Considerations
- Lack of ethical concerns
- Cost effectiveness
- Risk vs. Benefits
- Excessive radiographic procedures

Patient Stressors
- Expense
- Travel
- Time including absence from work or school
- Outcomes
So how do we decide...

- Know the limits of the test
  - Signs and symptoms
  - Risk factors
  - Pathophysiology
- Step 1: Screening tests
- Step 2: Secondary tests
- Remember the individual patient!
  - Basic decision trees will not work for all patients

---

**EXAMPLE**

- 35 yo female presents to office c/o "difficulty breathing" and some hemoptysis.

1. Initial survey:
   - Onset?
   - URI symptoms?
   - Fever?
2. Check out risk factors:
   - Recent surgery
   - Leg, pelvic pain
   - Immobility

---

**Plain Radiograph v. V/Q v. CT w/ Contrast**

<table>
<thead>
<tr>
<th>CHEST X-RAY</th>
<th>V/Q LUNG SCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually normal</td>
<td>Used most frequently</td>
</tr>
<tr>
<td>Hampton’s Hump</td>
<td>Noninvasive</td>
</tr>
<tr>
<td>Westermark’s sign</td>
<td>Normal</td>
</tr>
<tr>
<td>Pleischner’s sign</td>
<td>High probability</td>
</tr>
<tr>
<td>Necessary for correct V-Q interpretation</td>
<td>Low probability</td>
</tr>
</tbody>
</table>
Slide 7

**Pulmonary C-T w/ Contrast**

- Increasingly replacing V-Q scanning
- Positive scan
  - Complete obstruction of a pulmonary vessel
  - Filling defect within the pulmonary artery
- Limitations:
  - Relatively high false-positive rate
  - Difficulty detecting lesions in the lung periphery

---

Slide 8

**Imaging Modalities**

---

Slide 9

**Ultrasound**

- High-frequency sound waves capture images in real-time
- Types:
  1. Conventional
  2. Doppler
    - Color doppler
    - Power doppler
    - Spectral doppler
**Slide 10**

**USN: Risks vs. Benefits**

<table>
<thead>
<tr>
<th>BENEFITS</th>
<th>RISKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Noninvasive</td>
<td>□ No real risks but this is a technician dependant modality</td>
</tr>
<tr>
<td>2. Widely available</td>
<td></td>
</tr>
<tr>
<td>3. Less expensive</td>
<td></td>
</tr>
<tr>
<td>4. No ionizing radiation</td>
<td></td>
</tr>
<tr>
<td>5. Clear pictures of soft tissues</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Slide 11**

**USN: Limitations and Indications**

Limitations:
- Disrupted by gas or air
- Limited by patient body habitus
- Doesn't penetrate bone.

Indications:
1. Heart and blood vessels
2. Internal organs including:
   - Thyroid and parathyroid
   - Liver, pancreas, and gallbladder
   - Kidneys, bladder, uterus, ovaries, scrotum
3. Guided biopsies

**Slide 12**

**Preferred Approach**

- Endometrium (transvaginal)
- Pelvic pain
- Prostate screening (transrectal)
- Testis
- Palpable breast mass
- Parathyroid
- Carotid bruit
- Peripheral vascular disease; peripheral aneurysm
- Renals (secondary HTN etiology)
CT Scanning
- Obtains views from multiple angles giving cross-sectional images of soft tissue and bone.
- 360 degree beam and computer produced images
- Ordered with or without contrast material
  - Water-soluble contrast media increases contrast resolution.
  - Can indicate increased or decreased vascularity in an abnormal area.
Computed Tomography

- Role of CT
  - Main further investigation for most CXR abnormality (eg nodule/mass) or to exclude disease with normal CXR.
  - Main investigation for certain scenarios (PE, dissection, trauma).

Radiation Dose

- Compare dose to normal background radiation (3mSv/year)
- CXR PA view: 3 days
- CXR PA Lat: 18 days
- Low Dose CT: 0.5 year
- HRCT: 1 year
- Helical CT: 2-3 years

Use CT for...

