TRAUMA- GENERAL CONSIDERATION

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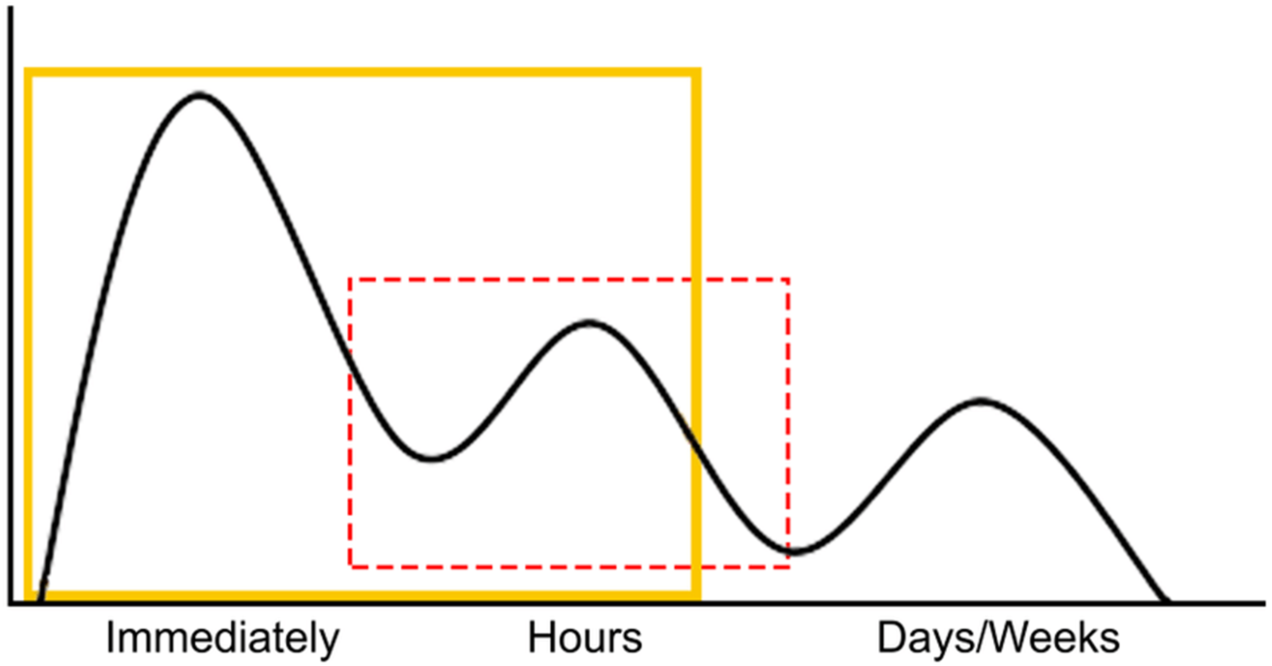
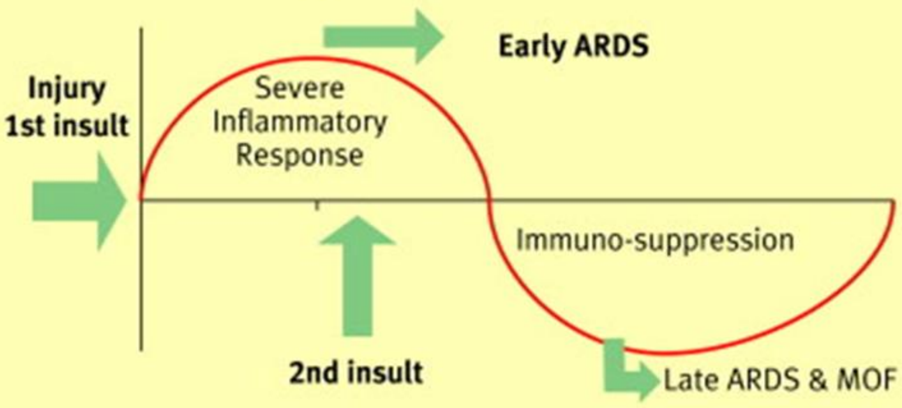
INTRODUCTION

- Trauma, or injury, is defined as cellular disruption caused by environmental energy that is beyond the body's resilience, which is compounded by cell death due to ischemia/reperfusion.
- Trauma must be considered a major public health issue.
- Trauma is the most common cause of death for all individuals between the ages of 1 and 44 years, and is the third image most common cause of death regardless of age.
- It is also the leading cause of years of productive life lost.
- The American College of Surgeons Committee on Trauma addresses this issue by assisting in the development of trauma centers and systems.
- The organization of trauma systems has had a significant favorable impact on patient outcomes, although system integration and maldistribution of trauma centers remain challenges.

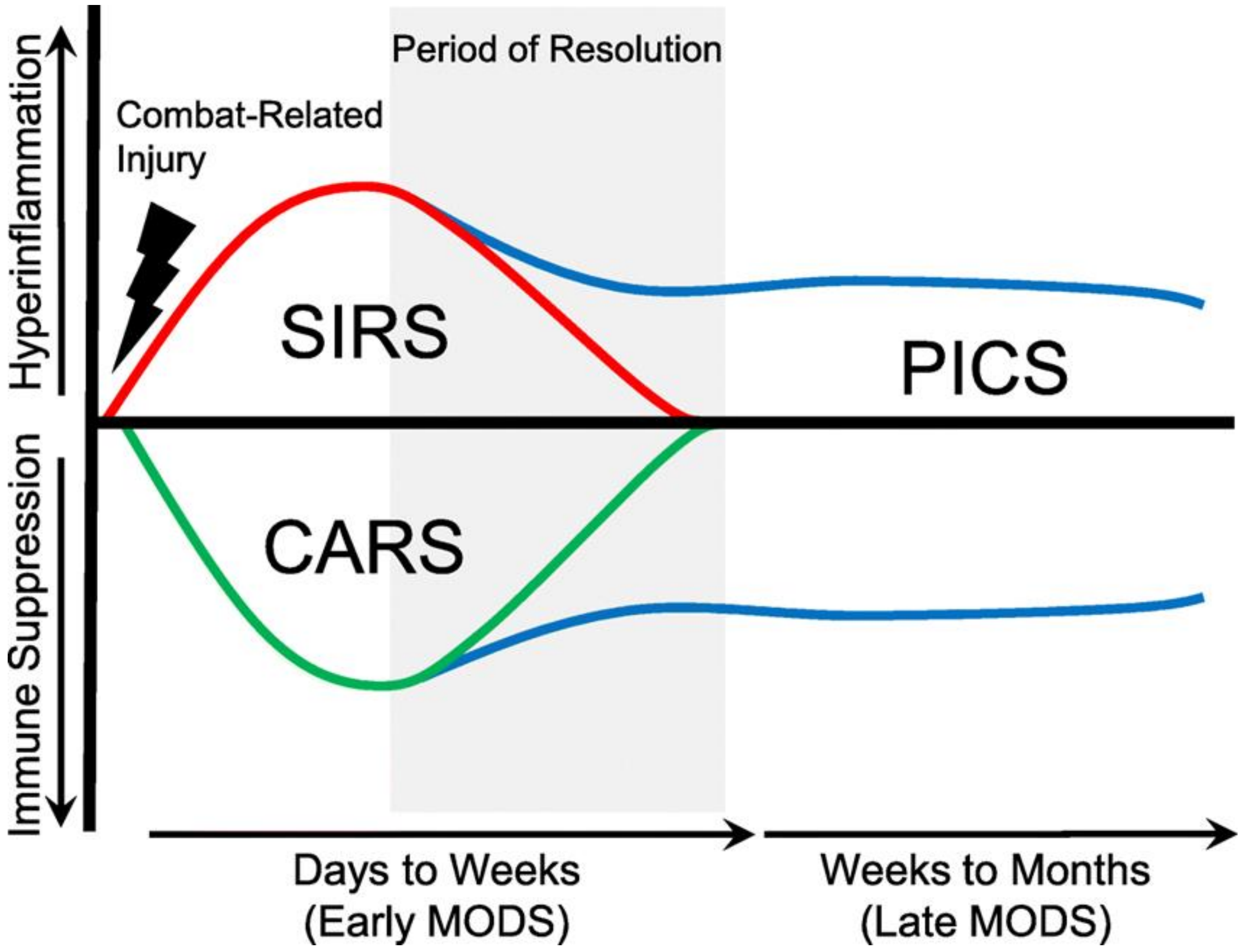
THE "GOLDEN HOUR" CONCEPT



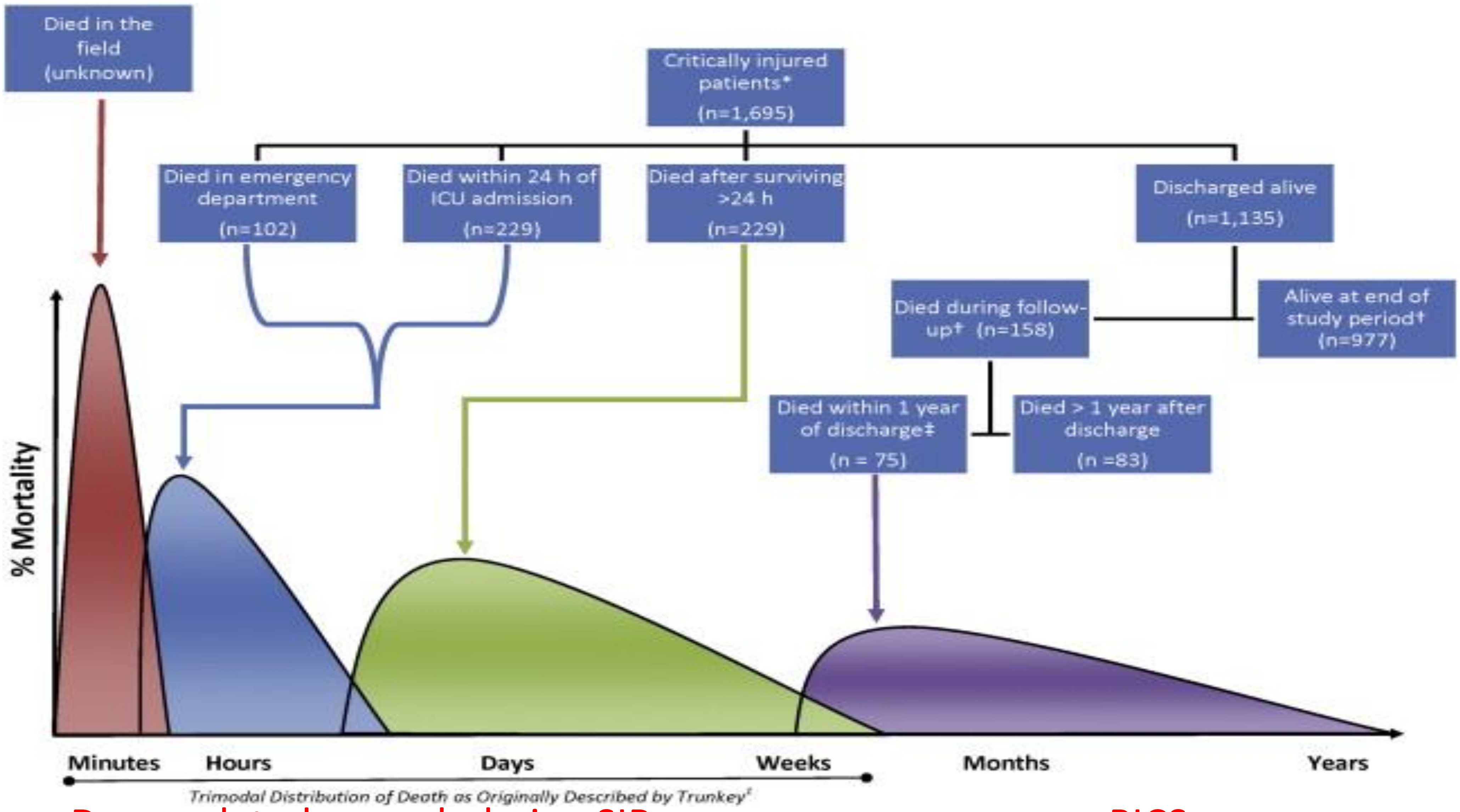
One and two hit hypothesis



Injury results in a systemic inflammatory response and concurrent state of relative immune-suppression. The inflammatory response changes dominate the first 3–5 days post injury, with raised pro-inflammatory mediators and PMN priming. A second insult in this period may tip the inflammatory response over the top and early ARDS/MOF results. The insult could be tardy haemorrhage control and prolonged hypovolaemic shock, or over aggressive reconstructive surgery with increased bleeding or marrow embolisation to the lung causing systemic hypoxia. After this period relative unresponsivenss in PMN function has been described, and circulating monocytes may fail to recover their capabilities, hence the risk of sepsis and late ARDS/MOF.



Systemic inflammatory response syndrome (SIRS)
Compensatory anti-inflammatory response syndrome (CARS)
Persistent inflammatory-immunosuppressive and catabolic syndrome (PICS)



Dysregulated overwhelming SIR

PICS

ATLS Course- ACS Committee on Trauma

- The initial management of seriously injured patients consists of phases:
    - ✓ Primary survey/concurrent resuscitation.
    - ✓ Secondary survey/diagnostic evaluation, definitive care.
    - ✓ Tertiary survey.

PTC Primary Trauma Care Foundation

WHAT W

World Health Organization

MEDECINS SANS FRONTIERES DOCTORS WITHOUT BORDERS

THE ROYAL COLLEGE OF SURGEONS OF EDINBURGH

WFSA

UNIVERSITY OF OXFORD

RCoA Royal College of Anaesthetists

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UKaid from the British people

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PRIMARY TRAUMA CARE FOUNDATION

PRIMARY TRAUMA CARE FOUNDATION COURSE

CERTIFICATE OF PARTICIPATION

This is to certify that **Dr.Ashraf Fayez Al-Faouri** has attended the course held in the National Emergency Medical Services Education Center, Amman-Jordan, from 7th- 8th May 2011

Brig. Gen. Dr. Husam F. Makhamreh *JRMS DIRECTOR OF PROFESSIONAL TRAINING*	**Dr. R. Jeanne Frossard** *PTCF COURSE DIRECTOR*	**Mr. Charles Clayton** *PTCF CHIEF EXECUTIVE*

الخدمات الطبية الملكية - الأردن

Royal Medical Services - Jordan

and the

PRIMARY TRAUMA CARE FOUNDATION

PRIMARY TRAUMA CARE INSTRUCTOR COURSE

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has attended one-day Instructor Course held in the National Emergency Medical Services Education Center,Amman-Jordan

9th May 2011

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Jordan Chapter of the American College of Surgeons

7,8 hilj. oznake "sviđa mi se" • 8,1 hilj. pratitelji

Primary Survey (ABCs)

- The "golden hour" concept: timely, prioritized interventions are necessary to prevent death and disability.
- The first step in patient management is performing the primary survey, the goal of which is to identify and treat conditions that constitute an immediate threat to life.

Airway

- Airway obstruction
- Airway injury

Breathing

- Tension pneumothorax
- Open pneumothorax
- Massive air leak from tracheobronchial injury
- Flail chest with underlying pulmonary contusion

Circulation

Hemorrhagic shock

- Massive hemothorax
- Massive hemoperitoneum
- Mechanically unstable pelvis fracture with bleeding
- Extremity blood loss

Cardiogenic shock

- Cardiac tamponade

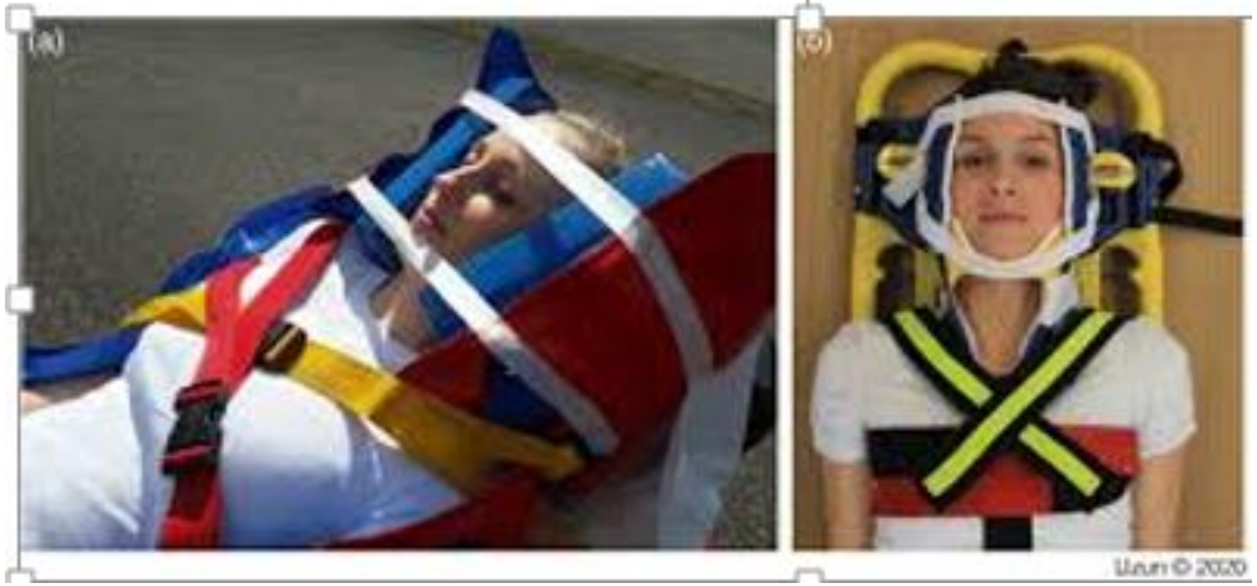
Neurogenic shock

Disability

- Intracranial hemorrhage
- Cervical spine injury

A: Airway with C spine protection

- All patients with blunt trauma require cervical spine immobilization until injury is excluded. This is typically accomplished by applying a hard cervical collar or placing sandbags on both sides of the head with the patient’s forehead taped across the bags.
- For penetrating neck wounds, cervical collars are not recommended because they provide no benefit and may interfere with assessment and treatment.



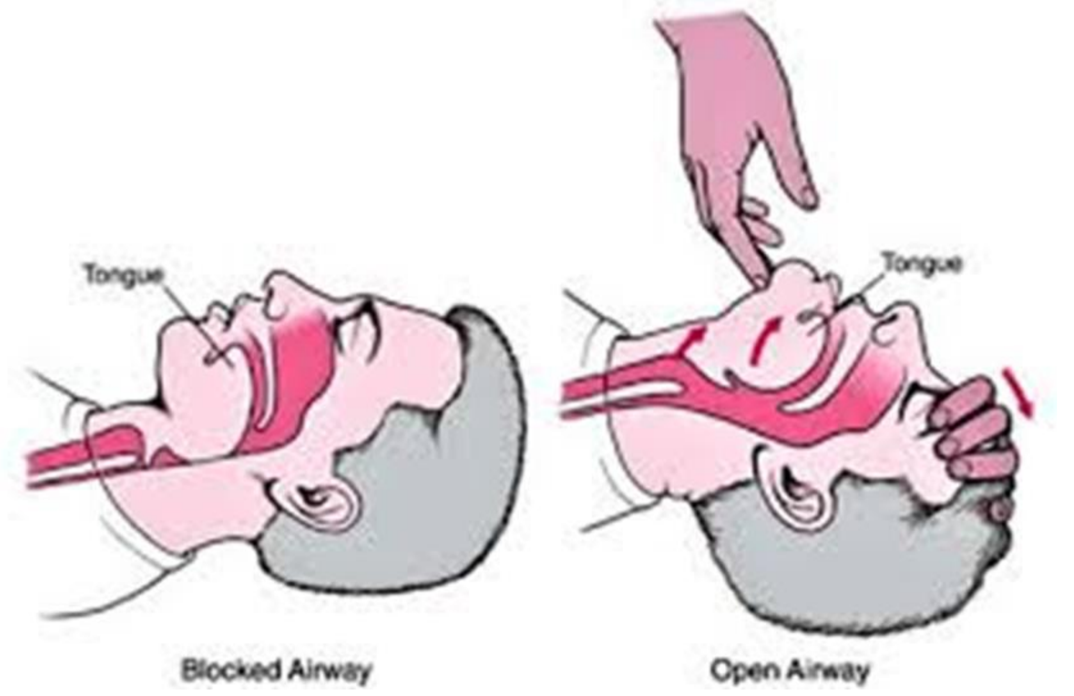
Airway

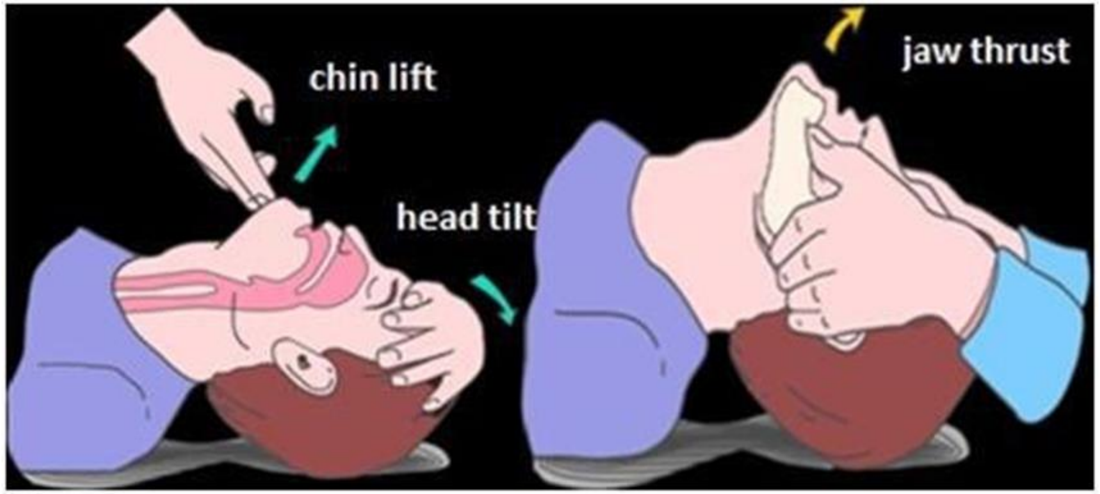
- Patients who are conscious, without tachypnea, and have a normal voice are unlikely to require early airway intervention.
- Exceptions(consider preemptive intubation)
  1) penetrating injuries to the neck with an expanding hematoma
  2) evidence of chemical or thermal injury to the mouth, nares, or hypopharynx
  3) extensive subcutaneous air in the neck
  4) complex maxillofacial trauma
  5) airway bleeding.

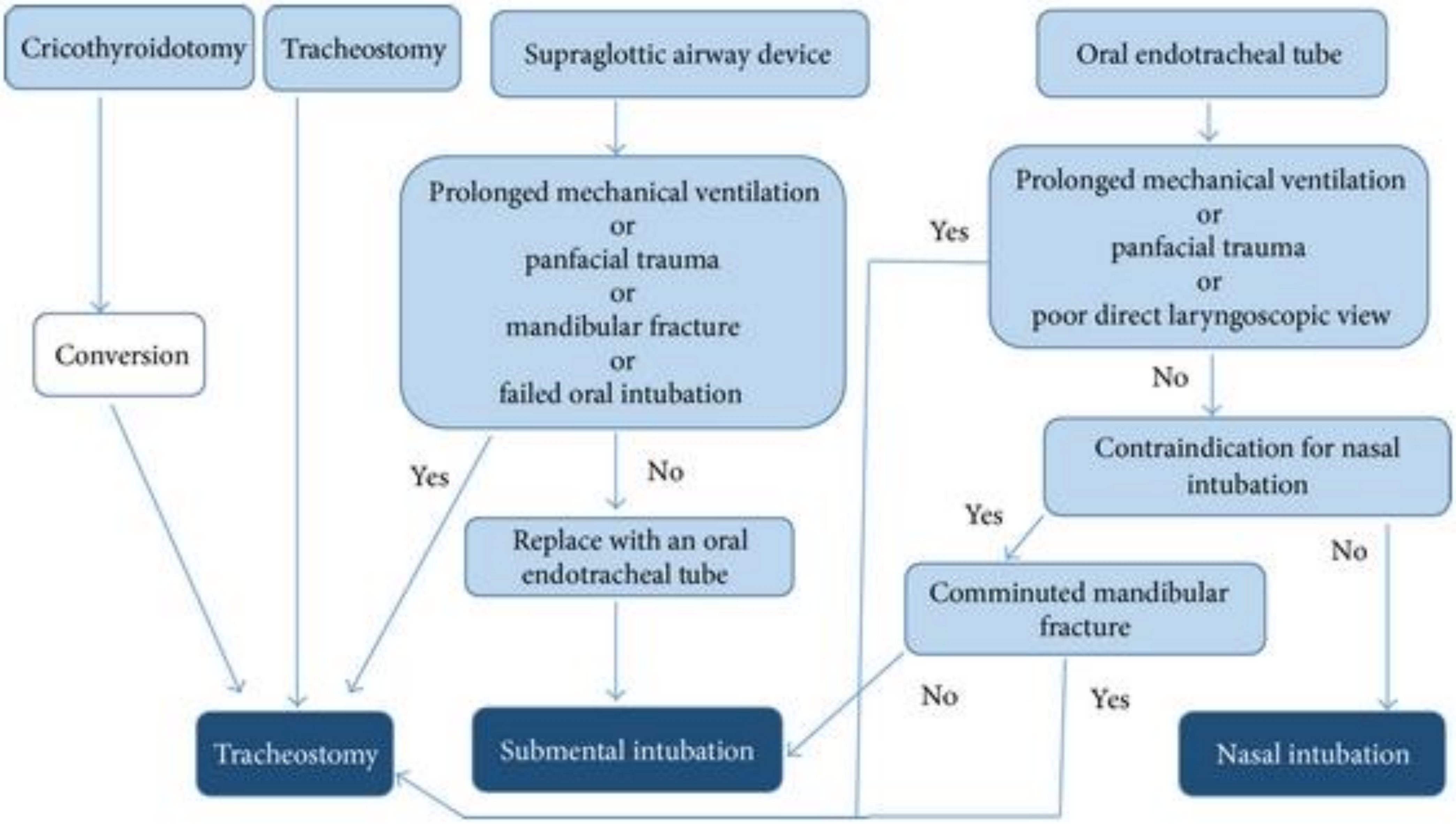
- Patients who have an
  1. Abnormal voice
  2. Abnormal breathing sounds
  3. Tachypnea / Apnea
  4. Altered mental status (Most common)
- Positive airway pressure may further compromise cardiac function and precipitate cardiac arrest; thus, Circulation may take priority over Airway.

Airway

- Suctioning
- Chin lift or jaw thrust.
- Establishing a definitive airway (i.e., endotracheal intubation) is indicated in patients with
  1. apnea
  2. inability to protect the airway due to altered mental status
  3. impending airway compromise due to inhalation injury, hematoma, facial bleeding, soft tissue swelling, or aspiration
  4. inability to maintain oxygenation.

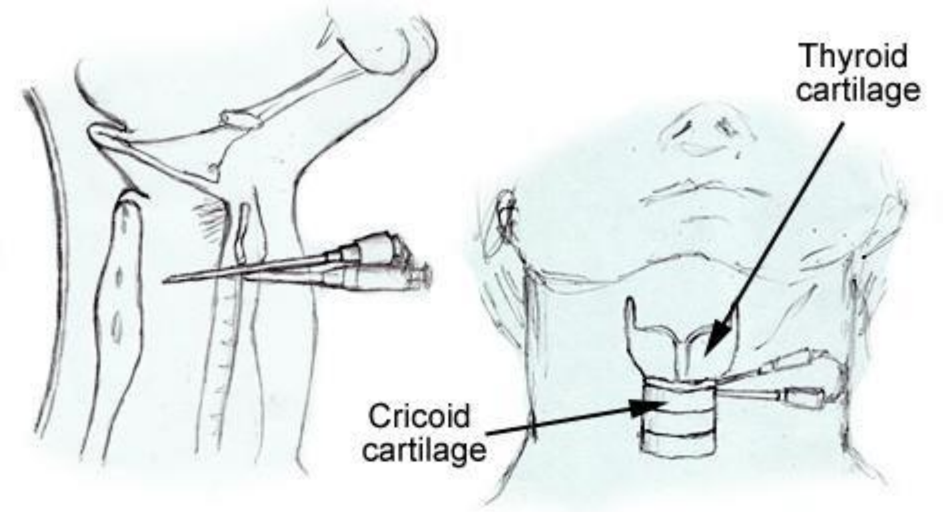


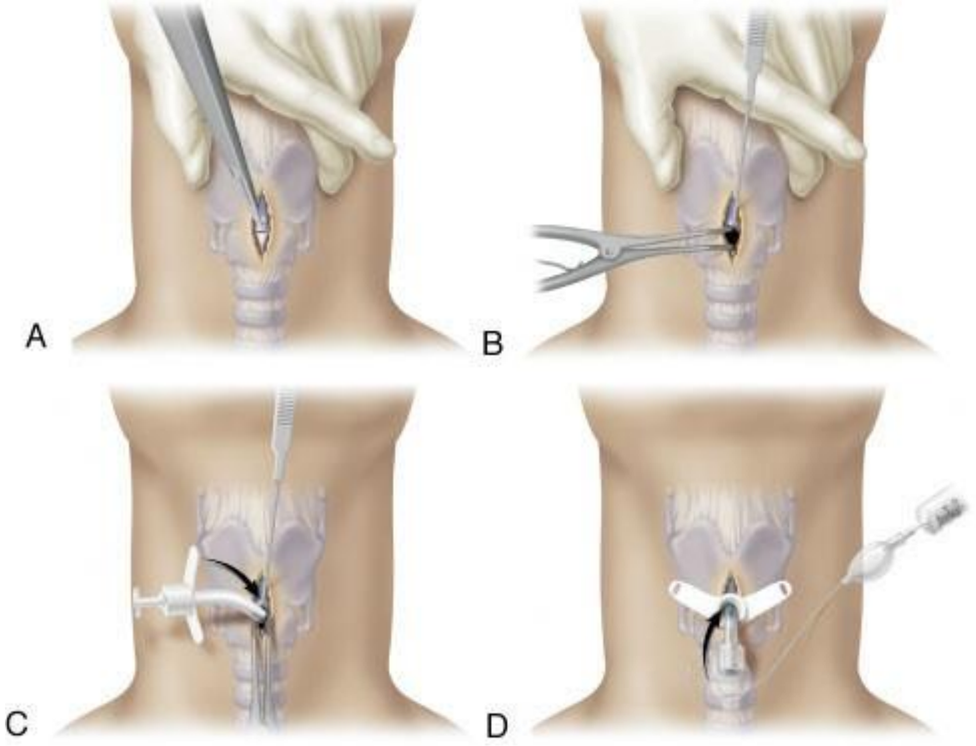



Cricothyroidotomy
Tracheostomy
Supraglottic airway device
Oral endotracheal tube
Prolonged mechanical ventilation or panfacial trauma or mandibular fracture or failed oral intubation
Prolonged mechanical ventilation or panfacial trauma or poor direct laryngoscopic view
Yes
Conversion
No
Contraindication for nasal intubation
Yes
No
Replace with an oral endotracheal tube
Yes
No
Comminuted mandibular fracture
No
Yes
Tracheostomy
Submental intubation
Nasal intubation

Cricothyroidotomy

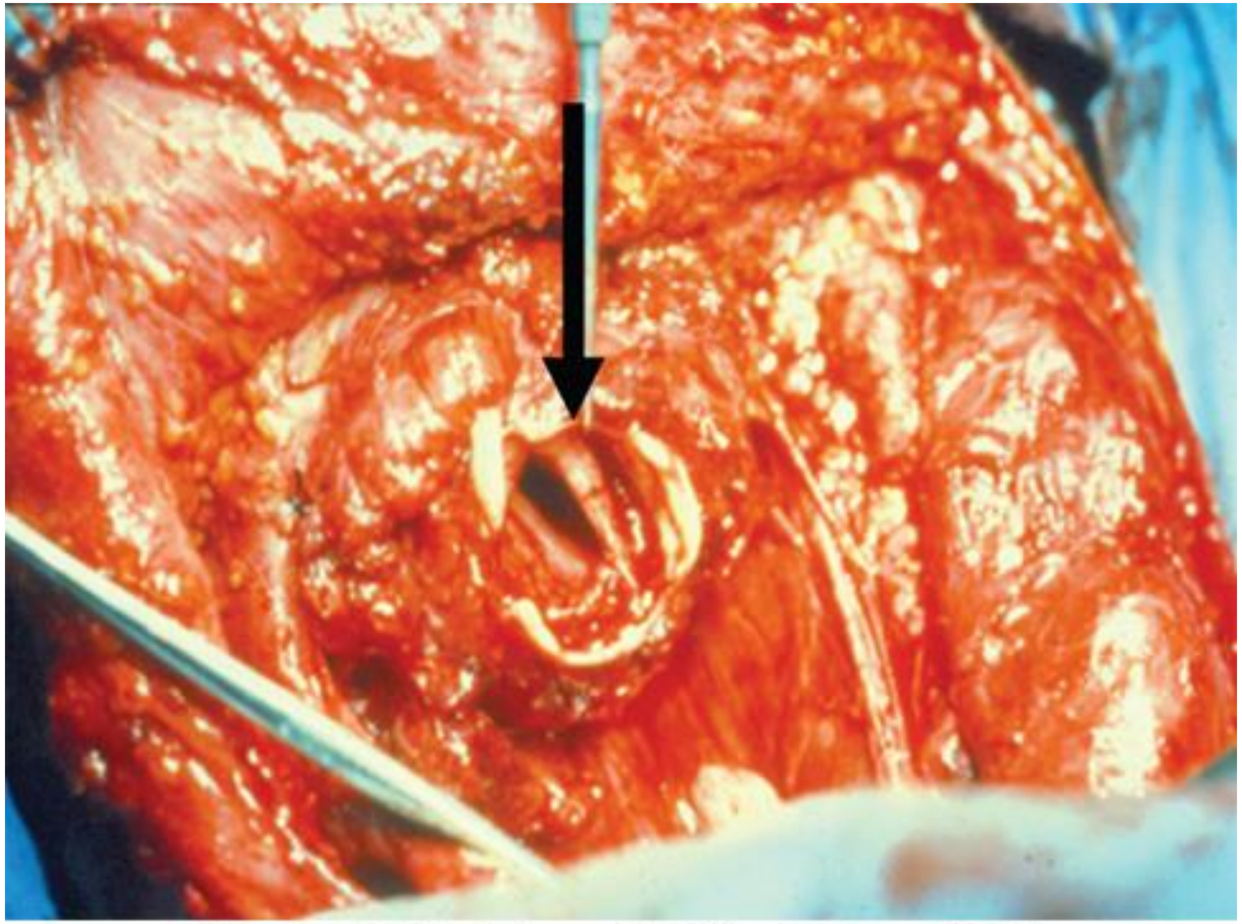
- Performed through a generous vertical incision, with sharp division of the subcutaneous tissues. Visualization may be improved by having an assistant retract laterally on the neck incision using retractors.
- The cricothyroid membrane is verified by digital palpation and opened in a horizontal direction. The airway may be stabilized before incision of the membrane using a tracheostomy hook; the hook should be placed under the thyroid cartilage to elevate the airway.
- A 6.0 endotracheal tube (maximum diameter in adults) is then advanced through the cricothyroid opening and sutured into place.
- In patients under the age of 11, cricothyroidotomy is relatively contraindicated due to the risk of subglottic stenosis, and tracheostomy should be performed.





Emergent tracheostomy

- Indicated in patients with laryngotracheal separation or laryngeal fractures, in whom cricothyroidotomy may cause further damage or result in complete loss of the airway.
- This procedure is best performed in the operating room (OR) where there is optimal lighting and availability of advanced equipment (e.g., sternal saw).
- In these cases, often after a “clothesline” injury, direct visualization and instrumentation of the trachea usually is done through the traumatic anterior neck defect or after a generous collar skin incision .
- If the trachea is completely transected, a nonpenetrating clamp should be placed on the distal aspect to prevent tracheal retraction into the mediastinum; this is particularly important before placement of the endotracheal tube.



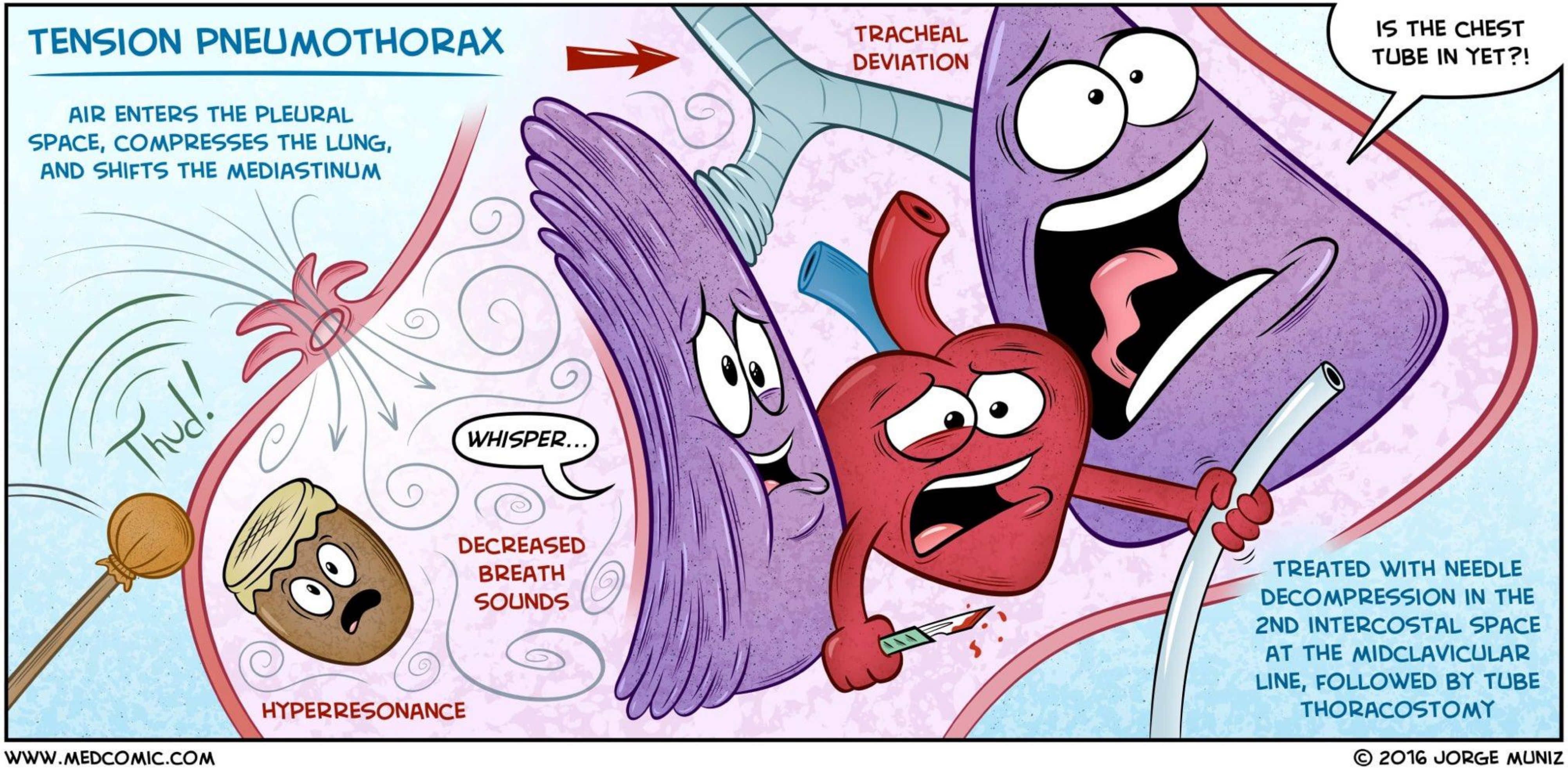
Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e

B: BREATHING

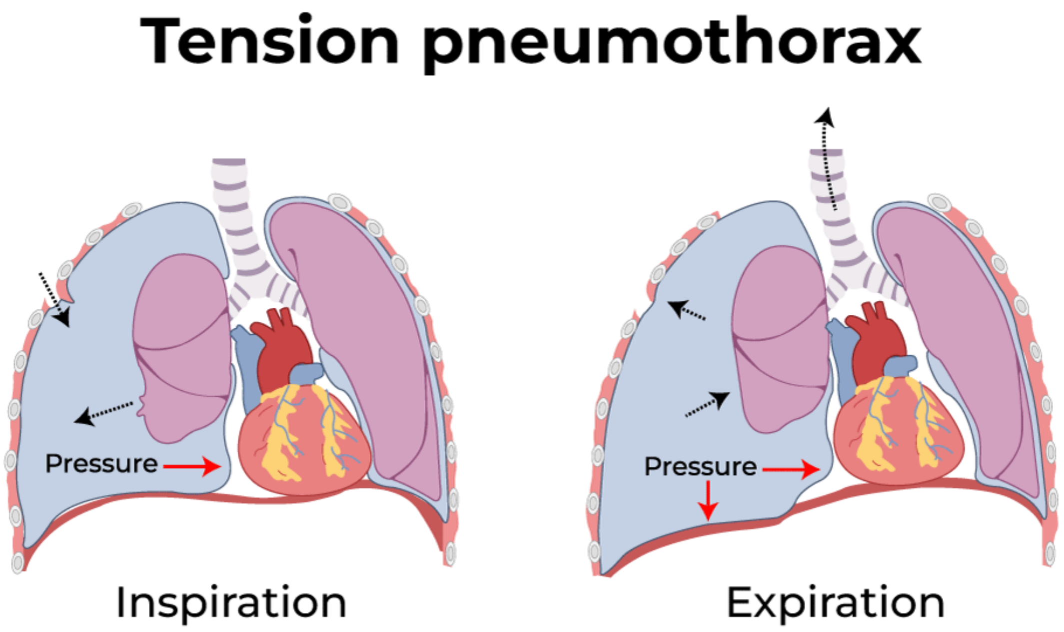
- The following conditions constitute an immediate threat to life due to inadequate ventilation and should be recognized during the primary survey:

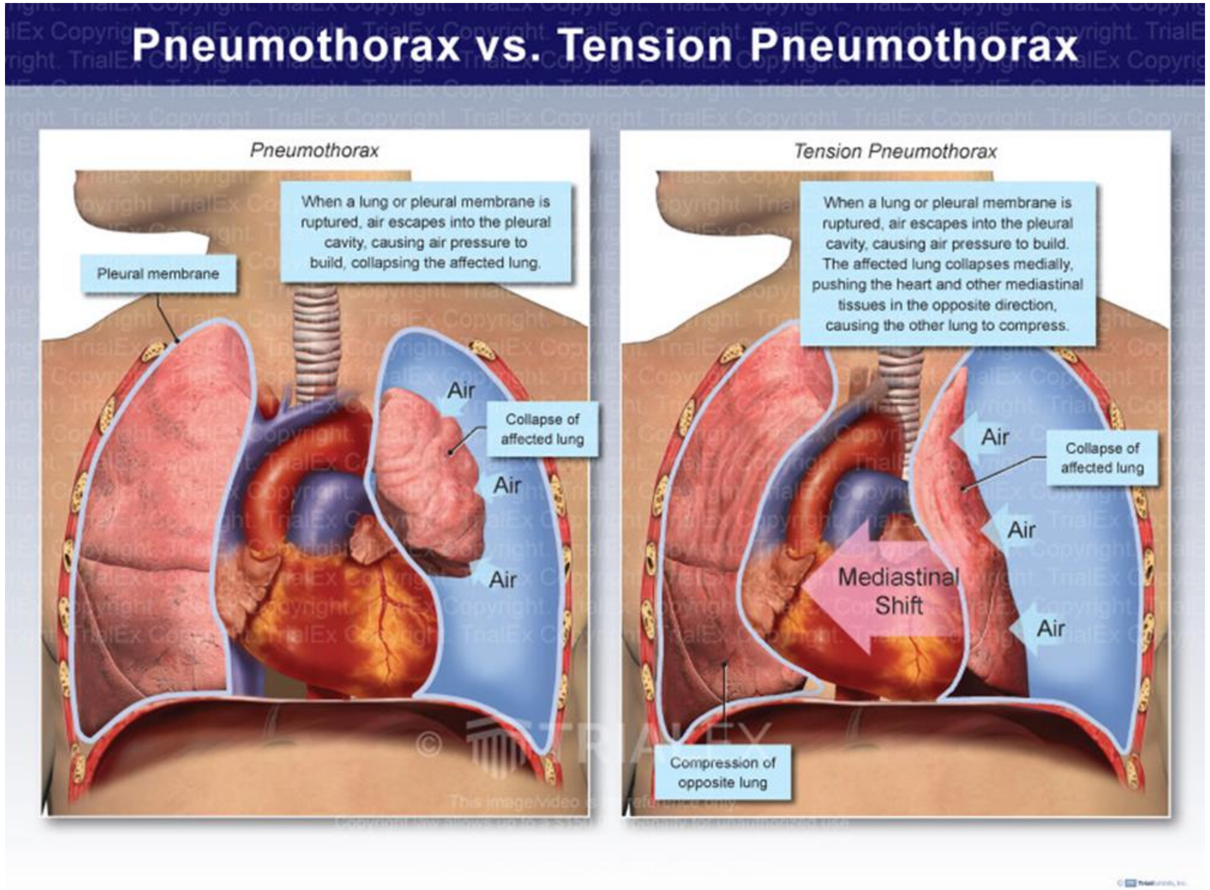
1. tension pneumothorax.
2. open pneumothorax.
3. flail chest with underlying pulmonary contusion.
4. massive hemothorax.
5. major air leak due to a tracheobronchial injury.

