Aortic diseases are important cause of cardiovascular morbidity & mortality. Except for acute aortic syndrome or aortic rupture, aortic diseases are asymptomatic & with no abnormalities on physical examination. Diagnosis & follow-up depend exclusively on imaging techniques. Echocardiography plays an important role in the diagnosis & follow-up of aortic diseases.
Include
- Trans-thoracic echocardiography, TTE
- Trans-esophageal echocardiography, TEE
- Abdominal ultrasound
- Intravascular ultrasound (IVUS).

This presentation will focus on TTE and TEE
- Methodologies in the assessment of aortic diseases
- Strengths and limitations for use in various clinical situations
- Recommendations for appropriate applications of echocardiography.
Recommendation

• TTE permits adequate assessment of several aortic segments, particularly the aortic root and proximal ascending aorta.

• All scanning planes should be used to obtain information on most aortic segments.

• However, if inconclusive information or abnormalities are present, another imaging modality is required to either complete or add diagnostic information.
(A) Ascending aorta in mid esophageal long-axis view at 120°.
(B) Aortic arch in transverse view.
(C) Descending aorta visualized by transverse view.
(D) Descending aorta visualized by longitudinal view.

(a) Upper esophageal aortic arch long-axis view
(b) Upper esophageal aortic arch short-axis view
(a) The A-view catheter.  
(b) The A-view catheter in the trachea and left main bronchus.  
(c) The A-view distal ascending aorta long-axis view. An image of the trachea and the ascending aorta as imaged with the A-view method with plaque formation on the posterior and anterior wall: 1) A-view catheter in the trachea, 2) Posterior wall of the distal ascending aorta 3) Anterior wall of the distal ascending aorta 4) A mobile protruding atheroma indicated by (arrow).  
(d) Diagrammatic representation of the image

Recommendation

- TEE is ultrasound technique of choice in thoracic aorta assessment providing high-resolution images of the entire thoracic aorta except for a small portion of the distal ascending aorta near Innominate artery, the blind spot.

- TEE overcomes limitations encountered by TTE.

- TTE and TEE should be used in a complementary manner.
• Accurate and reproducible
• 2D preferable to M-mode
• Aorta size is related to BSA & age.
• Upper normal range for ascending aorta in adults = 2.1 cm/m²

(Adapted from Devereux et al. 2012)

3D configuration of the aortic root
(A) Schematic representation of the aortic root with its anatomic landmarks
(B) Volume-rendered longitudinal view of the aortic root by transthoracic 3DE.
(C) By slightly rotating the 3D data set, a better perception of the 3D configuration of Valsalva sinuses is demonstrated.
(D) Further rotating the 3D data set, the ostium of the right coronary artery is seen en face in the corresponding sinus.

adapted from Anderson RH, 2007
• The 3D spatial configuration of the AV cusps resembles a crown.
• The cusps are thicker towards their free margin, and semilunar hinge-lines at insertion in aortic root wall are noticeable as prominent ridges.
• The basal attachment of the aortic cusps extend within the left ventricle, below the anatomic ventriculo-aortic junction.
• True anatomic aortic annulus is not actually the ring projected at the most basal leaflet insertion—as usually defined and measured with various imaging techniques—but a crown-like 3D structure.
• For these reasons, the term ‘aortic annulus’ was deemed inappropriate by anatomists, Ho SY, 2009
• The size of aortic annulus and root is influenced by inner pressure and is dynamically changing during cardiac cycle by 12 and 16%, Raanani E et al, 2011
Recommendation

• TTE permits precise and reproducible measurements of diameters of aortic root and proximal part of ascending aorta.

• The relationship between aorta size and age and body surface should be considered when defining normal ranges.

• TEE is ultrasound modality of choice for measuring size of aortic arch and descending aorta.

• With the introduction of 3D more precise measurements are taken.

Aortic atherosclerosis

• Characterized by irregular intimal thickening of at least 2 mm, with increased echogenicity.

Aortic plaque in the descending thoracic aorta visualized by 2-dimensional TEE.
A. Simple atherosclerotic plaque, measuring >2 mm
B. Complex atherosclerotic plaque with deep ulcerations (arrow).
C. Complex atherosclerotic plaque with a mobile component (arrow) that represents a thrombus.

