2017 ASE Echo Florida, Orlando, FL

Guidelines for the Use of Echocardiography in the Evaluation of a Cardiac Source of Embolism

Sunday, October 8, 2017 | 1:30 – 1:50 PM | 20 min

NYU
SCHOOL OF
MEDICINE

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Disclosures

Medtronic & Philips
Speakers' Bureaus

ASE Guidelines Related to Stroke

There are several recent ASE guidelines related to echocardiography in patents with stroke and systemic embolism:

2015	Multimodality Imaging of Diseases of the Thoracic Aorta in Adults
2015	Guidelines for the Echocardiographic Assessment of Atrial Septal Defect & Patent Foramen Ovale
2016	Guidelines for the Use of Echocardiography in the Evaluation of a Cardiac Source of Embolism

GUIDELINES AND STANDARDS

Multimodality Imaging of Diseases of the Thoracic Aorta in Adults: From the American Society of Echocardiography and the European Association of Cardiovascular Imaging

Endorsed by the Society of Cardiovascular Computed Tomography and Society for Cardiovascular Magnetic Resonance

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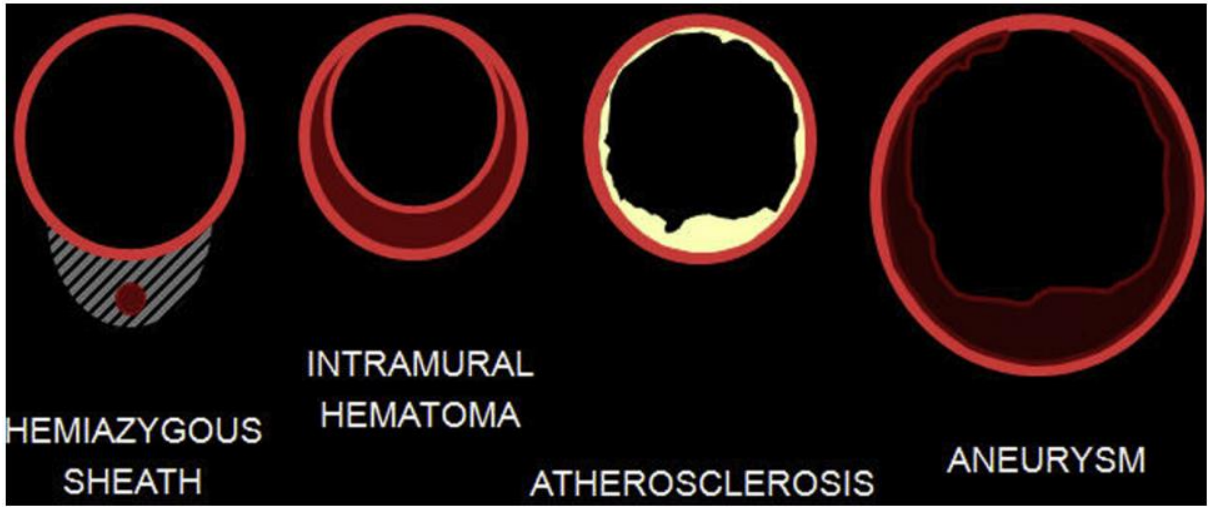
(J Am Soc Echocardiogr 2015;28:119-82.)

VII. ATHEROSCLEROSIS

Various terms have been used to describe the appearance of atherosclerotic lesions of the aorta on imaging. The simplest lesions are usually reported as "atheroma" or "atheromatous plaque." When mobile components are seen attached to these plaques, the terms *ruptured plaque, mobile plaque, mobile debris,* and *superimposed thrombi* are used. Some believe that mobile echodensities represent fibrous caps of ruptured plaques,[330] but autopsy and surgically examined specimens indicate that they are most often superimposed thrombi.[331-335] Supporting the latter conclusion, mobile lesions have been shown to disappear after anticoagulant therapy.[336] Both necropsy[337] and TEE[338,339] have demonstrated that the frequency and severity of atherosclerotic plaque is lowest in the ascending aorta, greater in the arch, and greatest in the descending thoracic aorta.



ASE GUIDELINES & STANDARDS

Guidelines for the Echocardiographic Assessment of Atrial Septal Defect and Patent Foramen Ovale: From the American Society of Echocardiography and Society for Cardiac Angiography and Interventions

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(J Am Soc Echocardiogr 2015;28:910-58.)

ASE GUIDELINES AND STANDARDS

Guidelines for the Use of Echocardiography in the Evaluation of a Cardiac Source of Embolism

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J Am Soc Echocardiogr. **2016** Jan;29(1):1-42.

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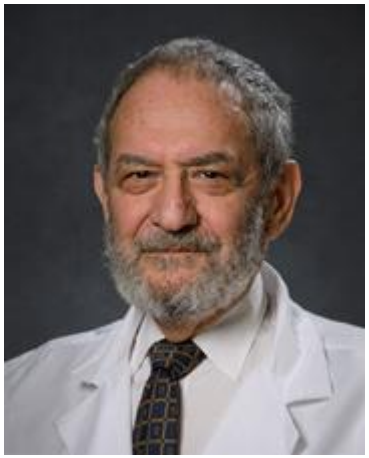

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Guidelines Committee Chair

2016 ASE Embolism Guidelines | Overall Design

- 2016 ASE guidelines on cardiac source of embolism are the **first set of guidelines** from the American Society of Echocardiography specific to this topic.
- Clinical utility of the 2016 guidelines is illustrated through figures, tables, and videos, which include imaging techniques, strategies for overall evaluation, reporting recommendations, and comparisons of echo modalities.
- 2016 ASE embolism guidelines are **harmonized** with the 2011 Appropriate Use Criteria for Echocardiography

Guidelines Rationale

- **Cardiac embolism** accounts for a large number of **ischemic** strokes and systemic emboli.
- **Paradoxical embolism** and embolism from the thoracic aorta, especially of its atheroma contents, is responsible for additional cases of stroke and systemic embolism.
- There were **no prior guidelines** from the American Society of Echocardiography specific to this topic.

Guidelines Clinical Utility

- **DIAGNOSIS**
  Transthoracic and transesophageal echocardiography serve as a cornerstone in the evaluation, diagnosis, and management of these patients.

- **MANAGEMENT**
  A clear understanding of the **various types of cardiovascular conditions associated with cardioembolic stroke** and their intrinsic risk is needed to manage and diagnose cardiac sources of embolism.

2016 ASE Guidelines | Cardiac Source of Embolism

Guidelines Overview

- Review potential cardiac sources of embolism
- Discuss the role of echocardiography in clinical management of cardioembolic stroke and systemic embolism
- Compare echocardiography to other imaging modalities used for diagnosis of cardiac sources of emboli
- Provide levels of recommendation:
  - Echocardiography recommended
  - Echocardiography potentially useful
  - Echocardiography not recommended

Recommendations for Performance of Echocardiography in Patients with Potential Cardiac Source of Embolism

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 Potentially Useful

- Patients with neurologic events and concomitant intrinsic cerebrovascular disease.