Tension Pneumothorax



Tension Pneumothorax

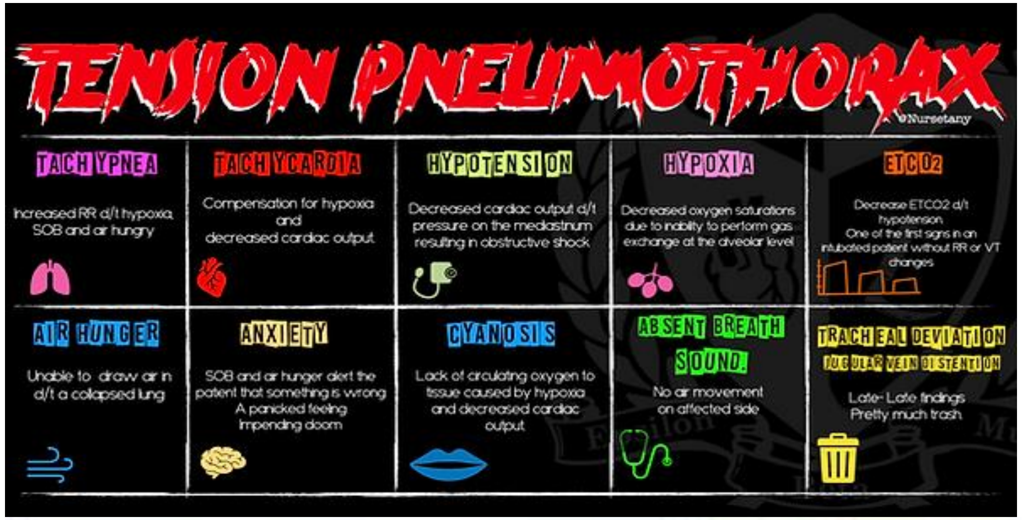




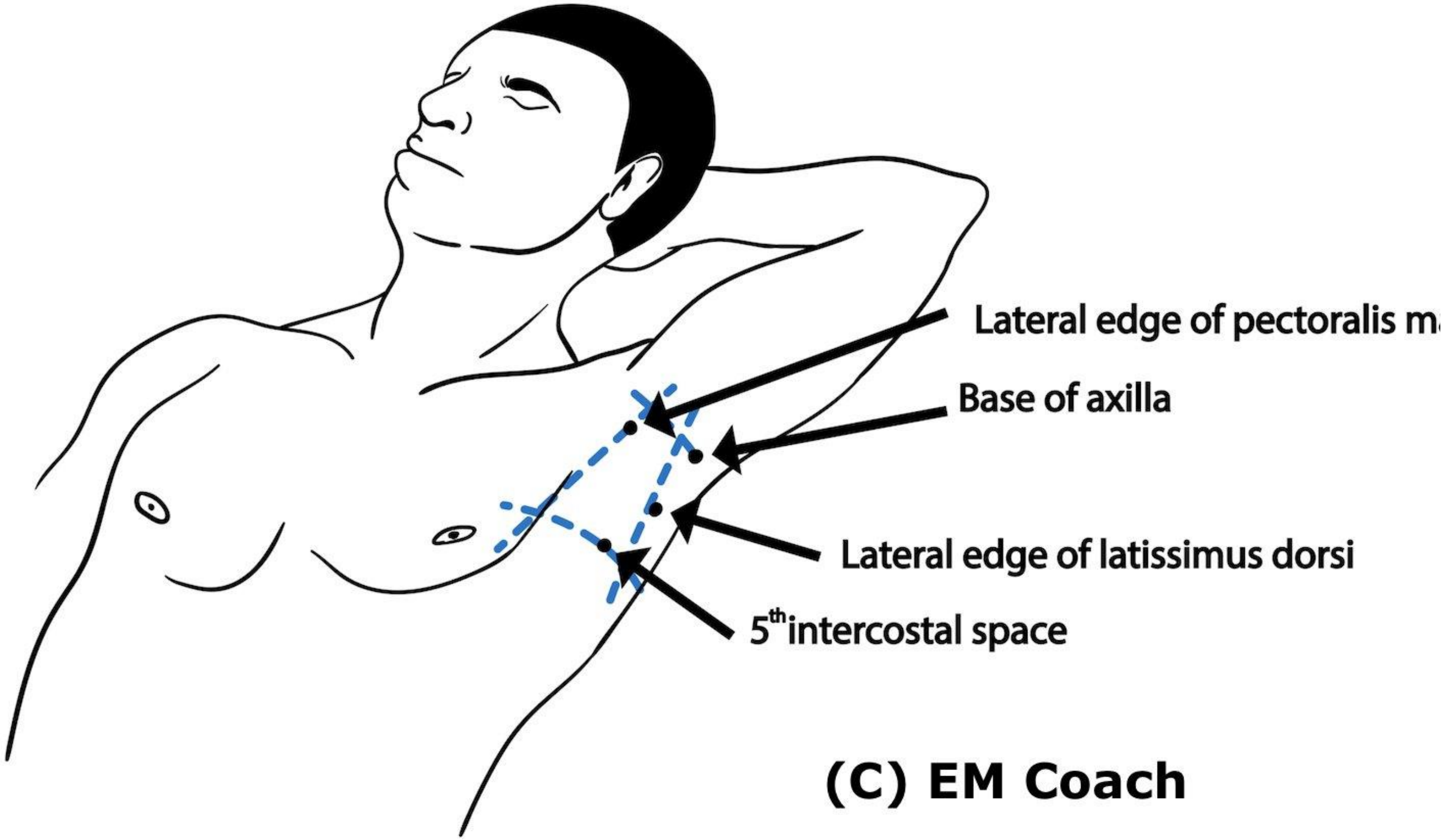

L
PORTABLE

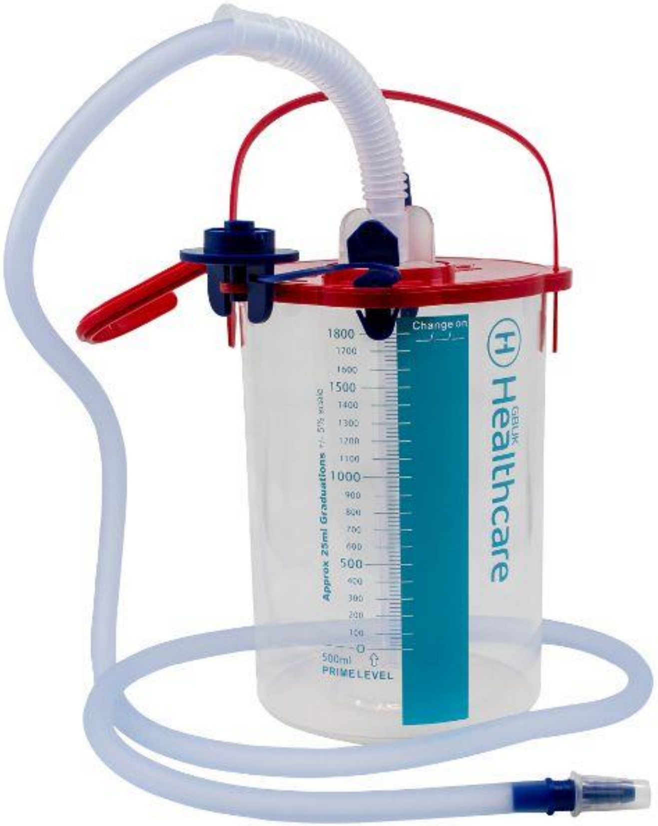
Tension Penumothorax
Sx & Sg

- Respiratory distress
- Chest pain
- Ipsilateral reduced breath sounds
- Ipsilateral hyperinflation of the hemithorax with hyper-resonance on percussion
- Tachycardia
- Low blood pressure.
- Cyanosis
- Jugular vein distention
- Tracheal deviation



Tube thoracostomy





Open pneumothorax

- An open pneumothorax or “sucking chest wound” occurs with full-thickness loss of the chest wall, permitting free communication between the pleural space and the atmosphere .
- This compromises ventilation due to equilibration of atmospheric and pleural pressures, which prevents lung inflation and alveolar ventilation, and results in hypoxia and hypercarbia.
- Complete occlusion of the chest wall defect without a tube thoracostomy may convert an open pneumothorax to a tension pneumothorax. Temporary management of this injury includes covering the wound with an occlusive dressing that is taped on three sides. This acts as a flutter valve, permitting effective ventilation on inspiration while allowing accumulated air to escape from the pleural space on the untapped side, so that a tension pneumothorax is prevented.
- Definitive treatment is closure of the chest wall defect and tube thoracostomy remote from the wound.

Open pneumothorax

A

Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e

B

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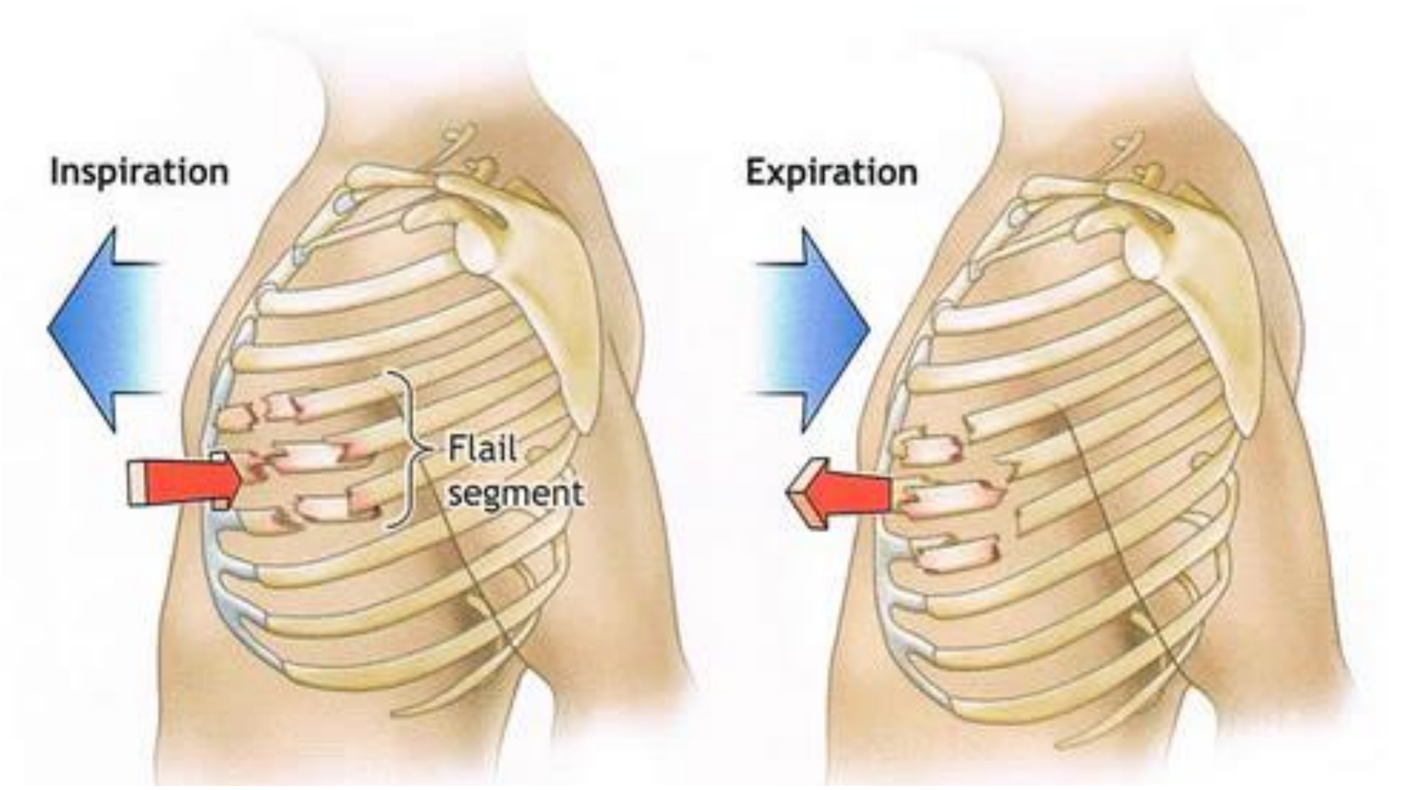
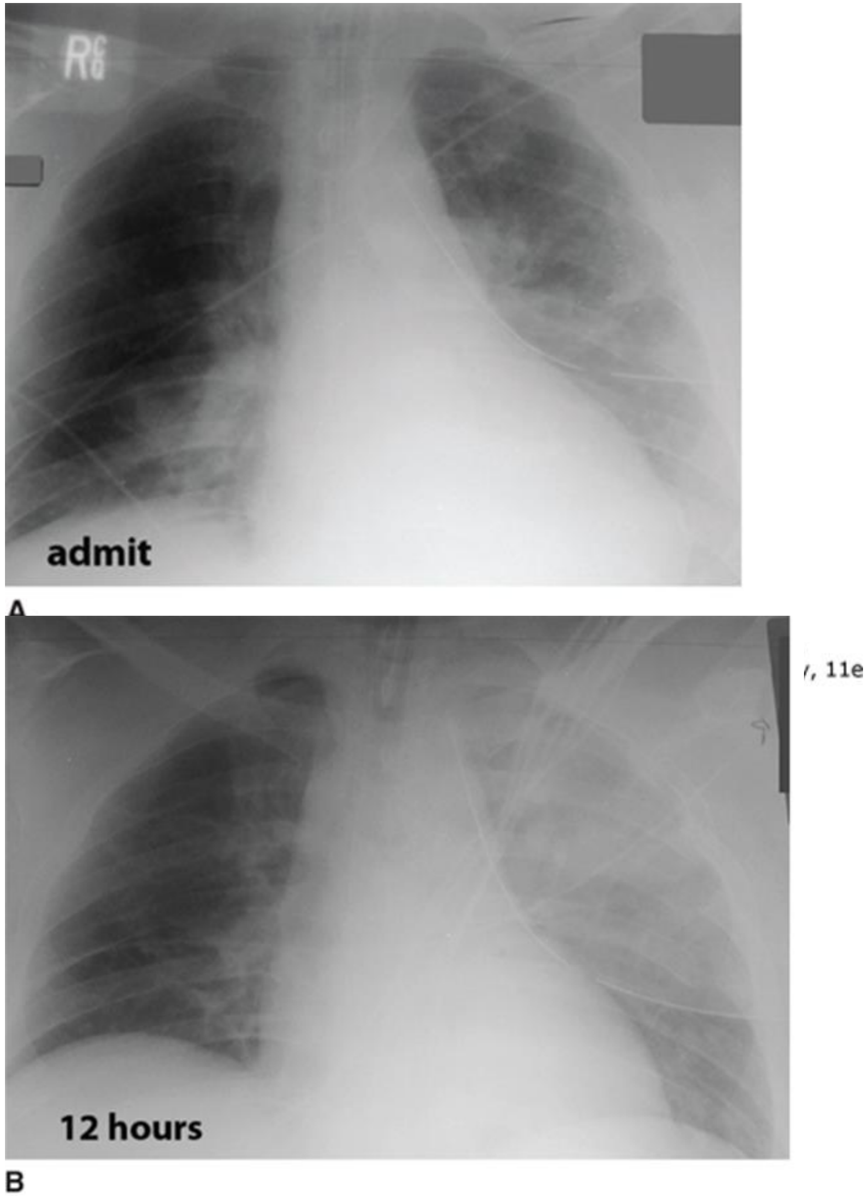
Flail chest

- Flail chest occurs when three or more contiguous ribs are fractured in at least two locations.
- Paradoxical movement of this free-floating segment of chest wall is usually evident in patients with spontaneous ventilation, due to the negative intrapleural pressure of inspiration.
- The additional work of breathing and chest wall pain caused by the flail segment is rarely sufficient to compromise ventilation. Instead, it is the decreased compliance and increased shunt fraction caused by the associated pulmonary contusion that is the source of acute respiratory failure.



Flail chest

- Pulmonary contusions often progress during the first 12 hours. Resultant hypoventilation and hypoxemia may require intubation and mechanical ventilation.
- The patient’s initial chest radiograph often underestimates the extent of the pulmonary parenchymal damage; close monitoring and frequent clinical reevaluation are warranted.



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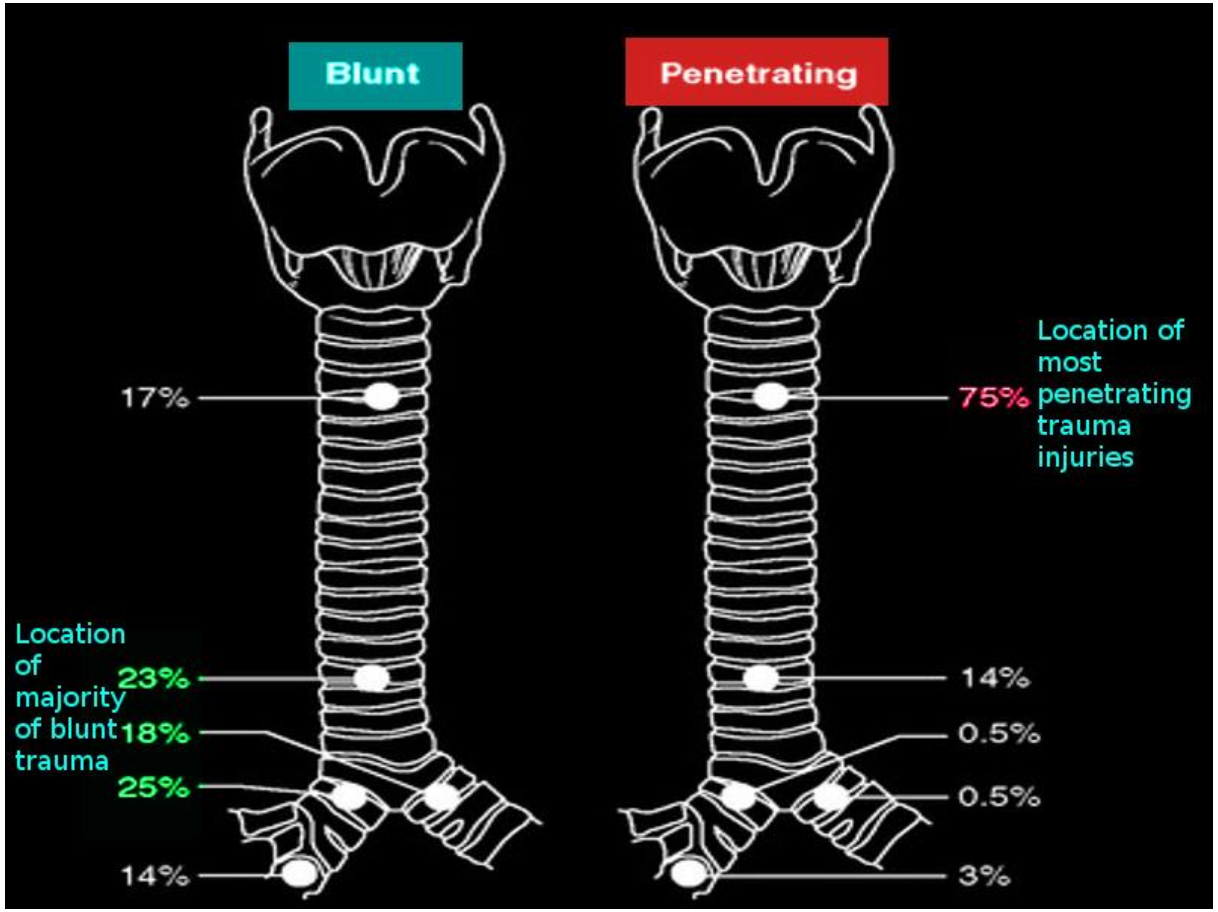
Major air leak

- occurs from tracheobronchial injuries.
- Type I injuries are those occurring within 2 cm of the carina. These may not be associated with a pneumothorax due to the envelopment in the mediastinal pleura.
- Type II injuries are more distal injuries within the tracheobronchial tree and hence manifest with a pneumothorax.
- Bronchoscopy confirms the extent of the injury and its location, and directs management.

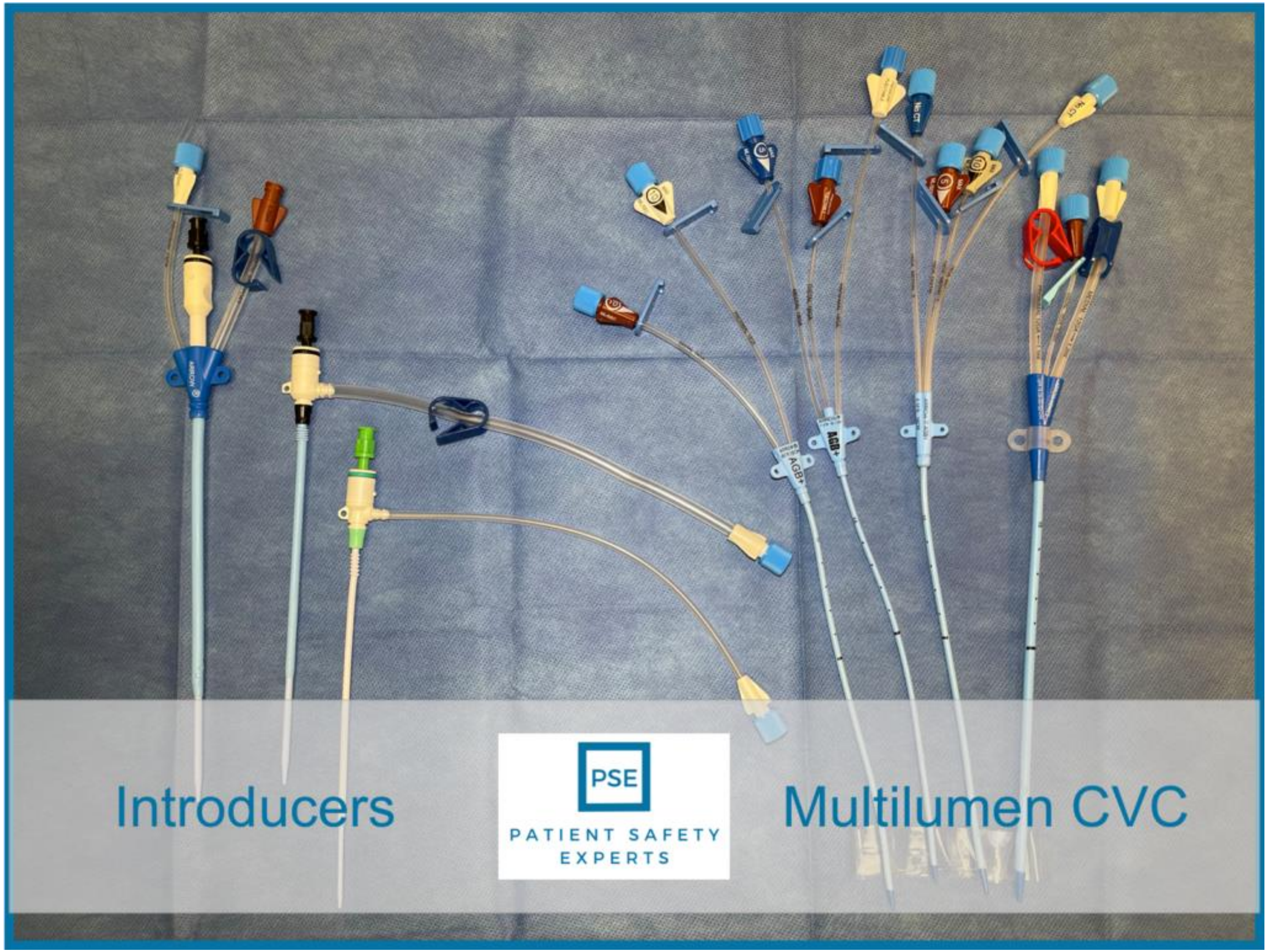


C: Circulation

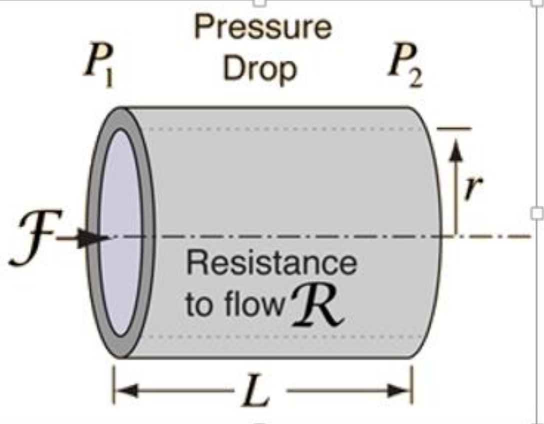
- Any episode of hypotension (defined as a SBP <90 mmHg) is assumed to be caused by hemorrhage until proven otherwise.
- An initial approximation of the patient's cardiovascular status can be obtained by palpating peripheral pulses. In general, systolic blood pressure (SBP) must be 60 mmHg for the carotid pulse to be palpable, 70 mmHg for the femoral pulse, and 80 mmHg for the radial pulse.
- Patients with rapid massive blood loss may have paradoxical bradycardia.
- Blood pressure and pulse should be measured at least every 5 minutes in patients with significant blood loss until normal vital sign values are restored.

C: Circulation

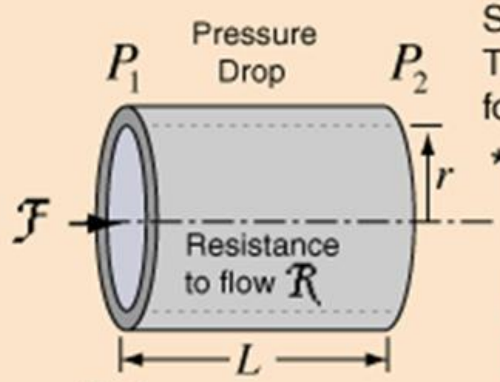
- Access:
  - Two peripheral catheters, 16-gauge or larger in adults.
  - Intraosseous (IO) needles
  - The femoral or subclavian veins
  - Saphenous vein cutdown
- A rule of thumb to consider for secondary access is placement of femoral access for thoracic trauma and jugular or subclavian access for abdominal trauma.
- Blood should be drawn simultaneously for:
  - Hemoglobin level
  - Arterial blood gas for base deficit (BD)
  - Cross-matching for possible blood component (RBC and plasma) transfusion
  - Coagulation panel/viscoelastic hemostatis assay (e.g., TEG, ROTEM) should be obtained.


Introducers
PSE
PATIENT SAFETY
EXPERTS
Multilumen CVC

Poiseuille's Law



Volume Flowrate $= \mathcal{F} = \dfrac{P_1 - P_2}{\mathcal{R}} = \dfrac{\pi(\text{Pressure difference})(\text{radius})^4}{8(\text{viscosity})(\text{length})}$



Suppose the original flowrate is 100 cm^3/sec. The effect of changes in the parameters is as follows:

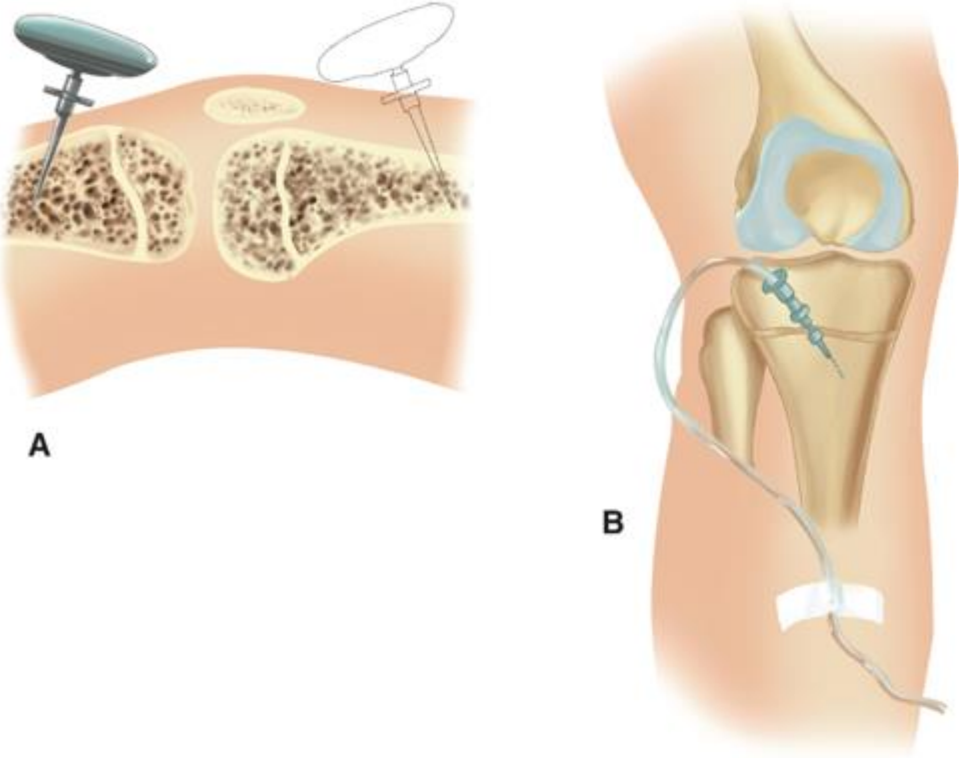
- *Double length ⇒ 50 cm^3/sec
- Double viscosity ⇒ 50 cm^3/sec
- Double pressure ⇒ 200 cm^3/sec
- Double radius ➡ 1600 cm^3/sec

$\mathcal{R} = \dfrac{8\eta L}{\pi r^4}$ where η = viscosity

* With other parameters held at original values

Volume Flowrate $= \mathcal{F} = \dfrac{P_1 - P_2}{\mathcal{R}} = \dfrac{\pi(\text{Pressure difference})(\text{radius})^4}{8(\text{viscosity})(\text{length})}$

A 19% increase in radius will double the volume flowrate!



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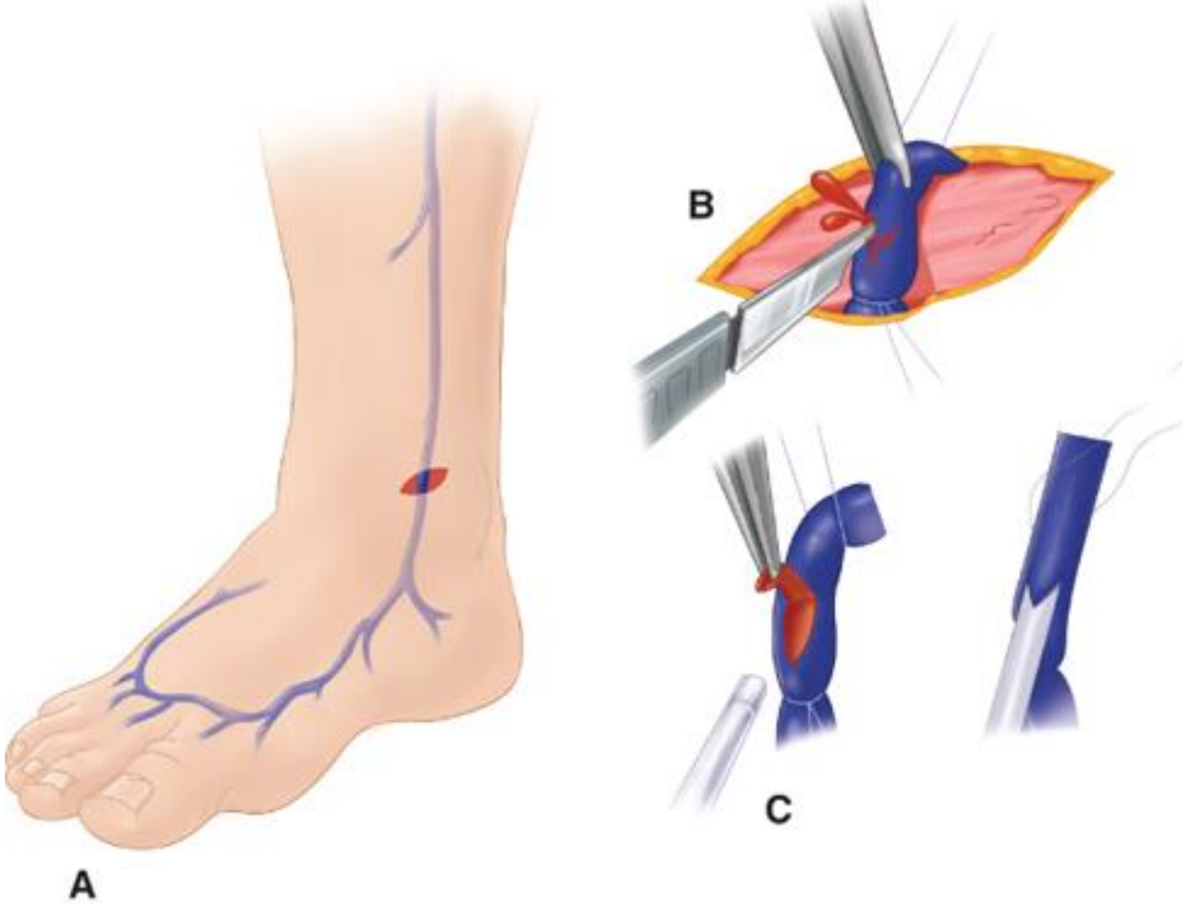

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RESUSCITATION

HEMORRHAGE CLASSIFICATION - MANAGEMENT

CLASS	BLOOD LOSS	HR	BP	PULSE PRESSURE	RR	URINARY OUTPUT	GCS	BASE DEFICIT	TRANSFUSE
I	<15%	↔	↔	↔	↔	↔	↔	0 to (-2)	Monitor
II (MILD)	15 – 30%	↔/↑	↔	↓	↔	↔	↔	(-2) to (-6)	Possible
III (MODERATE)	31 – 40%	↑	↔/↓	↓	↔/↑	↓	↓	(-6) to (-10)	Yes
IV (SEVERE)	>40%	↑/↑↑	↓	↓	↑	↓↓	↓	(-10) or less	Massive Transfusion

RESUSCITATION

- Based on the initial response to fluid resuscitation, hypovolemic injured patients can be separated into three broad categories:
- Responders: Individuals who are stable or have a good response to initial fluid therapy as evidenced by normalization of vital signs, mental status, and urine output are unlikely to have significant ongoing hemorrhage, and further diagnostic evaluation for occult injuries can proceed in an orderly fashion (Secondary Survey).
- Transient responders are those who respond initially to volume loading with improvement in vital signs, but subsequently deteriorate hemodynamically. This group of patients can be challenging to triage for definitive management.
- Nonresponders: have persistent hypotension despite aggressive resuscitation. These patients mandate immediate identification of the source of hypotension with appropriate intervention to prevent a fatal outcome.

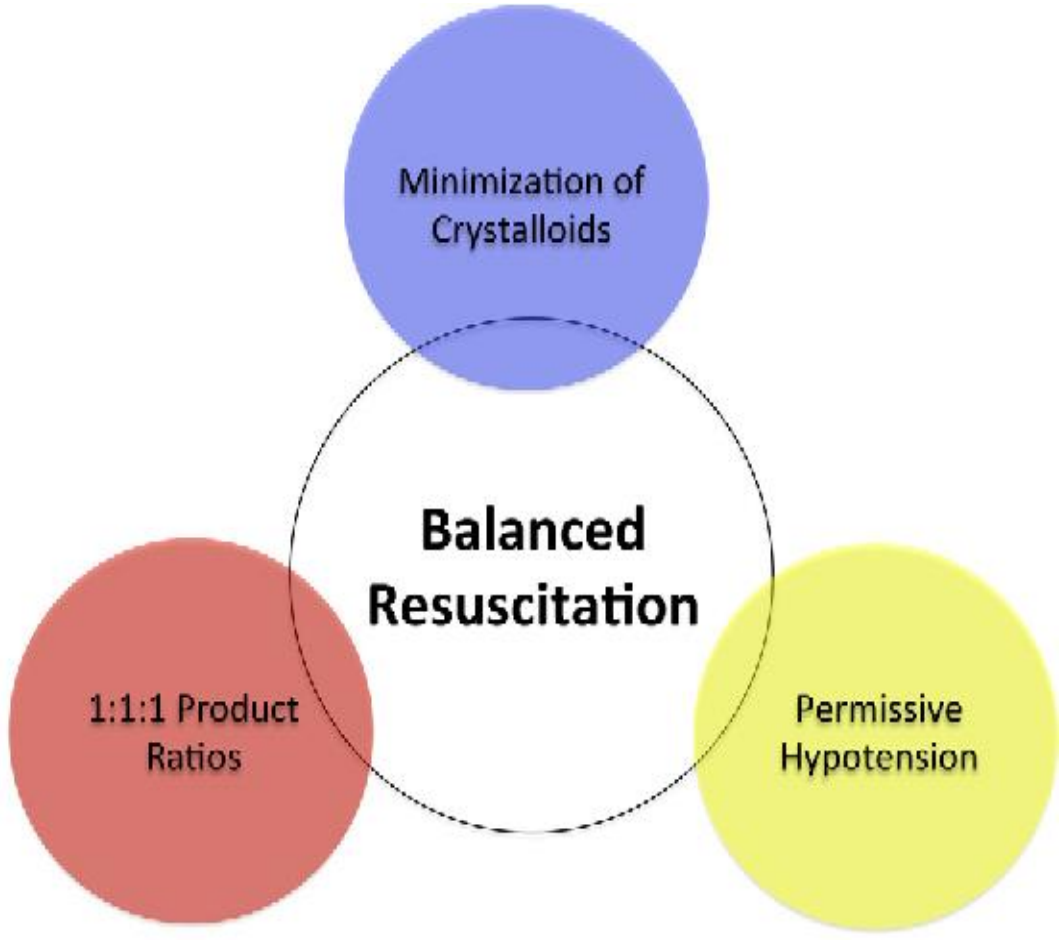
Management

	Rapid response	Transient response	Minimal or no response
Vital signs	Return to normal	Transient improvement, recurrence of decreased blood pressure and increased heart rate	Remain abnormal
Estimated blood loss	Minimal (10% to 20%)	Moderate and ongoing (20% to 40%)	Severe (>40%)
Need for more crystalloid	Low	Low to moderate	Moderate as bridge to transfusion
Need for blood	Low	Moderate to high	Immediate
Blood preparation	Type and crossmatch	Type-specific	Emergency blood release
Need for operative intervention	Possibly	Likely	Highly likely
Early presence of surgeon	Yes	Yes	Yes

Table reprinted with permission from the American College of Surgeons [57]. *Isotonic crystalloid solution, 2,000 ml in adults; 20 ml/kg in children.

Hypotensive resuscitation (Damage control resuscitation)

- Any delay in surgery for control of hemorrhage increases mortality (1%/ each 3 minutes)
- With uncontrolled hemorrhage, attempting to achieve normal BP increases mortality
- A Goal of SBP of 80-90mmHg is reasonable in patients with penetrating trauma (Exc: Brain injury)
- Profound hemodilution should be avoided by early blood transfusion



Fluid resuscitation

- Crystalloids better than colloids
- Hypertonic Saline has immunomodulatory effects:
  - ✓↓ ROS & reperfusion injury
  - ✓Less impairment of immune function
  - ✓Less brain swelling in multi-trauma patients
  - ✓Decrease incidence of ARDS

- Blood products:
  - ✓Should be used early in severely hypotensive patients
  - ✓Ratio Plasma-Platelets-RBCs= 1:1:1
  - ✓Adjuncts:
    - Fibrinogen concentrates
    - Prothrombin complex concentrates
    - Early use of Tranexamic acid (TXA)
  - ✓Maintenance of Normothermia

Crash -2 Trial

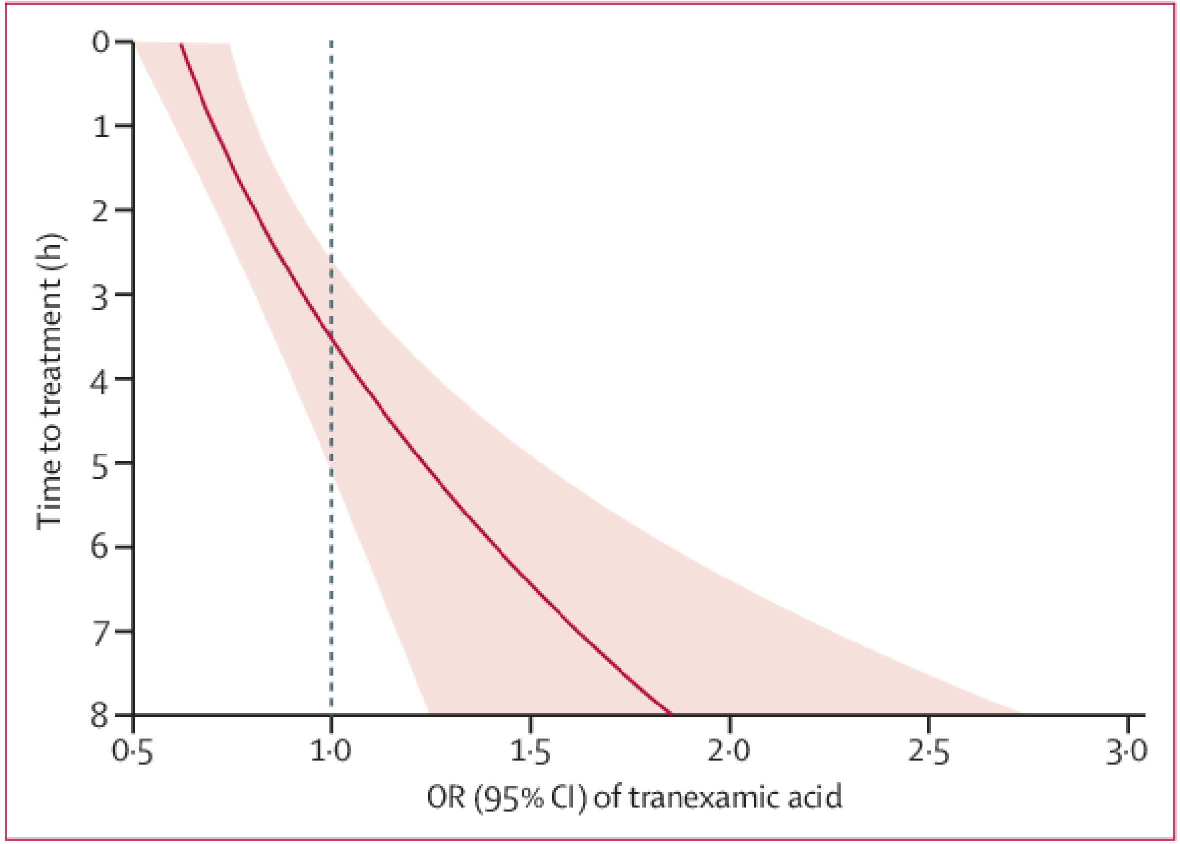
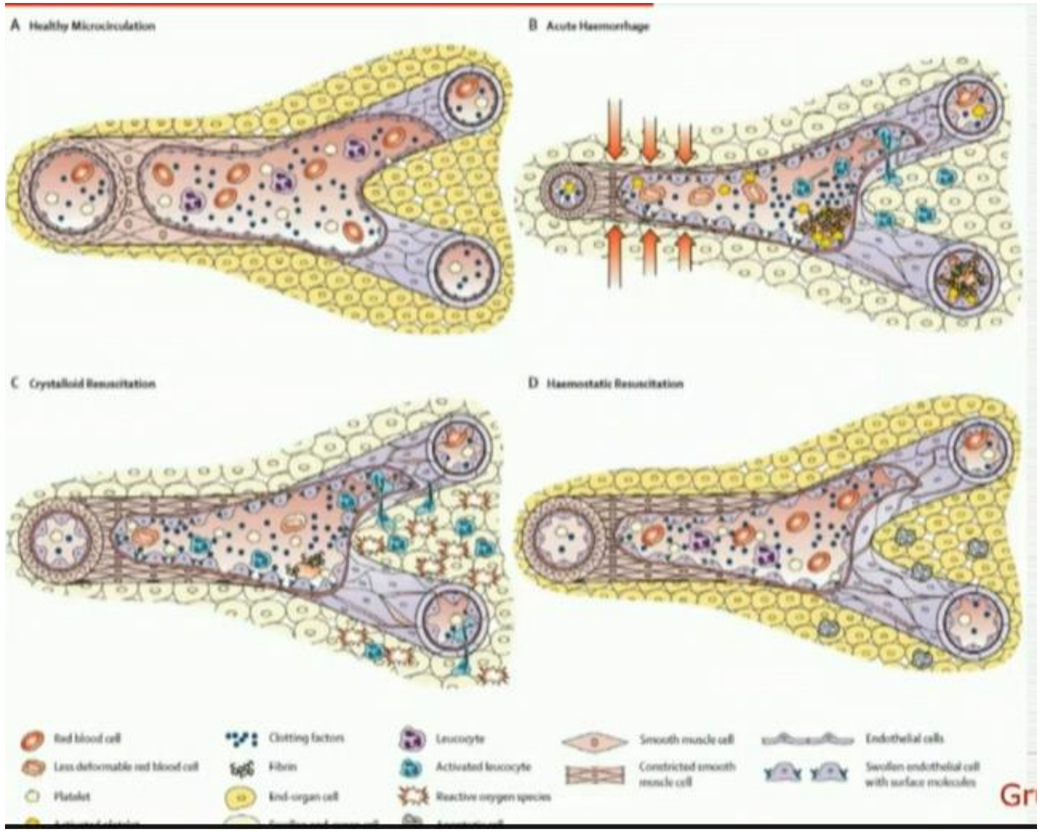
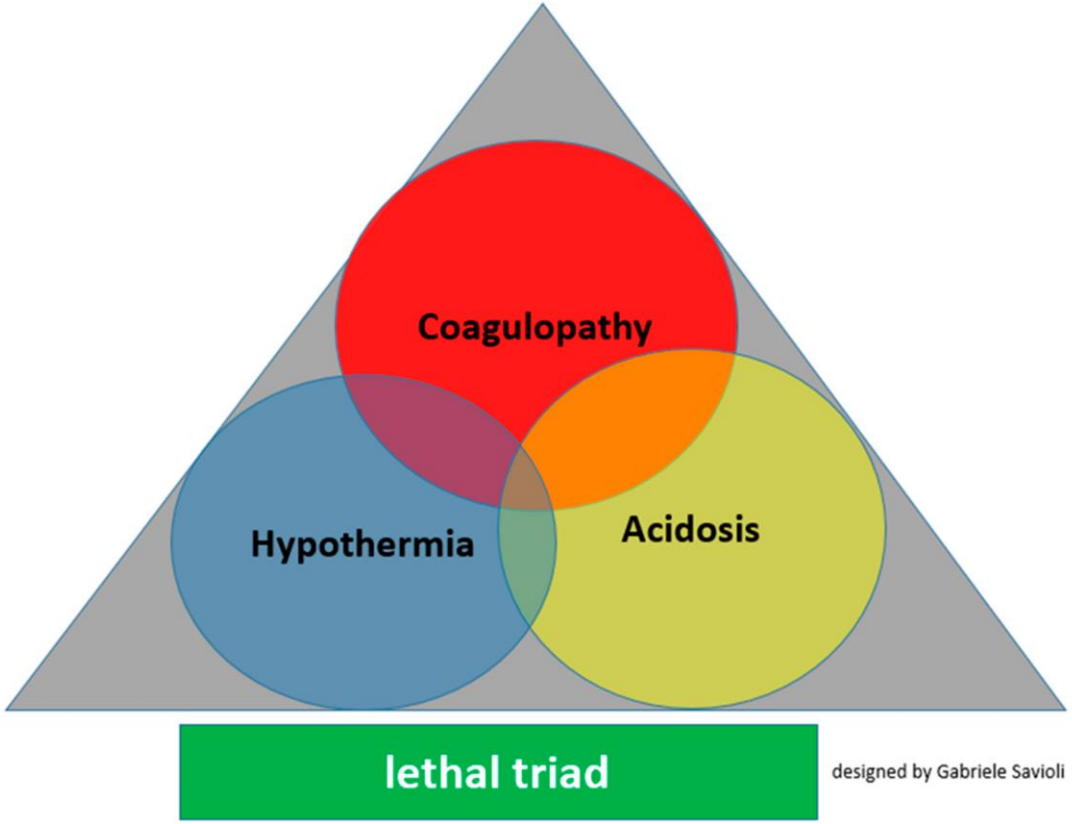


***Figure 2*: Effect of tranexamic acid on death due to bleeding by time to treatment**

Shaded area shows 95% CI. OR=odds ratio.

Homeostatic resucitation





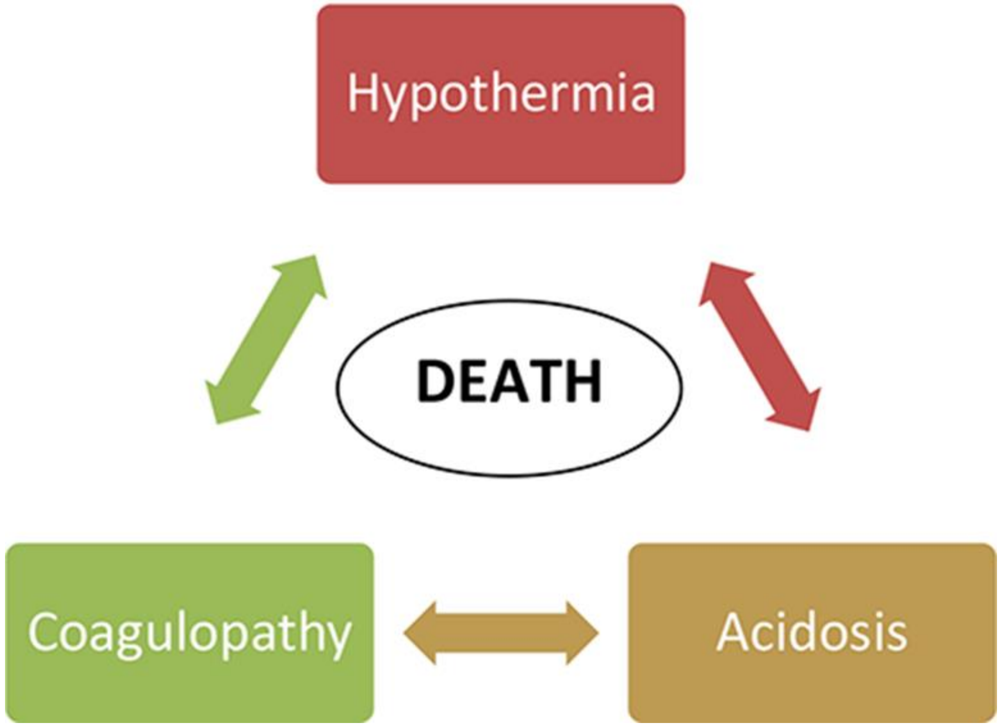
ACOT

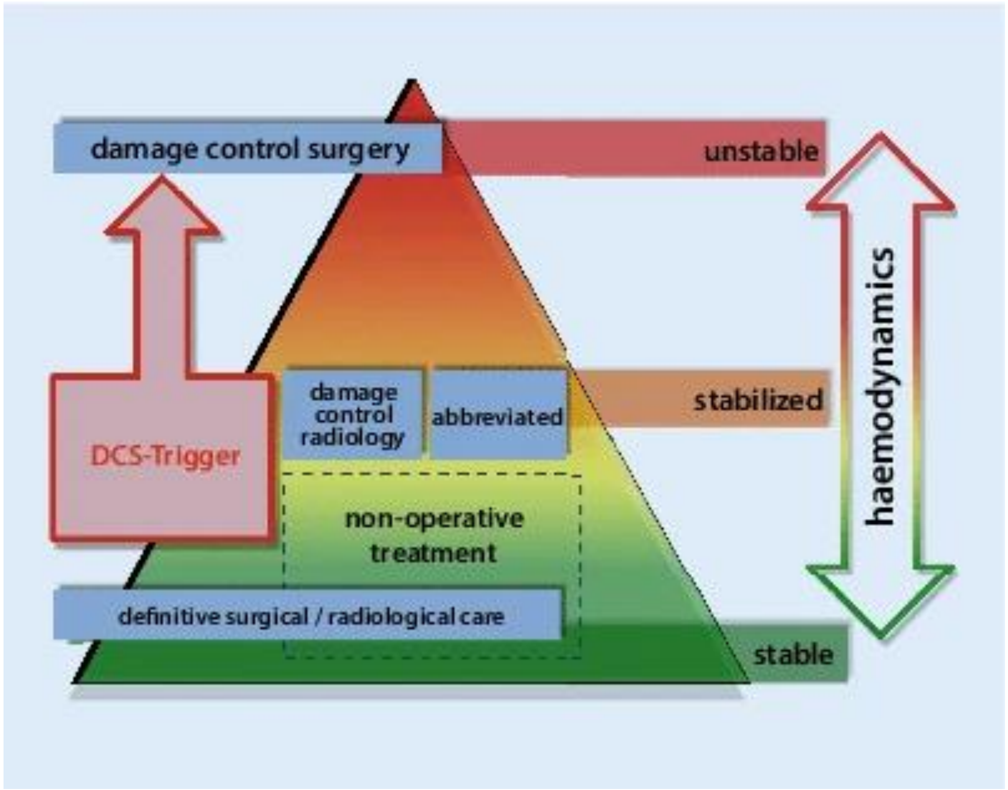
Damage Control Surgery (DCS)

1. Decision to perform DCS
2. initial operation
3. ICU resuscitation
4. Second-look/definitive operation.

- Absolute indications for DCS:
  - A. Base deficit >8 mEq/L or worsening base deficit
  - B. pH < 7.2
  - C. Hypotension < 90 mm Hg systolic
  - D. Hypothermia < 34° C
  - E. PTT > 60 seconds
  - F. Operative “clinical” coagulopathy
- Early recognition of significant physiologic derangement and the need for DCS are critical as inability to correct pH >7.21 and PTT >70 is associated with near certain mortality.

