Disclosures

- No financial disclosures
Goals

- Indications
- Technique
- Feasibility
- Safety
- Efficacy and accuracy
- Cases
Introduction
Introduction

- I know what you’re thinking
Introduction

- But, someone has thought that about
  - Stethoscope
  - ED Clinical ultrasound
  - Iphone
  - Stuffed crust pizza
Introduction

- Transthoracic echo currently routinely used in management of critically ill patients and in cardiopulmonary arrest

Limitations

- Body habitus
- Compressions
- Subcutaneous air
- Comorbidities
  - COPD
  - Intubation/High PEEP
Introduction

- Advantages to TEE
  - Esophageal placement = optimal window
  - Quality not affected by lungs or body habitus
  - Images with much greater detail
    - Multiplane probes
  - Better visualization of valves
  - Continuous imaging
  - Can leave in during cardioversion/defib
  - Assessment of compression quality
  - Fewer CPR interruptions
Introduction

- Disadvantages to TEE
  - Training
  - Cost
  - Staffing
Indications
Indications

- Presentations
  - Cardiac arrest
  - Hypotension
  - Chest trauma

- Diagnoses
  - Endocarditis
  - Pulmonary embolism
  - Aortic dissection
  - AMI
Indications

- Cardiac arrest
  - PEA
    - Greatest utility
    - “True” PEA vs “Pseudo” PEA
  - Evaluation for reversible causes of arrest
Indications

- Hypotension
  - TEE changes management
    - Khoury et. al. Transesophageal echocardiography in critically ill patients: feasibility, safety, and impact on management
      - 48% had management change based solely on TEE
Indications

- Hypotension
  - General utility
    - Faster and more reliable than pulmonary artery catheter in determining cause of hypotension
  - ED utility
    - Hemodynamically unstable patients
Assessment of cardiac function in the critically ill patient - Diagnostic approach.

Legend:
This figure illustrates the diagnostic approach to a critically ill patient presenting with acute hemodynamic instability. RASPV: respiratory arterial systolic pressure variation.
Indications

- Chest trauma
  - General utility
    - Myocardial contusion/rupture
    - Pericardial effusion/tamponade
    - Hemomediastinum
    - Aortic rupture
  - ED utility
    - Unstable patients?
Indications

- **Endocarditis**
  - General utility
    - TEE much more sens than TTE for both native and prosthetic valve endocarditis
  - ED utility
    - Most patients don’t need it emergently
Indications

- Pulmonary embolism
  - General utility
    - TTE
      - Acute RV overload
      - RV dilation
      - Paradoxical septal motion
      - Loss of IVC inspiratory collapse
      - Tricuspid regurgitation
    - TEE
      - Direct visualization of thrombus
      - Patients in shock, central thromboemboli
        - 80-92% sensitivity, ~100% specificity
      - Can visualize pulmonary arteries (R more than L)
      - Patent foramen ovale for higher risk stratification
  - ED utility
    - Cardiac arrest
    - Hemodynamic instability? safety of ED TEE (unless intubated)
Indications

- Aortic dissection
  - General utility
    - Diagnosis
    - Dissection vs. hematoma/ulcer
    - True vs. false lumen
    - Aortic regurgitation
    - Coronary involvement
    - Tamponade
  - ED utility
    - Portability
    - Unstable patients
    - Contraindications to IV contrast
Indications

- Myocardial infarction
  - General utility
    - Wall motion abnormalities seen better
    - Extent of involvement
    - Complications
    - Acute valvular insufficiency
  - ED utility
    - Undifferentiated hypotension or arrest
Technique

- NGT for decompression
  - May need to be removed afterwards for insertion of TEE probe
- Bite block, probe cover
- Flex the neck
- May need to
  - Deflate ETT cuff
  - Use DL to guide insertion
  - Paralyze patient
  - Jaw thrust
Technique

- Technical considerations
  - Multiplane views
    - Depth
    - Twist
    - Anterior/Posterior flexion
    - Right/Left flexion
    - 360 degree rotation
  - “Blind”
    - Can’t see your probe
Technique

- [https://pie.med.utoronto.ca/TEE/TEE_content/assets/applications/standardViews/index.htm](https://pie.med.utoronto.ca/TEE/TEE_content/assets/applications/standardViews/index.htm)
Feasibility
Feasibility

