- ❑ withdrawal state generally opposite to the physiological effect of the drug
 - ❑ signs and symptoms of sedative withdrawal
 - increased temperature
 - tachycardia
 - hypertension
 - dilated pupils
 - diaphoresis
 - ❑ drugs
 - sedatives/hypnotics
 - alcohol
- agitation
 - tremor
 - hallucinations
 - seizures

Cholinergic

- ❑ signs and symptoms (DUMBELS)
 - Diaphoresis, diarrhea, decreased blood pressure
 - Urination
 - Miosis
 - Bronchorrhea, bronchospasm, bradycardia
 - Emesis, excitation of skeletal muscle
 - Lacrimation
 - Salivation, seizures
- ❑ drugs
 - cholinergics (nicotine, mushrooms)
 - anticholinesterases (physostigmine, organophosphates)

Anticholinergics

- ❑ signs and symptoms
 - hyperthermia "Hot as a Hare"
 - dilated pupils "Blind as a Bat"
 - decreased sweating "Dry as a Bone"
 - vasodilatation "Red as a Beet"
 - agitation "Mad as a Hatter"
 - tachycardia
 - hypo/hypertension
 - ileus
 - urinary retention
- ❑ drugs
 - antidepressants
 - Flexeril
 - Tegretol
 - antihistamines (e.g. Gravol, diphenhydramine)
 - antiparkinsonians
 - antipsychotics
 - antispasmodics
 - belladonna alkaloids (e.g. atropine, scopolamine)

Extrapyramidal

- ❑ signs and symptoms
 - dysphonia • rigidity and tremor
 - dysphagia • torticollis
 - laryngospasm • trismus
 - oculogyric crisis
- ❑ drugs
 - major tranquilizers

Hemoglobin Derangements

- ❑ signs and symptoms
 - increased respiratory rate
 - decreased level of consciousness
 - seizures
 - cyanosis (unresponsive to O₂)
- ❑ causes
 - carbon monoxide poisoning (carboxyhemoglobin)
 - drug ingestion (methemoglobin, sulfhemoglobin)

Metal Fume Fever

- ❑ signs and symptoms
 - abrupt onset of fever, chills, myalgias
 - metallic taste in mouth
 - nausea and vomiting
 - headache
 - fatigue (delayed respiratory distress)
- ❑ caused by fumes from heavy metals (welding, brazing, etc...)

G - GIVE SPECIFIC ANTIDOTES AND TREATMENTS

Toxin	Antidote/Treatment
Acetaminophen	N-acetylcysteine
Anticholinergics	*Physostigmine
Benzodiazepines	Flumazenil
Beta-blockers	Glucagon
Calcium Channel blockers	Calcium chloride or gluconate, glucagon
Carbon Monoxide	100% oxygen, hyperbaric O ₂
Cyanide	Lilly kit (amyl nitrite, then sodium nitrite): Na thiosulfate
Digitalis	stop dig, use FAB fragments, restore K ⁺
Heparin	Protamine Sulfate
Iron	Deferoxamine
Methanol/Ethylene glycol	Ethanol
Nitrites	Methylene Blue
Opioids	Naloxone
Organophosphates	Atropine, Pralidoxime
Salicylates	alkalinize urine, restore K ⁺
TCA's	Sodium bicarbonate
Warfarin	Vitamin K; (FFP if necessary)
	* No longer available in Canada

SPECIFIC TREATMENTS

ASA Overdose

- acute and chronic (elderly with renal insufficiency)
- clinical
 - hyperventilation (central stimulation of respiratory drive)
 - metabolic acidosis
 - tinnitus, confusion, lethargy
 - coma, seizures, hyperthermia, non-cardiogenic pulmonary edema, circulatory collapse
- blood gases:
 1. respiratory alkalosis
 2. metabolic acidosis
 3. respiratory acidosis
- treatment
 - decontamination
 - 10:1 charcoal:drug ratio
 - close observation - serum level
 - alkalinization of urine as in Table 10 to enhance elimination
 - may require K⁺ supplements for adequate alkalinization
 - consider hemodialysis when
 - severe metabolic acidosis (intractable)
 - increased levels
 - end organ damage (unable to diurese)

Plasma pH	Urine pH	Treatment
alkaline	alkaline	D5W - 1/4 NS with 20 mEq KCl/L + 2 amp HCO ₃ /L at 2-3 cc/kg/hr
alkaline	acid	D5W - 1/4 NS with 40 mEq KCl/L + 3 amps HCO ₃ /L at 2-3 cc/kg/hr
acid	acid	D5W with 80 mEq KCl/L + 4 amps HCO ₃ /L

