US of the Chest

Monica Epelman  MD
monica.epelman@nemours.org
Historical perspective

• Initially for cardiac echo
• Subsequent studies \(\rightarrow\) non-cardiac applications
  – 1973: Goldberg et al in JCUS
    • 30 mediastinal masses in pts. age 1-84 yrs.
  – 1977: Kangarloo et al in Radiology
    • Juxtadiaphragmatic lesions in children, value of liver window
  – 1980: Haller et al in AJR
    • 28 children - 93% success rate; evaluation of opaque hemithorax, characterizing pleural fluid, guiding drainage, integrity of diaphragm
  – 1984: Claus and Coppens in Ann Radiol
    • Value of thymus as a window for US for mediastinal masses
  – 1984: Miller et al in Radiology
    • “Water path ultrasound of chest disease in childhood”
      – 82 children placed in “Octoson” to expand windows
Diagram of the Otocon, demonstrating the relationship of the patient's chest to the scanning arm and the 8-transducer array (arrowhead) in the decubitus position. Arrow = membrane.

Water-Path Ultrasound of Chest Disease in Childhood

Radiology 1984; 152: 401-408

Empyema.
- Chest radiograph demonstrates almost total opacification of the left hemithorax.
- CT scan through the mid-crest demonstrates opacification of the left hemithorax and displacement of the heart to the right. The nature of the opacification was not resolved by CT.
- Longitudinal (c) and transverse sonograms (d) show that the process in the left chest is a complex mass consisting of large anechoic areas separated by thick septa (arrows).
Historical perspective cont.

- 1986: Rosenberg HK in RG
  - Complimentary role of US and CXR in differentiating pediatric chest abnormalities

- 1989: Glasier et al in J Pediatr
  - Modality of choice for opaque chest, mediastinal masses, and pleural disease

- 1993: Ben-Ami TE et al in RCNA
  - Review

- 2005: Coley BD in RCNA
  - Review
Advantages

• Generic
  – Non invasive, inexpensive, no “contrast”, realtime, Doppler, bedside/portable, some tissue characterization

• Pediatric
  – No radiation
  – Paucity of fat
  – Smaller, more superficial structures

• Pediatric chest
  – Portable
  – Cartilagenous sternum and ribs
  – Thymic window

Disadvantages

• Pediatric chest
  – Aerated lung
    • Requires parenchymal lesion to be superficial
  – Older children
    • Sternum ossified, thymus small
Applications

- Thoracic cage
- Diaphragm
- Mediastinum
- Pleura & Parenchyma
Thoracic Cage
Breast Lumps

• Etiology of breast lumps in children can be clinically challenging

• Anterior chest wall lesions can masquerade as breast lumps due to anatomical relationship between the chest wall and the breast

• Sonography is useful for characterization of these lesions
Technique

- High frequency linear array transducers (7-12 MHz) are useful as the structures evaluated are superficial
- Longitudinal and transverse sections in orthogonal planes
- **Contralateral comparison**
- Compression
- Creating an adequate window
- Making patient comfortable
- Warm gel
US Normal Chest wall

US transverse section at midline
Sternum is hyperechoic (thick arrow), costal cartilage is hypoechoic (thin arrows)
US Normal Chest wall

US longitudinal section
the costal cartilage is hypoechoic
Anterior chest wall masses: “Pseudo” breast lumps

- Prominent anterior convexity of rib or costal cartilage
- Prominent asymmetric costochondral junction
- Tilted sternum
- Subcutaneous/Parachondral nodule

- Phlegmon/Collection
- Lymph node
- Hemangioma
- Hematoma
- Costochondritis
- Lipoma
- Lipoblastoma
Normal variant:
Prominent anterior convex rib
Normal variant: Tilted sternum

- Rib
- Lung
- Pleural reflection
Normal variant:
Asymmetric costochondral junction
Chostochondritis

AREA OF PALP
Chest wall collection
VP shunt disruption
Chest wall hemangioma
Chest wall post-op hematoma
Diaphragm
M-mode sonography of diaphragmatic motion: description of technique and experience in 278 pediatric patients
Background

• Why is this important?
Despite “misleading” benign presentation → high morbidity → 4 main consequences:

**Analogy with obstructive sleep apnea**

- **Sleep fragmentation**
  - Daytime sleepiness
  - Hyperactivity
  - Aggressive behaviour
  - Inverse correlations between memory and learning performance and the severity of OSA

- **Increased work of breathing**
  - Major cardiovascular consequence in adults → Arterial Hypertension → heightened sympathethic tone and enhanced sympathico-adrenal discharge
  - Children → FTT

