• Guidelines released in 2016
  – Guidelines for the Use of Echocardiography in the Evaluation of a Cardiac Source of Embolism
  – Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update
Guidelines for Use of Echo in the Evaluation of a Cardiac Source of Embolism
Evaluation of suspected cardiac source of embolism

“Echocardiography should be the primary form of cardiac imaging”
**Appropriate Use: Transthoracic Echocardiography**

Symptoms or conditions potentially related to suspected cardiac etiology

- Suspected cardiac mass
- Suspected cardiovascular source of embolus
- *Initial* evaluation of suspected infective endocarditis (IE) with positive blood culture results or new murmur
- **Reevaluation of IE at high risk for** progression, complication, or with a change in clinical status
- Known acute pulmonary embolism (PE) **to guide** therapy
- Reevaluation of known PE after thrombolysis or thrombectomy for assessment of change in right ventricular (RV) function and/or pulmonary artery pressure
Inappropriate Use: TTE

- **Transient fever** without evidence of bacteremia or new murmur
- **Transient bacteremia** with a pathogen not typically associated with IE and/or a documented nonendovascular source of infection
- **Routine** surveillance of uncomplicated IE when no change in management is contemplated
- Suspected PE to establish diagnosis
- Routine surveillance of prior PE with normal RV function and pulmonary artery systolic pressure
Appropriate Use: TEE

- As initial or supplemental test for evaluation for cardiovascular source of embolus with no identified noncardiac source
- As initial or supplemental test for to diagnose IE with a moderate or high pretest probability
- Initial test for evaluation to facilitate clinical decision making with regard to anticoagulation, cardioversion, and/or radiofrequency ablation
Inappropriate Use: TEE

- Evaluation for cardiovascular source of embolus with a known cardiac source in which TEE would not change management
- *Routine use* of TEE when diagnostic TTE is reasonably anticipated to resolve all diagnostic and management concerns
- Surveillance of prior TEE finding for interval change when no change in therapy is anticipated
- To diagnose IE with low pretest probability (e.g., transient fever, known alternative source of infection, negative blood culture results or atypical pathogen for endocarditis)
- Evaluation when a decision has been made to anticoagulate and not to perform cardioversion
Echocardiography Recommended

• Echocardiography should be considered in all patients with suspected cardiac sources of embolism, especially in patients for whom clinical therapeutic decisions (such as anticoagulation or cardioversion) will depend on echocardiographic findings.

Echocardiography Not Recommended

• Echocardiography is not recommended in patients for whom the results will not guide therapeutic decisions.

TTE versus TEE

• TEE is not indicated when TTE findings are diagnostic for a cardiac source of embolism.
Evaluation of suspected cardiac source of embolism

- Thromboembolism from the left atrium and LAA
- Thromboembolism from the left ventricle
- Valve disease
- Cardiac tumors
- Embolism from the thoracic aorta
- Paradoxical embolism

- Cardiac and aortic embolism during cardiac surgery and percutaneous interventions
Evaluation of suspected cardiac source of embolism:

THROMBOEMBOLISM FROM THE LEFT ATRIUM AND LAA
Echocardiographic Evaluation of the Left Atrium and LAA

- LA thrombus identification by TTE:
  - Specificity – High
  - Sensitivity – unacceptably low in part because most atrial thrombi are located in the LAA

→ The LAA is best viewed by TEE
Thromboembolism from the left atrium (LA) and LA appendage

Recommendations:

Echocardiography Recommended

- TTE is recommended in patients with suspected LA or LAA thrombus
  - to assess LA size and LV size and function
  - to assess for underlying etiologies of AF and additional risk factors for stroke

- TEE is superior to TTE in assessment of LAA
  - before cardioversion
  - ablation of atrial arrhythmias
  - percutaneous LAA closure
Echocardiography **Potentially Useful**

- Contrast echo may aid in detecting LA and LAA thrombi and may help differentiate avascular thrombi from vascular tumors.
- 3D echocardiography may provide more precise assessment of LA and LAA size and morphology.

