Getting a Good Chest Radiograph: How to

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I have no financial disclosures to report.
Background

• Plain radiographs are common
• Large population based study (Dorman, et al; 2011)
  – 436,711 studies performed using ionization radiation
  – 84.7%: Plain radiography
  – Chest X ray was the most common
Optimizing Image Quality

- Radiologist
- Technologist
- Physicist
- Nursing
- Parents
Goals and Objectives

• Review common errors in obtaining diagnostic quality radiographs in children

• Review new IEC standard nomenclature for receptor exposure
Obtaining a Chest X-Ray: Steps

1. Patient set-up
2. Patient positioning
3. Exposure
Set-up: Removal of Overlying Structures

- Patient clothing
- Tie up hair
- Removal of all overlying structures
- Pitfalls
- Distraction
- Obscuration
4yo female, history of asthma with cough for one week.

Report: Left mid lung opacity suspicious for developing pneumonia. Follow-up radiographs following resolution.
4yo female, history of asthma with cough for one week.
28 weeker; DOL 1; status post surfactant.

Report: ET tube and UV line in appropriate position. UA line projecting over the T6 vertebral body; recommend retraction. Multiple addition lines project over the patient. Surfactant deficiency with right lower lobe atelectasis.
28 weeker; DOL 1; status post surfactant.

Report: Stable positioning of ET tube, UA and UV lines. Multiple additional lines and tubes overly the patient. Increasing right middle and lower lobe atelectasis in the setting of surfactant deficiency.
Following flexible bronchoscopy: broken NG tube from surfactant administration
Root Cause Analysis

1. Technologists must remove all structures overlying and underneath the patient with assistance from nursing.

2. Radiologists must describes all overlying structures.
Patient positioning

- Inherently challenging in pediatric imaging
  - Parental involvement!

Motion degradation
Patient positioning

• Inherently challenging in pediatric imaging
  • Parental involvement!
  • Immobilization devices

https://www.cmxmedicalimaging.com/
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• Rotation
  • The most common cause of unilateral hyper-lucent lung
Patient positioning

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• Rotation
  • The most common cause of unilateral hyper-lucent lung
18 mos, with cough and fever

Report: Small airways inflammation with left lower lobe consolidation. Asymmetric lucent left lung felt to be secondary to rotation to the left.
Repeat radiograph: Non-rotated
2 yo with fever and cough
F/U radiograph two weeks later
Exposure

- Collimation
  - Poor collimation
    - Increases dose
    - Increases scatter

- Technique
Exposure: Screen-Film

- Underexposed – white
- Overexposed – dark
- Easily identifiable
  - Prompt feedback
Exposure: Digital Radiography

- Wide latitude
- Image processing
  - Histogram analysis
  - Automatic rescaling
- Consistent imaging appearance despite variations in technique

Seibert J, Pediatr Radiol. 2011 May;41(5):573-81
Exposure: Digital Radiography

- Significant underexposure: quantum mottle
- Overexposure
  - Unnoticed by radiologists
  - Technologists favor overexposure
  - “dose creep”

Exposure: Digital Radiography

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How can exposure be assessed?

Receptor exposure

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Value</th>
<th>Acceptable range</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUJI</td>
<td>S number</td>
<td>150-300</td>
<td>200/mR</td>
</tr>
<tr>
<td>Carestream</td>
<td>EI</td>
<td>1850-2150</td>
<td>2000 + [1000 x log(mR)]</td>
</tr>
<tr>
<td>Agfa</td>
<td>IgM</td>
<td>2.05-2.35</td>
<td>2.2 + log(mR)</td>
</tr>
</tbody>
</table>

Don, S et al., AJR. 2012 Dec; 199(6):1337-41.
Exposure Reporting

• Lack of uniformity across manufactures
  – Creates confusion
  – Quality difficult to ensure
Standardized Exposure Terminology

- International Electrotechnical Commission (IEC) and American Association of Physicists in Medicine (AAPM)
  - IEC standard terminology

- Exposure Index (EI)
- Target Exposure (EI_T)
- Deviation Index (DI)

What is the Exposure Index?

• Measure of the radiation to the image receptor
• Linearly related to mAS
• Not a measure of the dose to the patient

Don, S et al., AJR. 2012 Dec; 199(6):1337-41.
What is the Target Exposure Index?

• Reference exposure when an *ideal* image is obtained

• Determined by:
  – Manufacturer
  – Modified by imaging center/institution

• Dependent on
  – Body part
  – View

Don, S et al. , AJR. 2012 Dec; 199(6):1337-41.
What is the Deviation Index

• Degree to which the exposure index deviates from the target exposure index.
  – $10 \times \log_{10} \left(\frac{EI}{EI_T}\right)$
  – Suitable radiographic technique

# Deviation Index Usage

## Guidelines for Clinical Practice

<table>
<thead>
<tr>
<th>DI</th>
<th>Exposure</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;3</td>
<td>Overexposure (100%)</td>
<td>Repeat if needed</td>
</tr>
<tr>
<td>1.0 to 3.0</td>
<td>Overexposure (26%)</td>
<td>Repeat if needed</td>
</tr>
<tr>
<td>-0.5 to 0.5</td>
<td>Ideal range</td>
<td></td>
</tr>
<tr>
<td>-1.0 to -3.0</td>
<td>Underexposure (20-50%)</td>
<td>Repeat if needed</td>
</tr>
<tr>
<td>&lt; -3.0</td>
<td>Underexposure (&gt;50%)</td>
<td>Repeat</td>
</tr>
</tbody>
</table>

Exposure Indices

• Deviation index should be displayed on the image
  – Along with mAS and KVP
• Radiologists should be familiar with exposure indicators for their equipment
• Routine monitoring in clinical practice
  – Prompt feedback to technologists
Summary

• Chest X rays are common

• Obtaining a good quality chest radiograph
  – Multiple steps
  – Multiple people, including the radiologist

• Monitor exposure index as part of routine clinical practice