DAMAGE CONTROL SURGERY (DCS)





Transfusion Practices

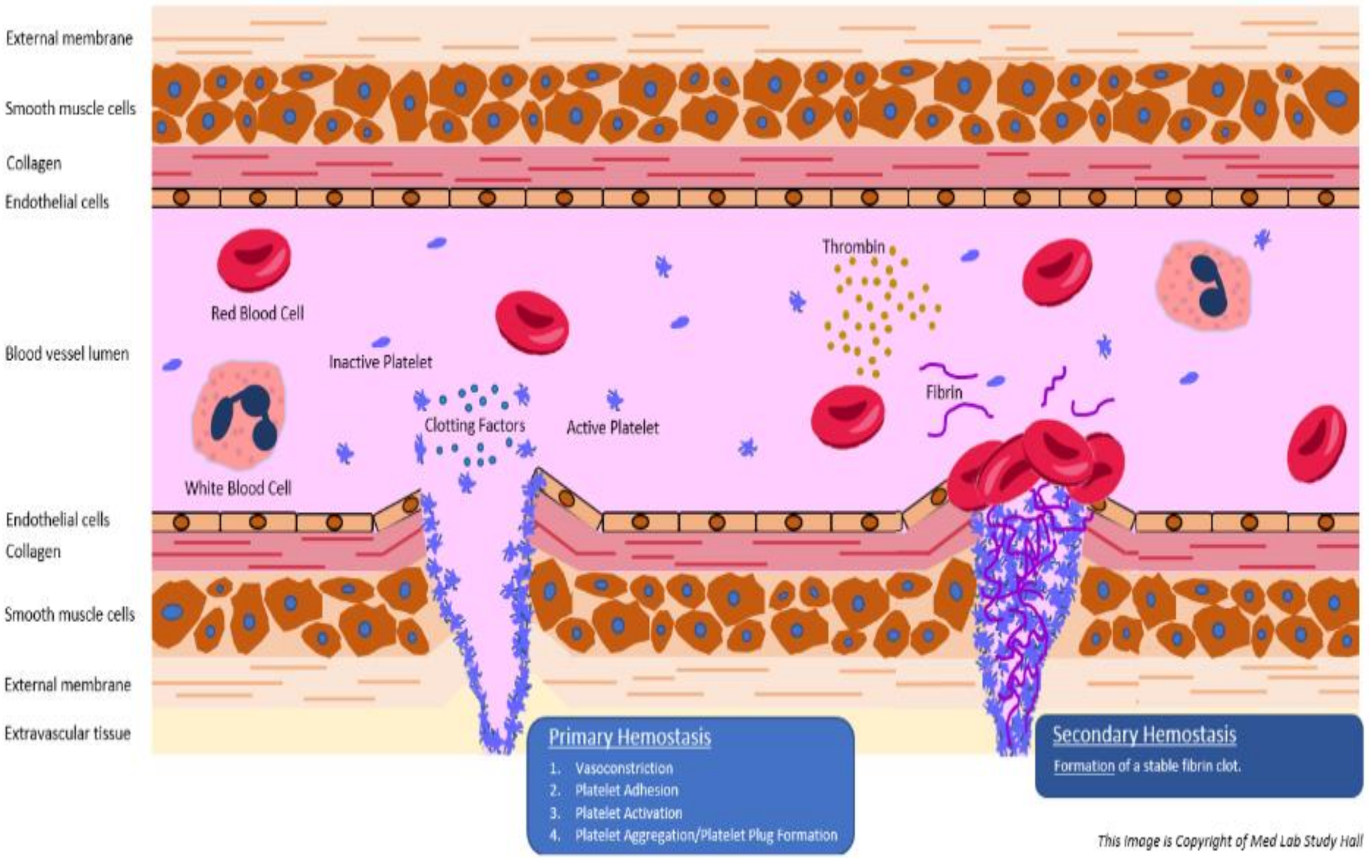
- The traditional thresholds for blood component replacement in the patient manifesting a coagulopathy have been INR >1.5, PTT >1.5 normal, platelet count >50,000/µL, and fibrinogen >100 mg/dl.

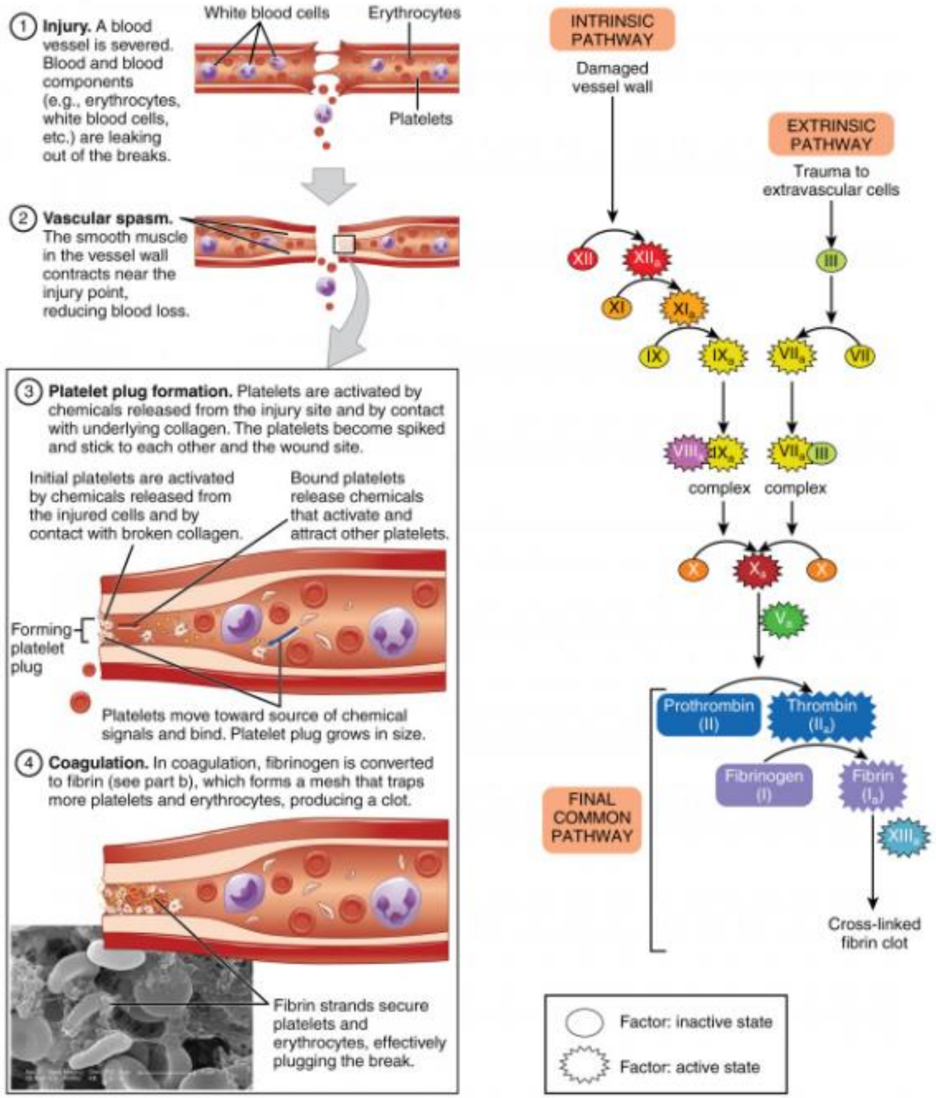
  a. These test various parts of the coagulation cascade but in isolation
  b. Static tests, which take time to complete and invariably lead to delay in a timely management.
  c. they need to be repeated at intervals and although they assess platelet number, they do not give accurate information on platelet function.
  d. Being plasma tests, they might not be accurately reflecting what actually happens to the patient

Basic Requirement for Clotting

- Membranes
- Clotting factors (enzymes!)
- Energy (High energy phosphate bound ~ ATP)
- Optimal physical, chemical environment
  - Temperature, pH, Calcium ...
- Cells

Hemostasis



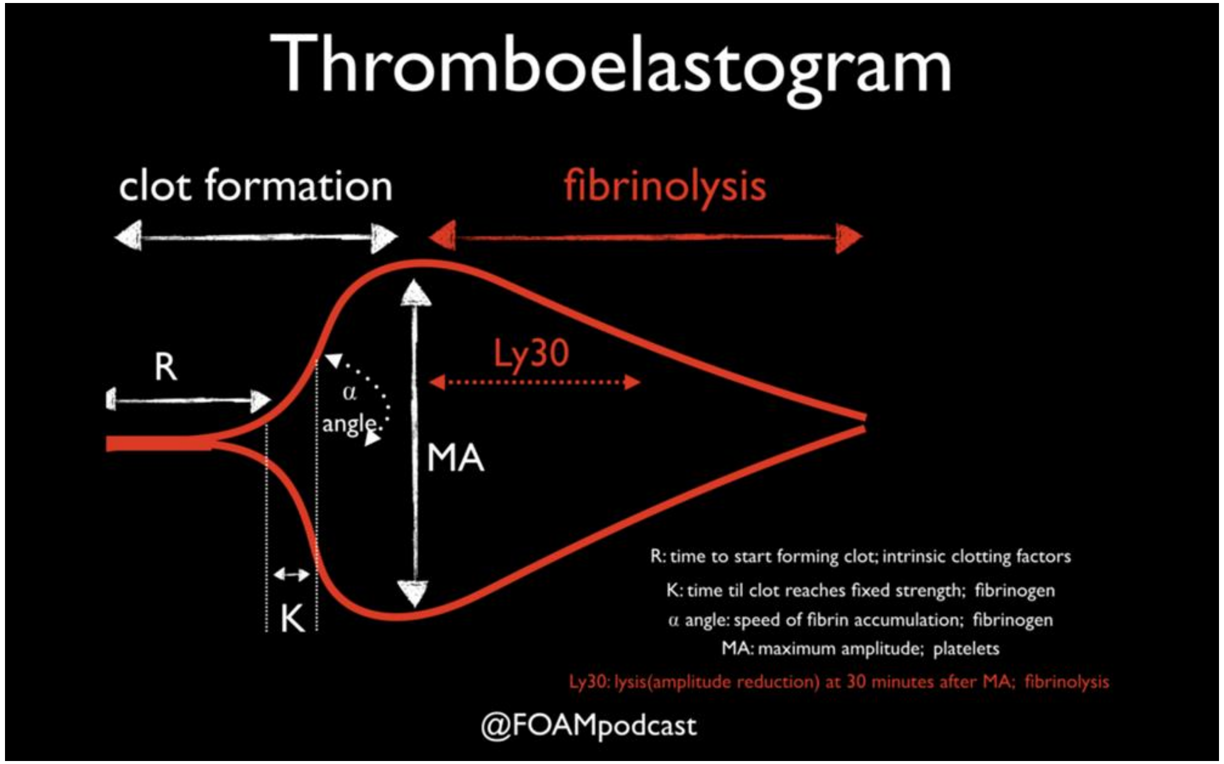


(a) The general steps of clotting

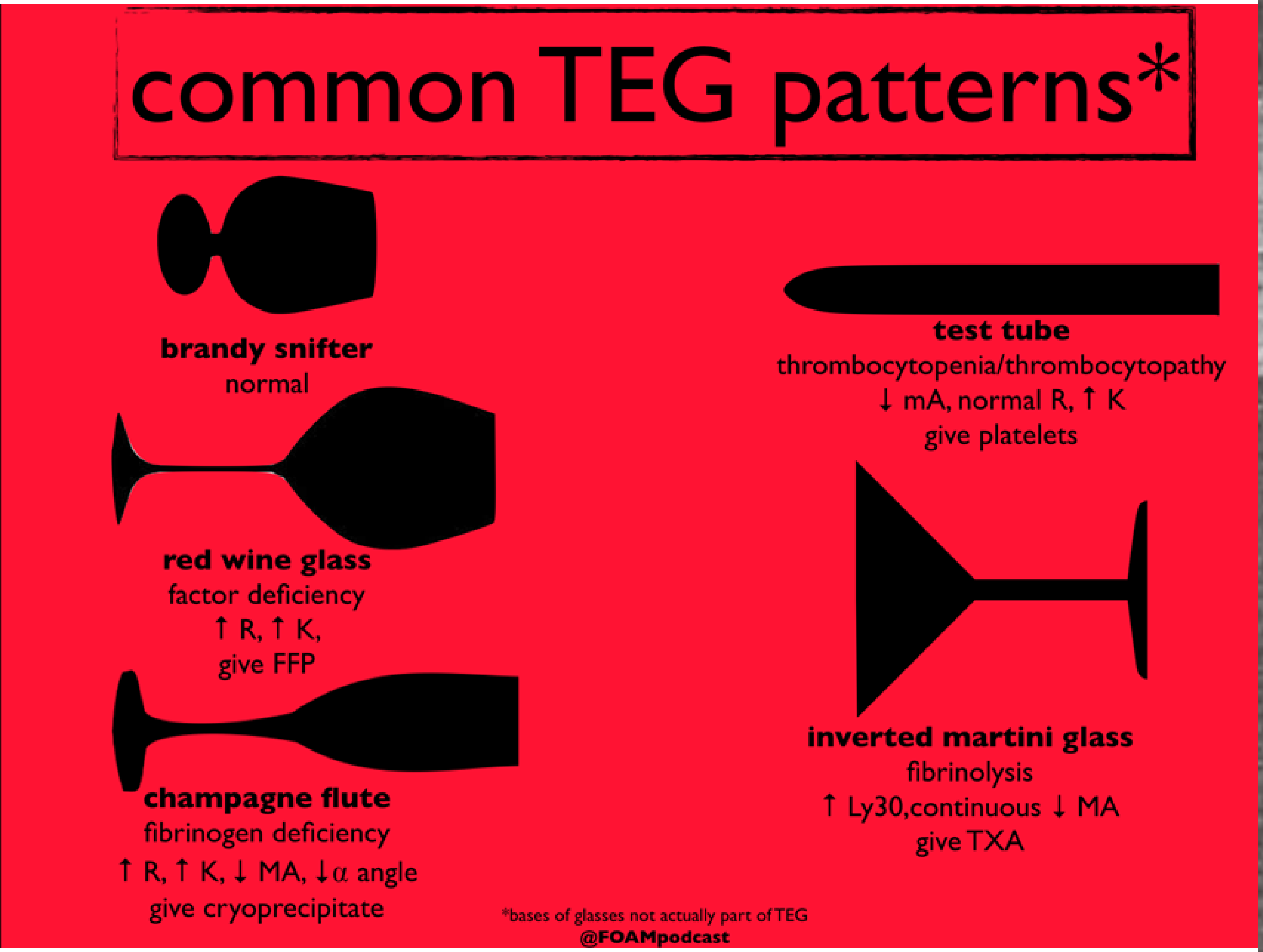
(b) Fibrin synthesis cascade

TEG

- r-time: Represents period of time of latency from start of test to initial fibrin formation. This represents the standard clotting studies. Normal range: 15 to 23 minutes (native blood); 5 to 7 minutes (kaolin-activated).
- k-time: Represents time taken to achieve a certain level of clot strength (where r-time = time zero)—equates to amplitude 20 mm. Normal range: 5 to 10 minutes (native blood); 1 to 3 minutes (kaolin-activated).
- α-angle: Measures the speed at which fibrin build-up and cross-linking takes place (clot strengthening), and hence assesses the rate of clot formation. Normal range: 22 to38 (native blood); 53 to 67 (kaolin-activated).
- Maximum amplitude: MA is a direct function of the maximum dynamic properties of fibrin and platelet bonding via GPIIb/IIIa and represents the ultimate strength of the fibrin clot and which correlates to platelet function: 80%platelets; 20% fibrinogen. normal range: 47 to 58 mm (native blood); 59 to 68 mm (kaolin-activated).
- LY30: This is percentage decrease in amplitude 30 minute spost-MA and gives measure of degree of fibrinolysis. Normal range < 7.5% (native blood); < 7.5% (celite-activated) and similarly, LY60 is the percentage decrease in amplitude 60 minutes post-MA.
- A30 (A60): Amplitude at 30 (60) minutes post-MA



EPL Represents 'computer prediction' of 30 minutes lysis based on interrogation of actual rate of diminution of trace amplitude commencing 30 seconds post-MA and is the earliest indicator of abnormal lysis.
Early EPL > LY30 (30 mins EPL = LY30)
Normal EPL < 15%
Fibrinolysis leads to ↑ LY30/↑ LY60 ↑ EPL and ↓ A30/↓A60



Hellmut Hartert, Surgeon, Father of Thrombelastography, 1918-1993

Massive Transfusion Protocol

Triggers: SBP <70 with penetrating torso injury, major pelvic injury, FAST +
SBP <71-90 mmHg and HR >108 with penetrating torso injury, major pelvic injury, FAST +
** order citrated rapid TEG

⇩

Empiric Transfusion Until Lab Results Available

Shipment	PRBCs	FFP	Platelets	Cryo
1	4	2		
2	4	2	1	10

Continued Treatment of Shock

Hemorrhage Control, Correct Hypothermia, Correct Acidosis
Normalize Ca^{++}

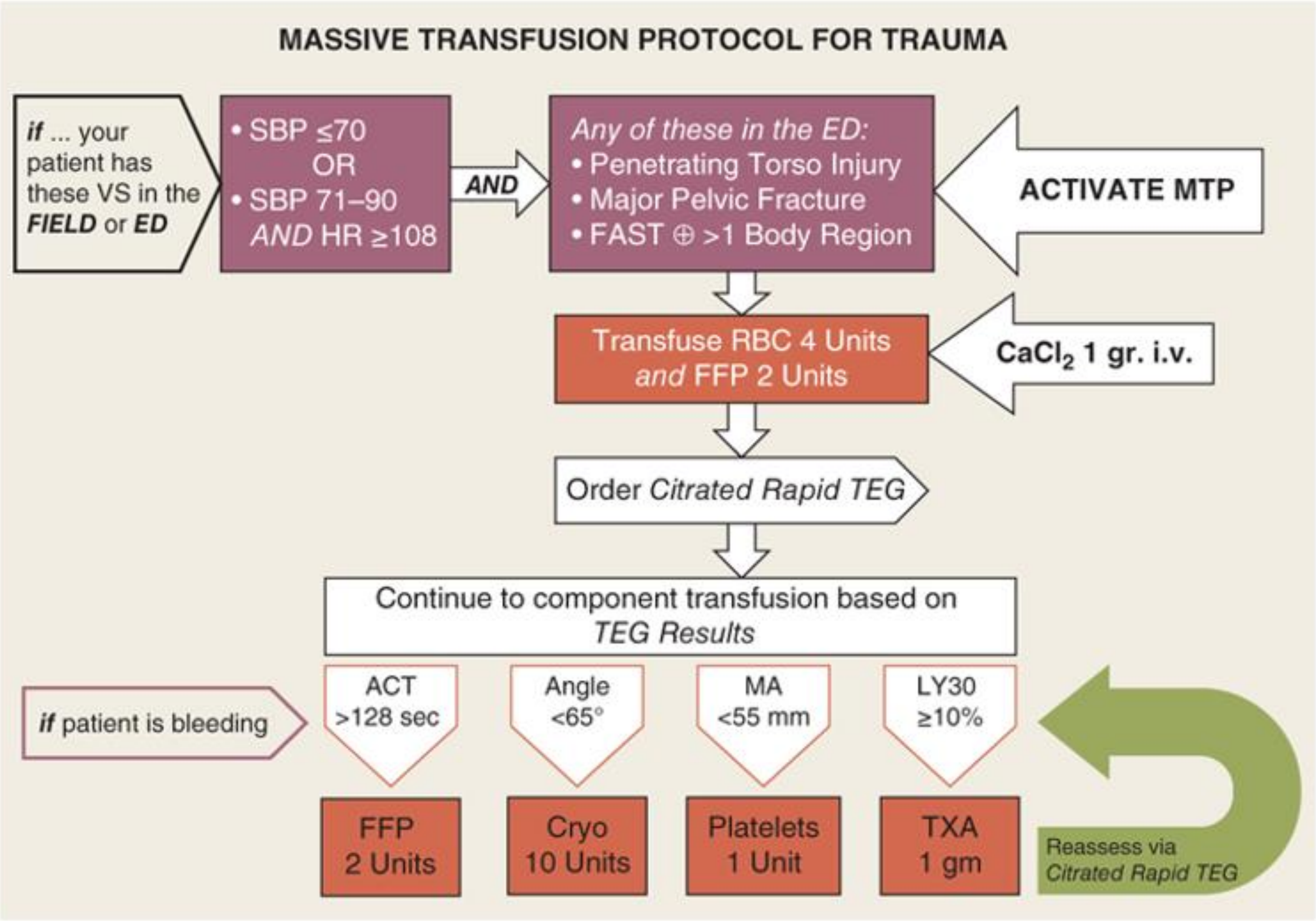
⇩

TEG Based Resuscitation*

rapidTEG-ACT >128 sec → 2 units thawed plasma
rapidTEG-MA <55mm → 1 unit of apheresis platelets
rapidTEG-angle <66 degrees → 10 units pooled cryoprecipitate
rapidTEG EPL >9% → 1g tranexamic acid

***Transfusion Triggers if TEG is Unavailable**

PT, PTT > 1.5 control
→2 units thawed plasma
Platelet count <50,000/mcL
→1 unit of apheresis platelets
Fibrinogen <100 mg/dL
→10 units pooled cryoprecipitate


MASSIVE TRANSFUSION PROTOCOL FOR TRAUMA
if ... your patient has these VS in the FIELD or ED
• SBP ≤70
OR
• SBP 71–90 AND HR ≥108
AND
Any of these in the ED:
• Penetrating Torso Injury
• Major Pelvic Fracture
• FAST ⊕ >1 Body Region
ACTIVATE MTP
Transfuse RBC 4 Units and FFP 2 Units
CaCl2 1 gr. i.v.
Order Citrated Rapid TEG
Continue to component transfusion based on TEG Results
if patient is bleeding
ACT >128 sec
Angle <65°
MA <55 mm
LY30 ≥10%
FFP 2 Units
Cryo 10 Units
Platelets 1 Unit
TXA 1 gm
Reassess via Citrated Rapid TEG

Forms of Shock- Traumatic Shock

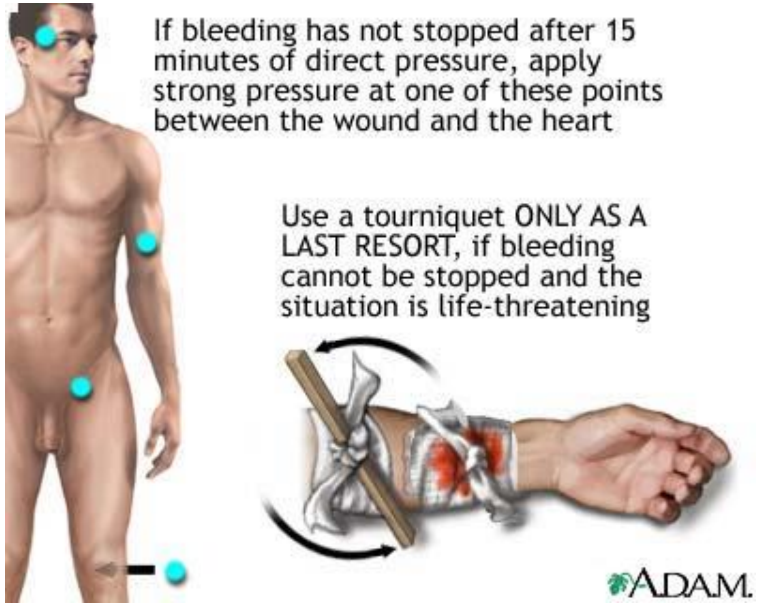
- Traumatic shock= Hemorrhagic shock + Severe tissue injury
- The usual response to Hemorrhagic shock is compounded by SIR to DAMPs.
- Lethal with significantly less blood loss & More likely to be complicated by MOFS
- Management:
  - Prompt control of Hemorrhage
  - Adequate volume resuscitation
  - Debridement of nonviable tissue
  - Stabilization of fractured bone
  - Appropriate treatment of Soft tissue / Internal organ injuries

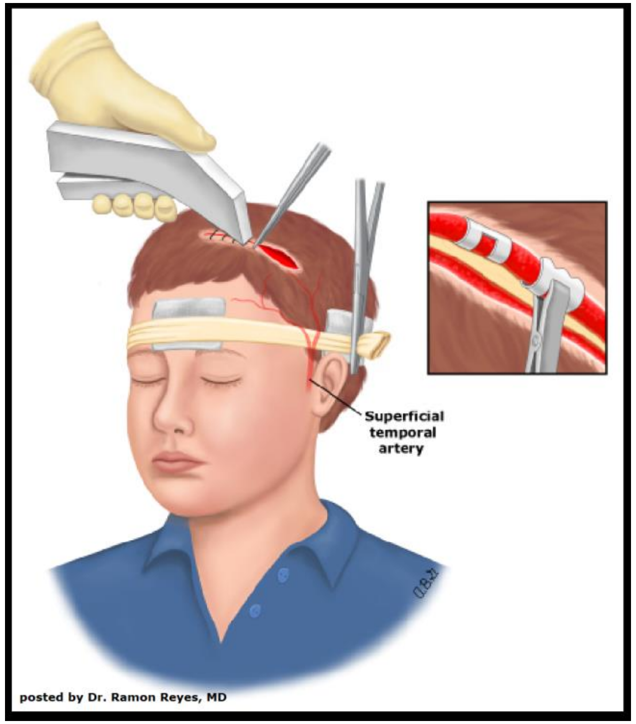
Control of hemorrhage – External (visible)

- For open wounds with ongoing bleeding, manual compression should be done with a single 4 × 4 gauze and a gloved hand.
- Blind clamping of bleeding vessels should be avoided because of the risk to adjacent structures, including nerves. This is particularly true for penetrating injuries of the neck, thoracic outlet, and groin, where bleeding may be torrential and arising deep within the wound.
- In these situations, a gloved finger placed through the wound directly onto the bleeding vessel can apply enough pressure to control active bleeding. The surgeon performing this maneuver must then walk with the patient to the OR for definitive treatment.

Control of hemorrhage – External (visible)

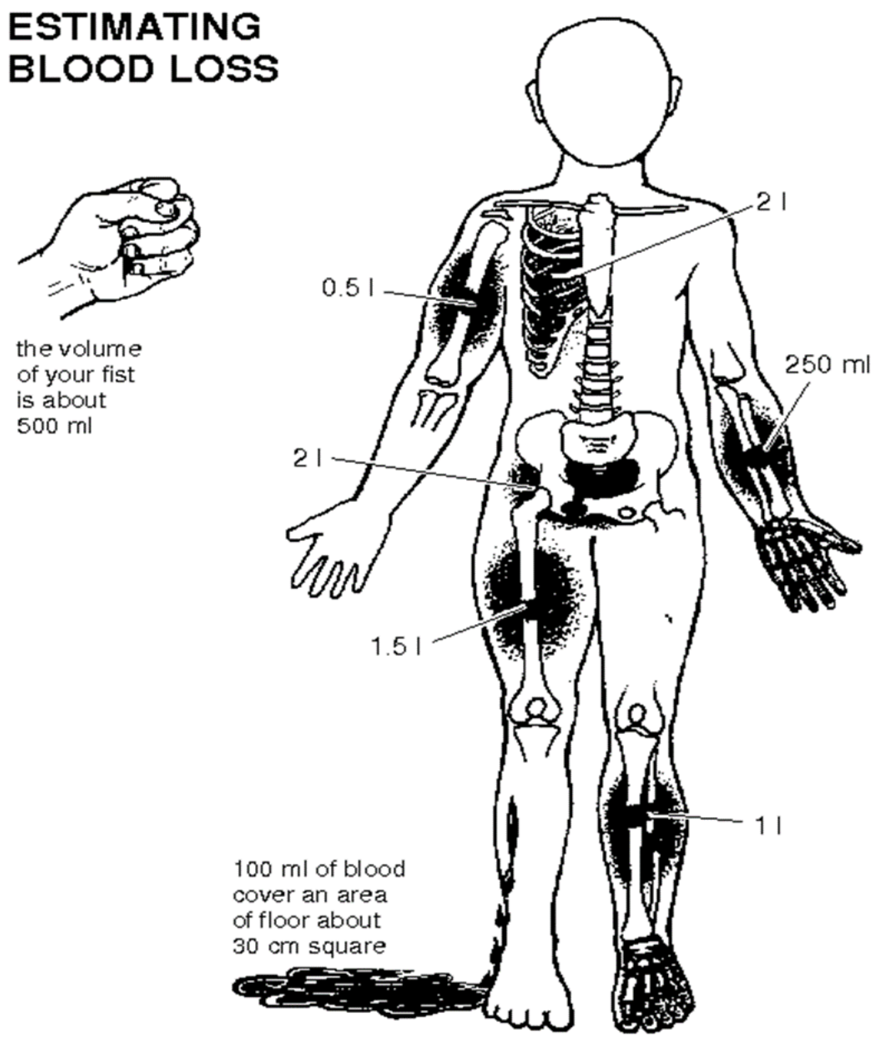
- For bleeding of the extremities, it is tempting to apply tourniquets for hemorrhage control, but digital occlusion will usually control the bleeding; complete vascular occlusion with a tourniquet risks permanent neuromuscular impairment.
- Patients in shock have a lower tolerance to warm ischemia, and an occluded extremity is prone to small vessel thrombosis.
- For patients with open fractures, fracture reduction with stabilization via splints will limit bleeding both externally and into the subcutaneous tissues.
- Scalp lacerations through the galea aponeurotica tend to bleed profusely; these can be temporarily controlled with skin staples, Raney clips, or a full-thickness continuous running nylon stitch.





CONTROL OF HEMORRHAGE – INTERNAL

- During the circulation section of the primary survey, four life-threatening injuries must be identified promptly:
  a. massive hemothorax
  b. cardiac tamponade
  c. massive hemoperitoneum
  d. mechanically unstable pelvic fractures with bleeding.



C: Circulation

- One must first consider the dominant categories of postinjury shock that may be the underlying cause:

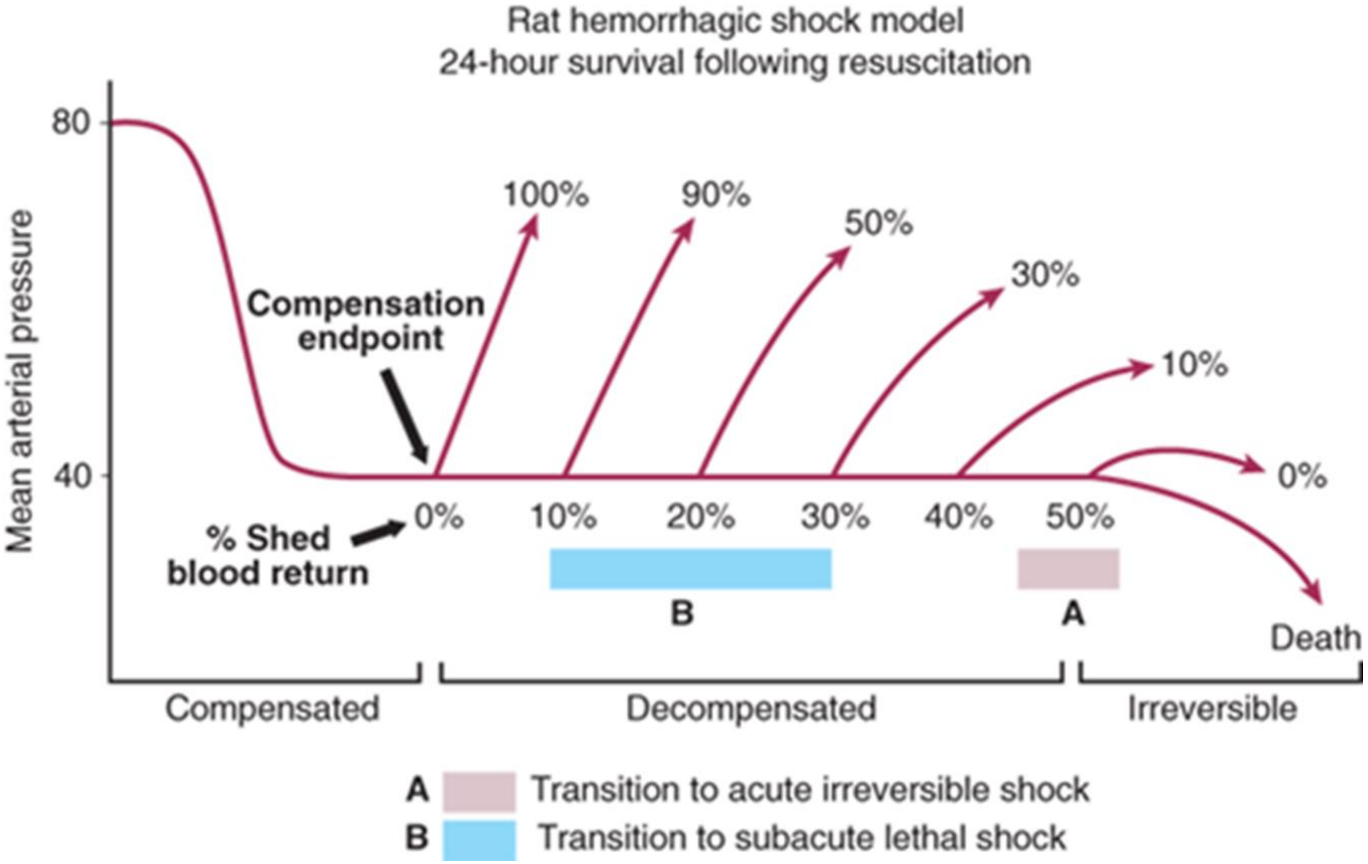
    A. hemorrhagic
    B. cardiogenic
    C. Neurogenic

- In patients with persistent hypotension and tachycardia, cardiogenic or hemorrhagic shock are the likely causes.
- Ultrasound evaluation of the pericardium, pleural cavities, and abdomen in combination with plain radiographs of the chest and pelvis will usually identify the source of shock.
- In patients with persistent hypotension following blunt trauma, the pelvis should be wrapped with a sheet for stabilization until radiography can be done; external blood loss should be controlled, and extremity fractures should be splinted to minimize further blood loss.
- Evaluation of the CVP or ultrasound of the IVC may further assist in distinguishing between cardiogenic and hypovolemic shock.
- Base deficit measurement is critical; a base deficit of >8 mmol/L implies ongoing cellular shock. Serum lactate also is used to monitor the patient's physiologic response to resuscitation.
- Evolving technology, such as measurement of the critical reserve index, may provide noninvasive monitoring.

THE COMPENSATORY RESERVE INDEX

CONCEPT

Humans are able to compensate for significant hemorrhage through various neural and hormonal mechanisms, allowing their vital signs to remain relatively stable until these adaptive compensatory mechanisms are gradually overwhelmed, resulting in hemodynamic compromise and the onset of hemorrhagic shock.



- One of the most challenging aspects of providing effective treatment of shock is an inability to recognize its early onset.
- Blood pressures, arterial oxygen saturation (Spo2), and heart rate measurements collected in the early prehospital setting were similar 30 to 45 minutes after traumatic injury in hemorrhaging patients who went on to die compared with those who survived.
- These results emphasize that current physiologic monitoring can be grossly misleading, and nonpredictive of hemodynamic collapse, because of the numerous compensatory mechanisms that "protect" these vital signs from significant clinical change.
- In other words, current vital sign monitoring lacks sensitivity and specificity to predict impending hemodynamic collapse and shock during the early compensatory stage of hemorrhage.

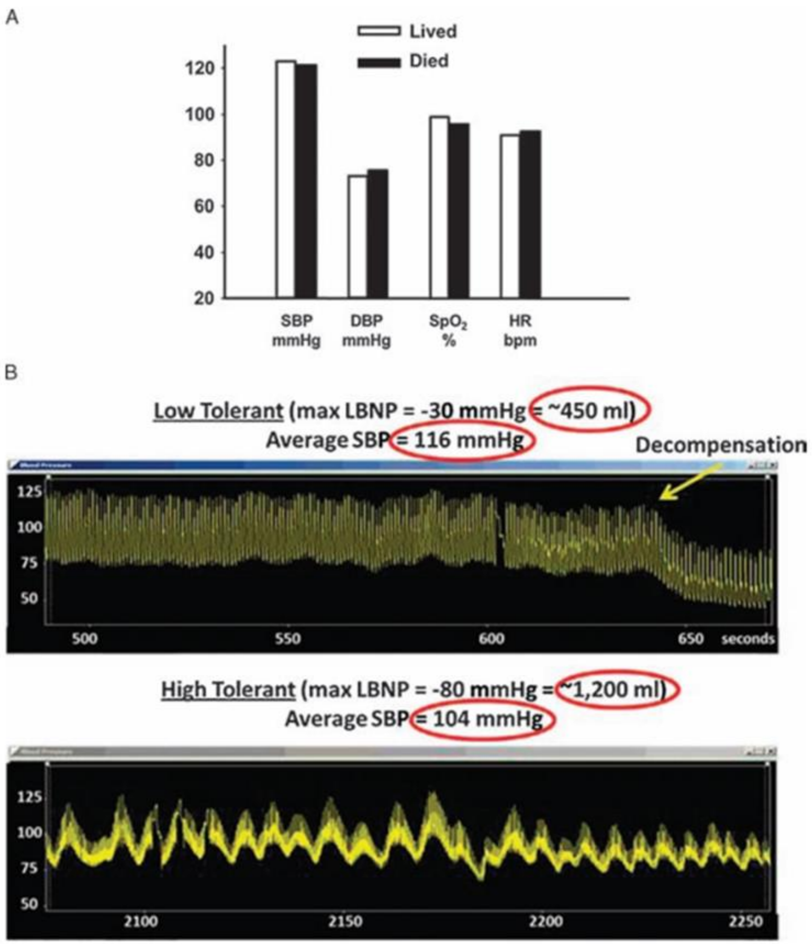
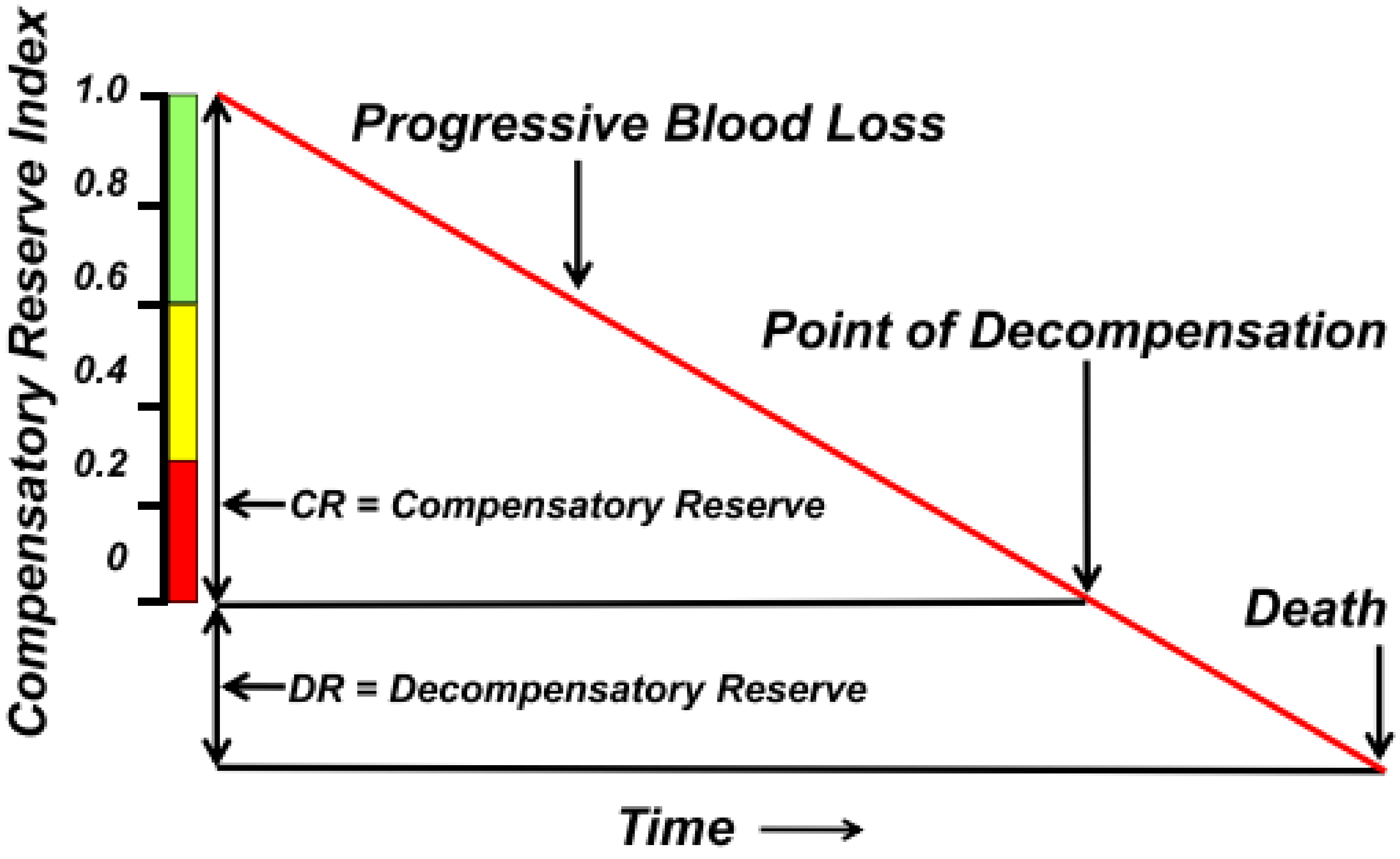


Figure 1. (*A*) Trauma patients with severe hemorrhage who lived (*open bars*) and died (*closed bars*) could not be differentiated by standard vital signs obtained 30 to 45 minutes after injury. Modified from Cooke et al.[27] (*B*) Arterial waveform recordings demonstrate pronounced oscillatory patterns in individuals with high tolerance to a progressive reduction in central blood volume (*bottom recording*) compared to low tolerance individuals (*top recording*). Modified from Convertino et al.[28]

Compensatory Reserve Index (CRI)



USAISR

- The use of lower-body negative pressure (LBNP) that has proven to produce repeatable tolerance times to *HYPOVOLEMIA*
- The integrated total of all mechanisms that compose the reserve to compensate for blood loss (the compensatory reserve):
  - Hemodynamic response
  - Metabolic response
  - Coagulation response
  - Respiratory response
  - Neuroendocrine response
  - Mental status responses

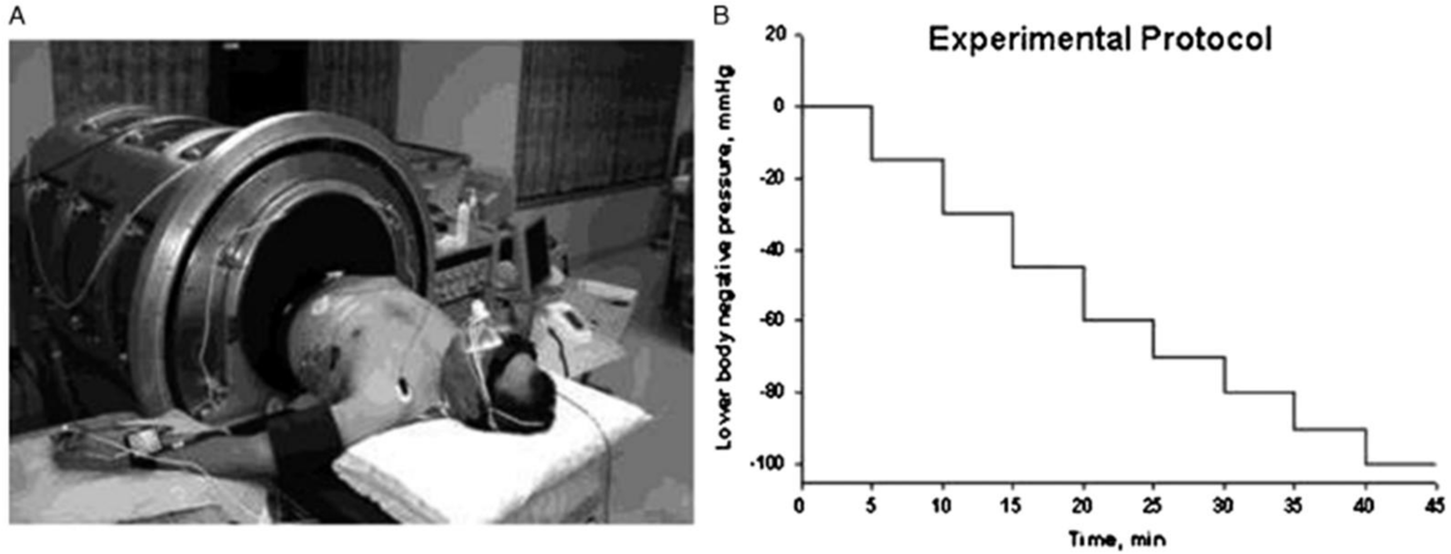


Figure 2. Subject in the LBNP device (*A*) and the LBNP protocol (*B*). See Convertino et al.[2]

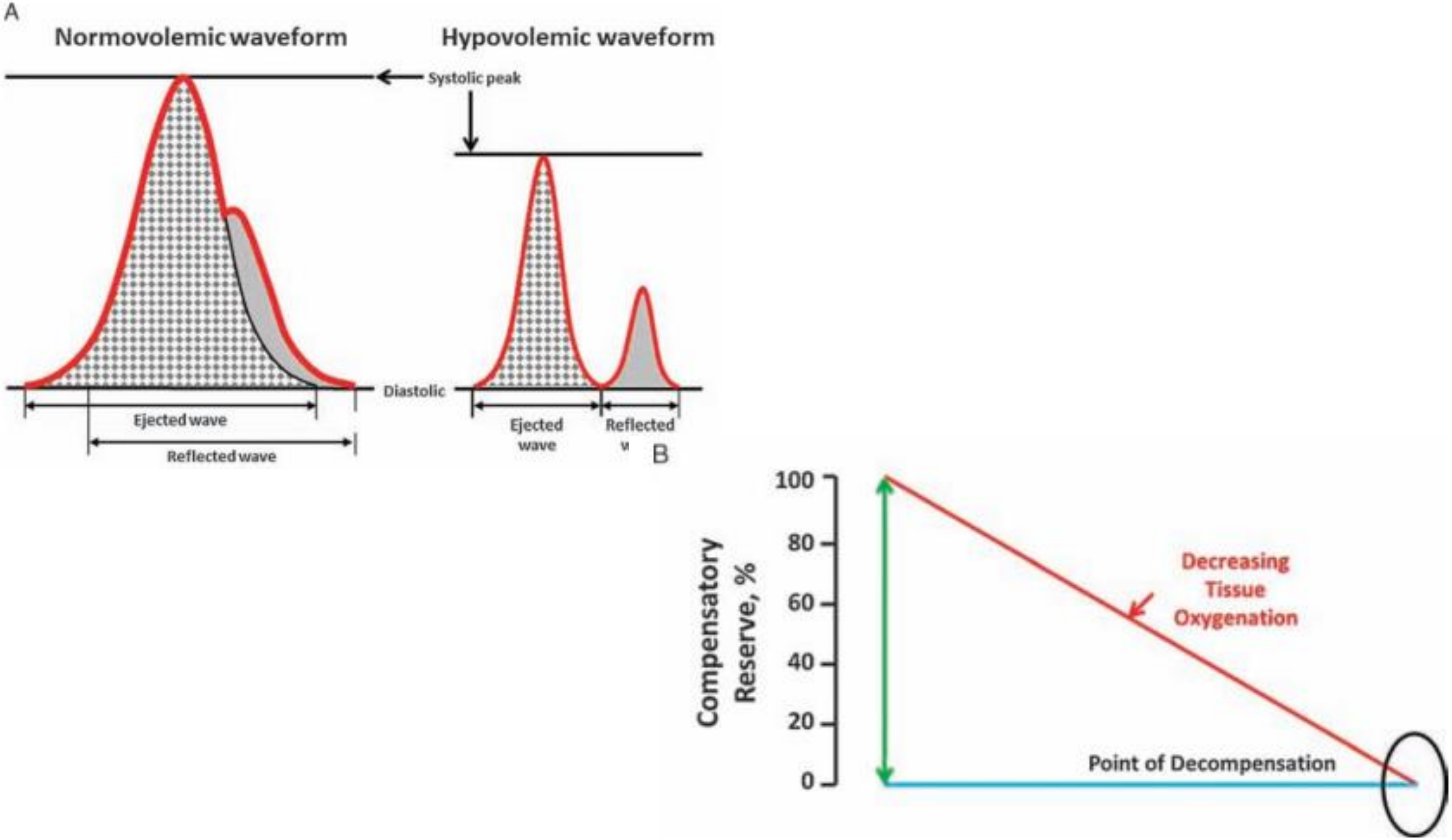

A
Normovolemic waveform
Hypovolemic waveform
Systolic peak
Diastolic
Ejected wave
Reflected wave
Ejected wave
Reflected
B
100
80
60
40
20
0
Compensatory Reserve, %
Decreasing Tissue Oxygenation
Point of Decompensation

TABLE 1. Times Course, Sensitivity and Specificity of Changes in Traditional Vital Signs and Hemodynamic Responses During Progressive Central Hypovolemia

Vital Sign	Change During Progressive Central Hypovolemia	Sensitivity	Specificity	Reference(s)
Systolic BP	Late	0.80	0.17	5,27,39–44
Diastolic BP	Late	0.40	0.53	40–44
Mean BP	Late	0.60	0.33	40–45
Heart rate	Not specific	0.80	0.02	27,39,40,45
Shock Index	Late	—	—	39,42
SpO_2	Late	0.60	0.00	40–43,45
Stroke volume	Early	0.60	0.33	31,41,42,44
Cardiac output	Late	0.80	0.02	41
Radial pulse character	Late	—	—	38
$EtCO_2$	Late			46
Respiratory rate	Late	—	—	37,46
GCS	Late	—	—	38
Blood pH	Late	—	—	4,40
Blood lactate	Late		0.03	4,40
Blood base excess	Late		0.02	4,40
Perfusion index	Late	0.71	0.29	47
Pulse pressure variability	Late	0.78	0.69	47
SmO_2	Early, but low specificity	0.65	0.63	48
Compensatory reserve	Early and specific	0.84–0.87	0.78–0.86	28,39–43,45,47–49

BP, blood pressure.