Echocardiography **Not Recommended**

- Echocardiography is not recommended in patients for whom the results will not guide therapeutic decisions.
Evaluation of suspected cardiac source of embolism:

THROMBOEMBOLISM FROM THE LEFT VENTRICLE
Recommendations for Performance of Echocardiography in Patients with Suspected LV Thrombus

**Echocardiography Recommended**

- TTE is recommended for the evaluation of possible LV thrombus
  - To confirm the diagnosis of a thrombus, it must be seen in at least two orthogonal (apical and short-axis) views.
  - Exclude -
    - artifacts
    - false tendons, LV trabeculations
    - apical foreshortenings
Echocardiography Recommended

- TTE is typically superior to TEE in the assessment of LV apical thrombus
  - Sensitivity 95%
  - Specificity 85% – 90%

- TEE has a limited role in the detection of LV thrombus
  - The apex is farthest from the transducer
  - The apex is often foreshortened and/or not well visualized
Echocardiography Potentially Useful

- Contrast echocardiography may aid in detecting LV thrombi
- 3D echocardiography may provide more precise assessment of LV thrombus.
Evaluation of suspected cardiac source of embolism:

VALVE DISEASE
Infective Endocarditis

Diagnosis:

According to the Proposed Modified Duke Criteria (Class I, ACC)
## Major and Minor Criteria in the Modified Duke Criteria for the Diagnosis of IE

### Major Criteria

#### 1. Blood culture positive for IE

Typical microorganisms consistent with IE from 2 separate blood cultures:
- *Viridans streptococci, Streptococcus bovis, HACEK group*  
  *(Haemophilus spp., Actinobacillus actinomycetemcomitans,  
  Cardiobacterium hominis, Eikenella spp., and Kingella kingae),*  
  *Staphylococcus aureus;* or community-acquired enterococci,  
  in the absence of a primary focus; or  

Microorganisms consistent with IE from persistently positive blood cultures,  
defined as follows:
- At least 2 positive cultures of blood samples drawn 12 h apart; or  
- All of 3 or a majority of ≥4 separate cultures of blood (with first  
  and last samples drawn at least 1 h apart)  
- Single positive blood culture for *Coxiella burnetii* or antiphase  
  IgG antibody titer >1:800

#### 2. Evidence of endocardial involvement

- Echocardiogram positive for IE defined as follows:
  - Oscillating intracardiac mass on valve or supporting structures, in  
    the path of regurgitant jets, or on implanted material in the absence  
    of an alternative anatomic explanation;  
  - Abscess; or  
  - New partial dehiscence of prosthetic valve  
- New valvular regurgitation (worsening or changing of pre-existing  
  murmur not sufficient)
Positive blood culture results + evidence of endocardial involvement constitute the definition of IE

→ Echocardiographic exploration for endocardial infection is mandatory

- Oscillating mass on valve or on implanted material
- Abscess
- New valvular regurgitation
- New partial dehiscence of prosthetic valve
Infective Endocarditis

Native valve

TTE
- Specificity >90%
- Sensitive 62% to 79%
- Vegetations < 2 to 3 mm in size may be missed

TEE
- Sensitivity and specificity > 90%

Prosthetic valve

TTE
- Sensitivity ~ 20% to 40%

TEE
- Sensitivity >80% to 90%
Infective Endocarditis

abscess diagnosis

TTE
- Sensitivity 28%
- Specificity 98%

TEE
- Sensitivity 87%
- Specificity 95%
TEE is considered a first-line modality when suspecting:

- endocarditis complications (perforation, abscess)
- prosthetic valve endocarditis
- S. aureus bacteremia
- intracardiac devices
- when TTE images are suboptimal
In the setting of intermediate or high clinical suspicion for endocarditis, negative results on TTE should always be followed by TEE.

