Point of Care Ultrasound in the ICU

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- I have no disclosures
Ultrasound

- "Ultrasound imaging is among the **fastest, safest** and most universal diagnostic methods ever invented. It provides much of the information that can be obtained by expensive technologies, such as X-ray, computed tomography, or magnetic resonance imagery, and it is the only method to **produce a real-time or live image** that can be interpreted and/or transmitted at the same time. **In the right hands, ultrasound instantly answers many clinical questions, shortening the assessment time and improving outcome.**" NASA website 2015

Ultrasound

- Observation of bat sonar
- Beginning in WWI to detect ships sunk by German subs
- Developed in the 1950s
Early Ultrasound

- 1950’s by radiologists
- 1960’s by cardiologists
- 1970’s by OB/GYN
- 1980’s ultrasound use transitioned to other fields and for use in battlefields, EMS and military
Bovine Ultrasound Specialist

- Development of small and portable machines
- Decreased costs
- Improved resolution of images
- Aka POCUS, WBU, FOCUS

Critical Care Ultrasound

- Development of small and portable machines
- Decreased costs
- Improved resolution of images
- Aka POCUS, WBU, FOCUS
Why CCUS

- Portable
- Lack of Radiation
- Ease of Use
- Rapid Results
- Repeatable exam
- Inexpensive
- Brings the physician back to the bedside

CCUS Elements

- Vascular
- Thoracic
- Abdominal-pelvic
- Cardiac- basic and Advanced
Vascular Ultrasound

- Catheter placement
  - TLC
  - A-lines
- Deep Venous Thrombosis
- Peripheral Vein Access

Ultrasound Use in Vascular Access

- Systemic review and meta analysis of RCT
- 18 Trials (1646 participants)
- Ultrasound resulted in a significantly lower failure rate cannulating the internal jugular- relative risk of 0.14
- Lower failure rate on the first attempt
- Fewer complications with placement

Hind, D et al BMJ 2003; 327
Ultrasound Use for Vascular Access

- Meta-Analysis comparing ultrasound guidance to landmark techniques
  - Decreases need for multiple attempts by 40%
  - Decreases complications by 78%
  - Decreases placement failure by 64%


- Agency for Healthcare Research and Quality listed real-time ultrasound guidance as one of the 12 most highly rated patient safety practices designed to decrease medical errors

Ultrasound Use for Vascular Access

- Ultrasound improved vascular access even in seasoned providers
- Decrease in infectious complications
- May be related to decrease number of attempts
- More attempts may also lead to break down in aseptic technique

Kirakitsos et al. Critical Care 2006; 10(6): 1-8
Peripheral Venous Access

- 3-1-3 Rule
- Veins should be 3cm straight
- Veins should be <1 cm deep
- Veins should be at least 3 mm in diameter

Abdominopelvic Ultrasound

- Possible source of sepsis
- Acute undifferentiated abdominal pain
  - Abdominal aortic anerysm
- Detection of urinary tract obstruction
  - Hydronephrosis
- Bladder Distension
- Ascites
Thoracic Ultrasound

- Presence or absence of pneumothorax
  - Post procedure
- Pleural effusion
  - Presence
  - Thoracentesis
- Normal aeration versus alveolar/interstitial abnormality
- Evaluation of respiratory failure

Advantages

- Study of 404 patients presenting with dyspnea to the ED
  - Ultrasound completed within minutes
  - CXR and interpretation in 1 hour 35 minutes
  - Better accuracy with ultrasound for pleural effusions

Zanobetti, M CHEST 2011;139; 1140-1147

- Observational study in the critical care unit of 301 consecutive patients
  - 90.5% accuracy when compared to standard methods including history, physical, CXR and CT when indicated
  - Test performed within 20 min of presentation to the ICU and lasting <3min

Lichtenstein, D CHEST 2008; 134; 117-125
Advantages

Lung Ultrasound
- Consolidation: 95% diagnostic accuracy
- Interstitial syndrome: 94% diagnostic accuracy
- Pneumothorax: 92% diagnostic accuracy
- Pleural Effusion: 100% diagnostic accuracy

Chest Xray
- Consolidation: 49% diagnostic accuracy
- Interstitial syndrome: 58% diagnostic accuracy
- Pneumothorax: 89% diagnostic accuracy
- Pleural Effusion: 69% diagnostic accuracy


Normal Lung
Pneumothorax

Pleural Effusion
Complex Pleural Effusion

B lines

- 3 or more indicate an alveolar interstitial process
Etiology of B lines

- Smooth pleural line and profuse B lines = CHF
- Irregular pleural line and focal B lines = Pulmonary process such as ARDS
  Copetti et al Cardiovasc Ultrasound 2008 Apr 29;6:16
Advantages of Thoracic Ultrasound

- Reduction in number of images during a hospital stay
- Reduced time to diagnosis
- Improved identification of pleural effusions and pneumothorax compared to chest x-ray

Atelectatic Lung with Small Effusion
Pneumonia

Watch the next four slides in succession- Recruitment Maneuver
Critical Care Echocardiography

- Distinct from complete cardiac echo
- Used to narrow the DDx
- Confirm a diagnosis
- Prompt changes in management
- Follow response to therapy
Critical Care Echo

- 5 Views
- Parasternal long
- Parasternal short
- Apical 4 chamber
- Subxiphoid view
- IVC view