- 97 – 100% feasibility in ICU patients
  - NG tube
  - Mechanical ventilation
Feasibility

- **Time for insertion**
  - Minimal with training
  - Takes longer than TTE
  - Less time than PA catheter

- **Resources**
  - Physician presence required for longer periods (ICU non-arrest patients)
Feasibility

- Limitations
  - Air (lack of gastric decompression)
  - Special training
- Expensive
  - 3x cost of other probes
- Too portable?
Safety
Safety

- Semi-invasive
- Complications (rare: ~ 2.6%)
  - Hypopharyngeal injury
    - 23.8%\(^1\)
  - Esophageal injury/perf
  - Emesis (not intubated)
  - Tube dislodgement
  - Hypotension
    - Sedation agents
    - Vasovagal
  - Hypoxemia
  - SVT
  - Oropharyngeal bleeding (anticoagulated)

- Complication rate higher with blind insertion
Safety

### Table II: Complications of TEE in the ICU (21 studies with n=2,508 examinations)

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
<th>N.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airway</td>
<td>Displacement of tracheostomy tube (1), pulmonary aspiration during tracheal intubation before TEE (1)</td>
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<tr>
<td>Ventilation</td>
<td>Respiratory failure (1), transient hypoxia (4)</td>
<td>5</td>
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<tr>
<td>Circulation</td>
<td>Hypotension (15), hypertension (4), increase in pulmonary artery pressure (1)</td>
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</tr>
<tr>
<td>Arrhythmias</td>
<td>Atrial flutter, atrial fibrillation (5), VES (1)</td>
<td>6</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>Circumstances not further specified (1), due to abruptly discontinued inotropic support but successful resuscitation - not related to TEE study (1)</td>
<td>2</td>
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<tr>
<td>Seizures</td>
<td>Grand mal seizure (1)</td>
<td>1</td>
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<tr>
<td>Vomitus</td>
<td>(1)</td>
<td>1</td>
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<td>Coughing</td>
<td>(7)</td>
<td>7</td>
</tr>
<tr>
<td>Oropharyngeal mucosal lesions</td>
<td>Superficial mucous lesion (1), self-terminating oral blood suffusion (15), oropharyngeal bleeding (1)</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.6%)</td>
</tr>
</tbody>
</table>
Safety

Other considerations

- Endocarditis prophylaxis?
  - No sig rise in bacteremia attributed to TEE
  - Prophylaxis did not affect rates of bacteremia
  - Consider in high-risk patients
Efficacy and Accuracy
Efficacy and accuracy

Diagnostic accuracy and therapeutic impact of transthoracic and transesophageal echocardiography in mechanically ventilated patients in the ICU.

- Prospective, 111 ICU patients
- TTE, then TEE done if TTE not helpful
- Outcomes
  - Proportion of solved problems (accuracy)
    - TTE: 38%
    - TEE: 97%
  - Therapeutic impact
    - TTE: 16%
    - TEE: 36%
      - Most notable for shock/hypotension
Efficacy and accuracy

Table 2—Therapeutic Impact of Transthoracic (TTE) and Transesophageal Echocardiography (TEE)*

<table>
<thead>
<tr>
<th>Therapeutic Changes</th>
<th>TTE (n=128)</th>
<th>TEE (n=96)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catecholamines infusion</td>
<td>(n=21)</td>
<td>10</td>
</tr>
<tr>
<td>Fluid challenge</td>
<td>(n=18)</td>
<td>6</td>
</tr>
<tr>
<td>Rapid cardiovascular surgery</td>
<td>(n=10)</td>
<td>2</td>
</tr>
<tr>
<td>Anticoagulation or fibrinolytic agents</td>
<td>(n=2)</td>
<td>1</td>
</tr>
<tr>
<td>Antibiotics for endocarditis</td>
<td>(n=2)</td>
<td>0</td>
</tr>
<tr>
<td>β-blockers</td>
<td>(n=1)</td>
<td>0</td>
</tr>
<tr>
<td>Pericardiocentesis</td>
<td>(n=1)</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>(n=55)</td>
<td>20</td>
</tr>
</tbody>
</table>

*Therapeutic impact was defined as changes on acute care that resulted directly from the procedure. Therapeutic changes based on TTE findings and confirmed by TEE in the same patients are indicated in parentheses.
### Efficacy and Accuracy