1. Sinus studies
2. Abdomen
3. Detecting loculated fluid collections, abscesses, strangulating obstructions.
4. Chest
5. Brain
Slide 19

CT Contrast: How and When

- 4 methods of administration:
  1. IV
  2. PO
  3. PR
  4. Inhalation

Slide 20

CT: Risks and Benefits

<table>
<thead>
<tr>
<th>BENEFITS</th>
<th>RISKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painless, noninvasive,</td>
<td>Radiation exposure</td>
</tr>
<tr>
<td>accurate</td>
<td>Contrast reaction</td>
</tr>
<tr>
<td>Fast, simple real time</td>
<td>Relatively high cost</td>
</tr>
<tr>
<td>images of bones, tissues,</td>
<td></td>
</tr>
<tr>
<td>vessels all at the same</td>
<td></td>
</tr>
<tr>
<td>time</td>
<td></td>
</tr>
<tr>
<td>Diagnostic</td>
<td></td>
</tr>
<tr>
<td>Cost effective</td>
<td></td>
</tr>
</tbody>
</table>

Slide 21

CT: Limitations and Indications

- Limitations:
  - Patient size
  - Pregnancy
  - MRI superior for some soft tissue details

- Indications:
MRI

- Uses a powerful magnetic field, radio pulses, computer
- Works by inducing transitions between energy states
- Certain hydrogen atoms within a powerful static magnetic field absorb energy and transfer that energy when impacted by a specific frequency radio pulse.
- Computer translates measures of time required to return to relaxation time to visual images.
MRI Images

- **T1-weighted imaging**
  - Bright signal intensity
  - Fat, highly proteinaceous material, subacute hemorrhage, slow-moving blood
  - On T1, water appears dark and soft tissue has intermediate intensity

- **T2-weighted imaging**
  - Bright signal intensity
  - Water
  - Soft tissues, muscles, fat appear dark

---

MRI: Risks and Benefits

<table>
<thead>
<tr>
<th>BENEFITS</th>
<th>RISKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No ionizing radiation</td>
<td>Less effect on specificity</td>
</tr>
<tr>
<td>2. Images directly in multiple planes</td>
<td>High cost</td>
</tr>
<tr>
<td>3. Less operator dependant than USN</td>
<td>Claustrophobia</td>
</tr>
<tr>
<td>4. Higher soft tissue contrast resolution than CT</td>
<td>Metal</td>
</tr>
</tbody>
</table>

---

MRI: Indications

- Imaging of choice for CNS
- Imaging of choice for musculoskeletal system
- Spine and joints
- Equivalent to contrast CT for:
  - Splenic and pancreatic disorders
  - Renal disorders
  - Lymphadenopathy
  - Focal hepatic disease
Slide 28

**Case Example**

- 14-year-old male presents with his father. He is crutch walking and tells you he can’t straighten his knee and when he tries to stand his knee “buckles and gives way.”
- Hint: he’s a catcher for a baseball team
- Diagnosis?
- Imaging?

Slide 29

Lateral view: ruptured patellar tendon
Lateral view: intact patellar tendon

Slide 30

**MRI Indications**

1. Meniscus tear, cruciate or multi ligament injury with pain and instability evidenced by:
   - Pivot shift test
   - McMurray’s sign (meniscus injury)
   - Lachman’s sign (ACL)
2. A suspected ligament injury or meniscus tear without instability AND non responsive to 4 weeks of PT and conservative therapy
3. Avascular necrosis AFTER standard x-rays
4. Baker’s cyst IF USN is non-diagnostic
19 yo female presents with lower abdominal pain and tenderness and fever. She also relates "pain during sex" and vaginal discharge.

**Case Example**

- Diagnosis?
- What imaging modality is preferred as #1?
Slide 34

Case Example

- 36 year old female presents with c/o being "bloated."
- She relates having vague abdominal pressure and "gaining weight" over the past 3-4 months. She now "feels run down" and states "I look pregnant."
- Diagnosis?
- Imaging?

