Diagnostic Imaging Dilemmas

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Disclosures

• None
Objectives

• Using a case based scenario, at the end of this session, the learner will be able to discuss the best imaging techniques for:
  – Minor head trauma
  – Neck injuries
  – Abdominal pain
  – Suspected pulmonary embolism
Frontmatter

• Vast increase in use of diagnostic imaging
  – CT scan use tripled between 1996 & 2010
  – MRI use quadrupled

• Concerns about $$

• Radiation exposure risks

• Pitfalls in diagnosis
  – Misreads
  – False + & -
Decision Support?

• Advent of widespread HER’s has brought clinical decision support

• Data mixed
  – Some show decrease in # of tests ordered, others don’t

• Clinical policies from multiple specialty societies

• ACR Appropriateness Criteria
ACR Appropriateness Criteria

• Evidence based guidelines for imaging use
• Updated frequently when new evidence arrives
• Sometimes in conflict with other specialty societies
• www.acr.org/appropriateness-criteria
Radiation Risk

• Rads, rems, grays, sieverts......
• Most risk is based on extrapolation
• Disconnect between physicians and radiation physicists
Case 1

• An 18 month old is brought in by his parents after a fall at home
• He has a left frontal goose egg and an otherwise normal exam
• No LOC, vomiting, or behavior changes
• What imaging does he need?
Case 1

- CT Head
- Skull Xrays
- Nothing
### Decision Rules for Avoiding CT in Children with Head Trauma

<table>
<thead>
<tr>
<th>&lt;2 Years</th>
<th>≥2 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal mental status</td>
<td>Normal mental status</td>
</tr>
<tr>
<td>No scalp hematoma except frontal</td>
<td>No loss of consciousness</td>
</tr>
<tr>
<td>Loss of consciousness for &lt;5 seconds</td>
<td>No vomiting</td>
</tr>
<tr>
<td>Nonsevere injury mechanism*</td>
<td>Nonsevere injury mechanism*</td>
</tr>
<tr>
<td>No palpable skull fracture</td>
<td>No signs of basilar skull fracture</td>
</tr>
<tr>
<td>Normal behavior</td>
<td>No severe headache</td>
</tr>
</tbody>
</table>

*Severe injury mechanism was defined as motor vehicle crash with patient ejection, death of a passenger, or rollover; pedestrian or bicyclist without helmet struck by a motorized vehicle; fall of >1.5 m for children ≥2 years and >0.9 m for children <2 years; or head struck by high-impact object.
Case 1a

- Now you have a 59 year old male patient arriving by EMS
- He was found face down on a sidewalk
- He smells strongly of ethanol
- He has a small abrasion above his left eye
- He moves everything symmetrically but doesn’t follow commands
- No other trauma noted
New Orleans Rule

Box 1. New Orleans Criteria

Computed tomography is required for patients with minor head injury with any 1 of the following findings. The criteria apply only to patients who also have a Glasgow Coma Scale score of 15.

1. Headache
2. Vomiting
3. Older than 60 years
4. Drug or alcohol intoxication
5. Persistent anterograde amnesia (deficits in short-term memory)
6. Visible trauma above the clavicle
7. Seizure
"Regardless of what your wife says, you do have a backbone and I have the X-ray to prove it."
Case 2

• You have a 30 yo male pt with sudden onset right flank pain
• He appears uncomfortable, is vomiting, and has hematuria
• His abdomen is nontender
• What is the best study?
Case 2

- CT scan of the abdomen w/o contrast
- Kidney US
- IVP
- Nothing
Ultrasonography versus Computed Tomography for Suspected Nephrolithiasis

US vs CT for Stones

- 3638 Patients were assessed for eligibility
  - 229 Were ineligible
  - 309 Declined to participate before eligibility confirmed
  - 324 Were eligible, but declined to participate

- 2776 Underwent randomization
  - 17 Withdrew before any data collected
    - 1 Underwent point-of-care ultrasonography
    - 8 Underwent radiology ultrasonography
    - 8 Underwent computed tomography

- 2759 Were included in intention-to-treat population

- 908 Were assigned to point-of-care ultrasonography
  - 32 (3.5%) Were lost to follow-up
  - 876 Had at least one follow-up assessment

- 893 Were assigned to radiology ultrasonography
  - 49 (5.5%) Were lost to follow-up
  - 844 Had at least one follow-up assessment

- 958 Were assigned to computed tomography
  - 32 (3.3%) Were lost to follow-up
  - 926 Had at least one follow-up assessment
Case 2a

- You have a 75 yo female patient with diffuse abd pain & vomiting
- He has a hx of afib, CAD & HTN
- Her coumadin was recently stopped due to multiple falls
- Her abdomen is diffusely tender with involuntary guarding
- What is the best imaging study?
Case 2a

• Ultrasound
• CT abd/pelvis with IV contrast only
• CT abd/pelvis with IV & PO contrast
• Angiography
### ACR Appropriateness Criteria