**Table 3—Transthoracic (TTE) vs Transesophageal (TEE) Echocardiographic Findings According to the Clinical Problems (n=98) in Patients Who Were Scheduled for Both Examinations (n=96)**

<table>
<thead>
<tr>
<th>Clinical Problems</th>
<th>No Superiority of TEE Over TTE</th>
<th>Diagnosis Ruled Out by TEE and Not Excluded by TEE</th>
<th>Additional Diagnosis Yielded by TEE Without Therapeutic Impact</th>
<th>Additional Diagnosis Yielded by TEE With Therapeutic Impact*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock, hypotension</td>
<td>(n=19)</td>
<td>0</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Endocarditis</td>
<td>(n=18)</td>
<td>1</td>
<td>10</td>
<td>4</td>
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<tr>
<td>Traumatic rupture of the aortic isthmus, acute aortic dissection</td>
<td>(n=16)</td>
<td>1</td>
<td>10</td>
<td>1</td>
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<tr>
<td>Valvulopathy or valvular prosthesis assessment</td>
<td>(n=12)</td>
<td>0</td>
<td>3</td>
<td>5</td>
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<tr>
<td>Left ventricular function</td>
<td>(n=9)</td>
<td>0</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Assessment of a cardiopathy after cardiac arrest</td>
<td>(n=6)</td>
<td>0</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Pulmonary hypertension, thrombus in right chambers</td>
<td>(n=5)</td>
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<td>4</td>
<td>0</td>
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<td>Systemic arterial embolism</td>
<td>(n=4)</td>
<td>0</td>
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<td>1</td>
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<td>Ventricular assistance device</td>
<td>(n=4)</td>
<td>0</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Patent foramen ovale</td>
<td>(n=3)</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Atrial compression by postoperative hematoma</td>
<td>(n=1)</td>
<td>0</td>
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<td>Tumor of the mediastinum</td>
<td>(n=1)</td>
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<tr>
<td>Total</td>
<td>(n=98)</td>
<td>2</td>
<td>44</td>
<td>22</td>
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</tbody>
</table>

*The number of patients who underwent cardiovascular surgery based on TEE findings are indicated in parentheses.
Efficacy and accuracy


- 41/48 patients: diagnosis established by TEE
  - MI, tamponade, PE, papillary rupture, AD
  - 93% sensitivity, 50% specificity, PPV 87%
- 30%: TEE affected management
- 4/28 (14%) survived to hospital discharge
  - Cardiac tamponade, MI, VT
Efficacy and accuracy

  - Literature review of 21 studies
    - Most data from ICU settings with high proportion of cardiac and surgical patients
      - Translation to ED
    - Sig variability in study design and patient population, and therefore diagnostic and therapeutic impact as well
  - 216 patients of author’s own experience
    - Retrospective
    - All patients with hypotension/shock states
      - Surgical findings much less frequent than in reviewed studies above
    - 88.4%: diagnoses identified and/or excluded
      - 11.6%: no significant pathology revealed
        - SIRS/Sepsis
    - 68.5%: management affected by TEE
      - 5.6% underwent surgery based solely on TEE
  - Mortality effect
    - Expected mortality based on scoring systems: 10-16%
    - Observed mortality of patients undergoing TEE as part of management: 43.5%
      - Non surgically-correctable causes of hypotension
<table>
<thead>
<tr>
<th>Author</th>
<th>Design</th>
<th>Year</th>
<th>Study period (months)</th>
<th>TEE (n)</th>
<th>ICU-type</th>
<th>Mortality (%)</th>
<th>Patients studied (% of ICU admissions)</th>
<th>Ventilated patients (%)</th>
<th>Feasibility (%)</th>
<th>Complications (%)</th>
<th>Impact</th>
<th>Overall therapeutic</th>
<th>Non-surgical</th>
<th>Surgical</th>
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<tr>
<td>Alam</td>
<td>R</td>
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<td>48</td>
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<td>43</td>
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<td>6</td>
<td>88</td>
<td>69</td>
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<td>6</td>
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</tbody>
</table>

Total 2506 (weighted mean) 67.2 36.0 14.1

*Non-surgical (pharmacological treatment, fluid therapy).

