Clinical Ultrasound Applications

Katrina Wogu PA-C RDMS
Charles T Dotter Department of Interventional Radiology
OHSU
Objectives

- Review common indications for obtaining ultrasound
- Review ultrasound machine fundamentals
- Discuss ultrasound imaging artifacts/pitfalls
- US workshop
- Clinical (bedside)
- Diagnostic (formal)
Indications for Clinical Ultrasound

- Trauma

- Quicker diagnosis
  - Abdomen - GB, Kidney, Ao/IVC
  - FAST
  - Small parts
  - Soft Tissue
  - Foreign bodies
  - Vascular
  - Musculoskeletal
  - US-guided procedures
Prerequisites for Clinical Ultrasound

- Operator dependent
  - Practice!
  - Comfortable with US interpretation
  - Know cross-sectional anatomy
- Certified training programs
- Obtain formal ultrasound if unsure
Indications for Diagnostic Ultrasound

- Abdomen
- Breast
- Thyroid
- Testes
- OB/Gyn
- MSK
- Vascular
- Cardiac
- Some foreign bodies
- Infants/Pediatrics
- Biopsy

- Large HCC
- Breast Cancer
- Thyroid Adenoma
- Testes w/ R Hydrocele
- Popliteal DVT
- Glass Fragments
- Neonatal Head ICH
- Gartner’s Duct Cyst
Physics
Instrumentation
Scanning Technique

US Machine Fundamentals
- Hertz (Hz) = cycles per second (c/s)
- US = 2-15MHz
- Wavelength
  - Long = low frequency
    - More penetration
    - Poor resolution
  - Short = high frequency
    - Less penetration
    - Good resolution
Basic Ultrasound Machine Operation

Propagation of Speed
- Optimal - fluid, soft tissue, organs

<table>
<thead>
<tr>
<th>Medium</th>
<th>Velocity (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>1450</td>
</tr>
<tr>
<td>Water</td>
<td>1480</td>
</tr>
<tr>
<td>Soft tissue</td>
<td>1540</td>
</tr>
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Basic Ultrasound Machine Operation

Propagation of Speed

- Suboptimal - air, gas, bone

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14 weeks

36 weeks
**Basic Ultrasound Machine Operation**

**Instrumentation**
- 2D (B-mode)
- 3D/4D
- M-mode
- Doppler - Pulsed, Color, Power
- Harmonics
- Gain
- TGC’s
- Depth
- Focal zone
Basic Ultrasound Machine Operation

Terminology

- Echogenicity = structure’s ability to produce echoes
  - **Anechoic**: does not reflect echoes
  - **Isoechoic**: reflects echoes equal to surrounding structures
  - **Hypoechoic**: reflects fewer echoes than surrounding structures
  - **Hyperechoic**: reflects more echoes than surrounding structures

*Terminology is relative to surrounding structures (i.e. kidney is hypoechoic to liver)*
Basic Ultrasound Machine Operation

Transducer Selection

**Curved**
- Larger footprint
- FAST, Abdomen, OB/Gyn, pediatrics

**Sector**
- Smaller footprint
- Lower resolution
- Cardiac, obese patients

**Linear**
- Soft tissue, small parts, FB, pediatrics, central line placement
- Highest resolution

**Endovaginal**

**Transrectal**
Basic Ultrasound Machine Operation

Transducer Selection
- Stand at patient’s right
- Hold transducer relative to anatomy
- **SAX**: notch toward patient’s right
- **LAX**: notch toward patient’s head
- **Exceptions**: cardiac imaging
- Use enough gel
FAST
Focused Assessment with Sonography for Trauma
FAST

- RUQ
- LUQ
- Pericardial
- Pelvis
- E-FAST (extended):
  - Pneumothorax
  - Hemothorax
  - Pleural effusion

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RUQ

Normal RUQ

Free Fluid in Morrison’s Pouch
FAST

LUQ

Normal LUQ

Perisplenic Fluid Collection

Perisplenic Clot
FAST

Pericardial/Subxiphoid

Normal 4Ch

Pericardial Effusion
FAST

Pelvis

- Free fluid
- Physiologic
- Ascites
- Blood
- Ruptured OV cyst
- Ruptured ectopic pregnancy