Slide 35

Image of abdominal CT scan with a possible mass.

Slide 36

Case Example

- A neonate is brought in for exam 2 days after hospital discharge. You palpate what feels like an abdominal mass during exam.
- Suspected origin?
- Preferred initial imaging?
Neonatal Obstruction

Meconium plug. Film done with contrast enema shows colon dilated proximally to the plug.

56 yo male presents to your office with a diffusely enlarged abdomen. He tells you he has had no medical care “since high school” but made this appointment because “I can’t button my pants and I feel lousy.”

- Differential diagnosis?
- Imaging technique?

USN

Irregular contour of the left lobe
Slide 40

Cirrhosis

Ascites (A)

Irregular, atrophic liver

Splenomegaly

Increased collaterals within the omentum

Cirrhosis. Taylor, C.R., Yale University School of Medicine

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Slide 41

Case example

- 16-year-old male presenting with right lower quadrant pain and fever.
- + guarding on palpation
- Differential diagnosis?
- Imaging?

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Slide 42

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Case Example

- 6-week-old female brought in by mom because of persistent vomiting. She tells you that a previous provider told her "not to worry" that she was "feeding to fast and not burping correctly."
- On questioning, vomiting is described as projectile, non-bilious. Baby cries if hungry "all the time."
- Diagnosis?
- Imaging?
Plain Radiography

- Least expensive choice
- #1 order for most musculoskeletal problems
  including:
  - Gout
  - OA and RA
  - Neuropathic arthropathy
  - Hip and pelvic fractures
  - Stress fractures
  - Osgood-Schlatter disease
Slide 52

Chest X-Ray: Basic Interpretation

CAREFUL OBSERVATION AND SYSTEMATIC REVIEW

Slide 53

Note the Basics

- Right patient
- Right date
- Position markers
- Upright
  - Right vs. left
  - Patient position
- Technical quality

Slide 54

General to Specific

- Male vs. female
- General body habitus
- Age
  - Infant
  - Child
  - Adult
  - Elderly
- Foreign objects
  - Medical and non-medical
Chest X-Ray: Approach

BE SYSTEMATIC
- Bone and Soft Tissue including abdomen
- Heart
- Mediastinum-aorta, trachea
- Hila
- Pulmonary Vasculature
- Lungs
- Pleura

Chest X-Rays: Know the View

- PA (posterior to anterior) and Lateral (left)
  - Minimizes magnification of heart (heart closest to film)
- Portable (nearly always AP)
  - Supine or Erect
- Specialized Views
  - Lordotic
  - Lateral decubitus (for effusions, pneumothorax)

Normal Anatomy
Lung Anatomy

- Lobes are separated by fissures
- Right
  - Upper Lobe
  - Middle Lobe
  - Lower Lobe
- Left
  - Upper Lobe (includes lingula)
  - Lower Lobe
### Pleura and Fissures

- **Pleura**
  - Lubricates and prevents friction during respiration
  - Potential Space

- **Parietal pleura**
  - Lines chest wall, mediastinal and diaphragmatic surfaces

- **Visceral pleura**
  - Lines lungs, fissures
Clavicles
Spinous Process
Vertebral Body
Visible
6
7
Counting anterior ribs
10
11
Counting posterior ribs
Inspiration/Expiration Images

- Expiration
  - Heart size appear larger
  - Mediastinum is wider
  - Pulmonary vasculature indistinct

Comparison Views

EXPIRATION
INSPIRATION
**Slide 82**

### Abnormal Cases

- Bone
- Cardiovascular
- Airspace Disease including Silhouette Sign
- Interstitial Disease and Pulmonary Edema
- Atelectasis
- Pulmonary Nodule
- Pleura and Diaphragm
- Mediastinal Mass

