Point of Care Ultrasound: Is it the new stethoscope?

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Division of Critical Care
Department of Anesthesiology
University of Michigan
Disclosures

None
Outline

- Clinical case
- History / Background
- Describe POCUS
  - Cardiac
  - Lung
  - Abdominal
  - Airway
- Technology updates
- Competency and training updates
It’s 3AM.....
It’s 3AM.....

“STAT Airway needed”
Dyspnea

Story from the intern:

• 83 yo M
• CAD s/p MI
• Severe AS s/p TAVR 6 days ago
  • c/b CHB → PPM 5 days ago
• “worsening respiratory insufficiency”
Dyspnea

• **Patient:**
  - Tachypnea, increased work of breathing
  - No secretions, “getting tired”
  - Ears becoming purple

• **Vitals:**
  - HR: 128 bpm
  - BP: 96/66 mmHg
  - SpO2: 90% on 100% NRB

• **Labs:**
  - Rising creatinine
  - Lactate 3.2
Dyspnea

- While the anesthesia resident set up for intubation….
- I performed a brief exam with my portable ultrasound….
Focused lung ultrasound
Focused echocardiogram
Change of plans!

- No intubation
- Stat to Cath Lab for pericardiocentesis
  - 750 cc removed
  - Subxiphoid drain left in place
Change of plans!

- No intubation
- Stat to Cath Lab for pericardiocentesis
  - Improved work of breathing
  - Resolution of SVC syndrome
  - Vitals:
    - HR 130s → 80s
    - SBP 80s → 100s
Change of plans!

- No intubation
- Stat to Cath Lab for pericardiocentesis

- Improved work of breathing
- Resolution of SVC syndrome

Vitals:
- HR 130s → 80s
- SBP 80s → 100s

- Avoided potential disaster with intubation!
Point of Care Ultrasound
Point of Care Ultrasound

- Significant role for perioperative care
Point of Care Ultrasound

- Significant role for perioperative care
- Support clinical assessment
Point of Care Ultrasound

- Significant role for perioperative care
- Support clinical assessment
- Feasible to learn
A look at the past...
A look at the past…

• Vascular access
A look at the past…

Internal Jugular Vein Location with the Ultrasound Doppler Blood Flow Detector

JAMES I. ULLMAN, MD*
ROBERT K. STOELTING, MD‡
Indianapolis, Indiana‡

• “Should increase success rate of IJ vein catheterization”
• “Although, some readers may feel [it] is not necessary”
A look at the past...

Doppler Localization of the Internal Jugular Vein Facilitates Central Venous Cannulation

DWIGHT LEGLER, M.D.,* AND MICHAEL NUGENT, M.D.†

TABLE 1. Patients Having Internal Jugular Cannulation

<table>
<thead>
<tr>
<th></th>
<th>Single Pass of Needle</th>
<th>Multiple Passes of Needle</th>
<th>Total No. of Patients</th>
<th>Single Pass Success Rate</th>
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<tbody>
<tr>
<td>With Doppler</td>
<td>17</td>
<td>5</td>
<td>22</td>
<td>77.3% (54.6–92.2)*</td>
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<tr>
<td>Without Doppler</td>
<td>6</td>
<td>15</td>
<td>21</td>
<td>28.6% (11.3–52.2)</td>
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</tbody>
</table>

χ² = 10.24; P = 0.0014. χ² (corrected) = 8.38; P < 0.005.
* 95% confidence intervals.
A look at the past...

Making Health Care Safer
A Critical Analysis of Patient Safety Practices

Evidence Reports/Technology Assessments, No. 43

Editors: Kaveh G Shojania, MD, Bradford W Duncan, MD, Kathryn M McDonald, MM, Robert M Wachter, MD, and Amy J Markowitz, JD, Managing Editor.

Editor Information

Rockville (MD): Agency for Healthcare Research and Quality (US); 2001 Jul.

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Patient Safety Target</th>
<th>Patient Safety Practice</th>
<th>Implementation Cost/Complex</th>
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<tbody>
<tr>
<td>21</td>
<td>Morbidity due to central venous catheter insertion</td>
<td>Use of real-time ultrasound guidance during central line insertion</td>
<td>High</td>
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</tbody>
</table>
A look at the past...