Echocardiography Not Recommended

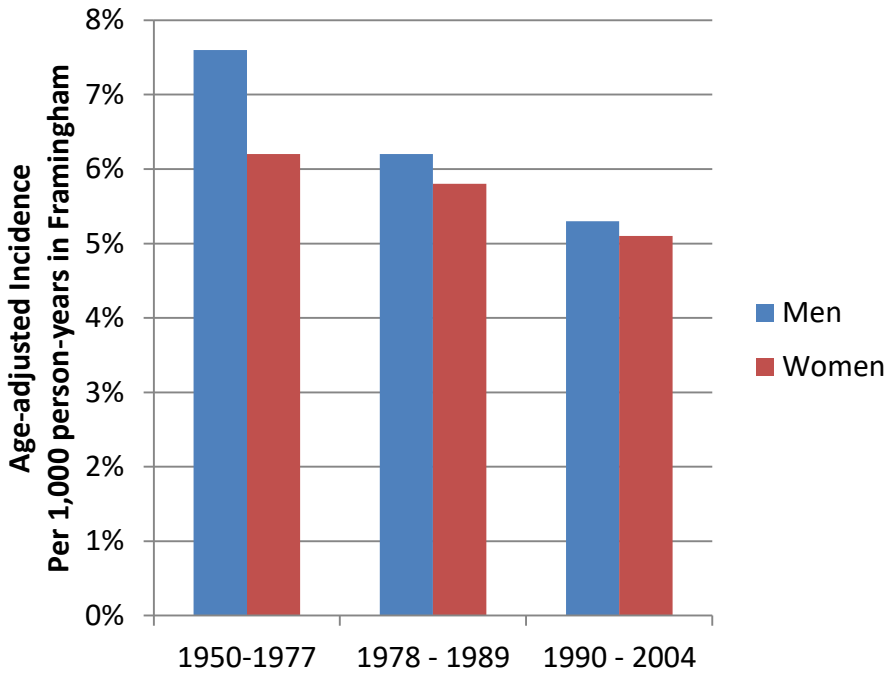
- Echocardiography is not recommended in patients for whom the results will not guide therapeutic decisions.

TTE versus TEE

- TEE is not indicated when transthoracic echocardiographic findings are diagnostic for a cardiac source of embolism.
- TTE may be unnecessary when TEE is already planned (e.g., for evaluation of intracardiac masses, prosthetic valves, and thoracic aorta or when TEE is used to guide a percutaneous procedure related to cardiac source of embolism).

STROKE: BASIC STATISTICS

- Stroke is a leading cause of death and disability worldwide
- In 2005, it was estimated that stroke accounts for 10% of all deaths worldwide
- More than 2,000 new strokes occur every day in the United States
- Stroke incidence is declining in developed countries, largely due to better hypertension control and less tobacco use

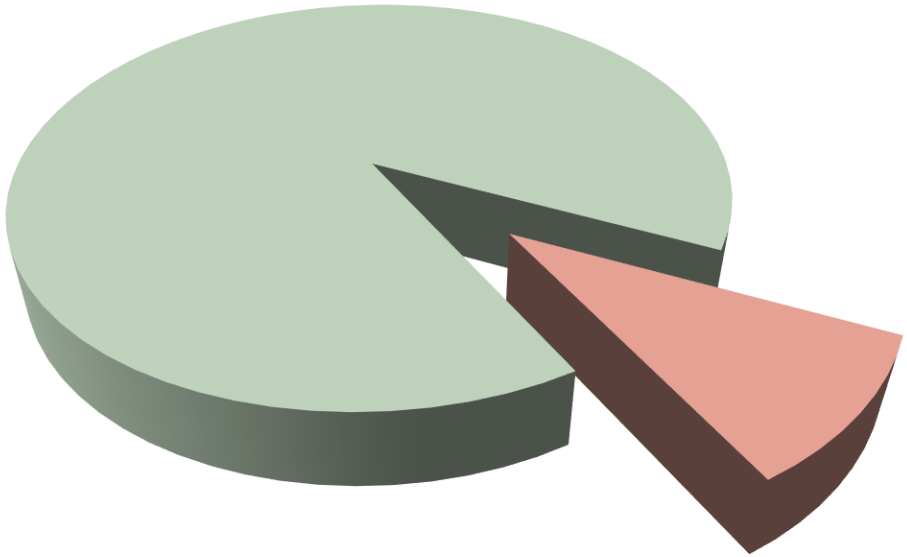


Neurol Clin **2008**;26:871–895
JAMA **2006**;296(24):2939–46

- However, the absolute number of strokes will continue to rise because of the aging population

Stroke Types

Based on data from a large Danish study of ~40,000 stroke patients.
Stroke **2009**;40:2068-2072



Ischemic Strokes	Hemorrhagic Strokes
~90%	**~10%**
Ischemic 'mini-strokes' that resolve spontaneously within 24-48 hours are called **transient ischemic attacks (TIAs)**.	Some hemorrhagic strokes start as ischemic strokes but later undergo hemorrhagic conversion.

Ischemic Stroke Subtypes

TOAST Criteria

Trial of **O**rg 10172 in **A**cute **S**troke **T**reatment

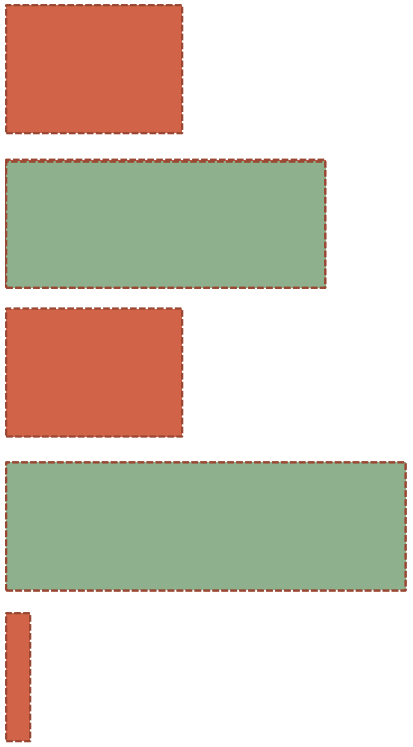
Stroke 1993;24:35-41

Org 10172 was a code name for danaparoid, a heparin-like drug used in the trial.

TOAST Subtype	Description
1. Large vessel stroke	Significant stenosis or occlusion of a large cervical or cerebral artery presumably due to atherosclerosis
2. Cardioembolic stroke	Cerebral vessel occlusion due to embolus arising in the heart (and thoracic aorta)
3. Small-vessel stroke	Lacunar brain infarcts
4. Cryptogenic stroke	Stroke of unknown cause
5. Stroke due to other known causes	Vasculopathies, hypercoagulable states etc.

ISCHEMIC STROKE SUBTYPES

Relative Prevalence of Ischemic Strokes in Rochester, Minnesota (N = 454; 1985-1989)



1. Large Vessel Stroke	**16%**
2. Cardioembolism	**29%**
3. Small Vessel Stroke	**16%**
4. Cryptogenic	**36%**
5. Other known causes	**3%**
TOTAL	**100%**

Approximately 1/3 of ischemic strokes are likely cardioembolic.

Some cryptogenic strokes may be cardioembolic.

