Ultrasound in Cardiac Arrest

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Kent Hospital
İzmir, Türkiye
Ultrasound in Cardiac Arrest

• As a diagnostic tool
• As a prognostic tool
• Ethics
Ultrasound in Cardiac Arrest

- As a diagnostic tool
- As a prognostic tool
- Ethics
Ultrasound in Cardiac Arrest: as a diagnostic tool

- Is the endotracheal tube in the trachea?
- Is a pneumothorax present?
- Is there a pulse?
- Is there cardiac motion?
- Is LV contractility normal? hyper? hypo?
- Is RV size normal?
- Is pericardial fluid present? Signs of tamponade?
Ultrasound in Cardiac Arrest: as a diagnostic tool

• Using ultrasound in the peri-arrest patient
  – hypovolemia
  – pericardial tamponade
  – tension pneumothorax
  – pulmonary embolism
  – myocardial dysfunction/failure
  – distributive shock (anaphylaxis, sepsis, neurogenic)
Ultrasound in Cardiac Arrest: as a diagnostic tool

- 2001 UHP undifferentiated hypotensive patient US protocol
- 2007 FEER focused echocardiographic evaluation in resuscitation
- 2008 C.A.U.S.E. cardiac arrest ultrasound exam
- 2009 RUSH rapid ultrasound for shock and hypotension
- 2010 FEEL focused echocardiographic evaluation in life support
- 2010 FOCUS focused cardiac ultrasound in the emergent setting
- 2010 RUSH rapid ultrasound in shock
- 2011 EGLS echo-guided life support
- 2014 CORE concentrated overview of resuscitative efforts
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Outcome in Cardiac Arrest Patients Found to Have Cardiac Standstill on the Bedside Emergency Department Echocardiogram

- 2001, Blaivas and Fox in *Acad EM*
- All CPR pts had parasternal or subxiphoid US during pulse checks
- 169 patients
  - 38% asystole, 22% PEA, 39% VF
  - 136 had cardiac standstill on initial ultrasound
    (71 with a rhythm on the monitor, 65 with asystole)
  - All patients with initial cardiac standstill died in the ED
Outcome in Cardiac Arrest Patients Found to Have Cardiac Standstill on the Bedside Emergency Department Echocardiogram

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    (71 with a rhythm on the monitor, 65 with asystole)
  – All patients with initial cardiac standstill died in the ED
Can Cardiac Sonography and Capnography Be Used Independently and in Combination to Predict Resuscitation Outcomes?

- 2001, Salen et al. in *Acad EM*
- 102 patients, 1-5 US exams + capnography
- Overall survival to hosp. admission 27% vs 3%
- PEA patients survival to hosp. admission 26% vs 4%
- No pulse but cardiac activity present in 40%
- 100% of patients with cardiac motion on *all* US exams during resuscitation survived to hospital admission
Can Cardiac Sonography and Capnography Be Used Independently and in Combination to Predict Resuscitation Outcomes?

- 1 of 63 with no movement on initial US exam...
- 1 PEA pt and 1 asystole pt without sonographic contractions survived to admission
- 7% of patients with no sonographic contractions at some time during resuscitation survived to hospital admission
Can Cardiac Sonography and Capnography Be Used Independently and in Combination to Predict Resuscitation Outcomes?

- 2001, 102 patients, 1-5 US exams + capnography
- Overall survival to hosp. admission 27% vs 3%
- PEA patients survival to hosp. admission 26% vs 4%
- No pulse but cardiac activity present in 40%
- If movement present on all US exams, 100% survival to hosp. admission
- very easy or moderately easy in 73% of cases
- helpful in 96% of cases
Can Cardiac Sonography and Capnography Be Used Independently and in Combination to Predict Resuscitation Outcomes?

- 2001, 102 patients, ultrasound + capnography
Focused echocardiographic eval. in resuscitation management: Concept of an advanced life support–conformed algorithm

- 2007, Breitkreutz et al. in *Crit Care Med*
Focused echocardiographic evaluation in resuscitation management: Concept of an advanced life support–conformed algorithm

- 2007, Breitkreutz et al. in Crit Care Med
Duration and success in obtaining a subcostal view after 1\textsuperscript{st} and 2\textsuperscript{nd} training sessions

- 2007, Breitkreutz et al. in *Crit Care Med*
- EM & ICU physicians

\begin{figure}
\centering
\includegraphics[width=\textwidth]{chart.png}
\caption{Comparison of success in obtaining a subcostal view after 1\textsuperscript{st} and 2\textsuperscript{nd} training sessions.}
\end{figure}