\(^1\) Unco-operativeness (2); \(^2\) Probe could not be advanced more than 30 cm (1); \(^3\) Probe could not be passed in one patient with a cervical fracture (1); \(^4\) Laryngoscopic guidance employed in 7%; \(^5\) Failed insertion (2); \(^6\) Laryngoscopic guidance employed in 7%; \(^7\) Failed insertion (patient with large aneurysm of the thoracic aorta compressing the esophagus) (1). Number of patients in parentheses.

CICU, ICUs with a high proportion of coronary and/or cardiac surgical patients, but not further specified; CT-SICU, cardiothoracic-surgical ICU; MICU, medical ICU; SICU, surgical ICU; CCU, coronary care unit; GICU, general ICU (general adult ICU (critical illness, trauma, major elective surgery); NICU, neurologic-neurosurgical ICU; ER, emergency room; M, miscellaneous.
### Efficacy and Accuracy

#### Table 2

<table>
<thead>
<tr>
<th>Diagnostic findings (LVD, RVD, BVD left-, right-, biventricular dysfunction)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main diagnosis (disease mechanism responsible for clinical condition)</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Hypovolemia</td>
<td>34</td>
<td>15.7</td>
</tr>
<tr>
<td>LVD and septic shock</td>
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<td>RVD and septic shock</td>
<td>24</td>
<td>11.1</td>
</tr>
<tr>
<td>RVD</td>
<td>12</td>
<td>5.6</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>10</td>
<td>4.6</td>
</tr>
<tr>
<td>Valve dysfunction</td>
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<td>4.6</td>
</tr>
<tr>
<td>Pericardial tamponade</td>
<td>8</td>
<td>3.7</td>
</tr>
<tr>
<td>Intracavitatory thrombi</td>
<td>8</td>
<td>3.7</td>
</tr>
<tr>
<td>Myocardial contusion</td>
<td>8</td>
<td>3.7</td>
</tr>
<tr>
<td>BVD and septic shock</td>
<td>7</td>
<td>3.2</td>
</tr>
<tr>
<td>BVD</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Endocarditis (vegetations)</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Miscellaneous</td>
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<td></td>
</tr>
<tr>
<td>Aortic dissection</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Aortic rupture</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Liver hematoma</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>2</td>
<td>1.0</td>
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<tr>
<td>Total diagnostic impact</td>
<td>191</td>
<td>88.4</td>
</tr>
</tbody>
</table>

#### Table 3

<table>
<thead>
<tr>
<th>Therapeutic impact (PTCA percutaneous transluminal coronary angioplasty)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapeutic impact</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Surgery (= surgical impact)</td>
<td>12</td>
<td>5.6</td>
</tr>
<tr>
<td>Replacement of the ascending aorta</td>
<td>1</td>
<td>1.0</td>
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<tr>
<td>Surgical repair of aortic rupture</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>Surgical evacuation of liver hematoma and liver tamponade to achieve control of bleeding</td>
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</tr>
<tr>
<td>Mitral valve replacement</td>
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</tr>
<tr>
<td>Surgical or percutaneous drainage of pericardial effusion</td>
<td>8</td>
<td>4.2</td>
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<tr>
<td><strong>Change in medical therapy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start/change of antibiotics</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Start of anticoagulation</td>
<td>8</td>
<td>3.7</td>
</tr>
<tr>
<td>PTCA</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Thrombolysis</td>
<td>9</td>
<td>4.2</td>
</tr>
<tr>
<td>Fluid administration</td>
<td>28</td>
<td>14.2</td>
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<tr>
<td>Start/change of inotropic and/or vasopressor drugs and fluid administration</td>
<td>45</td>
<td>23.1</td>
</tr>
<tr>
<td>Start/change of inotropic and/or vasopressor drugs</td>
<td>8</td>
<td>3.7</td>
</tr>
<tr>
<td>Total</td>
<td>148</td>
<td>72.3</td>
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<tr>
<td>No therapeutic impact</td>
<td>68</td>
<td>37.7</td>
</tr>
</tbody>
</table>

Total: 148 (68.5% of total)
Efficacy and Accuracy

Fig. 2. Diagnosis established by TEE in the ICU based on 2508 studies.
Cases
Cases

Case 1

- 35 yo unwitnessed cardiac arrest
- PMH: HTN, EtOH, IVDA
- Initial rhythm: PEA
- POC TTE completed
  - Limited view, no clear cardiac movement
- 3 rounds of cpr with epi, no ROSC
Case 1