- Regional anesthesia
  - Localization of vasculature before block
  - Real-time imaging of anesthetic spread

- Cardiac anesthesia
  - Transesophageal Echocardiography: Independent image acquisition and interpretation
Translational research

“Studies suggest that it takes an average of 17 years for research evidence to reach clinical practice.”


“It takes an estimated average of 17 years for only 14% of new scientific discoveries to enter day-to-day clinical practice.”

A look at the past…

15-20 years

Simple descriptions
Acknowledging advantages
Adequate scientific evaluation
Integration into clinical practice

Vascular access
Regional anesthesia
Cardiac anesthesia
A look at the past…

15-20 years

Simple descriptions
Acknowledging advantages
Adequate scientific evaluation
Integration into clinical practice

Point of Care Ultrasound

Vascular access
Regional anesthesia
Cardiac anesthesia
More recently…

Point of Care Ultrasound Adoption

Emergency Medicine
Critical Care Specialties
More recently…

Point of Care Ultrasound Adoption

Emergency Medicine
Critical Care Specialties

Perioperative Anesthesia
Point of Care Ultrasound

“POCUS”

Goal Directed Exam

https://www.asra.com
Point of Care Ultrasound

“POCUS”

Goal Directed Exam

Airway
Heart
Lungs
Vascular

Abdomen
Point of Care Ultrasound

“POCUS”

Yes, No, or...
I don’t know

Goal Directed Exam

Airway

Heart

Lungs

Abdomen

Vascular

https://www.asra.com
Point of Care Ultrasound

“POCUS”

Goal Directed Exam

Heart
Lungs
Vascular

Yes, No, or...
I don’t know

Comprehensive or Limited

https://www.asra.com
Point of Care Ultrasound

Bedside  Non-invasive  Available
POCUS: Point of Care Ultrasound
FoCUS: Focused Cardiac Ultrasound
P-POCUS: Perioperative POCUS
PAUSE: Perioperative Anesthesiology UltraSonographic Evaluation
CCUS: Critical Care Ultrasound
BLUE: Bedside Lung Ultrasound in Emergency
FATE: Focused Assessed Transthoracic Echocardiography
FORESIGHT: Focused perioperative Risk Evaluation Sonography Involving Gastro-abdominal, Hemodynamic, and Transthoracic ultrasound
POCUS indications perioperatively

- Preoperative assessment
- Hemodynamic compromise
- Respiratory compromise
- Adjunct to physical exam
POCUS exam features

- Cardiac
- Lung
- Abdominal
- Airway
POCUS: Cardiac exam
Subcostal view
Back to my case...
Plethoric IVC and hepatic veins

RA collapse

RV diastolic collapse
How much pericardial fluid?

- **Trivial**: < 10 mm, < 100 cc
- **Small**: 10-20 mm, < 500 cc
- **Moderate**: > 20 mm, > 500 cc
- **Large**: > 20 mm, > 500 cc
Qualitative assessment of cardiac function

“Eyeballing”
Visually estimated left ventricular ejection fraction by echocardiography is closely correlated with formal quantitative methods

Petri Gudmundsson¹,*, Erik Rydberg², Reidar Winter², Ronnie Willenheimer²


A

4-chamber Simpson Ejection Fraction

Eyeballing Ejection Fraction

r = .86

B

Biplane Simpson Ejection Fraction

Eyeballing Ejection Fraction

r = .90

C

Wall Motion Score Index

r = .92

dyskinetic; akinetic; hypokinetic; normokinetic; hyperkinetic
Visual Estimation of Ejection Fraction by Two-Dimensional Echocardiography: The Learning Curve


Olakunle Akinboboye, M.D., John Sumner, M.D., Aasha Gopal, M.D.,* Donald King, M.D.,* Zhang Shen, M.D.,* Philip Bardfeld, M.D.,† Lisa Blanz, R.N., Edward J. Brown, Jr., M.D.

