Diagnostics in Trauma: Looking into the Shadows

Daria C. Ruffolo
Loyola University Medical Center - Chicago
At the end of this session the participant will be able to:

- Describe the impact radiographic diagnostic therapies have on the trauma population
- Discuss the indications for studies for major body systems and injuries
- Identify the most current treatment radiographic diagnostic and modalities in trauma care
- Take a nap
Basic Concepts

- > 1/3 are emergent
- They are sick
- Will require either GETA or conscious sedation
- Be PREPARED for any and everything
  * integrity of access
  * check labs
  * bring meds with you if needed
  * check suction and 02
Keep the patient SAFE

* informed
* warm
* monitored
* comfortable
* breaks in technique
* positioning
* secure connections
Check site and distal pulse over and over and over again!

Feel under the patient!
- X-ray is shortwave of electromagnetic radiation that penetrates matter.
- Medically useful and can be harmful
- The radiation waves are absorbed in black and white hues---the more dense the lighter the color on film
- Brightest to darkest, most dense to least dense
  - Metal > bone > blood > brain > soft tissue > water > fat > air
<table>
<thead>
<tr>
<th>Structure</th>
<th>Color</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas/air</td>
<td>black</td>
<td>pneumo</td>
</tr>
<tr>
<td>Fat</td>
<td>grey</td>
<td>tissue</td>
</tr>
<tr>
<td>Fluid</td>
<td>white +/-</td>
<td>vessels</td>
</tr>
<tr>
<td>Bone/metal</td>
<td>white</td>
<td>heart/muscle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bone/foreign</td>
</tr>
<tr>
<td></td>
<td></td>
<td>objective</td>
</tr>
</tbody>
</table>
Tricks

- RIGHT PATIENT RIGHT FILM RIGHT TIME
- Work around the patient NOT he around you
- Positioning is KEY
- Symmetry is your friend
- Look again and again and again
- Look at ALL films then abnormal will become more obvious
- Look at all films in the same order
There is NO substitute for looking at, touching, and speaking to the patient!!
Common Associated Injuries

Maxillofacial
Ribs 6-12
AP compression pelvic fx
Lateral compression pelvic
Lap belt
Shoulder belt

Cervical spine
Liver/spleen
IP bladder
EP bladder
Mesentery, bowel,
Chance injury
Carotid, C spine
injury
THINK ENERGY
Overview of Chest X-ray

- Positioning
- Technique
- Indication
- Full inspiration
- Structures reviewed systematically
Order to Review Structures

- Side to side
- Top to bottom
- Structures
Structures

- Lung fields
- Trachea
- Mediastinum
- Bony structures/ribs
- Diaphragms
- Structures below diaphragms
- Intercostal spaces
- Soft tissues
- Tubes
The Radiologic ABC’s

GOAL: To detect correctable problems that cause hypoperfusion or hypoxia

AIRWAY:
- ETT position is unreliable on PE ~75%
- ~10% are malpositioned on CXR
- ~3 cm above the carina
- Remember neck excursion is ~ 4cm
Thoracic Aortic Disruption

- Defined
  - MOI → deceleration
  - Typically patients will survive the initial injury insult
    - 30% mortality in 6 hrs
    - 50% mortality in 24 hrs
    - 70% mortality in 1 week
  - Injury may be confined to areas of aorta attachment
  - Signs & Symptoms
    - Rapid and deterioration of vitals
    - Pulse deficit between right and left upper or lower extremities
Site of Disruption

• Locations
  - Ligamentum arteriosum – 85%
  - Ascending root
  - Descending diaphragm attachment
Avulsion Sites

Figure 19–25. Sites of aortic rupture in order of frequency. A. Dista to left subclavian artery at the level of the ligamentum arteriosum. B. Ascending aorta. C. Lower thoracic aorta above diaphragm. D. Avul sion of innominate artery from aortic arch. (From Frey C. Initial Management of the Trauma Patient. Philadelphia, Lea & Febiger, 1976.)

Ligamentum arteriosum
Why Are These Injuries So Morbid (5-28%)?

