Perioperative Transesophageal Echocardiography

JOHN SHIELDS CRNA
Learner Outcomes

- Describe cardiac anatomy and pathology associated with the eleven basic perioperative TEE views
- Discuss the practical application of Doppler as used for basic TEE
- Identify billing considerations for TEE
- Discuss TEE and scope of practice acquisition
Transesophageal Echo

- Most robust monitor of cardiac and hemodynamic function
  - Direct assessment vs. indirect assessment
  - May be placed any time intraoperatively as long as the head is accessible
- Use of ultrasound imaging
- Observer dependent interpretation
Ultrasound and Transesophageal Echo

- Echo passes sound waves through a medium or tissue
  - Transducer converts electrical energy into pulses of sound
  - Returning pulses of sound are converted into energy which generates an image

- Acoustic impedance of different tissues affects wave propagation and image
2-D Ultrasound Imaging

- Probe is placed in the esophagus in one of three positions and US beam generated
- Reflected signals are collated to produce an image
- A two-dimensional (2-D) image is generated of the structures
Information Available by Basic TEE

- Left and right ventricular function
- Heart wall motion
- Heart chamber volume
- Vessel integrity
- Valve function and integrity
- Heart tumors
- Pericardial effusion
Indications for Basic PTE

- Cardiopulmonary instability
- Suspicion of global and regional left ventricular dysfunction
- Myocardial ischemia and wall motion abnormalities
- Right ventricular dysfunction
- Hypovolemia
- Pulmonary/venous air embolus

- Aortic dissection
- Basic valve lesions (stenosis and regurgitation)
- Cardiac tumors
- Pericardial/pleural effusion
- Simple congenital heart disease in adults
Probe/Equipment Considerations

Probe Insertion
- Bite block
- Generous lubrication
- Jaw thrust may be utilized
- Mac blade (?)
- Insert to 30-35 cm
- Contraindications include esophageal and gastric pathology

Complications
- Esophageal perforation
- Gastrointestinal hemorrhage
- Oral/lip damage (most common)
- Airway compromise
- Distraction from patient
- Misinterpretation
**TEE Knobology**

1. On/Off
2. Quick keys
3. Gain
4. iScan (auto gain)
5. Depth adjustment
6. Zoom image
7. Color imaging
8. Freeze the image
9. Acquire an image
10. Caliper (straight line)
11. Trace image (area)
12. Pulse Wave Doppler
13. Continuous Wave Doppler
Probe Manipulations

- Lateral tilt
- Ante/retroflex
- Omniplane
Transesophageal Echo Imaging Maneuvers

- Advance or withdraw the probe
- Turn the probe from side to side
- Rotate the sector (imaging plane) from 0-180 degrees ("omni")
- Change the angle of the probe
  - Forward (anteflex)
  - Backward (retroflex)
  - Left or right
Transthoracic vs. Transesophageal Views

Normal FATE views

Pos 1: Subcostal 4-chamber
Pos 2: Apical 4-chamber
Pos 3: Parasternal long axis
Pos 3: Parasternal LV short axis
Pos 4: Pleural scanning

Key TEE Views

LA, RA, AO, PA, RV, LV, DA, LV, RV, RA, LA
Basic 11 TEE Windows

ME 4 chamber  ME 2 chamber  ME LAX  ME Ascending Aorta LAX
ME Ascending Aorta SAX  ME Aortic Valve SAX  ME RV Inflow-Outflow  ME Bicaval
Transgastric Mid SAX  ME Desc Aorta SAX  ME Desc Aorta LAX

Mitral Prolapse and Aortic Stenosis
Desc Thoracic Ao LAX
Descending Aorta SAX and LAX
Doppler Imaging

- Doppler ultrasound provides **direction** and **velocity** of flow
  - Moving objects change the frequency of returning sound waves
  - Shift in frequency is determined by the velocity and direction of the object
- Direction and velocity of blood is depicted as:
  - Red-towards the transducer
  - Blue-away from the transducer
- “BART”
Use of Doppler to Plot Velocity over Time

- Flow towards and away from the transducer is plotted as velocity vs. time.
- High velocity flow across a valve signifies stenosis.
- Bidirectional flow may signify regurgitation.
- Pulse wave Doppler measures flow in a specific sample.
- Continuous wave Doppler measures all flow along a line.
Calculating Ejection Fraction

- Ejection Fraction may be calculated by “eyeball EF” or formula

\[
\text{Ejection Fraction} = \frac{\text{End-diastolic area} - \text{end-systolic area}}{\text{End-diastolic area}}
\]

\[
\text{EF} = \frac{(9.46 \text{ cm}^2 - 4.08 \text{ cm}^2)}{9.46 \text{ cm}^2} = 57\%
\]
Calculating Ejection Fraction

“Good vs bad” instead of exact EF

Calculation is the same:

EF = (EDA - ESA) / EDA

EF = (25.6 - 17.3) / 25.6

= 32%
Eyeball EF
Calculating Stroke Volume

- Outside of Doppler flow waveform is traced to provide velocity time integral (VTI)
- VTI is multiplied by the orifice’s cross sectional area (CSA) to obtain stroke volume
- $SV = VTI \times CSA$

VTI = 19 cm

Diameter = 2.0 cm

$CSA = 2^2 \times 0.785 = 3.14$

$SV = 19 \times 3.14 = 60 \text{ ml}$
Calculating Pulmonary Artery Systolic Pressure (PASP)

- Doppler of tricuspid regurgitation measures maximum velocity ($V_{\text{max}}$)
- Peak gradient across the valve is calculated using modified Bernoulli equation
  \[
  (4 \times V_{\text{max}}^2)
  \]
- $PASP = CVP + \text{peak gradient}$

For CVP 12, max TR velocity 2 m/s,

\[
PASP = 12 + (4 \times 2^2) = 28 \text{ mmHg}
\]
Calculating Valve Area Using the Continuity Equation

- Continuity equation is used to assess aortic valve area \( (CSA_{AV}) \)
- \( CSA_{AV} = CSA_{LVOT} \times \left( \frac{VTI_{LVOT}}{VTI_{AV}} \right) \)
- \( CSA_{AV} = 3.14 \times \frac{15}{60} = 0.79 \) cm
- Aortic Valve Area = 0.79 cm (severe Aortic Stenosis)
Calculating Valve Gradients

- Pressure drop across an orifice may be calculated using the modified Bernoulli equation
  - Gradient=4(V)^2
  - “V” is the velocity across the orifice

- Gradient across a valve is calculated and degree of stenosis assessed
  - <36 mmHg is mild
  - > 36 mmHg is moderate to severe

Gradient=4 x (1.5 m/s)^2=9 mmHg
Utility of Perioperative TEE

- Entire perioperative pathway
  - TTE preop/postop
  - Intraoperative hemodynamic monitoring and rescue

- Subspecialties already utilizing TEE
  - Liver transplant
  - Vascular/neuroanesthesia
  - Intensive care/ER
  - Cardiac anesthesia
  - Obstetrics

- Major issue is manpower and training
Transesophageal Echo Training and Accreditation

- Training
  - Point of care
  - Simulation

- Training pathways
  - Fellows/resident anesthesiologists
  - ER physicians
  - Nurse anesthetists?

- Accreditation/certification
  - Monitoring
  - Diagnostic
  - Interventionalist

Documentation and Billing for TEE

**Reporting**

- Date and time of study
- Name and MR number of patient
- DOB, age, gender
- Indication for study
- Documentation of informed consent for TEE
- Name of interpreting physician
- Findings/impression
- Complications if any
- Date/time report was signed
- Mode of archiving video

**Billing**

<table>
<thead>
<tr>
<th>CPT</th>
<th>Description</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>93312</td>
<td>TEE including probe placement, image acquisition, interpretation and report</td>
<td>$334</td>
</tr>
<tr>
<td>93313</td>
<td>TEE probe placement only</td>
<td>$43</td>
</tr>
<tr>
<td>93314</td>
<td>TEE including image acquisition, interpretation and report</td>
<td>$309</td>
</tr>
<tr>
<td>93318</td>
<td>TEE including probe placement, image acquisition, interpretation and report leading to ongoing (continuous) assessment of cardiac pumping function and to therapeutic measures on an immediate time basis</td>
<td>$114</td>
</tr>
<tr>
<td>93320</td>
<td>Doppler pulsed wave and/or continuous wave with spectral display (listed separately, complete study)</td>
<td>$55</td>
</tr>
</tbody>
</table>
Scope of Practice and Transesophageal Echo

- Basic PTE exam is not designed to prepare practitioners for the full potential of TEE as a diagnostic tool (monitoring only)
- ASE/SCA have described the critical role of TEE in the care of an unstable surgical patient for non-cardiac anesthesiologists
- Role of the CRNA and advanced practice nurses is part of the evolution of care

Other Providers and Point of Care Ultrasound (POCUS) Training

- ACGME (IV.A.5.a).(2).(m) requires competency in ultrasound for cardiac, thoracic, vascular and regional techniques.
- Nurse midwives are ultrasound certified, document and can bill for their services.
- Nurse practitioners in the ICU are currently using POCUS and have demonstrated 86% accuracy in acquiring and interpreting images.
- Council on Accreditation declared TEE scope of practice but no prerequisites for graduation.
Utilizing standardized exam (Toronto PIE) students scored 35% on pre-test.

Post-simulation simulator scores averaged 70%, online simulation (PIE) 42%.

Resident anesthesiologists, surgeons and cardiologists had similar scores.

Conclusions

- **Qualitative assessments** include valve competence, embolism, ventricular function, volume status and pericardial effusion
- **Quantitative assessment** includes valve area, degree of stenosis, valve pressure gradients, stroke volume and pulmonary artery pressure
- Echo is very useful as a diverse hemodynamic monitoring modality and is no longer just for cardiac anesthesia
References
