

# **Penetrating Trauma**

## ***“The Violent Side of Pediatrics”***

**David Seastrom RN, BSN**  
**Trauma Injury Prevention, Outreach  
& Education Coordinator**  
**Children’s Mercy Hospital & Clinics**

# Disclosure

I have  
financial



interest or  
for this

I H

NEY

# Objectives

**Describe common penetrating injuries in the pediatric population**

**Discuss the importance of effective communication in the trauma bay**

# **CME Question – Show of Hands**

**Which of the following is an indication for laproscopic or laparotomy exploration in a pediatric patient with penetrating abdominal trauma?**

- A. Violation of the fascia**
- B. GSW or other high velocity projectile**
- C. Hemodynamically unstable patient**
- D. All of the above**

# What is Penetrating Trauma?

- Penetrating trauma is an injury that occurs when an object pierces the skin and enters a tissue of the body, creating an open wound.



- May include
  - Firearms
  - Knives and swords
  - Animal related injuries
  - Tools and lawnmowers
  - Impalements



# Epidemiology

- Despite widespread publicity penetrating trauma relatively less common
- Recent study 154,045 patients treated in 125 US trauma centers – 6.4% volume (GSW), 1.5% (SW)
- Some studies show GSW 20% of the volume, but accounts for 50% of the mortality rate



# Less “well known”



# Even less known Nokia's Version















In a moment's notice...

You must be ready  
for ***ANYTHING!!***





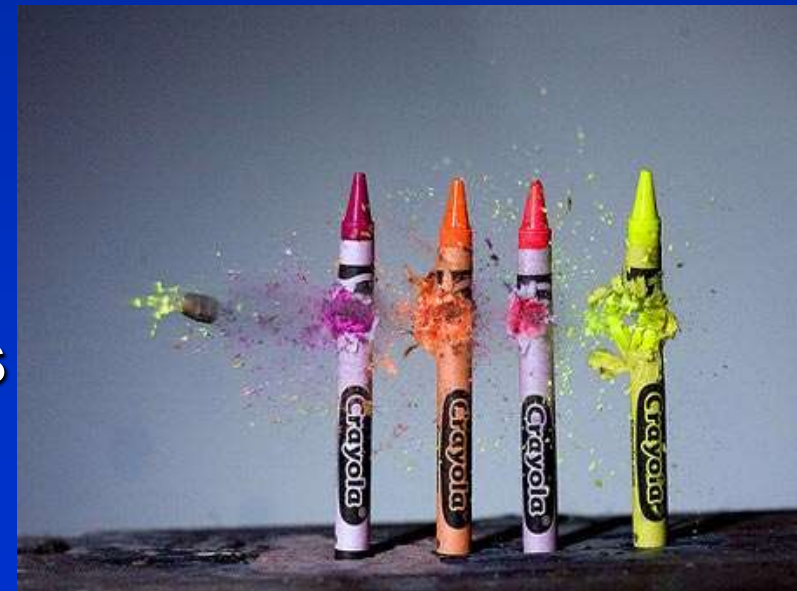
# Pediatric Differences

- More cartilaginous chest wall
- Less soft tissue protection
- Greater risk for hypoxia
  - Pliable ribs
  - Poorly developed intercostals
  - Fewer & smaller alveoli
- Mediastinal structures
- Compensatory mechanisms
- Increased body surface area



# Mechanisms of Injury in Penetrating Trauma

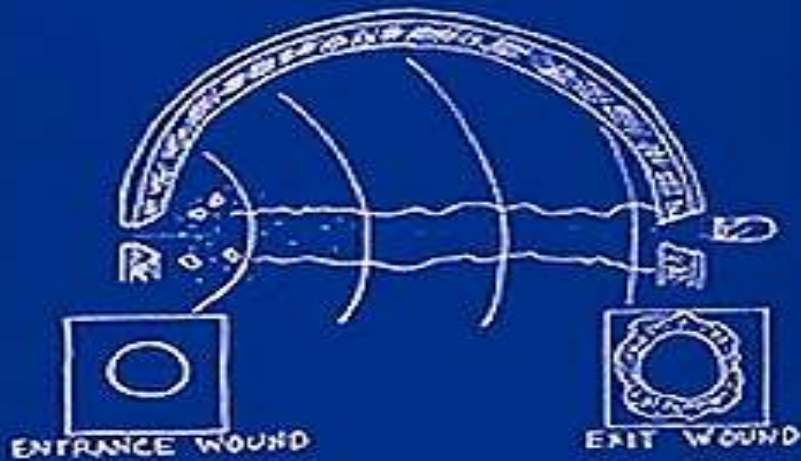
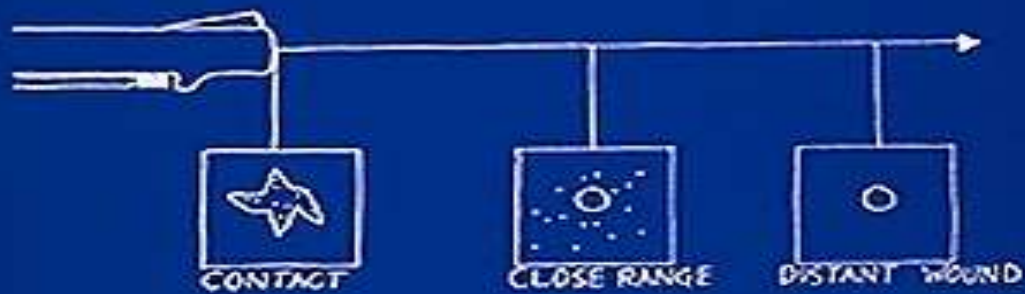
- **Low velocity injuries**
  - Stab wounds
  - Disrupt only the structures penetrated
- **Medium velocity injuries**
  - Handguns and pellet guns
  - Shotguns
  - Secondary cavitation
- **High Velocity Injuries**
  - Military weapons and rifles
  - Secondary cavitation