1st year fellow

Private practice

Experienced sonographer

r = .76

r = .68

r = .72
## Table 2. Differential diagnosis for hemodynamic failure

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<th>Filling</th>
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<th>Contractility</th>
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<td>Tamponade</td>
<td>Sepsis</td>
<td>Pulmonary embolus</td>
<td>Myocardial ischemia</td>
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<tr>
<td>Pneumothorax</td>
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<td>Pulmonary hypertension</td>
<td>LV systolic dysfunction</td>
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<td>Hypovolemia</td>
<td></td>
<td>LVOT obstruction</td>
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<td></td>
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<td>Severe aortic stenosis</td>
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Deshpande R et al. Curr Opin Anaesthesiol. 2017
Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the cause of nontraumatic hypotension in emergency department patients

Alan E. Jones, MD; Vivek S. Tayal, MD; D. Matthew Sullivan, MD; Jeffrey A. Kline, MD

• 184 patients presenting to emergency department in non-traumatic, symptomatic, undifferentiated shock.

<table>
<thead>
<tr>
<th>Group 1 (88pts)</th>
<th>Group 2 (96pts)</th>
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</thead>
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<tr>
<td>• Standard care</td>
<td>• Standard care</td>
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<tr>
<td>• POCUS at time 0</td>
<td>• POCUS at time 15</td>
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<th>Median # viable dx:</th>
<th>6</th>
<th>9</th>
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<tr>
<td>Correct dx @ 15min</td>
<td>80%</td>
<td>50%</td>
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Crit Care Med 2004
POCUS during cardiac arrest

• FEEL protocol:
  • Focused Echocardiographic Evaluation in Life support.

• Adjunct to resuscitation in ACLS
  • Identify or exclude treatable causes:
    • Tamponade, PE, ventricular dysfunction, hypovolemia, fine ventricular fibrillation
    • Differentiating between true PEA or pseudo PEA
ACLS compliant echocardiography (FEEL protocol)

Unresponsive?

Open Airway, look for signs of life

CPR: 30:2 for 2 minutes

Defibrillator/Monitor

Assess Rhythm

Shockable (VF/pulseless VT)

1 shock

Immediately resume CPR for 2 min

On 2nd (and subsequent pulse checks) FEEL and rhythm assessment

Yes: sonographic evidence of reversible causes OR PEA with cardiac activity: Initiate targeted therapy

No sonographic evidence of reversible causes OR PEA without cardiac activity (=EMD)
ACLS compliant echocardiography (FEEL protocol)

- Unresponsive?
  - Open Airway, look for signs of life
  - CPR: 30:2 for 2 minutes
  - Defibrillator/Monitor
  - Assess Rhythm

- Shockable (VF/pulseless VT)
  - 1 shock
  - Immediately resume CPR for 2 min

- Non-shockable PEA/Asystole
  - On 2nd (and subsequent pulse checks) FEEL and rhythm assessment

  - Yes: sonographic evidence of reversible causes OR PEA with cardiac activity: Initiate targeted therapy
  - No sonographic evidence of reversible causes OR PEA without cardiac activity (=EMD)

POCUS on 10s pulse checks
• **Goal:**
  - Evaluate the feasibility and impact of POCUS in ACLS (FEEL protocol)

• **Study description:**
  - prospective observational study
  - undergoing CPR or in a shock state
  - 230 patients

• **Results:**
  - **Cardiac motion detected:**
    - 35% of patients with ECG diagnosis of asystole
    - 58% of patients with PEA arrest
  - **POCUS changed management 78% of the cases**
    - Medications used
    - Identification of fine V-fib
    - Supplementing finger pulse checks
    - Non-ACLS therapy: Pericardiocentesis, Chest tube, TPA
    - Triage
793 patients out-of-hospital or in-ED arrest (PEA or asystole)
POCUS at $T = 0$
Non-randomized, prospective, protocol-driven
20 hospitals
Caution ....