Repeat TEE at an interval of ~7 days is reasonable if the clinical suspicion of IE remains high even after negative results on initial TEE.
Echocardiography *Recommended*

TTE is recommended for the following:

- Initial evaluation of suspected endocarditis
  - positive blood culture results
  - new murmur

- Reevaluation for complication with a change in clinical status.

- Evaluation of hemodynamic consequences
  - regurgitation, shunt/fistulas, chamber enlargement, and function

- Repeat TTE at the end of antimicrobial therapy to serve as a baseline for future comparisons.
Echocardiography Recommended

TEE is recommended for the following:

- To diagnose IE and its complications when *clinical suspicion is intermediate or high*, regardless of negative results on TTE.

- As the first-line modality when *complications* of IE are suspected
  - Abscesses
  - Fistulas
  - Valve perforation
  - When prosthetic valve endocarditis is suspected
**Echocardiography Not Recommended**

Transient fever without bacteremia or a new murmur.

Transient bacteremia with a nontypical organism and/or documented nonintravascular infection source.

Routine surveillance of uncomplicated IE when imaging is not expected to change management.
2014 AHA/ACC Recommendations for Imaging Studies in NVE and PVE

Patient at Risk or With Suspected NVE or PVE

Blood cultures × 2

TTE

Nondiagnostic TTE
Complications present or suspected
Intracardiac lead present
S. aureus bacteremia without known source
Prosthetic valve with persistent fever
Suspected paravalvular infection with inadequate TTE/TEE
Nosocomial S. aureus bacteremia with portal of entry from known extra cardiac source
Undergoing surgery for IE

TEE* (I)
TEE (IIa)
Cardiac CT (IIa)
TEE (IIb)
Intraoperative TEE (I)
Nonbacterial Thrombotic Endocarditis

Verrucous Endocarditis or Libman-Sacks Endocarditis

- Composed of granular material containing immune complexes, hematoxylin bodies, and platelet thrombi, without bacteria.
- Found in up to 43% of patients with lupus
- Usually asymptomatic and not associated with valvular destruction
- Can be complicated by IE and systemic embolization.
- Affect typically the free edges of the mitral leaflets
Nonbacterial Thrombotic Endocarditis

Marantic Endocarditis or NBTE

• Commonly refers to noninfectious thrombotic endocarditis a/w malignancy
• Composed of platelets and fibrin
• Significant valvular dysfunction rare
• Affect the atrial side of the MV and ventricular side of the AV
• Up to 50% of patients with NBTE may incur systemic embolic events
Recommendations for Performance of Echocardiography in Patients with Suspected Noninfective Endocarditis

Echocardiography Recommended

- TTE surveillance in patients with
  - primary antiphospholipid syndrome
  - SLE with secondary antiphospholipid syndrome
Nonbacterial Thrombotic Endocarditis

**Echocardiography Not Recommended**

- **Routine** echocardiography is not recommended for patients with lupus in the absence of clinical signs such as fever, embolic phenomena, and new murmurs.
Valvular Strands and Lambl’s Excrencescences

• **Echocardiographical Definition:**
  – filiform structures, with undulating motion
  – width < 2 mm
  – 3 - 10 mm, localized to the line of leaflet closure

• **No robust evidence that valvular strands cause systemic embolism**
Prosthetic Valve Thrombosis

• Difficult to distinguish thrombus from vegetation echocardiographically

→ Patient’s clinical background and associated imaging findings become critical

• Echocardiographer must follow a systematic method of analysis and reporting
  • Begin with a careful echocardiographic description of findings
  • End with a differential diagnosis in the report and a most likely diagnosis
Prosthetic Valve Thrombosis

- The first step of the evaluation when thrombosis is suspected
  - Evaluate the presence and hemodynamic significance of prosthetic dysfunction
  ➔ Gold standard is TTE
Prosthetic Valve Thrombosis

- difficult to distinguish thrombosis from pannus formation (chronic fibrous tissue ingrowth)
- Mixed pannus-thrombus pathology is not uncommon

