Trauma- Concepts and Treatments

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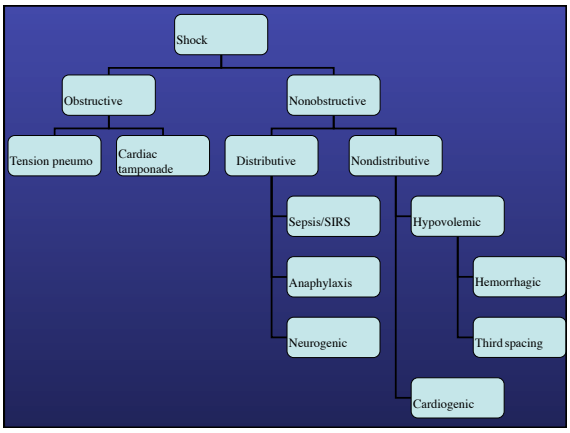
Objectives

- Pathophysiology of shock in the trauma patient
- Concept of a golden hour
- resuscitation according to ATLS principles
  - overview
  - specifics

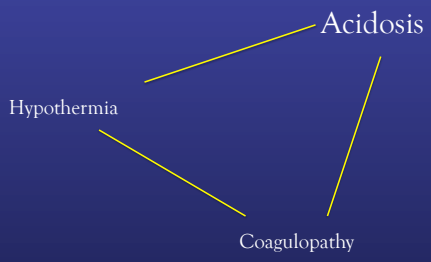
Shock

- Shock is a state in which the delivery of oxygen to the tissues (DO_2) does not meet their oxygen requirement (VO_2).



Hemorrhagic shock

Lethal Triad



Hypothermia

- Central thermoregulation lost
- ↓Metabolic activity
- Cold IV fluid

- Platelet dysfunction
- Clotting factors kinetics disturbance
- Cardiac dysfunction
- Vasoconstriction
- Hypoperfusion

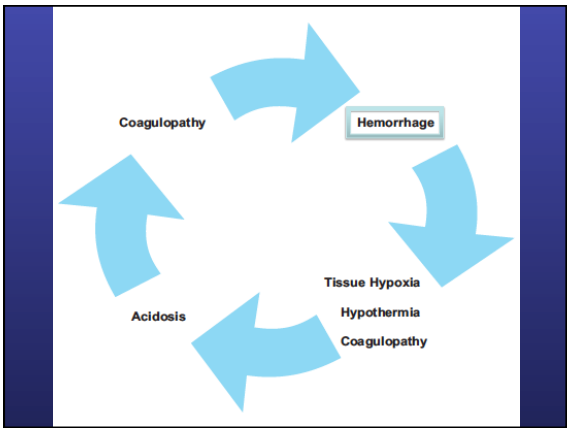
Acidosis

- ↓ Cardiac contractility
- Dysrhythmias
- Synergize with hypothermia in its detrimental effect on the coagulation cascade

Coagulopathy

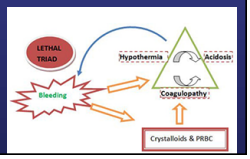
- Platelet dysfunction
- Clotting cascade disturbed
- Haemodilution

Uncontrolled bleeding from all cut surfaces

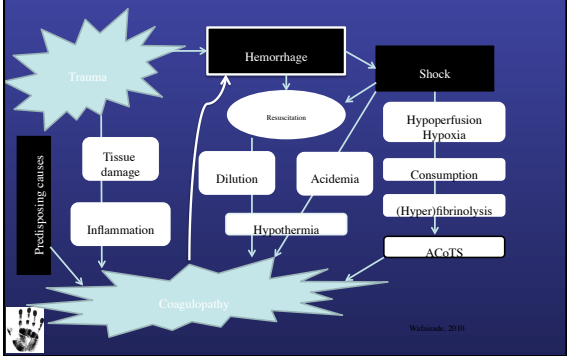


Iatrogenic coagulopathy?

- Resuscitation-associated coagulopathy (aka "lethal triad" or "bloody viscous cycle") → hypothermia, acidosis, coagulopathy (Pieracci, 2013)
- Clotting factor depletion due to hemorrhage and consumption
- Iatrogenic coagulopathy (Cohen, 2012)
  - Surgery → hypothermia
  - Large volume, cool fluids → dilution and hypothermia
  - pRBCs→ dilution
  - Sick patients → acidotic



More than just a triangle…



Shock

- Shock is a state in which the **delivery of oxygen to the tissues (DO_2)** does not meet their oxygen requirement (VO_2).