Do not let POCUS interfere with ACLS

- Scanning technique
- Operator experience
Ultrasound use during cardiopulmonary resuscitation is associated with delays in chest compressions

- POCUS during CPR can cause delays in resuscitation
- Prospective cohort study of adults in cardiac arrest
- Mean duration of pulse checks 21.0s with POCUS vs 13.0s without POCUS

Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study

- POCUS during CPR can cause delays in resuscitation
- Prospective cohort study of adults in cardiac arrest
- Median duration of pulse checks 17.0s (13-22.5s) with POCUS vs 11.0s (7-16s) without POCUS
- Shorter pauses with POCUS trained faculty
Transesophageal Echocardiography During Cardiopulmonary Resuscitation Is Associated With Shorter Compression Pauses Compared With Transthoracic Echocardiography

- 139 pulse check CPR pauses among 25 patients during cardiac arrest
- TEE 9s (5-12s) vs POCUS 19s (16-22s)

Diagnostic Accuracy of Transesophageal Echocardiography During Cardiopulmonary Resuscitation

- 48 patients with cardiopulmonary arrest
- Sensitivity 93%
- Specificity 50%
- Positive predictive value 87%
If a qualified sonographer is present and use of ultrasound does not interfere with the standard cardiac arrest treatment protocol, then ultrasound may be considered as an adjunct to standard patient evaluation (Class IIb, LOE C-EO).
POCUS: Lung Exam

Many uses:

- Acute respiratory failure
- Undifferentiated shock
- Management of fluid resuscitation
- Evaluation of intubation
- Serial evaluations: effusion, edema, functional lung volume
- Diaphragm function
POCUS: Lung Exam

Findings:
• Ultrasound artifacts: normal vs abnormal
• Normal, Edema, COPD, Asthma, PE
• Mainstem intubation
• Pneumothorax
• Alveolar interstitial fluid: Congestive heart failure
• Consolidation: PNA, atelectasis
• Pleural effusion
Bedside Lung Ultrasound in Emergency (Acute Dyspnea) — the “BLUE Points”
"A" lines: normal artifact

- Pleural line
- A line
- Bat wings
- Ribs w/ shadowing below "Bat wings"
Lung sliding: normal pleura
Lung sliding: normal pleura

- Pleural line w/ lung sliding
- A line
- Rib
Lung sliding: normal pleura

M mode

Seashore Sign

- Motionless soft tissues
- Pleural line
- Sandy beach
  - Moving
  - Alveolar gas
  - No PTX

No Pneumothorax
• Presence of lung sliding = no PTX at that location

• Absence of lung sliding = possibility of PTX, but....
Absence of Lung sliding?

- Possibility of PTX
- Apnea
- Mainstem intubation
- Pleurodesis
- Severe parenchymal lung disease
Pneumothorax

PTX: “Lung point”
100% specific for PTX
Pneumothorax

M Mode Stratosphere sign

A' profile: A lines, no lung sliding

Lung point
• 382 trauma patients; Lung US compared to CXR
• 100% specific, 95% sensitive for PTX by US

• 176 blunt trauma patients; with CT as gold standard
• US is more sensitive than CXR in the diagnosis of traumatic PTX (98% vs 75%)
• US allowed differentiation between small, medium, and large PTXs with good agreement with CT results.
### Sensitivity

- **US:** 91%
- **CXR:** 50%

![Sensitivity](image)

### Specificity

- **US:** 98%
- **CXR:** 99%

![Specificity](image)

WMD = weighted mean difference; CI = confidence interval

*CHEST 2012; 141(3):703–708*
Back to my case.....Lung exam

- Air rises, fluid sinks to dependent area
- Interaction between air and fluid creates artifacts
“B” lines: Edema
“B” lines: Edema

My case: mild to moderate  
Example: significant
“B” lines: Edema

- Intralobular septa thickening due to edema
- Ground glass pattern due to alveolar edema
Curtain sign: Normal

My case: Normal, no effusion
Curtain sign: Normal

Example: Presence of effusion
Curtain sign: Normal

Pleural effusion w/ consolidation
Pleural effusion: Qualitative volume estimation

- Severe: fluid above AAL
  - $\sim > 1L$
- Moderate: fluid above MAL
  - $\sim > 500cc$
- Mild: fluid above PAL
  - $\sim < 500cc$
Comparative Diagnostic Performances of Auscultation, Chest Radiography, and Lung Ultrasonography in Acute Respiratory Distress Syndrome

Daniel Lichtenstein, M.D.,* Ivan Goldstein, M.D.,† Eric Mourgeon, M.D.,† Philippe Cluzel, M.D., Ph.D.,‡ Philippe Grenier, M.D.,§ Jean-Jacques Rouby, M.D., Ph.D.‖

