## Neonatal Point of Care Ultrasound

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#### Outline

- Benefits
- Limitations
- Basics
  - How to intro
  - Important physics
  - Applications
  - Tips and tricks

#### • Point of care:

- Pneumothoraces
- Necrotizing enterocolitis (NEC)

#### **Benefits & value of ultrasound**

- Widely applicable
- Non invasive
- Portable and accessible = bed side / point of care investigation
- Relatively inexpensive
- No radiation
  - can be repeated
- Functional information
  - real time observation- like a "film"
  - Doppler-ultrasound... some value

#### **Restrictions and limitations**

• Frequently used, but often misused

- Equipment
  - Use the right transducer and high resolution
- Personnel
  - Adequate training required (skills and knowledge)
  - Technique variances: inter-observer variability
  - Standardization difficult
- Indications
  - Cannot replace all other imaging eg VCUG or MRI
  - No image if no sound access
    - Bone or gas filled bowel

#### **Basics of ultrasound**

- Image composition
  - sound wave emitted, reflected & received echoes used to calculate an image
- Echo intensity- grayness of image point
- Position calculated from Δ time between sending & receiving
- Visualization
  - echo profile at one point (A-mode)
  - fast serial images (B-mode)
- Two types:
  - Sonoscope
  - Detailed ultrasound

# 50 Shades of Grey

- Echogenicity: ability to return the echo / sound wave
- Hypoechoic: low echogenicity; appears darker
- Hyperechoic: high echogenicity; appears lighter
- Anechoic: lack of echogenicity; completely dark



#### Echogenicity

- Measure of "Acoustic impendence" not density
- Relative to other elements in the frame
- Bones: hyperechoic
- Tendons: hyperechoic
- Nerves: variable (hyperechoic in the upper extremity, hypoechoic in the lower extremity)
- Fat: hypoechoic
- Arteries and Veins: anechoic

### **Types of ultrasound**

#### Sonoscope

- focused
- fast orientation
- extension of clinical exam
- POC
- limited field

#### Detailed

- Meticulous scan
- Need better equipment
- Need proper transducer
- More patient prep (e.g. full bladder, etc.)

### **Some Important Tips**

- Always correlate findings with
  - clinical & laboratory findings
  - patient symptoms & history
- Consider:
  - does US impact treatment?
  - is enough information provided?
  - is additional imaging necessary / useful?
- Important questions:
  - What do I do?
  - How do I do it?
  - When do I do what?
  - How does it look?
  - What shall I do with this now?

#### Lung Ultrasound

- BLUE and FALLS protocol in adults
- Different diseases:
- BLUE = Pneumonia, pulmonary oedema, COPD, asthma, pulmonary embolism, pneumothorax
- FALLS = Tamponade, enlarged right ventricle (PE),
  PTX, cardiogenic (pulmonary oedema)
- Neonates?
- Premature and term = RDS, PTX, PIE, CLD, pulmonary haemorrhage, TTN, MAS, congenital pneumonia

# Technique for Lung Ultrasound (LUS)

- Supine and lateral decubitus ( ± prone)
- High frequency linear probe
  - 10MHz or higher
- Divide chest into 3 areas each side
- Anterior chest (sternum to ant axillary line)
- Lateral (between anterior axillary line and posterior axillary line)
- Posterior (posterior to posterior axillary line)
- Longitudinal / sagittal plane
- 2 additional views
  - Transverse / axial subcostal



#### Planes





#### Longitudinal / sagittal plane

Transverse / axial plane



## What are the main signs to look for?

Normal lung	Abnormal lung
Lung sliding	No lung sliding
Pleural line	Thickened, disappearing, irregular pleural line
A line	No A line
B line	> 3 B lines
Seashore sign	Stratosphere / Barcode
	Lung point
	Bat sign
	Quad sign
	Lung pulse
	Sinusoid sign
	Tissue sign (hepatization)
	Air bronchograms

### **Pleural Line**

- White line
  - Underneath chest wall
  - Visceral and parietal pleura
- Abnormal if:
  - Thickened, disappear, irregular
  - RDS, pneumonia, pulmonary haemorrhage



#### **A lines**

- Horizontal lines in normal lung
- Parallel to chest
- Same distance from each other
- = Reverberation artifact
- Disappear with pathology



#### A Line



### **Normal Lung Sliding**

- Normal lung:
- Lung slides up and down Between parietal and visceral pleura

#### **Sliding Sign**



#### **Seashore Sign**

- Switch to M-mode
- Normal lung :
- Lung sliding seen as a series of straight lines and blurred pattern





#### **B** lines

- Vertical, hyper echoic lines arising from the pleural line, spread downwards
- Well defined, reach edge, erase A lines, move with lung sliding
- "lung rockets"
- Increased lung fluid in interlobular septae, interstitial fluid
- 1 = Normal
  - ≥ 3 Abnormal = "Alveolar Interstitial Syndrome"
- If B lines increase, get "white" lung



## Neonatal Lung Diseases and LUS?

Pneumothorax (PTX)



- RDS
- TTN
- Neonatal Pneumonia
- MAS
- Interstitial Syndrome
- Pleural Effusion

#### Pneumothorax

- Lung US Signs
  - Absence of lung sliding
  - A lines present
  - Lung point NB
  - Barcode / stratosphere sign + (M mode)
  - Absence of B lines
- Presence = 100% NPV, specificity 96.5%
- US shown to be more sensitive than CXR in detecting PTX
- Adults lung ultrasound (LUS )and PTX sensitivity 98.1%, specificity 99.2%