**Table 8** Echocardiographic evaluation of prosthetic valve obstruction mechanism

<table>
<thead>
<tr>
<th>Favors pannus</th>
<th>Favors thrombus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical prosthesis in the aortic position</td>
<td>Mechanical prosthesis in the tricuspid or mitral position</td>
</tr>
<tr>
<td>No significant decreased occluder motion</td>
<td>Abnormal occluder motion with obstruction</td>
</tr>
<tr>
<td>Therapeutic anticoagulation</td>
<td>Attachment to the occluder itself</td>
</tr>
<tr>
<td>Identified mass not significantly mobile</td>
<td>Subtherapeutic anticoagulation</td>
</tr>
</tbody>
</table>

Prosthetic Valve Thrombosis

- TEE is superior in detecting
  - thrombus
  - prosthetic leaflet motion

- TEE can reliably identify embolization risk and facilitate the decision between thrombolysis and redo surgery
  - Mobile
  - >5 to 10 mm in length
  - > 0.8 cm² in area
Prosthetic Valve Thrombosis

2014 AHA/ACC Evaluation and Management of Suspected Prosthetic Valve Thrombosis

Suspected Prosthetic Valve Thrombosis

TTE to evaluate hemodynamic severity (I)

CT or fluoroscopy to evaluate valve motion (IIa)

Left-sided prosthetic valve thrombosis

TEE for thrombus size (I)

Right-sided prosthetic valve thrombosis

NYHA class III-IV symptoms

Mobile or large (≥0.8 cm³) thrombus

Recent onset (<14 d)
NYHA class I-II symptoms
Small thrombus (<0.8 cm³)

Emergency Surgery (I)

Emergency Surgery (IIa)

Fibrinolytic Rx if persistent valve thrombosis after IV heparin therapy* (IIa)

J Am Coll Cardiol. 2014;63(22):e57-e185
Prosthetic Valve Thrombosis

Echocardiography *Recommended*

- Both TTE and TEE are indicated when prosthetic valve thrombosis is suspected
- Interval studies are appropriate for re-evaluation when it would change management or guide therapy
- TTE and/or TEE are recommended for evaluation of success post thrombolysis therapy
  - improved valvular hemodynamics
  - thrombus resolution
Evaluation of suspected cardiac source of embolism:

CARDIAC TUMORS
Cardiac Tumors

• Mets to the heart 40 X more common than primary cardiac tumors
• Primary cardiac neoplasms:

  • Benign – 94%
    – Myxoma
    – Lipoma
    – Fibroelastoma
    – Rhabdomyoma
    – Fibroma

  • Malignant – 6%
    – Sarcoma
    – Mesothelioma
    – Lymphoma
Cardiac Tumors

The 2 most common primary cardiac tumors in adults: myxoma & PFE

- **Myxoma**
  - Embolism in up to 1/3 of cases
  - Located in LA >75%
  - >90% attached with a stalk to the fossa ovalis
- **Carney complex**
  - ~ 7% of all cardiac myxomas
  - autosomal dominant
  - multiple myxomas
  - blue nevi
  - Endocrine disorders
Papillary Fibroelastoma

- second most common primary cardiac tumor in adults.

- 80% located on the cardiac valves
  - AV > MV

- May be seen on any endocardial surface.

- Located on the downstream side of the valve
  - Opposite of the typical location of IE lesions.

- High risk for embolism.
Echocardiography Recommended

• TTE in all patients suspected of having cardiac tumors

• TEE may be superior to TTE in evaluating cardiac tumors, especially myxomas and PFEs

• Surveillance echo after surgical removal of cardiac tumors with high recurrence potential (such as myxomas)
Echocardiography Not Recommended

Echocardiography is not recommended in patients for whom the results will not guide therapeutic decisions.
Evaluation of suspected cardiac source of embolism:

EMBOLISM FROM THE THORACIC AORTA
Aortic Sources of Embolism

TEE together with CT and MRI is the primary means of aortic plaque visualization

TEE ‘blind spot’
• A small segment of the distal ascending aorta because of trachea between the esophagus and the aorta

Risk of embolic CVA
• Plaque thickness > 4mm in the ascending aorta or arch visualized by TEE
Aortic Sources of Embolism

3D TEE may provide incremental diagnostic information on aortic plaques
Echocardiography **Recommended**

- TEE is the preferred echocardiographic method for the evaluation of aortic sources of emboli.