Plaque are defined as complex in presence of protruding atheromas of ≥4 mm in thickness, mobile debris, or the presence of plaque ulceration.
Significance of Aortic Atheroma

The French Aortic Plaque in Stroke group

Increased embolic risk:
- Plaque thickness ≥4 mm
- Superimposed mobile lesions (thrombi) on aortic plaques
- Ulceration ≥2 mm in aortic plaques
- Non-calcified plaques

Homma S. et al, 2009

- The embolic potential of atherosclerotic aortic lesions during invasive procedures or during open-heart surgery is well established.
- Identification of significant disease by TEE permits alterations in the surgical procedure.

Lindblom D., 2001

Recommendation

TEE is the imaging modality of choice for diagnosing aortic atheromas.

Advantages of TEE over other non-invasive modalities, CT and MRI include accurate measurement of size and mobility of the plaque in real time.

Severity and location of aortic atheromas should be reported.

The supra-sternal window may be useful for diagnosis of plaques in the aortic arch by TTE when the acoustic window is optimal.
Aortic Aneurysm

- Aneurysm is defined as dilation of aorta > 50% of normal diameter involving all the three layers of its wall.
- Aorta considered to be Dilated; diameter varies 3.7 - 5.0 cm
- Aneurysmal; diameter > 5.0 cm and Dissected if presents with an intimal flap.
- Aortic aneurysm is either saccular or fusiform.
- Aneurysms are primarily diseases of aging, CT disorder, trauma, and hypertension.

- Thoracic aortic aneurysms are divided into three groups depending on location: AA, aortic arch, and descending thoracic aneurysms or thoracoabdominal aneurysms.

Aortic Aneurysm

Para-sternal long-axis view by TTE.
(A) Annulo-aortic ectasia
(B) Ascending aorta aneurysm located in upper part of sino-tubular junction.

- Determinants of functional AR with normal AV & ascending aorta aneurysm by TEE for planning surgical management strategies:
  Mid-esophageal long-axis TEE view showing AV and root in end-diastole.
  Measurements: made at the level of aortic annulus, sinuses of Valsalva & sino-tubular junction.
  The length of cusp apposition (a), and effective height (b) are measured

- End-diastolic coaptation of cusps tips & annulus plane=Diastolic tenting of cusps > 8-10 mm
- Sinotubular junction/annulus ratio >1.6
Aortic dissection is formed by intimal tear which is contained by the media leading to the development of a true and false lumen.

- The false lumen may extend into branches of aorta in chest or abdomen.
- Dissection can progress proximally involving the aortic sinus, AV and may also involve the coronary arteries.

Aortic dissection diagnosis by transthoracic echocardiography. Intimal flap (arrows) and two lumina are visualized in:
- (A) aortic root
- (B) aortic arch and distal ascending aorta,
- (C) proximal descending aorta (arrowhead shows the entry tear),
Aortic Dissection

• TEE is highly sensitive and specific in diagnosis of aortic dissection

Sensitivity & Specificity of imaging modalities in evaluating suspected aortic dissection in a meta-analysis of 1,139 patients. Massachusetts General Hospital

• The mortality rate is extremely high, 1-3%/h during the first 48 h. Jaup T, et al., 1992

• Pts. with Marfan syndrome are at an increased risk of aortic dissection. An aortic ratio (Ao) <1.3 indicates a low-risk group.

Ano ratio = Sinus of valsalva diameter / Predicted sinus diameter for given age & BSA

Predicted sinus dimension (cm) = 1.92 + [0.74 × BSA (m²)].

• Patients with aortic root diameter ≥ 50 mm undergoing coronary revascularization are at increased risk of aortic dissection.

Aortic Dissection Classification: DeBakey and Stanford

Reprinted with permission from the Cleveland Clinic Foundation.
TEE is a valuable imaging modality to locate
• Intimal tear (I.T.) entry & exits sites, determine type of dissection and success of surgical repair.
  I.T. occurs in AA, 1-3 cm above the Rt.or Lt. sinus of valsalva in 70% of cases at site of ligamentum arteriosum in 30% of cases.
• Identification of true and false lumen.
  True lumen expands during systole and compressed during diastole, smaller than false lumen and exhibits a forward systolic flow pattern.
Aortic Dissection

Distal Dissection

Distal dissection that has hemodynamically stabilized by organized clot of false lumen

INTRAMURAL HEMATOMA

- Intramural hematomas are characterized by thickened aortic walls without an intimal flap nor tear involving ascending or descending aorta, probably due to rupture of vasa vasorum leading to hemorrhagic vessel wall.