- Left thoracotomy
- Single-lung ventilation
- Aortic cross-clamping
- Interposition grafting
- Systemic heparinization
Thoracic Aortic Disruption

- **Aortography**
  - *Gold Standard*

- **CT**
  - Spiral
  - Specificity comparable to A-gram
  - Utilized on stable patients

- **TEE**
  - Utilized on unstable patients to be “lost” to the OR
  - Positive → OR
  - Negative → A-gram
Thoracic Aortic Disruption

Management

- ABC’s
- Maintain normotension $\Delta P/\Delta T - \beta$ - blockade < 135/70

Operative management

Post-operative care

- “Clamp-time sequelae”
- Maintain normotension
Thoracic Aortic Disruption

• THINK MOI

• Radiographic studies
  ■ Plain film
    • Wide mediastinum*
    • Loss of aortic knob*
    • Tracheal deviation
    • Left pleural cap
    • Thickening/deviation tracheal stripe

*Watch Quality of Film*
Thoracic Aortic Disruption

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CT Scan Evaluation of the TAI

What is a “Multi-detector scanner”?  
--A rapid scanner  
--Multi-slicer thin sections (2.5 mm)  
--Power contrast injectors  
--Multiplannar reformats
Is CT the Answer?

- Multi-center trials
- Results > 95% sensitivity/>93% specificity in evaluating the TAI
- Branch vessels, unstable patients in need of potential embolization; angiography remains the diagnostic of choice

Miller, et al JOT 4/05  Maturen et al JOT 3/10
If They Need Intervention Does Everyone Get Their Chest Cracked?

- Endoluminal grafting initiated in the 1980’s for AAA
- Application to the TAI
- Multiple centers have initiated this approach
- Improved outcome
  -- less morbid
  -- less bleeding
  -- earlier mobilization
Treatment Options

- **Surgical repair:**
  - The treatment of choice is surgical repair.
  - Two options are “clamp and sew” and distal aortic perfusion techniques.

- **Endovascular stent-graft placement:**
  - A minimally invasive approach to aortic repair.
  - A small incision is made in the femoral artery and with the aid of angiography and fluoroscopy, a self-expanding wall stent is placed in the region of trauma.
Traumatic Brain Injury And Imaging

1. In acute head injury the CT is done without contrast
2. Review the brain, blood, and bone images
3. Clinical exam is VITAL
4. Always compare studies
5. Watch for mass effect
Cerebral Contusion

- Mechanism can be coup/contre-coup
- Pathologically consists of small hemorrhagic areas with necrotic core
- Mostly involves poles
- “Blossoms”
- Defects are determined by the location
Epidural Hematoma

- Classic lucid interval seen 30%
- Often caused from middle meningeal artery bleed
- Biconvex finding with sharply demarcated against the calvarium.
- Skull fracture seen ~90%
Poor prognosis:
- EDH > 2 cm
- midline shift > 1.5 cm
- brainstem deformity
- extensive associated injuries
Acute Subdural Hematoma

- Below the dura and superficial to the arachnoid space
- “Smudge” appearance
- Tearing of bridging veins
- SDH with contusion has 2X mortality of SDH alone
- Better visualized in blood windows
- Often associated with midline shift
Chronic Subdural Hematoma

- SDH is > 3 weeks in age
- ~ 60 yo is peak age
- 50% report no injury
- Bleed with osmotic expansion into the SH space
- Low density extra axial collection that conforms to the skull (hypodense)
- May be better visualized on MR
Depressed Skull Fracture

- DSF are elevated if the inner and outer tables are compromised, if there is an open wound, cosmesis is an issue, or there is a deficit
- Utilize the bone windows to get a good interpretation
First Things First—Can You Clinically Clear Them?

- NEXUS study says YES! (>90%)  
  --Are they drunk, head injured, obtunded, have distracting pain or neck pain? NO! Clear them!
- Current information is a little unclear
- Recent publication of a large randomized, prospective study found ~ 70% sensitivity (few needed tx)
- How is the clinical exam???

(Duane, Ivatury, et al JOT 6/08)
Cervical Spine

- If you cannot clear them clinically how do you study them?
- Plain film: 45% sens 97% spec
- CT c-spine: 98% sens 99.5% spec

High powered, prospective trials
Plain film can miss ~55% of injuries that are clinically significant
Blunt Cerebrovascular Injury of the Neck (BCVI)

- The incidence is < 1%
- Associated stroke when untreated ~30%
- **Risk factors:** Clinical
  - Hemorrhage nose/mouth
  - Expanding neck hematoma
  - Wounds over neck region
  - Unexplained lateralizing signs
Risk factors: **Mechanism**

- Hyperflexion/hyperextension/rotation
- Complex midface or mandibular injury
- Near-hanging
- Seat-belt sign or swelling over anterior neck