What is oxygen delivery?

Oxygen Delivery (DO_2)

DO_2

=

Cardiac output (CO) x arterial oxygen content (CaO)

Cardiovascular Monitoring

Oxygen Delivery =

Oxygen Content
X
Cardiac Output

DO_2

CaO_2

Q

Cardiac Output (CO)

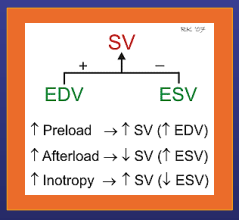
CO

=

Stroke Volume (SV) x Heart Rate (HR)

Stroke Volume

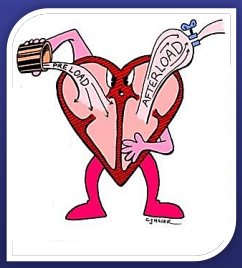
- Amount of blood pumped with each beat.
- Dependent on…
  1. Preload
  2. Afterload
  3. Contractility (inotropy)



Preload vs. Afterload

Venous return

Valvular regurgitation

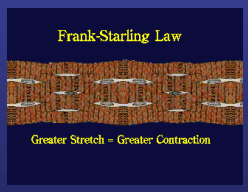


Hypertension

Vasoconstriction

Frank-Starling Law

- Increased heart volume stretches muscles and causes stronger contraction.
- Stretch increases heart rate as well.



Determinants of Venous Return

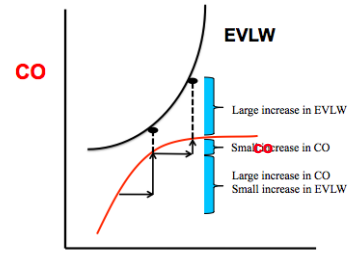
Mean systemic filling pressure

Resistance to Flow

Right Atrial Pressure

Pressure change is slight. Thus, small increase in RA pressure causes dramatic reduction in venous return.

The Frank-Starling & Marik-Phillips Curves



Cardiac Output (Q)

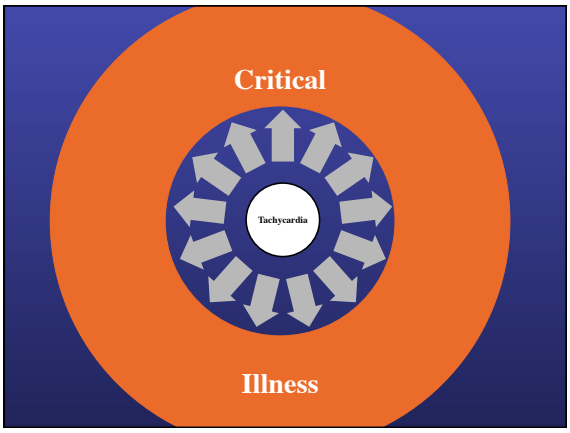
HEART RATE

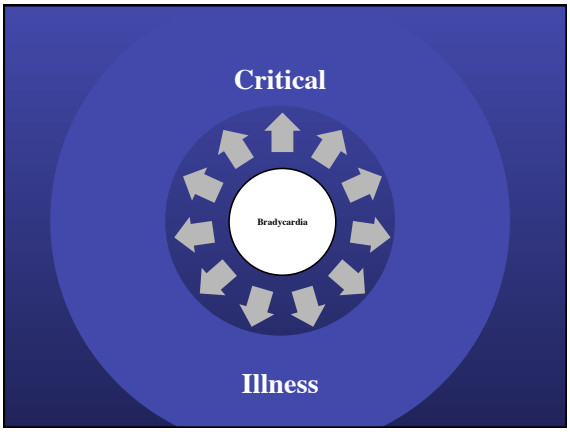
X

STROKE VOLUME

Heart Rate

- SA node = intrinsic
- Parasympathetic NS
  - SLOWS
- Sympathetic NS
  - SPEEDS
- Baroreceptors
- Mechanoreceptors





Arterial Oxygen Content

CaO_2 (mL O_2/dL)

=

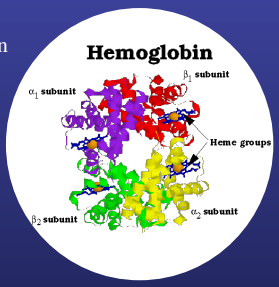
(Hgb x 1.34 x SaO_2) + (PaO_2 x 0.003)

Arterial Oxygen Content

- Depends on:
  - Hemoglobin
  - Lung function
  - FiO2

What Is Oxygen Content?