Normal Pelvis

Ruptured Ectopic w/ FF in CDS
E-FAST

Lung & Pleural Space

Pneumothorax

Hemothorax

Normal Lung

M Mode Marker at Pleura

No Motion
Chest Wall Waves

Positive
Motion Lung Beach

Seashore Sign

No Motion
Lung

Pneumothorax

No Motion
Chest Wall

Barcode/Stratosphere Sign
E-FAST

Lung & Pleural Space

Hemothorax

Pleural Effusion
IVC & Aorta
<table>
<thead>
<tr>
<th>IVC</th>
<th>Aorta</th>
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<tbody>
<tr>
<td>Right side</td>
<td>Left side</td>
</tr>
<tr>
<td>Intrahepatic</td>
<td>Extrahepatic</td>
</tr>
<tr>
<td>Varies with respiration and volume status</td>
<td>Pulsatile</td>
</tr>
<tr>
<td>Connects to RA/HV</td>
<td>Seagull sign</td>
</tr>
<tr>
<td></td>
<td>Possibly atherosclerotic</td>
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# IVC vs. Aorta

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![Transverse view of IVC and Aorta](image.png)
Indications
- Volume status
- PE/DVT
- Post-thrombotic syndrome
- Subxiphoid or R intercostal approach
- Transducer marker toward head (sagittal) or R flank/side (TRV)
  - <2cm TRV diameter = Normal
  - Inspiratory collapse - consider hypovolemia
  - >2cm = clinical correlation
    - Pressure or volume overload
    - Athlete
Subxiphoid or R intercostal approach

Transducer marker toward head (sagittal) or R flank/side (TRV)
  - <2cm TRV diameter = Normal
    - Inspiratory collapse - consider hypovolemia
  - >2cm = clinical correlation
    - Pressure or volume overload
    - Athlete
**IVC**

**Respiratory variation**
- Normal, euvoicmic

**No respiratory variation**
- Congestion, obstruction

Stanford University. Echocardiography in ICU
Caval Thrombus

- Blood clots - higher risk of propagation
- Tumor - extrinsic compression
- Post-thrombotic syndrome
IVC Filters

- Multiple designs
  - Permanent versus Retrievable
- Typically infrarenal
- Evaluation
  - 2v XR Abd (AP & lat)
  - CT w/ delayed venous phase

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**Retrievable**

<table>
<thead>
<tr>
<th>Type</th>
<th>Densil</th>
<th>OptEase</th>
<th>Gunther tulip</th>
<th>Cook Celect</th>
<th>Option</th>
<th>ALN filter</th>
<th>Crux filter</th>
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<tr>
<td>Diagram</td>
<td><img src="image1.png" alt="Diagram" /></td>
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<td><img src="image6.png" alt="Diagram" /></td>
<td><img src="image7.png" alt="Diagram" /></td>
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</table>

**Non-retrievable**

<table>
<thead>
<tr>
<th>Type</th>
<th>Titanium Greenfield</th>
<th>Over the Wire Greenfield</th>
<th>Vena Tech LP</th>
<th>Vena Tech LGM</th>
<th>Simon Nitinol Filter (SNF)</th>
<th>TrapEase</th>
<th>Gianfitto-Roncalli Bird’s nest</th>
</tr>
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<tr>
<td>Diagram</td>
<td><img src="image8.png" alt="Diagram" /></td>
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<td><img src="image14.png" alt="Diagram" /></td>
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Many more!!
IVC Filters

- Multiple designs
  - Permanent versus Retrieved
- Typically infrarenal
- Evaluation
  - 2v XR Abd (AP & lat)
  - CT w/ delayed venous phase

CTV - thrombus w/in filter
XR - normal GT
Aorta
Aorta

**Indications**
- Pulsatile mass
- Known AAA, new symptoms
- AAA surveillance
- **Proximal**: subxiphoid or R intercostal approach
- **Mid/distal to iliacs**: mid abdomen to umbilicus
- Transducer marker toward head (sagittal) or R flank/side (TRV)
  - <3cm TRV diameter = Normal
  - Measure outer to outer
Aorta