Stroke **1999**;30:2513-2516

Cardiac Source and Risk of Embolism

Cardiac sources differ in their embolic potential

HIGH-RISK POTENTIAL

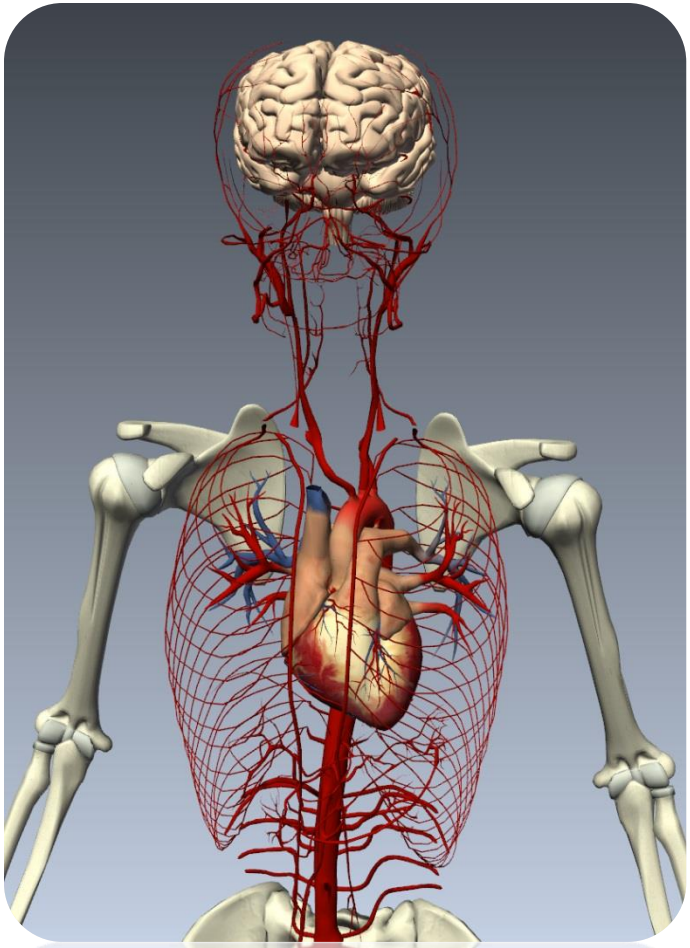
- **THROMBI**
  - Atrial fibrillation
  - Myocardial infarction
  - Cardiomyopathies
  - Mechanical prosthetic valves
- **VEGETATIONS**
  - Valvular and nonvalvular infective endocarditis
- **TUMORS**
  - Myxoma
  - Papillary fibroelastoma
- **AORTIC ATHEROMA**

MODERATE-RISK POTENTIAL

- **THROMBI & SIMILAR PATHOLOGIES**
  - 'Smoke' and 'Sludge'
  - Mitral stenosis with sinus rhythm
  - Atrial flutter
- **VALVULAR DISEASE**
  - Bioprosthetic valves
  - Giant Lambl's excrescence
  - Calcific aortic stenosis
  - Mitral annular calcifications
  - Mitral valve prolapse
  - Nonbacterial thrombotic endocarditis
- **ATRIAL SEPTUM**
  - Atrial septal aneurysm
  - Patent foramen ovale

Stroke 1993;24:35-41

How Do Clinicians Suspect a Cardioembolic Stroke?



BRAIN

- Sudden onset of often severe neurologic deficit without prodromes
- Multiple brain lesion in multiple vascular territories
- Recurrent strokes (waves of emboli) over a short period of time

PRESUMED CARDIAC SOURCE OF EMBOLI

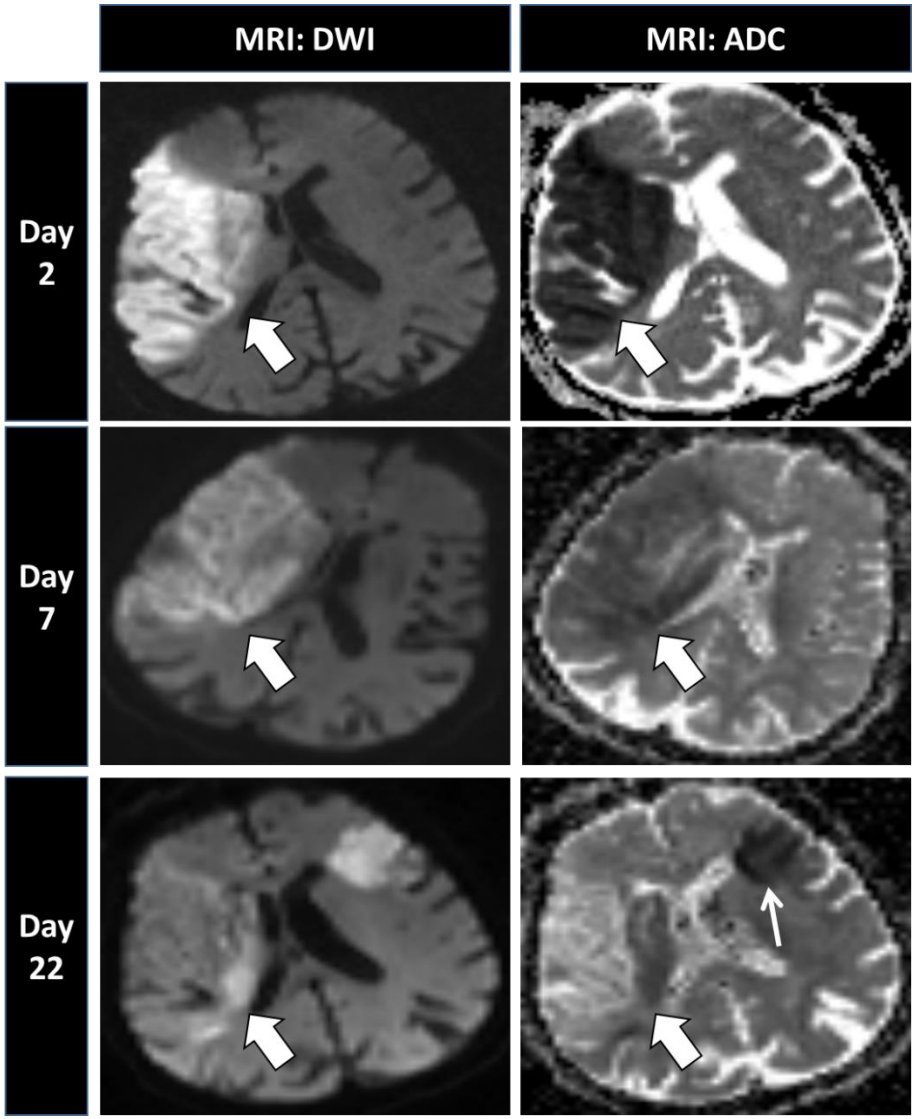
OTHER ARTERIAL TERRITORIES

- Spleen, kidney or other organ infarcts occurring at time of strokes support cardioembolic mechanism