- The amount of oxygen in the body.
- Dependent on:
  - Bound oxygen
    - Hemoglobin
  - Unbound oxygen
    - Dissolved



What Is Oxygen Content?

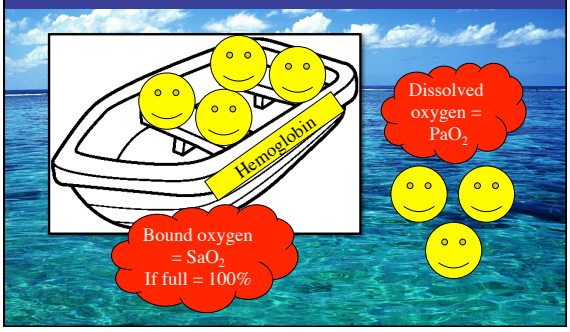
$CaO_2 = (Hb \times 1.34 \times SaO_2) + (PaO_2 \times 0.003)$

Units
ml/dl

Bound Oxygen
Hb = Hemoglobin (g/dl)
1.34 = Constant, 1.34 ml oxygen binds 1 g Hb
SaO_2 = % of hemoglobin saturated w/ oxygen

Dissolved Oxygen
PaO_2 = partial pressure of oxygen in arterial blood (mm Hg)
0.003 = Constant (ml/dl/mm Hg)

I'm Lost…SaO_2 vs. PaO_2?

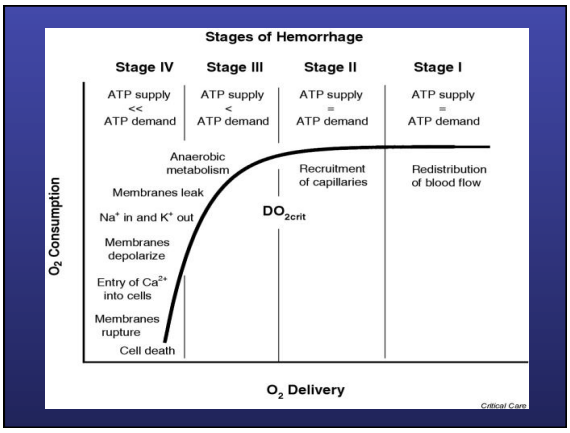


Your Turn…!

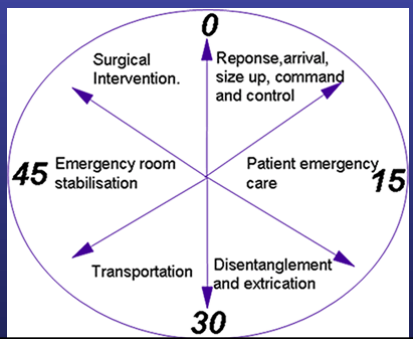
- Hemoglobin = 15 g/dL
- SaO_2 = 99%
- PaO2 = 105 mm Hg

- Bound oxygen
  - 15 x 1.34 x 0.99 = 19.9
- Dissolved oxygen
  - 105 x 0.003 = 0.32
- CaO_2 = 20.2 ml/dl

	Class I	Class II	Class III	Class IV
Blood Loss mL	Up to 750	750-1500	1500-2000	>2000
Blood Loss %	Up to 15%	15-30%	30-40%	>40%
Pulse rate	<100	>100	>120	>140
Systolic blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure	Normal	Decreased	Decreased	Decreased
Respiratory rate	14-20	20-30	30-40	>35
Urine output	>30	20-30	5-15	Negligible
Mental status	Slightly anxious	Mildly anxious	Anxious, confused	Confused, lethargic
Fluid (3:1 rule)	Crystalloid	Crystalloid	Crystalloid and blood	Crystalloid and blood