- seconds

\begin{itemize}
\item p<0.05
\end{itemize}
Ability to recognize an echo finding in a 5-second videoclip

- 2007, Breitkreutz et al. in *Crit Care Med*
C.A.U.S.E.: Cardiac arrest ultra-sound exam—
A better approach to managing patients in primary non-arrhythmogenic cardiac arrest

- 2008, Hernandez et al. in *Resuscitation*
- Look for one of four shapes:
C.A.U.S.E.: Cardiac arrest ultra-sound exam—
A better approach to managing patients in primary non-arrhythmogenic cardiac arrest

• 2008, Hernandez et al. in Resuscitation

• Look for one of four shapes:

• If ‘normal’, think of MI, toxins, acidosis, hypothermia,
2009, Querello, et al.
Focused echocardiographic evaluation in life support and peri-resuscitation of emergency patients: a prospective trial

- 2010, Breitkreutz et al. in *Resuscitation*
- Pre-hospital phase, physicians (Germany)
- **FEEL**: motion, LV function, RV size, pericardial fluid
- 204 patients: **100 cardiac arrest** , 104 shock

<table>
<thead>
<tr>
<th></th>
<th>pre-FEEL</th>
<th>post-FEEL</th>
<th>survival to admission</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEA</td>
<td></td>
<td>pseudo-PEA</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>true-PEA</td>
<td>8%</td>
</tr>
<tr>
<td>asystole</td>
<td></td>
<td>pseudo-asystole</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>true-asystole</td>
<td>11%</td>
</tr>
</tbody>
</table>
Focused echocardiographic evaluation in life support and peri-resuscitation of emergency patients: a prospective trial

- 2010, Breitkreutz et al. in *Resuscitation*
- Pre-hospital phase, physicians (Germany)
- **FEEL**: motion, LV function, RV size, pericard. fluid
- 204 patients: **100 cardiac arrest**, 104 shock
- Altered management in 78% of cases
Impact of Modified Treatment in Echocardiographically Confirmed Pseudopulseless Electrical Activity in Out-of-hospital Cardiac Arrest Patients with Constant End-tidal Carbon Dioxide Pressure during Compression Pauses

• 2010, Prosen et al. in *J Int Med Research*
• Before and after study, modified treatment of PEA
• 15 of 16 PEA patients had ROSC
• 8 of 16 PEA patients had good neuro outcome
Impact of Modified Treatment in Echocardiographically Confirmed Pseudopulseless Electrical Activity in Out-of-hospital Cardiac Arrest Patients with Constant End-tidal Carbon Dioxide Pressure during Compression Pauses

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Echo-guided Life Support

- 2011, Lanctôt in Crit Ultras. J

1. Is there a pneumothorax?
   Thoracic views for: B-Lines or lung sliding as it excludes pneumothorax Lung point(?)

   NO

2. Is tamponade present?
   Subcostal window for: Pericardial effusion RA and RV diastolic collapse Plethoric IVC without respiratory variation

   YES

   Drain and administer fluid
   Perform EFAST if trauma patient

   NO

3. Is the patient hypovolemic?
   Subcostal window for: Dynamic LV function LV walls kissing Small or collapsing IVC Clear lungs

   YES

   Consider sepsis, occult blood loss, distributive shock
   Administer aggressive fluid resuscitation, antibiotics, steroids if indicated Ultrasound search for specific causes

   NO

Complete focused echocardiography
Echo-guided Life Support

- 2011, Lanctôt in Crit Ultras. J

Complete focused echocardiography (parasternal long/short axis, apical view)

4. If poor LV function noted: Is it the main cause of hypotension?
   Look for:
   - Association with B-Profile plus
   - Plethoric IVC without respiratory variation

   YES

   Consider myocardial infarction, intoxication, electrolytes and acid-base disturbances
   - Perform EKG
   - Consider revascularisation
   - Consider antidotes
   - Early intubation

   NO

5. Are there signs of RV strain?
   Look for:
   - Dilated RV
   - "D-shape" left ventricle in short axis view
   - Paradoxical septal wall movement
   - Plethoric IVC without respiratory variation

   YES

   Consider massive pulmonary embolism, RV infarction, chronic disease,
   - Perform EKG
   - Consider thoracic CTA
   - Consider thrombolysis
Assessment of Cardiac Ultrasonography in Predicting Outcome in Adult Cardiac Arrest