<table>
<thead>
<tr>
<th>Appropriateness Designation</th>
<th>Score</th>
<th>AHA/ACC Rec.</th>
<th>Level of Evidence</th>
<th>Additional Published Characteristics Appropriate Imaging Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate</td>
<td>9</td>
<td>I</td>
<td>A - B</td>
<td>- Wide spectrum of patients studied</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>IIA</td>
<td>A - B</td>
<td>- No patient selection bias (consecutive)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>IIB</td>
<td>C</td>
<td>- All patient image results verified (&quot;gold standard&quot; or prognosis)</td>
</tr>
<tr>
<td>Uncertain</td>
<td>6</td>
<td>IIB</td>
<td>B - C</td>
<td>- Blinded interpretation</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>IIB</td>
<td>B - C</td>
<td>- Reproducible acquisition and interpretation</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>IIB</td>
<td>B - C</td>
<td></td>
</tr>
<tr>
<td>Inappropriate</td>
<td>3</td>
<td>III</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>III</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>III</td>
<td>A - B</td>
<td></td>
</tr>
</tbody>
</table>
# ACR Appropriateness Criteria

## Table 1. Variant 1: Acute mesenteric ischemia

<table>
<thead>
<tr>
<th>Radiologic procedure</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTA abdomen with contrast</td>
<td>9</td>
<td>Fast noninvasive study that also evaluates other causes of abdominal pain.</td>
</tr>
<tr>
<td>Arteriography abdomen</td>
<td>8</td>
<td>Allows diagnosis and treatment with a single procedure.</td>
</tr>
<tr>
<td>X-ray abdomen</td>
<td>7</td>
<td>Initial study for patients with acute abdominal pain.</td>
</tr>
<tr>
<td>MRA abdomen without and with contrast</td>
<td>7</td>
<td>Longer when compared to CT. Limited in distal thrombus/embolism or nonocclusive mesenteric ischemia. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
</tr>
<tr>
<td>US abdomen</td>
<td>6</td>
<td>High sensitivity and specificity for venous occlusion, and can assess other causes of abdominal pain.</td>
</tr>
<tr>
<td>MRA abdomen without contrast</td>
<td>3</td>
<td>Lower sensitivity and specificity than MRA that incorporates contrast.</td>
</tr>
</tbody>
</table>
Case 2b

• A 28 yo 27 week pregnant f pt presents with RLQ pain x 24 h
• She is tender in her R mid and lower abd
• She ahs nausea, anorexia, no fevers
• Her FHT are in the 160’s
• She has a WBC count of 16000
• What is the bets imaging study?
Imaging for Appendicitis in Pregnancy

Flowchart:
- Suspected Appendicitis
  - 32 weeks or more
  - <15 weeks
  - >15 weeks
    - BMI
      - <30
        - Ultrasound
      - >30
        - Ultrasound
          - If ultrasound is non-diagnostic
            - MRI (or CT*)
  - MRI (or CT*)
Case 3

- A 24 yo, 32 weeks pregnant f pt presents with pleuritic chest pain and acute dyspnea
- She has had an otherwise uncomplicated pregnancy
- She is tachycardic with symmetric lower extremity edema, a sat of 94%, and a clear CXR
- What imaging study should be done next?
What About Radiation in Pregnancy?

<table>
<thead>
<tr>
<th>X-Ray Examinations</th>
<th>Fetal Absorbed Dose (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical spine (AP, lat)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chest X Ray (PA, lat)</td>
<td>0.002</td>
</tr>
<tr>
<td>Thoracic Spine X Ray (AP, lat)</td>
<td>0.003</td>
</tr>
<tr>
<td>Abdomen X Ray (AP)</td>
<td>1–3</td>
</tr>
<tr>
<td>Lumbar Spine X Ray (AP, lat)</td>
<td>1</td>
</tr>
<tr>
<td>Limited IVP</td>
<td>6</td>
</tr>
<tr>
<td>Barium Enema</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CT Examinations†</th>
<th>Fetal Absorbed Dose (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Head</td>
<td>0</td>
</tr>
<tr>
<td>CT Pulmonary Angiogram</td>
<td>0.2</td>
</tr>
<tr>
<td>CT Abdomen</td>
<td>4</td>
</tr>
<tr>
<td>CT Abdomen Pelvis</td>
<td>25</td>
</tr>
<tr>
<td>CT KUB</td>
<td>10</td>
</tr>
<tr>
<td><strong>Background for 9 months of pregnancy†</strong></td>
<td><strong>0.5 - 1</strong></td>
</tr>
</tbody>
</table>
What About Radiation in Pregnancy?