Brain MRI: Evolution of AF-related Embolic Strokes

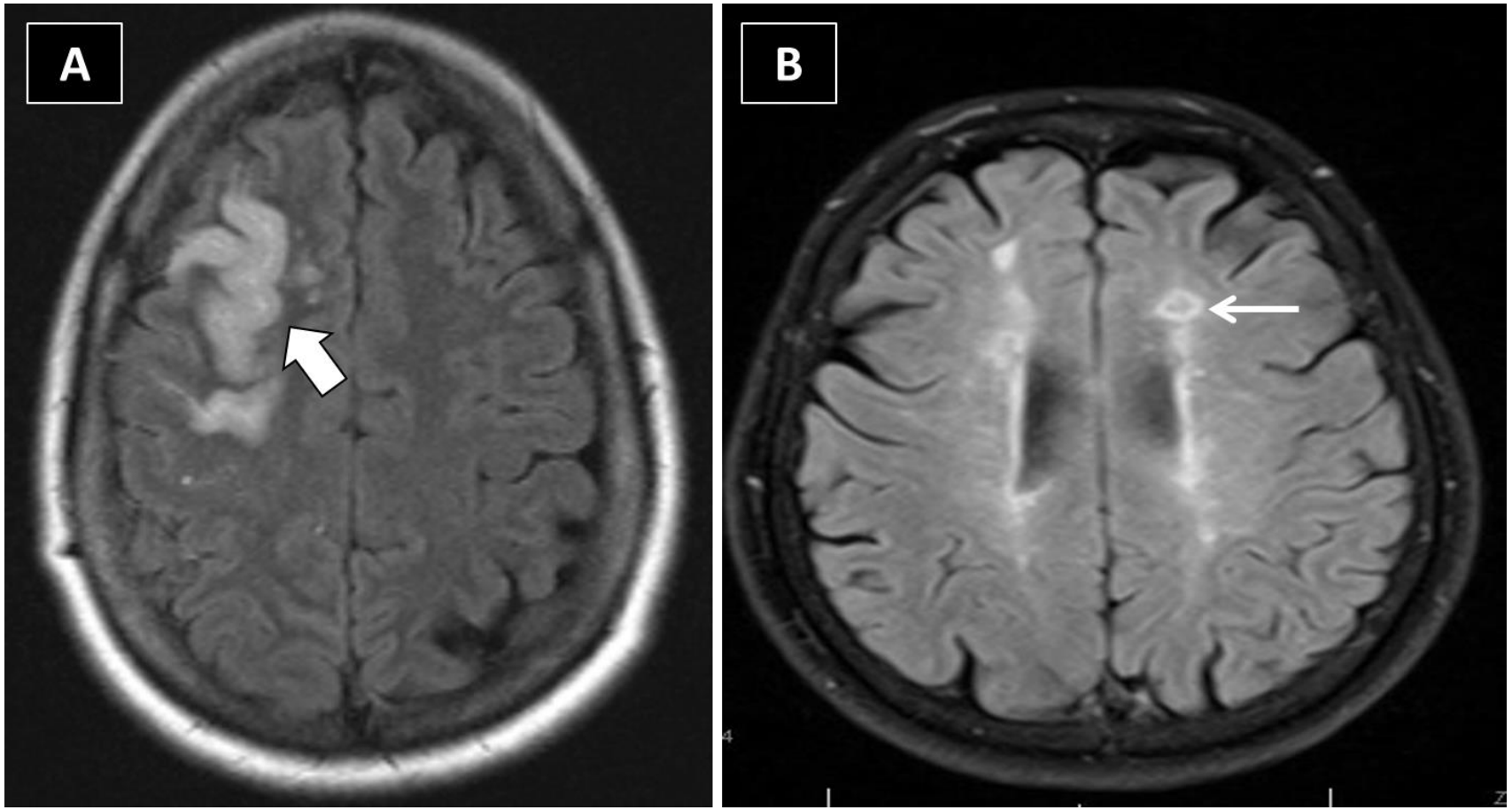
DWI: Diffusion-weighted imaging ADC: apparent diffusion coefficient

The patient first had an embolic stroke to the **right middle cerebral artery** territory (thick arrows).



Three weeks later, the patient had a new stroke in the territory of **the left middle cerebral artery** (thin arrow).

Brain MRI: Nonembolic Strokes



Thick arrow points to a **watershed infarct** at the boundary of right anterior and right middle cerebral artery territories in a middle-aged woman with headache.

Thin arrow points to a **lacunar infarct** in the left frontal paraventricular region of a patient with systemic hypertension.

APPROPRIATE USE OF ECHOCARDIOGRAPHY

ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/ SCCT/SCMR 2011 Appropriate Use Criteria for Echocardiography

A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Society of Echocardiography, American Heart Association, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance American College of Chest Physicians

(J Am Soc Echocardiogr 2011;24:229-67.)

Keywords: ACCF Appropriate Use Criteria, Cardiac imaging, Coronary artery disease, Diagnostic testing, Echocardiography

Appropriate Use: Transthoracic Echocardiography (TTE)

- Symptoms or conditions potentially related to suspected cardiac etiology, including but not limited to chest pain, shortness of breath, palpitations, TIA, stroke, or peripheral embolic event
- 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 or complication or with a change in clinical status or cardiac examination results
- Known acute pulmonary embolism (PE) to guide therapy (e.g., thrombectomy and thrombolytic therapy)
- Reevaluation of known PE after thrombolysis or thrombectomy for assessment of change in right ventricular (RV) function and/or pulmonary artery 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 to diagnose IE with a moderate or high pretest probability (e.g., staph bacteremia, fungemia, prosthetic heart valve, or intracardiac device)
- As initial test for evaluation to facilitate clinical decision making with regard to anticoagulation, cardioversion, and/or radiofrequency ablation

ECHO IN CARDIAC SOURCE OF EMBOLISM | INAPPROPRIATE USE

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

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 transesophageal echocardiographic finding for interval change (e.g., resolution of thrombus after anticoagulation, resolution of vegetation after antibiotic therapy) 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

Cardiac Source of Embolism

LEFT VENTRICULAR THROMBUS

Left Ventricular Thrombus

Basic Characteristics

- Typically, LV thrombus is associated with a hypokinetic, akinetic or aneurysmal LV segment.
- LV thrombi can be seen in both ischemic and nonischemic cardiomyopathy.
- Ischemic LV thrombi can occur with either acute myocardial infarction of after chronic remodeling of LV (such as LV aneurysm)

Imaging Recommendations

- Because LV is in anterior chest, LV thrombi are typically well seen on **transthoracic echocardiography (TTE)**
- Use of **microbubble (transpulmonary) contrast agents** enhances the diagnosis of LV thrombi