<table>
<thead>
<tr>
<th></th>
<th>Auscultation, %</th>
<th>Chest Radiography, %</th>
<th>Lung Ultrasonography, %</th>
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<tbody>
<tr>
<td>Pleural effusion</td>
<td></td>
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<tr>
<td>Sensitivity</td>
<td>42</td>
<td>39</td>
<td>92</td>
</tr>
<tr>
<td>Specificity</td>
<td>90</td>
<td>85</td>
<td>93</td>
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<tr>
<td>Diagnostic accuracy</td>
<td>61</td>
<td>47</td>
<td>93</td>
</tr>
<tr>
<td>Alveolar consolidation</td>
<td></td>
<td></td>
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<tr>
<td>Sensitivity</td>
<td>8</td>
<td>68</td>
<td>93</td>
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<tr>
<td>Specificity</td>
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<td>95</td>
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<td>Diagnostic accuracy</td>
<td>36</td>
<td>75</td>
<td>97</td>
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<tr>
<td>Alveolar-interstitial syndrome</td>
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<tr>
<td>Sensitivity</td>
<td>34</td>
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<tr>
<td>Specificity</td>
<td>90</td>
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<tr>
<td>Diagnostic accuracy</td>
<td>55</td>
<td>72</td>
<td>95</td>
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</tbody>
</table>

- 384 Lung regions in 32 ICU pts with ARDS
- Compared to gold standard of CT
- Lung US better:
  - Effusion
  - Consolidation
  - Edema

Anesthesiology 2004; 100:9-15
Putting it all together

• A lines
• B lines
• Lung sliding
• Lung pulse
• Lung point
• Effusion
• Consolidation

BLUE-Protocol and FALLS-Protocol
Two Applications of Lung Ultrasound in the Critically Ill

Daniel A. Lichtenstein, MD, FCCP
CHEST 2015
Bedside Lung Ultrasound in Emergency (Acute Dyspnea) —the BLUE protocol
 Fluid Administration Limited by Lung sonography (FALLS)-protocol

1) Ruling out obstructive shock
   Simple cardiac sonography:
   - Pericardial tamponade
   - Right ventricle dilatation
   BLUE-protocol: pneumothorax (A’-profile)

2) Ruling out cardiogenic shock
   BLUE-protocol: pulmonary edema (B-profile)

3) Ruling out hypovolemic shock
   Correction of parameters of shock under fluid administration

4) Detecting distributive shock, septic shock currently
   Fluid therapy not able to improve circulation, eventually generating a B-profile

Cardiac exam
What about volume status?

- Targeted endpoints frequently remain elusive
  - Static parameters: CVP, RAP, PAD
  - Dynamic indicators: PPV

- POCUS can help!
  - 2-D Qualitative assessment
    - Hyperdynamic
      - End-systolic LV effacement “kissing ventricles”
      - SAM physiology
    - Small collapsed: IVC or SVC
    - Respiraophasic: IVC, SVC, LVOT VTI
IVC diameter and delta
## IVC diameter and delta

<table>
<thead>
<tr>
<th>IVC diameter</th>
<th>Collapse w/ sniff</th>
<th>Estimated RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2.1 cm</td>
<td>&gt; 50%</td>
<td>&lt; 5 mmHg</td>
</tr>
<tr>
<td>Indeterminate</td>
<td></td>
<td>5-10 mm Hg</td>
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<tr>
<td>&gt; 2.1</td>
<td>&lt; 50%</td>
<td>15 mmHg</td>
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</tbody>
</table>

Rudski et al. J Am Soc Echo 2010

![IVC and M-Mode images](image-url)
Fluid responsive?

More likely

Less likely
Hyperdynamic “kissing ventricles”
Which would you give fluid to?