- 2012, Tomruk et al. in *J Int Med Research*
- 149 adult cardiac arrest patients
- subxiphoid view with a curved 7 mHz probe

<table>
<thead>
<tr>
<th>successful resusc.</th>
<th>+</th>
<th>−</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial cardiac activity by US</td>
<td>+</td>
<td>27</td>
</tr>
<tr>
<td>−</td>
<td>122</td>
<td>55</td>
</tr>
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<thead>
<tr>
<th>Initial rhythm</th>
<th>Cardiac activity</th>
<th>Total</th>
<th>Successful resuscitation</th>
<th>Unsuccessful resuscitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEA</td>
<td>Standstill</td>
<td>42 (28.2)</td>
<td>20 (47.6)</td>
<td>22 (52.4)</td>
</tr>
<tr>
<td></td>
<td>Contractions</td>
<td>22 (14.8)</td>
<td>15 (68.2)</td>
<td>7 (31.8)</td>
</tr>
<tr>
<td>Asystole</td>
<td>Standstill</td>
<td>72 (48.2)</td>
<td>31 (43.1)</td>
<td>41 (56.9)</td>
</tr>
<tr>
<td></td>
<td>Contractions</td>
<td>5 (3.4)</td>
<td>4 (80.0)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>VF/VT</td>
<td>Standstill</td>
<td>8 (5.4)</td>
<td>4 (50.0)</td>
<td>4 (50.0)</td>
</tr>
<tr>
<td></td>
<td>Contractions</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Transesophageal echocardiography during cardiopulmonary arrest in the emerg. dept.

• 2008, Blaivas in
• 6 cases in which TEE greatly helped
  – 35 y/o OD?, TTE—, CPR ended, TEE placed, EF 15%
  – 73 y/o dyspnea, asystole, TEE placed, showed VF...
  – 73 y/o syncope, pulses+ but TTE—, TEE placed, standstill then thrombus seen
  – 45 y/o with PICC, arrest, VF, TTE standstill, TEE placed, PICC line hitting wall of RA, PICC pulled back...
  – 37 y/o hx PE, dyspnea, TTE showed EF 5%, presumed PE, tPA ready, TEE placed, aortic dissection seen...
Transesophageal echocardiography during cardiopulmonary arrest in the emerg. dept.

• Advantages:
  – images are not affected by body habitus, COPD or subcutaneous emphysema
  – probe can be left in place throughout the resuscitation
  – chambers, wall motion, and valves are seen in greater detail
  – quality of CPR can be monitored

• Disadvantages
  – cost (machine/probe/training)
Does the Absence of Cardiac Activity on Ultrasonography Predict Failed Resuscitation in Cardiac Arrest? (meta-analysis)

- 2013, Cohn in *Annals of EM*
- 8 studies, 568 patients

<table>
<thead>
<tr>
<th>Cardiac activity on ultrasound</th>
<th>Return of spontaneous circulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+ 98</td>
</tr>
<tr>
<td>-</td>
<td>- 9</td>
</tr>
</tbody>
</table>

(2.4%)
Ultrasound in Cardiac Arrest: ethics

• To obtain sufficient US images, how long will CPR be interrupted?
• Physicians are not 100% accurate in diagnosing cardiac problems...
• 7% of patients with ROSC had cardiac standstill on at least one ultrasound during their resusc.
Areas for further study:

- What is the accuracy of ultrasonography *during* chest compressions?
Areas for further study:

• What is the accuracy of ultrasonography *during* chest compressions?

• Which sonographic window is best for viewing cardiac activity?
Areas for further study:

• What is the accuracy of ultrasonography during chest compressions?
• Which sonographic window is best for viewing cardiac activity?
• How much time is spent doing the ultrasound?
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• What is the accuracy of ultrasonography *during* chest compressions?
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• To what extent is CPR interrupted when ultrasound is performed?
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• What is the accuracy of ultrasonography during chest compressions?
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• To what extent is CPR interrupted when ultrasound is performed?
• Should we be using TEE instead of TTE?
Areas for further study:

- What is the accuracy of ultrasonography *during* chest compressions?
- Which sonographic window is best for viewing cardiac activity?
- How much time is spent doing the ultrasound?
- To what extent is CPR interrupted when ultrasound is performed?
- Should we be using TEE instead of TTE?
- Does seeing cardiac standstill help/hurt the family?
Summary: bedside ultrasound...