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**Slide 83**

### Bone and Soft Tissues

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**Slide 84**

### Focus! Soft Tissue and Bones

- Soft tissue
  - Calcifications
  - Abnormal air (subcutaneous emphysema)
  - Any obvious mass effect
- Bones
  - Size, shape, contour
  - Mineralization
  - Fractures or erosions
  - Lytic or blastic regions
Concentrate on the bones.
Alignment
Symmetry
Density
Soft tissues
Subcutaneous emphysema
Calcifications
Tracheal position, size
C-spine:
Alignment
Congenital abnormalities

Lordotic View
Increased Cardiac Size: Cardiac or Pericardial

- Dilated Cardiomyopathy
- Pericardial Effusion
Slide 91

Left Ventricular Enlargement

Slide 92

Airspace Disease

- Filling in of acini (air space)
- Air space (acinar) nodules
- Coalesce to consolidation
- Air bronchograms
- Silhouette Sign

Slide 93
Slide 94

Bronchopneumonia

Airspace Nodules

___________________________________
___________________________________
___________________________________
___________________________________
___________________________________
___________________________________
___________________________________

Slide 95

Air Bronchogram

- Airways
  - Not normally seen in a normal chest radiograph
  - Aerated lung opacification allows visualization of the bronchi due to surrounding contrast effect

Slide 96

Airways

- Not normally seen in a normal chest radiograph
- Aerated lung opacification allows visualization of the bronchi due to surrounding contrast effect
Where is the Pneumonia?

Right Lower Lobe Pneumonia

- Right heart border: Well Defined
- Diaphragm: Some margins poorly seen

Right Lower Lobe Pneumonia

- Right: Partially seen
- Left: Normal
Slide 100

Left Lower Lobe Pneumonia

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Where is the pneumonia?

Slide 102

Horizontal (superior) fissure

Indistinct right heart border
Slide 103: Oblique (major) fissure, Horizontal (minor fissure)

Slide 104: Right Middle Lobe Pneumonia

Slide 105: Interstitial Disease
Interstitial Disease: Pulmonary Fibrosis

Interstitial Disease
- Reticular
  - net-like
- Nodular
- Reticulonodular:
  - Combination of the two patterns

Reticular Pattern

Interstitial Disease Pulmonary Fibrosis
Pulmonary Edema

- Pleural Effusions/Cardiomegaly
- Vascular Redistribution / Enlargement
- Interstitial Changes
  - Indistinct pulmonary vasculature
  - Kerly lines
  - Fissural Thickening
  - Bronchial Cuffing
- Alveolar Edema
  - Perihilar air space disease
  - “Batwing” or “butterfly” appearance
Atelectasis

Left lower lobe collapse
Slide 118

Pulmonary Nodule

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Slide 119

Multiple Nodules

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Pleura and Diaphragm

- Pleural Effusion
  - Lateral decubitus > Lateral > PA in sensitivity
- Pneumothorax
  - Upright
  - Deep sulcus sign in supine
Pleural Effusion in Supine Patient

- Effusion layers posteriorly
- Diffuse increase in density
Classification of Mediastinum

- Anatomic
  - Superior: above sternal angle
  - Anterior
    - Anterior to the heart and great vessels
  - Middle: heart and pericardium
    - Contains heart, great vessels, lymph nodes
  - Posterior
    - Contains descending aorta, esophagus, thoracic duct, lymph nodes
Anterior Mediastinal Mass

- The 4 T’s
  - Thyroid
  - Thymus (Thymoma)
  - Teratoma
  - Tumor (Lymphoma)

Thyroid Goiter
Most common superior mediastinal mass extending to thoracic inlet

Thyroid Goiter
Most common superior mediastinal mass extending to thoracic inlet

Thyroid Goiter
Most common superior mediastinal mass extending to thoracic inlet
Slide 142

40 year old female w/ fever, cough

Slide 143

Post Chest Tube Insertion
Large Pleural Effusion

Slide 144

Large Pleural Effusion Post Chest Tube Insertion
Slide 145

Slide 146

Atelectasis

Slide 147

THANKS FOR LISTENING...