Benztropine (Cogentin)

- useful for acute dystonic reaction/dystonia
- has euphoric effect and potential for abuse
- for acute dystonic reaction
 - 1-2 mg IM/IV then 2mg PO bid x 3 days

Calcium Gluconate

- for hypotension with Ca^{++} antagonists
- for hydrogen fluoride burns
 - Ca gluconate gel topical or intradermal or both
 - intravenously for systemic hypocalcemia, hyperkalemia

Cholinergic Overdose

- atropine
 - anticholinergic / antimuscarinic
 - for anticholinesterase poisonings and cholinergic poisonings with muscarinic symptoms
 - 0.03 mg/kg to max 2 mg/dose (may repeat q 10-15 min until secretions dry)
- pralidoxime (Protopam, 2-PAM)
 - cholinesterase reactivation, nicotinic symptoms
 - time limited to 24 hours
 - organophosphate poisonings only
 - 25-50 mg/kg over 5 min IV q6h up to 1-2 g for adults

Diphenhydramine

- for acute dystonic reactions
 - 1-2 mg/kg IM/IV then 25 mg PO qid x 3 days

Ethanol

- used to block the metabolism of methanol and ethylene glycol preventing toxicity
- dialysis if ethanol treatment unsuccessful

FAB (Digibind)

- for acute overdose of digoxin
- use in combination with activated charcoal
- indications
 - life threatening arrhythmias unresponsive to conventional therapy (ventricular fibrillation, ventricular tachycardia, conduction block)
 - 6 hr serum digoxin > 19 nmol/L (therapeutic < 2.6)
 - initial serum K^+ > 6 mmol/L
 - history of ingestion > 10 mg adult, 6 mg child
- dose
 - 1 vial = 40 mg Digibind neutralizes 0.6 mg digoxin
 - cost of one vial = \$200
 - empirically: 20 vials
 - onset of action 30 minutes
 - renal elimination half life 16-20 hours

Flumazenil

- specific benzodiazepine (BZ) antagonist
- indications
 - iatrogenic BZ oversedation
 - to reverse BZ anesthesia
- contraindications
 - known seizure disorder
 - mixed OD (especially if TCA suspected)
 - BZ dependence or chronic use
- dose
 - adult: 0.3 mg IV (q5minutes to maximum 1.0 g)
 - child: 10 $\mu\text{g}/\text{kg}$ (as above, maximum 0.3 mg)
- CAUTION - most BZ have prolonged half life compared to flumazenil
 - if re-sedation occurs, repeat doses or IV infusion may be indicated

Fomepizole (4-mp)
 for ethylene glycol overdoses

Glucagon
 for propranolol, Ca⁺⁺ antagonist overdoses

- works as non-beta-adrenergic receptor agonist to increase production of cAMP, thereby increasing contractility
- 50-100 mg/kg (5-10 mg for adults) slow IV push, then IV at 70 µg/kg/hour

 for insulin OD (if no access to glucose)

- 1-2 mg IM

Glucose
 for oral hypoglycemics, insulin, ethanol, ASA, hepatotoxins
 can be given IV, PO or via NG

N-acetylcysteine – for Acetaminophen Overdose
 in metabolizing acetaminophen, cytochrome P450 creates a toxic metabolite that is scavenged by anti-oxidant glutathione, which leads to exhaustion of glutathione stores. N-acetylcysteine substitutes for glutathione to prevent liver damage.

- minimum toxic dose of acetaminophen: 150-200 mg/kg
- increased risk of toxicity if: chronic EtOH and/or anti-convulsant drugs

 clinical: no symptoms

- serum acetaminophen level, see nomogram
- evidence of liver/renal damage - delayed > 24 hours
- increased AST, PT
- decreased glucose, metabolic acidosis, encephalopathy indicates a poor prognosis

 treatment

- decontamination
- serum acetaminophen level 4 hours post ingestion
- measure liver enzymes and PT/PTT
- use the Rumack-Matthew Nomogram
- N-acetylcysteine according to dosing nomogram

Oxygen
 critical for CO poisoning
 hyperbaric O₂ (efficacy unclear) suggested for pregnant and unconscious patients with CO poisoning
 hyperbaric O₂ (efficacy unclear) suggested for cyanide, hydrogen sulfide poisoning, etc...

