PEDiatric Lung Ultrasound

Michalle Soudack MD
Israel
LUNG US - RATIONALE

- Plain films: radiation, takes time
- CT involves radiation, transport
- MR is expensive, compatibility issues, time consuming, transport
LUNG US – RATIONALE 2

Have Gun - Will Travel

Have Probe – Will Scan
“AIR is the enemy of ultrasound”
Lung US - YES

• Lung is not all air

• When there is pathology some of the air is replaced by fluid

• Normal and abnormal lung cause artifacts

• These artifacts can be used for diagnosis
Artifacts:

• any structure in an ultrasound image that does not have a corresponding anatomic tissue structure

• common: they are often the result of the physical properties of ultrasound itself
LUNG US - ARTIFACTS

Clinical Use of Ultrasound in the Early Diagnosis of Pulmonary Embolism

Leonard D. Miller, M.D., Claude R. Joyner, Jr., M.D., Stanley J. Dudrick, M.D., David J. Eskin, B.S.

Characterization of Normal and Abnormal Pulmonary Surface by Reflected Ultrasound

Kiran B. Sagar, M.D.; Theodore L. Rhyne, Sc.D.; Gordon S. Myers, M.D.; and Robert S. Lees, M.D.
PIONEER

- Daniel Lichtenstein MD
- University Hospital Ambroise Paré, France
Lung Ultrasound in the Critically Ill Neonate

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Same signs for neonates!!!
pleural line

A lines
Lung sliding: visceral pleura sliding on parietal pleura lubricated by a small amount of pleural fluid
Normal:
- Regular pleural line
- Vague “A” lines
- Sliding

Pnx:
- Regular pleural line
- “A” lines pronounced
- Absent sliding
Normal
“seashore” sign

Pneumothorax
“stratosphere” sign
“barcode” sign
LUNG POINT

normal  pneumothorax
LUNG POINT
Lung Ultrasound for Diagnosing Pneumothorax in the Critically Ill Neonate

Francesco Raimondi, MD, PhD¹, Javier Rodriguez Fanjul, MD², Salvatore Aversa, MD³, Gaetano Chirico, MD³, Nadya Yousef, MD⁴, Daniele De Luca, MD, PhD⁴, Iuri Corsini, MD⁵, Carlo Dani, MD⁵, Lidia Grappone, MD⁶, Luigi Orfeo, MD⁶, Fiorella Migliaro, MD¹, Gianfranco Vallone, MD⁷, and Letizia Capasso, MD, PhD¹, on behalf of the Lung Ultrasound in the Crashing Infant (LUCI) Protocol Study Group*

**Objectives** To evaluate the accuracy of lung ultrasound for the diagnosis of pneumothorax in the sudden decompensating patient.

**Study design** In an international, prospective study, sudden decompensation was defined as a prolonged significant desaturation (oxygen saturation <65% for more than 40 seconds) and bradycardia or sudden increase of oxygen requirement by at least 50% in less than 10 minutes with a final fraction of inspired oxygen ≥0.7 to keep stable saturations. All eligible patients had an ultrasound scan before undergoing a chest radiograph, which was the reference standard.

**Results** Forty-two infants (birth weight = 1531 ± 812 g; gestational age = 31 ± 3.5 weeks) were enrolled in 6 centers; pneumothorax was detected in 26 (62%). Lung ultrasound accuracy in diagnosing pneumothorax was as follows: sensitivity 100%, specificity 100%, positive predictive value 100%, and negative predictive value 100%. Clinical evaluation of pneumothorax showed sensitivity 84%, specificity 56%, positive predictive value 76%, and negative predictive value 69%. After sudden decompensation, a lung ultrasound scan was performed in an average time of 5.3 ± 5.6 minutes vs 19 ± 11.7 minutes required for a chest radiography. Emergency drainage was performed after an ultrasound scan but before radiography in 9 cases.

**Conclusions** Lung ultrasound shows high accuracy in detecting pneumothorax in the critical infant, outperforming clinical evaluation and reducing time to imaging diagnosis and drainage. (*J Pediatr* 2016;175:74-8).
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B - LINES

• Vertically oriented artifacts

• Indicate an abnormality in the interstitial or alveolar compartment

• Correlate with the amount of lung interstitial fluid
B - Lines

Normal

B lines
B - LINES

- Generated by an air fluid mixture: edematous subpleural interlobar septa surrounded by subpleural air-filled alveoli
- Vertical long comet tail artifacts extending from the visceral pleura
- Obscure A-lines
B - LINES

- Comet tail artifact
- Few – numerous - confluent
- Move with lung sliding
- Are absent with PNX
<table>
<thead>
<tr>
<th>TTN</th>
<th>RDS</th>
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<tbody>
<tr>
<td>• Delayed resorption of fetal lung fluid</td>
<td>• Deficiency of pulmonary surfactant in an immature lung</td>
</tr>
<tr>
<td>• Caesarian section</td>
<td>• Extreme prematurity</td>
</tr>
<tr>
<td>• Self limited</td>
<td>• Antenatal corticosteroids, exogenous surfactant, assisted ventilation</td>
</tr>
<tr>
<td>• Supportive care</td>
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Lung Ultrasound Accuracy in Respiratory Distress Syndrome and Transient Tachypnea of the Newborn