# Penetrating Trauma

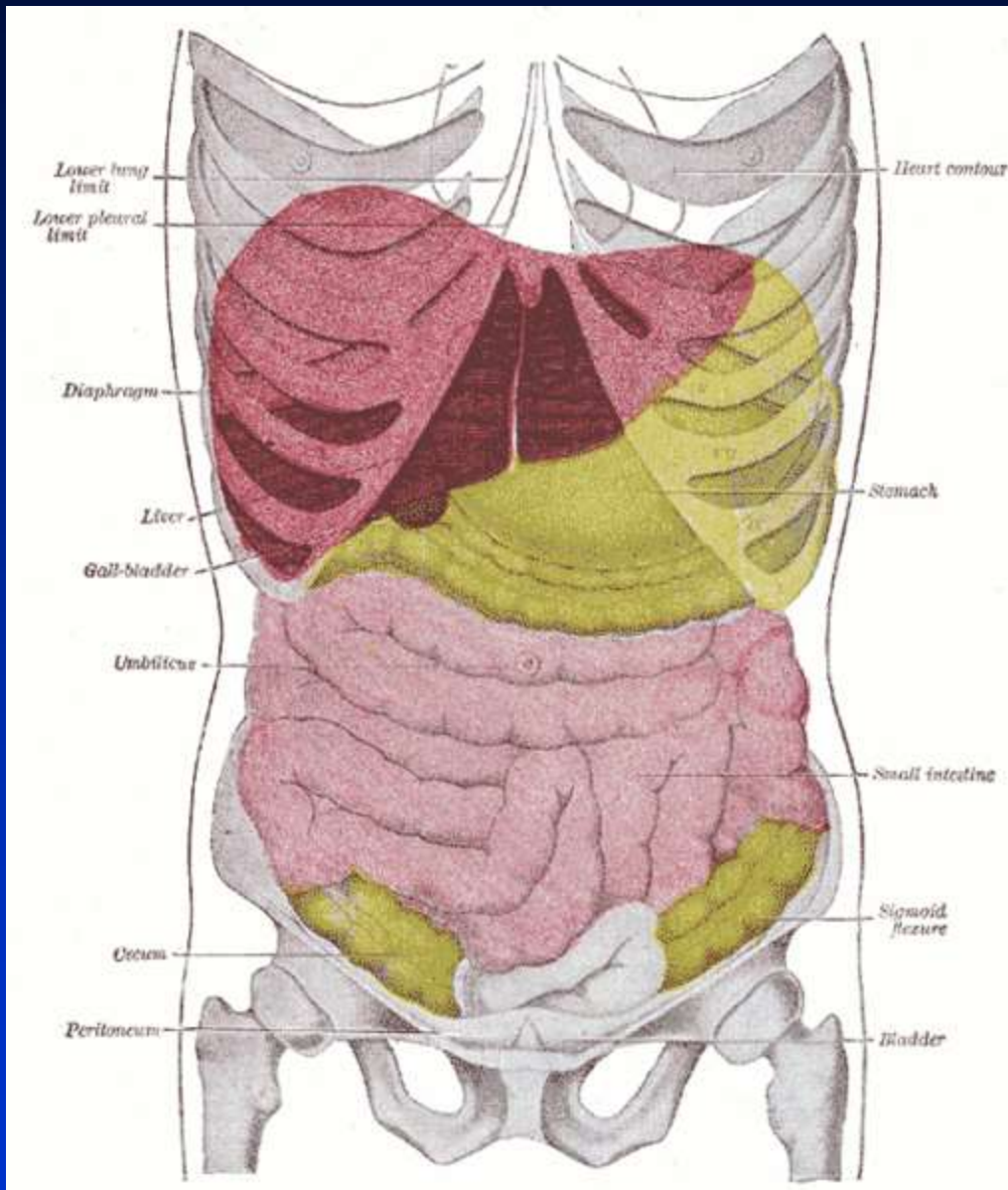
- **Approximately 8% at CMH**
- **8-12% of pediatric abdominal trauma admissions (nationally)**
- **GSWs most common cause of penetrating trauma in pediatrics**
- **GSWs leading cause of death in black males 15-24 y/o**

# Wound types by range





# Penetrating Abdominal Trauma



- Abdomen extends from the nipples to the groin crease anteriorly, and the tips of the scapulae to the gluteal skin crease inferiorly.

# Organs most often injured

Frequency of Organ Injury	Blunt	Penetrating
Liver	15%	22%
Spleen	27%	9%
Pancreas	2%	6%
Kidney	27%	9%
Stomach	1%	10%
Duodenum	3%	4%
Small Bowel	6%	18%
Colon	2%	16%
Other	17%	6%

Saxena, et al, Medscape Reference, May 9,2011

# Evaluation

- **ABC's**
  - **Airway – with cervical spine control**
  - **Breathing**
  - **Circulation – with hemorrhage control**
  - **Disability**
  - **Expose/Environment – with temp control**
- **Good exam**
  - **Avoid multiple repeated exams if findings positive**
    - **Peritonitis**
    - **Pelvic instability**

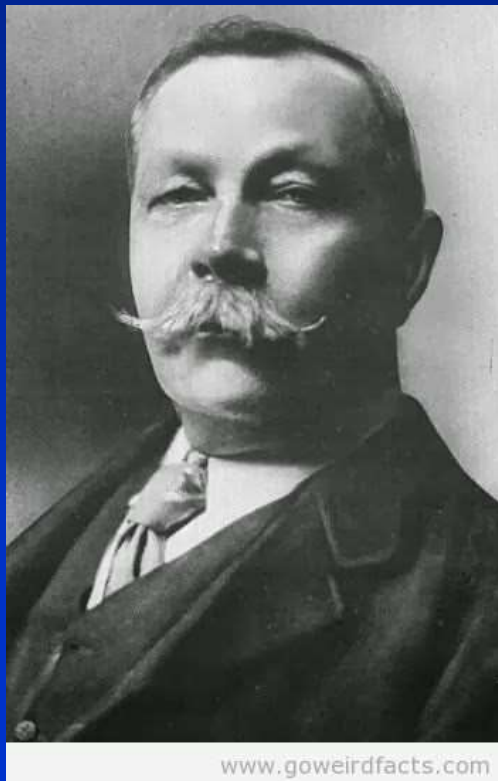
# PEARL...

*Any injured* child who is cool and tachycardic is in shock until proven otherwise...



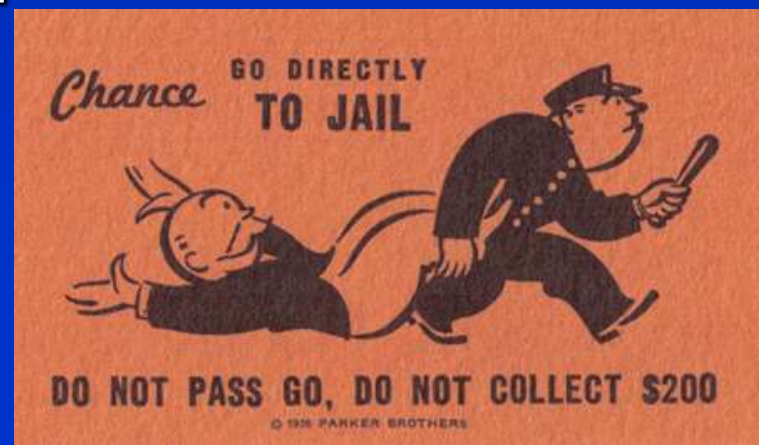
# Pearl #2....