LEFT VENTRICULAR THROMBUS

Highlights

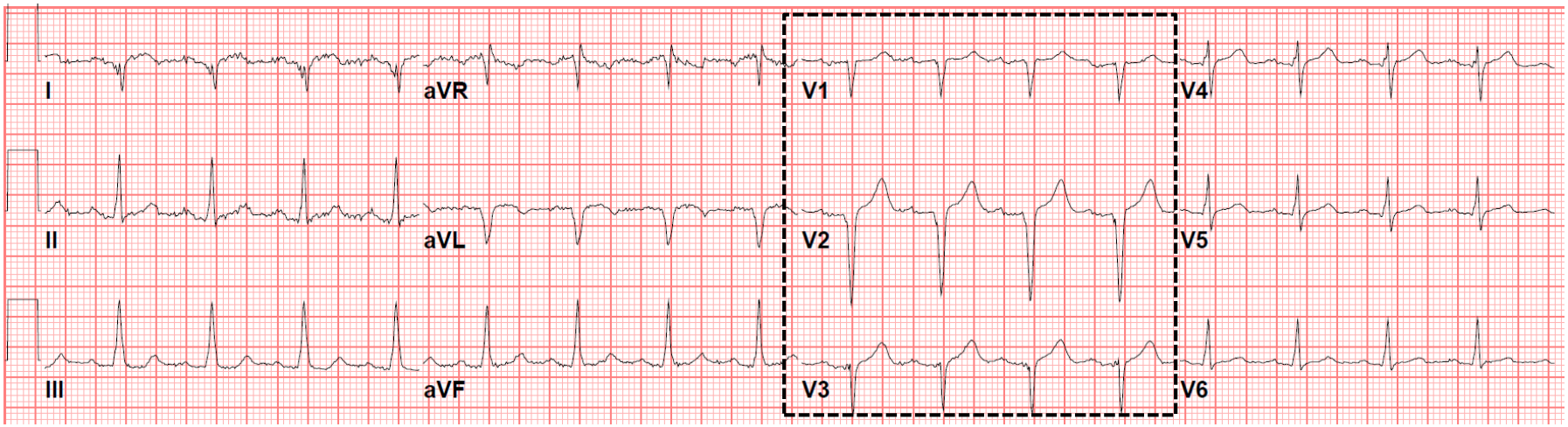
- **ISCHEMIC CARDIOMYOPATHY**
  Prior to modern therapy:
  - 35% of patients with recent anterior wall MI would developed mural thrombi if not anticoagulated
  - 40% of them would embolize systemically within 4 months after the MI in the absence of anticoagulation

- **NONISCHEMIC CARDIOMYOPATHY**
  - 3.5% annual embolic risk

Left Ventricular Thrombus

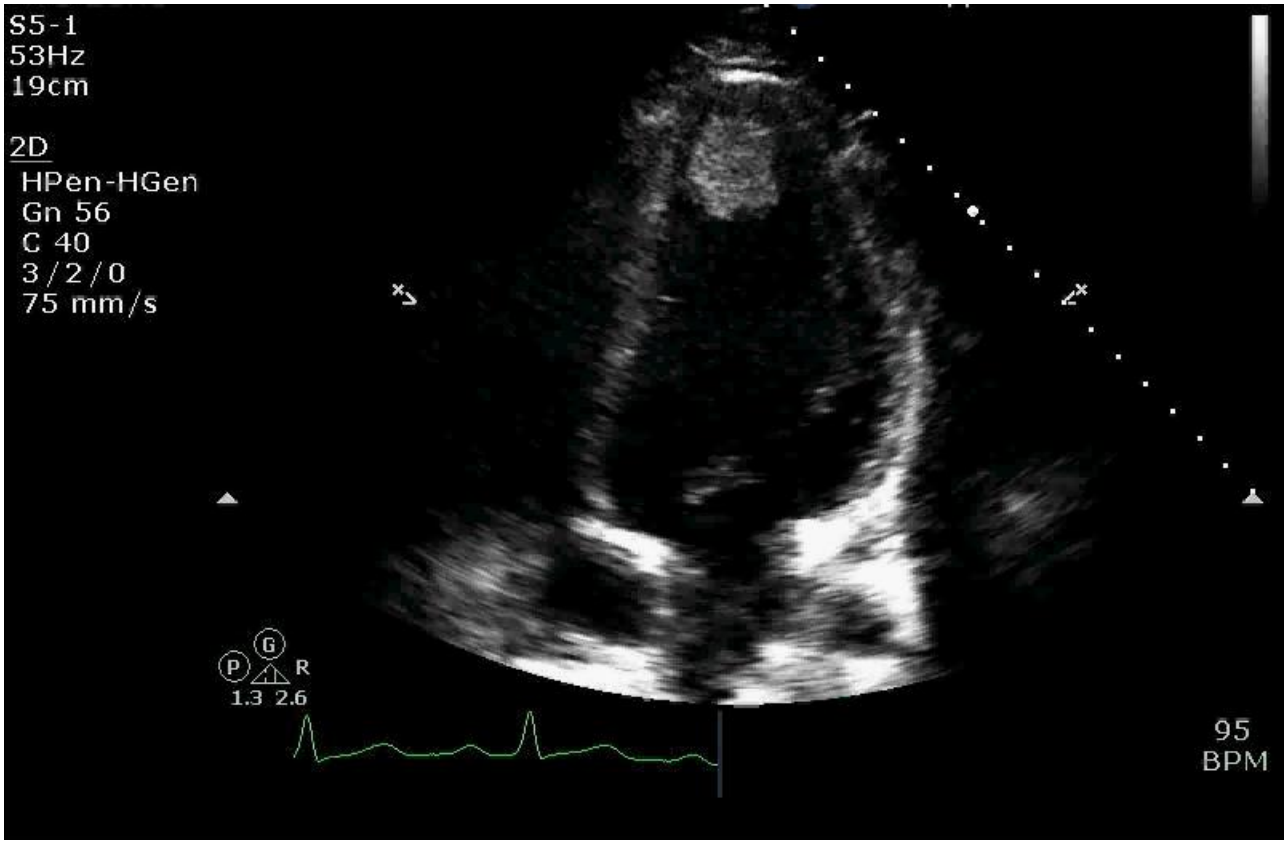
Clinical History

- 24-year-old man with acute anterior wall MI 3 weeks earlier
- Now presents with stoke AND bilateral lower extremity thromboemboli



EKG consistent with completed anteroseptal wall MI
(Q waves in V1-V3)

LEFT VENTRICULAR THROMBUS



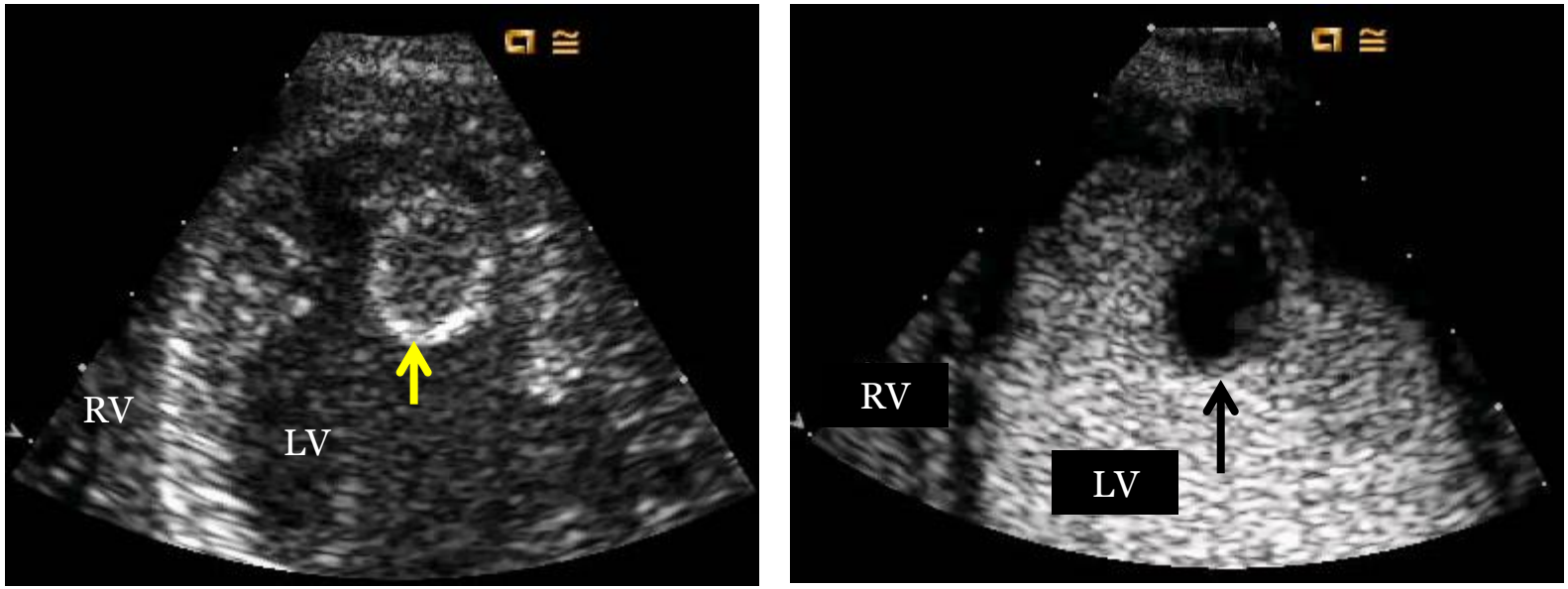
APICAL 4-CHAMBER VIEW
Arrow points to a large (3.1 x 2.2 cm) LV apical thrombus
in this patient with recent LAD infarct