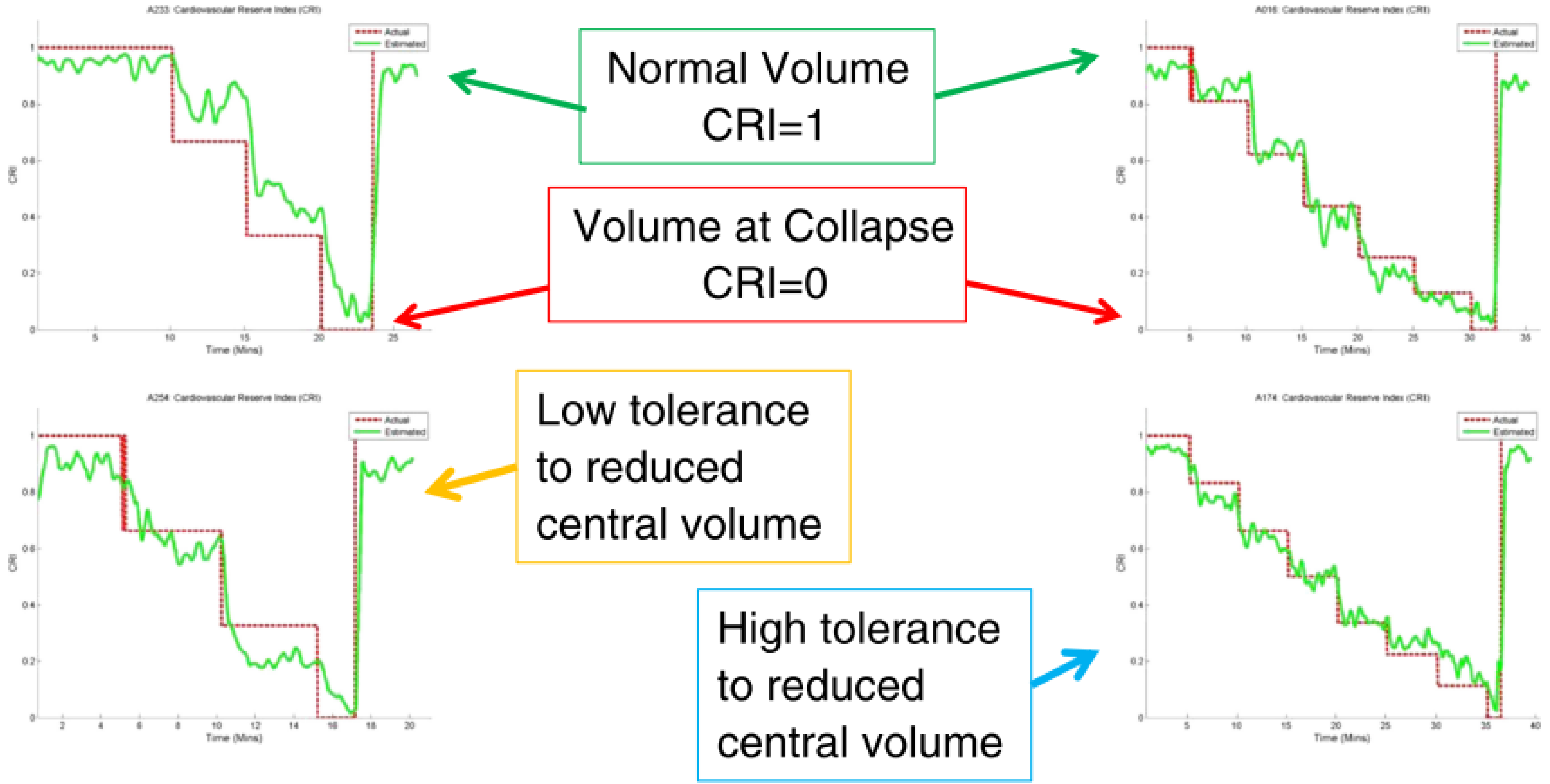
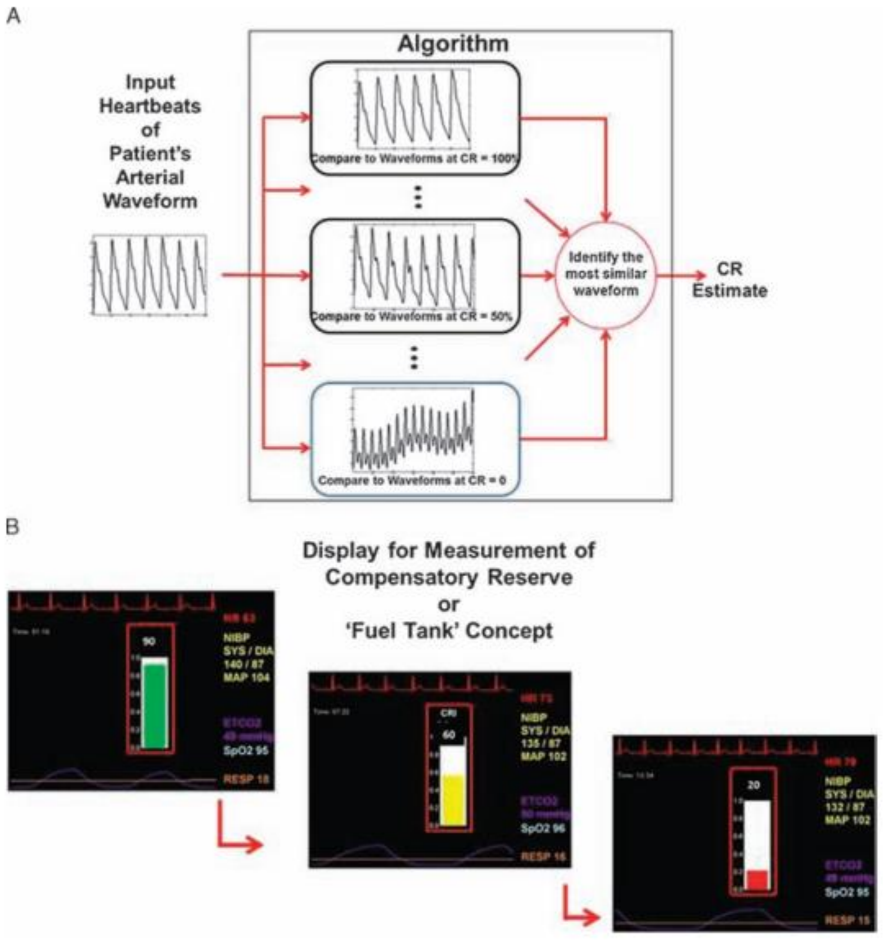


Figure 3. CRI estimation accuracy results on 4 of the 184 LBNP subjects who went to presyncope during LBNP studies. The *red line* indicates the ground truth CRI value, which can only be determined using the maximum tolerated LBNP (blood loss) after a subject achieves hemodynamic decompensation. The *green line* shows the beat-to-beat CRI estimates by CipherBP. As can be seen from the plots, there is a wide range of reserve volumes between subjects, and they can be generally classified as having low or high tolerance to blood loss. In either case, the CRI estimates by CipherBP effectively track the true CRI value.


A
Algorithm
Input
Heartbeats
of
Patient's
Arterial
Waveform
Compare to Waveforms at CR = 100%
Compare to Waveforms at CR = 50%
Compare to Waveforms at CR = 0
Identify the
most similar
waveform
CR
Estimate
B
Display for Measurement of
Compensatory Reserve
or
'Fuel Tank' Concept

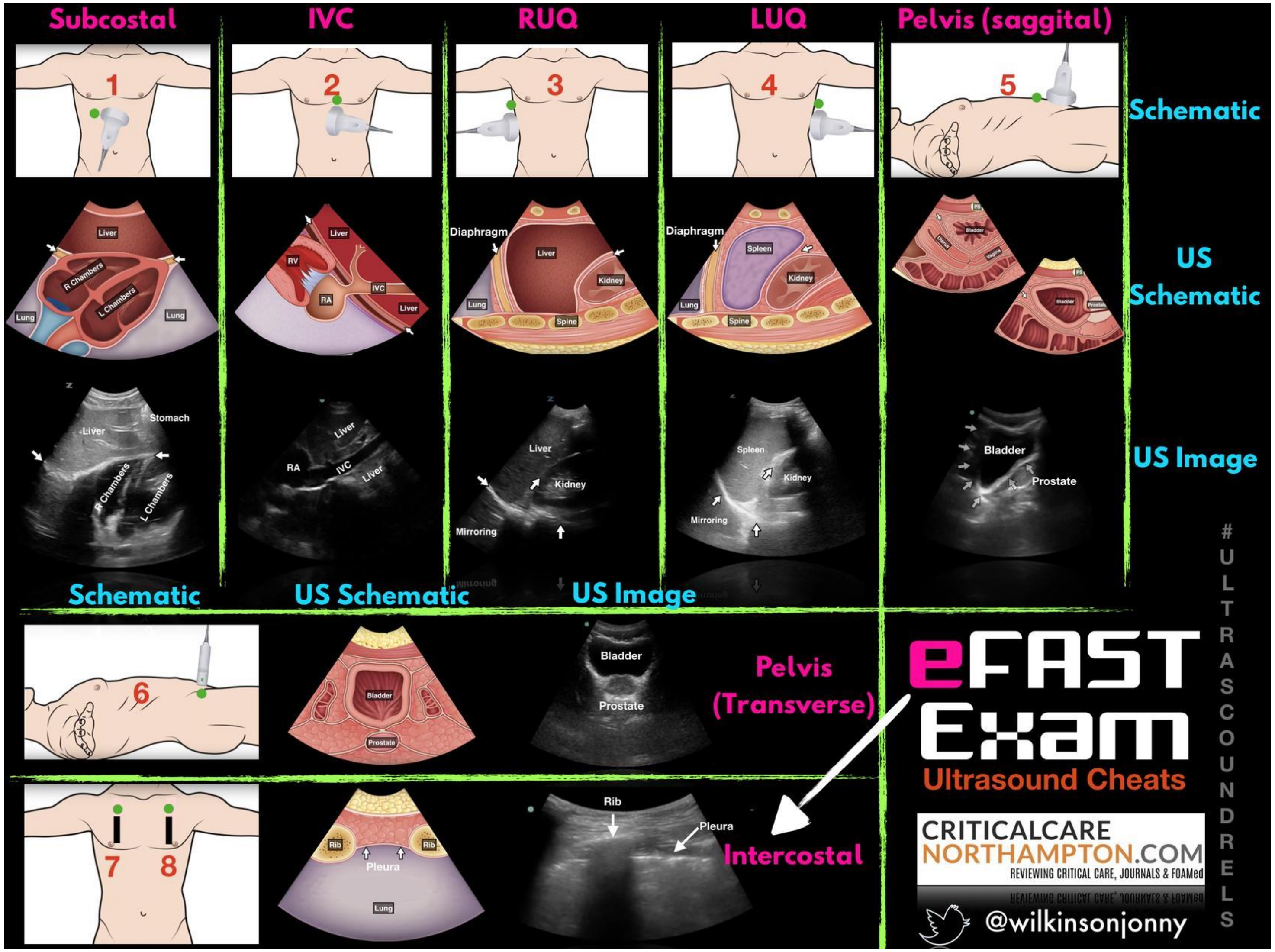

FLASHBACK

C: Circulation

- The differential diagnosis of cardiogenic shock in the trauma patient is:
- Tension pneumothorax
- Pericardial tamponade
- Blunt cardiac injury
- Myocardial infarction
- Bronchovenous air embolism.

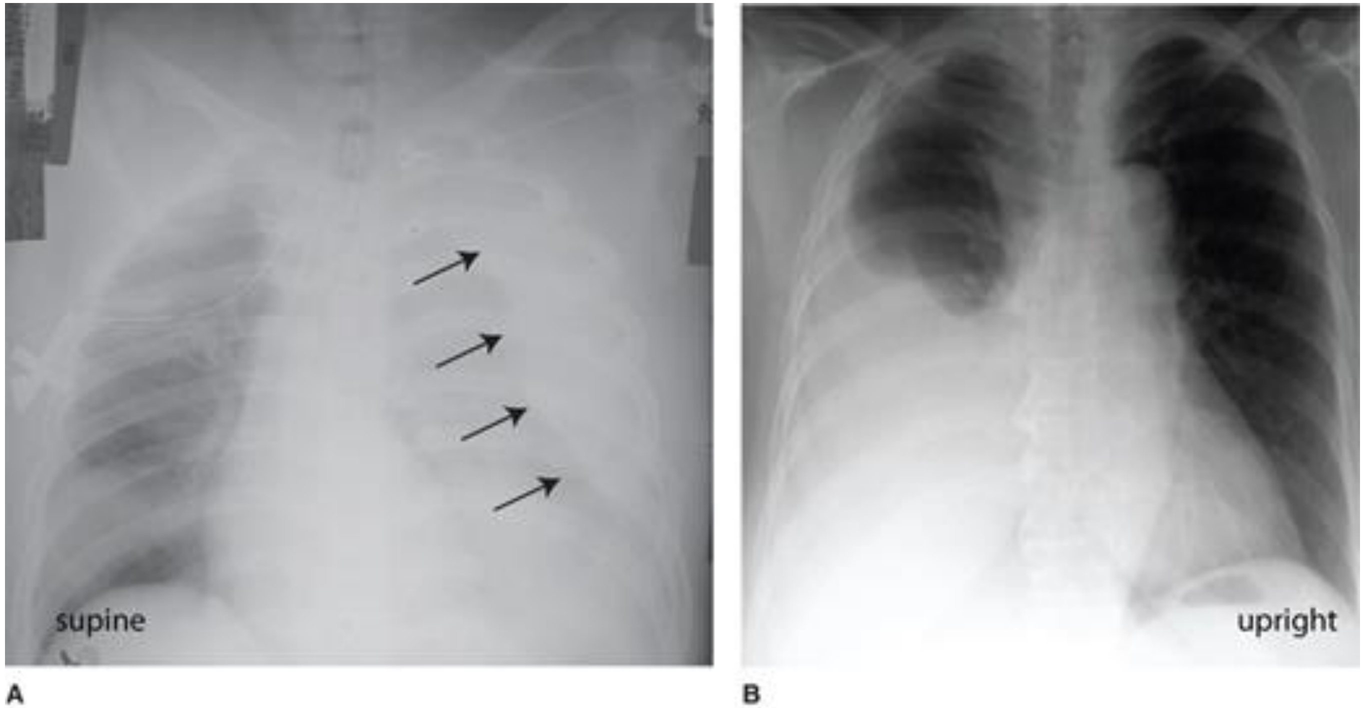
- Transport of a hypotensive patient out of the ED for CT scanning is hazardous; monitoring is compromised, and the environment is suboptimal for dealing with acute problems.
- Fast track CT scanning should be used in all patients manifesting evidence of shock. The surgeon must accompany the patient and be prepared to abort the CT scan with diversion to the OR.
- This dilemma is becoming less common in many trauma centers where CT scanning is available in the ED.

Extended focused assessment with sonography for trauma (eFAST)



MASSIVE HEMOTHORAX

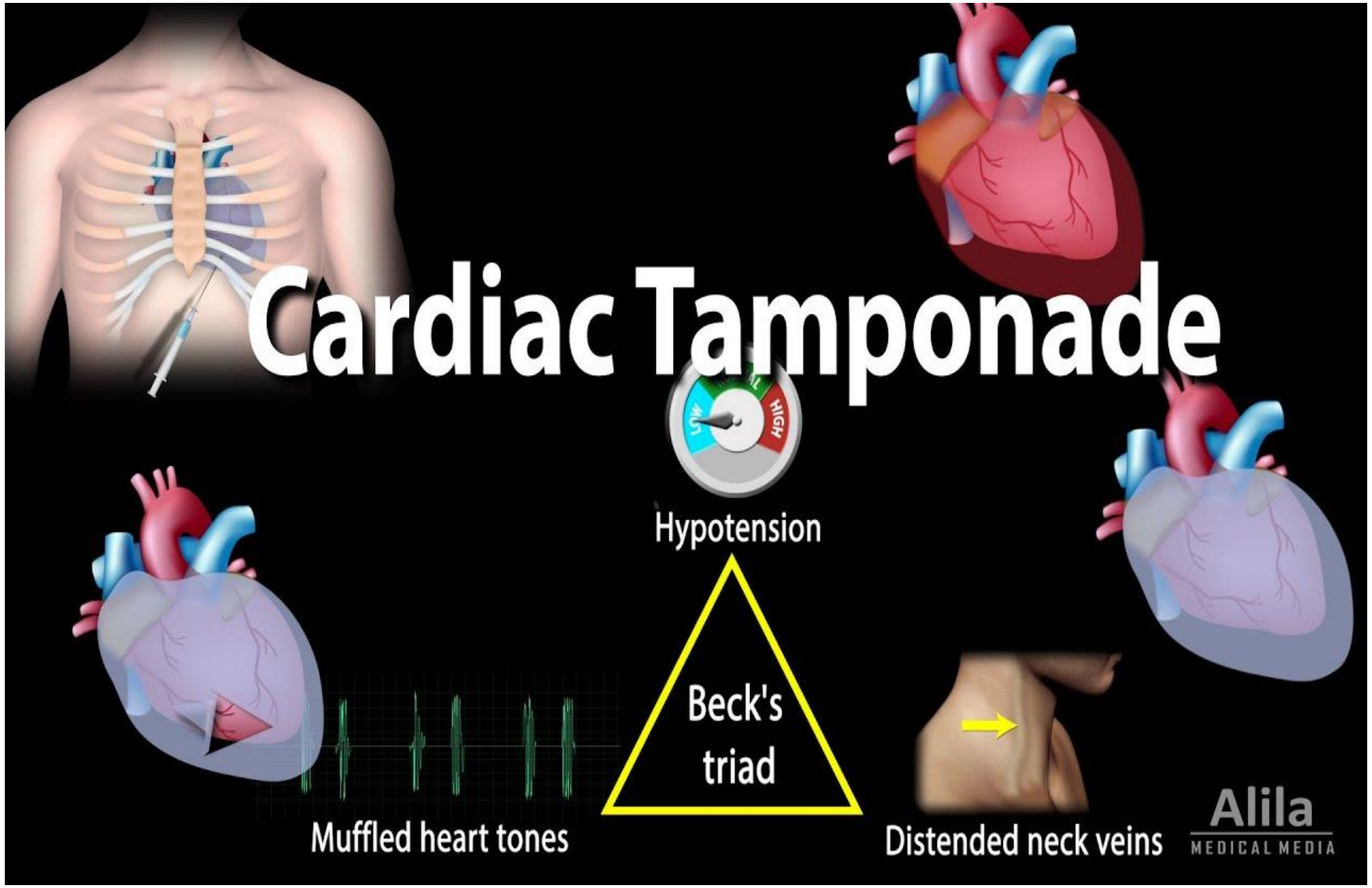
- defined as >1500 mL of blood or, in the pediatric population, >25% of the patient's blood volume in the pleural space.
- After blunt trauma, a hemothorax is usually due to multiple rib fractures with severed intercostal vessels, but occasionally bleeding is from lacerated lung parenchyma, which is usually associated with an air leak.
- After penetrating trauma, a great vessel or pulmonary hilar vessel injury should be presumed.
- In either scenario, a massive hemothorax is an indication for operative intervention, but tube thoracostomy is critical to facilitate lung reexpansion, which may improve oxygenation and cardiac performance as well as tamponade venous bleeding.

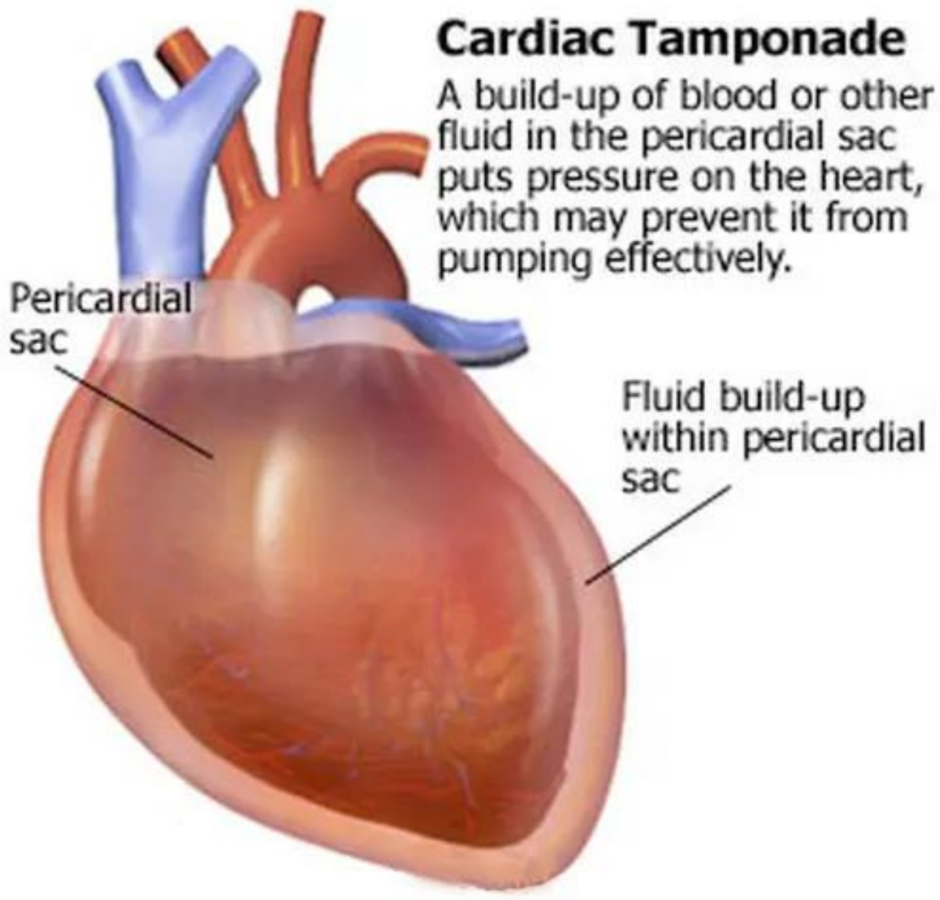


Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e

"OPEN-BOOK" PELVIC FRACTURES

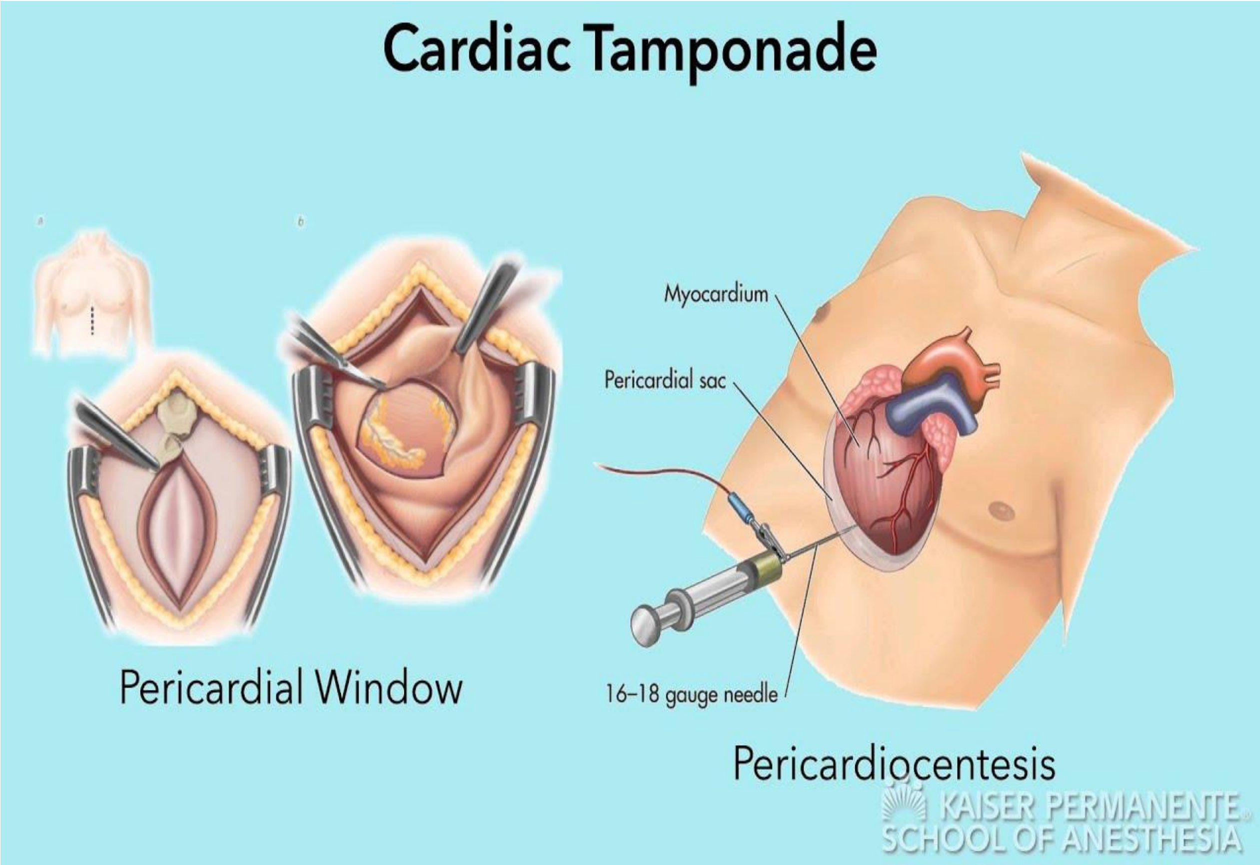
Cardiac tamponade





Diagnosis & Management

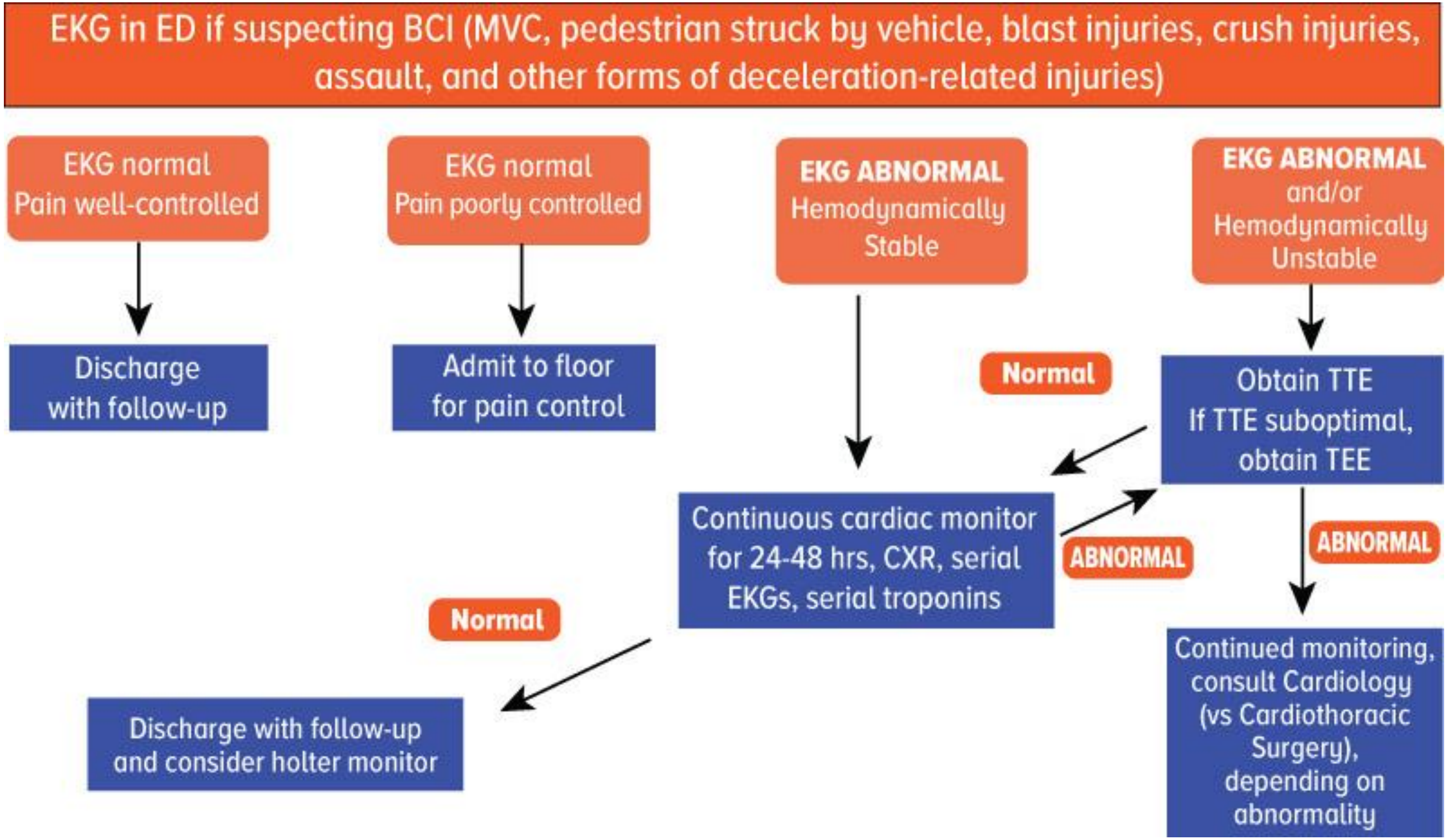
- Invasive monitoring (↑CVP, ↑RA & RV pressures, pulsus paradoxus)
- CXR
- Echocardiography
- FAST
- Pericardioentesis
- Pericardial window



BLUNT CARDIAC INJURY (BCI)

- one-third of patients sustaining significant blunt chest trauma experience some degree of blunt cardiac injury (BCI), few such injuries result in hemodynamic embarrassment.
- Patients with electrocardiographic (ECG) abnormalities or dysrhythmias require continuous ECG monitoring and antidysrhythmic treatment as indicated.
- Unless myocardial infarction is suspected, there is no role for routine serial measurement of cardiac enzyme levels—they lack specificity and do not predict significant dysrhythmias.
- The patient with hemodynamic instability from BCI requires appropriate resuscitation and may benefit from hemodynamic monitoring to optimize preload and guide inotropic support.
- Echocardiography (ECHO) is performed to exclude valvular or septal injuries; the most common ECHO finding in BCI is right ventricular dyskinesia due to the anterior orientation of the right ventricle.
- Rarely, patients with refractory cardiogenic shock may require placement of an intra-aortic balloon pump to enhance coronary perfusion and decrease myocardial work.
- Acute myocardial infarction may be the cause of a motor vehicle collision or other trauma in older patients. Although optimal initial management includes treatment for the evolving infarction, such as thrombolytic therapy, anticoagulation, and emergent angioplasty, these decisions must be individualized in accordance with the patient’s other injuries.

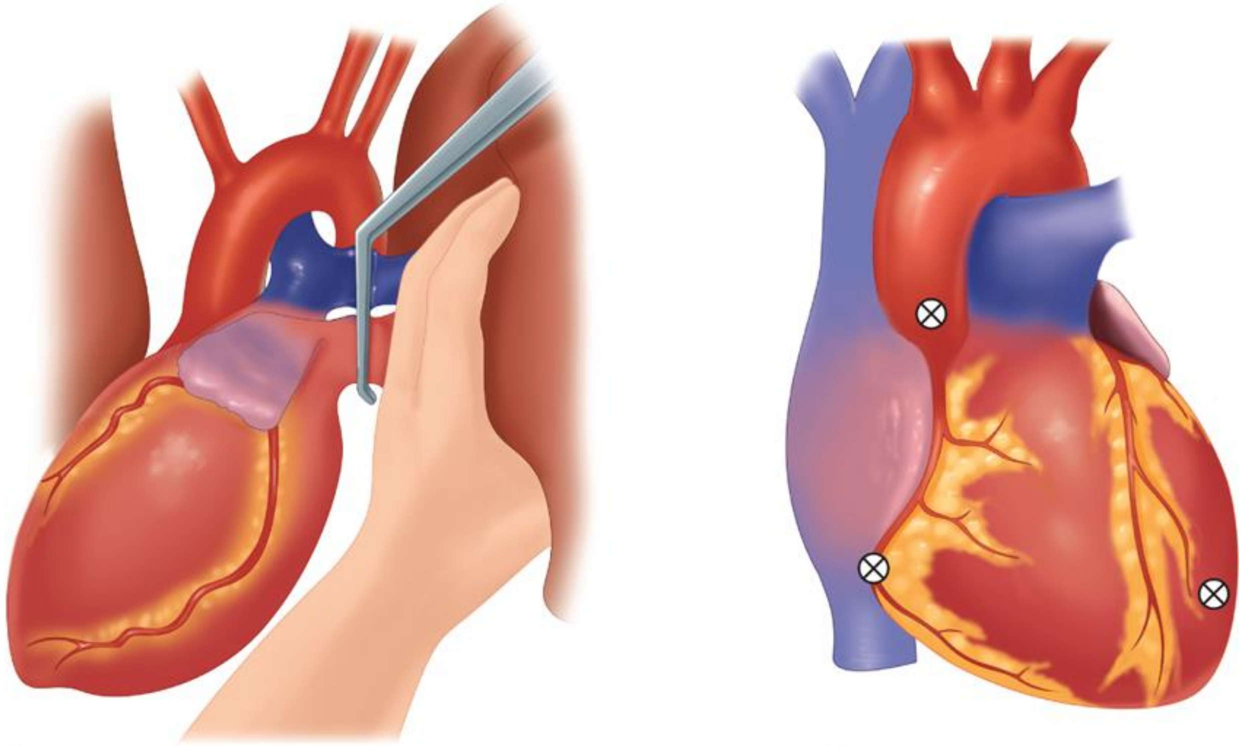
BLUNT CARDIAC INJURY (BCI)



Bronchovenous Air Embolism

ED Thoracotomy: Air embolism

- Pulmonary broncho-venous air emolism
- Penetrating > blunt injuries
- Scenario: hypotension/arrest after intubation/PPV
- Management:
  - ED thoracotomy
  - Hilar clamping
  - Pericardiotomy, de-air the heart



A B

Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e

Resuscitative Thoracotomy (RT)

- RT is associated with the highest survival rate after isolated cardiac injury; 35% of patients presenting in shock and 20% without vital signs (i.e., no pulse or obtainable blood pressure) are salvaged after isolated penetrating injury to the heart. For all penetrating wounds, survival rate is 15%.
- Conversely, patient outcome is limited when RT is done for blunt trauma, with 2% survival among patients in shock and <1% survival among those with no vital signs.
- Thus, patients undergoing cardiopulmonary resuscitation (CPR) upon arrival to the ED should undergo RT selectively based on injury and duration of CPR
- Cross-clamping of the aorta improves central circulation, augments cerebral and coronary blood flow, and limits further abdominal blood loss.
- The patient must sustain a SBP of 70 mmHg after RT and associated interventions to be considered resuscitable, and hence transported to the OR.

Indications

•**Salvageable postinjury cardiac arrest:**

•Patients sustaining witnessed penetrating trauma to the torso with <15 min of prehospital CPR

•Patients sustaining witnessed blunt trauma with <10 min of prehospital CPR

•Patients sustaining witnessed penetrating trauma to the neck or extremities with <5 min of prehospital CPR

•**Persistent severe postinjury hypotension (SBP ≤60 mmHg) due to:**

•Cardiac tamponade

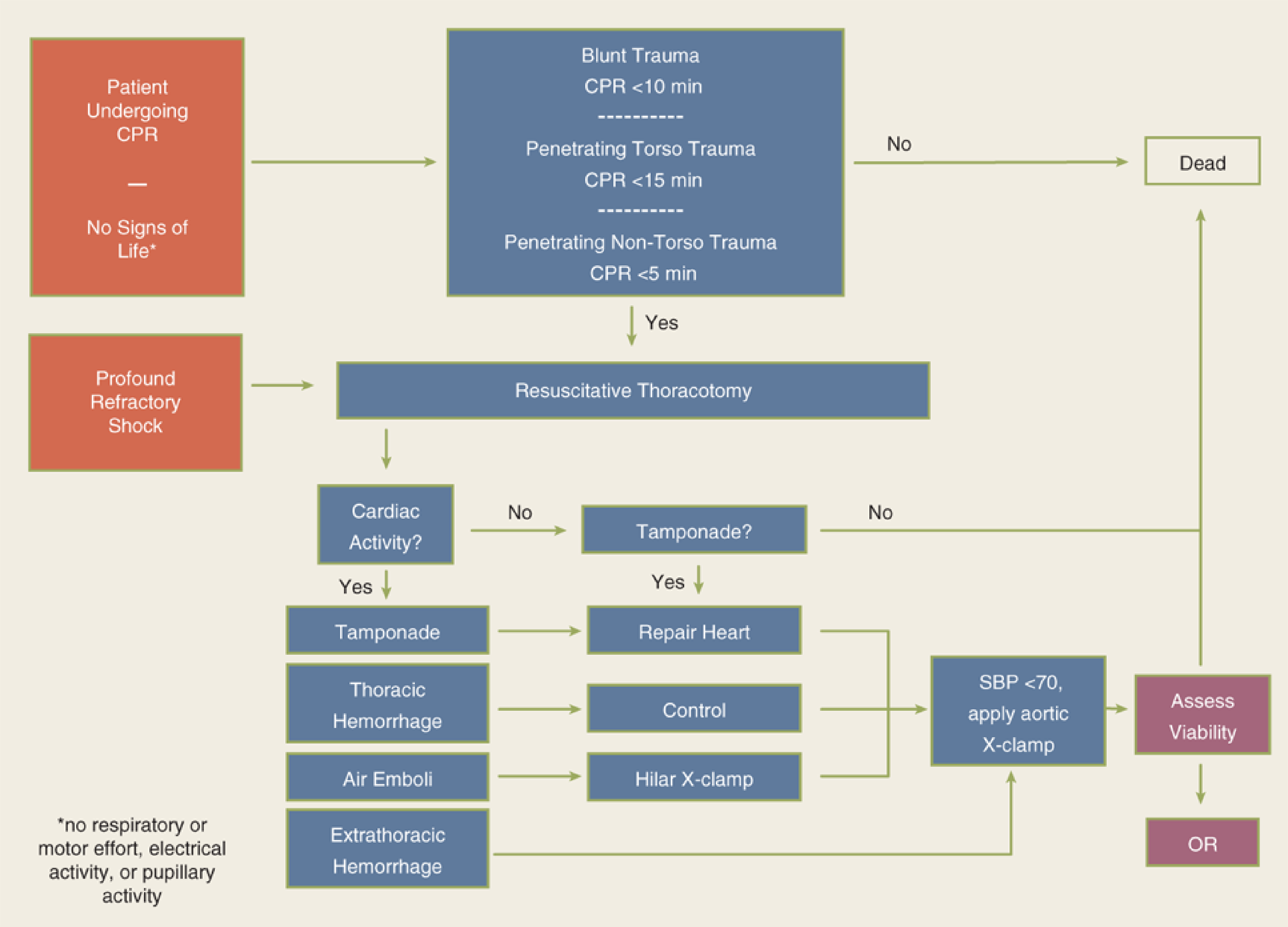
•Hemorrhage—intrathoracic, intra-abdominal, extremity, cervical

•Air embolism

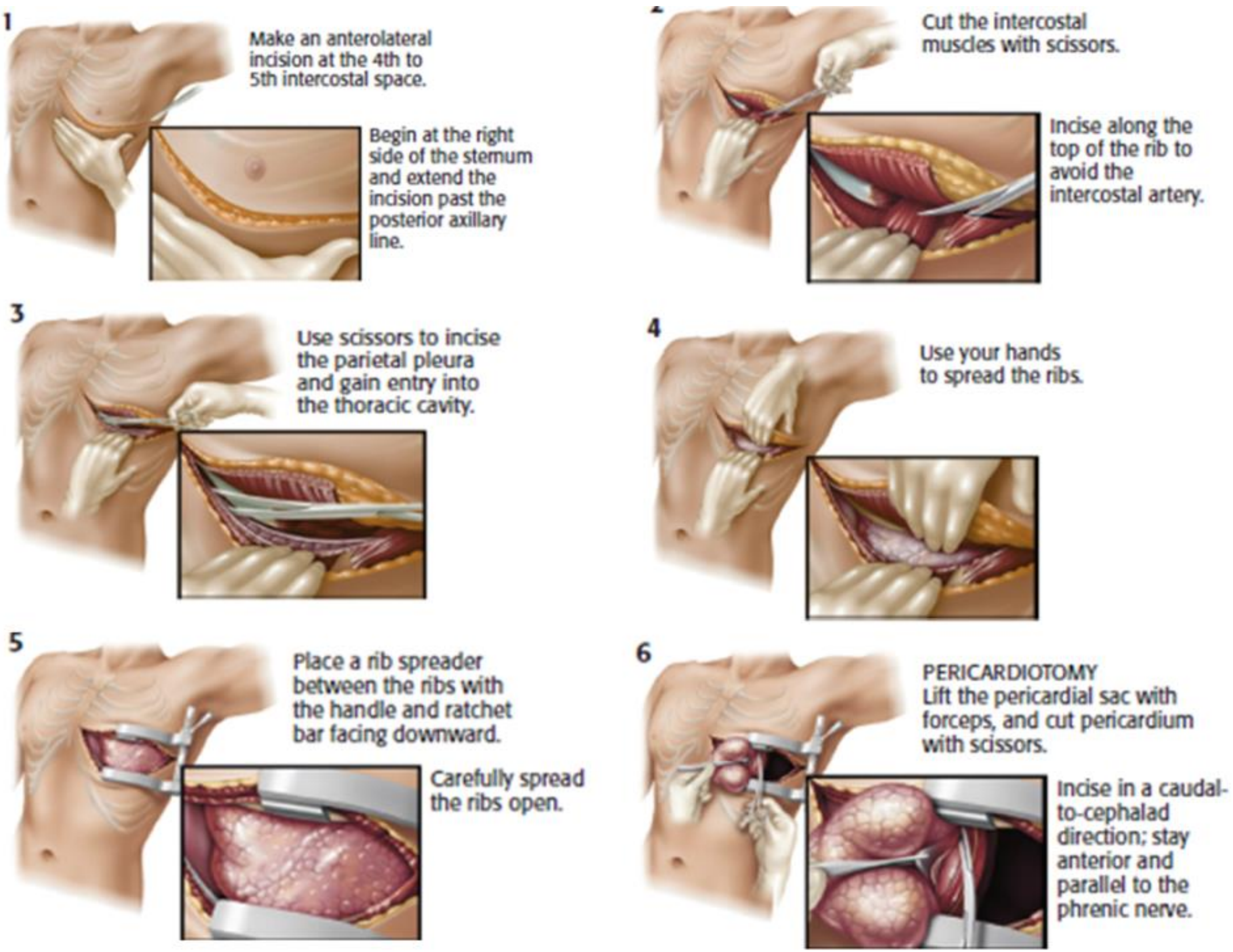
Contraindications

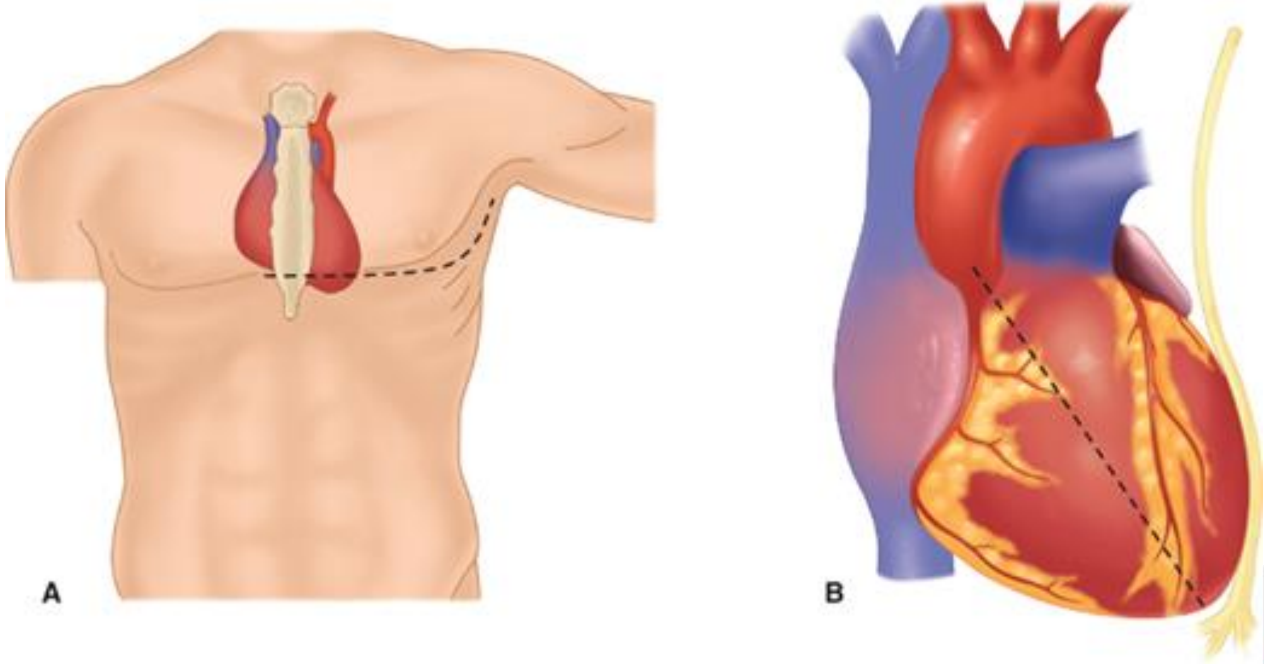
•Penetrating trauma: CPR >15 min and no signs of life (pupillary response, respiratory effort, motor activity)

•Blunt trauma: CPR >10 min and no signs of life or asystole without associated tamponade



Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e


1
Make an anterolateral incision at the 4th to 5th intercostal space.
Begin at the right side of the sternum and extend the incision past the posterior axillary line.
Cut the intercostal muscles with scissors.
Incise along the top of the rib to avoid the intercostal artery.
3
Use scissors to incise the parietal pleura and gain entry into the thoracic cavity.
4
Use your hands to spread the ribs.
5
Place a rib spreader between the ribs with the handle and ratchet bar facing downward.
Carefully spread the ribs open.
6
PERICARDIOTOMY
Lift the pericardial sac with forceps, and cut pericardium with scissors.
Incise in a caudal-to-cephalad direction; stay anterior and parallel to the phrenic nerve.