Michela Vergine\textsuperscript{a}  Roberto Copetti\textsuperscript{c}  Giacomo Brusa\textsuperscript{b}  Luigi Cattarossi\textsuperscript{b}

Departments of \textsuperscript{a}Pediatrics and \textsuperscript{b}Neonatology, Azienda Ospedaliero Universitaria ‘S. Maria della Misericordia’, Udine, and \textsuperscript{c}Department of Emergency Medicine, Ospedale Civile di Latisana, Latisana, Italy
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<tr>
<td>Sensitivity</td>
<td>95.6 %</td>
<td>96.5 %</td>
</tr>
<tr>
<td>Specificity</td>
<td>94.4 %</td>
<td>96.5 %</td>
</tr>
<tr>
<td>PPV</td>
<td>91.6 %</td>
<td>93.4 %</td>
</tr>
<tr>
<td>NPV</td>
<td>97.1 %</td>
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TTN

Inferior pulmonary field

Superior pulmonary field

“Double lung point”
PNEUMONIA

- Still a major cause of death in children
- Guidelines include chest radiography
- Guidelines include ultrasound for complications and monitoring thoracocentesis
Pneumonia on US

- Consolidation (air replaced by soft tissue echogenicity)
- Lobar or sub-lobar
- Echogenicity similar to liver ("hepatization")
- Air or fluid bronchogram
PNEUMONIA ON US

- Consolidation (air replaced by soft tissue echogenicity)
- Lobar or sub-lobar
- Echogenicity similar to liver (“hepatization”)
- Air or fluid bronchogram
- Thin pleural line
- Reduced lung sliding
- Shred sign
Lung Ultrasound for the Diagnosis of Pneumonia in Children: A Meta-analysis

Maria A. Pereda, MD⁰, Miguel A. Chavez, MD⁰, Catherine C. Hooper-Miele, MD⁰, Robert H. Gilman, MD, DTMH⁰,
Mark C. Steinhoff, MD⁰, Laura E. Ellington, MD⁰, Margaret Gross, MA, MLIS⁰, Carrie Price, MLS⁰, James M. Tielsch, PhD⁰,
William Checkley, MD, PhD⁰,⁰

⁰Division of Pulmonary and Critical Care and ⁰Welch Medical Library, School of Medicine, and ⁰Department of International Health, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, Maryland; ⁰Biomedical Research Unit, A.B. Prisma, Lima, Peru; ⁰Global Child Health Center, Cincinnati Children’s Hospital Medical Center, College of Medicine, University of Cincinnati, Cincinnati, Ohio; and ⁰Department of Global Health, Milken Institute School of Public Health, George Washington University, Washington, District of Columbia

PEDIATRICS Volume 135, number 4, April 2015
US AND DIAGNOSIS OF PNEUMONIA: THE EVIDENCE

• 2016: 13 papers addressing the topic!!!
US AND DIAGNOSIS OF PNEUMONIA: DISADVANTAGES

• Time consuming?

• Non pleural-based opacities?
  - 98.5% of **adult** lung consolidations extend to the pleura
  - ____% of **peds**?
bacterial consolidation, involves the air space. Characteristically the infection starts in the periphery of the lung, against the pleural surface, and works its way in toward the center of the chest producing a homogenous dense infiltrate.
US AND DIAGNOSIS OF PNEUMONIA: DISADVANTAGES

- Time consuming?
- Non pleural-based opacities?
  - 98.5% of adult lung consolidations extend to the pleura
  - ____% of peds?
- The “big picture” (=whole picture= situation as a whole)?
2 years old, cough and fever, s/p colon interposition due to esophageal atresia.
1.2 years old, cough and fever, diminished breath sounds on left
- US positive for pneumonia in 88/89 patients
- Chest X-ray positive for 81/89 patients
- US identified pleural effusion in 16 cases
- Chest x–ray 3

Caiulo et al, Eur J Ped, 2011
• US positive for pneumonia in 60/79 patients w/susp pneumonia

• Chest X-ray positive for 53 of these patients

Copetti et al, Neonatology, 2007
LUNG ULTRASOUND

- Pnx
- TTN
- RDS
- Pneumonia
- BPD
- Bronchiectasis
- ............ ????????
Pleural / Lung Ultrasound: A Paradigm Shift

• Bedside

• Point of care

• Non radiologists ?????

• Pediatric lungs are little adult lungs

• AIR and it’s artifacts and are now our friends!
PEDIATRIC LUNG ULTRASOUND: CONCLUSIONS

Enemies, a love story

AIR