Every child deserves a Sherlock  
Holmes



# Stable Patients

- Evaluate for injury – “Tubes & fingers in every orifice”      Still true?
  - Chest Xray
  - Other plain films- mark entrances and exits
  - NG Tube
  - Urinary Catheter
  - Rectal Exam/Vaginal Exam
  - Other imaging modalities
- OR?



# Unstable Patients

- **Need to go to OR**
- **Decide which cavity to open first**
  - **Obvious penetrating injury to abdomen requires laparotomy/laproscopy**
  - **Questions may arise if multiple area penetrating trauma, massive hemothorax, evidence of tamponade, “grey zone areas” such as thoracoabdominal junction, buttock wound**
- **Sometimes need diagnostic testing**
  - **Diagnostic Peritoneal Lavage (?)**
  - **FAST Scan (user dependent)**
  - **CT (?)**

# Indications for OR (per ATLS)

- Any patient with hemodynamic abnormalities
- Gunshot wounds
- Signs of peritoneal irritation
- Signs of fascial penetration



# Evisceration



# Evisceration?



# Non-operative GSWs?

- Fikry, et al (Harvard)
- 11 year retrospective study
- Level 1 trauma center
- Excluded tangential injuries, deaths and transfers
- 125 patients
- 38(30%) managed nonoperatively initially
  - Serial exams and CTs
- 7 ended up with operation
- 10 patients had nontherapeutic laparotomies- 3 developed complications

# **Non-Operative Penetrating Wounds in Children**

- **Cigdem, et al**
- **Turkish chart review**
- **90 children, mean age 9.9 years**
- **2/3 stab wounds, 1/3 GSW**
- **Most common injury- bowel**
- **56.6% (51 patients) treated nonoperatively**

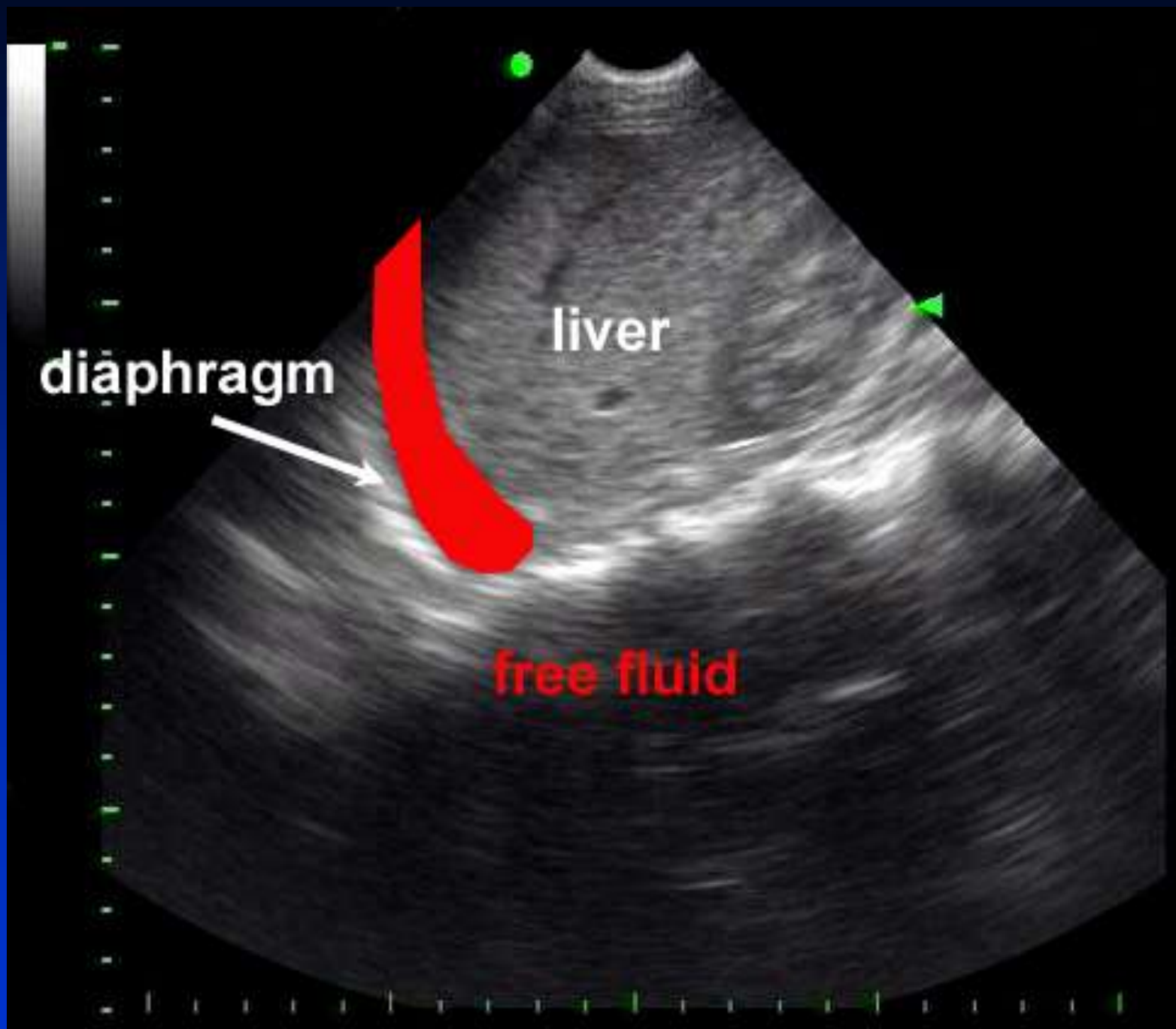
# **Non-Operative Penetrating Wounds in Children**

- **Non-operative group: (n=51)**
  - **41 stab, 10 GSW**
  - **All had detailed ultrasounds**
  - **2 went to OR**
  - **One ileum perforation (OR at 20 hours)**
  - **One with signs of peritonitis at 24 hours (no injury found in OR)**