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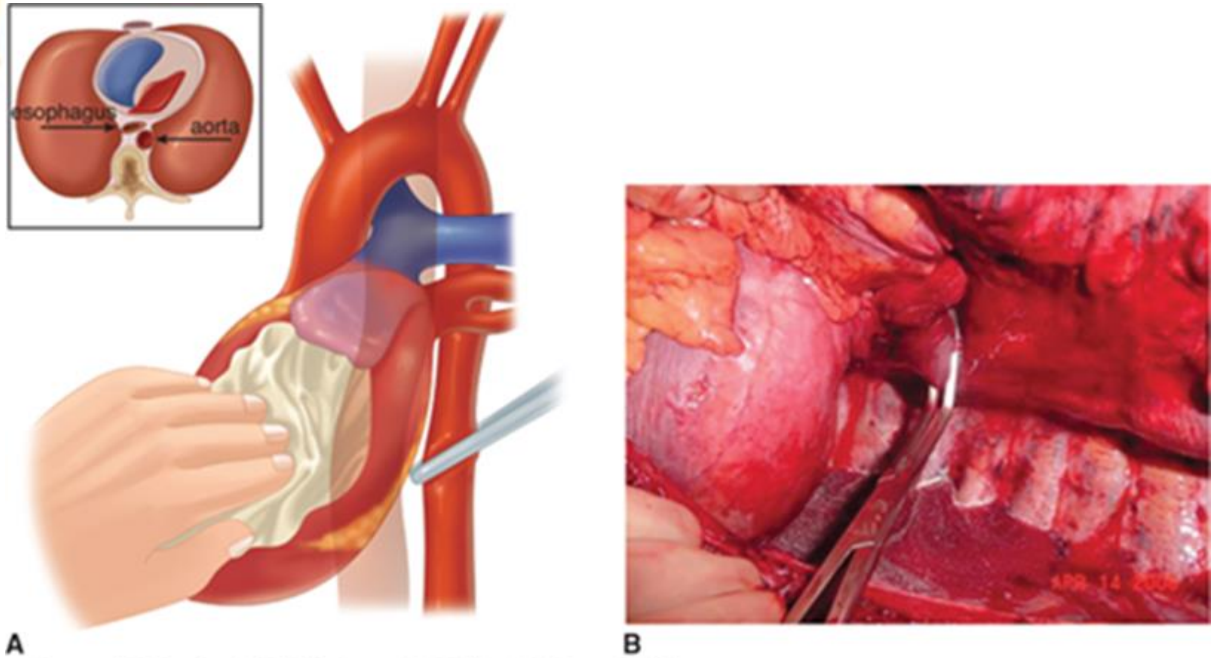

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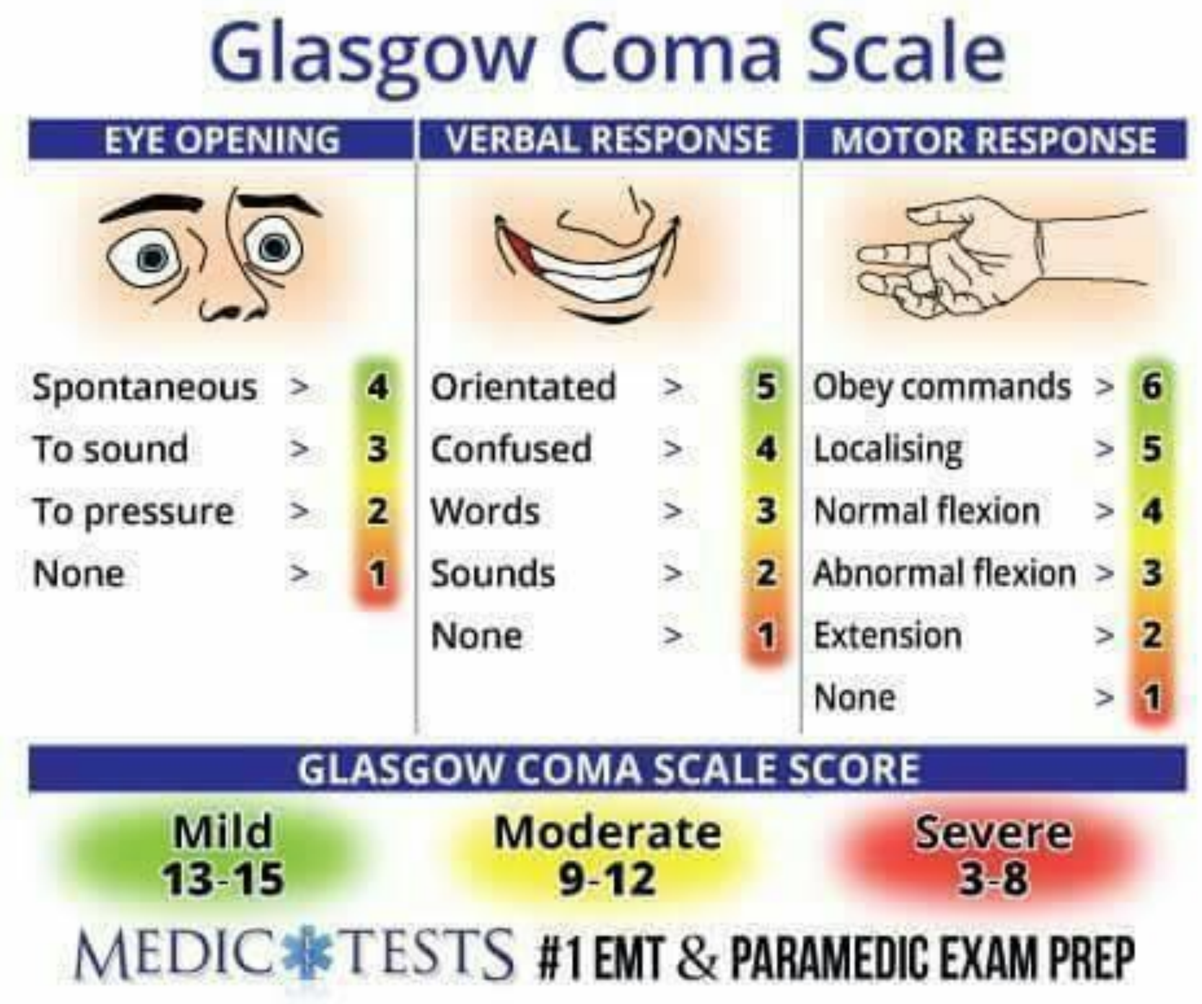
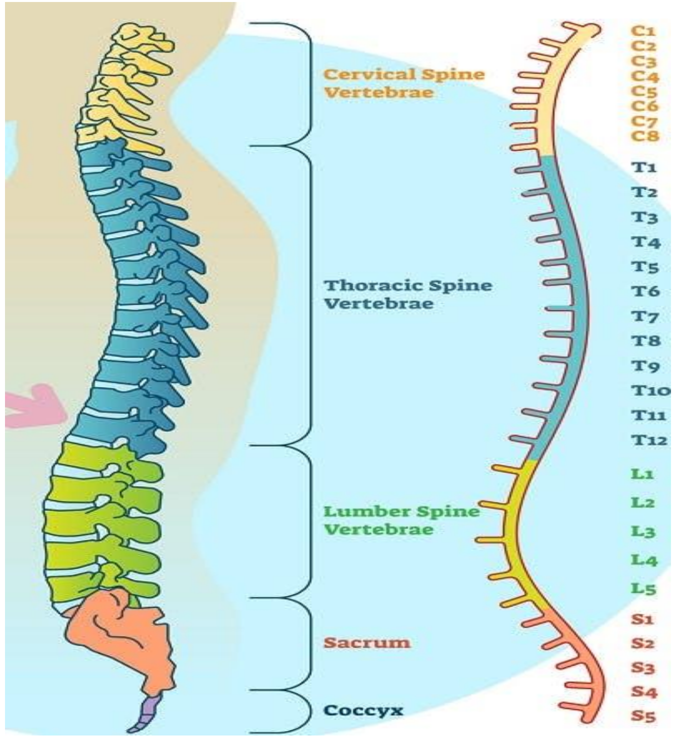
DISABILITY AND EXPOSURE

- Neurologic evaluation, including spinal cord integrity, is critical before administration of neuromuscular blockade for intubation.
- Subtle changes in mental status can be caused by hypoxia, hypercarbia, or hypovolemia, or may be an early sign of increasing intracranial pressure.
- An abnormal mental status should prompt an immediate reevaluation of the patient's ABCs and consideration of central nervous system injury.
- Deterioration in mental status may be subtle and may not progress in a predictable fashion. For example, previously calm, cooperative patients may become anxious and combative as they become hypoxic. However, a patient who is agitated and combative from drugs or alcohol may become somnolent if hypovolemic shock develops.



Neurogenic Shock

- Spinal cord trauma
- Spinal anesthesia
- Guillain-Barre Syndrome.
- ANS- toxins
- Transverse myelitis
- Trisomy 21 (atlanto-axial or atlanto-occipital instability)
- Skeletal dysplasia
- Other neuropathies



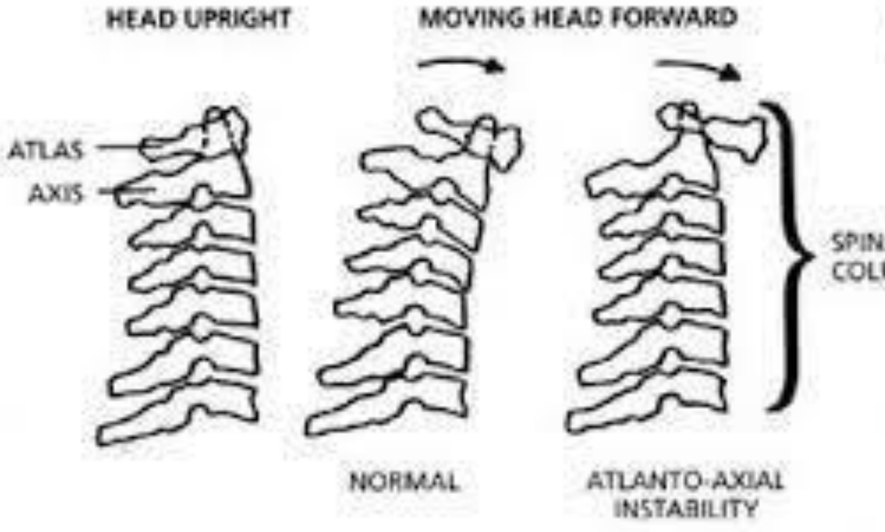
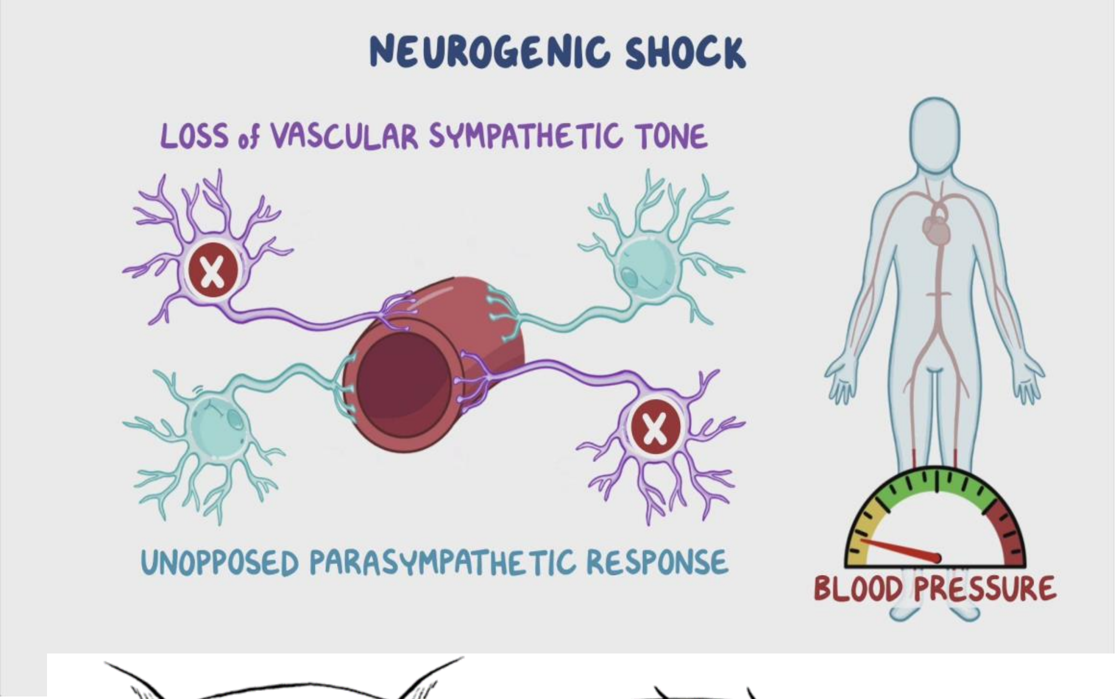
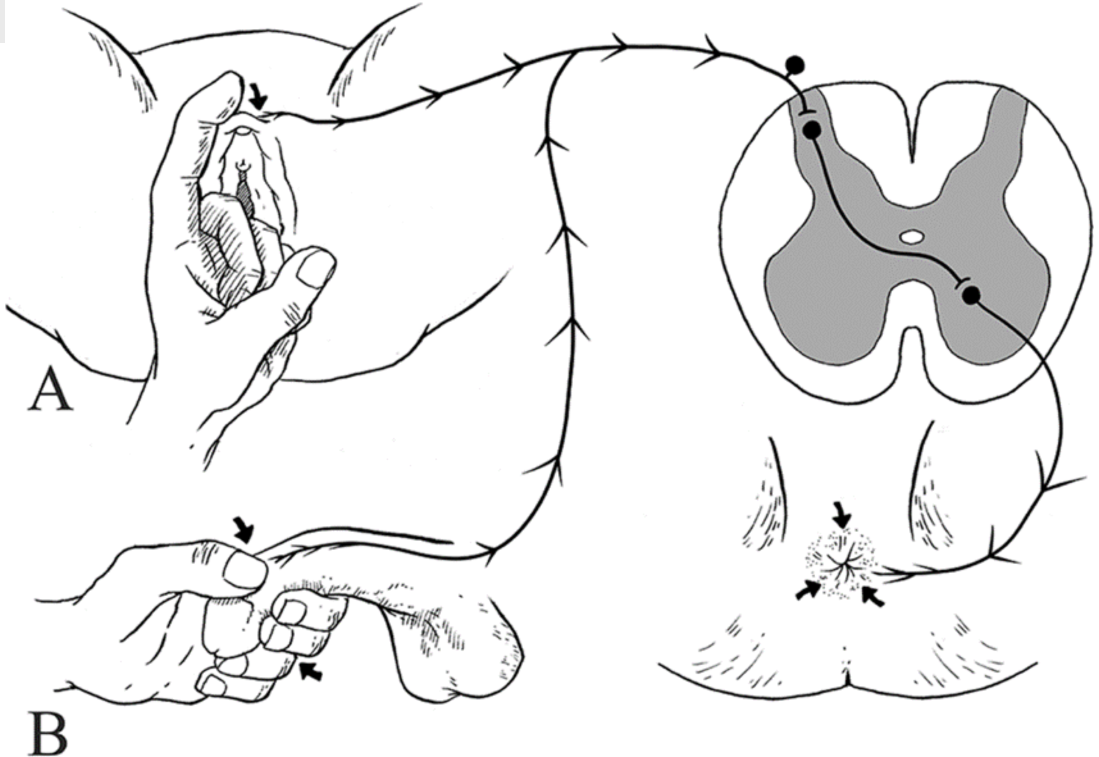


Fig 2


NEUROGENIC SHOCK
LOSS of VASCULAR SYMPATHETIC TONE
UNOPPOSED PARASYMPATHETIC RESPONSE
BLOOD PRESSURE


A
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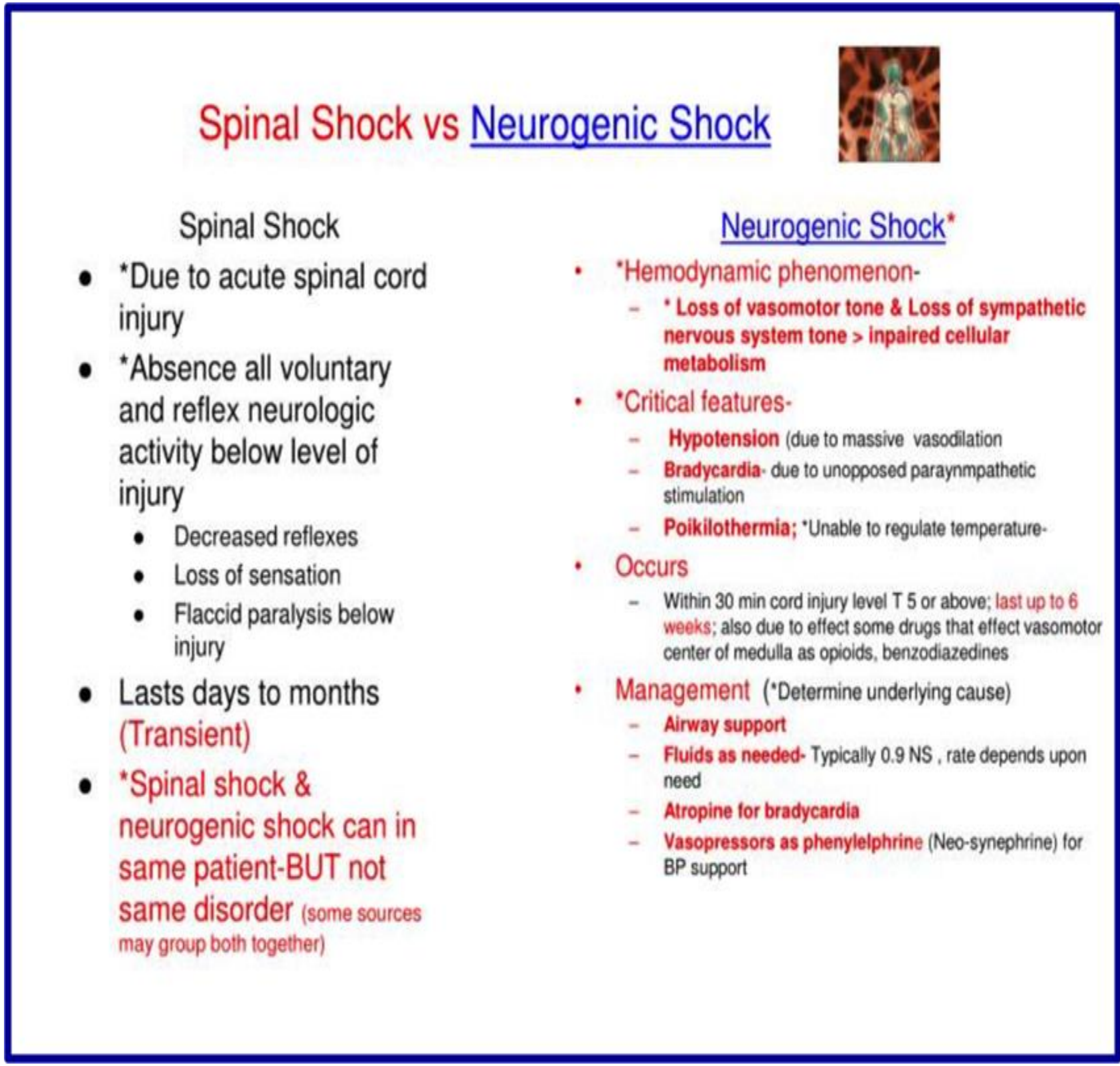

Spinal Shock vs Neurogenic Shock
Spinal Shock
*Due to acute spinal cord injury
*Absence all voluntary and reflex neurologic activity below level of injury
Decreased reflexes
Loss of sensation
Flaccid paralysis below injury
Lasts days to months (Transient)
*Spinal shock & neurogenic shock can in same patient-BUT not same disorder (some sources may group both together)
Neurogenic Shock*
*Hemodynamic phenomenon-
* Loss of vasomotor tone & Loss of sympathetic nervous system tone > impaired cellular metabolism
*Critical features-
Hypotension (due to massive vasodilation
Bradycardia- due to unopposed paraynmpathetic stimulation
Poikilothermia; *Unable to regulate temperature-
Occurs
Within 30 min cord injury level T 5 or above; last up to 6 weeks; also due to effect some drugs that effect vasomotor center of medulla as opioids, benzodiazedines
Management (*Determine underlying cause)
Airway support
Fluids as needed- Typically 0.9 NS , rate depends upon need
Atropine for bradycardia
Vasopressors as phenylelphrine (Neo-synephrine) for BP support

Sx & Sg

- Hypotension
- Bradycardia
- Warm, dry extremities
- Peripheral vasodilation and venous pooling
- Poikilothermia
- Decreased cardiac output (with cervical or high thoracic injury)

- Secondary damage:
  1. Spinal cord ischemia
  2. Cellular response (Loss of membrane integrity & impaired energy metabolism)
  3. Neurotransmitter accumulation
  4. Release of free radicals
  5. DAMPs

Damage control surgery (DCS)

1. Decision to perform DCS
2. initial operation
3. ICU resuscitation
4. Second-look/definitive operation.

TRAUMA- REGIONAL ASSESSMENT

Ashraf Al-Faouri MD, MRCS, FACS
Consultant HBPS & Liver Transplantation

SECONDARY SURVEY

- ***AMPLE history :***
  1. Allergies
  2. Medications
  3. Past illnesses
  4. Pregnancy
  5. Last meal
  6. Events related to the injury

- ***The physical examination***
  - ✓ vital sign
  - ✓ Head to toe
  - ✓ special attention to the patient's back, axillae, and perineum, because injuries here are easily overlooked.
  - ✓ All seriously injured patients should undergo digital rectal examination to evaluate for sphincter tone, presence of blood, rectal perforation, or a high-riding prostate; this is particularly critical in patients with suspected spinal cord injury, pelvic fracture, or transpelvic gunshot wounds.
  - ✓ Vaginal examination with a speculum should be performed in women with pelvic fractures to exclude an open fracture.

Adjuncts to the physical examination

- ECG monitoring
- Nasogastric tube placement
  - ✓The awake patient
  - ✓Complex mid-facial fractures
  - ✓Base of skull fracture
- Foley catheter placement
  - ✓blood at the meatus,
  - ✓perineal or scrotal hematomas
  - ✓a high-riding prostate.
- Radiographs
- Hemoglobin
- Base deficit measurements
- Urinalysis
- repeat FAST exam.

MECHANISMS AND PATTERNS OF INJURY

BLUNT

- Multiple widely distributed injuries
- Organs that cannot yield to impact by elastic deformation are most likely to be injured, namely, the solid organs (liver, spleen, and kidneys).

Penetrating

- Damage is localized to the path of the bullet or knife & adjacent structures are commonly injured.
- Organs with the largest surface area are most prone to injury (small bowel, liver, and colon).

BLUNT

- For automobile collisions:
  - Speed of the vehicles involved,
  - Angle of impact
  - Location of the patient within the vehicle
  - Use of restraints
  - Airbag deployment
  - Condition of the steering wheel and windshield
  - Amount of intrusion
  - Ejection of the patient from the vehicle, and
  - Fate of other passengers.
- For other injury mechanisms, critical information includes such things as height of a fall, surface impact, helmet use, and weight of an object by which the patient was crushed.

Penetrating

- In patients sustaining gunshot wounds, bullet characteristics, distance, and presumed path of the bullet are important, if known.
- For patients with stab wounds, the length and type of object is helpful.
- Some patients experience a combination of blunt and penetrating trauma. Do not assume that someone who was stabbed was not also assaulted; the patient may have a multitude of injuries and cannot be presumed to have only injuries associated with the more obvious penetrating wound.

MECHANISMS AND PATTERNS OF INJURY- BLUNT

high energy transfer injuries

- Auto-pedestrian accidents
- Change of velocity (ΔV) exceeds 20 mph
- The patient has been ejected
- Motorcycle collisions
- Falls from heights >20 ft.
- Death of another occupant in the vehicle
- Extrication time of >20 minutes
- Lack of restraint use
- Lateral impact.

low energy transfer injuries

- Being struck with a club
- Falling from a bicycle

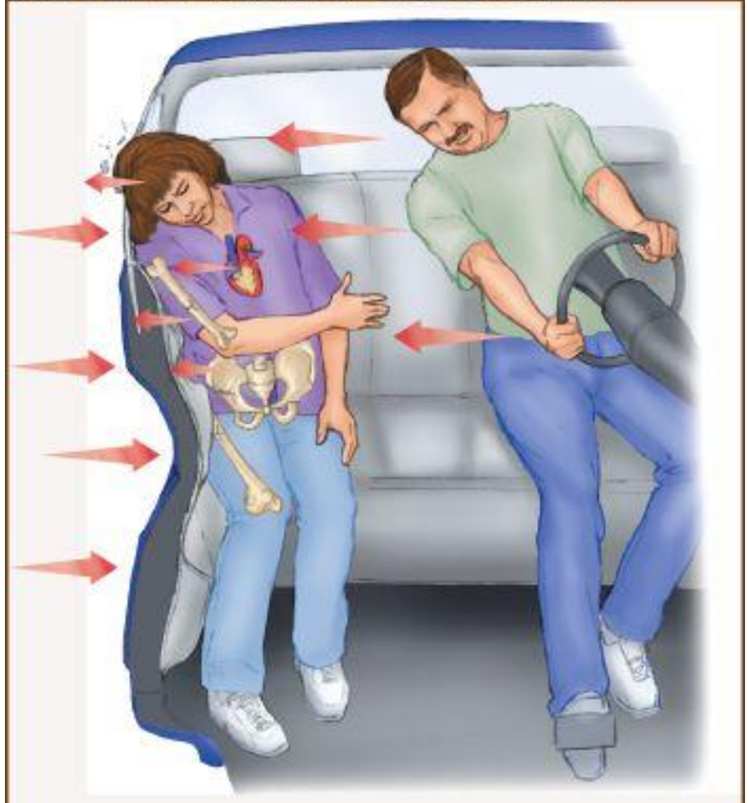
MECHANISMS AND PATTERNS OF INJURY- BLUNT

- When an unrestrained driver sustains a frontal impact, the head strikes the windshield, the chest and upper abdomen hit the steering column, and the legs or knees contact the dashboard.
- The resultant injuries can include facial fractures, cervical spine fractures, injury of the descending thoracic aorta, myocardial contusion, injury to the spleen and liver, and fractures of the pelvis and lower extremities.

COLLISIONS WITH SIDE IMPACT

- Cervical spine
- Thoracic trauma
- Diaphragm rupture
- Crush injuries of the pelvic ring
- Solid organ injury usually is limited to either the liver or spleen based on the direction of impact.
- Patients ejected from a vehicle or thrown a significant distance from a motorcycle have the risk of any injury pattern.

FIGURE 1-4: SIDE IMPACT CRASH

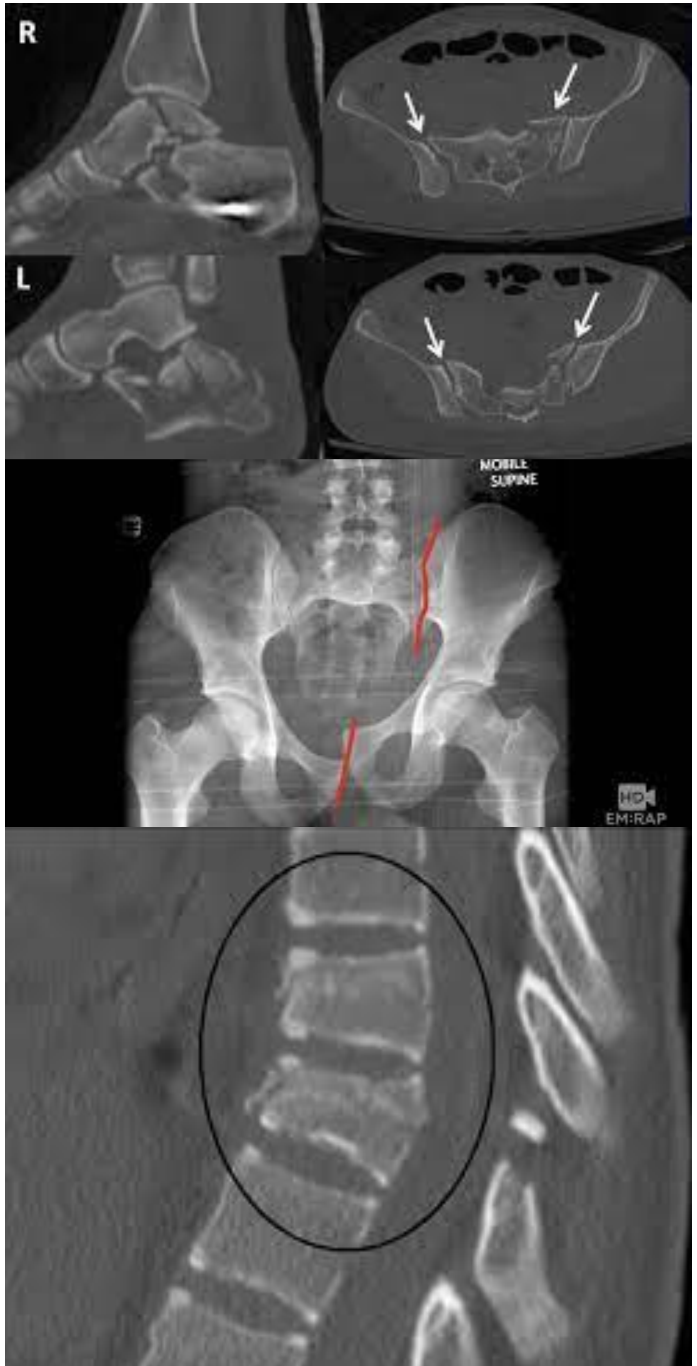


b.

Note. From International Trauma Life Support (ITLS), ...; Campbell, John, R. *International Life Support for Emergency Care Providers, 7th*; © 2012. Printed and electronically reproduced by permission of Pearson Education, Inc., New York, New York.

VERTICAL DECELERATION INJURIES

- Heal
- Pelvic
- Spinal fractures.



SEAT BELT INJURIES

- Skin abrasions and bruising occur on the surface
- Bowel and mesenteric injuries
- Fractures of the lumbar spine, cervical spine fracture, or clavicle fracture.
- Solid-organ injuries such as liver and spleen laceration can occur in these patients. Likewise, injuries to the
- Pancreas, kidneys, and Duodenum
- Cervical vascular injury
- Thoracic injuries due to seat belt force include sternal fracture, rib fracture, pulmonary contusion, and more rarely myocardial contusion.

Kinetic Energy

$$K.E. = \frac{1}{2} MV^2$$

M: Mass (Kg)

V: Velocity (m/s)

PENETRATING INJURIES

high- velocity injuries

- High-velocity gunshot wounds (bullet speed >2000 ft/s)
- Close-range shotgun wounds are tantamount to high-velocity wounds because the entire energy of the load is delivered to a small area, often with devastating results.

low-velocity injuries

- Guns
- long-range shotgun blasts result in a diffuse pellet pattern in which many pellets miss the victim, and those that do strike are dispersed and are of comparatively low energy.
- Knifes and other sharp objects

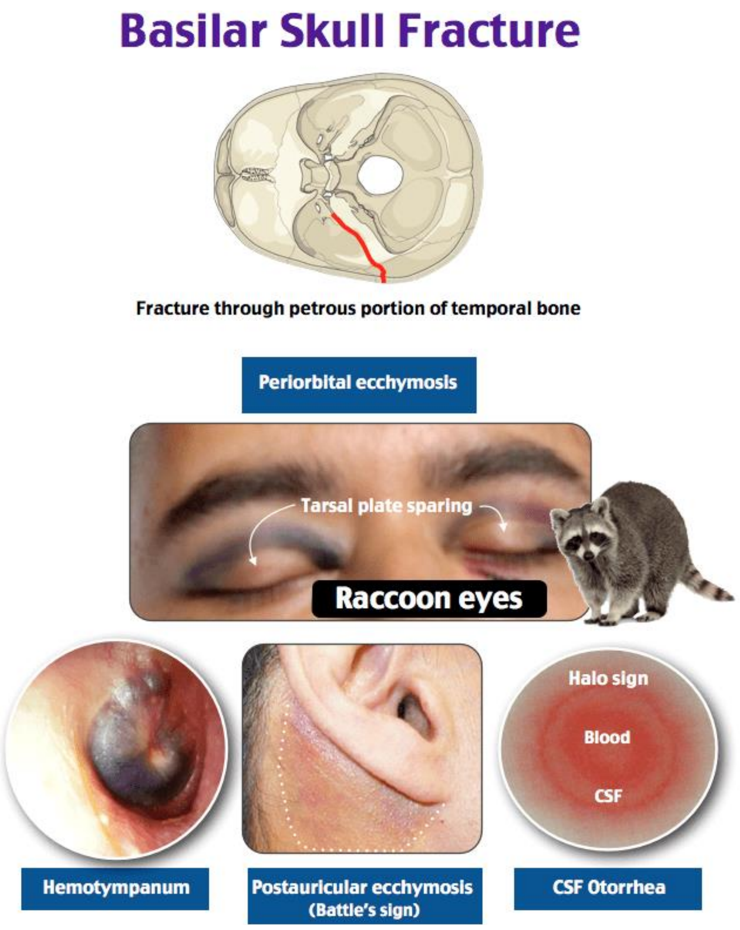
Regional Assessment and Special Diagnostic Tests- HEAD

Palpation of the head is done to identify scalp lacerations, which should be evaluated for depth, and presence of associated depressed or open skull fractures.

The tympanic membrane is examined to identify hemotympanum, otorrhea, or rupture, which may signal an underlying head injury.

BASILAR SKULL FRACTURE

- Otorrhea, rhinorrhea, raccoon eyes, and Battle's sign (ecchymosis behind the ear) suggest a basilar skull fracture.
- May not require treatment
- Blunt cerebrovascular injuries
- Cranial nerve injuries
- Risk of meningitis.



EYE EXAM

- ✓ Pupillary size and reactivity
- ✓ Visual acuity
- ✓ Hemorrhage within the globe.
- ✓ Ocular entrapment, caused by orbital fractures with impingement of the ocular muscles, is evident when the patient cannot move his or her eyes through an entire range of motion.
- ✓ It is important to perform the eye examination early because significant orbital swelling may prevent later evaluation.
- ✓ A lateral canthotomy may be needed to relieve periorbital pressure.

FACE

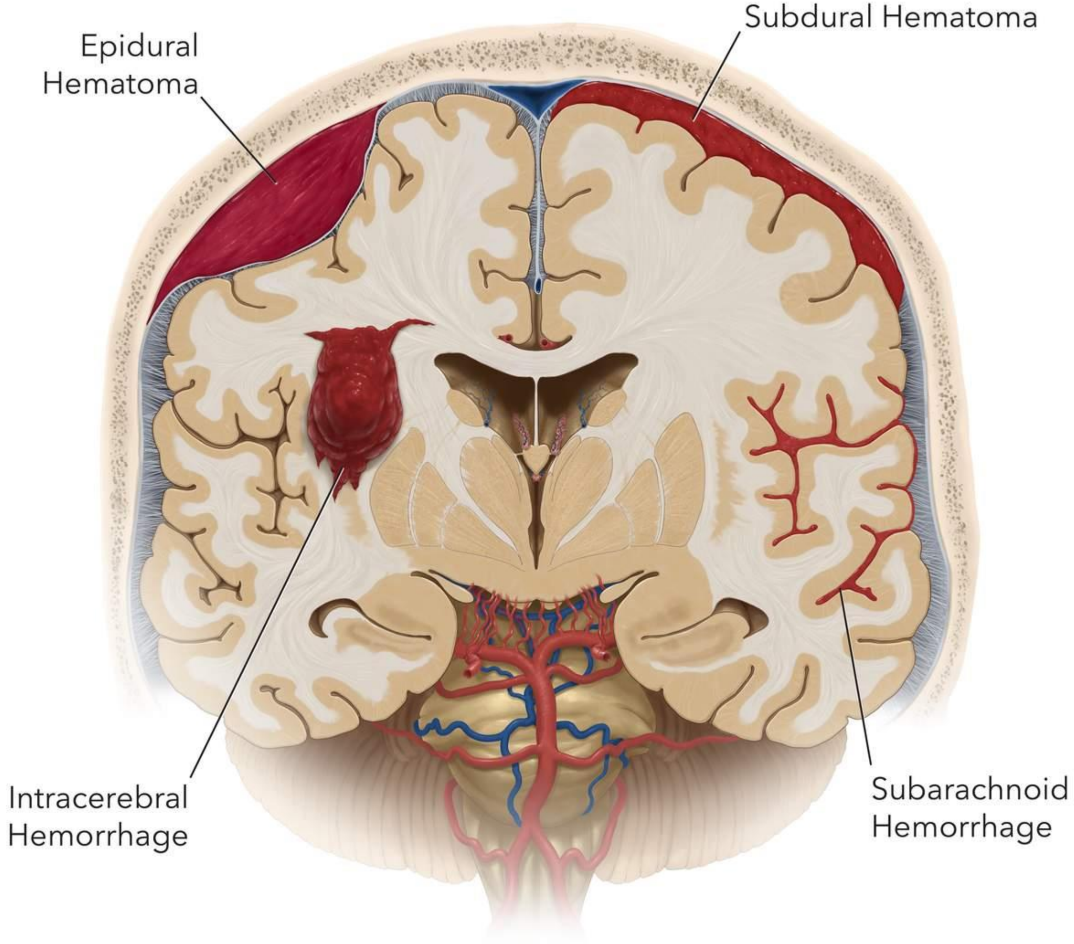
- Anterior facial structures should be examined to rule out fractures. This entails palpating for bony step-off of the facial bones
- instability of the midface (by grasping the upper palate and seeing if this moves separately from the patient's head).
- ask awake patients is whether their bite feels normal to them; abnormal dental closure suggests malalignment of facial bones and the possibility for a mandible or maxillary fracture.
- Nasal fractures, which may be evident on direct inspection or palpation, typically bleed vigorously. This may result in the patient having airway compromise due to blood running down the posterior pharynx, or there may be vomiting provoked by swallowed blood. Nasal packing or balloon tamponade may be necessary to control bleeding.
- Examination of the oral cavity includes inspection for open fractures, loose or fractured teeth, and sublingual hematomas.

CLOSED HEAD INJURY

- All patients with a significant closed head injury (GCS score <14) should undergo CT scanning of the head. Additionally, elderly patients or those patients on antiplatelet agents or anticoagulation should be imaged despite a GCS of 15.
- For penetrating injuries, plain skull films may be helpful in the trauma bay to determine the trajectory of the bullet.
- The presence of lateralizing findings (e.g., a unilateral dilated pupil unreactive to light, asymmetric movement of the extremities either spontaneously or in response to noxious stimuli, or unilateral Babinski's reflex) suggests an intracranial mass lesion or major structural damage.

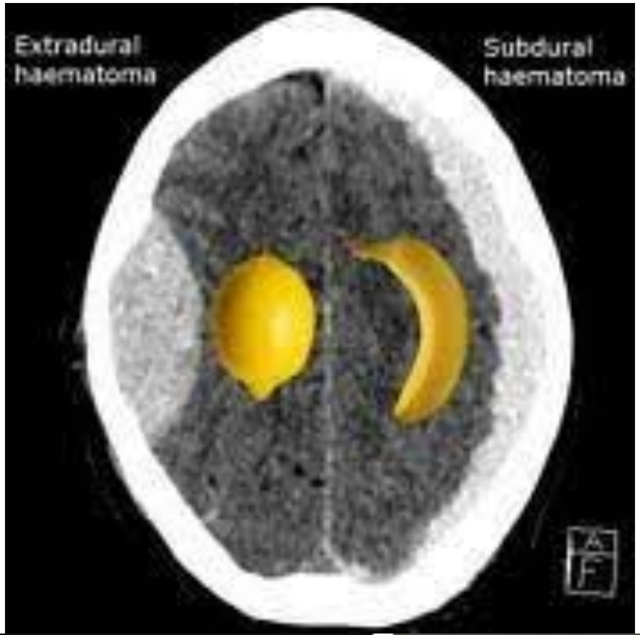
CLOSED HEAD INJURY

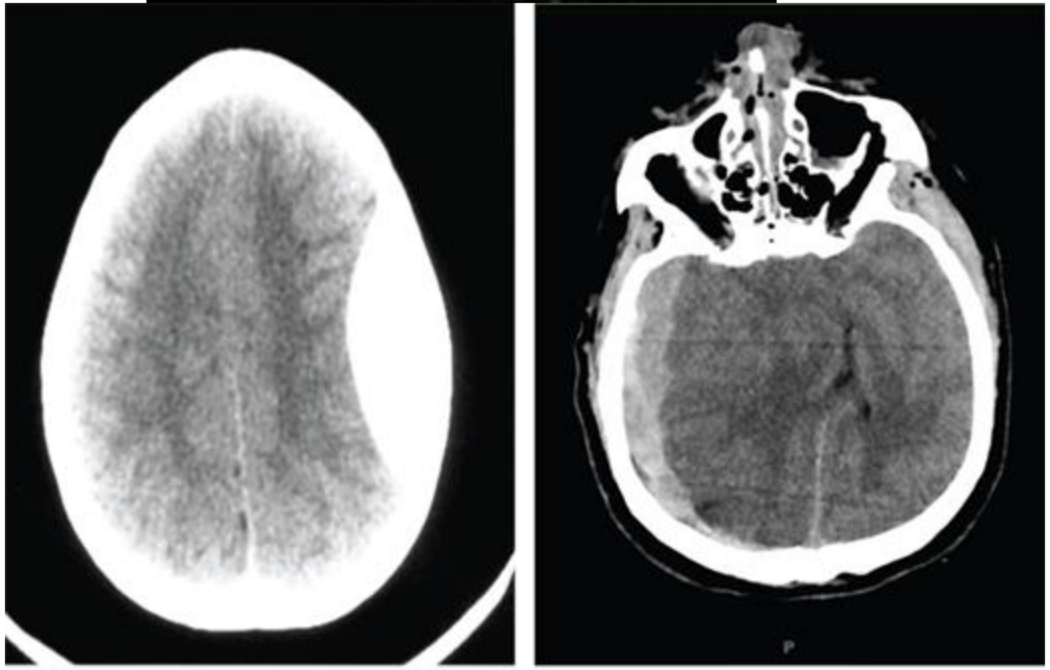
- Extradural hematomas (EDH)
- Subdural Hematoma (SDH)
- Contusions
- Intraventricular hemorrhage(IVH)
- Subarachnoid hemorrhage (SAH)
- Diffuse axonal injury (DAI).
- Stroke syndromes



EDH VERSUS SDH

- Epidural hematomas occur when blood accumulates between the skull and dura, and are caused by disruption of the middle meningeal artery or other small arteries in that potential space, typically after a skull fracture.
- Subdural hematomas occur between the dura and cortex and are caused by venous disruption or laceration of the parenchyma of the brain. Due to associated parenchymal injury, subdural hematomas have a much worse prognosis than epidural collections.





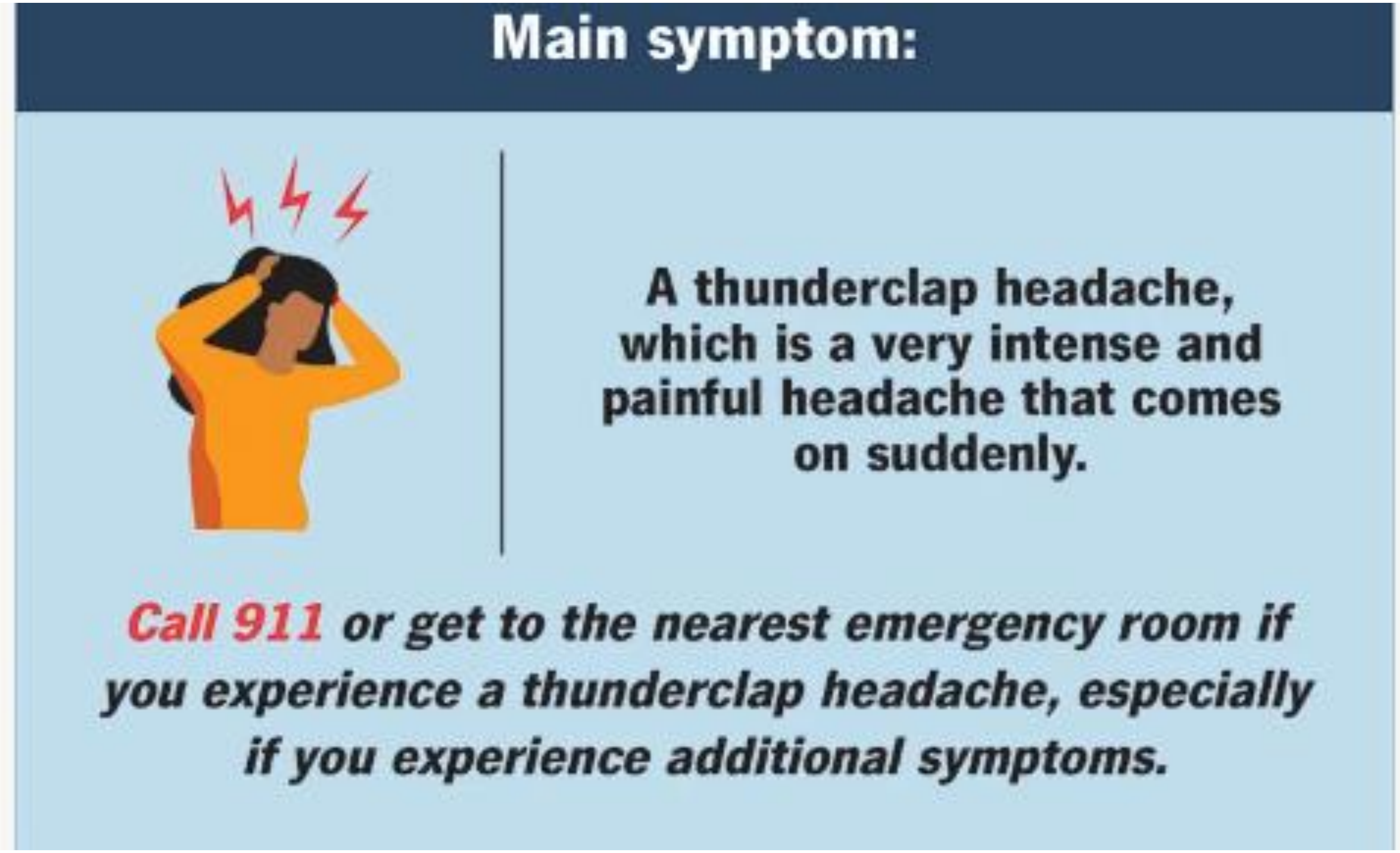
A B

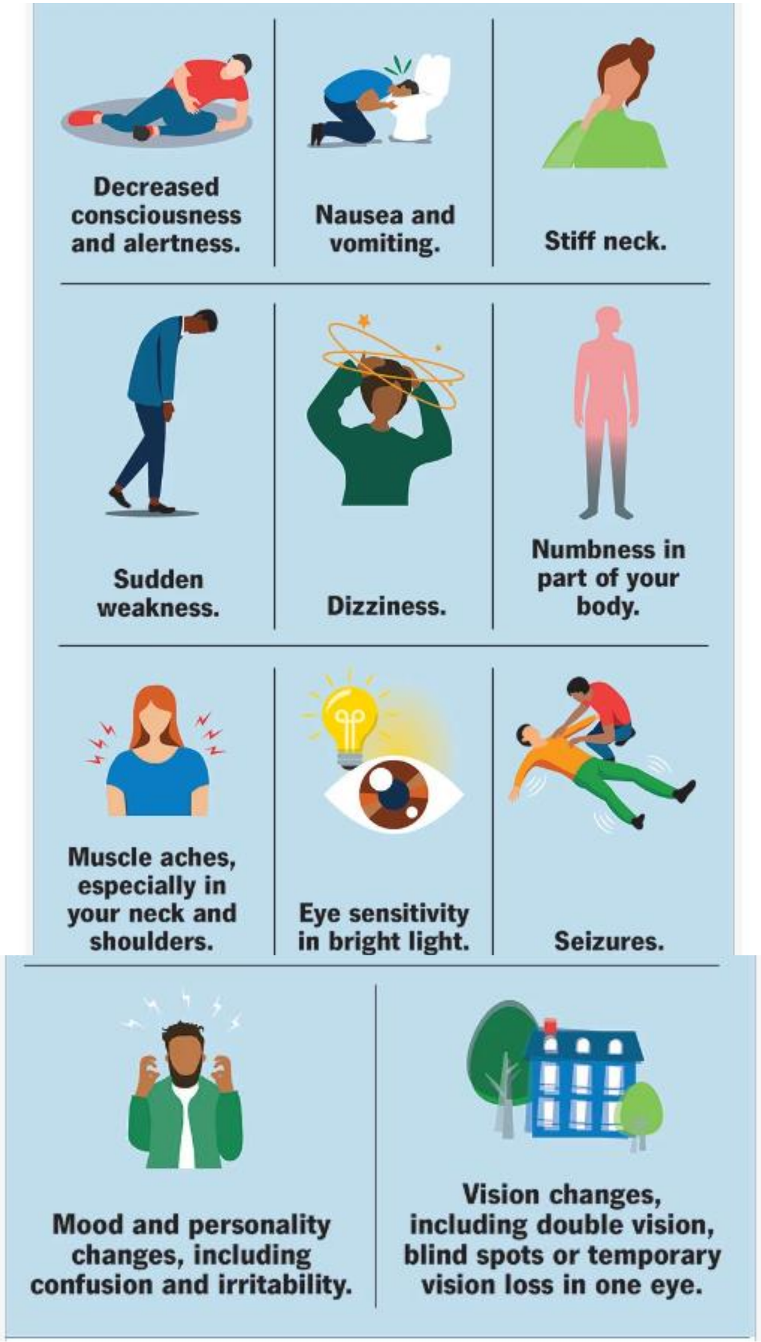
Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e

SAH

- Hemorrhage into the subarachnoid space may cause vasospasm and further reduce cerebral blood flow.