Echocardiography **Potentially Useful**

- Aortic plaque may occasionally be seen on TTE. However, TTE has low sensitivity for the detection of aortic pathology, including aortic plaques, compared with TEE.

Echocardiography **Not Recommended**

- Echocardiography is not recommended in patients for whom the results will not guide therapeutic decisions.
Evaluation of suspected cardiac source of embolism:

PARADOXICAL EMBOLISM
PFO

- PFO is typically closed because of the gradient between the LA and RA

- R→L shunt with transient pressure gradient from the RA to LA (↑ RAP)
  - PHTN
  - Valsalva maneuver

- Atrial septal aneurysm a/w PFO
  - mobile excursion of the septum toward the RA or LA >10 mm or
  - a combined total excursion > 15 mm from the midline
Evaluation of Suspected Paradoxical Embolism

Agitated saline contrast

- Perform at rest and with provocative maneuvers to increase the RAP
  - R→L shunt:
    - 57 % at rest
    - 92 % with straining or coughing
  - Cough - rapid intrathoracic pressure ↑ up to 250 mmHg
  - Valsalva – up to 40 mmHg

- Identify deviation of the interatrial septum to the LA side, confirming ↑ RAP
PFO

- PFO is presumed when agitated saline contrast is noted in the LA within 3 cardiac cycles after complete opacification of the RA
- > 5 cardiac cycles → intrapulmonary shunt or pulmonary AVM
- Timing of contrast appearance is used as a rough guide
- The best discriminator to accurately predict the location of shunting is direct visualization of the shunt.
+ TTE for a R-to-L shunt $\rightarrow$ TEE to confirm the PFO and to exclude other shunts (e.g. secundum ASDs)

3D TEE to define the anatomy and evaluate for structural relationships
Echocardiography Recommended

• TTE is recommended for the evaluation of a R-to-L shunt and atrial septal anatomy in a patient with cryptogenic stroke:
  • ↑ RAP with PE or DVT

• No shunt by color Doppler
  → agitated saline injection at baseline and after coughing or Valsalva maneuver)

• TEE may be performed if TTE fails to demonstrate a R-to-L shunt
Recommendations for Echocardiographic Evaluation of Suspected Paradoxical Embolism

**Echocardiography Potentially Useful**

3D TEE may provide incremental value in assessing atrial septal anatomy.

**Echocardiography Not Recommended**

Echo to establish a R-to-L shunt is not recommended in patients (typically older ones) who have other probable causes of stroke or systemic embolism.
Evaluation of suspected cardiac source of embolism:

PULMONARY EMBOLISM
Role of Echocardiography in Evaluation of PE

- 90%–95% of PE are a result of DVT originating in the legs
- PE is the 3rd most common cause of vascular death after MI and stroke
- Rapid distinction of high-risk from low-risk patients important so that further management strategies can be tailored → Echocardiography shown to be a good discriminator
Role of Echocardiography in Evaluation of PE

- Echocardiography is not a diagnostic modality of choice for the diagnosis of PE per se
- Rarely thrombus in transit
- **Echo for risk stratification**
The typical **echocardiographic features of hemodynamically significant PE:**

- RV strain (RV dilatation and dysfunction)
- IVS bulging into the LV
- Dilated proximal PA
- Elevated RVSP
- Increased TR jet severity
- Elevated RAP as evidenced by plethora of IVC with no inspiratory collapse
- McConnell sign (hypokinesis of the basal and mid RV free wall, with preserved contractility of apex)
- Visualization of thrombi in transit from systemic veins to pulmonary arteries
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Echocardiographic images showing:
- RV strain
- IVS bulging into the LV
- Dilated proximal PA
- Elevated RVSP
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\[ \text{RVSP} \approx 4(V_{TR})^2 \]
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- McConnell sign (hypokinesis of the mid RV free wall, with preserved contractility of apex)
- Visualization of thrombi in transit from systemic veins to pulmonary arteries
Echocardiography **Recommended**

- TTE is recommended for risk stratification in patients with PE (primarily for assessment of RV size and function).