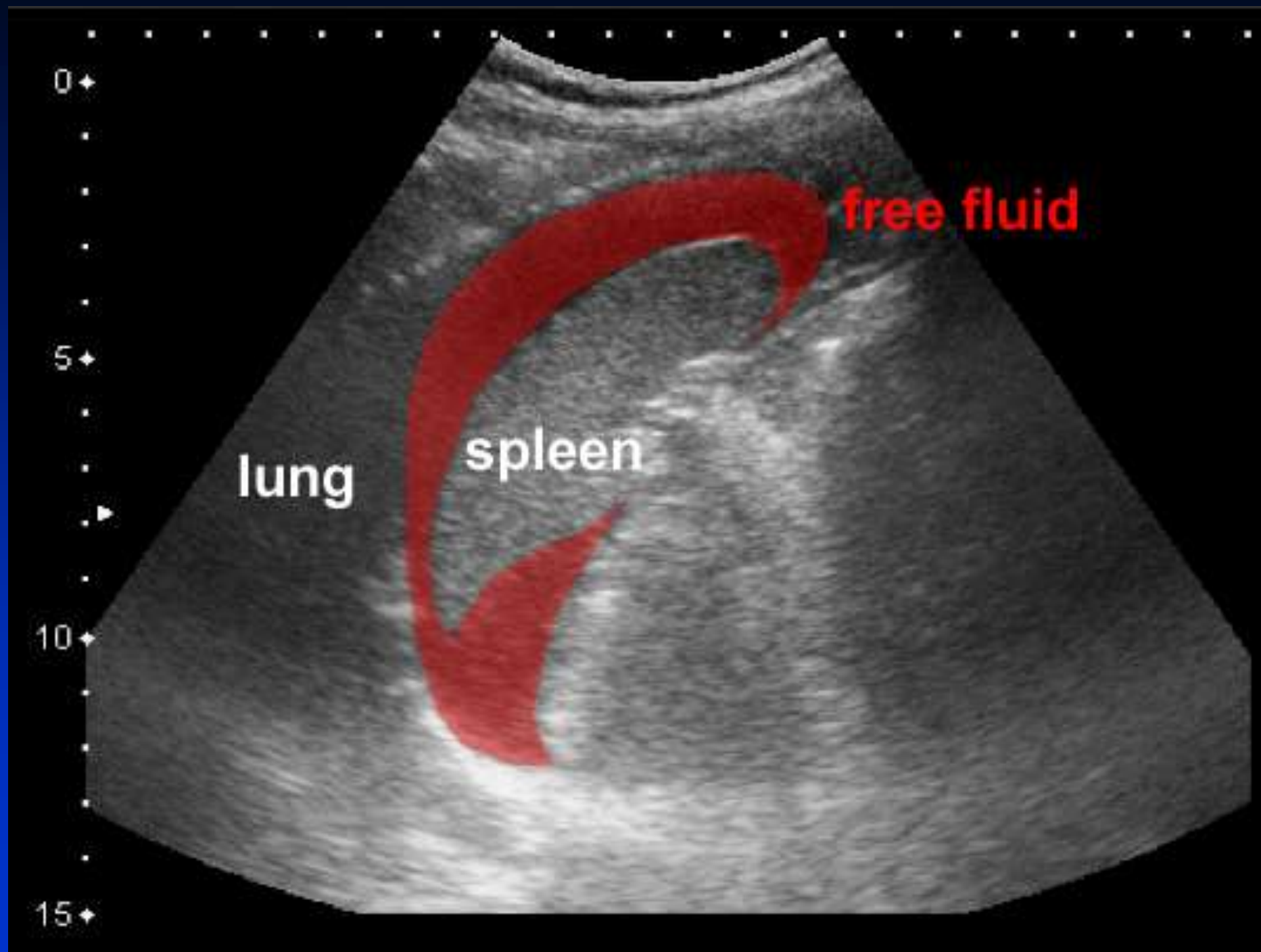


# **Focused Assessment Sonography in Trauma (FAST)**

- **Rapid, noninvasive, inexpensive**
- **Accurate (if experienced user)**
- **Indications- same as DPL**
- **Limitations:**
  - Limited in detecting <250 cc intraperitoneal fluid
  - Particularly poor at detecting bowel and mesentery damage (44% sensitivity)
  - Difficult to assess retroperitoneum
  - Small spaces / relatively larger organs / etc.
- **Easy to reproduce**
- **Utility may be compromised if:**
  - **Obesity**
  - **Subcutaneous air**
  - **Previous abdominal surgeries**







# Abdominal CT

- **Requires transport**
- **Requires contrast**
- **Time consuming-**
  - **Only use if hemodynamically stable**
- **Relatively specific**
- **Good for retroperitoneal injuries**
- **May miss gastrointestinal, diaphragmatic and pancreatic injuries**



# **Abdominal CT**

## **Features of Penetrating Trauma CT's**

**Signs of peritoneal violation**

**Free intra-peritoneal air**

**Free intra-peritoneal fluid**

**Wound track extending through  
peritoneum**

**Bowel wall defect/thickening**

**Intraluminal contrast leak**

**Diaphragmatic defect**

# CT Before OR?

- **Neal, et al.**
  - Pittsburgh- retrospective study**
  - National Trauma Data Bank Review**
  - Patients >14 y/o**
  - Came from scene**
  - Hypotensive upon arrival**
  - Abbreviated Injury Score >3**
  - Underwent laparotomy within 90 min**

# CT Before OR?

- 3218 patients
- Abdominal CT group-
  - More likely penetrating (49% vs 43%)
  - More intubations before leaving ED
  - More commonly undergoing head injury eval as well
  - Higher mortality (70% higher risk)
  - Significant delay in getting to OR if abdominal CT
    - Head CT didn't impact OR time

# Interpreting CT

- **2008 study**
- **Compared surgical residents' interpretation to radiologist**
- **84 injuries in 31 patients**
- **Residents correctly identified:**
  - **96% (25/26) of head injuries – vs 89% radiologists**
  - **67% (28/42) of chest injuries – vs 90% radiologists**
  - **94% (15/16) of abdomen/pelvis injuries – vs 88% radiologists**
  - **None of missed injuries were life threatening or required immediate attention**

# Local Wound Exploration

- **Extend wound and follow the tract**
- **Penetration of the anterior abdominal fascia is considered positive and patient gets laparotomy/laparoscopy**
- **25% of anterior abdominal stab wounds do not penetrate**
- **Only 50% of stab wounds that do penetrate actually require surgical intervention**





# Laparoscopy??

- **Less invasive**
- **Adult literature**
  - **Laparotomy with 5% associated mortality**
  - **Relatively high incidence adhesions and obstruction later**
  - **Limited literature suggests utility of laparoscopy**

# Laparoscopy

- **Adult literature – Yecul, et al**
- **Prospective study**
- **Stab wounds**
- **Hemodynamically stable without abdominal tenderness**
- **36 patients all had exploratory laparoscopy**
- **36.1% had diaphragmatic injury**
- **53% of those had associated abdominal injury**
- **Laparotomy required in only one case**