<table>
<thead>
<tr>
<th>PREGNANCY PHASE</th>
<th>WEEKS POST CONCEPTION</th>
<th>RADIATION EXPOSURE</th>
<th>POSSIBLE CONCEPTUS HEALTH EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-implantation</td>
<td>0 to 2 weeks</td>
<td>Diagnostic exposure (less than 100 mGy [10 rad]) Greater than 100 mGy (10 rad)</td>
<td>Embryo implantation failure; embryo death by cytogenic damage Lethality</td>
</tr>
<tr>
<td>Organogenesis</td>
<td>2 to 7/8 weeks</td>
<td>Less than 50 mGy (5 rad) Greater than 100 mGy to 150 mGy (10 rad to 15 rad)</td>
<td>No increase of significant congenital malformations above background incidence Malformations due to call killing; growth retardation; cataracts, skeletal anomalies, central nervous system abnormalities: microcephaly, mental retardation (risk of severe mental retardation is not increased over background levels)</td>
</tr>
<tr>
<td>Fetal Development</td>
<td>8/9 weeks to 15 weeks</td>
<td>Less than 50 mGy (5 rad) 50 mGy to 500 mGy (5 rad to 50 rad) Greater than 500 mGy (50 rad)</td>
<td>Cancer is the only detectable health risk Dose dependent growth retardation, IQ reduction Increased risk of growth retardation/spontaneous abortion, major malformation, IQ reduction, severe mental retardation</td>
</tr>
<tr>
<td>Mid</td>
<td>16 weeks to 25 weeks</td>
<td>Less than 50 mGy (5 rad) 50 mGy to 500 mGy (5 rad to 50 rad) Greater than 500 mGy (50 rad)</td>
<td>Cancer is the only detectable health risk Not likely to produce health risk except cancer Increase in major malformations and spontaneous abortions; dose dependent growth retardation, IQ reduction, severe mental retardation</td>
</tr>
<tr>
<td>Late</td>
<td>26 weeks to delivery</td>
<td>Less than 50 mGy (5 rad) 50 mGy to 500 mGy (5 rad to 50 rad) Greater than 500 mGy (50 rad)</td>
<td>Cancer is the only detectable health risk Dose dependent neonatal death and spontaneous abortion, major functional anomalies or malformations unlikely</td>
</tr>
</tbody>
</table>

Imaging Options for Suspected PE

Suspected PE in pregnancy

- **Yes**
  - Leg symptoms?
    - **Yes**
      - CUS
        - +
          - Treat
    - **No**
      - CXR
        - Abnl
          - CTPA
            - Nondx
              - Technically inadequate
                - Stop
            - +
              - CUS, CTPA
              - Treat
        - NI
          - V/Q
            - +
              - Stop
            - -
              - CUS, CTPA
              - Treat
              - Stop
Case 3

• A 35 yo m pt is brought in after a motor vehicle collision
• He is intoxicated but alert and can describe the accident well
• He has mild tenderness to his cervical paraspinal muscles but no stepoff or point tenderness to the spine
• What imaging does he need?
Case 3

- Cervical spine XR
- CT cervical spine
- MR cervical spine
- Nothing
### Table 2. NEXUS Criteria For Radiographic Evaluation Of The Cervical Spine Following Blunt Trauma\(^{91}\)

1. Midline cervical tenderness
2. Focal neurologic deficits
3. Altered level of consciousness
4. Evidence of intoxication
5. Painful distracting injury

### Table 4. Canadian Criteria For Detecting Clinically Important Cervical Spine Injury\(^{46}\)

<table>
<thead>
<tr>
<th>High Risk Factors</th>
<th>Low Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 65</td>
<td>Simple rear-end MVC</td>
</tr>
<tr>
<td>Fall &gt; 1 meter</td>
<td>Not pushed into oncoming traffic</td>
</tr>
<tr>
<td>Axial loading injury</td>
<td>Not hit by large bus or truck</td>
</tr>
<tr>
<td>High speed MVC/ rollover/ejection</td>
<td>No rollover</td>
</tr>
<tr>
<td>Motorized recreational vehicle or bike collision</td>
<td>Not hit by high-speed vehicle</td>
</tr>
<tr>
<td>Presence of paresthesias</td>
<td>Sitting position in the ED</td>
</tr>
<tr>
<td></td>
<td>Ambulatory anytime</td>
</tr>
<tr>
<td></td>
<td>Delayed onset of neck pain</td>
</tr>
<tr>
<td></td>
<td>No midline cervical tenderness</td>
</tr>
</tbody>
</table>
CT or Xray?

• Ct largely replacing XR at trauma centers
  – Last EAST guidelines recommend CT as first line
• XR may miss up to 25% of clinically significant spinal injuries
• XR only recommended for low risk neuro intact patients
• C spine fx may be associated with blunt cervical vascular injury
Conclusions

• Multiple data sources to help make imaging recommendation
• If in doubt ask your radiologist
• Take home points
  – CT similar radiation to fetus as VQ
  – US or MRI best initial imaging for suspected appy in pregnancy
  – CT replacing plain films for c spine injury
Questions?

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