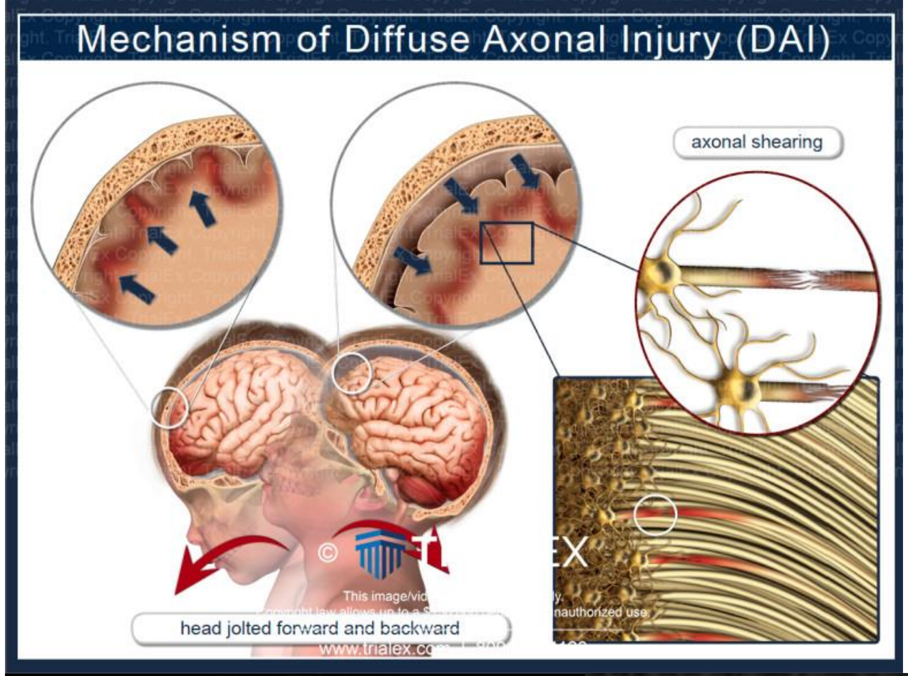
SAH

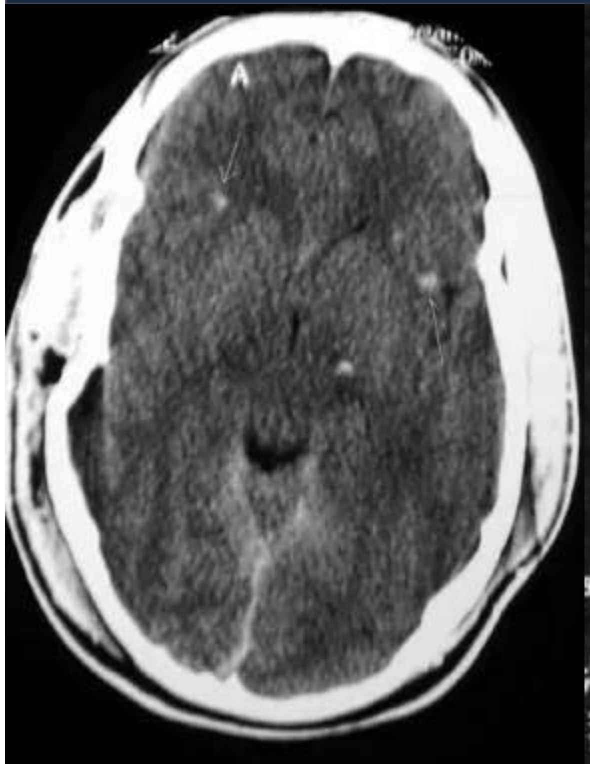

Main symptom:
A thunderclap headache, which is a very intense and painful headache that comes on suddenly.
Call 911 or get to the nearest emergency room if you experience a thunderclap headache, especially if you experience additional symptoms.

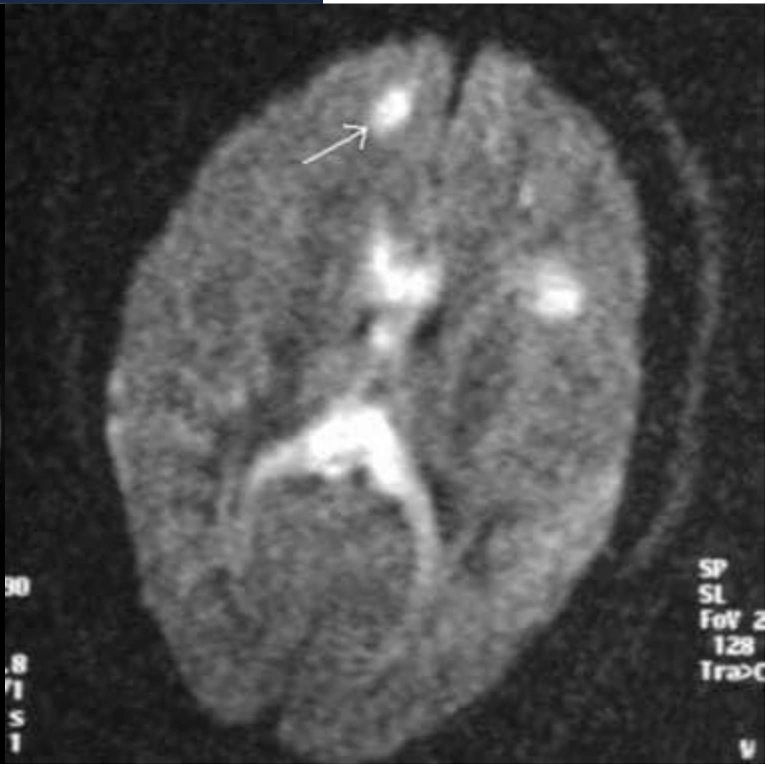

Decreased consciousness and alertness.
Nausea and vomiting.
Stiff neck.
Sudden weakness.
Dizziness.
Numbness in part of your body.
Muscle aches, especially in your neck and shoulders.
Eye sensitivity in bright light.
Seizures.
Mood and personality changes, including confusion and irritability.
Vision changes, including double vision, blind spots or temporary vision loss in one eye.

DAI

- results from high-speed deceleration injury and represents direct axonal damage from shear effects.
- CT scan may demonstrate blurring of the gray and white matter interface and multiple small punctate hemorrhages, but magnetic resonance imaging is a more accurate test.
- Although prognosis for these injuries is extremely variable, early evidence of DAI is associated with a poor outcome.



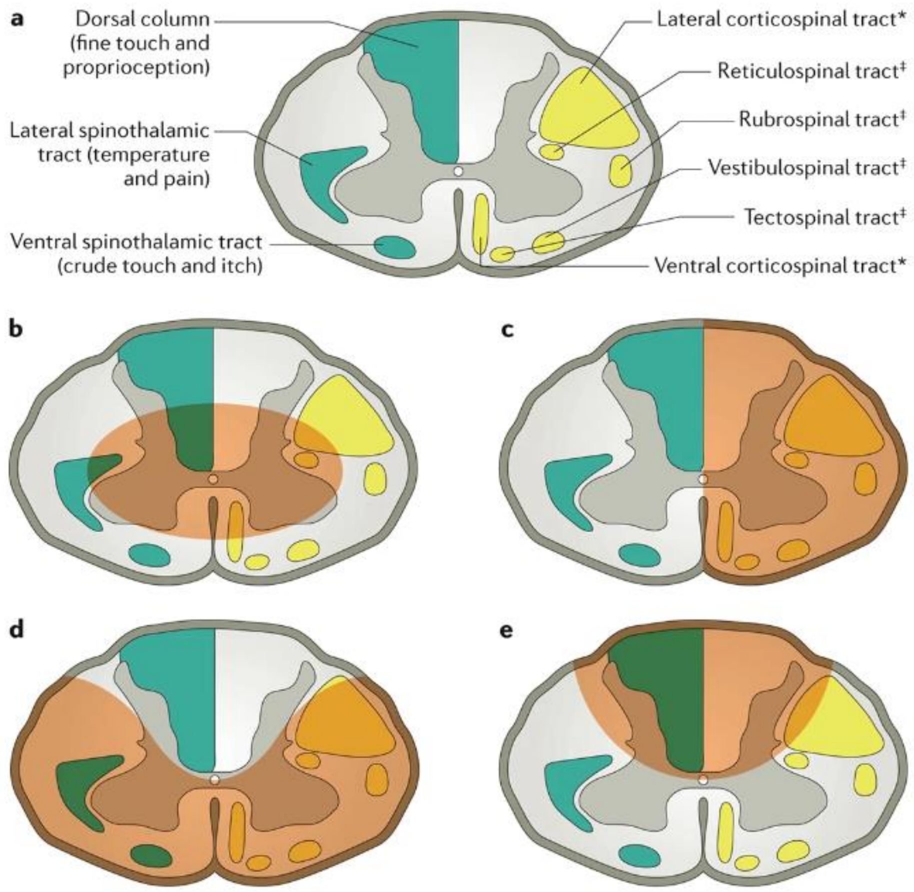




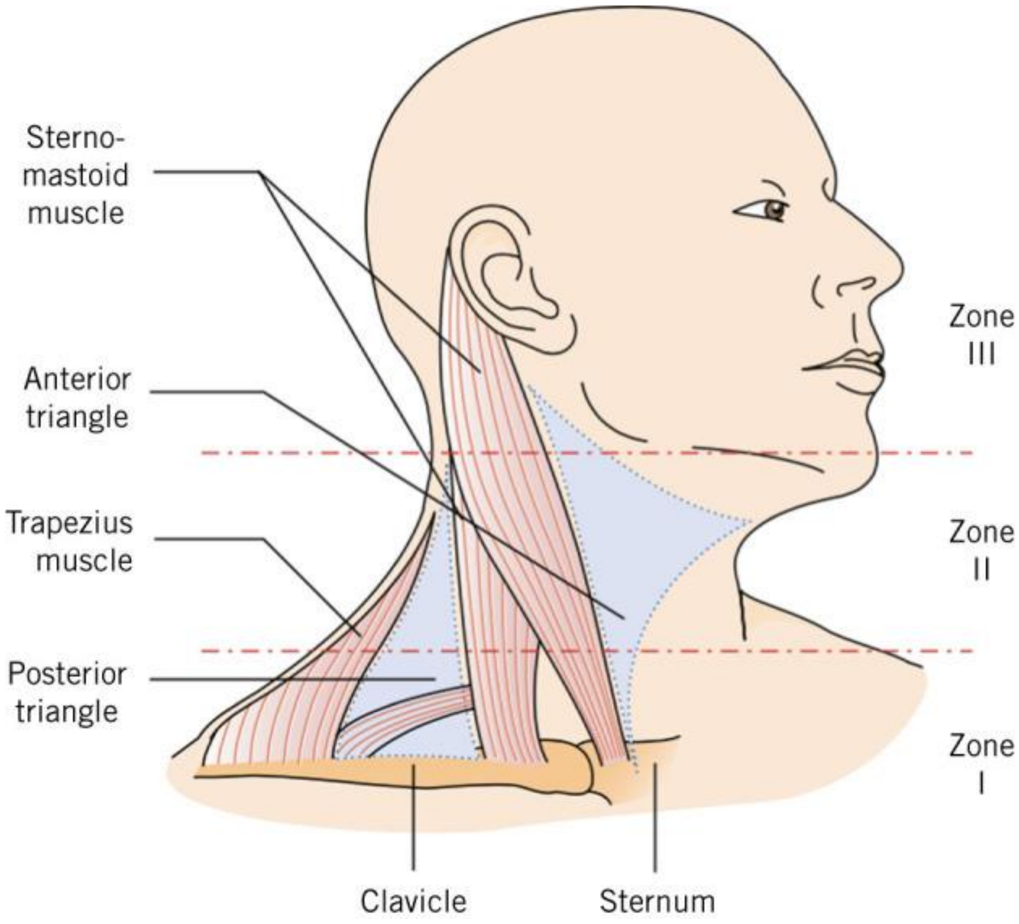
Regional Assessment and Special Diagnostic Tests- Neck

- Complete injuries cause either quadriplegia or paraplegia, depending on the level of injury. These patients have a complete loss of motor function and sensation two or more levels below the bony injury. Patients with high spinal cord disruption are at risk for shock due to physiologic disruption of sympathetic fibers. Significant neurologic recovery is rare.
- Central cord syndrome typically occurs in older persons who experience hyperextension injuries. Motor function, pain, and temperature sensation are preserved in the lower extremities but diminished in the upper extremities. Some functional recovery usually occurs, but is often not a return to normal.
- Anterior cord syndrome is characterized by diminished motor function, pain, and temperature sensation below the level of the injury, but position sensing, vibratory sensation, and crude touch are maintained. Prognosis for recovery is poor.
- Posterior cord syndrome results in loss of light touch and proprioception but preservation of motor function, and pain and/or temperature sensation.
- Brown-Séquard syndrome is usually the result of a penetrating injury in which one-half of the spinal cord is transected. This lesion is characterized by the ipsilateral loss of motor function, proprioception, and vibratory sensation, whereas pain and temperature sensation are lost on the contralateral side.

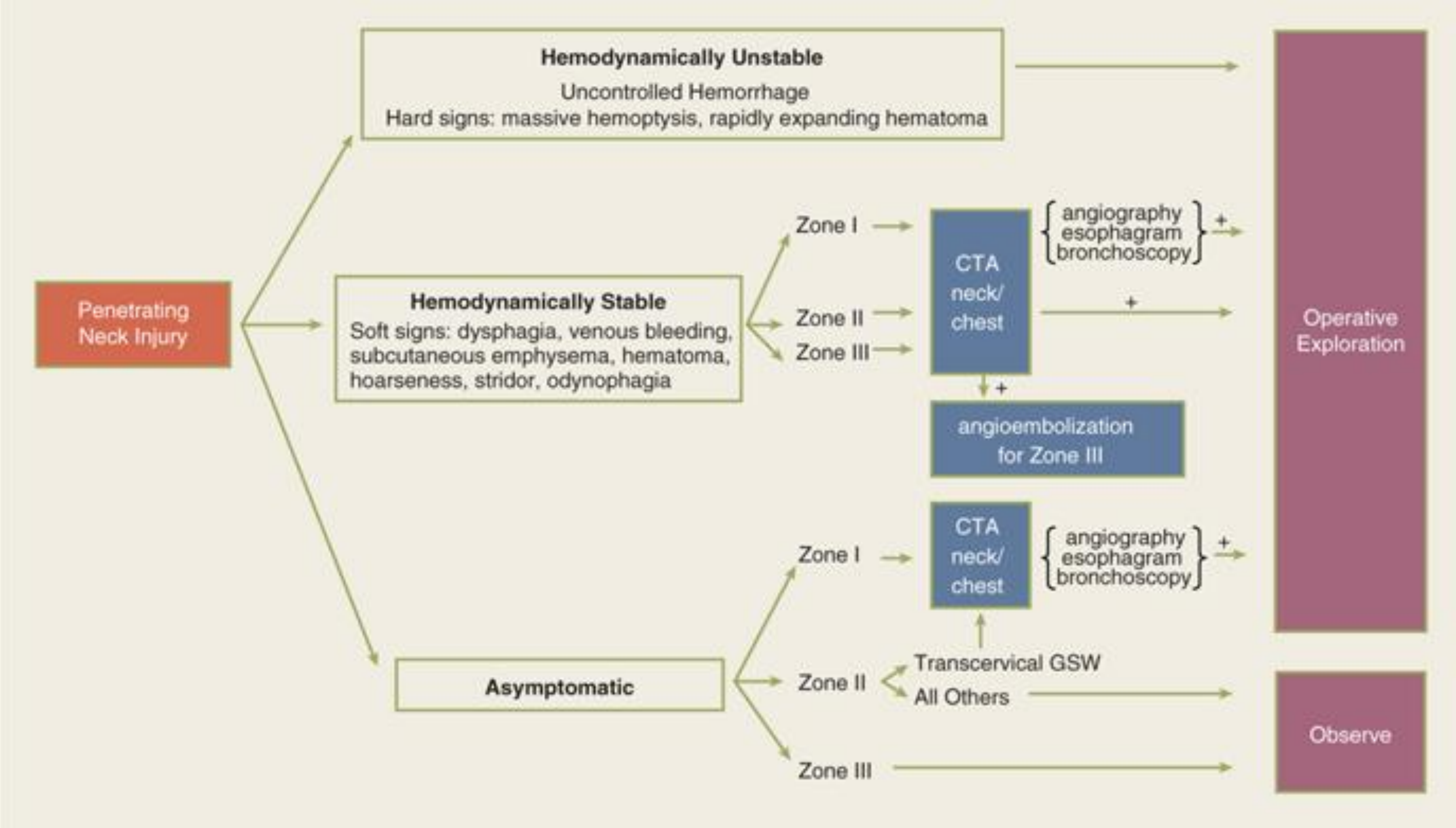
From: Traumatic spinal cord injury



Penetrating Neck injuries



Penetrating Neck injuries



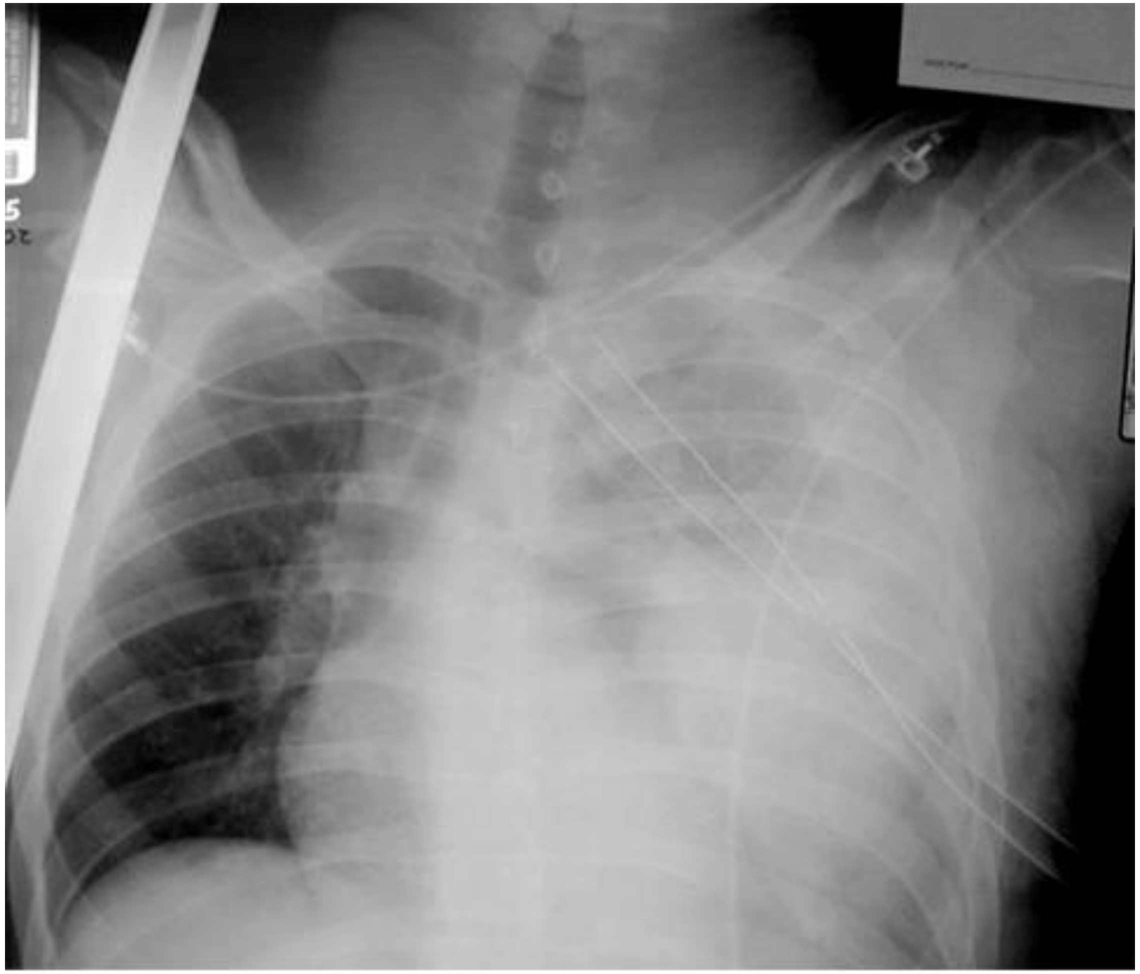
Penetrating Neck injuries

- Specific symptoms or signs:
  - Dysphagia
  - Hoarseness
  - Hematoma
  - Venous bleeding
  - Minor hemoptysis
  - Subcutaneous emphysema.

- Symptomatic patients, without overt injuries, should undergo CTA with further evaluation or operation based upon the imaging findings.
- Asymptomatic patients are typically observed for 6 to 12 hours.
- The one caveat is asymptomatic patients with a transcervical gunshot wound; these patients should undergo CTA to determine the trajectory of the bullet; further studies are performed based on proximity to major structures.
- Such additional imaging includes angiography, soluble contrast esophagram followed by barium esophagram, esophagoscopy, or bronchoscopy.
- Angiographic diagnosis, particularly of zone III injuries, can then be managed by selective angioembolization.

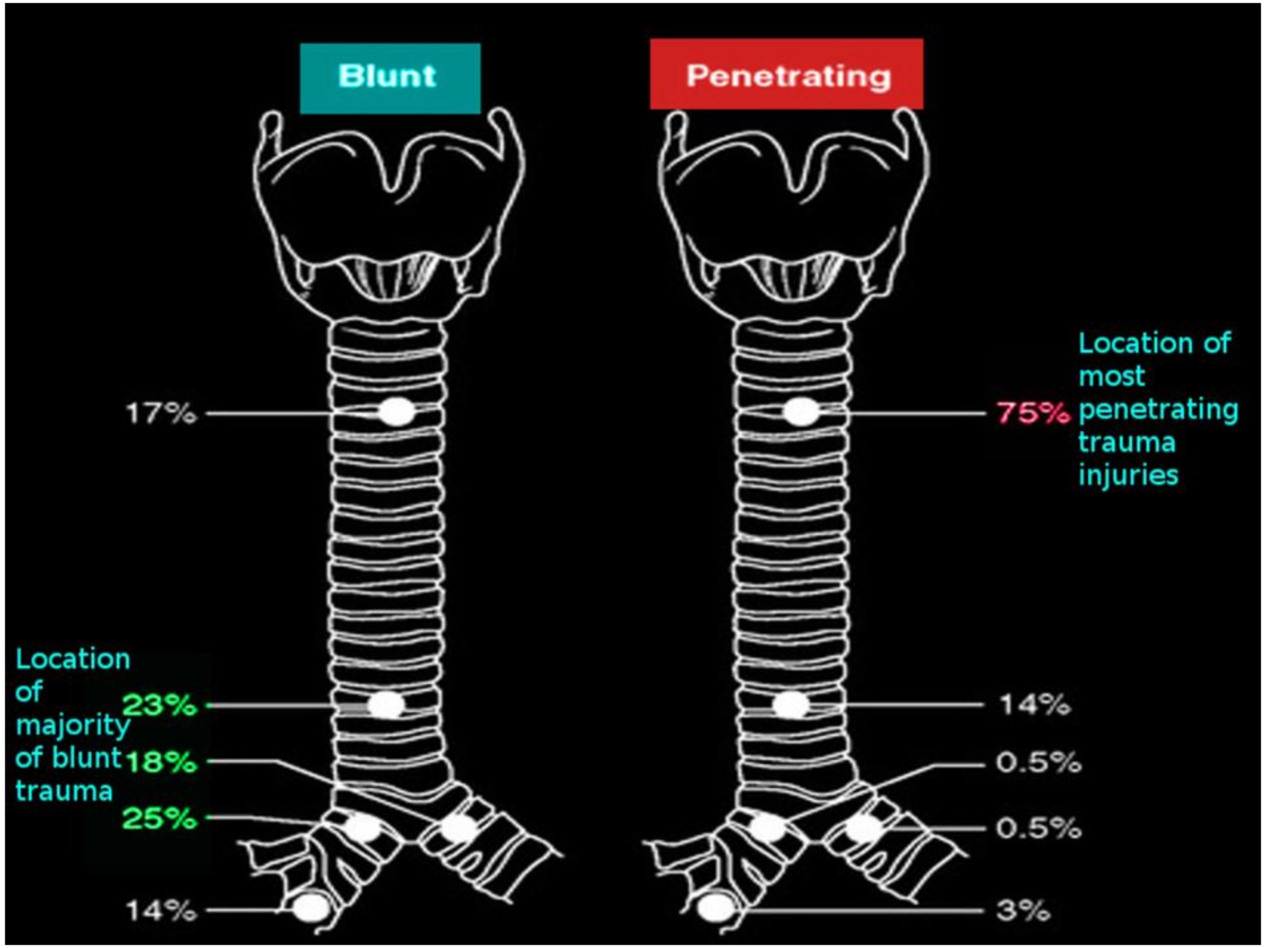
Regional Assessment - Chest

- Most of these injuries can be evaluated by physical examination and chest radiography, with supplemental CT scanning to exclude vascular injury.
- Any patient who undergoes an intervention in the ED—endotracheal intubation, central line placement, tube thoracostomy—needs a repeat chest radiograph to document the adequacy of the procedure.

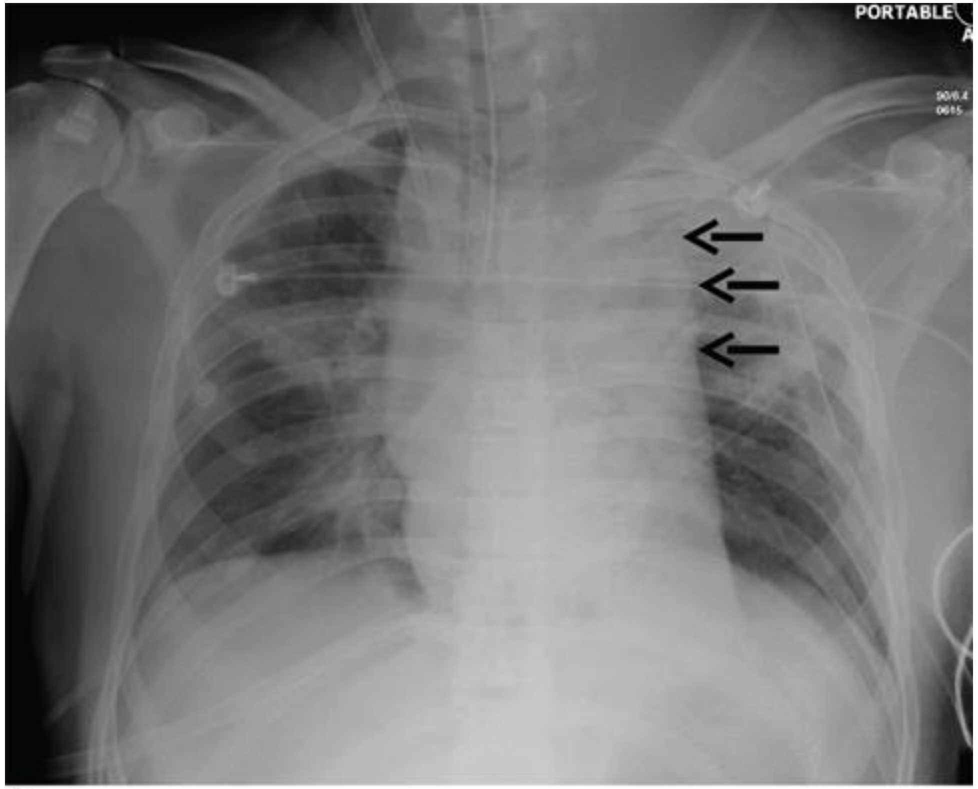


Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e

- Patients with persistent pneumothorax, large air leaks after tube thoracostomy, or difficulty ventilating should undergo fiber-optic bronchoscopy to exclude a tracheobronchial injury or presence of a foreign body.



Occult thoracic vascular injury



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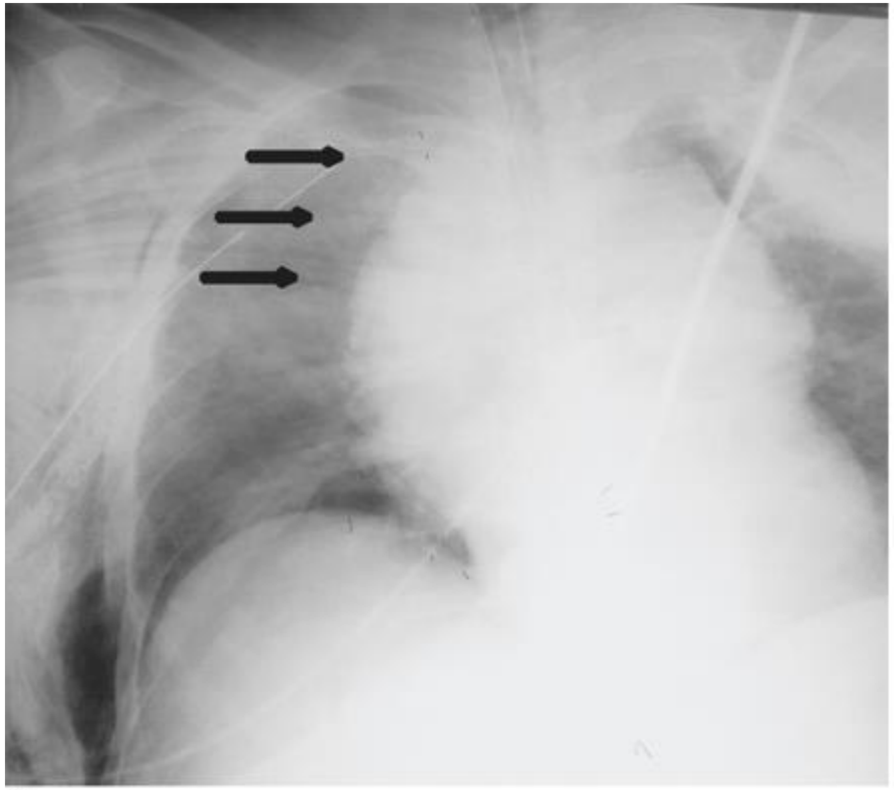
Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e



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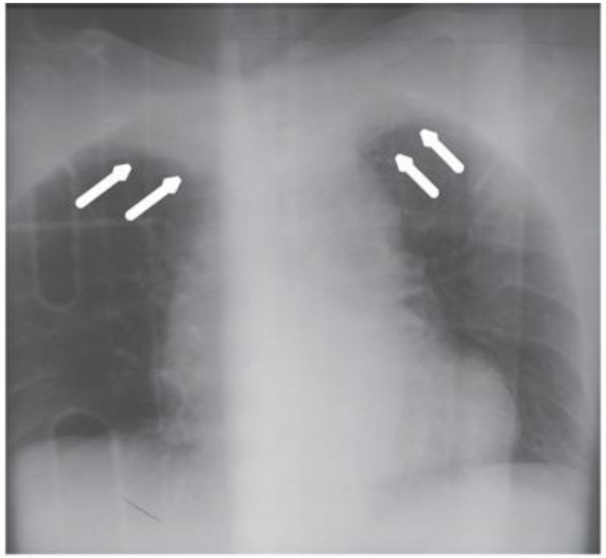
Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e



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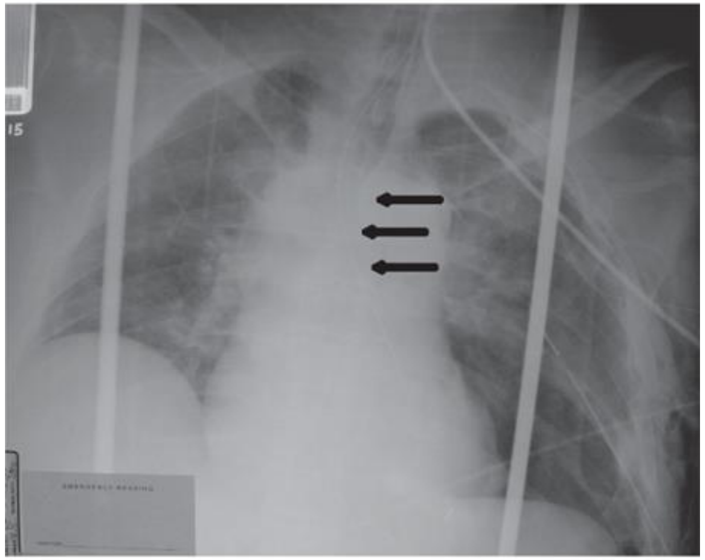

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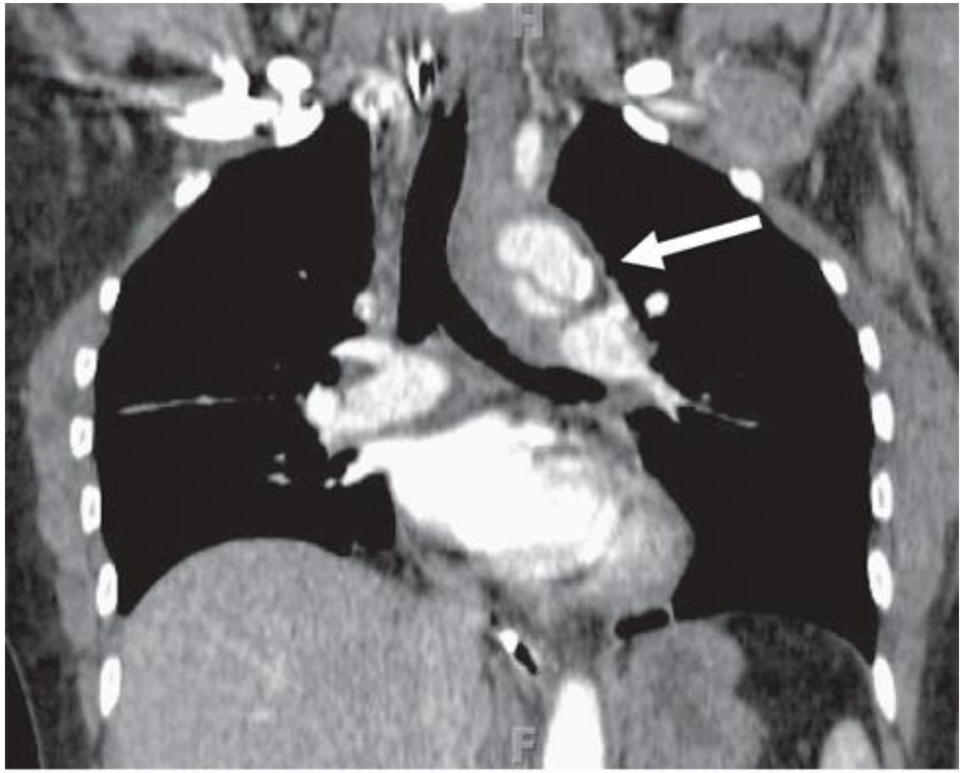

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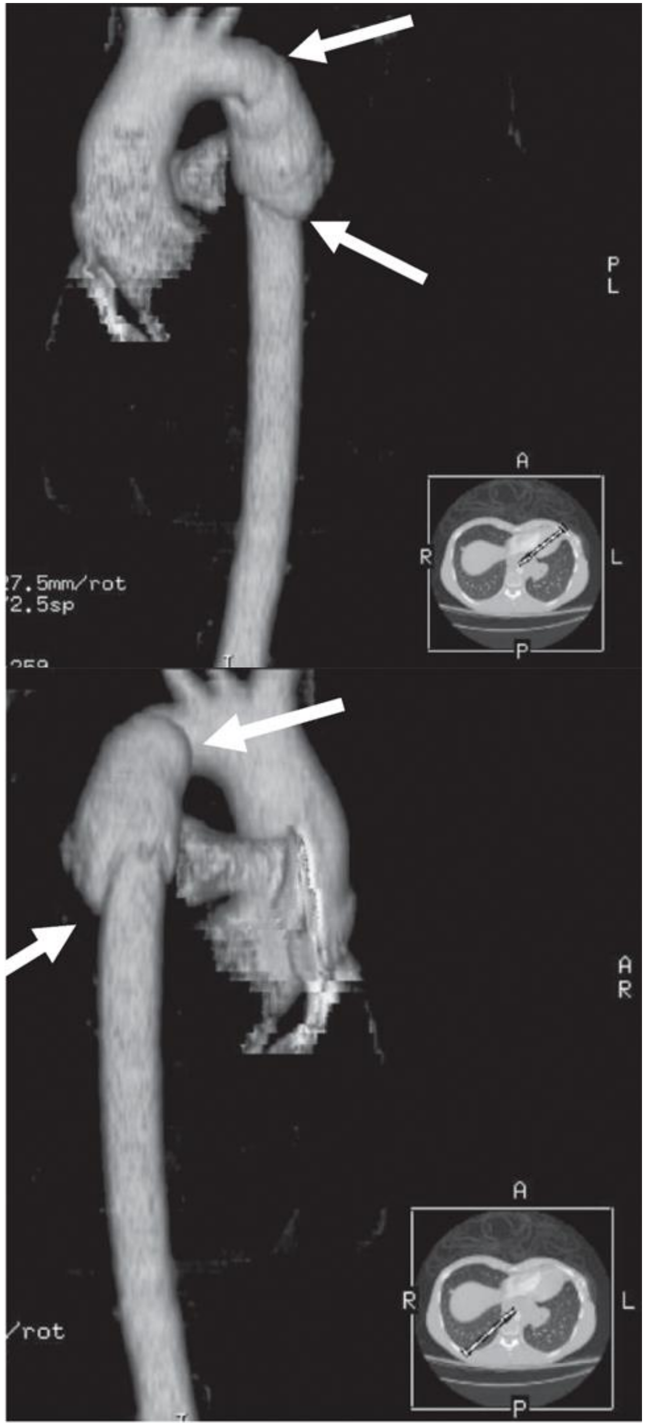
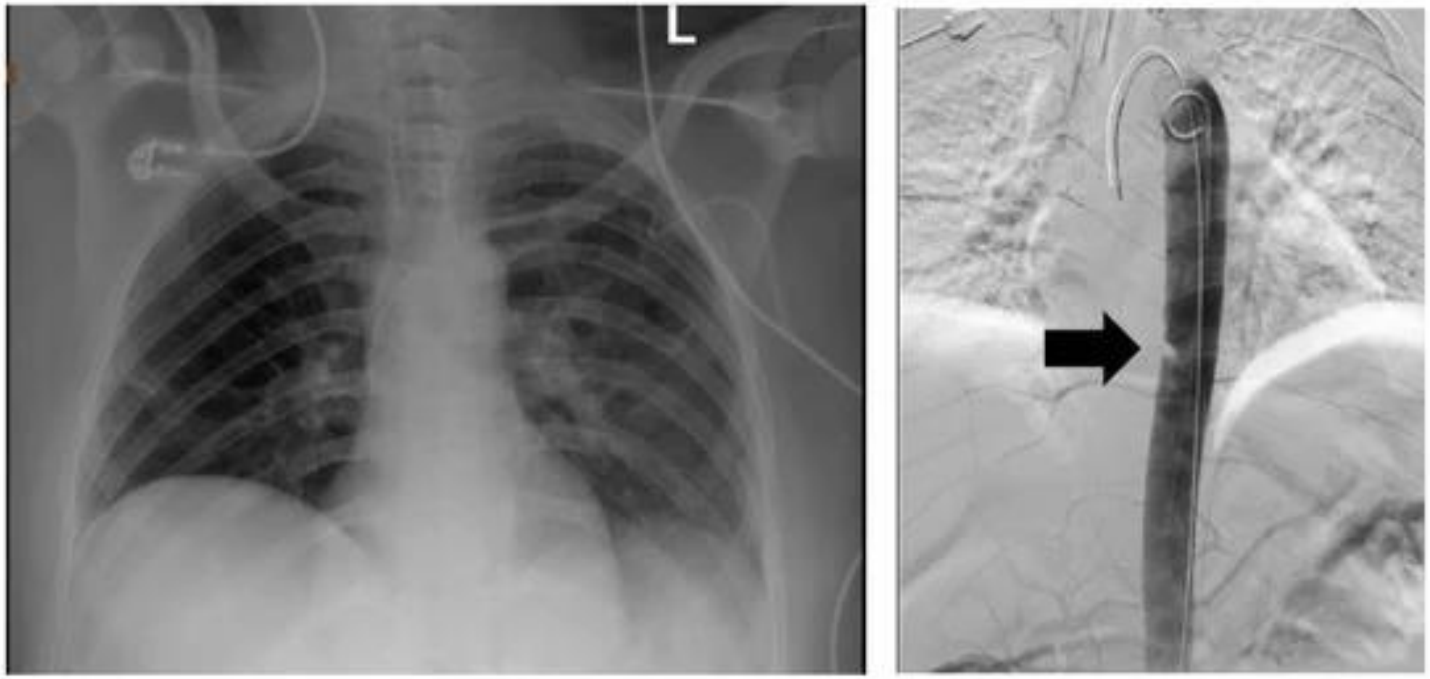


Occult thoracic vascular injury

- At least 7% of patients with a descending BAI have a normal chest image radiograph.
- Screening CTA is performed based on the mechanism of injury:
  - high-energy deceleration motor vehicle collision with frontal or lateral impact (>30 mph frontal impact and >23 mph lateral impact)
  - motor vehicle collision with ejection
  - falls of >25 ft
  - direct impact (horse kick to chest, snowmobile, or ski collision with tree).

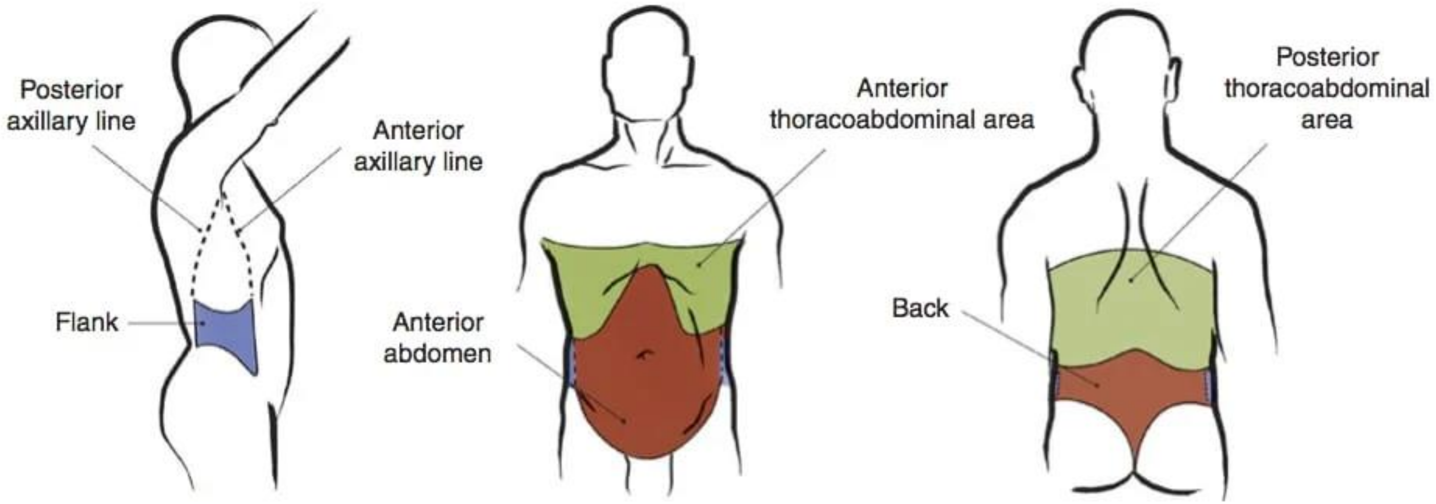


(a) (b)

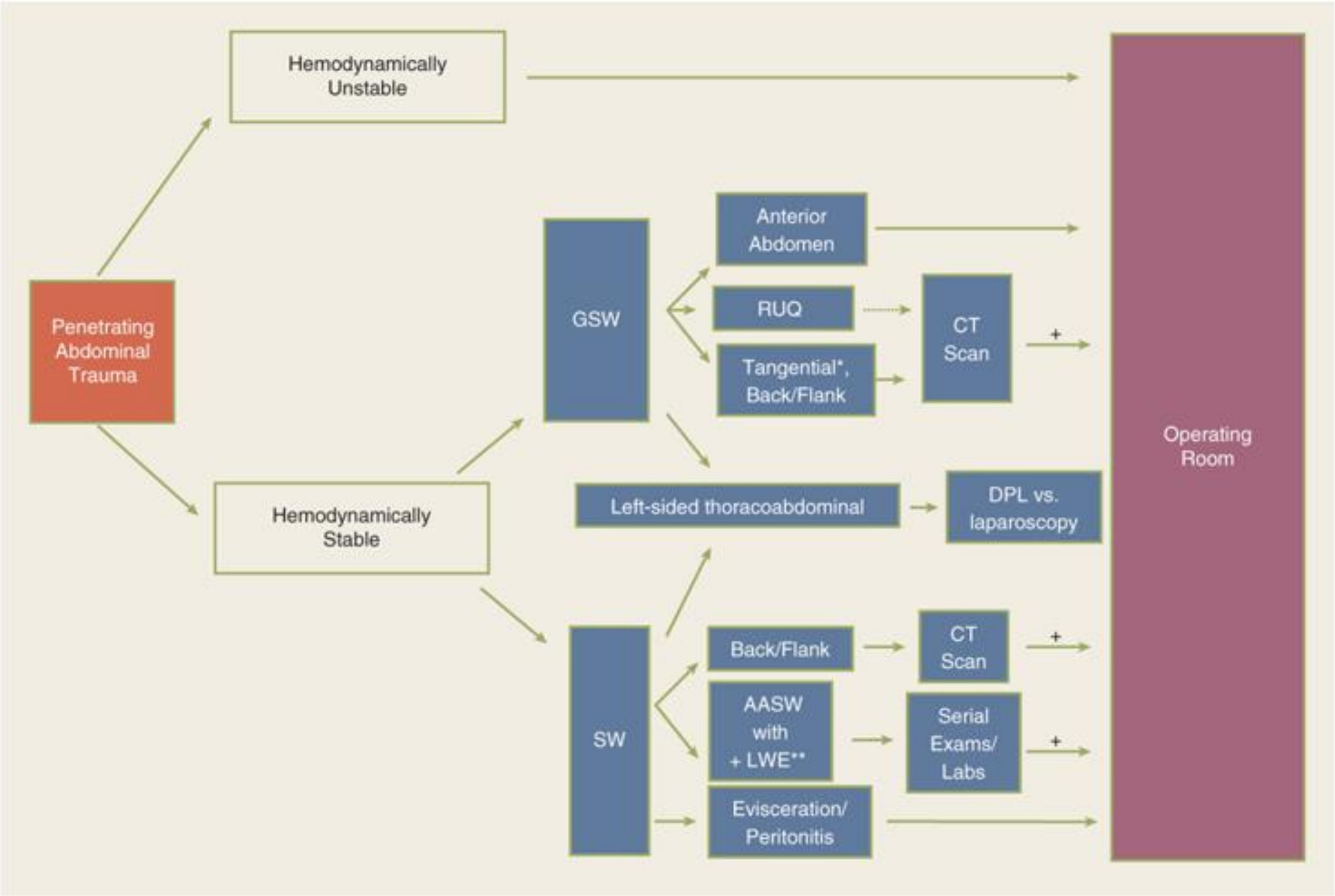
Penetrating thoracic trauma

- Physical examination,
- Plain posteroanterior and lateral chest radiographs with metallic markings of wounds
- Pericardial ultrasound
- Bronchoscopy should be performed to evaluate the trachea in patients with a persistent air leak from the chest tube or mediastinal air.
- Patients at risk for an esophageal injury should undergo bedside esophagoscopy or soluble contrast esophagography followed by barium examination to look for extravasation of contrast.
- As with neck injuries, hemodynamically stable patients with transmediastinal gunshot wounds should undergo CT scanning to determine the path of the bullet; trajectory in proximity to vascular or visceral structures dictates the need for angiography, endoscopy, or operative plan.
- Finally, with GSWs identified on the chest, penetrating trauma should not be presumed to be isolated to the thorax. Injury to contiguous body cavities (i.e., the abdomen and neck) must be excluded; plain radiographs are a rapid, effective screening modality to identify retained bullet fragments.