Left Ventricular Thrombus

Clinical History

- 52-year-old woman with nonischemic cardiomyopathy
- Now presents with recent sudden onset of left sided weakness

Apical 4-chamber View Zoomed to LV Apex

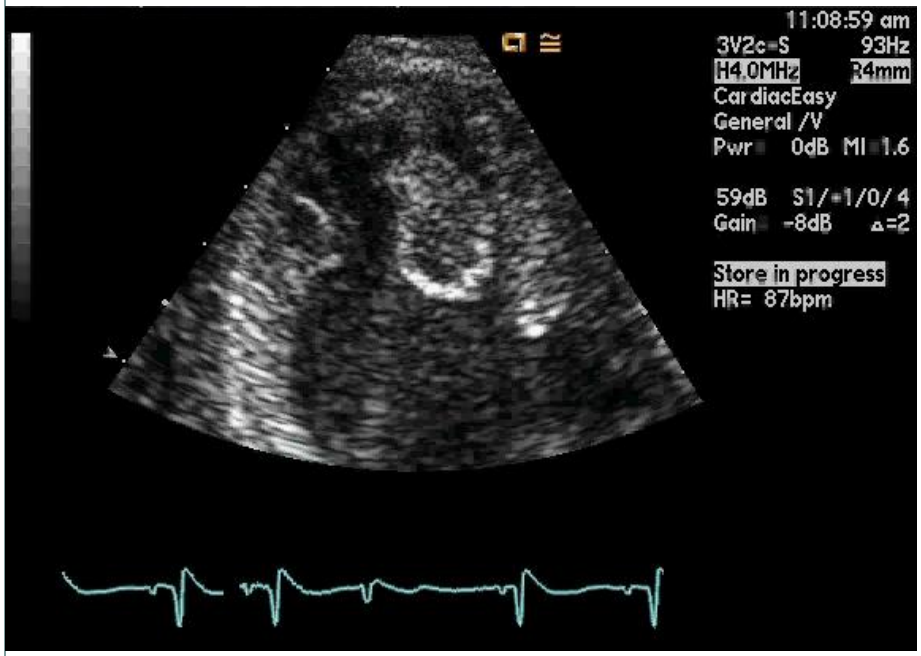


BEFORE microbubble injection

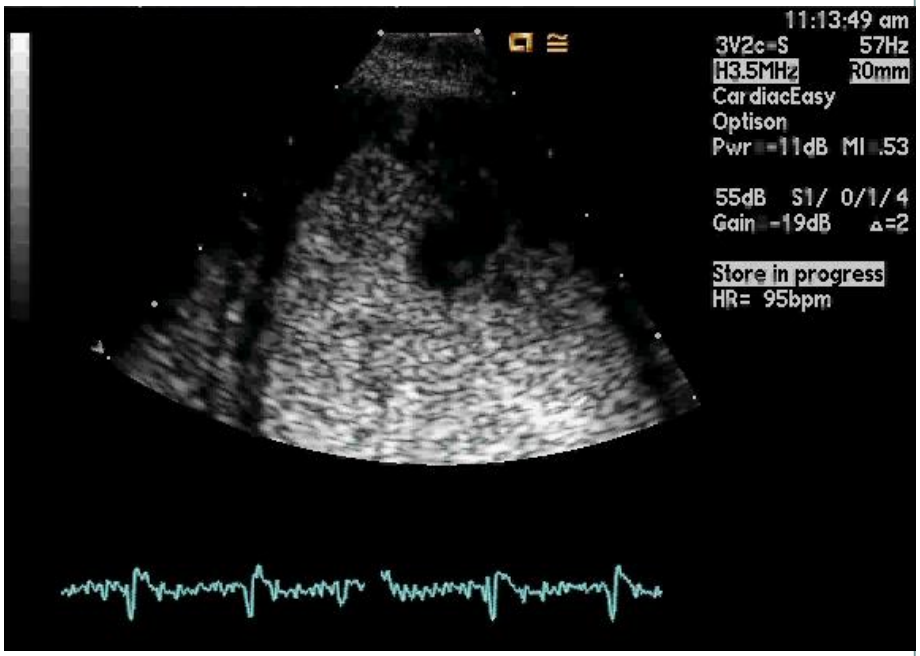
AFTER microbubble injection

Left Ventricular Thrombus

Apical 4-chamber View Zoomed to LV Apex

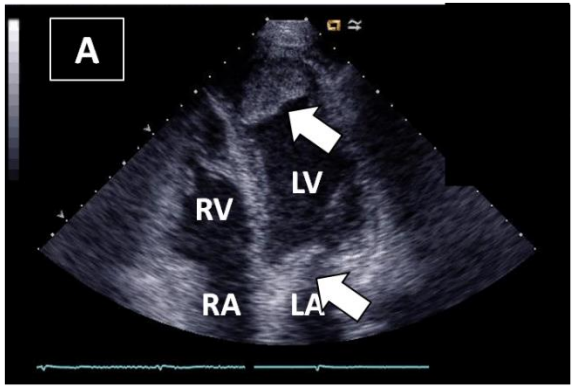


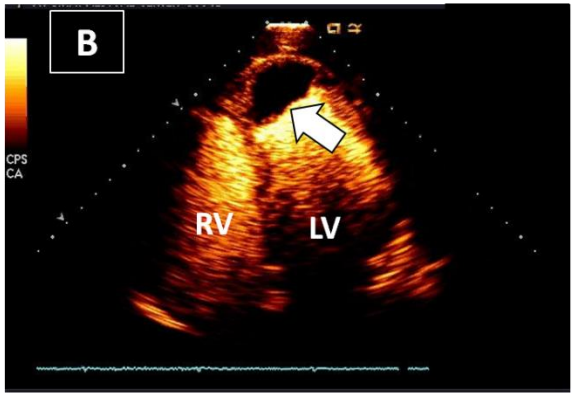
BEFORE microbubble injection

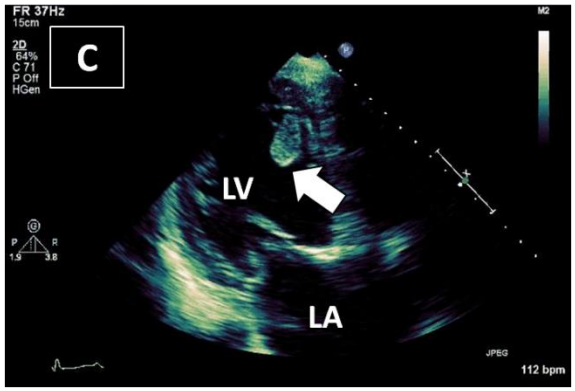


AFTER microbubble injection
(Note the absence of contrast uptake by the thrombus)