Biffl et al JOT 6/10
CT for Evaluation of Abdominal Injuries

- Computed tomography (CT) can evaluate solid organ injury, intra-abdominal fluid/blood/air, and retroperitoneal organ injury in hemodynamically stable patients using both oral and intravenous contrast.
CT

Contraindications:

- i) hemodynamically unstable patient
- ii) obvious need for laparotomy
Can miss pancreatic and diaphragmatic injuries—especially early on

Excellent at diagnosis and evaluation of solid organs

Helical brings evaluation of hollow viscous injury to 94%

Debate the need for oral contrast
Hepatic injuries

- Due to size and location commonly injured in trauma
- 70% blunt
- 30% penetrating
- Unique because of its regeneration capabilities
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<th>Laceration</th>
<th>Hematoma</th>
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<td>I</td>
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<td>&lt;1cm NB</td>
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<td>10–50%</td>
<td>1–3 cm AB</td>
</tr>
<tr>
<td>III</td>
<td>&gt;50%</td>
<td>&gt;3 cm</td>
</tr>
<tr>
<td>IV</td>
<td>Ruptured parenchyma</td>
<td>Lobe fx</td>
</tr>
<tr>
<td>V</td>
<td>Ruptured parenchyma</td>
<td>VC/Hep disruption</td>
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Non-Operative Management (NOM)

- 80% are NOM (AAST, 2001)
- Much less likely to have delayed bleeding < 10% (Knudson, 2004)
  Undetermined which grades may be treated NOM

REQUIRES SERIAL CT EXAM AND EXPECTANT CARE
Splenic Injuries

- Single most injured organ in blunt trauma
- 10% mortality
- S & S:
  - Profound shock from blood loss
  - Positive Kehr’s (50%)
  - Left rib fractures
  - Generalized abdominal pain (30%)
  - Palpable mass in left flank
How is the Spleen Damaged?

- Side impact (particularly smaller cars)
- Restraint devices
- Falls (usually striking stationary object with height/weight/velocity)
- Contact sports
# AAST Organ Injury

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<tr>
<td>IV</td>
<td>Ruptured Parenchyma</td>
<td>Hilar lac/ Devitalized</td>
</tr>
<tr>
<td>V</td>
<td>SHATTERED/DEVITALIZED</td>
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“Why Save the Bloody Thing?”

- Overwhelming Post-Splenectomy Infection (OMSI)
  - First identified in the 1950’s
  - Incidence ~ .05-2 %
  - Death rate in presence of OMSI ~ 50%
Splenic Function

- Opsonin production
- ~25% of reticuloendothelial cell mass
- Clearance of blood borne bacteria
- Reservoir of ~ 200 cc blood
Pseudoaneurysm (PS)

- There is no one single finding more predictive of DSR then that of a PS

- The process was first described in 1995 by Sugg et al

- The work of Davis, 1998, 2009 et al reported the presence of a “blush” on CT
“The Blush”

- Def. A well circumscribed, intraparenchymal contrast collection that represents the formation of a pseudoaneurysm of the splenic artery branches.
What Then Shall We do?

- Shurr, Fabian et al, JOT 1995 the blush needs angiography and embolization

- Davis, JOT 2009 decreased the DSR rate from 13% to 6% with this practice

- Bee, JOT 2006 presence of large volume of hemoperitoneum and blush there was > 24x DSR rate
Hemodynamically Stable

CT with contrast

Blush

| Worsens

No Blush

OR

Arteriogram

OR

Successful

Unsucc. 

CT 24-48 hrs.

Observe

Bee, 2005 JOT
Focused Abdominal Sonography for Trauma (FAST)

- Ultrasound has been used extensively in Europe and Japan for 20 years and is now being used increasingly in North America, primarily as a rapid noninvasive means of identifying hemoperitoneum in the trauma resuscitation area.
■ **Advantages**
  -- quick
  -- non-invasive
  -- requires no contrast (full bladder)
  -- reproducible

■ **Disadvantages**
  -- learning curve
  -- artifact DPL fluid, bladder injury, women
  -- ? accuracy in obese patients
**Indications:** are likely similar to the indications for DPL. Its major role may be in the rapid diagnosis of hemoperitoneum.

**Contraindications:** to the use of ultrasound are an obvious need for laparotomy and inadequate training or experience of the trauma team member performing the examination.