- **Alveolar hypoventilation**
  - Hypercapnia, particularly while asleep

- **Intermittent hypoxemia**
  - ↑ pulmonary vasoconstriction
  - ↑ pulmonary artery Pressure
  - Pulmonary HTN
  - Cor pulmonare
Clinical conditions suspicious for diaphragmatic dysfunction:

- Unexplained difficulties in weaning a patient from mechanical ventilation
- Persistent elevated hemidiaphragm on chest radiographs
- Unexplained respiratory distress or dependence on oxygen supplementation
- Signs of respiratory distress
- Asymmetric breathing pattern
- Paradoxical movement of the epigastrium
- Recurrent pneumonia
- Recurrent unilateral lung collapse
- Tachypnea / polypnea
<table>
<thead>
<tr>
<th>Associated clinical conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac surgery</td>
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<tr>
<td>Heart transplant</td>
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<tr>
<td>Chest surgery</td>
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<tr>
<td>Lung transplant</td>
</tr>
<tr>
<td>Brachial plexus injury</td>
</tr>
<tr>
<td>Abnormality on CXR</td>
</tr>
<tr>
<td>Abdominal surgery</td>
</tr>
<tr>
<td>Neurological disease</td>
</tr>
<tr>
<td>Myopathy</td>
</tr>
<tr>
<td>Trauma</td>
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<tr>
<td>Spinal surgery</td>
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<tr>
<td>Neck surgery</td>
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</tbody>
</table>
Diagnosis

- CXR $\rightarrow$ non-specific $\rightarrow$ may or may not show elevation of hemidiaphragm
- Fluoroscopy $\rightarrow$ “gold standard”
  - May show conflicting results 😞
  - Radiation exposure 😞
  - Need to transport patient to fluoroscopy unit 😞
  - Need of an assistant to observe the phases of respiration 😞
  - Visualization least mobile anterior third of diaphragm on A-P view 😞
  - Potential misinterpretation if paralysis is bilateral 😞
• Assessment of VC in sitting and supine positions 😷

• Real time US “alone”:
  – Direct assessment, +/- “sniff” test 😷
  – Indirect assessment:
    • Measurement of renal excursion 😷
    • Measurement of cranio-caudal displacement of the left branches of the portal vein 😷
Technique

• Initial conventional B-mode US:
  – Evaluation of upper quadrants and lower chest in longitudinal and transverse planes
  – Midline transverse subxyphoid plane
Technique

• M-mode US:
  – Interrogation of each hemidiaphragm in the longitudinal plane
  – Recording of at least 4 respiratory cycles during spontaneous respiration
  – If patient is mechanically ventilated → temporary disconnection & recordings in both situations

Technique

• Normal excursion:
  – Diaphragmatic motion towards the transducer on inspiration
  – Excursion exceeds 4-5mm
  – Difference of excursion between hemidiaphragms less than 50%

• Decreased excursion

• Paradoxical motion

• Absent motion
## Technique

<table>
<thead>
<tr>
<th>Direction</th>
<th>Transition between inspiration and expiration</th>
<th>Excursion in mm, absolute value</th>
<th>Difference from contralateral side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>normal</td>
<td>sharp/rounded</td>
<td>&gt; 4-5mm</td>
</tr>
<tr>
<td>Paralysis</td>
<td>paradoxical</td>
<td>rounded</td>
<td>variable</td>
</tr>
<tr>
<td>Paresis/dysfunction</td>
<td>normal</td>
<td>rounded/flat</td>
<td>&lt; 4-5mm</td>
</tr>
</tbody>
</table>

4 days later

3 months later
Addition of M-US:

- Allows precise measurement of absolute distance of diaphragmatic displacement
- Permits continuous recording of diaphragm displacements, with measurements of:
  - Amplitude
  - Duration
  - Velocity
- Allows quantification of motion → more “objective” evaluation
- Better for comparison with contralateral hemidiaphragm
- Particularly helpful in tachypnea
- More helpful for comparison on F/U studies
Lungs & Pleura
Technique

- IMAGING PLANES - Coronal, axial, sagittal
- WINDOW - Transabdominal, Transthoracic
  - Loculations: require evaluation of the entire chest
- PATIENT POSITION
  - Supine and Upright
    - Determines loculation vs. free flowing
    - Identify appropriate site for thoracentesis
Pneumonia
Beware!
Conclusion

• Back to the future
• To stay...
  – ...The beautiful images provided by current CT and MR imaging techniques are aesthetically seductive, but it should be remembered that US often provides the clinically needed information at lesser cost, without sedation or radiation exposure...

» From Coley B, RCNA 2005
Thank you for your attention!

Special Thanks to my IR colleagues:
Drs. Craig Johnson and Fab Weber