# Laparoscopy?? Pediatric

- Marwan, et al, University of Alabama
- Retrospective review 1997-2009
- Blunt and penetrating trauma-
- 71 laparotomies, 21 laparoscopies
- All acute laparoscopies (19/21) were diagnostically successful
  - Not as successful in delayed cases (2)
- 5 had therapeutic laparoscopies as well
- Laparotomy avoided in 13/21 patients and 10/10 penetrating trauma patients
- Laparoscopy not done if peritoneal violation

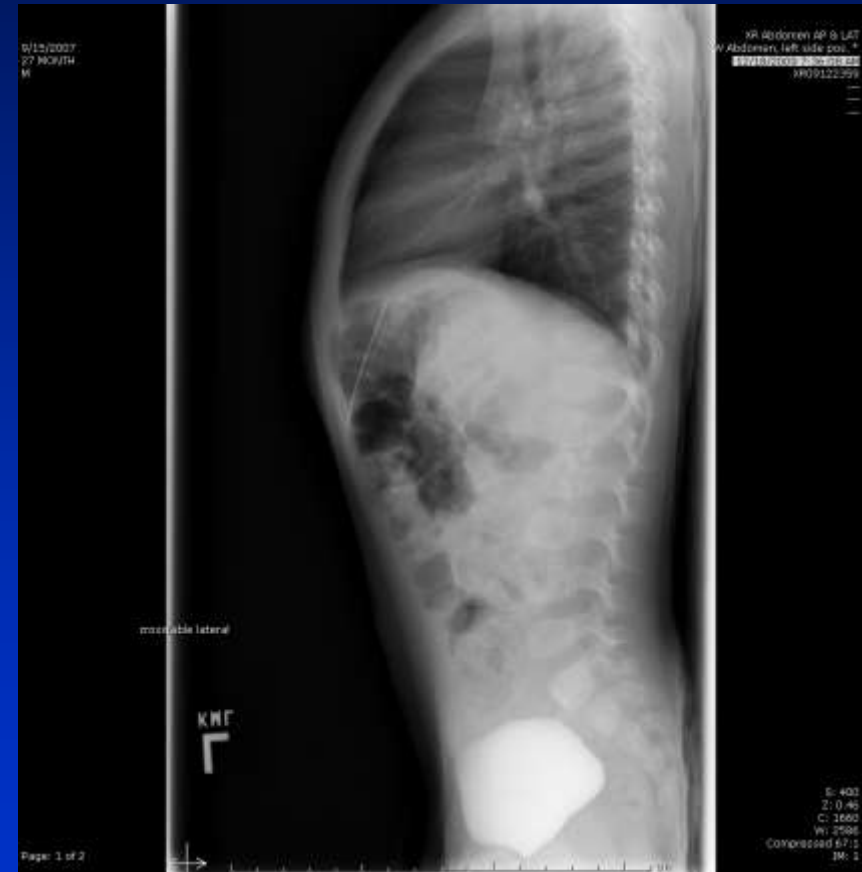
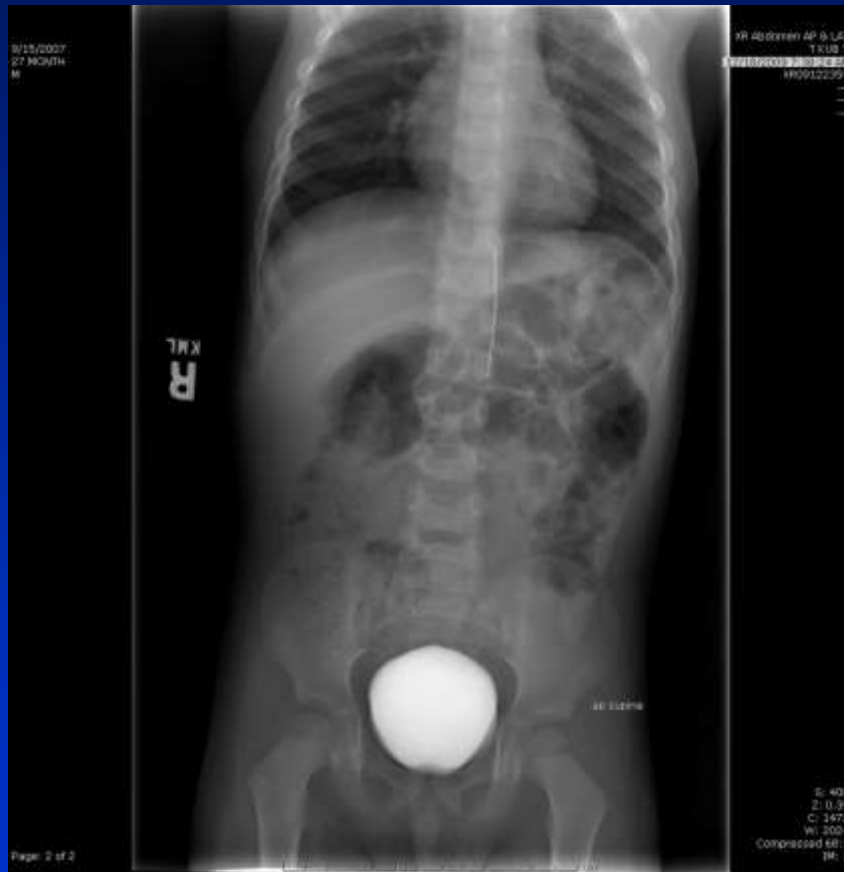
# **Case #1- 2 year old fell off bed**

- **2 Days prior, fell off bed onto carpet**
- **Landed on abdomen**
- **Family noted tiny drop of blood midline upper abdomen**
- **Seen at outside hospital next day, discharged**
- **Seen at CMHK for continued tenderness next day**



# Case #1

## 2 year old fell off bed



# **Case 2**

## **Penetrating Trauma**

- **14 year old boy**
- **Fell from second story window**
- **Landed on a pipe sticking out of the ground**
- **Presents to ED triage**