The Golden Hour



The Golden Hour

- Originated by R Adams Cowley
- First sixty minutes after the occurrence of multi-system trauma
- Victim's chances of survival are ***greatest*** if they receive definitive care in the OR within the first hour after a severe injury

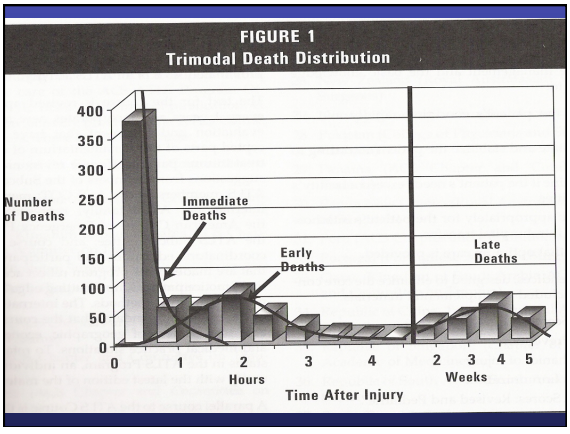
The Golden Hour

- Recently, the validity of the "golden hour" as a rigidly defined timeframe scrutinized
- Core principle of rapid intervention in trauma cases remains universally accepted

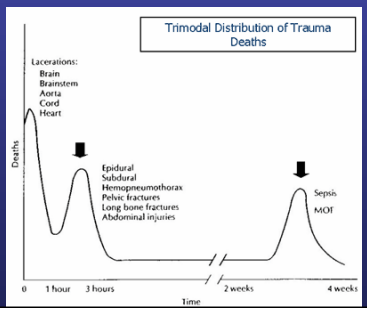
The Golden Hour

- "There is a golden hour between life and death. If you are critically injured you have less than 60 minutes to survive. You might not die right then; it may be three days or two weeks later -- but something has happened in your body that is irreparable."

  - R Adams Cowley



Trimodal Death Distribution



Deadly Dozen

Lethal Six

- airway obstruction
- tension PTX
- open PTX
- flail chest
- massive hemothorax
- cardiac tamponade

Hidden Six

- pulmonary contusion
- diaphragmatic tear/rupture
- tracheobronchial injury
- blunt cardiac injury
- thoracic aortic disrupt
- esophageal injury

The Golden Hour

Time and Trauma Outcomes

- no convincing studies that time to treatment consistently leads to better outcome
- outcome related to many factors including reduced time between injury and definitive care

Ann Surg. 2003;237(2):153-60

The Golden Hour

Shock Pathophysiology

- inadequate organ **perfusion** and tissue **oxygenation**

3 factors determine:

1. *oxygen content*
2. *oxygen delivery*
3. *distribution*

The Golden Hour

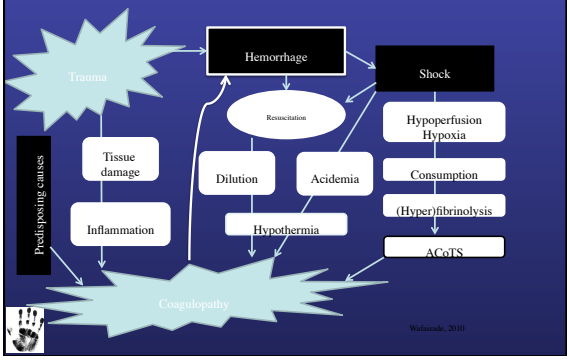
Shock Pathophysiology

- prolonged hypoperfusion creates a vicious cycle of ischemia and shock

2 most important steps in managing shock:

1. recognition
2. treatment

More than just a triangle…



The Golden Hour

Rapid Resuscitation

- restores circulating volume
- improves oxygen delivery
- prevents cellular ischemia and tissue necrosis
- prevents onset of secondary cellular injury
- prevents onset of MODS

The Golden Hour

What should we be doing?