- TEE may be considered in acutely ill, unstable patients in whom hemodynamically significant PE is suspected.

Echocardiography **Not Recommended**

- Echocardiography is not recommended as a primary means of diagnosing PE.
Evaluation of suspected cardiac source of embolism:
CARDIAC AND AORTIC EMBOLISM DURING CARDIAC SURGERY AND PERCUTANEOUS INTERVENTIONS
Cardiac Catheterization

• embolism during cardiac catheterization = 1.4% - 1.9%
• the ascending aorta is likely the main source of emboli

Cardiac Surgery

• The risk for embolism from the aorta during cardiac surgery is strongly correlated with the degree of atherosclerosis in the ascending aorta

Percutaneous Interventions

• Percutaneous wires, catheters, and other devices may dislodge preexisting intracardiac and intra-aortic masses to cause systemic embolism
• Periprocedural stroke during TAVR = 1.5% - 6%
Echocardiography Recommended

- TEE or ICE is recommended in all patients before intracardiac percutaneous intervention to exclude potential cardiac sources of emboli.

- The routine preoperative TEE to identify and manage aortic atheromatous disease is recommended in patients with increased risk for embolic stroke
  - histories of CVA or PAD
  - those with evidence of aortic atherosclerosis or calcification by MRI, CT, or CXR.
Thank you for your attention.

Questions?
Rims – Nomenclature

1. AV valve rim
2. Aortic rim
3. SVC rim
4. RUPV rim
5. Posterior rim
6. IVC rim
7. ? CS rim

http://www.pedicardiology.net/2011/03/echo-asd-tee-evaluation-of-rims-for.html
ASD - Echocardiogram

0 deg TEE
4-Chamber view

AV valve rims
RUPV rim

90 deg TEE
Bicaval view

SVC rim
IVC rim

30 deg TEE
Aortic root view

Ao. Rim
Post. Rim

http://www.pedicardiology.net/2011/03/echo-asd-tee-evaluation-of-rims-for.html
Mitral Annular Calcification (MAC)

Recommendations for Performance of Echocardiography in Patients with MACs.

Echocardiography Potentially Useful.

Echocardiography can establish the presence, extent, and severity of MACs.

However, MACs are typically an incidental finding and unlikely to be an independent cause of a cardiac source of embolism.
1. Careful echocardiographic description

- **Echogenicity/echo texture**: differentiate “myocardial-like” echogenicity vs more echogenic patterns
- **Size**: length and width in millimeters
- **Shape**: sessile or pedunculated; amorphous, lobulated, linear, rounded, strand-like, etc
- **Location**: side of valves, free edge vs base of leaflet
- **Motion**: dependent or independent of valvular motion; mild, moderate, or highly mobile*
- **Associations**: regurgitation, stenosis, mycotic aneurysms, valvular destruction, perivalvular abscess, perforation, prosthetic dehiscence
- **A description of prosthetic valve annular position** (i.e., well seated), presence of rocking motion, and opening-closure of mechanical mechanisms (i.e., normal disk or leaflet diastolic excursion for a mitral prosthesis)
2. Differential diagnosis

• Always attempt to answer the clinician’s question/indication
• Report 2-3 most likely explanations
  – if patient’s clinical presentation is typical and echo characteristics are highly suggestive of pathology:
    → may use terms as *suggestive of* or *likely represents, most consistent with*, followed by terms such as *less likely represents* or *unlikely to be*.
• If clinical presentation unclear, and/or echocardiographic characteristics indistinct, report the most likely 2-3 DDx according to echocardiographic appearance, patient’s age, predisposing factors, and epidemiology