- Hematomas involving the AA need emergent surgical therapy, while those involving the descending aorta can be managed medically.

(a) Three-dimensional (zoom) image of descending aortic short-axis view showing a 5 mm intra-mural hematoma in wall of the descending aorta.
(a) X-plane color Doppler imaging of the descending aorta showing intramural hematoma
COARCTATION OF AORTA

- This is a congenital narrowing of the aorta at the level of the aortic isthmus.
- It can be preductal, ductal, or postductal.
- Coarctation is commonly associated with a bicuspid AV and patent ductus arteriosus.
- Upper esophageal aortic arch shot and LAX views are the recommended views by TEE.
- TTE is more favorable due to its anatomical location.

(a) Upper esophageal aortic arch short-axis view demonstrating the narrowing (arrow) of the aorta below the level of left subclavian artery.
(b) Turbulent flow across the narrowed segment

TEE ASSESSMENT
OF ENDOVASCULAR REPAIR OF AORTIC ANEURYSMS

- Endovascular repair is gaining popularity as alternative to open surgical repair of aortic aneurysms, minimizing the risk of surgery.
- TEE is invaluable tool for identification of aortic pathology, confirmation of placement of the guide wire within true lumen, helps in stent graft positioning, detecting endoleaks, and evaluating the cardiac function.

(a) Descending aortic short-axis view demonstrating color flow Doppler in true lumen, arrow (black) pointing toward guide wire in the center.
(b) Descending aortic long-axis view demonstrating true lumen with the two guide wires (yellow arrows) in situ.
(c) Descending aortic long-axis view demonstrating (arrow) endovascular stent in situ.
SUMMARY

TEE is an invaluable imaging modality in management of aortic pathology.

TEE has to a large extent improved patient outcomes.

Thank You
Introduction

- Echocardiography provides comprehensive assessment of cardiac structures, functions & hemo-dynamics with minimal discomfort to patient.
- Echo data speeds up clinical decision making
- Safely and easily repeatable for follow up without hazards of radiologic contrast media or ionizing radiation
- Strict requirements for education, training and level of competence in echocardiography should be reached by emergency health-care professionals to ensure quality and accuracy of data obtained by echo.

Definition of Emergency Echocardiography

- Echocardiography in assessments of patients with unstable clinical condition
- A comprehensive study that should be distinguished from focused exams performed by pocket-size imaging devices, echo scanning.
- An investigation performed by a trained individual who can independently perform a comprehensive study using a fully equipped echo machine and interpret results unaided.
- Often challenging; key decisions should be taken quickly in a stressful situation.
Training Requirements
○ To achieve basic & advanced level of expertise in echocardiography

<table>
<thead>
<tr>
<th>Echocardiographic technique</th>
<th>Minimum number of examinations performed to become competent</th>
<th>Level of competence*</th>
<th>Minimum number of examinations performed/yr to maintain competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTE</td>
<td>350 (basic)</td>
<td>III</td>
<td>Reasonable exposure</td>
</tr>
<tr>
<td></td>
<td>750 (advanced)</td>
<td>III</td>
<td>100</td>
</tr>
<tr>
<td>TEE</td>
<td>75 (advanced)</td>
<td>III</td>
<td>50</td>
</tr>
<tr>
<td>Stress echocardiography</td>
<td>100 (advanced)</td>
<td>III</td>
<td>100</td>
</tr>
</tbody>
</table>

○ Minimal requirements for cardiologists & non-cardiologists training to perform/interpret adult echocardiography in emergency setting

Transesophageal Echocardiography in Emergency Rooms
• TEE offers several advantages over TTE in the management of critically ill patients.

• TEE reliably obtains high-quality images in nearly all circumstances due to the probe’s indwelling esophageal location, millimeters behind the heart.