# Case 2

## Penetrating Trauma



# Case 2

## Penetrating Trauma





## **Case 3**

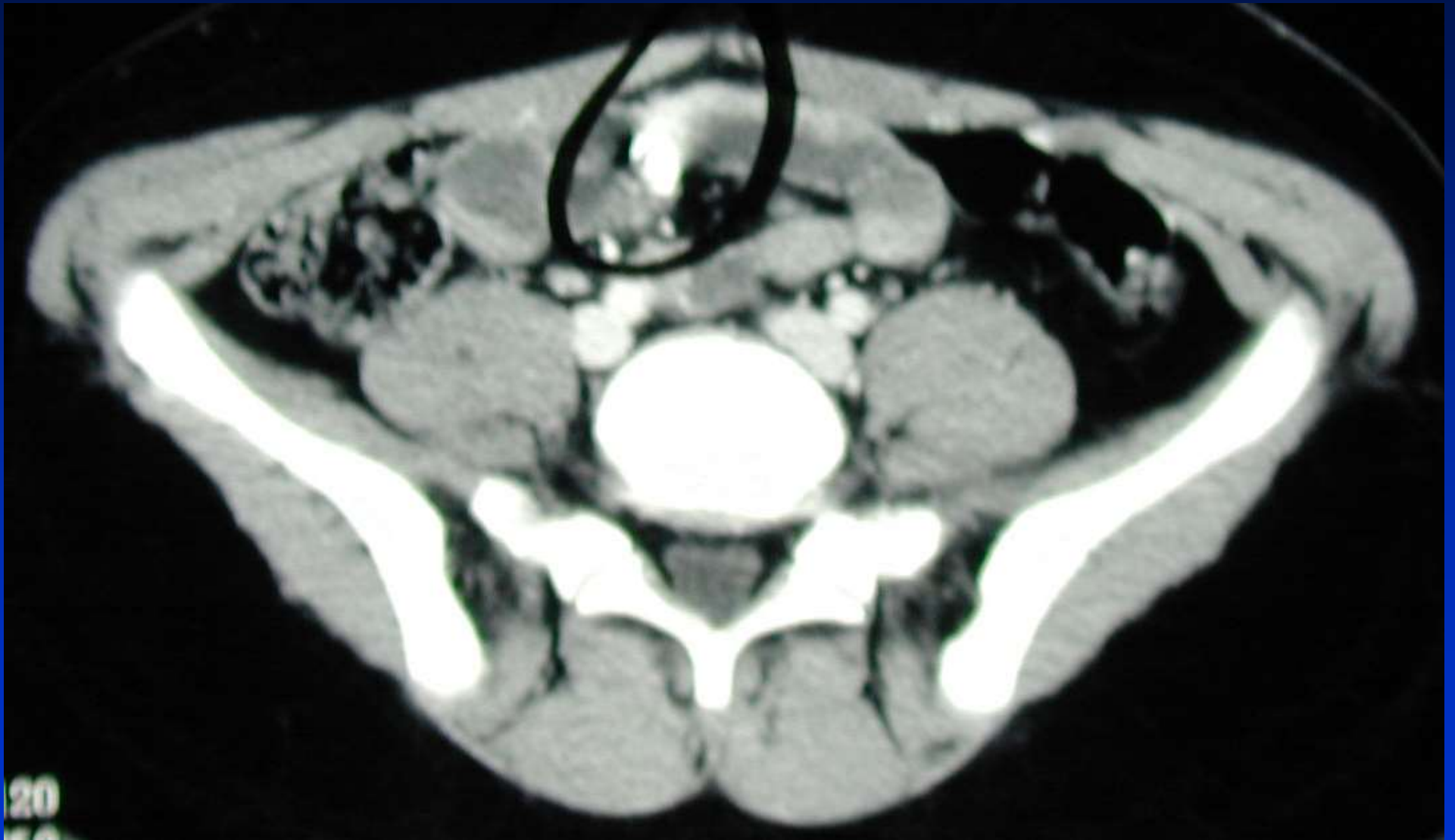
### **“Pen”etrating trauma**

- **9 year old boy with wound to abdomen**
- **Fell on a gel pen**
- **Tip broke off**
- **Mild pain at entrance**
- **Ink oozes from entrance site if pressure applied.**
- **Minimal abdominal pain**

# “Pen”etrating Trauma



# “Pen”etrating Trauma



# Case Study #4

- **12y/o M – 45KG**
  - **Shot in chest with BB gun**
    - **Single 3mm wound L midline**
    - **3<sup>rd</sup> intercostal space**
    - **Minimal bleeding**
  - **Found sitting on couch obtunded**
  - **Radial pulse absent**
    - **Heart tones normal**



# Case Study #4

- **Vital Signs**
  - 67/47, 140, 22, GCS 8, RTS 8
- **Treatment**
  - Full Spinal Immobilization
  - ECG
  - O2 @ 12LPM via NRB
  - NS Bolus – 900ml (f/u 49/28, 120, 20)

# **So what should we expect?**

- **Tube thoracostomy**
- **Needle thoracostomy**
- **Pericardiocentesis**
- **Thoracotomy**
- **IVF Bolus**
- **Vasopressors**
- **Intubation**
- **I don't wanna be here anymore!**

# Case Study #4

- **ED Arrival**
  - 1800 Pelvis X-Ray
  - 1802 Muffled heart tones
  - 1812 NS @ 999ml/hr (warmed)
  - 1817 Abd FAST (-), + Pericardial fluid
  - 1819 GCS <10 – Intubation
  - 1820 Pericardiocentesis – drain placed
  - 1820 Ketamine/Roc/Versed/Fent
  - 1827 CR <2sec, 2+ distal pulses

# **So what should we expect now?**

- **Tube thoracostomy**
- **Needle thoracostomy**
- **Pericardiocentesis**
- **Thoracotomy**
- **IVF Bolus**
- **Vasopressors**
- **Intubation**
- **I don't wanna be here anymore!**

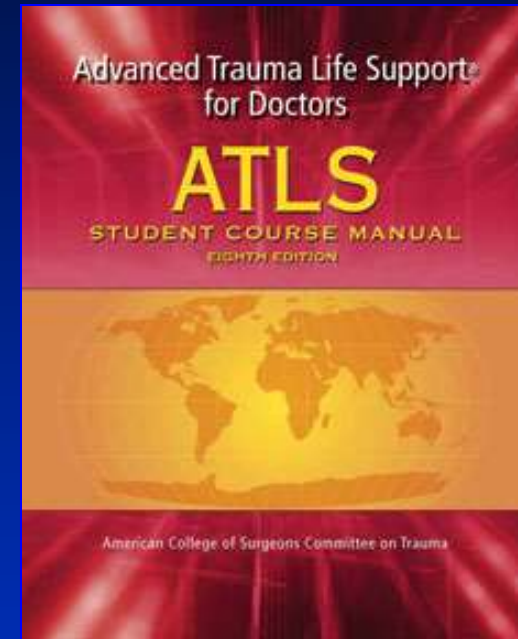
# **Case 5**

- **10 year old tornado victim**
- **Sustained right thoracic trauma**
  - **Right flail chest**
- **Intubated at scene for distress**