#### **Pneumothorax and lung sliding**



#### **Barcode Sign**

- Switch to M Mode
- "Stratosphere" sign
- Soft tissue and parietal pleura
- Reverberation artifact from the air in PTX
- Barcode = PTX







### "Seashore" = No PTX

"Barcode" + PTX

#### Lung point

- In presence of PTX
- M mode
- Barcode sign anteriorly = PTX
- Move probe laterally
- Pattern may change abruptly
- Barcode NO seashore sign
- If lung point never occurs = Large PTX
- Lung Point "pathognomonic" for PTX
- 100% specific, not very sensitive



# Quick questions for diagnosing pneumothorax

- Lung sliding?
- If "No", A lines?
- If A lines present, is there a lung point?
- Positive lung point = Pneumothorax
- Negative lung point, is there barcode sign?
- Possible large PTX





Protocol and Guidelines for Point-of-Care Lung Ultrasound in Diagnosing Neonatal Pulmonary Diseases Based on International Expert Consensus Liu J, et al. J. Vis. Exp.145 (2019).

### **A Virtual Teaching Technique**

 Shokoohi H, Boniface K. Hand Ultrasound: A highfidelity simulation of lung sliding. Academic Emergency Medicine 2012; 19: 1079-1083



Figure 1. (A) Hand ultrasound: starting probe position against palm. (B) Sliding fingers across the dorsum of the hand or placing the finger in constant contact, with the skin of the dorsum of the hand and moving the dorsal skin of the hand back and forth to create lung sliding and lung point images.



#### **Neonatal Ultrasound for NEC**



#### Pathophysiology of NEC and correlation with radiographic and ultrasonographic



Abdominal ultrasound should become part of standard care for early diagnosis and management of necrotising enterocolitis: a narrative review van Druten J, et al. Arch Dis Child Fetal Neonatal Ed 2019

### **Benefits of abdominal US**

- Current Gold standard: abdominal xray for diagnosing NEC (1 or more of below)
  - Pneumotosis
  - Portal venous gas
  - Pneumoperitonuem

None of XR markers reflecting the degree of ischaemia

#### Can assess the following with US:

#### By 2D

Free air

Mural air

Portal venous gas

Thickened bowel>0.26cm

Thin bowel<0.11cm

Peristalsis

Intestinal signature

Complex fluid

Peritoneal fluid

#### **By Doppler colour**

Normal colour flow

Abnormal colour pattern

Absent colour flow

### **Intestinal signature**

- 1 Mucosal interface with lumen content (echogenic / bright)
- 2 Mucosa (hypo echoic)
- 3 Submucosa (echogenic)
- 4 Musculosa (hypo echoic)
  - 5 Serosa (echogenic)



### **Clinical signs Vs AXR Vs AUS**

Table 3 Stage of NEC<sup>66 74</sup> with correlating presentation on AUS<sup>25 27 35</sup> and abdominal radiograph VON categorisation (modified Bell Progressive wall thickening up to 2.5 mm dominal ultracound (ALIC Suspected NEC ension Progressive wall thickening up to 2.5 mm (Bell's IA) NEC mimickers: Increased bowel wall perfusion and Increased bowel wall perfusion and increased bowel wall echogenicity. mild ileus, FIP Reduced peristalsis. suspected NEC increased bowel wall echogenicity. van unickenning (>2.5 mm). r (Bell's IB) or free (AUS can detect small amounts of Reduced peristalsis. extraintestinal air, not detectable by AR). Reduced or absent peristalsis with or sent. without disorganised peristalsis. ..ວn of intestine and mild ileus. Medical NEC Same as stage IB but may show absent bowel PI Increasing PI. (Bell's IIA) sounds. ±abdominal tenderness. Other further radiographic signs Early PVG (usually detected earlier on NEC mimickers: such as dilated loops of intestine AUS vs AR). cow's milk intelerance and ileus natterns are not considered Diminishing bowel wall perfusion or Medical NEC PVG (air present in the main portal vein out (Bell's IIB) and peripheral portal veins). absence of perfusion. NEC mimicker: systemic illnes Abdominal free fluid in the abdomen and/ Medical NEC Diminishing bowel wall perfusion or (Bell's IIIA) absence of perfusion. NEC mimicker or between the loops. Abdominal free fluid in the abdomen and/ systemic illnes or between the loops. Bowel wall thinning. Bowel wall thinning. Surgical NEC persiste (Bell's IIIB) coupled Complex abdominal free fluid. NEC mimickers: SIP decreasing neutrophil and platelet counts). with FIA on abdominal radiograph after Complex abdominal fluid collections. initial medical signs and symptoms.

FIA, free intraperitoneal air; FIP, feeding intolerance of prematurity; NEC, necrotising enterocolitis; PI, pneumatosis intestinalis; PVG, portal venous gas; SIP, spontaneous intestinal perforation; VON, Vermont Oxford Network.

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## Normal looking bowel LUQ 2.0 C 30/30 H 251 Normal air artifact with active peristalsis

# Bowel wall in NEC-intramural gas







## Bowel wall changes and grading of ischaemia by US



#### **Peritoneal Fluid**



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#### **Colour Doppler imaging**









Necrotizing Enterocolitis: Review of State-of the-Art Imaging Findings with Pathologic Correlation **Epelman et al; Radiographics; 2007** 

#### Portal venous gas



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#### The future....