**Accuracy:** Reports of sensitivity (>90%) and specificity vary.
Pelvic Fractures
Epidemiology

- Pelvic fractures account 1-3% of all fxs
- 60% Male
- Mechanism
  - MVC (57-71%)
  - Collision w/ pedestrian (13-18%)
  - Motorcycle accident (5-9%)
  - Falls (4-9%)
  - Crush injury (4-5%)
Key Point

- Presence of a pelvic fracture indicates the profound magnitude of disruptive energy at the time of injury
  - Alerts to likelihood of major injury to other body systems
Epidemiology

- Overall reported mortality figures for pelvic injuries range from 8%-13%
  - Higher energy injuries greater mortality
  - Peds vs car (23%)


Pelvic Anatomy

- Inominate bones (2)
  - ilium, ischium & pubis
- Sacrum
Question?

- Name the 2 major complications that are directly related to pelvic fracture.
  - Hemorrhage
  - Urologic injuries
Why is this important?
Why is this important?

- It underscores the importance of anatomic relationships and injuries associated with pelvic fractures.
Why is this important?

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Pelvic fractures bad, associated injuries very bad!
Pelvic Radiography
Pelvic Radiography

- Unique skeletal evaluation in trauma setting
  - Only one view is obtained
    - AP Pelvis
- Most injuries can be identified
- More commonly missed
  - Acetabulum, sacroiliac joints, sacrum
- May not define the extent of the injury
**AP Pelvis**

- **Adequacy:**
  - Both iliac crests
  - Proximal femurs
  - Lower lumbar spine
  - No rotation
  - Pubic symphysis aligns midline with sacral spinous processes
Pelvic CT

- CT has replaced supplementary plain-films
- Greater anatomic detail
- The best study for acetabular & sacral fxs
- Assesses extent of instability
- Evaluates retroperitoneal hematoma
Pelvic CT

- In a study comparing plain films & CT scans in patients with sacral trauma
- Plain films were not diagnostic...
  - 29% of SI diastasis
  - 57% of acetabular rim fractures
  - 34% of vertical shear fractures
- All Diagnosed by CT

Pelvic CT

- Specific indications for pelvic CT
  - Acetabular fractures
  - Dislocations of the hip
  - All potential or recognized sacral fractures
  - All potential or recognized SI injuries
  - Question of instability

- Patient must be hemodynamically stable

Question?

- Can anyone identify the following equation?

- $V = \frac{4}{3} \pi r^3$
Can anyone identify the following equation?

\[ V = \frac{4}{3} \pi r^3 \]

Volume of a sphere

What is the significance of this equation?
Pelvic volume is approximated by volume of a sphere.

Control of pelvic radius is critical as doubling the radius theoretically leads to an 8-fold increase in volume.
What Bleeds?

- Arteries
- Veins (90%)
- Bone
The Sad Facts

- Remember of those that are embolized > 95% STOP BLEEDING

- < 14% of patient with significant pelvic arterial bleeding are in the angio suite within 90 minutes

Pelvic Packing

- RARE
- Only in skilled hands
- Pack the pre-peritoneal space
- Return to fight another day
Hemorrhage

- Primary cause of death
  - Retroperitoneal space can accommodate 6 L

- Three sources
  - Arterial
  - Venous
  - Osseous

- Life-threatening hemorrhage is most commonly associated with venous source
  - Lack muscular wall for post-traumatic constriction
  - Rely on intact peritoneum to contain & tamponade
Angiography

- Method of diagnosing & controlling life-threatening arterial hemorrhage in pelvic fractures
- Indicated in hemodynamic instability when...
  - Thoracic source r/o
  - External source r/o
  - Negative DPL
  - Presence of pelvic fx
- Use in conjunction with mechanical fracture stabilization (Ex-Fix)
Pelvic Fractures

- Several classification systems exist
  - Young & Burgess
    - Based on mechanism of injury & direction of force
    - "most clinically useful" – Tintinalli 6th Ed.
  - Kane Modification of the Key & Caldwell
    - Morphological, based on xray & number of breaks
  - Tile Classification
    - 3 groups based on energy, mechanism & direction
    - Does not include acetabular fractures
Young & Burgess Classification

- Lateral Compression
- AP Compression
- Vertical Shear
Lateral Compression

- Laterally directed force
- Inward rotation of the hemipelvis
- Coronal fx of pubic rami
- Impaction fx of ipsilateral sacral wing posteriorly
- Compression of ipsilateral sacrotuberous & sacrospinous ligaments
- Three grades of LC injury