• Dramatic success rates (97 % for TEE and 38 % for TTE) in answering clinical questions in a critically ill population

• TEE also has a unique role in cardiac arrest resuscitation due to its ability to interrogate the heart without interrupting chest compressions.
FOCUSED TRANSESOPHAGEAL ECHOCARDIOGRAPHY BY EMERGENCY PHYSICIANS IS FEASIBLE AND CLINICALLY INFLUENTIAL: OBSERVATIONAL RESULTS FROM A NOVEL ULTRASOUND PROGRAM

Robert Amsfield, vs, t Jacob Pace, vs, t Michael Hewak, ass, t and Drew Thompson, vo, t

*Division of Emergency Medicine, †Division of Critical Care Medicine, and ‡Faculty of Medicine and Dentistry, Western University, London, Ontario, Canada

A retrospective review to describe feasibility, findings, and clinical impact of TEE in ED from the first 2 years of a novel ED TEE program.

Focused Transesophageal Echocardiography for Emergency Physicians

- Despite advantages offered by TEE over TTE; use of TEE by emergency physicians (EPs) remains rare.
- No focused TEE protocol for emergency department (ED) use has been defined nor have methods of training been described.
- Objectives: aim 1. to develop a focused TEE examination tailored for ED
  2. to evaluate TEE skill acquisition and retention by TEE-naïve EPs following a focused 4-h curriculum.
Focused TEE for Emergency Physicians

• Participant, EP, Demographics & Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No and % of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>25-34</td>
<td>4 (26.6)</td>
</tr>
<tr>
<td>35-44</td>
<td>5 (35.7)</td>
</tr>
<tr>
<td>45-54</td>
<td>5 (35.7)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12 (85.7)</td>
</tr>
<tr>
<td>Female</td>
<td>2 (14.3)</td>
</tr>
<tr>
<td>Years as staff</td>
<td></td>
</tr>
<tr>
<td>Resident</td>
<td>2 (14.3)</td>
</tr>
<tr>
<td>0-4</td>
<td>4 (26.6)</td>
</tr>
<tr>
<td>5-9</td>
<td>1 (7.1)</td>
</tr>
<tr>
<td>10-14</td>
<td>3 (21.4)</td>
</tr>
<tr>
<td>15+</td>
<td>4 (26.6)</td>
</tr>
</tbody>
</table>

• Workshop was taught by an emergency physician with significant echo experience in TTE & TEE; and a testamur with the National Board of Echocardiography.

Focused Transesophageal Echocardiography for Emergency Physicians

• Focused scanning protocol was designed to address common scope of ED cardiac ultrasound.

• Recent agreement over scope of focused cardiac ultrasound in ED has been defined to include:
  1. Assessment of qualitative global LV function,
  2. Assessment of global RV size and function,
  3. Assessment PE,
  4. Guidance of procedures (pericardiocentesis & transvenous pacemaker)

Focused Transesophageal Echocardiography for Emergency Physicians

Four TEE views were included for ability to capture scope of ED cardiac ultrasound:
1. Mid-esophageal four-chamber view,
2. Mid-esophageal long-axis view,
3. Transgastric short-axis
4. Bicaval view

**Four Views of Focused TEE Exam For EP**

<table>
<thead>
<tr>
<th>View</th>
<th>Location</th>
<th>Transducer controls</th>
<th>Structures of interest</th>
<th>TEE equivalent</th>
<th>Questions answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-esophageal four-chamber view</td>
<td>Mid-esophagus, 0°, neutral flexion</td>
<td></td>
<td>All chambers, valves, and pericardium</td>
<td>Apical four chamber</td>
<td>Left and right ventricular function, mitral/tricuspid valve lesions, pericardial effusion</td>
</tr>
<tr>
<td>Mid-esophageal long-axis view</td>
<td>Mid-esophagus, 110-120°, neutral flexion</td>
<td>With and without color</td>
<td>Left ventricle, mitral valve, aortic valve, pericardium, left atrium</td>
<td>Parasternal long-axis with and without color</td>
<td>Left ventricular function, catastrophic mitral/aortic valve lesion, pericardial effusion</td>
</tr>
<tr>
<td>Transgastric short-axis</td>
<td>Mid-stomach, 0°, anteflexed</td>
<td></td>
<td>Left ventricle</td>
<td>Parasternal short axis</td>
<td>Left ventricular function, pericardial effusion</td>
</tr>
<tr>
<td>Bicaval view with M mode</td>
<td>Mid-esophagus, 90°-100°, neutral flexion</td>
<td></td>
<td>Superior vena cava, inferior vena cava, right atrium</td>
<td>Subcostal IVC</td>
<td>Hypoxemia/volume responsiveness, procedural guidance</td>
</tr>
</tbody>
</table>
Conclusions

This first focused TEE scanning protocol for emergency physicians concluded:

• Emergency physicians with experience in point-of-care ultrasound are able perform a four-view, focused TEE exam with high success using a simulator, after 4 h of training with retention of these skills at 6 weeks.