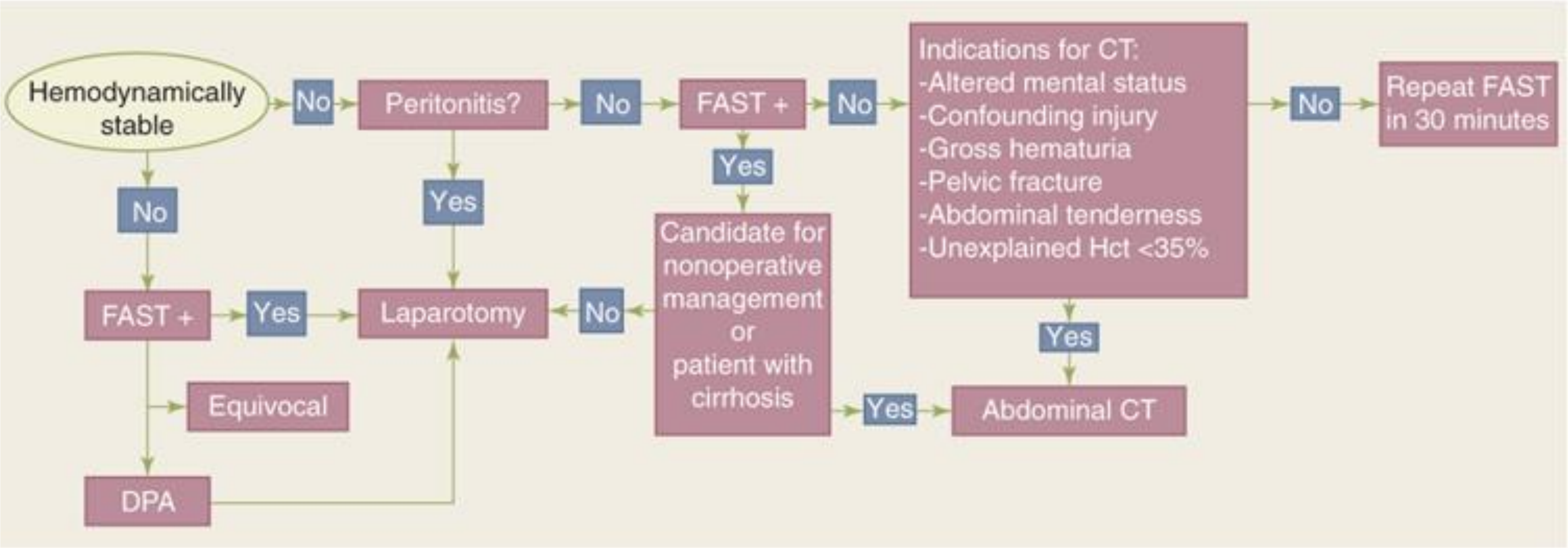
Regional Assessment and Special Diagnostic Tests- Abdomen



PENETRATING ABDOMINAL TRAUMA



BLUNT ABDOMINAL TRAUMA



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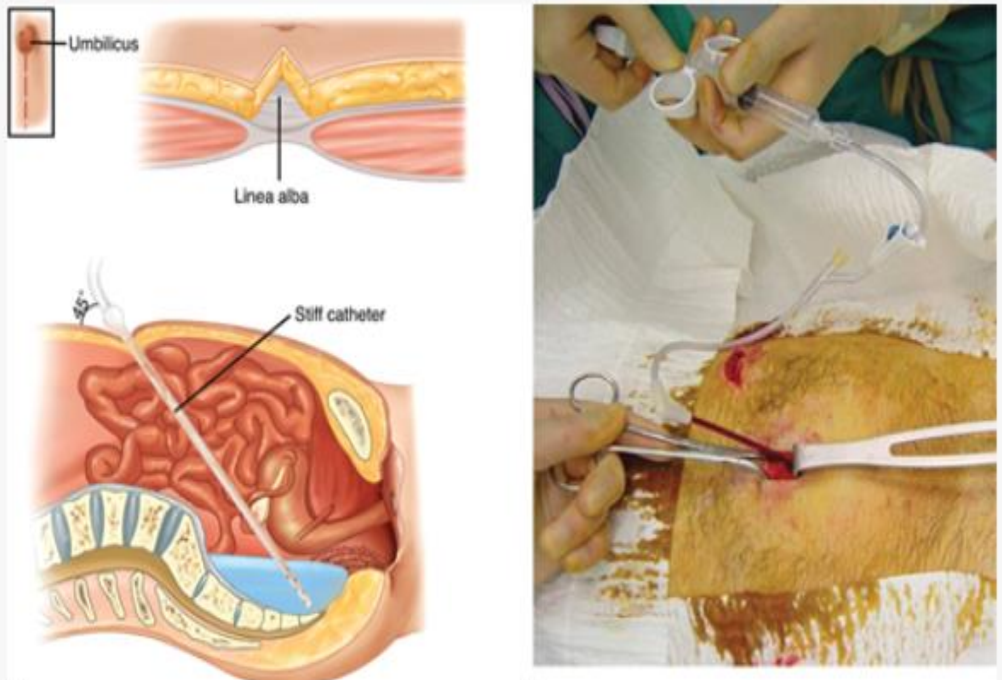

A B

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Criteria for “positive” finding on diagnostic peritoneal lavage

	ABDOMINAL TRAUMA	THORACOABDOMINAL STAB WOUNDS
Red blood cell count	>100,000/mL	>10,000/mL
White blood cell count	>500/mL	>500/mL
Amylase level	>19 IU/L	>19 IU/L
Alkaline phosphatase level	>2 IU/L	>2 IU/L
Bilirubin level	>0.01 mg/dL	>0.01 mg/dL

	SUBCAPSULAR HEMATOMA	LACERATION
Liver Injury Grade		
Grade I	<10% of surface area	<1 cm in depth
Grade II	10%–50% of surface area	1–3 cm
Grade III	>50% of surface area or >10 cm in depth	>3 cm
Grade IV	25%–75% of a hepatic lobe	
Grade V	>75% of a hepatic lobe	
Grade VI	Hepatic avulsion	

From: Liver trauma: WSES 2020 guidelines

	WSES grade	AAST	Hemodynamic
Minor	WSES grade I	I–II	Stable
Moderate	WSES grade II	III	Stable
Severe	WSES grade III	IV–V	Stable
	WSES grade IV	I–VI	Unstable

Splenic Injury Grade		
Grade I	<10% of surface area	<1 cm in depth
Grade II	10%–50% of surface area	1–3 cm
Grade III	>50% of surface area or >10 cm in depth	>3 cm
Grade IV	>25% devascularization	Hilum
Grade V	Shattered spleen Complete devascularization	

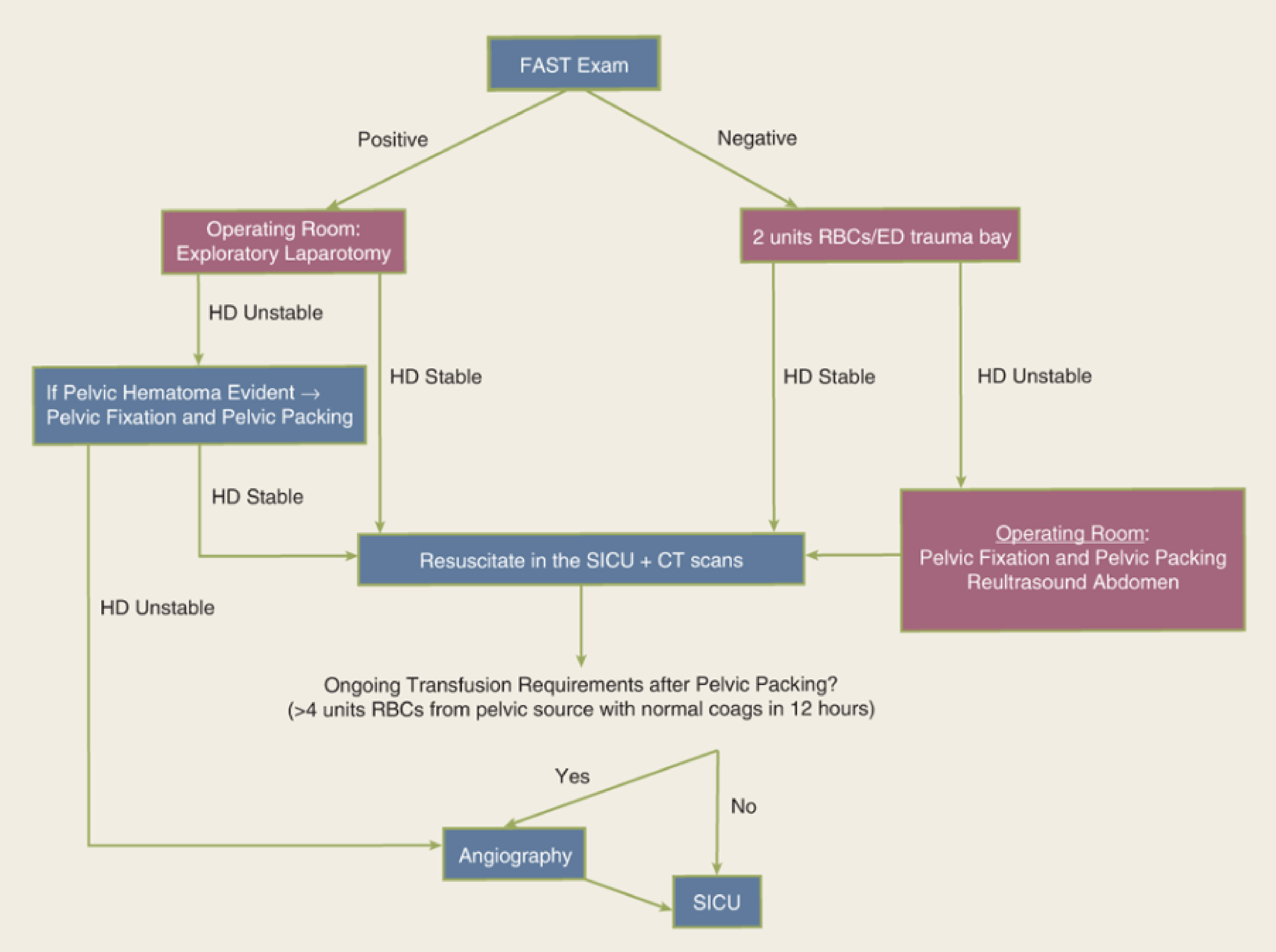
	WSES class	Mechanism of injury	AAST	Hemodynamic status[a, b]	CT scan	First-line treatment in adults	First-line treatment in pediatric
Minor	WSES I	Blunt/penetrating	I–II	Stable	Yes + local exploration in SW[d]	NOM[c] + serial clinical/laboratory/radiological evaluation Consider angiography/angioembolization	NOM[c] + serial clinical/laboratory/radiological evaluation Consider angiography/angioembolization
Moderate	WSES II	Blunt/penetrating	III	Stable			
	WSES III	Blunt/penetrating	IV–V	Stable		NOM[c] All angiography/angioembolization + serial clinical/laboratory/radiological evaluation	
Severe	WSES IV	Blunt/penetrating	I–V	Unstable	No	OM	OM

Regional Assessment and Special Diagnostic Tests- Pelvis

- Sharp spicules of bone can lacerate the bladder, rectum, or vagina.
- Bladder rupture may result from a direct blow to the torso if the bladder is full. CT cystography is performed if the urinalysis demonstrates RBCs.
- Urethral injuries are suspected if examination reveals blood at the meatus, scrotal or perineal hematomas, or a high-riding prostate on rectal examination.
- Major vascular injuries of the external iliacs causing bleeding are uncommon in blunt pelvic trauma; however, thrombosis of either the arteries or veins in the iliofemoral system may occur, and CTA should be performed for evaluation if there is a pulse differential.

C

Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e


FAST Exam
Positive
Negative
Operating Room:
Exploratory Laparotomy
2 units RBCs/ED trauma bay
HD Unstable
HD Stable
HD Stable
HD Unstable
If Pelvic Hematoma Evident →
Pelvic Fixation and Pelvic Packing
HD Stable
Resuscitate in the SICU + CT scans
Operating Room:
Pelvic Fixation and Pelvic Packing
Reultrasound Abdomen
HD Unstable
Ongoing Transfusion Requirements after Pelvic Packing?
(>4 units RBCs from pelvic source with normal coags in 12 hours)
Yes
No
Angiography
SICU

Regional Assessment and Special Diagnostic Tests- Extremities

- Blunt or penetrating trauma to the extremities requires an evaluation for fractures, ligamentous disruption, and neurovascular injury.
- Plain radiographs are used to evaluate fractures, whereas ligamentous injuries, particularly those of the knee and shoulder, can be imaged with magnetic resonance imaging.

- Life-threatening injuries include:
  - Pelvic disruption with massive hemorrhage
  - Severe arterial hemorrhage
  - Crush syndrome (the complex of electrolyte disturbances, metabolic acidosis and rhabdomyolysis resulting from crush injury)
- Limb-threatening injuries include:
  - Open fractures/ dislocations
  - Traumatic amputation (an injury that results in loss of the extremity distal to the wound) and severe vascular injuries
  - Compartment syndrome
  - Neurological compromise due to limb injury
  - Degloving injuries (involve separation of the skin and underlying subcutaneous connective tissue from the underlying fascia. They are usually but not always open injuries causing exposure of the underlying structures and are associated with high morbidity)

- Bony fractures or knee dislocations should be realigned before definitive vascular examination.
- In management of vascular trauma, controversy exists regarding the treatment of patients with soft signs of injury, particularly those with injuries in proximity to major vessels.
- It is known that some of these patients will have arterial injuries that require repair.
- The most common approach has been to measure SBP using Doppler ultrasonography and compare the value for the injured side with that for the uninjured side, termed the A-A index.
- If the pressures are within 10% of each other, a significant injury is unlikely, and no further evaluation is performed.
- If the difference is >10%, CTA or arteriography is indicated.
- Others argue that there are occult injuries, such as pseudoaneurysms or injuries of the profunda femoris or peroneal arteries, which may not be detected with this technique.

- If hemorrhage occurs from these injuries, compartment syndrome and limb loss may occur.
- Although busy trauma centers continue to debate this issue, the surgeon who is obliged to treat the occasional injured patient may be better served by performing CTA in selected patients with soft signs.
- In patients with hard signs of vascular injury, on-table angiography may be useful to localize the arterial injury and thus, limit tissue dissection. For example, a patient with an absent popliteal pulse and femoral shaft fracture due to a bullet that entered the lateral hip and exited below the medial knee could have injured either the femoral or popliteal artery anywhere along its course.

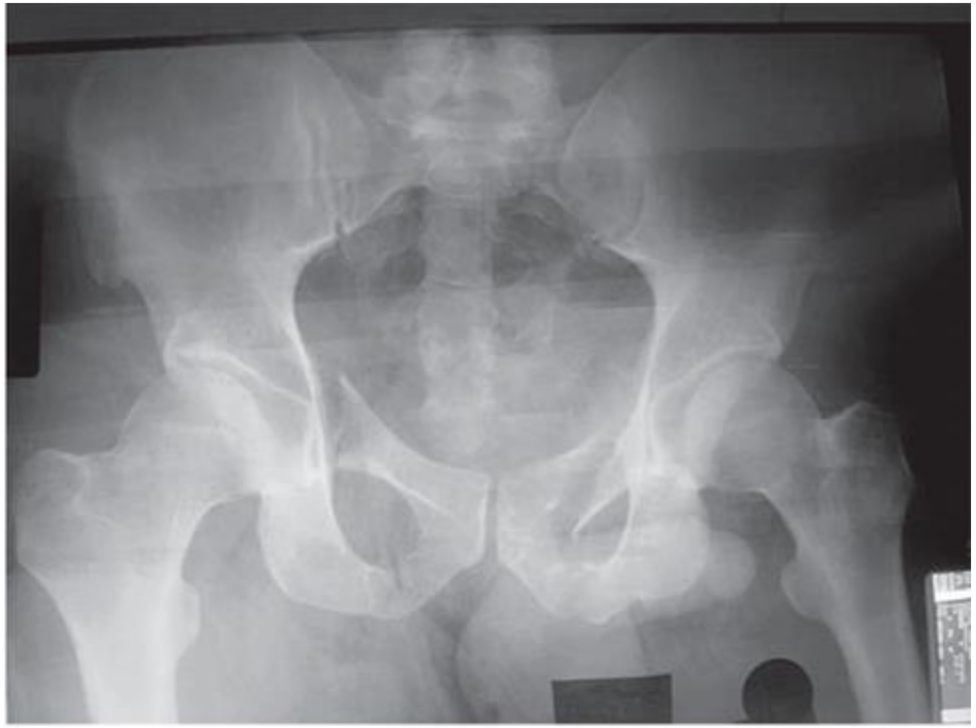
Regional Assessment and Special Diagnostic Tests- Extremities

- Physical examination identifies the majority of arterial injuries, and findings are classified as either hard signs or soft signs of vascular injury .
- In general, hard signs constitute indications for operative exploration, whereas soft signs are indications for further testing or observation.
- Bony fractures or knee dislocations should be realigned before definitive vascular examination.
- In management of vascular trauma, controversy exists regarding the treatment of patients with soft signs of injury, particularly those with injuries in proximity to major vessels. It is known that some of these patients will have arterial injuries that require repair.
- The A-A index: If the pressures are within 10% of each other, a significant injury is unlikely, and no further evaluation is performed. If the difference is >10%, CTA or arteriography is indicated.

Signs and symptoms of peripheral arterial injury

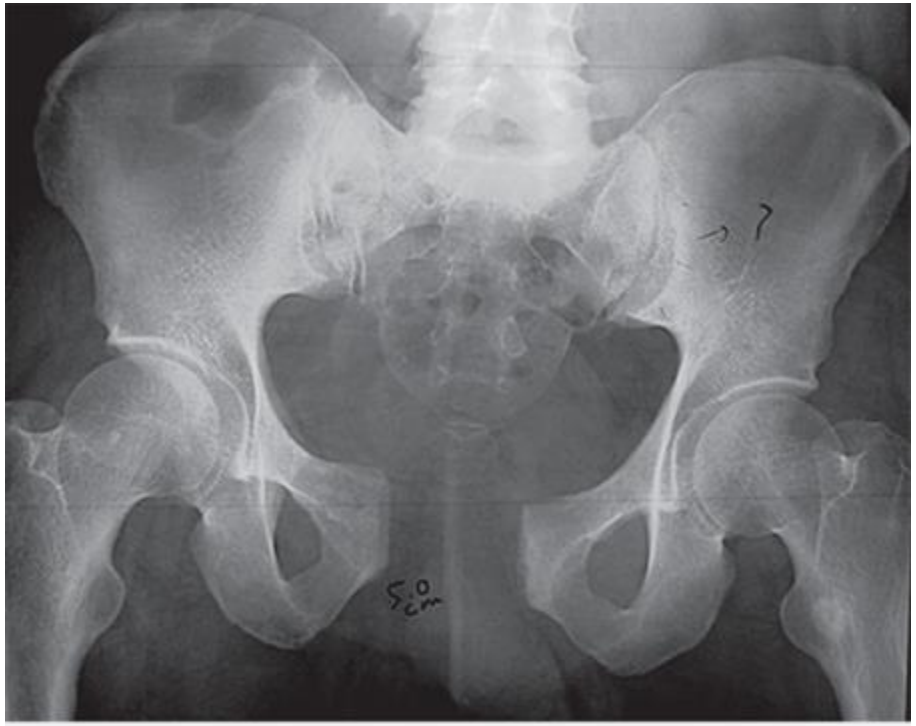
HARD SIGNS (OPERATION MANDATORY)	SOFT SIGNS (FURTHER EVALUATION INDICATED)
Pulsatile hemorrhage	Proximity to vasculature
Absent pulses	Significant hematoma
Acute ischemia	Associated nerve injury
	A-A index of <0.9
	Thrill or bruit

Regional Assessment and Special Diagnostic Tests- Pelvis



A

Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e



B

Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e

Prophylactic Measures

- Preoperative antibiotics
- Administration of low molecular weight heparin (LMWH)
- Thermal protection

Abdominal compartment syndrome

- The abdominal compartment syndrome is classified as pathologic intra-abdominal hypertension
  - A. intra-abdominal injury (primary)
  - B. splanchnic reperfusion after massive resuscitation (secondary).
- Secondary abdominal compartment image syndrome may result from any condition requiring extensive crystalloid resuscitation, including extremity trauma, chest trauma, or even postinjury sepsis.
- The sources of increased intra-abdominal pressure include
  - ✓ bowel edema
  - ✓ ascites
  - ✓ bleeding
  - ✓ packs.

<u>Definitions</u>

IAH: a sustained or repeated pathological elevation in IAP ≥ 12mmHg

ACS: a sustained IAP > 20mmHg that is associated with new organ dysfunction/failure

IAP is graded as follows:

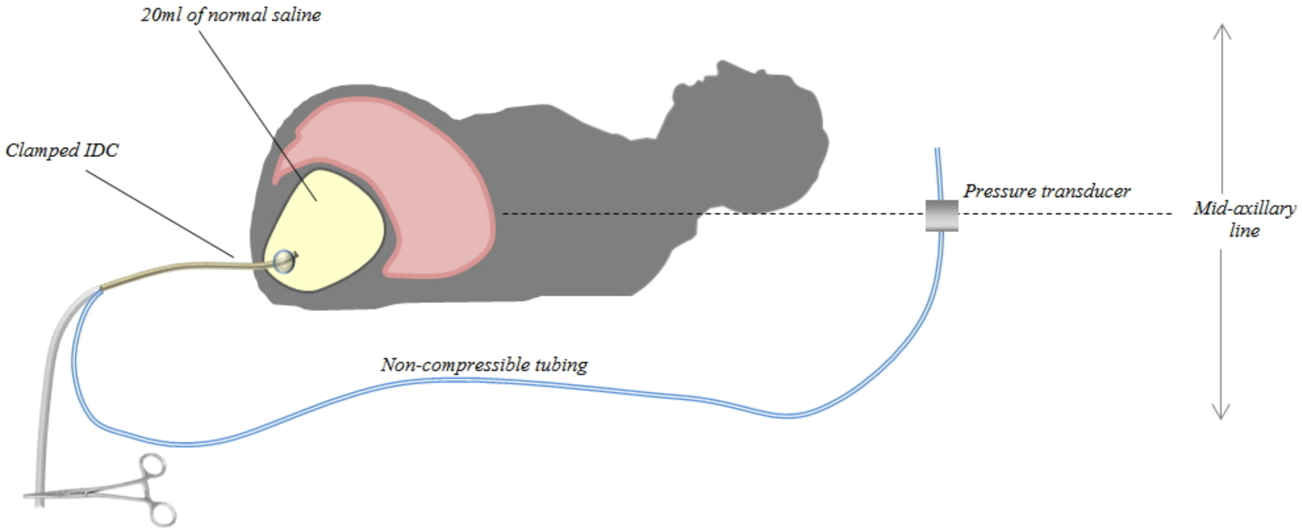
- Grade I, IAP 12 – 15mmHg
- Grade II, IAP 16 – 20mmHg
- Grade III, IAP 21 – 25mmHg
- Grade IV, IAP > 25mmHg

ABDOMINAL COMPARTMENT SYNDROME

Primary abdominal compartment syndrome	Secondary abdominal compartment syndrome
• Intra-abdominal infection • Abdominal trauma • Ascites • Ileus • Intra-abdominal hematoma • Acute pancreatitis • Laparoscopy with excessive inflation pressures • Peritoneal dialysis	• Massive transfusion • Massive fluid resuscitation • Sepsis • Mechanical ventilation • Abdominal wall burns • High body mass index (>30) • Prone positioning

Abdominal Compartment Syndrome

- A diagnosis is obtained by measuring the intraperitoneal pressure.
- The most common technique is to measure the patient's bladder pressure. Fifty milliliters of saline is instilled into the bladder via the aspiration port of the Foley catheter with the drainage tube clamped, and a three-way stopcock and water manometer is placed at the level of the pubic symphysis. Bladder pressure is then measured on the manometer in centimeters of water and correlated with the physiologic sequelae.
- Conditions in which the bladder pressure is unreliable include bladder rupture, external compression from pelvic packing, neurogenic bladder, and adhesive disease.

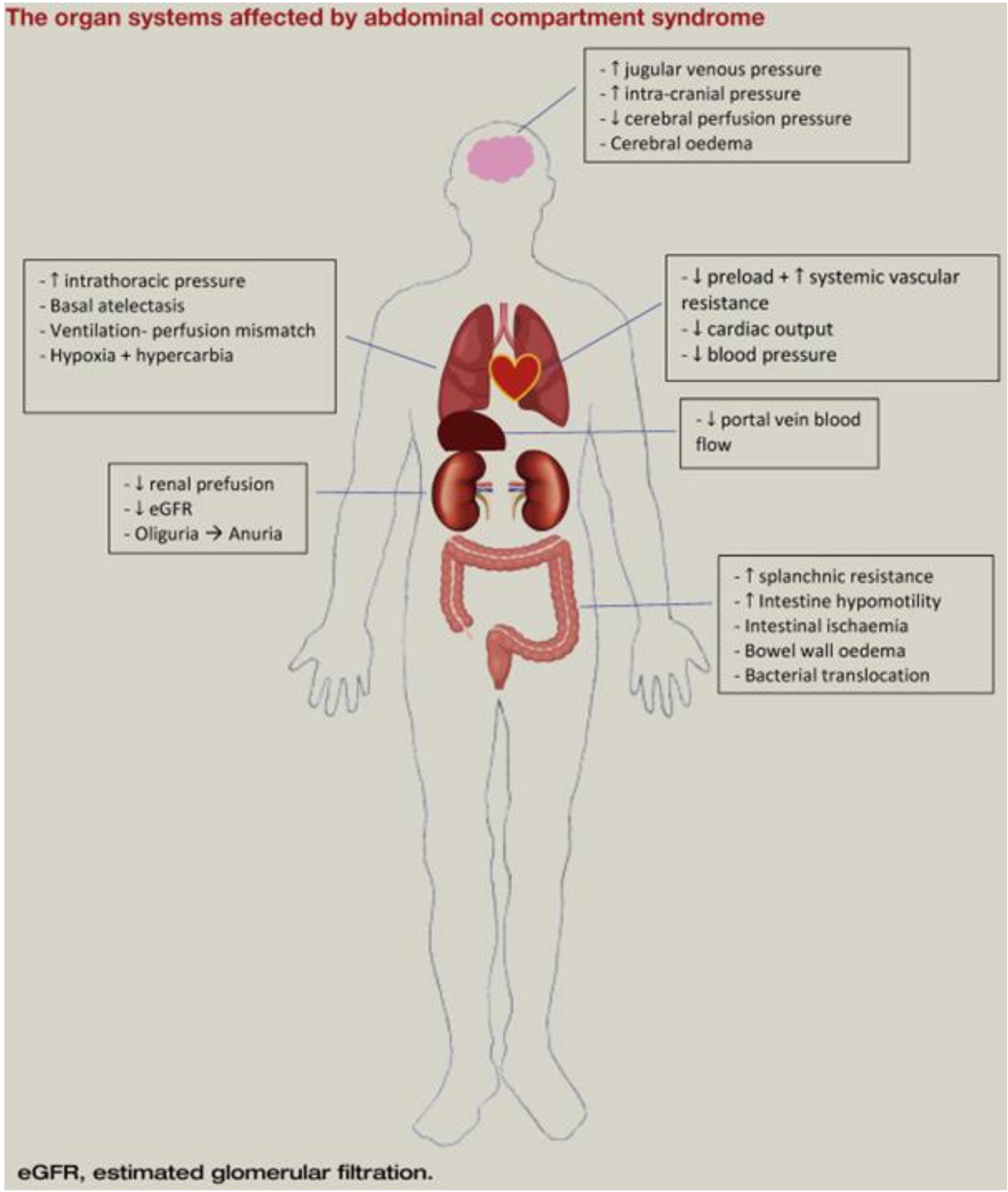


The bladder pressure is unreliable:

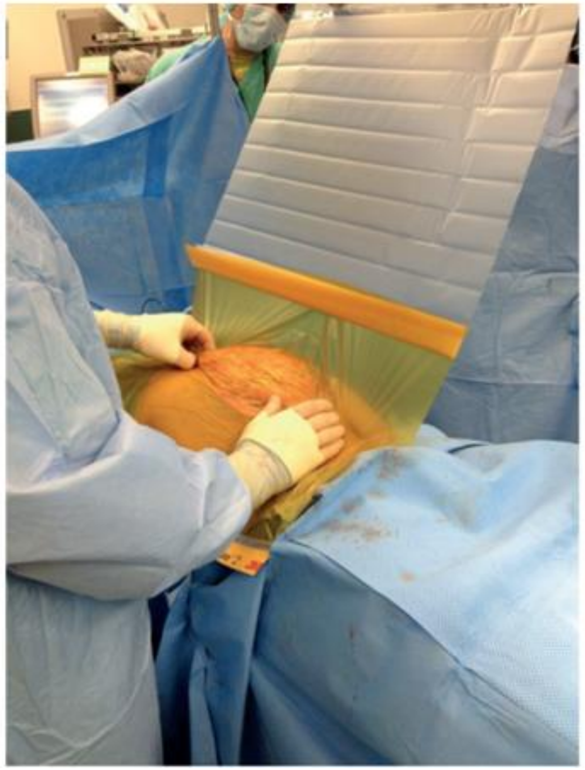
1. Bladder rupture.
2. External compression from pelvic packing.
3. Neurogenic bladder.
4. Adhesive disease.

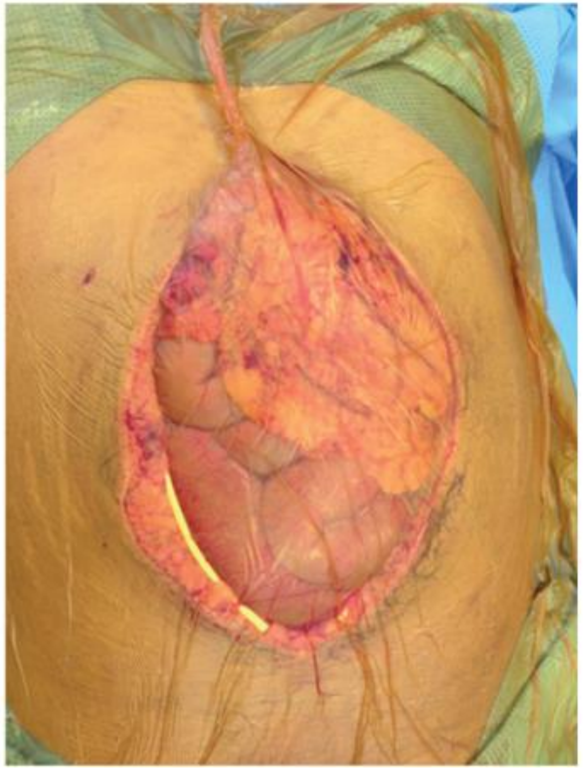
Pathophysiology

- Renal failure: This is not prevented by intraureteral stents, which suggests direct compression of renal parenchyma and decreased renal perfusion as causes
- Respiratory distress and failure: Initial signs of abdominal compartment syndrome include elevated peak airway pressures in intubated patients with decreased tidal volumes
- Bowel ischemia
- Increased intracranial pressure (ICP): Decompressive laparotomy has been shown to reduce intractable elevated ICP in patients with IAH
- Failing cardiac output and refractory shock: Abdominal compartment syndrome factitiously elevates central venous pressure (CVP) and pulmonary capillary wedge pressure (PCWP) in patients who are hypovolemic or euvolemic

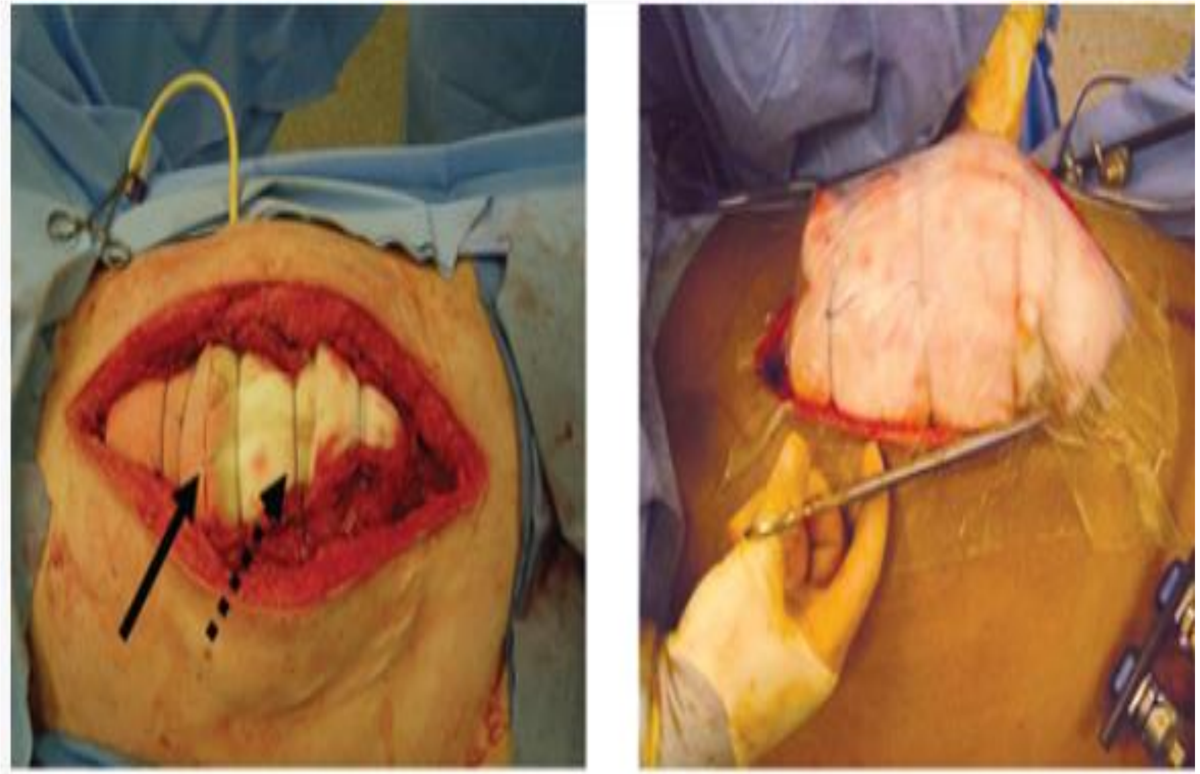


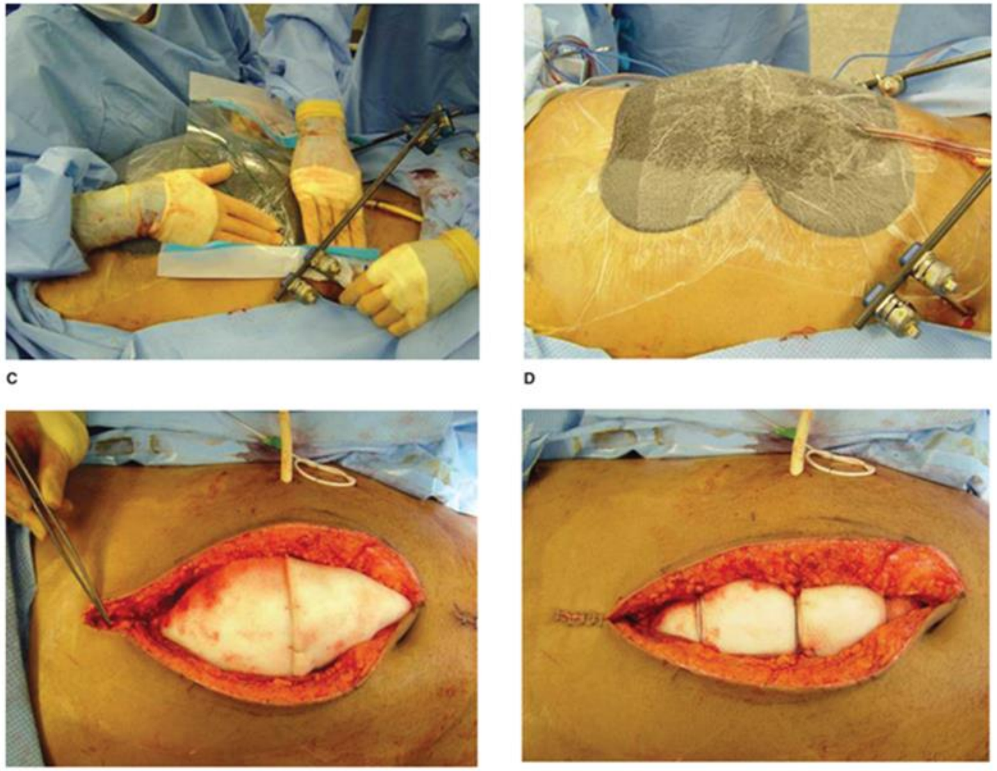
Temporary Abdominal closure



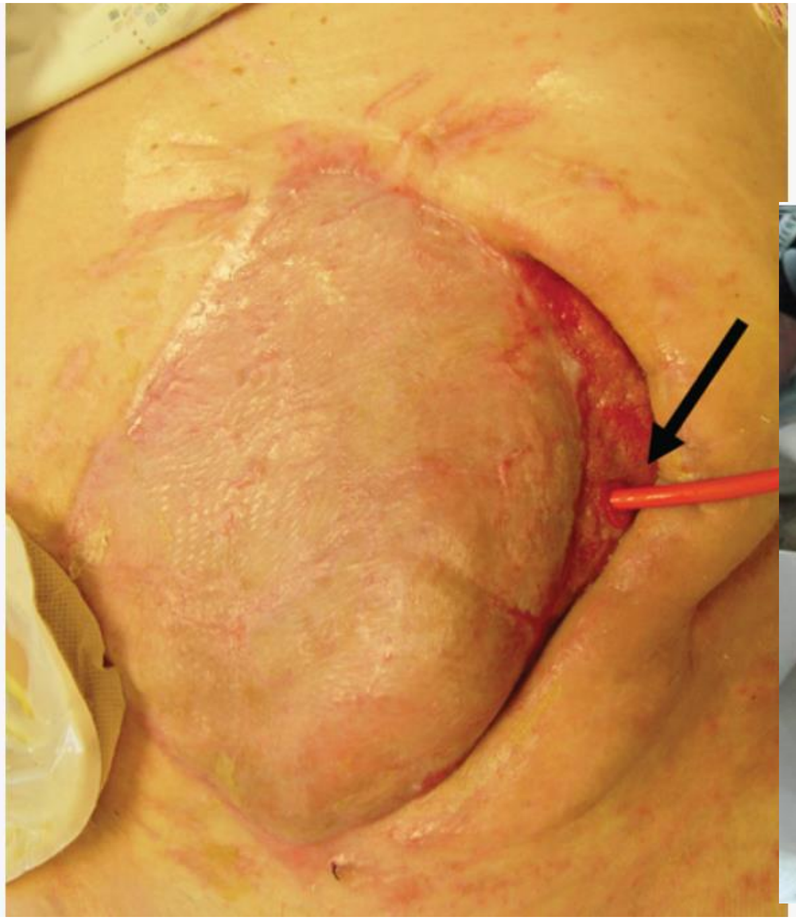


VAC Dressing & sequential closure technique



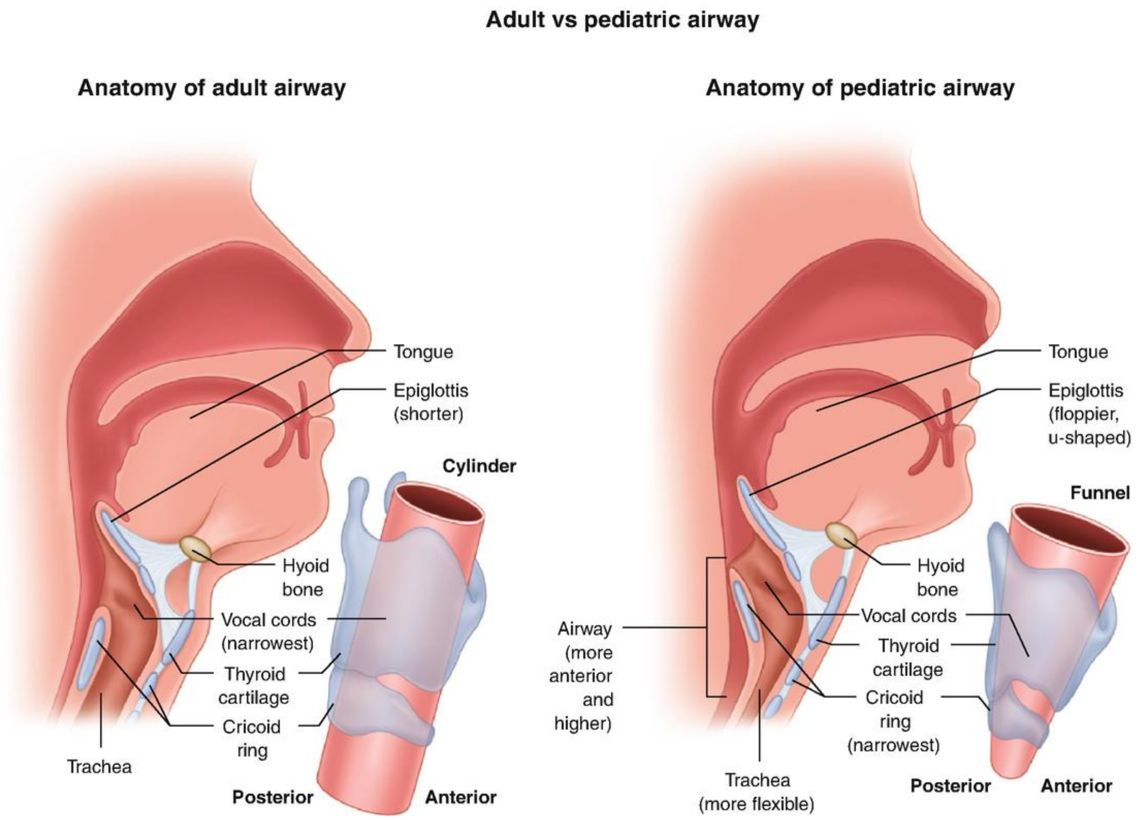


STSG & Mesh closure



Special Population- Pediatric Patients

- Approximately one-third of preventable deaths in children are related to airway management.
- In children, the airway is smaller and more cephalad in position compared with that of adults, and in children younger than 10 years, the larynx is funnel shaped rather than cylindrical as in adults.
- the child's tongue is much larger in relation to the oropharynx. Therefore, a small amount of edema or obstruction can significantly reduce the diameter of the airway (thus increasing the work of breathing), and the tongue may posteriorly obstruct the airway, causing intubation to be difficult.
- During intubation, a Miller (straight) blade rather than a Macintosh (curved) blade may be more effective due to the acute angle of the cephalad, funnel-shaped larynx.
- Administration of atropine before rapid-sequence intubation will prevent bradycardia.
- In children older than 11 years, standard cricothyroidotomy is performed. Due to the increased incidence of subglottic stenosis in younger patients, needle cricothyroidotomy with either a 14- or 16-gauge catheter is advocated, although it is rarely used.



Pediatric Patients

- Because gastric distension can inhibit adequate ventilation, placement of a nasogastric tube may facilitate effective gas exchange.
- Adequate ventilation is critical because oxygen consumption in infants and young children is twice that in adults; onset of hypoxemia, followed by cardiac arrest, may be precipitous.