Sodium Bicarbonate (HCO³⁻)
 for TCAs
 indications with TCAs

- prolongation of QRS > 0.16 msec
- ventricular arrhythmias
- conduction delays
- seizures at pH ~7.55

 dose: 1 mEq/kg q 10-15 min bolus slowly (no indication for continuous infusion)

Vitamin K1
 for coumadin, rat poison overdose
 dosage protocol (adjust to INR ratios as needed)

PT 25-30	withhold drug
PT 30-40	K1 2.5-5.0 mg PO
PT 40-50	admit

Vit K1 10 mg IV over 10 min
 require 1 mg/mL to drive coagulation factor synthesis
 onset ~ 2 hours

PT > 50, bleeding give stored plasma (~3000 mL plasma for 70 kg male)
 need 1000 ml to restore 33% factors
 increased Vit K dosing (q4h)
 may require phenobarbital, factor IX
 concentrate, repeated charcoal, exchange transfusion

pH ALTERATION

- see Table 10
- if toxin has potential for ion-trapping at physiologically achievable pH
- urine alkalinization
 - urine pH 7.5-8.0
 - potentially useful for salicylates, phenobarbital
 - evidence of usefulness for phenobarbital is equivocal

EXTRA-CORPOREAL DRUG REMOVAL (ECDR)**Criteria for Hemodialysis**

- toxins that have
 - water solubility
 - low protein binding
 - low molecular weight
 - adequate concentration gradient
 - small volume of distribution (VD) or rapid plasma equilibration
- removal of toxin will cause clinical improvement
- advantage is shown over other modes of therapy
- greater morbidity from prolonged supportive care
- predicted that drug or metabolite will have toxic effects
- impairment of normal routes of elimination (cardiac, renal, or hepatic)
- clinical deterioration despite maximal medical support
- useful for toxins at the following blood levels:
 - alcohols
 - methanol: > 15.6 mmol/L
 - ethylene glycol: > 8 mmol/L
 - salicylates
 - acute: > 7.2-8.7 mmol/L (within 6 hours of ingestion)
 - chronic: > 4.3-4.8 mmol/L
 - lithium
 - acute: > 4.0 mmol/L (within 6 hours of ingestion)
 - chronic: > 2.5-4.0 mmol/L
 - bromine: > 15 mmol/L
 - phenobarbital: 430-650 mmol/L
 - chloral hydrate (→ trichloroethanol): > 200 mg/kg

Criteria for Hemoperfusion

- as for hemodialysis
- absorbent has greater drug binding capacity than protein or tissue
- useful for
 - theophylline: > 330 mmol/L (chronic), > 550 mmol/L (acute)
 - short acting barbiturates (secobarbital)
 - non-barbiturate sedative-hypnotics
 - (phenytoin, carbamazepine, disopyramide, paraquat, methotrexate, Amanita phalloides)

DISPOSITION FROM THE EMERGENCY**DEPARTMENT**

- discharge home vs. prolonged ED observation vs. admission
- methanol, ethylene glycol
 - delayed onset
 - admit and watch clinical and biochemical markers
- tricyclics
 - prolonged/delayed cardiotoxicity warrants admission to monitored (ICU) bed
 - if asymptomatic and no clinical signs of intoxication
 - 6 hour Emergency Department observation adequate with proper decontamination
 - sinus tachycardia alone (most common finding) with history of OD warrants observation in ED

- ❑ hydrocarbons/smoke inhalation
 - pneumonitis may lag 6-8 hours
 - consider observation for repeated clinical and radiographic examination
- ❑ ASA, acetaminophen
 - if borderline level, get second level 2-4 hours after first
- ❑ oral hypoglycemics
 - admit all patients for minimum 24 hours if hypoglycemic

Psychiatric Consultation

- ❑ once patient medically cleared, arrange psychiatric intervention (if required)
- ❑ beware - suicidal ideation may not be expressed
 - older, solitary male, incarcerated individual