B lines = edema
Focused Abdominal Ultrasound Exam

• Intraperitoneal:
  • Free fluid: ascites, blood
  • Free air
  • FAST / E-Fast exam
• Gastric evaluation
• Renal: hydronephrosis, bladder obstruction
• Abdominal Aorta: Aortic Aneurysm/dissection
FAST / E-Fast exam

TRAUMA FAST EXAM

1. Cardiac-Subxiphoid
2. RUQ-Hepatorenal
3. LUQ-Splenorenal
4. Suprapubic Views
Okay for MAC?

66 yo F for G-tube placement

Appropriately NPO, but…

PMH:
  • Myasthenia Gravis: bulbar, dysphagia
  • DM2
Distance: 2.17 cm
Circumference: 7.39 cm
Area: 4.34 cm²
(< 25 cc)
Gastric Content: Nature and Volume

- Empty, not empty
- Gas, fluid, or solid
- **Gastric antrum** provides the most reliable quantitative information for gastric volume

Perlas A. Anesthesiology 2009
Gastric Content: Nature and Volume

Supine

Cranial

Posterior

Anterior

Caudal
Gas while supine

Solid

Gas while right lat decub

Perlas et al. Anesthesiology, V 111, No 1, Jul 2009
Antral cross-sectional: estimate gastric volume

- Right lateral decubitus
- $5 \text{ cm}^2 < 50\text{cc}$
- $25 \text{ cm}^2 > 300\text{cc}$

Perlas et al. Anesthesiology, V 111, No 1, Jul 2009
gastric volume predicted by gastric antral CSA, stratified by patient age

<table>
<thead>
<tr>
<th>Right lat CSA (cm²)</th>
<th>Age (yr)</th>
<th>20</th>
<th>30</th>
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<td>386</td>
<td>373</td>
<td>360</td>
<td>347</td>
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</table>

Airway exam with ultrasound

- Features predictive of difficult intubation
- Confirmation of endotracheal vs esophageal intubation
- Differentiation between tracheal and bronchial intubation
- Predict size of SLT and DLT
Endotracheal vs endobronchial?

POCUS vs Auscultation

42 patients randomized to L, R or tracheal and positioned fiberoptically.

Blinded anesthesiologists assessed

POCUS or auscultation
Check for lung sliding bilaterally
Check for tracheal dilation
Esophageal intubation
POCUS vs auscultation

<table>
<thead>
<tr>
<th></th>
<th>True Position</th>
<th></th>
<th></th>
<th>True Position</th>
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<tbody>
<tr>
<td></td>
<td>Ultrasound</td>
<td></td>
<td>Auscultation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Main stem</td>
<td>Trachea</td>
<td>Total</td>
<td>Main stem</td>
<td>Trachea</td>
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<td>Trachea</td>
<td>1</td>
<td>14</td>
<td>15</td>
<td>11</td>
<td>10</td>
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<tr>
<td>Main stem</td>
<td>26</td>
<td>1</td>
<td>27</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>15</td>
<td>42</td>
<td>27</td>
<td>15</td>
</tr>
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</table>

Chi-square Comparison (ultrasound vs. auscultation) $P = 0.0005$

<table>
<thead>
<tr>
<th></th>
<th>Number correct</th>
<th>40 (95%)</th>
<th></th>
<th>Number correct</th>
<th>26 (62%)</th>
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</thead>
<tbody>
<tr>
<td>% (95% CI)</td>
<td>Sensitivity</td>
<td>PPV</td>
<td>Sensitivity</td>
<td>PPV</td>
<td></td>
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<tr>
<td>% (95% CI)</td>
<td>Specificity</td>
<td>NPV</td>
<td>Specificity</td>
<td>NPV</td>
<td></td>
</tr>
</tbody>
</table>

POCUS: 95% correct
Sn: 93%
Sp: 96%

Ausc: 62% correct
Sn: 66%
Sp: 59%
Technology updates are making POCUS more accessible

- Ultrasound probes ➔ new tech
- Ultrasound machines ➔ hand held
Traditional probes: Piezoelectric elements

A. Linear array probe
B. Curved array probe
C. Phased array probe
CMUTs – capacitive micromachined ultrasonic transducers

https://www.innovationservices.philips.com
## Portable handheld systems

![Image of portable handheld ultrasound systems]