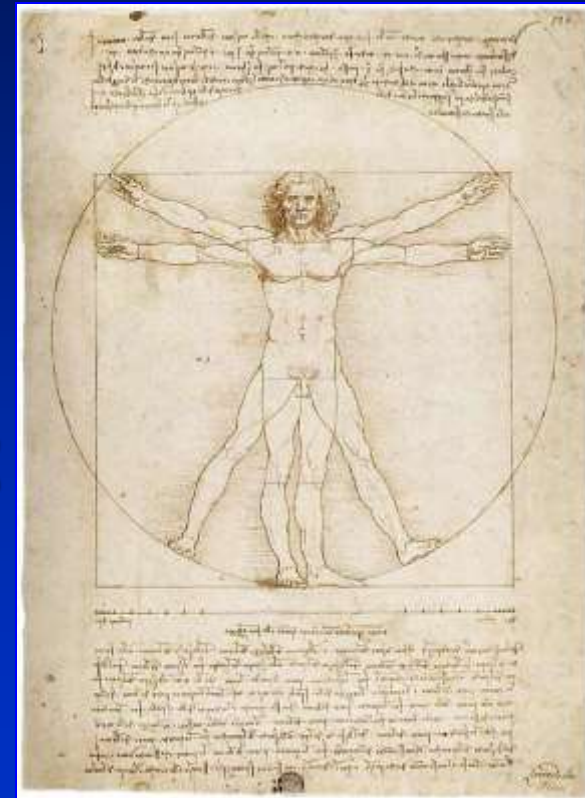
# Primary Survey

- **A – Direct laryngoscopy?**
- **B – ↓ BS on the right**
  - **Intervention?**
  - **Right tube thoracostomy**
- **C – Aggressive fluid resuscitation?**
  - **“Pop the clot”**
  - **Contribute to coagulopathy**
  - **1:1:1**
- **D – Moving all 4 extremities at scene**
- **E – Metal rod right back/shoulder (TEMP!)**
- **CXR +/- Pelvis**



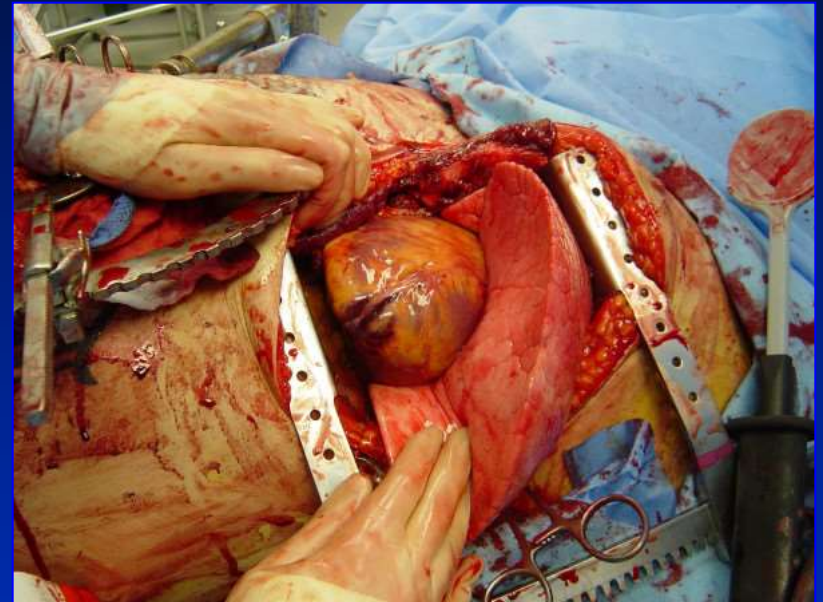
# Secondary Survey

- Gen- Intubated & sedated
- HEENT- Orally intubated
- Spine- C-collar
- Chest- Increased BS on right
- CV- Tachycardic, BP WNL
- Abd-soft, non-distended