Complete Echo

- Table 1. Recommended images for complete adult 2D transthoracic echocardiography with Doppler* Parasternal long axis 2D image: M mode of left ventricle and left atrium/aorta (if lab standard) Color flow Doppler of valves RV inflow view Color and spectral Doppler Parasternal short axis Short axis view at the aortic valve level and RVOT Color flow Doppler should be used to evaluate aortic, mitral and tricuspid valves Spectral Doppler of RVOT and pulmonary valve Left ventricle at LV level Left ventricle at mid LV level M mode if lab standard Left ventricle at apex Apical four chamber 2D imaging of the four chambers (maximizing length of left ventricle) Color flow Doppler of valvular inflow and regurgitation should be assessed at all valves Pulsed wave Doppler of all valves should be assessed Pulled wave Doppler of pulmonary veins (for diastolic function) Doppler tissue imaging (for diastolic function) Strain and strain rate are optional CW Doppler to evaluate valves Multiple views should be used to get highest velocity of abnormal flows. Transmural color M mode is optional Color flow Doppler of interatrial septum Color flow at interatrial septum to assess for shunt Short axis views Apical five chamber 2D imaging Color flow Doppler of LVOT if aortic stenosis or insufficiency is present or suspected or for calculation of stroke volume/cardiac output CW Doppler of aortic valve if aortic stenosis is present or suspected Apical two chamber 2D imaging Color flow Doppler of IVC assessment IVC images to evaluate size and dynamics Doppler of hepatic veins, when appropriate (Continued)
Goals of Limited Echo

- Is the heart working well?
- Is there a pericardial effusion?
- Identification of right or left ventricular enlargement
- Intravascular volume assessment

Goals of Limited Echo

- Rapid evaluation of hemodynamics
- Characterization of shock state
- Guide management
- Follow evolution and response to therapy
- Used in CPR resuscitation
Complete Echo

- Time delay in performing
- Time delay in interpretation
- Not repeated in time
- TREMENDOUS VALUE IN SERIAL ECHOS
- Clinical disassociation
- Goal directed echo is a supplement not a replacement

Can Intensivists Perform Echocardiograms?

Feasibility and Utility of Goal Directed Echo

- Prospective, observational study
- Intensivists trained with 10 one hour tutorials
- Performed a limited goal directed echo, interpreted images and determined if echo added any information
- Cardiologist repeated exam and gave an opinion of technical adequacy and accuracy of interpretation


Feasibility and Utility of Goal Directed Echo

- Successfully performed diagnostic study 94%  
- Correct interpretation 84%  
- Acquisition time 10.5 minutes ± 4.2 minutes  
- Change in management 37%  
- New information but no change in management 47% of patients

Goals of Limited Echo

- Rapid evaluation of hemodynamics
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Etiology of Shock

- Physician performed goal directed ultrasound protocol for diagnosis and management of hypotension
  - Early goal directed ultrasound led to a more focused differential diagnosis
  - Median number of diagnoses of 4 vs. 9
  - More accurate physician impression of final diagnosis

Jones et al Crit Care Med 2004 Vol 32 No 8 1703-1708
Normal Cardiac Function

Cardiogenic Shock
Goals of Limited Echo

- Rapid evaluation of hemodynamics
- Characterization of shock state
- Guide management
- Follow evolution and response to therapy
- Used in CPR resuscitation

Volume Status

- IVC diameter < 1cm in hypotensive patient indicates preload responsiveness
- Intubated patients who are passively breathing measurement of IVC, respiratory variation in IVC size and small hyperdynamic LV indicate preload sensitivity. Kaplan A et al CHEST 2009; 135: 529-535
- In a patient with sepsis who is passive on mechanical ventilation and in regular cardiac rhythm, IVC variability >12% indicates fluid responsiveness. IVC variability is calculated as follows:
  - maximum IVC diameter - minimum IVC diameter
  - mean IVC diameter
  Barber et al Intensive Care Med 2004; 30:1740-1746
**IVC**

- CVP=3 (0-5 mmHg)
  - IVC diameter <2.1 cm, >50% collapsibility
  - Hypovolemic and distributive shock
- CVP=15 (10-20 mmHg)
  - IVC diameter >2.1 cm, <50% collapsibility
  - Cardiogenic and obstructive shock

- American Society of Echocardiography 2010

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**IVC Collapse**
Plump IVC

Goals of Limited Echo

- Rapid evaluation of hemodynamics
- Characterization of shock state
- Guide management
- Follow evolution and response to therapy
- Used in CPR resuscitation
CPR Resuscitation

- Aide in diagnosis
  - Pericardial Tamponade
  - Profound hypovolemia
- Access for cardiac contractility following a reasonable period of CPR

Cardiac standstill
Cardiac Tamponade

Future of Point of Care Ultrasound

- Transcranial dopplers
- Transesophageal echocardiograms by intensivists
- Ultrasound machines that trend VTI, LVOT allowing providers to trend cardiac output
Conclusion

- Point of Care Ultrasound is fast, inexpensive and portable
- Helpful in narrowing differential diagnoses
- Useful in following patient response to therapeutic maneuvers
- Necessary in bedside procedures such as central line placement, thoracentesis and paracentesis

Conclusion

- Point of Care Ultrasound is valuable in the evaluation of respiratory failure
- Worthwhile in evaluation of the etiology of shock and during CPR resuscitation
Practical Concerns

- Billing
  - CPT 99308 with “26” modifier
  - Must have image and report
  - Independent of critical care time
- Image storage
- Training and Education
- Certification and accreditation
- Quality assurance