• This may serve as a model for widespread dissemination and training.

Clinical Impact of TEE exam in ED

Divided into 1) Diagnostic influence on clinical decision-making
2) Therapeutic influence on procedures, prescription of medication or fluids, or ceasing resuscitation based on findings (prognosis).

• Influential Diagnostic Findings from 54 Focused TEE Exam.

<table>
<thead>
<tr>
<th>Diagnostic Finding</th>
<th>Number of Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruled out cardiac cause of arrest</td>
<td>27 (43%)</td>
</tr>
<tr>
<td>Ascertaining etiology of arrest</td>
<td>9 (14%)</td>
</tr>
<tr>
<td>LV dysfunction</td>
<td>5 (8%)</td>
</tr>
<tr>
<td>Hypovolemic shock</td>
<td>4 (6%)</td>
</tr>
<tr>
<td>Aortic dissection</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Identification of different underlying rhythm</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>No influence</td>
<td>15 (24%)</td>
</tr>
</tbody>
</table>
Clinical Impact of TEE exam in ED

- Breakdown of the management changes made in response to TEE findings.

CONCLUSION

TEE showed a high degree of feasibility (98% determinate rate) and clinical utility, with a diagnostic and therapeutic influence seen in the majority of cases.

Focused TEE demonstrates the most promise in patients who are intubated and have either undifferentiated shock or cardiac arrest.
Original Research

Emergency Physician-performed Transesophageal Echocardiography in Simulated Cardiac Arrest

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Michael J. Vitto, DO*
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Turan Kayagil, MD*
Matt Jones, MD*
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Introduction: Transesophageal echocardiography (TEE) is a well-established method of evaluating cardiac pathology. It has many advantages over transthoracic echocardiography (TTE), including the ability to image the heart during active cardiopulmonary resuscitation. This prospective simulation study aims to evaluate the ability of emergency medicine (EM) residents to learn TEE image acquisition techniques and demonstrate those techniques to identify common pathologic causes of cardiac arrest.

Original Research

Emergency Physician-performed Transesophageal Echocardiography in Simulated Cardiac Arrest

Methods: This was a prospective educational cohort study with 40 EM residents from two participating academic medical centers who underwent an educational model and testing protocol. All participants were tested across six cases, including two normals, pericardial tamponade, acute myocardial infarction (MI), ventricular fibrillation (VF), and asystole presented in random order. Primary endpoints were correct identification of the cardiac pathology, if any, and time to sonographic diagnosis. Calculated endpoints included sensitivity, specificity, and positive and negative predictive values for emergency physician (EP)-performed TEE. We calculated a kappa statistic to determine the degree of inter-rater reliability.

Results: Forty EM residents completed both the educational module and testing protocol. This resulted in a total of 80 normal TEE studies and 180 pathologic TEE studies. Our calculations for the ability to diagnose life-threating cardiac pathology by EPs in a high-fidelity TEE simulation resulted in a sensitivity of 98%, specificity of 99%, positive likelihood ratio of 78.0, and negative likelihood ratio of 0.025. The average time to diagnose each objective structured clinical examination case was as follows: normal A in 35 seconds, normal B in 31 seconds, asystole in 13 seconds, tamponade in 14 seconds, acute MI in 22 seconds, and VF in 12 seconds. Inter-rater reliability between participants was extremely high, resulting in a kappa coefficient across all cases of 0.95.
Conclusion

EM residents with varying levels of experience in echocardiography were able to uniformly obtain two standard TEE views and diagnose common pathologic conditions in simulated cardiac arrest after a series of brief teaching sessions with a high degree of sensitivity, specificity, and inter-rater reliability. Further research efforts are needed to determine if the success of this study can be repeated in the in-vivo setting, and if the diagnostic benefits translate to improvements in survival.