M-mode US of diaphragmatic motion Technique

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• No disclosures
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 sympathetic tone and enhanced sympaticoadrenal discharge
  - Children → FTT

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

- **Intermittent hypoxemia**
  - ↑pulmonary vasoconstriction
  - ↑pulmonary artery Pressure
  - Pulmonary HTN
  - Cor pulmonare
Pathophysiology - complications

- Desaturations
- Hypercapnia with pulmonary hypertension
- Systemic hypertension
- Arrhythmias
Infants are more severely affected than older children and adults with ↑morbidity (more vulnerable to resp failure):

- Diaphragmatic contraction is less efficient in infants
- Horizontal orientation of the ribs and greater compliance of the rib cage
- Accessory muscles of respiration (intercostals) → poorly developed and adequate ventilation is almost totally dependent on diaphragmatic function
- Increased mediastinal mobility
- Paralyzed diaphragm → ascends into the thorax → reduction of vital capacity especially in the recumbent position
- Small caliber of the bronchial tree → easier to become occluded
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
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OSCAR
Diagnosis

- CXR $\rightarrow$ non-specific $\rightarrow$ may or may not show elevation of hemidiaphragm
Diagnosis

• Fluoroscopy → “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 😞
6 y.o. post surgery for Chiari I and a small syrinx, difficult intubation/extubation, history of LT brachial plexus injury
Advantages of US over fluoroscopy:

- Visualization of all portions of each hemidiaphragm – not just anterior third
- Lack of radiation exposure
- Portability
- Evaluation of adjacent pathology
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
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
How to measure?

LONG RT

Dist = 1.14cm
ΔT = 0.158s
ΔT→ = 379bpm
Slope = 7.20cm/s

45dB ±/+1/ ±/5
M Gain = -16dB

LONG RT

Dist = 1.37cm
ΔT = 0.467s
ΔT→ = 128bpm
Slope = 2.93cm/s

45dB ±/+1/ ±/5
M Gain = -9dB

Cal = 5mm
Beware!
Now is Dr Navarro’s turn...

Thank you for your attention!