### Table 1: List of portable handheld ultrasound systems with features

<table>
<thead>
<tr>
<th>Name</th>
<th>Probes</th>
<th>Imaging modes</th>
<th>Transducer</th>
<th>Link</th>
<th>Company</th>
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</thead>
<tbody>
<tr>
<td>Vscan</td>
<td>dual heads</td>
<td>2D, CDI</td>
<td>piezoelectric ceramics</td>
<td>cable</td>
<td>GE Healthcare, USA</td>
</tr>
<tr>
<td>Lumify</td>
<td>S4-1 phased, C5-2 curved, L12-4 linear</td>
<td>2D, M, CDI</td>
<td>piezoelectric ceramics</td>
<td>cable</td>
<td>Philips, USA</td>
</tr>
<tr>
<td>Clarius</td>
<td>C3 Convex, L7 linear, C7 Microconvex, EndoEC7</td>
<td>2D, M, CDI, PDI, PW, PDI</td>
<td>piezoelectric ceramics</td>
<td>wireless</td>
<td>Clarius, CA</td>
</tr>
<tr>
<td>SonoStar</td>
<td>L6C, C6C, Dual heads C5DC, L5P, C5, C5D</td>
<td>2D, M, PW, PDI, CDI</td>
<td>piezoelectric ceramics</td>
<td>wireless</td>
<td>SonoStar, China</td>
</tr>
<tr>
<td>Butterfly iQ</td>
<td>single probe</td>
<td>2D, M, CDI</td>
<td>CMUT/CMOS-based</td>
<td>cable</td>
<td>Butterfly Network, USA</td>
</tr>
</tbody>
</table>
Competency and training updates

- Residents
  - ACGME
  - ABA
    - ITE, Basic, Advanced Exams
    - Applied Exam
- Faculty
# ACGME Program Requirements for Graduate Medical Education in Anesthesiology

**Effective July 1, 2019**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV.</td>
<td>Educational Program</td>
<td>18</td>
</tr>
<tr>
<td>IV.A.</td>
<td>Curriculum Components</td>
<td>18</td>
</tr>
<tr>
<td>IV.B.</td>
<td>ACGME Competencies</td>
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</tr>
<tr>
<td>IV.C.</td>
<td>Curriculum Organization and Resident Experiences</td>
<td>30</td>
</tr>
<tr>
<td>IV.D.</td>
<td>Scholarship</td>
<td>35</td>
</tr>
</tbody>
</table>
ACGME Competency Requirements related to POCUS

• “using surface ultrasound….and transthoracic echocardiography…to evaluate organ function and pathology.”

• “understanding principles of ultrasound…physics, transducer construction and selection.”

• “able to obtain images with understanding of limitations and artifacts.”

• “using transthoracic ultrasound for detection of pneumothorax and pleural effusion.”
• Principles of Ultrasound:
  • Obtaining image, resolution, depth, frequency and resonance
  • Doppler ultrasound
• Echocardiography:
  • Clinical methods and uses
  • Technical aspects and complications
• POCUS:
  • Lung, IVC, Bladder, Gastric
• ABA: Applied Examination
  • Now includes POCUS exam
    • Interpretation of echocardiograms and lung ultrasound
  • Demonstration of views starting 2021
2020: Identify and interpret views
- Heart, lung, diaphragm
- Identify the view and relevant anatomy
- Make qualitative diagnostic assessments
- Provide treatment recommendations

2021: Demonstrate view
- TTE: PLAX, PSAX, A4C, SubC, IVC
- Lung, pleura, diaphragm, A-lines, B-lines

2022: Demonstrate view
- Abdomen: RUQ, LUQ, Pelvis, Gastric
Faculty
No consensus yet for anesthesiologists

- **Competency**: having knowledge, skills, judgment to perform.

- **Certification**: regulatory body recognition of competence.

- **Credentialing**: assessment of qualifications to practice.
Competence vs credentialing vs certification

- Competency:
  - Society recommendations/training
    - Society of Critical Care Medicine (SCCM)
    - American College of Chest Physicians and La Socie´te´ de Re´animation de Langue Francaise
    - American Society of Echocardiography
    - American College of Emergency Medicine
    - Society of Critical Care Anesthesiologists
    - American Society of Regional Anesthesia
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    • Society of Critical Care Anesthesiologists
    • American Society of Regional Anesthesia - **Formal statement 2020!**
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• **Competency:**
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    • American Society of Echocardiography
    • American College of Emergency Medicine
    • Society of Critical Care Anesthesiologists
    • American Society of Regional Anesthesia - Formal statement 2020!
    • American Society of Anesthesiologists – Certificate of competency late 2020 or early 2021!
### Requirements for Competence in Critical Care Ultrasound Core Applications – SCCM