- Is a valuable diagnostic tool in cardiac arrest patients, changing management in >70%
- Is easy to perform
- Does not interrupt resuscitative efforts

- But, it is perhaps only 80% accurate
Summary: bedside ultrasound...

• Is a valuable diagnostic tool in cardiac arrest patients, changing management in >70%
• Is easy to perform
• Does not interrupt resuscitative efforts

• But, it is perhaps only 80% accurate
• Cannot be used alone to make the decision to terminate resuscitative efforts
Ultrasound in Cardiac Arrest

Questions? Comments?

johnfowlermd@gmail.com
Rapid Ultrasound for Shock and Hypotension

• HI-MAP (2 minutes)
• Heart: parasternal long axis, subcostal, (apical) pericardial effusion? LV contractility? RV strain?
• IVC with same probe (cardiac or abdominal)
• Morison’s, LUQ, L&R thorax (fluid?), suprapubic
• Aorta with same probe (abdominal)
• Pneumothorax? with same probe or linear probe
Rapid Ultrasound for Shock and Hypotension

RUSH Exam Sequencing

1. Parasternal Long Cardiac View
2. Apical Four-Chamber Cardiac View
3. Inferior Vena Cava View
4. Morison’s with Hemothorax View
5. Splenorenal with Hemothorax View
6. Bladder View
7. Aortic Slide Views
8. Pneumothorax View
9. Pneumothorax View

Use Curvilinear Array for 1-7
Use High-Frequency Array for 8 & 9
# Rapid Ultrasound for Shock and Hypotension

<table>
<thead>
<tr>
<th>RUSH Evaluation</th>
<th>Hypovolemic Shock</th>
<th>Cardiogenic Shock</th>
<th>Obstructive Shock</th>
<th>Distributive Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pump</strong></td>
<td>Hypercontractile heart Small chamber size</td>
<td>Hypocontractile heart Dilated heart</td>
<td>Hypercontractile heart Pericardial effusion Cardiac tamponade RV strain Cardiac thrombus</td>
<td>Hypercontractile heart (early sepsis) Hypocontractile heart (late sepsis)</td>
</tr>
<tr>
<td><strong>Tank</strong></td>
<td>Flat IVC Flat jugular veins Peritoneal fluid (fluid loss) Pleural fluid (fluid loss)</td>
<td>Distended IVC Distended jugular veins Lung rockets (pulmonary edema) Pleural fluid Peritoneal fluid (ascites)</td>
<td>Distended IVC Distended jugular veins Absent lung sliding (pneumothorax)</td>
<td>Normal or small IVC (early sepsis) Peritoneal fluid (sepsis source) Pleural fluid (sepsis source)</td>
</tr>
<tr>
<td><strong>Pipes</strong></td>
<td>Abdominal aneurysm Aortic dissection</td>
<td>Normal</td>
<td>DVT</td>
<td>Normal</td>
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**HI-MAP (2 minutes)**
- Heart: parasternal long axis, subcostal, (apical)
- Pericardial effusion? LV contractility? RV strain?
- IVC with same probe (cardiac or abdominal)
- Morison's, LUQ, L&R thorax (fluid?) suprapubic
- Aorta with same probe (abdominal)
- Pneumothorax? use linear probe (or abd probe)
Rapid cardiac ultrasound of *inpatients* suffering PEA arrest performed by nonexpert sonographers

- 2005, 5 patients
Rapid cardiac ultrasound of inpatients suffering PEA arrest performed by nonexpert sonographers

At pulse check, emergency sonographer records a 10 second video loop of ultrasound motion. Sonographer then moves away from the patient and evaluates the loop.

- Cardiac Motion?
  - Yes: Adequate images
    - Pericardial Effusion
      - Yes: "A pericardial effusion is seen, tamponade is a possible cause of PEA"
      - No: Right Ventricle larger than Left Ventricle in the Presence of a small dynamic Left Ventricle
        - Yes: "The findings of right heart strain are seen, Pulmonary Embolus is a possible cause of PEA"
        - No: Under filled Right Ventricle in the presence of a small dynamic Left Ventricle
          - Yes: "The findings of hypovolemia are seen, hypovolemia is a possible cause of PEA"
          - No: "No suggestive findings are seen"
    - No: "This is a limited screening examination"
- Inadequate for interpretation
  - Repeat loop x 2 if needed
    (One of these attempts may be made during a requested 10-second pause)

- 2005, 5 patients