Rapid assessment

Resuscitation and stabilization

Definitive management/Transfer

⇨ ATLS (Advanced traumatic life support)

ATLS (Advanced traumatic life support) Overview

The ATLS Concept

- Primary Survey
- Adjuncts
- Secondary Survey
- Definitive Care/Transfer

ATLS Overview

The ATLS Concept

- treat life threatening injuries as they are identified
- assessment/diagnosis and resuscitation are simultaneous

ATLS Overview

Primary Survey

- **A** Airway
- **B** Breathing
- **C** Circulation
- **D** (neurologic) Disability
- **E** Exposure / Environment

ATLS Overview

Adjuncts

- Urinary catheter
- NG tube
- Xrays

ATLS Overview

Secondary Survey

- Thorough "head to toe" assessment

Definitive Care/Transfer

ATLS Specifics

A - airway (*with C-spine protection*)

Preventable Deaths from Airway Problems

- failure to recognize need for airway
- inability to establish airway
- failure to recognize incorrect placement
- displacement of previously placed airway
- failure to recognize need for ventilation
- aspiration of gastric contents

ATLS Specifics

B – breathing

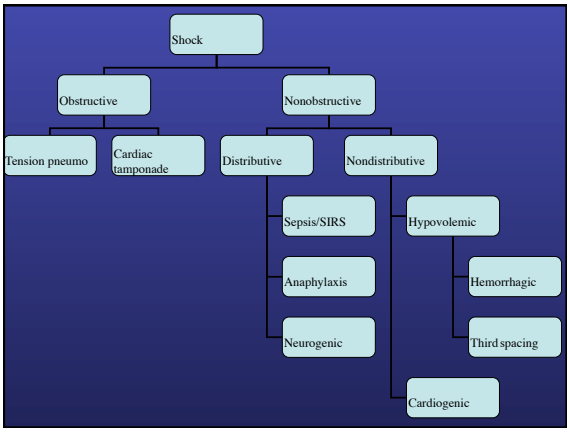
- oxygenation
- ventilation
- monitoring

clinical (auscultation)
O_2 saturation
$EtCO_2$
ABG's

ATLS Specifics

C - circulation (shock management)

- recognition and resuscitation from shock
- post traumatic shock is hemorrhagic shock ***until proven otherwise***



ATLS Specifics

C - circulation (shock management)

Classification and mechanisms of shock

- **obstructive**
  - tension pneumothorax
  - cardiac tamponade

Tension pneumothorax is the most EASILY corrected cause of shock

ATLS Specifics

C - circulation (shock management)

Classification and mechanisms of shock

- **distributive**
  - spinal cord injury
  - sepsis
  - anaphylaxis

ATLS Specifics

C - circulation (shock management)

Classification and mechanisms of shock

- **cardiogenic**
  - myocardial contusion
  - valvular disruption
  - ischemic injury

ATLS Specifics

C - circulation (shock management)

Classification and mechanisms of shock

- **hypovolemic**
  - blood loss
  - fluid loss

ATLS Specifics

C - circulation (shock management)

ACS Classes of Hemorrhage

- classes I - IV
- based on estimated blood loss and effect on vital signs

	Class I	Class II	Class III	Class IV
Blood Loss mL	Up to 750	750-1500	1500-2000	>2000
Blood Loss %	Up to 15%	15-30%	30-40%	>40%
Pulse rate	<100	>100	>120	>140
Systolic blood pressure	Normal	Normal	Decreased	Decreased
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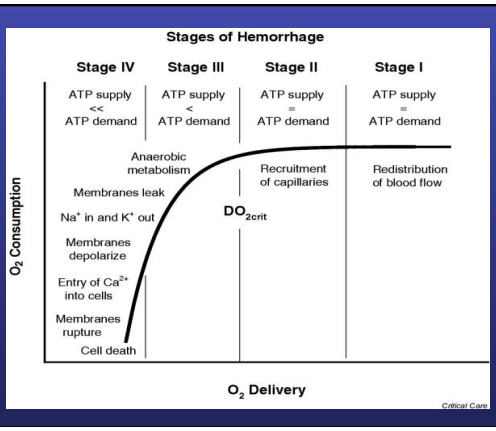


Type of Hemorrhage

- Category 1 15% of blood loss >>> Do Nothing
- Category2 30% of blood loss >>> Iv fluid therapy
- Category 3 40% of blood loss >>> PRBC transfusion
- Category 4 >40% Life threatening >>>PRBC+FFP transfusion

RESPONSES TO INITIAL FLUID RESUSCITATION[1]

	Rapid Response	Transient Response	No Response
Vital Signs	Return to normal	Transient improvement; recurrence of ↓BP and ↑HR	Remain abnormal
Estimated Blood Loss	Minimal (10%–20%)	Moderate and ongoing (20%–40%)	Severe (>40%)
Need for More Crystalloid	Low	High	High
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

[1] 2000 mL Ringer's lactate solution in adults, 20 mL/kg Ringer's lactate bolus in children.