Aneurysms

True aneurysm
- Intima, media, adventitia intact
- Fusiform or saccular

Pseudoaneurysm
- Trauma
- Recent intervention

Infrarenal vs suprarenal

Courtesy: radiopaedia.org
Aorta

Aneurysms

True aneurysm
- Intima, media, adventitia intact
- Fusiform or saccular

Pseudoaneurysm
- Trauma
- Recent intervention

Infrarenal vs suprarenal

 Courtesy: ultrasoundcases.info
Aorta

Aneurysms

True aneurysm
- Intima, media, adventitia intact
- Fusiform or saccular

Pseudoaneurysm
- Trauma
- Recent intervention

Infrarenal vs suprarenal

Fusiform AAA with turbulent flow

Courtesy: Medscape, UC Davis
Aorta

Dissection

- Aortic root > 4cm
  - PLAX
  - measure diam @ end diastole
- Presence of intimal flap

Abdominal aortic dissection

Aortic root dilatation

Courtesy: ultrasoundcases.info; thepocusatlas.com
Gallbladder
Gallbladder

Indications

- RUQ pain, fever, leukocytosis
- Suspect cholecystitis
R subcostal/intercostal approach
Supine or LLD positioning
Transducer marker toward head (sagittal) or R flank/side (TRV)
Normal size <5cm TRV
Normal wall thickness <3mm
Anechoic

Gallbladder
Gallstones

- Single or multiple
- Round or jagged
- Mobile?
- Impacted in neck?
- Wall echo shadow (WES) sign
- +/- Sonographic Murphy’s sign

Gallbladder
Gallbladder

Wall Thickening

- >3 mm
- Measure perpendicular to GB

Courtesy: Ultrasoundcases.info
Gallbladder

Adenomyomatosis
- “Comet-tail artifact”
- Cholesterol deposits in Rokitansky-Aschoff sinuses
- Chronic inflammation
- Typically asymptomatic
Gallbladder

Acute cholecystitis
- Calculous vs acalculous (10%)
- Wall thickening
- +Sonographic Murphy’s
- Pericholecystic fluid

Acute acalculous cholecystitis

Acute calculous cholecystitis
Gallbladder

Sludge

- Layering
- Positional
- Absence of Doppler flow

Sludge with stone in neck

Tumefactive sludge
Gallbladder

Tumor

- Presence of Doppler flow
- Heterogenous
- Similar appearance to sludge

GB carcinoma with lymph mets and stones
US-Guided Procedures

- Central Line Placement
- Chest Tube Placement
- Joint Injection
- Abscess/cyst Aspiration
Central Line Placement

Always visualize needle tip
Chest Tube Placement
Joint Injections

https://www.youtube.com/watch?v=TLpNsmwBGS4
Abscess/Cyst Drainage

Diverticulitis w/ abscess
Artifacts & Pitfalls
Artifacts

- Refraction
- Reverberation
  - Comet-tail
  - Ringdown
- Scatter
- Shadowing
  - Posterior
  - Lateral edge
- Enhancement
Artifacts

- **Mirror Image**
  - Highly reflective surface in path of primary beam
Pitfalls

Normal bowel versus Intra-abdominal abscess
- Peristalsis
- Contrast-enhanced CT
  - Phlegmon vs drainable?
  - Accessibility
- Clinically stability
- Consult IR

Normal gas & fluid-filled bowel

Right adnexal abscess
Pitfalls

Normal bowel versus Intra-abdominal abscess

- Peristalsis
- Contrast-enhanced CT
  - Phlegmon vs drainable?
  - Accessibility
- Clinically stability
- Consult IR
Pitfalls

Normal bowel versus Intra-abdominal abscess

- Peristalsis
- Contrast-enhanced CT
  - Phlegmon vs drainable?
  - Accessibility
- Clinically stability
- Consult IR
Pitfalls

Ascites vs bladder

- Identify bladder jets
- Have patient void
- Presence of Foley?

Normal Bladder (male)

Free Fluid Superior to Bladder

Bladder Jet via Color Doppler
Anderson. Echocardiography: The Normal Examination and Echocardiographic Measurements. 3rd Ed. 2017
Basics of US machine: https://www.youtube.com/watch?v=JqVGq5bE-Y
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Ultrasoundpodcast.com
"There are no mistakes, just happy little accidents"