ACLS ALGORITHMS

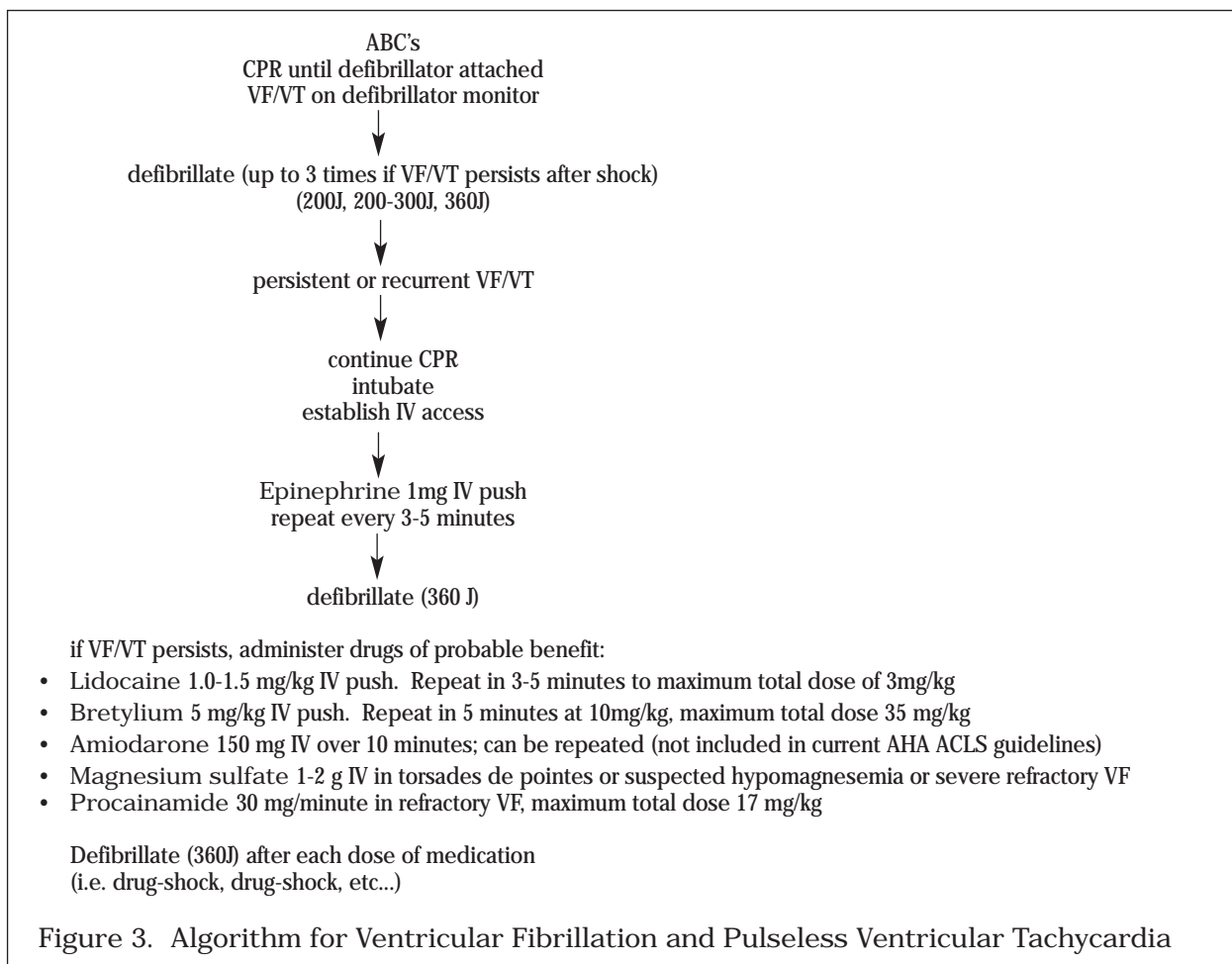


Figure 3. Algorithm for Ventricular Fibrillation and Pulseless Ventricular Tachycardia

Adapted from American Heart Association Advanced Cardiac Life Support. JAMA 268:2217, 1992. Reproduced with permission.