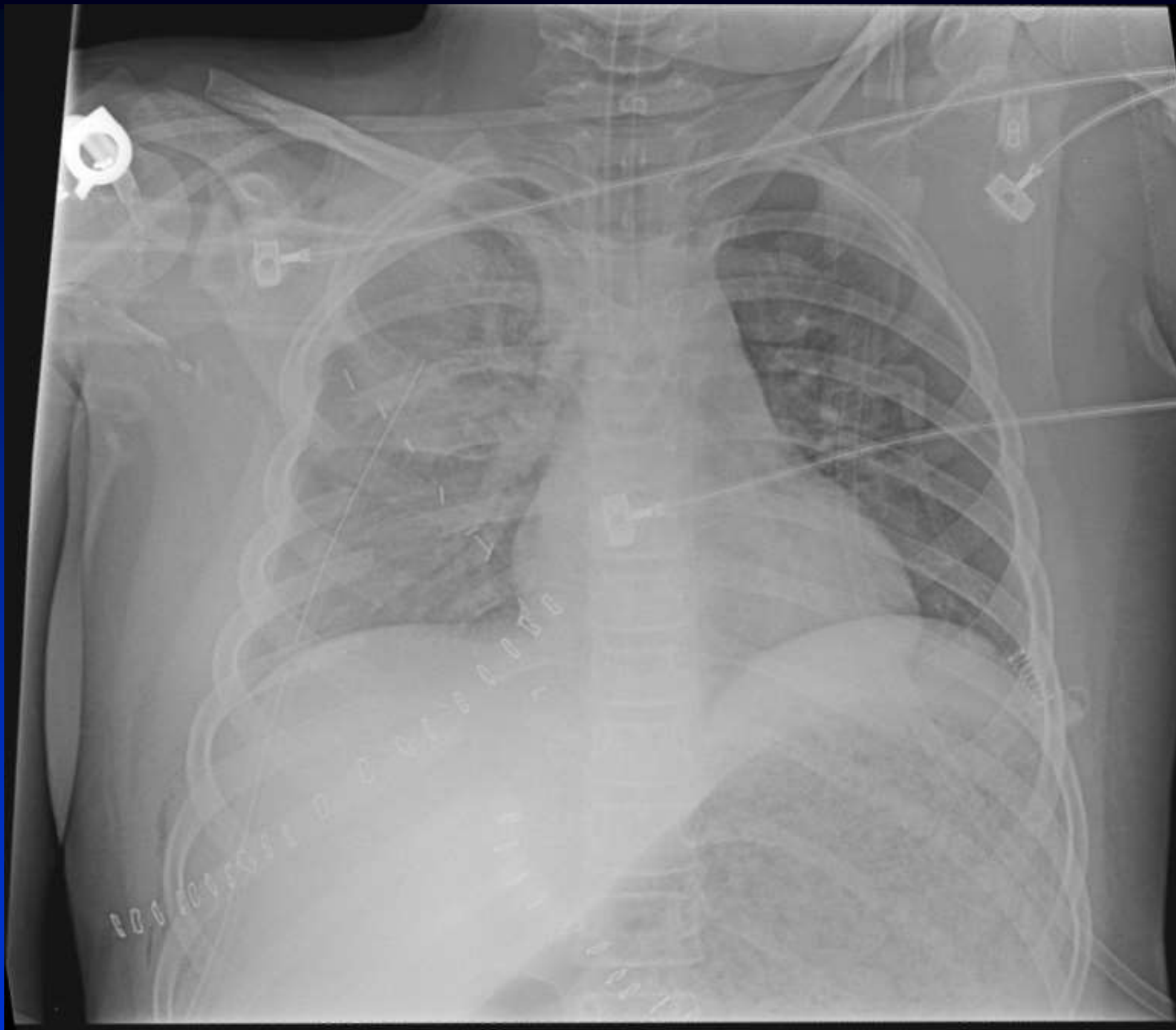


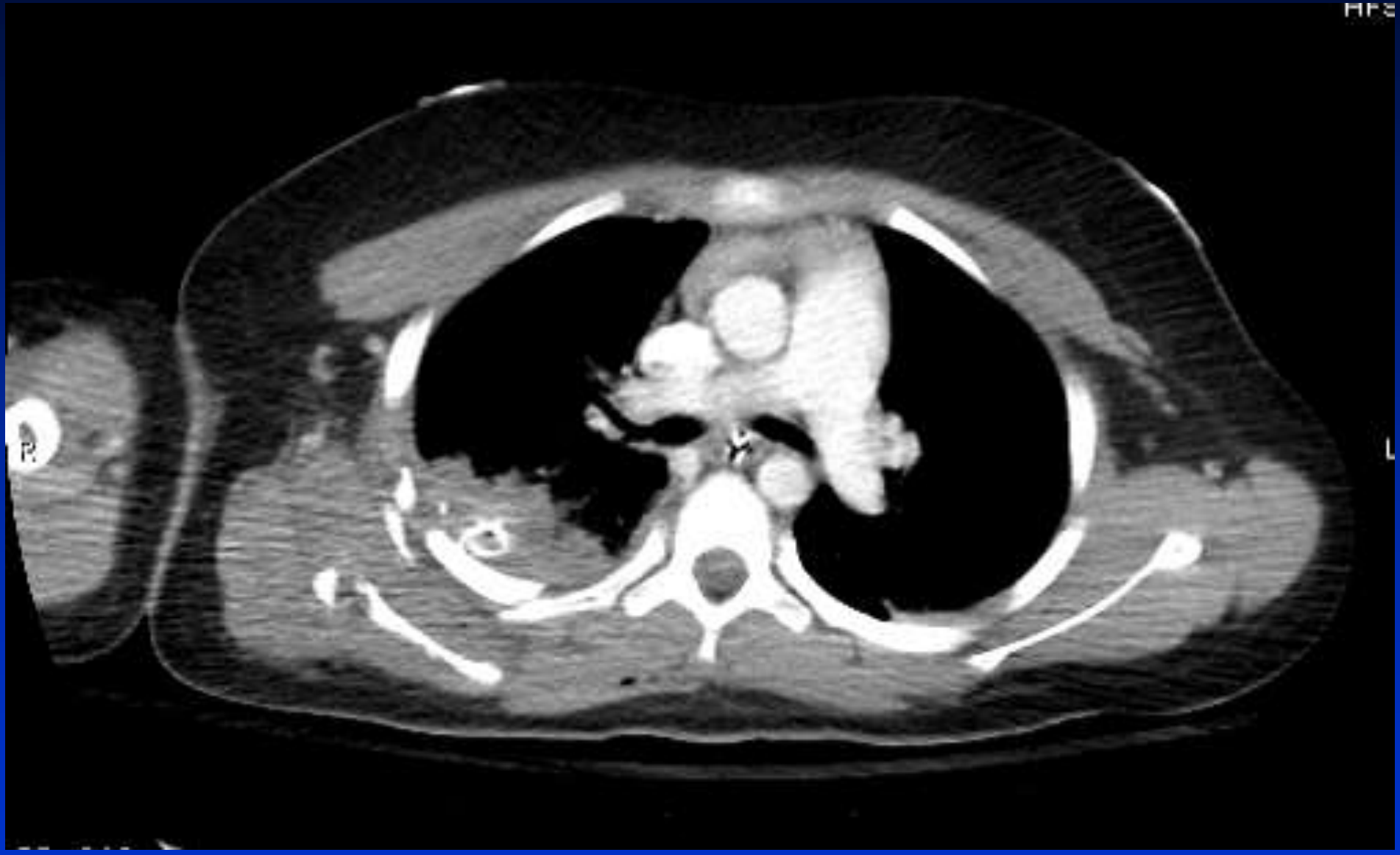
# What Now?

- OR?
- ED Thoracotomy?
- Imaging?
  - CT
  - Angiography



1. Clinical Condition
2. Chest Tube Output







Portable

XR  
5/23/20



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**Portable**  
**AP**



# Management

- OR
  - Removal of bar, debridement and drainage of open right humerus fracture
  - Thoracotomy, evacuation of hemothorax and control of bleeding

# Indications for Thoracotomy

- Initial CT output  $> 15$  ml/kg
- CT output of 2-3ml/kg/hr x3hours
- Cardiac tamponade
- Trans-mediastinal injury with HD instability
- Massive air leak



# Chest or Abdomen??





# **Thoracoabdominal Injuries**

- **Any penetrating injury that traverses the diaphragm**
- **Suspect between nipples and umbilicus**
- **Always get chest xray!**
- **Most require exploration to rule out diaphragmatic injury**

# Remember the diaphragm

- Diaphragm can rise as high as the 4<sup>th</sup> thoracic vertebrae
- Diaphragmatic injury occurs in
  - 45% of thoracoabdominal GSWs
  - 15% of thoracoabdominal stab wounds
- Injuries are more common on the left

# Miscellaneous

- Consider all penetrating injuries to be contaminated
- Tetanus prophylaxis
- 15% with thoraco-abdominal penetrating injuries will have other injuries
- Gluteal injuries- up to 50% with intrabdominal injuries
- For penetrating rectal injuries, consider triple contrast CT

# **Social Considerations**

- **History often inaccurate**
- **Reportable to PD**
  - **All pediatric GSW and stab wounds should be reported**
- **Consider hotline to child protective services**

# The End(s)...



**Thank You!!**



# References

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