Damage Control Resuscitation

Damage Control Resuscitation

- Proactive early treatment to address the lethal triad (by rapid reversal of acidosis, prevention of hypothermia and coagulopathy) on admission to combat hospital.
- Assumption that coagulopathy is actually present very early after injury

Holcomb J, Jenkins D, Rhee P et al. Damage Control Resuscitation: Directly Addressing the Early Coagulopathy of Trauma. J Trauma 2007; 62: 307-310.

Damage Control Resuscitation

- Early use of blood product over isotonic fluid for volume replacement
- Early correction of coagulopathy with components, ie. Massive transfusion protocol
  - PRBCs: FFP: Platelet = 1:1:1

ATLS Specifics

C – circulation (shock management)

STOP the BLEEDING
- External blood loss
- Internal blood loss

REPLACE blood loss

ATLS Specifics

C – circulation (shock management)

- Vascular access
- Direct pressure
- Fluid administration
- Assessment of response

ATLS Specifics

Fluid Administration - which fluid?

- Crystalloid
  - massive fluid administration
  - diffuse edema (worsens cerebral edema)
  - contributes to "compartment syndrome"
- Colloid
  - no demonstrated benefit (SAFE trial)
  - costlier
- Hypertonic saline (3%, 7.5%)
  - hypernatremia

ATLS Specifics

C – circulation (shock management)

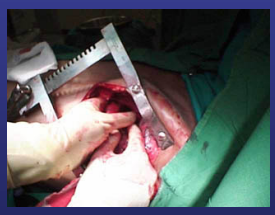
Stop *Internal* Bleeding

chest, abdomen, pelvis

ATLS Specifics

Recognition of thoracic hemorrhage

- clinical
- CXR
- Chest tube(s)

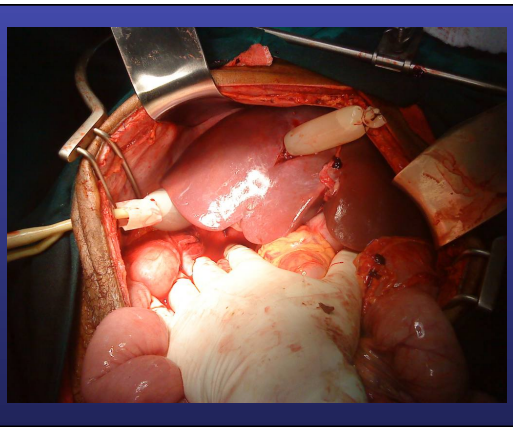


ATLS Specifics

Recognition of abdominal hemorrhage

- clinical
- FAST
- DPL
- laparotomy

Questions



Damage Control Laparotomy

Part 1

- stop all overt arterial bleeding
- pack other bleeding
- control contamination
- modified closure

Damage Control Laparotomy

Part 2

- return to ICU for warming, correction of coagulation and acidosis

Part 3

- return to OR for definitive closure

1. What is the most common cause of shock in the trauma patient?

A) septic

B) cardiogenic

C) hemorrhagic

D) neurogenic

2. The most easily reversible cause of shock in the trauma patient is:

A) hemorrhagic

B) neurogenic

C) tension pneumothorax

D) cardiac tamponade

3. The most commonly injured solid intraabdominal organ in blunt trauma is:

A) liver

B) spleen

C) kidney

D) small bowel

4. The bloody vicious cycle of trauma refers to:

A) bleeding, hypothermia, and acidosis

B) bleeding, hyperthermia, acidosis

C) transfusion, hypothermia, acidosis

D) transfusion, hypothermia, alkalosis

5. Hemorrhagic shock is usually caused by bleeding into or from:

A) abdomen

B) pelvis

C) chest

D) head

E) all of the above

F) A,B,C