Non-Interpretive Skills

Proper Pulmonary & Cardiac Imaging Ordering
Before You Begin

This module is intended primarily for *clinical medical students* or *interns* intending to learn or review non-interpretive radiology skills.

Please note that while not integral, this module series assumes some familiarity with basic imaging techniques and interpretive skills. If you wish to learn or review these concepts, please see our “Interpretive Skills” module series.

If material is repeated from another module, it will be outlined as this text is so that you are aware
Topics

• Indications
• Tips and tricks for ordering
• Special applications
  • What about MRI?
  • What about CT guided procedures?
• Practice scenarios
Indications
Common clinical scenarios

Symptomatic

• Shortness of breath
• Cough
• Chest pain
• Fever
• Malignancy workup

Asymptomatic

• Lung cancer screening
• Incidental pulmonary nodules
Indications for cardiac imaging

- Aorta
- Pulmonary arteries
- Coronary arteries
- Ischemia
- Cardiomyopathy
- Congenital
Indications for thoracic imaging

- Infection
- Trauma/injury
- Lung cancer
- Metastatic disease
- Diffuse lung disease
Every modality has strengths/weaknesses

- **CXR**
  - Very limited, used for screening

- Non-gated study
  - **Most chest CTs**

- Gated CTA and cardiac MRI
  - High clinical suspicion for a cardiac problem
Which test?

- ACR appropriateness criteria
## ACR Appropriateness Criteria

<table>
<thead>
<tr>
<th>Topic Name</th>
<th>Narrative &amp; Rating Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Chest Pain — Suspected Aortic Dissection</td>
<td>PDF Narrative &amp; Rating Table</td>
</tr>
<tr>
<td>Acute Nonspecific Chest Pain — Low Probability of Coronary Artery Disease</td>
<td>PDF Narrative &amp; Rating Table</td>
</tr>
<tr>
<td>Asymptomatic Patient at Risk for Coronary Artery Disease</td>
<td>PDF Narrative &amp; Rating Table</td>
</tr>
<tr>
<td>Blunt Chest Trauma</td>
<td>PDF Narrative &amp; Rating Table</td>
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<tr>
<td>Chest Pain Suggestive of Acute Coronary Syndrome</td>
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</tr>
<tr>
<td>Chronic Chest Pain—High Probability of Coronary Artery Disease</td>
<td>PDF Narrative &amp; Rating Table</td>
</tr>
<tr>
<td>Chronic Chest Pain-Noncardiac Etiology Unlikely: Low to Intermediate Probability of Coronary Artery Disease</td>
<td>PDF Narrative &amp; Rating Table</td>
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<tr>
<td>Dyspnea-Suspected Cardiac Origin</td>
<td>PDF Narrative &amp; Rating Table</td>
</tr>
<tr>
<td>Imaging for Transcatheter Aortic Valve Replacement</td>
<td>PDF Narrative &amp; Rating Table</td>
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<tr>
<td>Known or Suspected Congenital Heart Disease in the Adult</td>
<td>PDF Narrative &amp; Rating Table</td>
</tr>
<tr>
<td>Nonischemic Myocardial Disease with Clinical Manifestations (Ischemic Cardiomyopathy Already Excluded)</td>
<td>PDF Narrative &amp; Rating Table</td>
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<tr>
<td>Suspected Infective Endocarditis</td>
<td>PDF Narrative &amp; Rating Table</td>
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<tr>
<td>Suspected New-Onset and Known Nonacute Heart Failure</td>
<td>PDF Narrative &amp; Rating Table</td>
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<tr>
<td>Suspected Pulmonary Embolism</td>
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</table>
Ordering tips and tricks
How does your order effect the CT?

• **Section thickness**
  - 1.25 mm is routine at most institutions

• Contrast and timing

• Radiation dose

• Special considerations (e.g. ECG-gating, expiratory imaging)
How does your order effect the CT?

• Section thickness

• **Contrast and timing**

• Radiation dose

• Special considerations (e.g. ECG-gating, expiratory imaging)
Risks of IV contrast

• Allergy
  • No overlap with shellfish allergy, any severe reaction puts patient at higher risk
  • Premedication protocols can help

• Renal toxicity
  • Biggest risk factors are renal insufficiency and contrast dose
## Benefits for chest CT

<table>
<thead>
<tr>
<th>IV contrast is necessary</th>
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<th>IV contrast is NOT helpful</th>
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<td>Pulmonary embolism</td>
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<td>Aortic dissection</td>
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<tr>
<td>CT venogram (e.g. rule out SVC syndrome)</td>
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<td></td>
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<tr>
<td>Cardiac CT</td>
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Pulmonary embolism

Acute pulmonary embolism
Aortic pathology

Aortic aneurysm

Aortic dissection
Coronary artery disease
# Intravenous contrast in chest CT

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<td>Aortic dissection</td>
<td>Lobar collapse</td>
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<tr>
<td>CT venogram (e.g. rule out SVC syndrome)</td>
<td>Mediastinal/hilar abnormalities</td>
<td></td>
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<td>Cardiac CT</td>
<td>Soft tissue infection</td>
<td></td>
</tr>
</tbody>
</table>
Metastatic pleural effusion
RUL collapse from tumor
Sarcoidosis: lymphadenopathy
### Intravenous contrast in chest CT

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<td>Pulmonary embolism</td>
<td>Pleural abnormalities</td>
<td>Lung cancer screening</td>
</tr>
<tr>
<td>Aortic dissection</td>
<td>Lobar collapse</td>
<td>Evaluation of lung nodules</td>
</tr>
<tr>
<td>CT venogram (e.g. rule out SVC syndrome)</td>
<td>Mediastinal/hilar abnormalities</td>
<td>Evaluation of diffuse lung disease</td>
</tr>
<tr>
<td>Cardiac CT</td>
<td>Soft tissue infection</td>
<td>Pretty much any other lung abnormality</td>
</tr>
</tbody>
</table>
Lung cancer
Pulmonary fibrosis
Pneumonia
Contrast timing matters

Early

Late
Alternatives to CT with IV contrast

PE CT → V/Q scan
Alternatives to CT with IV contrast

Dissection CT → MRI or ECHO
How does your order effect the CT?