<table>
<thead>
<tr>
<th>Type of Ultrasound</th>
<th>Application</th>
<th>Minimum Number Interpreted</th>
<th>Minimum Number Personally Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic</td>
<td>Basic Critical Care Echo</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Pleural/pulmonary ultrasound</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Focused abdominal ultrasound</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Vascular ultrasound</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>
Competence vs credentialing vs certification

- **Certification**:
  - Special Competency in Critical Care Echocardiography exam (CCEeXAM)
    - National Board of Echocardiography (NBE).
    - January, 2019, the first formal exam
    - Passing this exam leads to Testamur status, a prerequisite for certification.
  - Certification requires:
    - 150 full TTE exams w/ all obtainable elements
    - Supervised Training vs Practice Experience Pathway
Challenge

• Educational mission for trainees
• Varied faculty experience
• Competing clinical demands
• No consensus on competency
• Developing infrastructure:
  • Equipment
  • Image archiving
  • Documentation process
  • Departmental / institutional policies
Challenge

- Educational mission for trainees
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    - Documentation process
    - Departmental / institutional policies
Investment

- POCUS curriculum
  - Pre and post assessment
  - Flipped classroom
  - In-person model/simulation teaching
  - Longitudinal due to knowledge attrition

- Departmental support
  - Faculty: training, teaching, clinical implementation
  - Resources: infrastructure (machines, archiving, policy)
Retention of Ultrasound Skills and Training in “Point-of-Care” Cardiac Ultrasound

Bruce J. Kimura, MD, Sean M. Sliman, DO, MPH, Jill Waalen, MD, MPH, Stan A. Amundson, MD, and David J. Shaw, MD, San Diego, California

J Am Soc Echo-cardiogr 2016;29:992-7
Impact Assessment of Perioperative Point-of-Care Ultrasound Training on Anesthesiology Residents

POCUS teaching service

Exam locations: Preop, OR, PACU, off-site

Main trigger for POCUS:
1. Medical history (51%)
2. Hemodynamic instability (14%)
3. Respiratory failure (13%)
4. ETT location verification (13%)
5. Venous access (9%)
POCUS teaching service

POCUS changed management 76% of cases:
1. New diagnosis (31%)
2. Verifying current known diagnosis (45%)
3. Aided by normal findings (24%)
Faculty Training

- ASRA (12/2019, 2/2020, 6/2020)
  - Usabcd.org
  - Focused Cardiac Ultrasound
  - Airway
  - Lung
  - Gastric
  - FAST
  - Basic Focus Assessed Transthoracic Echocardiography certification (FATE)

15 hrs e learning
Hands-on
Lectures
2-3 days
Faculty Training

- CHEST – Critical Care Ultrasonography
  - Focused Cardiac Ultrasound
  - Airway
  - Lung
  - Gastric
  - FAST
  - Vascular – DVT exam
  - CHEST certificate of completion

- e learning modules
- Hands-on
- Lectures
- 2-3 days
- On-line portfolio
- On-line portfolio
Free resources

• Loma Linda University:
  https://www.foresightultrasound.com/lectures
• POCUS atlas:
  http://www.thepocusatlas.com/
• University of Utah:
  https://echo.anesthesia.med.utah.edu/pocus-content/
The future is bright!

- Many medical schools have incorporated POCUS into curriculum
- Earlier training in anesthesiology residency
- Leveraging ultrasound skills and knowledge:
  - Regional and cardiac anesthesia
  - Emergency medicine and critical care
Summary

- POCUS improves bedside assessments
Summary

• POCUS improves bedside assessments

• Perioperative POCUS
  • Anesthesiology is leading the development and application
  • Momentum, growth in applications and users
Summary

- POCUS improves bedside assessments

- Perioperative POCUS
  - Anesthesiology is leading the development and application
  - Momentum, growth in applications and users

- Education is the biggest challenge
  - Formal training is required to ensure competency - no standards yet
  - ACGME and ABA are increasing content
  - Trainees will know more and are required to demonstrate knowledge
  - Longitudinal, consistent: training, clinical application
Thank you!