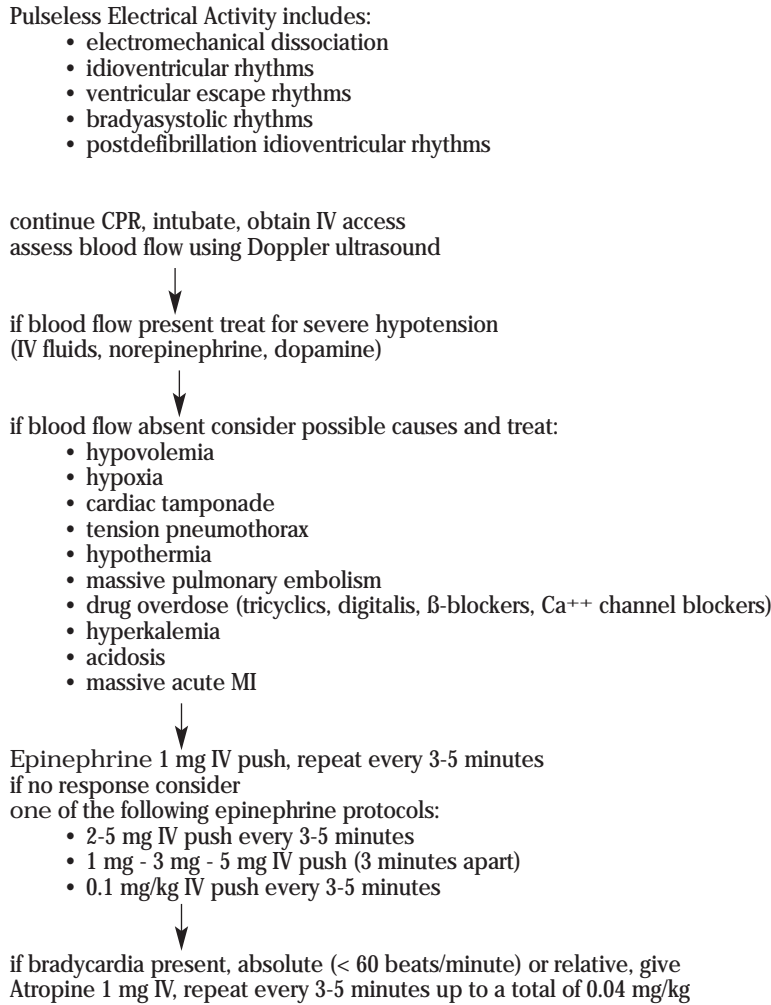


Figure 4. Algorithm for Pulseless Electrical Activity Algorithm

Adapted from American Heart Association Advanced Cardiac Life Support. JAMA 268:2217, 1992. Reproduced with permission.

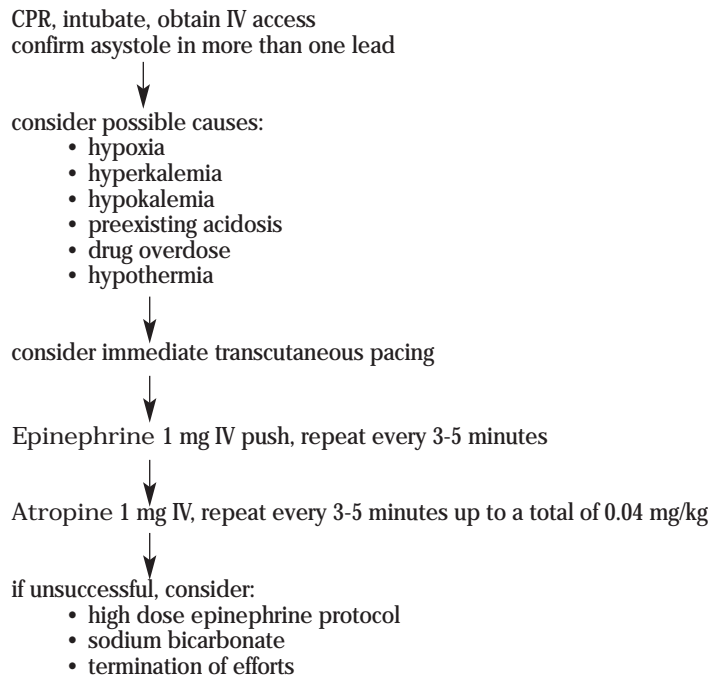


Figure 5. Algorithm for Asystole

Adapted from American Heart Association Advanced Cardiac Life Support. JAMA 268:2217, 1992. Reproduced with permission.

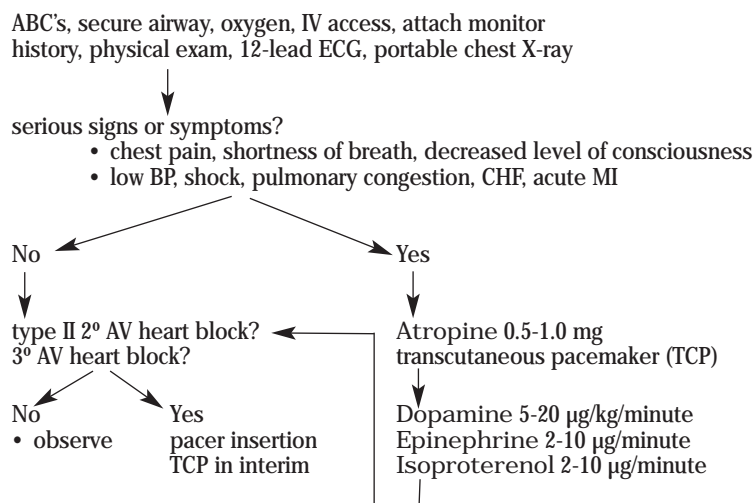


Figure 6. Algorithm for Bradycardia

Adapted from American Heart Association Advanced Cardiac Life Support. JAMA 268:2217, 1992. Reproduced with permission.