- TEE completed
  - Organized contraction with EF 15%
  - Carotid u/s revealed blood flow despite lack of palpable pulses
  - Compressions stopped
  - IVF, dobutamine, levophed initiated
  - BP rose, pulses became palpable
  - Weaned off pressors and discharged 2 days later
Case 1

- PEA arrest
  - “Pulseless” can be overly called
    - Palpation in stressful situation
    - Organized contraction not generating a pulse
    - True PEA vs. Pseudo-PEA arrest
      - Not all PEA is the same
Case 2

- 73 yo female in respiratory distress
- PMH: HTN, bronchitis
- PE: dyspneic, 92% on RA
- CXR unremarkable
- 2 hours later: respiratory failure, intubated, then cardiac arrest (asystole on monitor)
- TTE poor quality images, no cardiac activity discerned
Case 2

- TEE done
  - Vfib clearly seen
  - Electrical defibrillation completed
  - Monitor showed asystole with occasional rare beat, which had good contractility on TEE visualization
  - K+ returned at 9.4
  - TEE helped guide when to switch out person doing compressions
  - Treatment of K+ done while continuing CPR
  - ROSC achieved, discharged home at baseline state 8 days later
Case 2

- PEA arrest
  - Fine vfib not always picked up on monitor
  - Treatment much different than true PEA
Case 3

- 73 to female with witnessed cardiac arrest
- PMH: HTN
- Sudden onset SOB then collapsed
- Intubated in field, ACLS initiated
- ROSC just before ED arrival
  - Palpable pulses with BP 88 mmHg systolic
  - HR 60’s on monitor
- TTE: no cardiac activity
Case 3

- TEE done
  - Myocardial standstill
  - Epi given with compressions guided by TEE
  - TEE showed thrombus going from RA through tricuspid into RV
  - Monitor and TEE continued to be in disparity, remainder of resuscitation guided by TEE
  - Patient died of ICH after being started on Warfarin
Case 3
Case 3

- More accurate assessment of rhythm
- Assessment of compression quality
- Served as “monitor”
  - Continuous visualization
  - No need to repeatedly find views again
- Etiology differentiation
  - PE
Case 4

- 45 yo obese male witnessed vfib arrest
- PMH: HTN, osteomyelitis with PICC
- EMS: CPR, amio, defib: no ROSC
- TTE: cardiac standstill
- Monitor: asystole vs fine vfib
Case 4

- **TEE**
  - Vfib
  - Catheter tip moving in entrance to the right atrium and periodically striking the wall
  - PICC pulled back
  - Defib again
    - NSR by monitor, but no pulses felt (obese?)
    - TEE: organized contractions with EF 30%
    - Dopamine drip started
  - Discharged on amiodarone
Case 4

A

B

LA
PICC Tip
AO
LV
RA
RV

LA
PICC Tip
AO
LV
RA
SVC

Case 4

- Pretty frigging cool
  - Easily reversible cause of vfib
  - Obesity limited TTE
Case 5

- 37 yo male chest pain, SOB
- PMH: DVT, PE
  - Recently stopped his coumadin
- Arrested on arrival to ED
- TTE: asystole
- ACLS continued
- Pulse check: bradycardia
- TTE: organized contraction with EF 5%
- PE presumed, TPA ordered
Case 5

- TEE done
  - Proximal aortic dissection
  - Prolonged hospital stay with complications, but eventual full recovery
Case 5

- TPA would have killed the patient
Case 6

- 61 yo female with witnessed arrest after complaining of SOB
- PMH: cancer, HTN, COPD
- Transient ROSC en route after defib for vfib
- In ED: pulseless, junctional rhythm
- TTE: organized contractions with severely depressed function; ? RA/RV dilation
- TPA ordered
Case 6

- TEE:
  - No sig right heart strain
  - No thrombus seen
  - Fine vfib (monitor showed asystole)
  - Defib, dobutamine started
  - CTA neg for PE
  - Pt expired later in the ICU
Case 6

- Helped guide decision on TPA
- Vfib vs asystole
Final thoughts

- TEE may aide diagnosis and guide management in critically ill patients in the ED
- Unclear as of yet whether any affect on mortality/morbidity
- Further research indicated
Resources

- Diagnostic accuracy and therapeutic impact of transthoracic and transesophageal echocardiography in mechanically ventilated patients in the ICU. Vignon et. al. CHEST 1994.