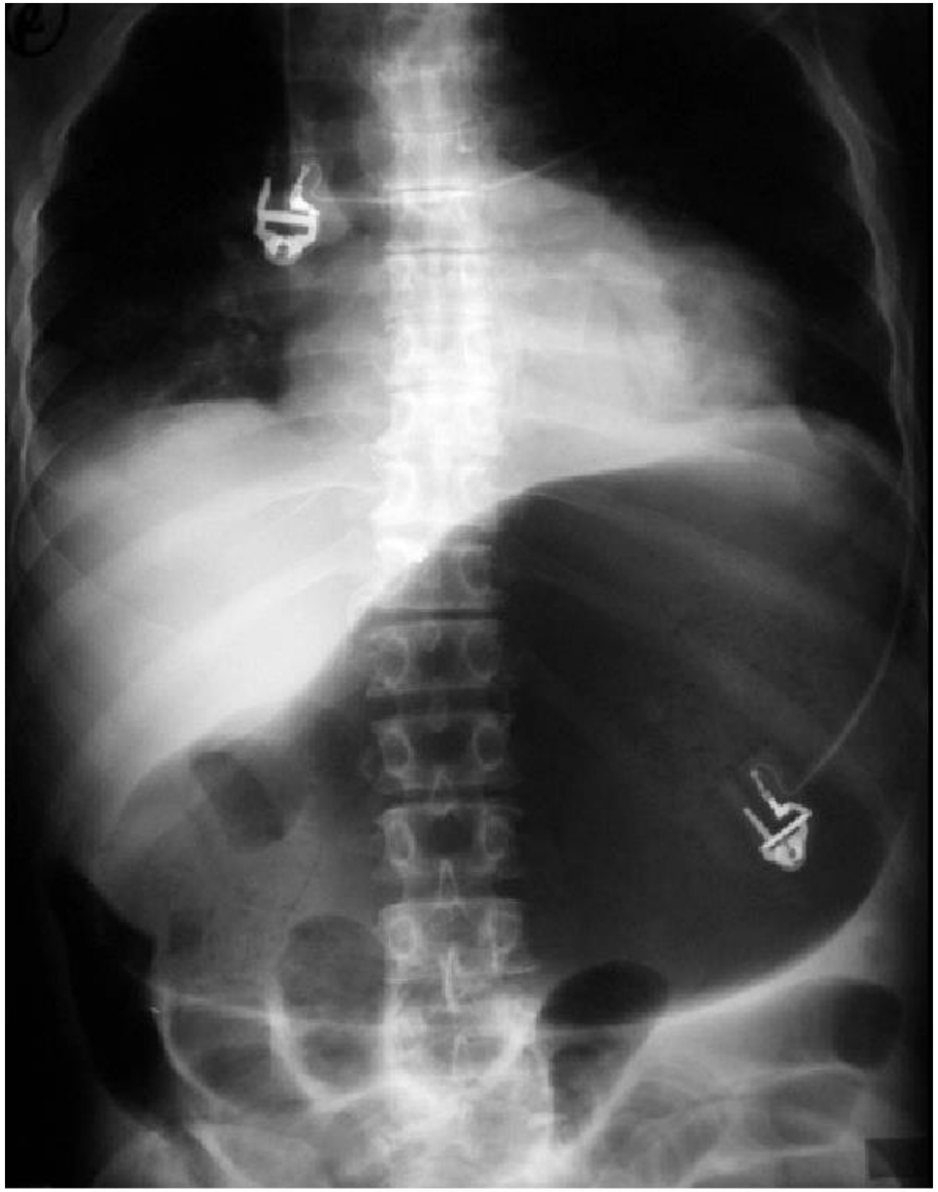
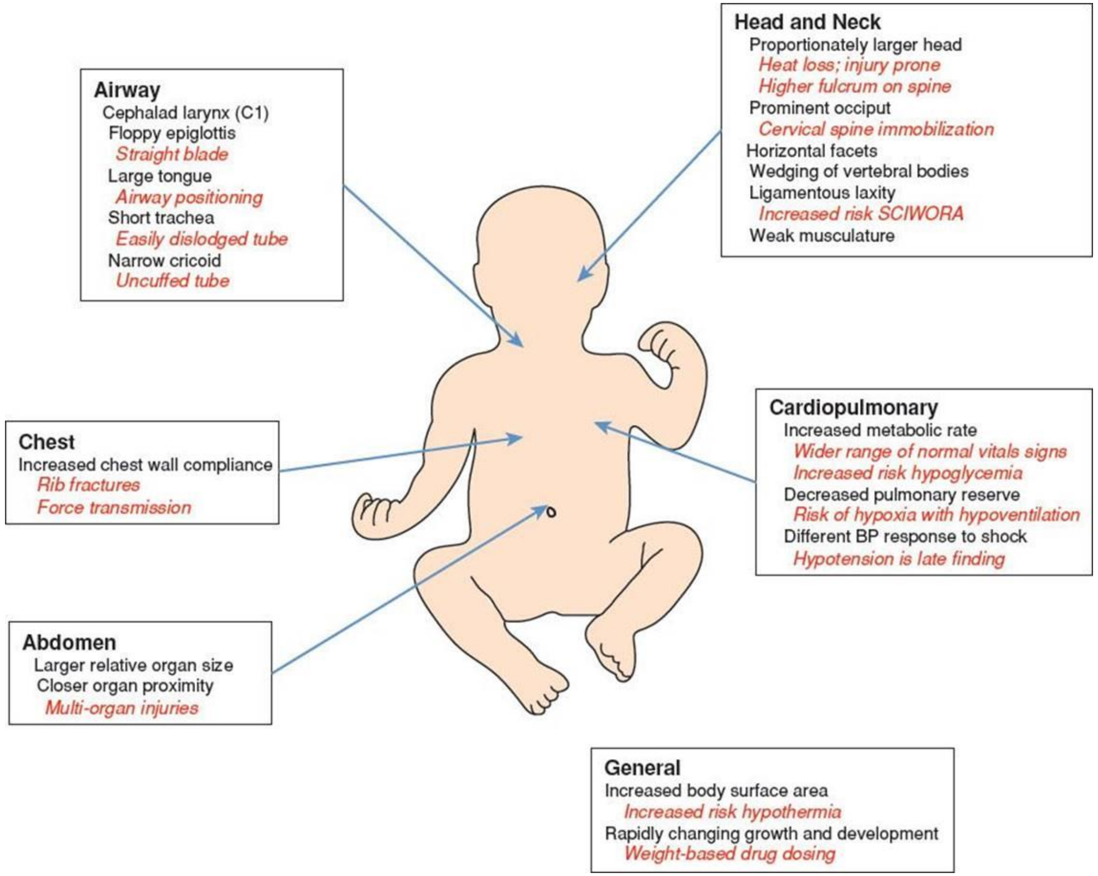


Fig. 1 Abdominal radiograph shows severe gastric dilatation

Pediatric Patients

- In children, the standard physiologic response to hypovolemia is peripheral vasoconstriction and reflex tachycardia; this may mask significant hemorrhagic injury because children can compensate for up to a 25% loss of circulating blood volume with minimal external signs.
- “Normal” values for vital signs should not necessarily make one feel more secure about the child’s volume status.
- Volume restoration is based on the child’s weight; two to three boluses of 20 mL/kg of crystalloid is appropriate.
- Hypotension in children may be due to TBI rather than hypovolemia and should be considered in the appropriate clinic scenario.155



Pediatric Patients

- Acute traumatic brain injury is the most common cause of death and disability in any pediatric age group. Although falls are the most common mechanism overall, severe brain injury most often is due to child abuse (in children <2 years) or motor vehicle collisions (in those >2 years).
- Head CT should be performed to determine intracranial pathology, followed by skull radiography to diagnose skull fractures.
- As in adults, CPP is monitored, and appropriate resuscitation is critical to prevent the secondary insults of hypoxemia and hypovolemia.
- Although some data indicate that the pediatric brain recovers from traumatic injury better than the adult brain, this advantage may be eliminated if hypotension is allowed to occur.

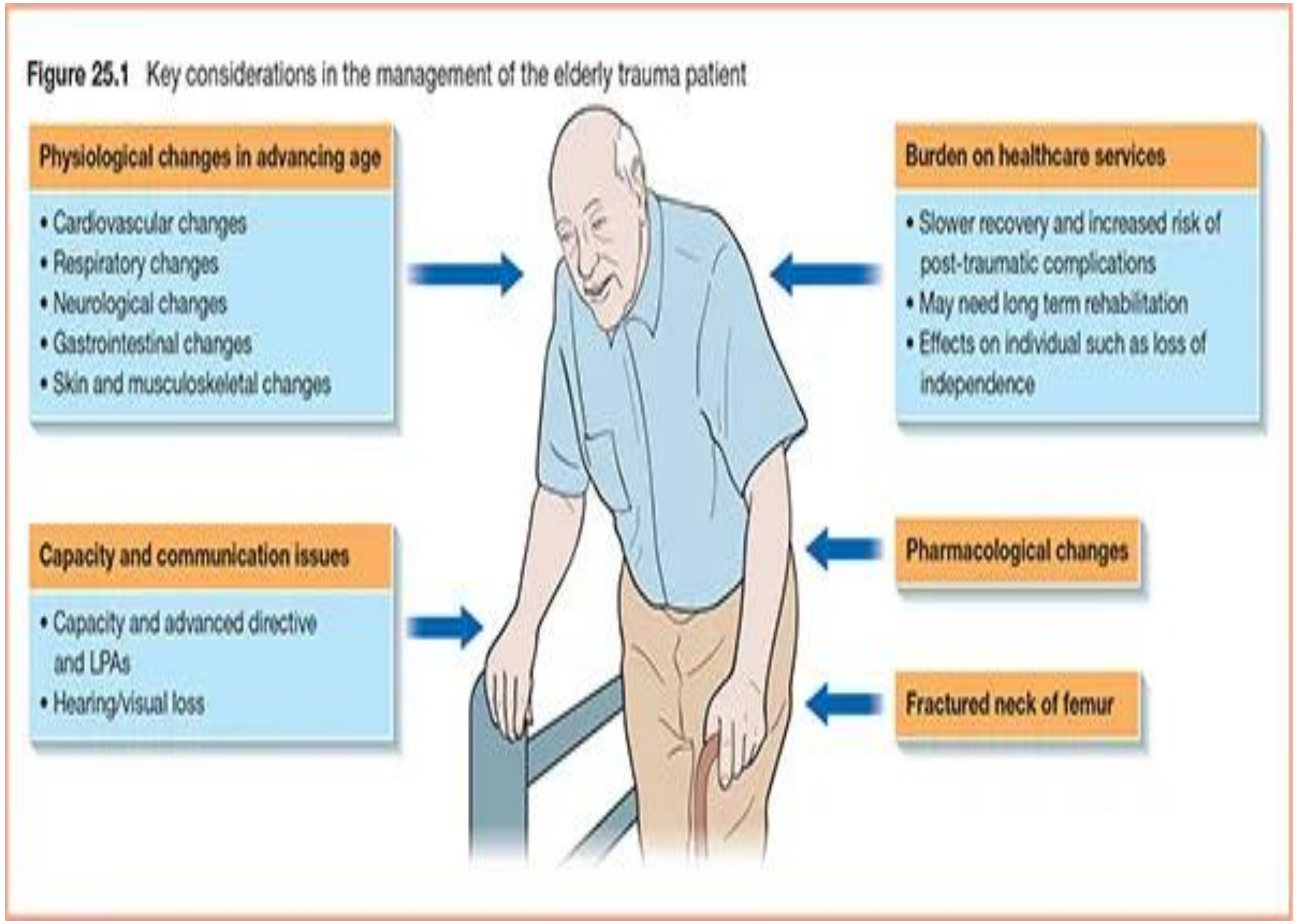
Pediatric Patients

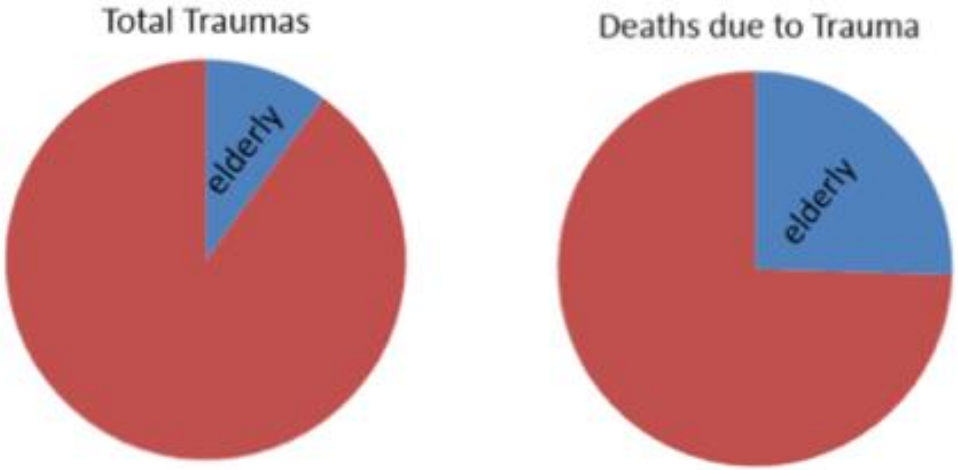
- Significant internal organ damage may occur without overlying bony fractures.
- Pneumothorax is treated similarly in the pediatric population; patients who are asymptomatic with a pneumothorax of <15% are admitted for observation, whereas those who have a pneumothorax of >15% or who require positive pressure ventilation undergo tube decompression.
- Presence of a hemothorax in this age group may be particularly problematic because the child's chest may contain his or her entire blood volume.
- If the chest tube output is initially 20% of the patient's blood volume (80 mL/kg) or is persistently >1 to 2 mL/kg per hour, thoracotomy should be considered.
- Tracheobronchial injuries are more amenable to nonoperative management.
- Penetrating thoracic trauma, although uncommon, has 35% operative intervention rate, which is considerably higher than that of the adult population.

Pediatric Patients

- FAST is valid in the pediatric age group to detect intra-abdominal fluid.
- The mechanism of injury often correlates with specific injury patterns. A child sustaining a blow to the epigastrium (e.g., hitting the handlebars during a bike accident) should be evaluated for a duodenal hematoma and/or a pancreatic transection.
- After a motor vehicle collision in which the patient was wearing a passenger restraint, injuries comprising the “lap belt complex” or “seat belt syndrome” (i.e., abdominal wall contusion, small bowel perforation, flexion-distraction injury of the lumbar spine, diaphragm rupture, and occasionally abdominal aortic dissection) may exist.
- Nonoperative management of solid organ injuries, first used in children, is the current standard of care in the hemodynamically stable patient. If the patient shows clinical deterioration or hemodynamic lability, has a hollow viscus injury, or requires >40 mL/kg of packed RBCs, continued nonoperative management is not an option.
- Success rates of nonoperative management approach 95%,157 with an associated 10% to 23% transfusion rate. Findings of a hepatic or splenic blush on CT imaging does not uniformly require intervention; patient physiology should dictate embolization or operative intervention.

Special Population-Geriatric Patients





Physiologic effects of aging

Cardiovascular

- Atherosclerotic disease that limits cardiac response to stress
- Progressive stiffening and loss of elasticity of the myocardium
- Diminished stroke volume, systolic contraction, and diastolic relaxation
- Decrease in cardiac output of 0.5% per year
- Thickening and calcification of the cardiac valves, which results in valvular incompetence

Pulmonary

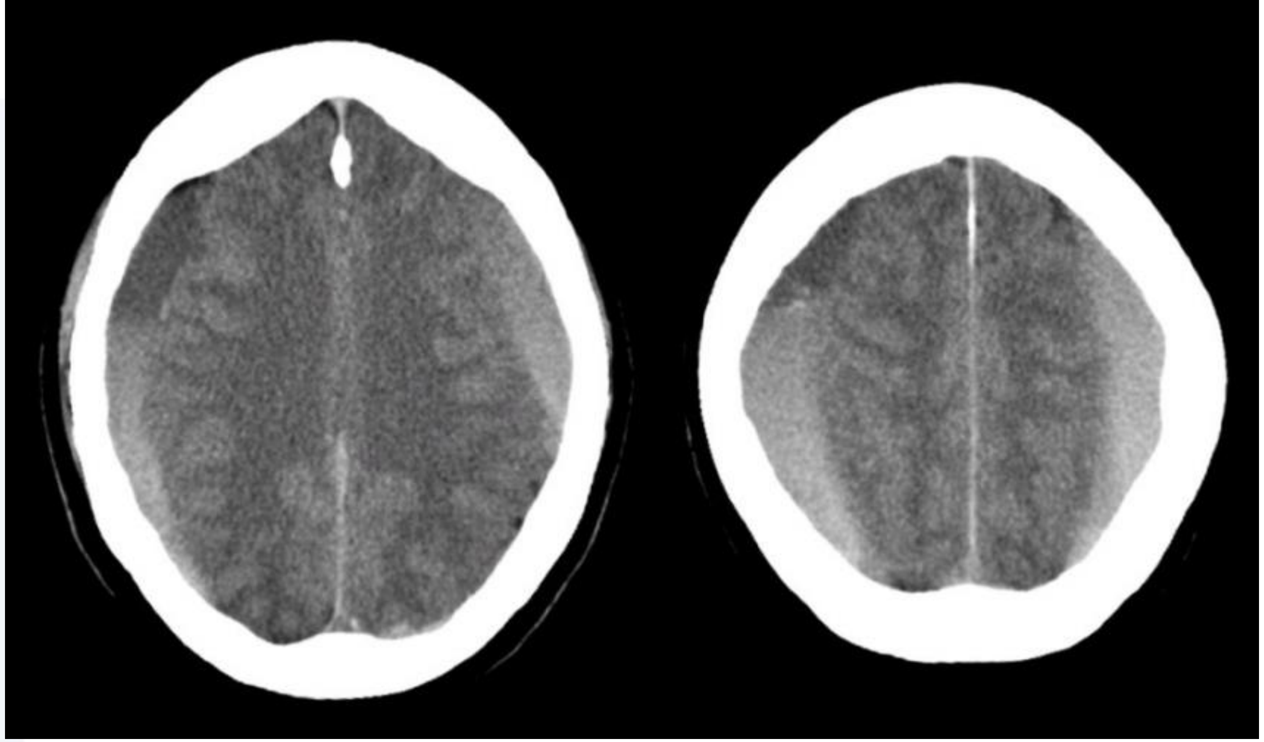
- Loss of compliance
- Progressive loss of alveolar size and surface area
- Air trapping and atelectasis

Intracranial

- Loss of cerebral volume, resulting in:
  - a. Increased risk of tearing of bridging veins with smaller injuries
  - b. Accumulation of a significant amount of blood before symptoms occur
  - c. muscle loss
- Senescence of the senses

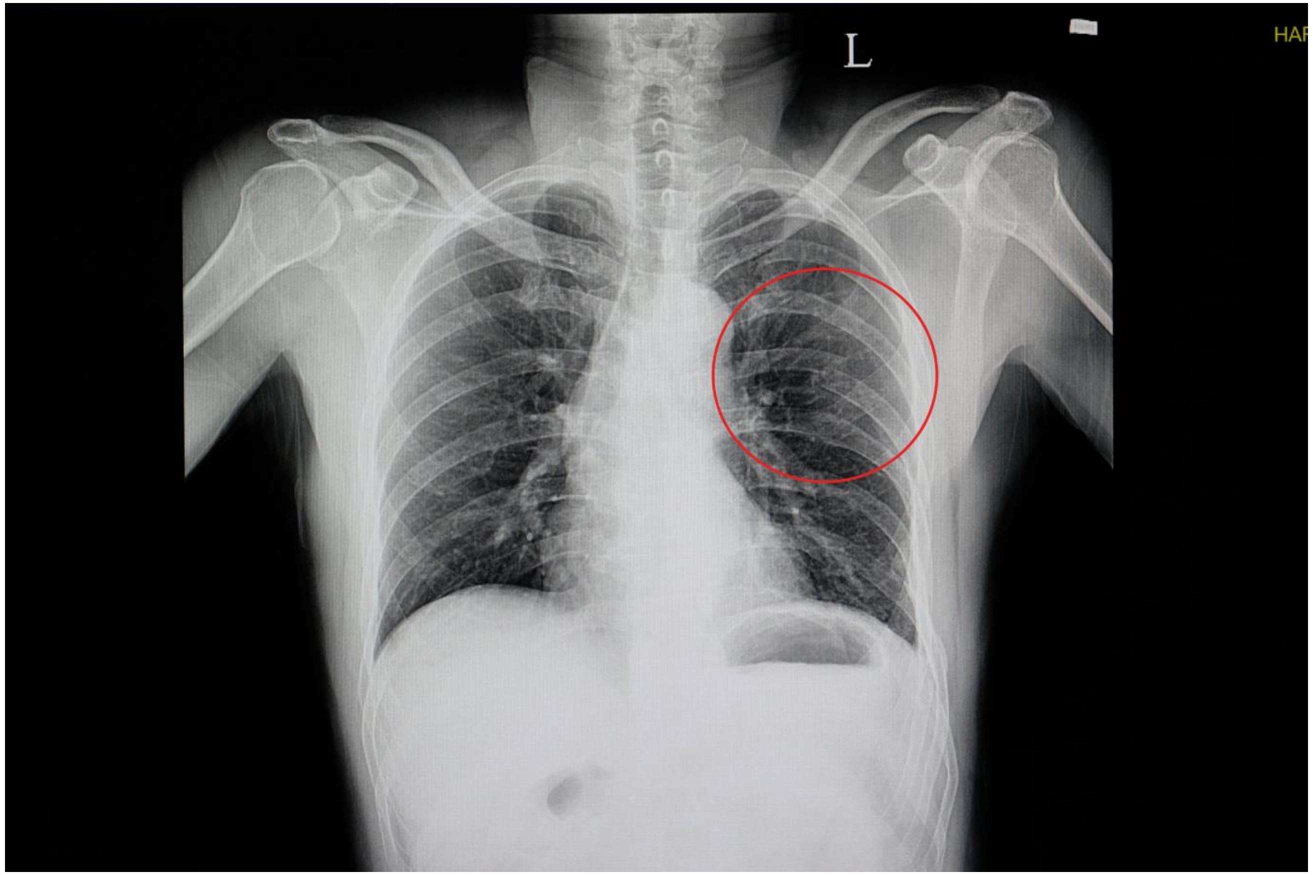
Other

- Decline in creatinine clearance by 80%–90%
- Osteoporosis, which causes a greater susceptibility to fractures



25% of patients with a normal GCS score of 15 had intracranial bleeding, with an associated mortality of 50%

- One of the most common sequelae of blunt thoracic trauma is rib fractures. In the aging population, perhaps due to osteoporosis, less force is required to cause a fracture.
- Concurrent pulmonary contusion is noted in up to 35% of patients, and pneumonia complicates the injuries in 10% to 30% of patients with rib fractures, not surprisingly leading to longer ICU stays.
- Additionally, mortality increases linearly with the number of rib fractures. Patients who sustain more than six rib fractures have pulmonary morbidity rates of >50% and overall mortality rates of >20%.



Pitfall: undertreating pain in older patients with rib fractures in the ED. Treat rib fractures in the older patient with aggressive early multimodal analgesia, regular pain assessment and early ambulation.

- Complications of rib fractures in older patients
  - 34% go on to develop pneumonia
  - Respiratory failure requiring mechanical ventilation
  - Pain leading to agitation and delirium
- Consider transfer to a lead trauma center if:
  - >3 rib fractures or
  - Bilateral rib fractures or
  - Flail segment (>3 contiguous ribs # in >2 or more place) or
  - Any number of rib fractures with significant underlying pulmonary disease
- Key goals in ED rib fracture management in older trauma patients
  - Early pain control with multimodal analgesia, access to regional analgesia, and regular pain assessments.
  - Early mobilization and physiotherapy. This involves clearing the spines as quickly as possible.
- Suggested step-wise treatment of rib fracture pain in the geriatric trauma patients
  1. Tylenol 650mg PO q6h
  2. Ibuprofen 400mg q6h Morphine 0.05 mg/kg IV q4h
  3. Ketamine 0.1-0.5mg/kg/hr (start at 0.2mg/kg/hr)
  4. Regional anesthesia: epidural, serrates anterior, paravertebral blocks etc. (have been shown to reduce mortality and delirium) and may obviate the need for analgesic medications

Special Population- Pregnant Patients

Cardiovascular

- Increase in heart rate by 10–15 bpm
  - a. Decreased systemic vascular resistance resulting in:
  - b. Increased intravascular volume
- Decreased blood pressure during the first two trimesters

Pulmonary

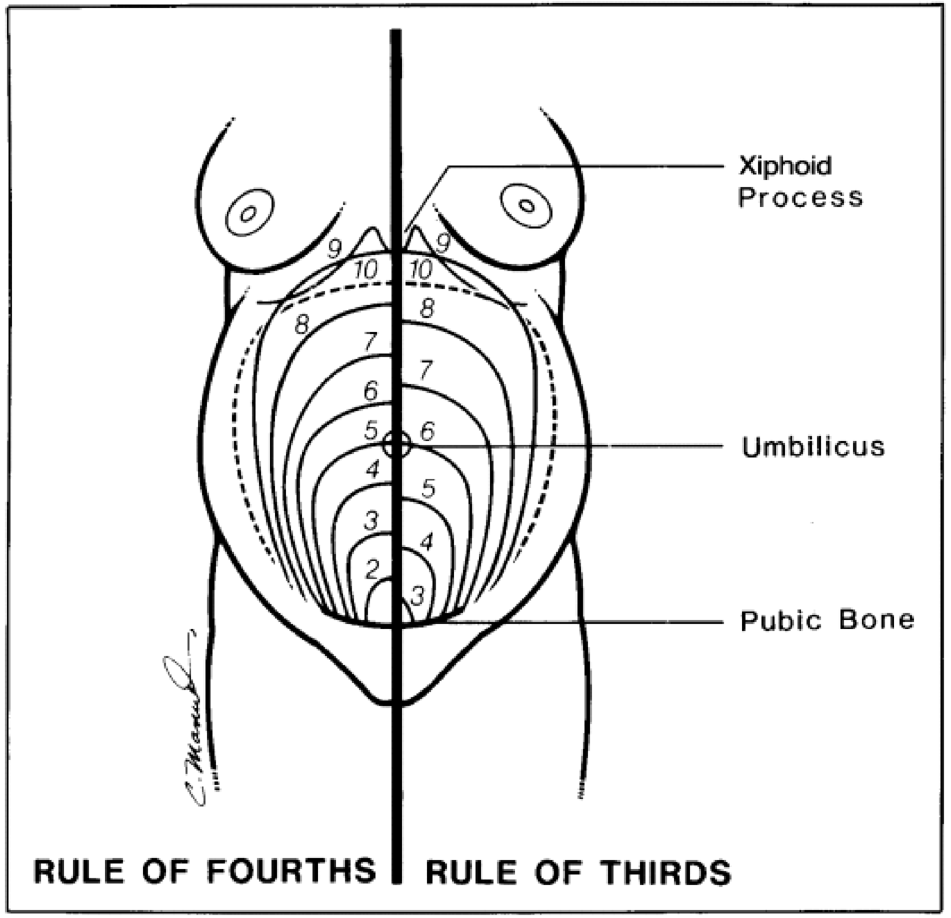
- Elevated diaphragm
- Increased tidal volume
- Increased minute ventilation
- Decreased functional residual capacity

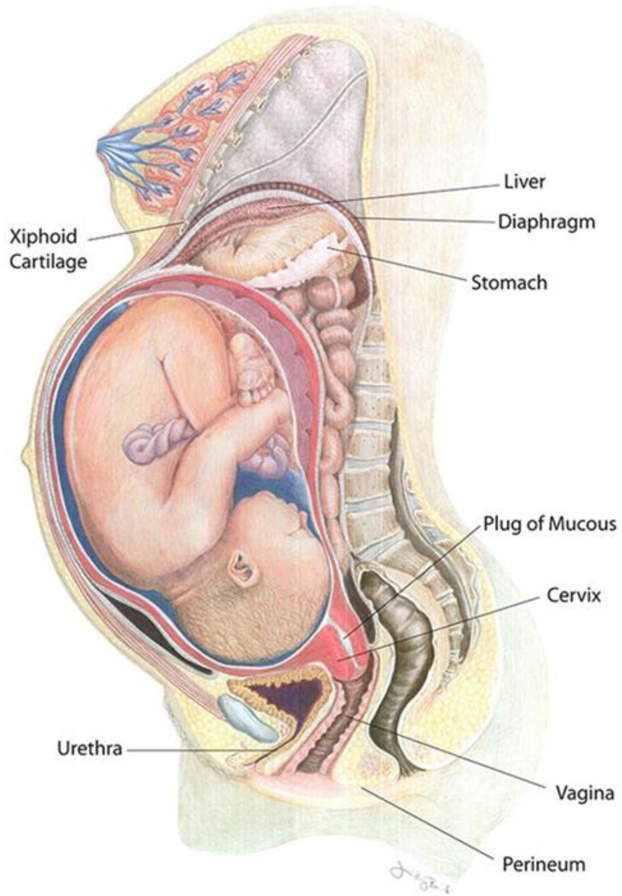
Hematopoietic

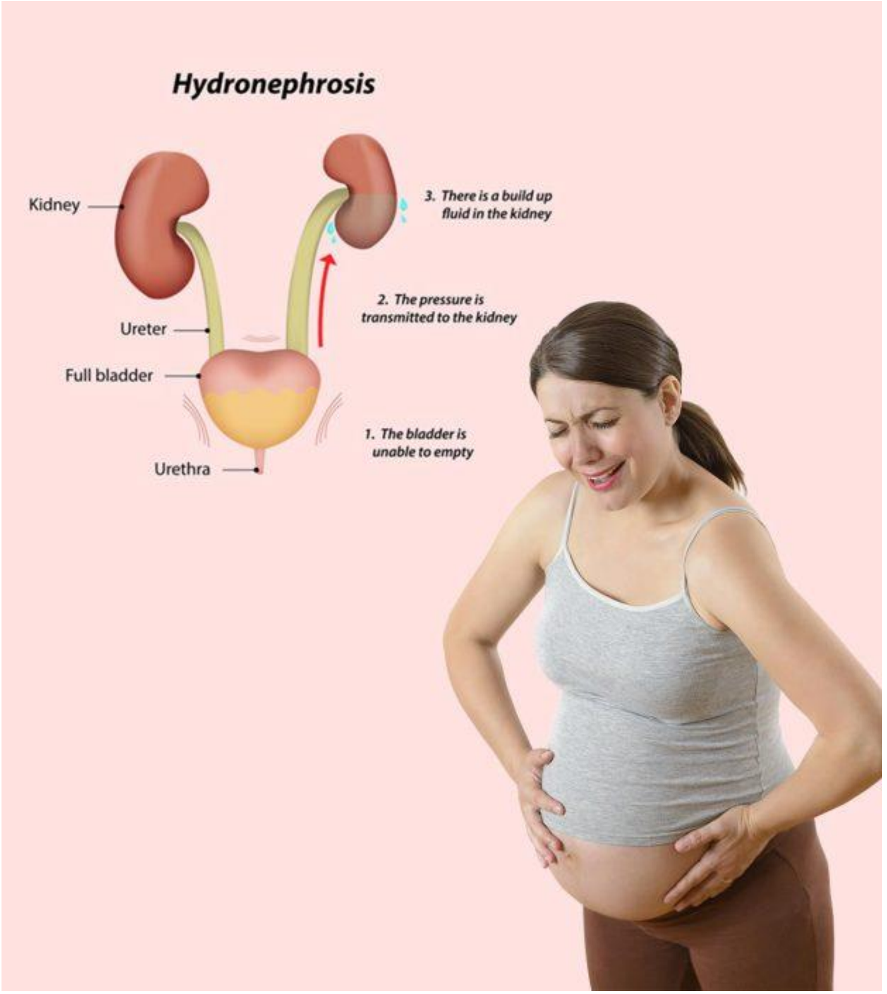
- Relative anemia
- Leukocytosis
- Hypercoagulability
  - a. Increased levels of factors VII, VIII, IX, X, XII
  - b. Decreased fibrinolytic activity

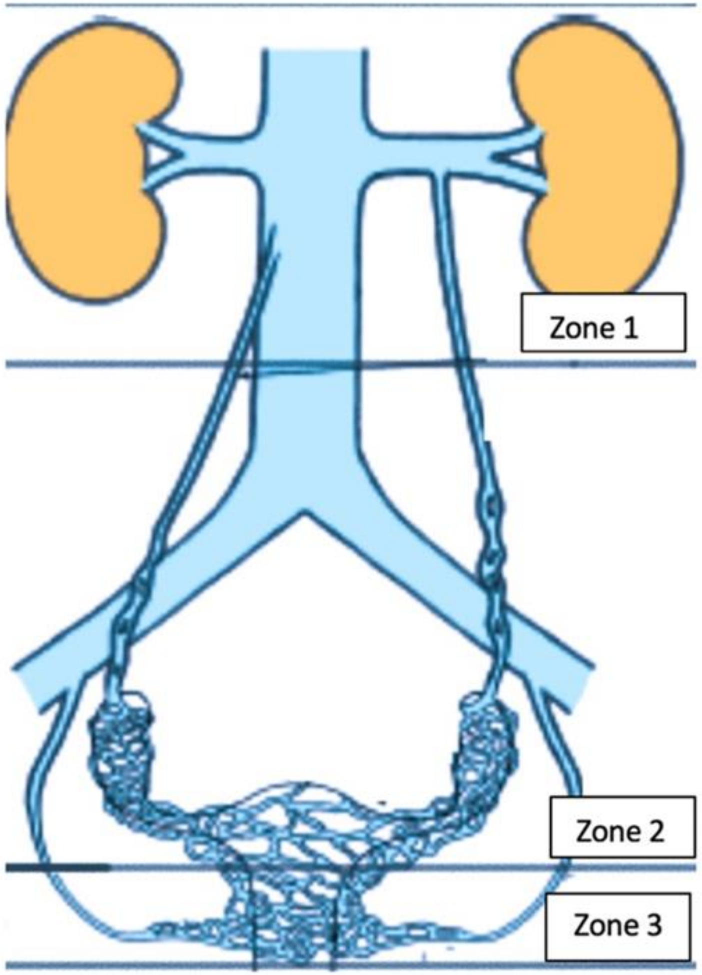
Other

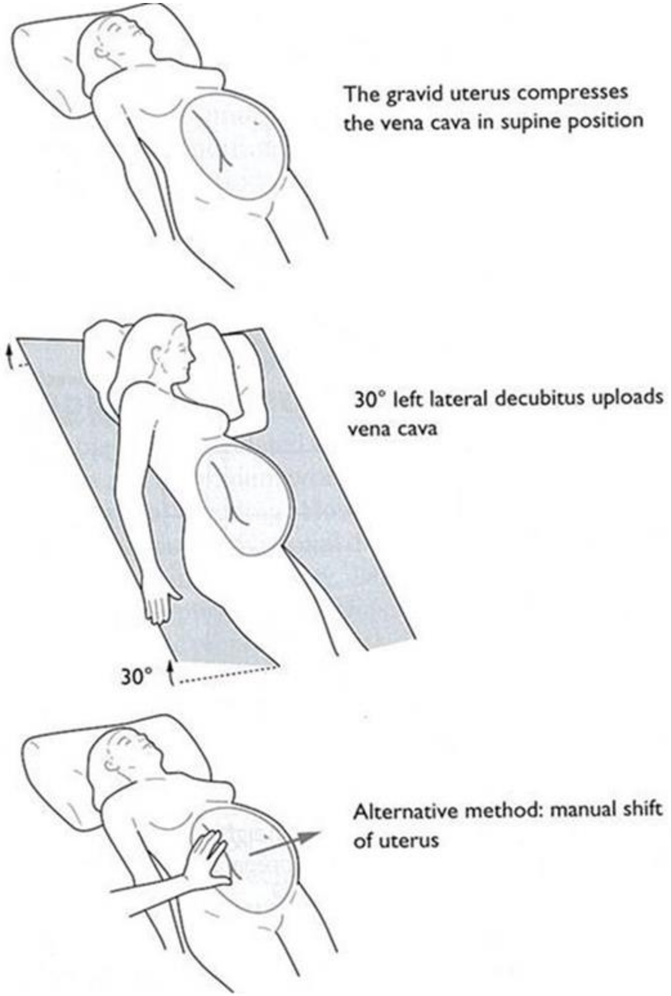
- Decreased competency of lower esophageal sphincter
- Increased enzyme levels on liver function tests
- Impaired gallbladder contractions
- Decreased plasma albumin level
- Decreased blood urea nitrogen and creatinine levels
- Hydronephrosis and hydroureter


Xiphoid Process
Umbilicus
Pubic Bone
RULE OF FOURTHS
RULE OF THIRDS
9
10
8
7
6
5
4
3
2

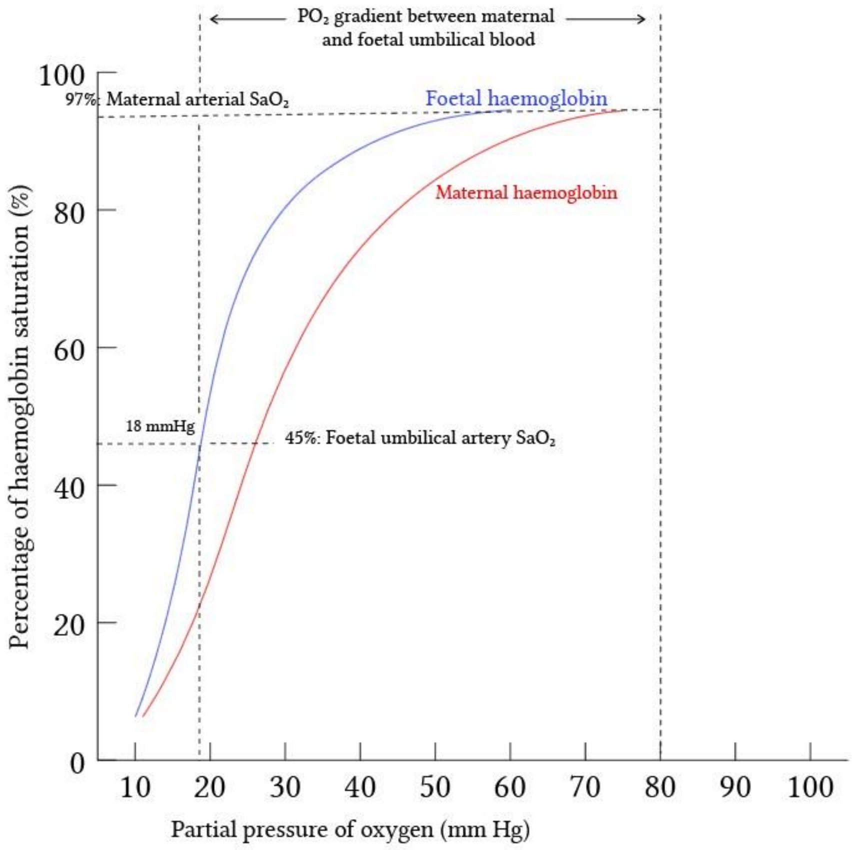

Liver
Diaphragm
Xiphoid Cartilage
Stomach
Plug of Mucous
Cervix
Urethra
Vagina
Perineum


Hydronephrosis
Kidney
3. There is a build up fluid in the kidney
2. The pressure is transmitted to the kidney
Ureter
Full bladder
1. The bladder is unable to empty
Urethra

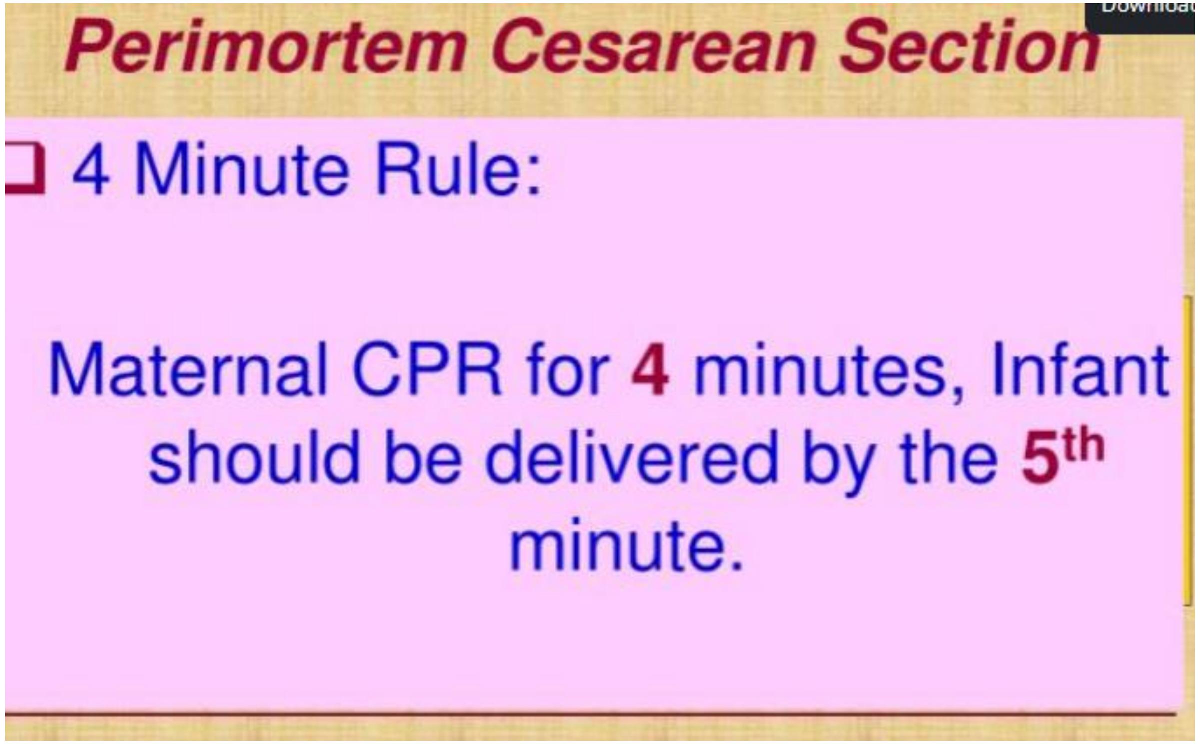

Zone 1
Zone 2
Zone 3


The gravid uterus compresses the vena cava in supine position
30° left lateral decubitus uploads vena cava
30°
Alternative method: manual shift of uterus

- Supplemental oxygen is always warranted in the trauma patient but is particularly critical in the injured pregnant patient because the oxygen dissociation curve is shifted to the left for the fetus compared to the mother (i.e., small changes in maternal oxygenation result in larger changes for the fetus because the fetus is operating in the steep portion of the dissociation curve).



- Fetal monitoring should initially be assessed with bedside FAST ultrasound to document the heart rate of the fetus; subsequent monitoring should be performed with a cardiotocographic device that measures both contractions and fetal heart tones (FHTs).
- Because change in heart rate is the primary response of the fetus to hypoxia or hypotension, anything above an FHT of 160 is a concern, whereas bradycardia (FHT of <120) is considered fetal distress.
- Indications for emergent cesarean section include: (a) severe maternal shock or impending death (if the fetus is delivered within 5 minutes, survival is estimated at 70%), (b) uterine injury or significant fetal distress (anticipated survival rates of >70% if FHTs are present and fetal gestational age is >28 weeks).



Radiology

Plain Films

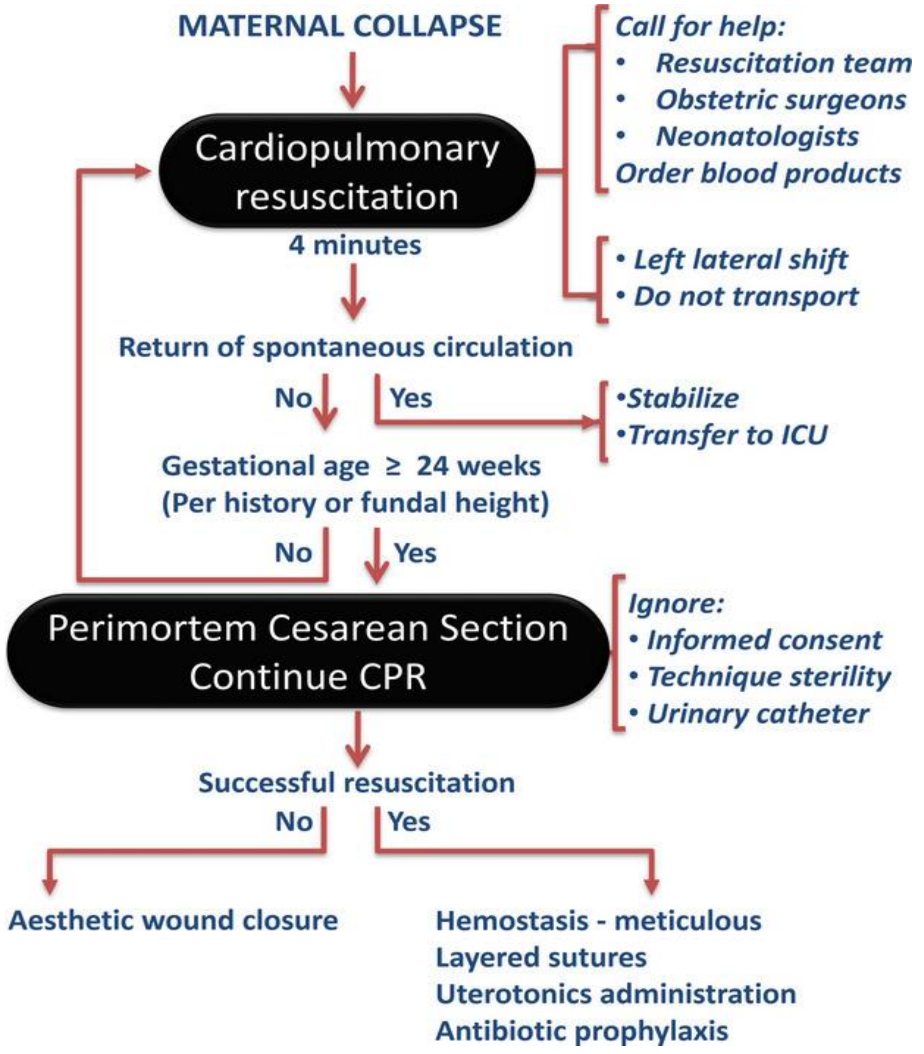
- Risk of 1 rad to fetus is approx. 0.003
- < 5-10 rads causes
  - No risk on congenital malformation, abortions or intra-uterine growth ret.
  - Smaller risk of increase in childhood cancer
- Radiation doses > 10 rads
  - 6 % chance of severe mental ret.
  - < 3 % chance childhood cancer.

Radiographic examination	Dose to Ovary/Uterus
Low Dose Group:	
Head	<1
C-Spine	<1
Thoracic Spine	<1
Chest	<1
Extremities	<1
High Dose Group:	
Lumbar Spine	204 – 1260
Pelvic	190 – 357
Hip	124 – 450
Intravenous pyelogram	503 – 880
Urethrocystogram	1500
KUB	200 – 503

Radiographic examination	Dose (m
Computed Tomography	
Head (1 cm slice)	< 50
Chest (1 cm slice)	< 1000
Upper Abdomen (20 slices 2.5 cm above uterus)	< 3000
Lower Abdomen (10 1 cm slices over the uterus/fetus)	3000 – 9000
Angiography	
Cerebral	< 100
Cardiac Catheterization	< 500
Aortography	< 100

A member of the obstetrics team should be present during initial evaluation

- Early cervical dilation and labor
- Abruptio placentae
- Placenta previa.
- Amniotic sac rupture can result in prolapse of the umbilical cord with fetal compromise.



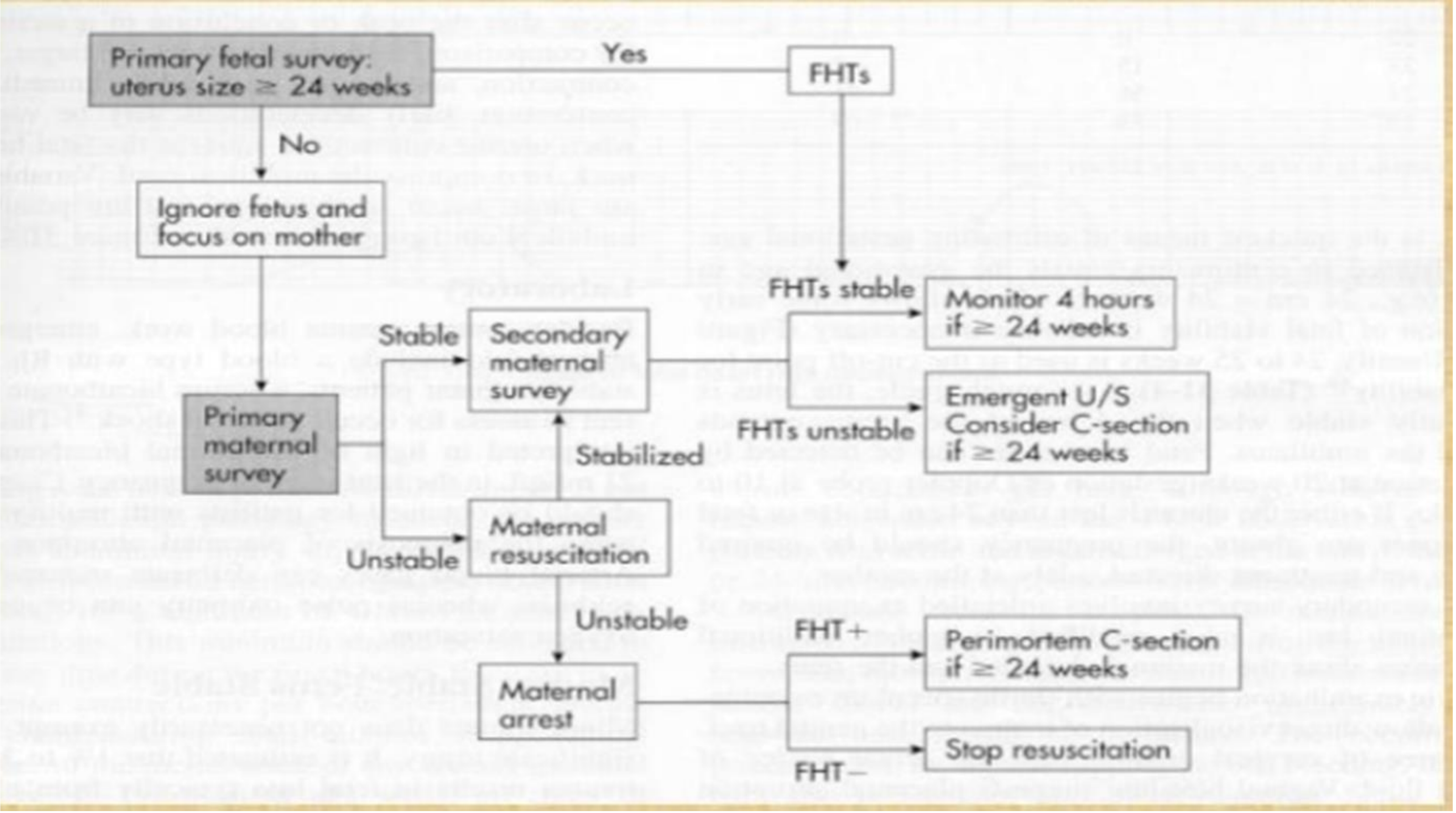
Perimortem Cesarean Section

- ~200 successful cases reported in the literature
- Maternal CPR <5 minutes, fetal survival excellent
- <23 weeks gestation survival chance is 0%
- Maternal CPR >20 minutes, fetal survival unlikely

Fetal Viability

Weeks gestation	6-month survival (%)	Survival with no severe abnormalities (%)
22	0	0
23	15	2
24	56	21
25	79	69

Data from Morris JA Jr et al: Ann Surg 223:481, 1996.



Primary fetal survey: uterus size ≥ 24 weeks
Yes
FHTs
No
Ignore fetus and focus on mother
FHTs stable
Monitor 4 hours if ≥ 24 weeks
Stable
Secondary maternal survey
Emergent U/S Consider C-section if ≥ 24 weeks
FHTs unstable
Primary maternal survey
Stabilized
Maternal resuscitation
Unstable
Unstable
FHT+
Perimortem C-section if ≥ 24 weeks
Maternal arrest
Stop resuscitation
FHT−