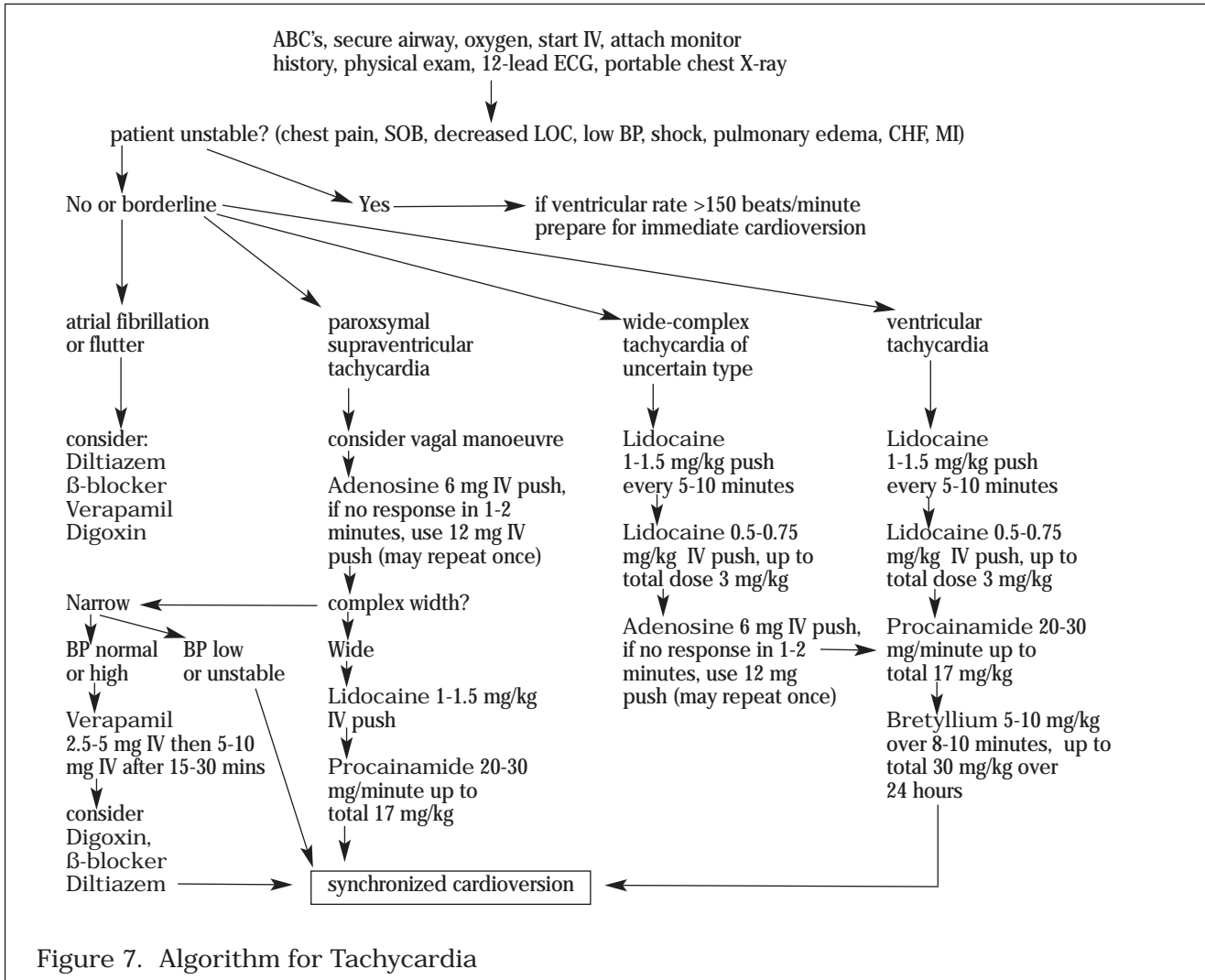


Figure 7. Algorithm for Tachycardia

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