Point of Care Ultrasound (PoCUS): Introduction

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Within the past 5 years, I have received financial sponsorship, honoraria and hospitality from the following pharmaceutical companies:

- Actelion
- Astra-Zeneca
- Bayer HealthCare
- Boehringer Ingelheim
- InterMune
- Novartis
Learning Objectives:

At the end of this session and workshop, the participant(s) will:

- **NOT** be skilled ultra-sonographer's
- **NOT** be able to perform a comprehensive “consultative” ultrasound procedure
- Recognize that ultrasound equipment in the hands of an inexperienced operator may cause patient harm
- Recognize your limitations in bedside ultrasound and outline steps to improve your skills
PoCUS

Definition:

– An ultrasound examination provided and performed at the bedside by the primary care physician (or their designate), usually as an adjunct to the physical examination, to identify the presence or absence of a limited number of specific findings.

CAR, 2013. www.car.ca
PoCUS

• Findings from the PoCUS examination **MUST** be correctly integrated into the clinical decision making process.

• If you are not certain of all, or part of the PoCUS examination, you should **NOT** rely on those uncertain findings in the clinical decision making process.
Why ultrasound?

- Portable
- Safe
- Repeatable
- Digital
- Decision support
- Battery operated
- Cost-effective
- Multi-use
“Discovery” in the 1820’s
Industrial Use
Military Use (SONAR)
Medical use begins in 1950’s
History of Ultrasound

Early use of ultrasound focused on therapy

Treatment of gastric ulcers (left) and arthritis (right) in the 1940s.
History of Ultrasound

- Karl Dussik, 1946
  - University of Vienna in Austria
  - Cerebral ventricles
History of Ultrasound

- Howry’s somascope
- 2-D images called “somagrams”
1950’s - Radiology
1960’s – Cardiology
1970’s – Obstetrics & Gynecology
ULTRASOUND FUNDAMENTALS

Many types of probes (also known as transducers) have been developed. A few examples are shown below:

CONVEX PROBE

LINEAR PROBE

PHASED-ARRAY PROBE
ULTRASOUND FUNDAMENTALS

A convex probe uses a lower frequency range, permitting deeper tissue penetration. A linear probe uses a higher frequency range, allowing higher image resolution.
ULTRASOUND FUNDAMENTALS

The convention when the screen marker is on the left of the screen is that the probe marker should be directed to the patient’s head or to the patient’s right side when scanning.
ULTRASOUND FUNDAMENTALS

Objects located closer to the probe marker will appear closer to the marker on the screen.

IMAGE PRODUCED
ULTRASOUND FUNDAMENTALS

Every ultrasound probe has an orientation marker that correlates with another marker displayed on the ultrasound screen.
ULTRASOUND FUNDAMENTALS

Ultrasound machines measure the amplitude or strength of a returning echo. The term echo is used to describe an ultrasound beam returning to its source.
ULTRASOUND FUNDAMENTALS

An ultrasound beam can be reflected back to its source.
ULTRASOUND FUNDAMENTALS

An ultrasound beam reflects back to its source when it encounters an interface between different tissues or media.
Reflection at an interface increases when the density difference between two tissues at an interface increases.
ULTRASOUND FUNDAMENTALS

An ultrasound beam can also be refracted in a new direction.
ULTRASOUND FUNDAMENTALS

Or it can be scattered by an irregular or small interface (such as air).
ULTRASOUND FUNDAMENTALS

Finally, an ultrasound beam can be absorbed by tissues that tend to hold on to acoustic energy.
ULTRASOUND FUNDAMENTALS

Strong returning echoes appear as bright & white (formally, hyperechoic) areas on the ultrasound screen. Weak returning echoes appear as dark gray & black (formally, hypoechoic) areas.
UNDERSTANDING THE IMAGE

There are a variety of scanning modes used in point of care ultrasound. Here we will discuss B- or brightness mode, M-mode or motion mode and D- or doppler mode.
**Table 1. Selected Applications of Point-of-Care Ultrasonography, According to Medical Specialty.**