• Section thickness

• Contrast and timing

• **Radiation dose**

• Special considerations (e.g. ECG-gating, expiratory imaging)
## Radiation doses in milliSieverts

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Dose</th>
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</thead>
<tbody>
<tr>
<td>Airplane flight from SF to NY</td>
<td>0.04</td>
</tr>
<tr>
<td>Yearly cosmic radiation</td>
<td>3</td>
</tr>
<tr>
<td>Yearly cosmic radiation in Denver</td>
<td>5</td>
</tr>
<tr>
<td>Definite increased risk of cancer</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal CXR</td>
<td>0.02</td>
</tr>
<tr>
<td>Lateral CXR</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Low dose chest CT</strong></td>
<td><strong>0.7</strong></td>
</tr>
<tr>
<td><strong>Standard chest CT</strong></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>
Low dose CT

- Follow-up of lung nodule
- Lung cancer screening
- Any young patient getting multiple serial exams
Regular vs. low dose CT

Hard to tell the difference!
How does your order effect the CT?

• Section thickness

• Contrast (intravenous, oral, other) and timing

• Radiation dose

• Special considerations (e.g. ECG-gating, expiratory imaging)
HRCT (high resolution chest CT)

- Bad name!

- Same slice thickness as routine CT nowadays (*routine CT used to have thicker slices years ago*)
  - +/- prone and expiratory imaging
  - Special reconstruction to enhance edges

- No contrast needed

- Use for diffuse lung diseases (aka fibrosis, interstitial lung disease)
Pulmonary fibrosis → CT
When is the prone helpful?

Mild fibrosis?

Gone!
Use of expiratory images
Air trapping

Inhalation

Expiratory
When do I need a gated study?

Gated

• Coronary arteries
• Ascending aorta, aortic root or valve problems (like TAVR)
• Congenital heart disease
Cardiac gating

**PROSPECTIVE** → 70% RR interval

Scanner on at specific points

**RETROSPECTIVE**

Scanner on the whole time
TAVR protocol ➔ gated

• Gated CTA helps plan procedures, such as transcatheter aortic valve replacement (TAVR)
Poor planning
Special applications
<table>
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<tr>
<th>Acquired</th>
<th>Congenital</th>
<th>Vascular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiomyopathy</td>
<td>Adults and children with congenital heart disease</td>
<td>Aortic pathology</td>
</tr>
<tr>
<td>Ischemia</td>
<td></td>
<td>Other vessels</td>
</tr>
<tr>
<td>Hypertrophy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Acquired and congenital pathology

Hypertrophic cardiomyopathy

Bicuspid valve
Acquired and congenital pathology

Normal

ASD and RV dilation
When to use gadolinium?
delayed enhancement patterns

Ischemic

Non-ischemic
Ischemic cardiomyopathy
Non-ischemic cardiomyopathy

Myocarditis

Sarcoidosis
Vascular imaging using MRI

- Can perform magnetic resonance angiography (MRA)
  - Gadolinium
  - New iron-based contrast agent ferumoxytol
Vascular MRI: aortic dissection surveillance
CT guided lung biopsy

• Useful in diagnosis of malignancy

• Needs to be safe/accessible

• Risk/benefit
Biopsy $\rightarrow$ risk/benefit analysis

- Pneumothorax
- Bleeding
- Air embolism
What are your other options?

1. Follow-up CT
2. PET/CT
3. Surgery
Infection resolves

Consider 2-3 month follow up
Practice scenarios
Case 1:

• 65 year old female with severe chest pain

• Ddx:
  • Aortic dissection
  • Myocardial infarction
  • Pulmonary embolism

• What study to order?
Contrast enhanced chest CT

- Acute type A dissection!
- Notice contrast density good in aorta, not very good in pulmonary artery
- Discuss optimal protocol with radiology
Case 2

• 37 year old male with 5 days of cough

• Ddx:
  • Pneumonia

• What study to order?
Start with CXR
CXR may underestimate noncontrast CT
Case 3

• 65 year old male with pulmonary nodule

• Ddx:
  • Lung cancer
  • Infection
  • Benign nodule (granuloma, hamartoma)

• What study to order?
Low dose chest CT
Case 4

• 52 year old with chest pain and new heart failure

• DDx:
  • Myocardial infarction
  • Ischemia cardiomyopathy
  • Nonischemic cardiomyopathy

• What study to order?
Coronary CT → clean
Cardiac MRI → sarcoidosis!
Other tests

• Cardiac catheterization and echocardiography → performed and interpreted by cardiology

• Nuclear medicine myocardial perfusion scan → performed and interpreted by radiology and cardiology
Summary

• Many different indications

• Use tips/tricks to decide the best option

• Call your friendly radiologist for help