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The University of Chicago

Advances in Thoracic Imaging
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- **CXR:** Digital capture – CR, DR
  - Dual Energy
  - Computer-aided Diagnosis

![X-ray Image]
Advances in Thoracic Imaging

• CXR: Digital capture – CR, DR
  Dual Energy
  Computer-aided Diagnosis

• MDCT: Newer image display options
  Emphysema Analysis
  Cardiovascular imaging
  Computer aided Diagnosis
Digital Radiography

**CR**: Computed Radiography with photostimulable phosphor plates
Digital Radiography

**CR**: Computed Radiography with photostimulable phosphor plates

**DR**: Digital Radiography with direct-readout detectors
Digital Radiography

- Image quality
  - Dynamic range
  - Processing

- Interactive
  - Window/Level
  - Zoom

- Image access
  - Local
  - PACS
• 90% of peripheral cancers visible in retrospect - Muhm 1983
• 90% of peripheral cancers visible in retrospect - Muhm 1983
Missed Lung Cancers:
JHM Austin et al. Rad 1992;182:115-122

- Size: 0.6 – 3.4 cm (mean 1.6)
- Location: Upper lobes 81%
- Conspicuity: Overlapping bones in 82%
Single exposure ES uses two detectors separated by a filter

Dual Energy CXR - Single Exposure Technique

X Ray Source

Patient

1st CR plate

Copper filter

2nd CR plate

Single exposure ES uses two detectors separated by a filter
Single exposure ES uses two detectors separated by a filter.

First plate records full energy spectrum for standard image.

X Ray Source

Patient

Copper filter

1st CR plate

2nd CR plate

Dual Energy CXR - Single Exposure Technique
Single exposure ES uses two detectors separated by a filter.

First plate records full energy spectrum for standard image.

Second plate records high energy photons.

Dual Energy CXR - Single Exposure Technique
Dual Energy CXR - Single Exposure Technique

1st CR plate
2nd CR plate

Copper filter

X Ray Source

Patient

Single exposure ES uses two detectors separated by a filter

First plate records full energy spectrum for standard image

Second plate records high energy photons

Weighted subtraction gives soft tissue and bone images
Dual Energy Chest Radiography
Dual Energy Chest Radiography
Dual Energy Chest Radiography
Dual Energy Chest Radiography
74 y/o man with COPD and rales
74 y/o man with COPD and rales
74 y/o man with COPD and rales

Lung Carcinoma
Conventional CXR  
Dual energy soft tissue image
Clinical Advantages of ES Radiography

- Improved detection of pulmonary nodules
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- Improved detection of pulmonary nodules
- Improved rejection of false positives
Clinical Advantages of ES Radiography

- Improved detection of pulmonary nodules
- Improved rejection of false positives
- Improved detection/characterization of calcified pleural plaques
- Improved detection of bone metastases
Previous and Current CXRs

Iterative Warping of Previous CXR

Subtraction
Temporal Subtraction

Benefits
• Improved detection for pulmonary, pleural, mediastinal disease

Status
• Used clinically in Japan, under investigation in the USA
CAD for Chest Radiographs

Enhancement
- Energy Subtraction
- Bone subtraction Imaging
- Temporal Subtraction
- Tomosynthesis

Detection
- Nodules
- Interstitial Dis
- Cardiomegaly
- Pneumothorax
Nodule CAD - True positive with three false positives
Nodule CAD - True positive with three false positives

Observers with CAD (Az=0.83)

Observers without CAD (Az=0.73)

P = 0.005
Advances in CT Technology

- Single slice spiral CT
- Multi-slice CT
Advances in CT Technology

Single slice
4 Slice
8 Slice
16 Slice
40 Slice
64 Slice
256 Slice
??
Isotropic Voxels

10 mm

5 mm

0.5 mm

0.5 mm

0.5 mm
Volume Rendering and Virtual Bronchoscopy
Thorax
MIP (Maximum Intensity Projection)
MINIP: Severe Emphysema
Emphysema: Quantitative Analysis

<table>
<thead>
<tr>
<th></th>
<th>Total Lung</th>
<th>Right Lung</th>
<th>Left Lung</th>
<th>Trachea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (cm³)</td>
<td>4879.14</td>
<td>2584.63</td>
<td>2294.61</td>
<td>44.37</td>
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<tr>
<td>Emphysema (cm³)</td>
<td>1771.49</td>
<td>1102.89</td>
<td>668.60</td>
<td></td>
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<tr>
<td>Ratio (%)</td>
<td>35.31</td>
<td>42.67</td>
<td>29.14</td>
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</table>

Total Lung
Mean: -904.979
SD: 88.6234
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Automated nodule Analysis
3D Nodule Analysis
Non solid and Part Solid Nodules

Benign

Malignant

Benign

Malignant
CT scan with nodule in RUL
Lung Cancer Screening: Prevalence Data from 3 Major US Trials

<table>
<thead>
<tr>
<th>Trial</th>
<th>ELCAP</th>
<th>Mayo</th>
<th>Moffet</th>
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</thead>
<tbody>
<tr>
<td>Subjects</td>
<td>1000</td>
<td>1520</td>
<td>1150</td>
</tr>
<tr>
<td>Nodules</td>
<td>23%</td>
<td>51%</td>
<td>32%</td>
</tr>
</tbody>
</table>
Likelihood of Malignancy Based on Nodule Size

Nodule Size in mm

Natural History and Evaluation of Prevalence Nodules
Midthun, Swensen, Jett et al (Unpublished Data)
Cardiovascular Applications: Coronary CT Angiogram
Cardiovascular Applications: Coronary CT Angiogram
Pulmonary CT Venogram – Pre-ablation
Conclusions

• Energy Subtraction is a powerful tool for nodule detection on CXRs
• Nodule detection CAD is available for CXRs and is improving steadily
• MDCT provides routine off-axis recons with improved depiction of pathology
• CT Nodule detection/comparison has great potential to improve accuracy & productivity