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Ultrasound Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia</td>
<td>Guidance for vascular access, regional anesthesia, intraoperative monitoring of fluid status and cardiac function</td>
</tr>
<tr>
<td>Cardiology</td>
<td>Echocardiography, intracardiac assessment</td>
</tr>
<tr>
<td>Critical care medicine</td>
<td>Procedural guidance, pulmonary assessment, focused echocardiography</td>
</tr>
<tr>
<td>Dermatology</td>
<td>Assessment of skin lesions and tumors</td>
</tr>
<tr>
<td>Emergency medicine</td>
<td>FAST, focused emergency assessment, procedural guidance</td>
</tr>
<tr>
<td>Endocrinology and endocrine surgery</td>
<td>Assessment of thyroid and parathyroid, procedural guidance</td>
</tr>
<tr>
<td>General surgery</td>
<td>Ultrasonography of the breast, procedural guidance, intraoperative assessment</td>
</tr>
<tr>
<td>Gynecology</td>
<td>Assessment of cervix, uterus, and adnexa; procedural guidance</td>
</tr>
<tr>
<td>Obstetrics and maternal–fetal medicine</td>
<td>Assessment of pregnancy, detection of fetal abnormalities, procedural guidance</td>
</tr>
<tr>
<td>Neonatology</td>
<td>Cranial and pulmonary assessments</td>
</tr>
<tr>
<td>Nephrology</td>
<td>Vascular access for dialysis</td>
</tr>
<tr>
<td>Neurology</td>
<td>Transcranial Doppler, peripheral-nerve evaluation</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>Corneal and retinal assessment</td>
</tr>
<tr>
<td>Orthopedic surgery</td>
<td>Musculoskeletal applications</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>Assessment of thyroid, parathyroid, and neck masses; procedural guidance</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>Assessment of bladder, procedural guidance</td>
</tr>
<tr>
<td>Pulmonary medicine</td>
<td>Transthoracic pulmonary assessment, endobronchial assessment, procedural guidance</td>
</tr>
<tr>
<td>Radiology and interventional radiology</td>
<td>Ultrasoundography taken to the patient with interpretation at the bedside, procedural guidance</td>
</tr>
<tr>
<td>Rheumatology</td>
<td>Monitoring of synovitis, procedural guidance</td>
</tr>
<tr>
<td>Trauma surgery</td>
<td>FAST, procedural guidance</td>
</tr>
<tr>
<td>Urology</td>
<td>Renal, bladder, and prostate assessment; procedural guidance</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>Carotid, arterial, and venous assessment; procedural assessment</td>
</tr>
</tbody>
</table>

* FAST denotes focused assessment with sonography for trauma.
Thoracic/Pleural Ultrasound

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Learning Objectives:

At the end of this session and workshop, the participant(s) will be able to:

• Discuss the appropriate choice of ultrasound probes
• Identify the structures when examining the lung and pleural space
• Identify the pleura, and describe the findings of a pneumothorax
• Describe how B-mode/M-mode are used to identify a pneumothorax
• Identify common ultrasound “patterns” visualized in the thorax
• Describe how to perform a thoracentesis using ultrasound guidance
• Describe static and dynamic ultrasound guidance
Thoracic Ultrasound:

Thoracic Ultrasound:

Solid Organ Ultrasound

Lung Ultrasound

Thoracic Ultrasound:

**B-mode:**
Thoracic Ultrasound:

*M-mode*:
Thoracic Ultrasound:

Thoracic Ultrasound:

Probes:

Phased Array Probe

Linear Vascular Probe

Thoracic Ultrasound:

Probe Location:
Thoracic Ultrasound:

Lichtenstein, D., CHEST 2008, 134:117
<table>
<thead>
<tr>
<th>Condition</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleural Effusion</td>
<td>94</td>
<td>97</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Alveolar Consolidation (Pneumonia)</td>
<td>90</td>
<td>98</td>
<td>88</td>
<td>95</td>
</tr>
<tr>
<td>Interstitial Syndrome (CHF, ARDS)</td>
<td>93</td>
<td>93</td>
<td>87</td>
<td>99</td>
</tr>
<tr>
<td>Complete Pneumothorax</td>
<td>100</td>
<td>96</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>Occult Pneumothorax</td>
<td>79</td>
<td>100</td>
<td>89</td>
<td>99</td>
</tr>
<tr>
<td>AECOPD</td>
<td>89</td>
<td>97</td>
<td>93</td>
<td>95</td>
</tr>
<tr>
<td>Pulmonary Embolism</td>
<td>81</td>
<td>99</td>
<td>94</td>
<td>98</td>
</tr>
</tbody>
</table>

Lichtenstein, D., Ann Int Care, 2014; 4:1-12
Thoracic Ultrasound:

Lichenstein, D., CHEST 2008, 134:117
Thoracic Ultrasound:

5 sonographic “signs” used in the BLUE Protocol:

– Sliding Lung
– A Lines
– B Lines
– Alveolar Consolidation
– Pleural Effusion
Thoracic Ultrasound:

*Lung Sliding:*

*Present*
Thoracic Ultrasound:

Lung Sliding:

Present?  Absent

Thoracic Ultrasound:

*Lung Sliding, B-mode:*
Thoracic Ultrasound:

Absent Lung Sliding, B-mode:
Thoracic Ultrasound:

Lung Sliding (B-mode/M-mode)

http://www.acep.org/
Thoracic Ultrasound:

Absent Lung Sliding:

Other causes:

- Pleural adhesion
- Atelectasis
- Lobectomy/Pneumonectomy
- Main-stem intubation
- Compare with other lung
- Look for “Lung Point” (100% specific for pneumothorax)
Thoracic Ultrasound:

“Lung Point”
Thoracic Ultrasound:

A Lines:

- Horizontal “reverberation” artifacts
- Generally seen in Aerated Lungs
- Parallel to the pleural line
- Decay with increasing depth
- Obliterated by B Lines
Thoracic Ultrasound:

A Lines:

- Seen in normal lung parenchyma
  - $P_{AOP} < 13$ mmHg
- DD(x):
  - Obstructive Lung Disease (COPD/Asthma)
  - Pulmonary Embolism
- $A$ Lines can be seen without lung sliding
  - search for pneumothorax
Thoracic Ultrasound:

A Lines:

http://www.pneumon.org
Thoracic Ultrasound:

A Lines:
Thoracic Ultrasound: 

**B Lines:**

- Hyperechoic rays projecting vertically from pleural line to bottom of screen
  - Obliterate *A Lines*
- Identifies fluid in interlobular septum
- “Interstitial” Syndrome
  - Bilateral
    - CHF, ARDS, ILD
  - Unilateral
    - Pneumonia
Thoracic Ultrasound: B Lines:

Thoracic Ultrasound: B Lines:

http://www.criticalecho.com
Thoracic Ultrasound: 

B Lines:

1st reflection 2nd 3rd n

US transducer
US beam
thoracic wall
pleura
lung
water rich structure
screen

time

n

http://www.criticalecho.com
Thoracic Ultrasound:

*B Lines:*
Thoracic Ultrasound

B Lines:

Clinical Role of B Lines:

Fluid “Intolerant” vs Fluid “Tolerant”
Thoracic Ultrasound:

A Lines vs B Lines:
Thoracic Ultrasound:

Consolidation:

Thoracic Ultrasound:

Consolidation:

Air bronchograms
Thoracic Ultrasound:

Consolidation:

LUNG CONSOLIDATION

AIR BRONCHOGRAMS

http://www.criticalecho.com/content/tutorial-9-lung-ultrasound
Thoracic Ultrasound:

**Consolidation:**

- **LUNG CONSOLIDATION**
- **AIR BRONCHOGRAHAM**

[Link](http://www.criticalecho.com/content/tutorial-9-lung-ultrasound)
Thoracic Ultrasound:

Pleural Effusion:

Thoracic Ultrasound:

**Pleural Effusion:**
Thoracic Ultrasound:

Pleural Effusion:
Thoracic Ultrasound:

Pleural Effusion:

“Jelly Fish” sign

http://www.critcaresono.com
Thoracic Ultrasound:

Pleural Effusion:

“Jelly Fish” sign / Lung Flapping
Thoracic Ultrasound:

Pleural Effusion:

- Septations
- "Plankton" sign
Thoracic Ultrasound:

Thoracentesis:

http://www.critcaresono.com/
Thoracic Ultrasound:

**Thoracentesis:**

Localize deepest "pocket" of fluid in longitudinal and transverse plane

Thoracic Ultrasound:

**Thoracentesis:**

Must Identify:
- Anechoic free space
- Chest wall
- Diaphragm
  - Above vs below
  - Respiratory Movement
- Compressed Lung
  - “Flapping”

http://link.springer.com/referenceworkentry
Thoracic Ultrasound:

Thoracentesis:

"Static" Guidance

"Dynamic" Guidance

http://www.critcaresono.com/
Thoracic Ultrasound:

Thoracentesis:

“Static” Guidance

“Dynamic” Guidance

Thoracic Ultrasound:

Thoracentesis:

1. Local anesthetic is used. Note that the needle should not be advanced beyond the distance from the skin to the chest cavity as demonstrated on ultrasound.

2. Insert needle while simultaneously aspirating on syringe. Note the needle should not be advanced more than the distance to the pleural fluid as demonstrated on ultrasound.

3. Remove syringe.

4. Attach 3-way stopcock, syringe and tubing.
Thoracic Ultrasound:

**Thoracentesis:**

1. Aspirate pleural fluid into syringe.
2. Turn stopcock valve to allow pleural fluid to drain into tubing.
3. Remove syringe.
4. Replace cap and puncture vacutainer with tubing needle to drain pleural fluid. (Ensure that the vacutainer is below the level of the insertion site)

[Image source: http://www.med.uottawa.ca/courses/]
Thoracic Ultrasound:  
*Thoracentesis*:  

**Pearls & Pitfalls:**

- Identify anatomic boundaries:
  - Anechoic free space
  - Chest wall
  - Diaphragm
    - Diaphragm movement?
  - Compressed lung
    - Lung flapping?

- R/O ascites:
  - Hepatorenal/splenorenal space vs pleural space?