ASE Guidelines | Cardiac Source of Embolism







[A] Apical four-chamber view of a **noncontrast** transthoracic echocardiographic study demonstrates a **large LV apical thrombus** (arrow).

[B] The same patient as in (A) was then imaged using **transpulmonary microbubble echocardiographic contrast**. The **LV apical thrombus**, lacking vascular supply, appears black (arrow) on contrast imaging.

[C] Apical three-chamber view demonstrates a **mobile LV thrombus** (arrow) attached to the apical portion of the anterior interventricular septum.

Recommendations for Performance of Echocardiography in Patients with Suspected LV Thrombus

Echocardiography Recommended

- TTE is recommended for the evaluation of patients with underlying cardiac disease known to predispose to LV thrombus formation (such as myocardial infarction or nonischemic cardiomyopathy).
- TTE is typically superior to TEE in the assessment of LV apical thrombus.

Echocardiography Potentially Useful

- Contrast echocardiography using microbubble agents (such as perflutren) may aid in detecting LV thrombi and may help differentiate avascular thrombi from vascular tumors.
- Three-dimensional echocardiography may provide more precise assessment of LV thrombus.

Echocardiography Not Recommended

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

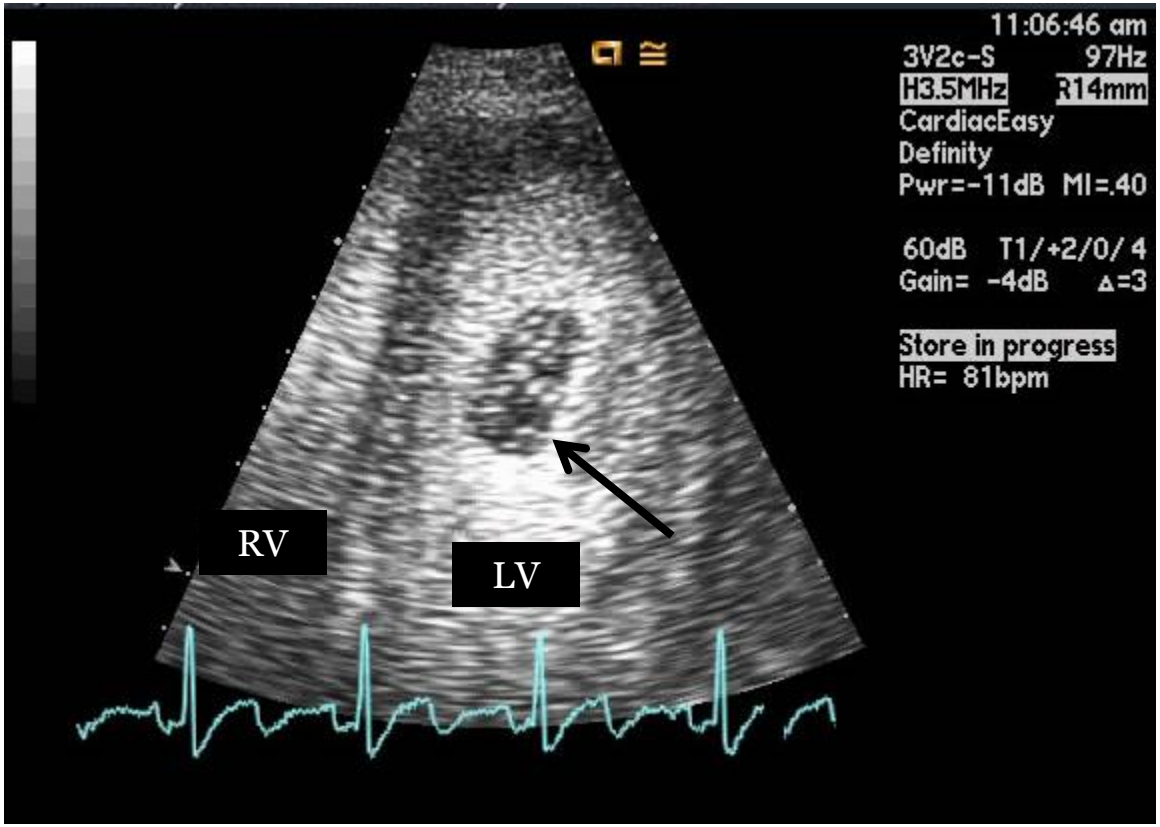
Cardiac Source of Embolism

LEFT VENTRICULAR TUMOR VS. THROMBUS

Left Ventricular Lymphoma

Clinical History

- 41-year-old woman HIV-associated Burkitt's lymphoma

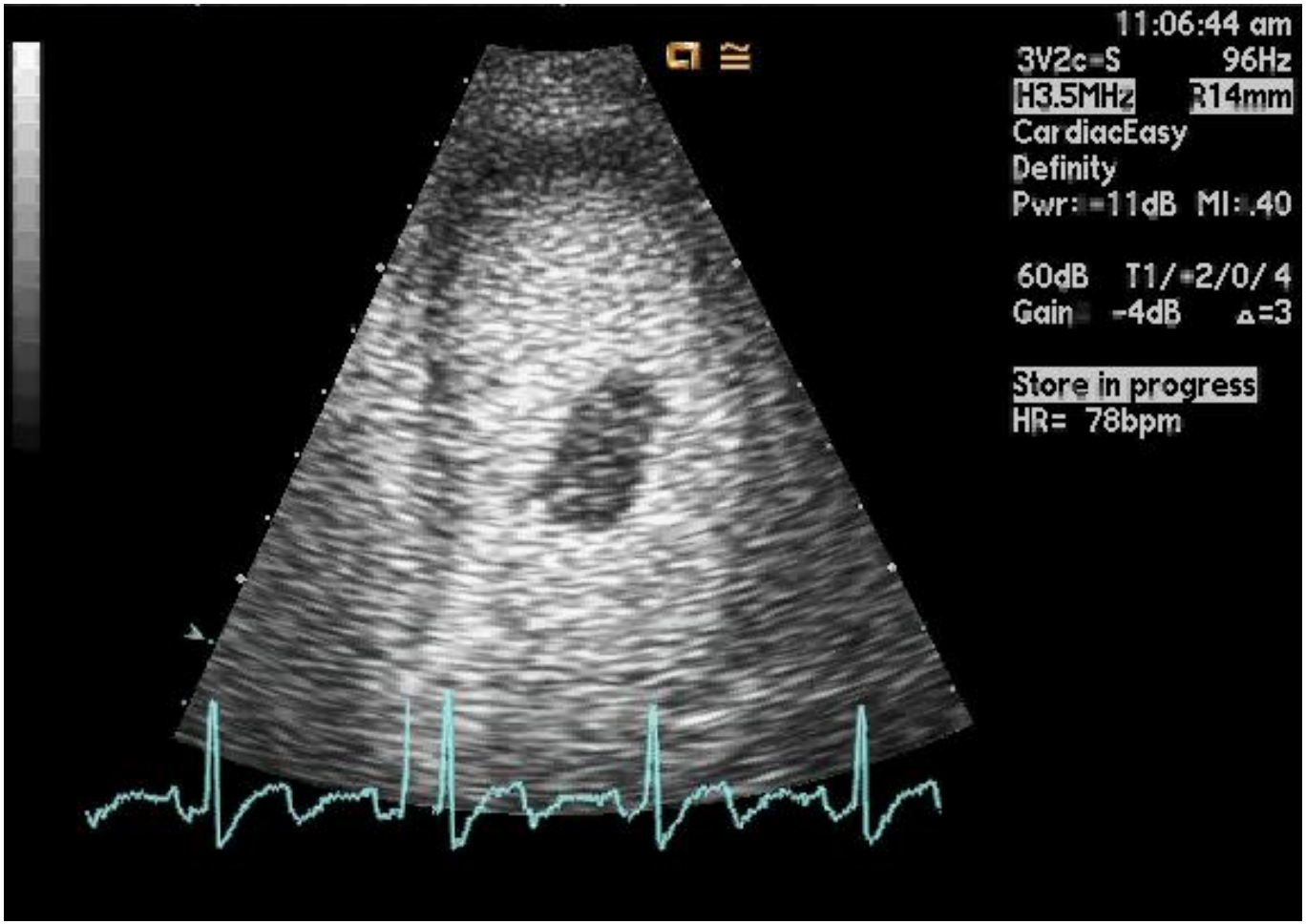


Apical 4-chamber View Post Microbubble Injection

Arrow points to a large (2.7 x 1.5 cm) LV lymphoma

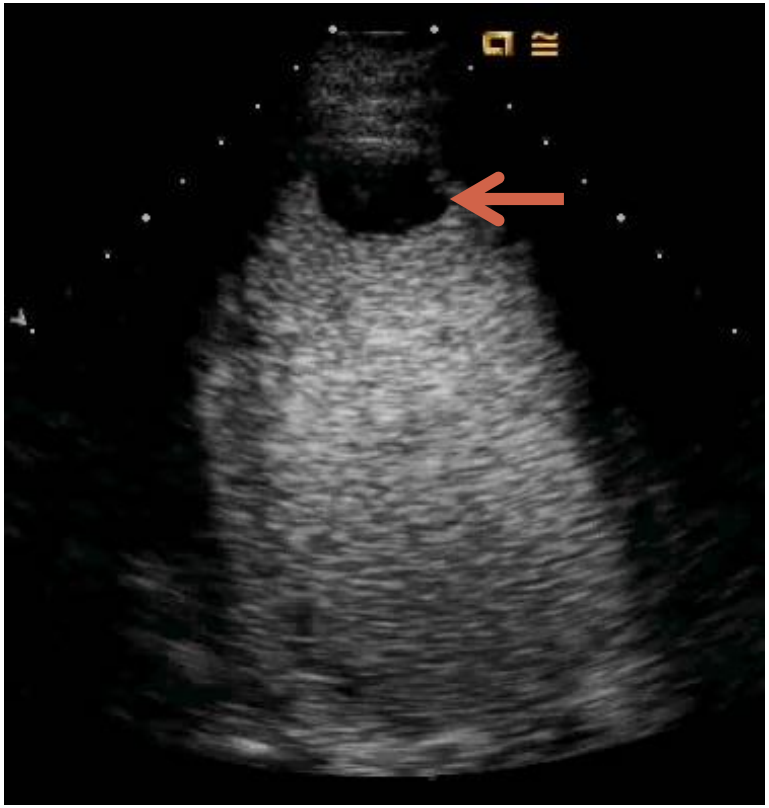
Note the contrast uptake by the tumor; thrombi typically do NOT opacify with microbubble contrast

Left Ventricular Lymphoma

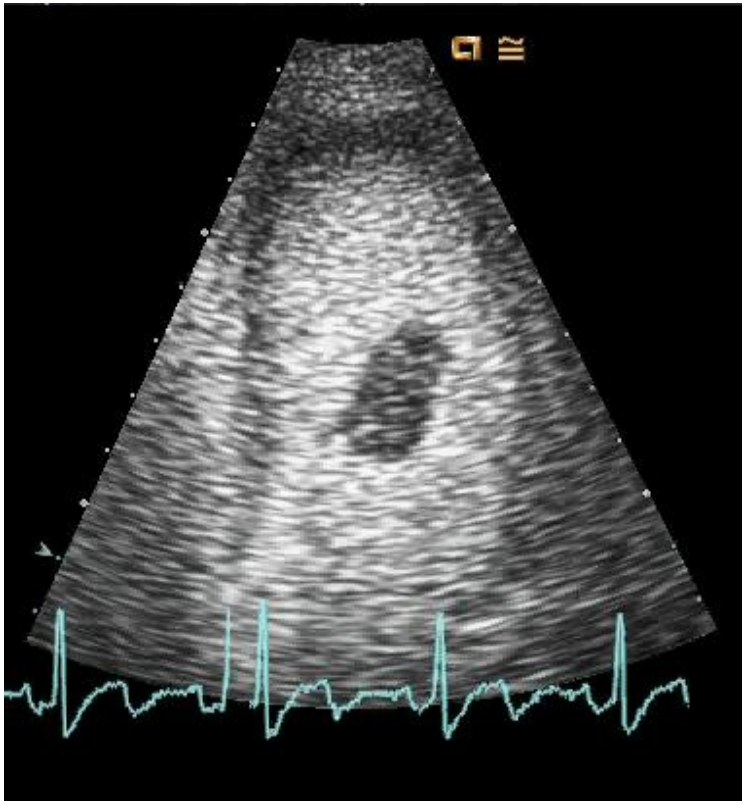


Apical 4-chamber View Post Microbubble Injection
Note the preserved LV contractility;
a mass in a normally contracting LV is more likely to be a tumor than a thrombus

2 Patients with LV Mass | Microbubble Injection



Patient #1
LV thrombus post LAD infarct



Patient #2
LV lymphoma in an AIDS patient

TEACHING POINTS

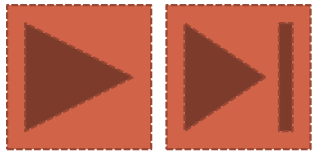
Differential diagnosis of an LV mass:

LV THROMUS

1. Adjacent to akinetic/hypokinetic LV segment
2. Does NOT take up microbubble contrast

LV TUMOR

1. Typically no primary LV wall motion abnormalities
2. Typically DOES take up microbubble contrast



Cardiac Source of Embolism

40

AORTIC ATHEROMA

CARDIAC SOURCE OF EMBOLISM: AORTIC ATHEROMA

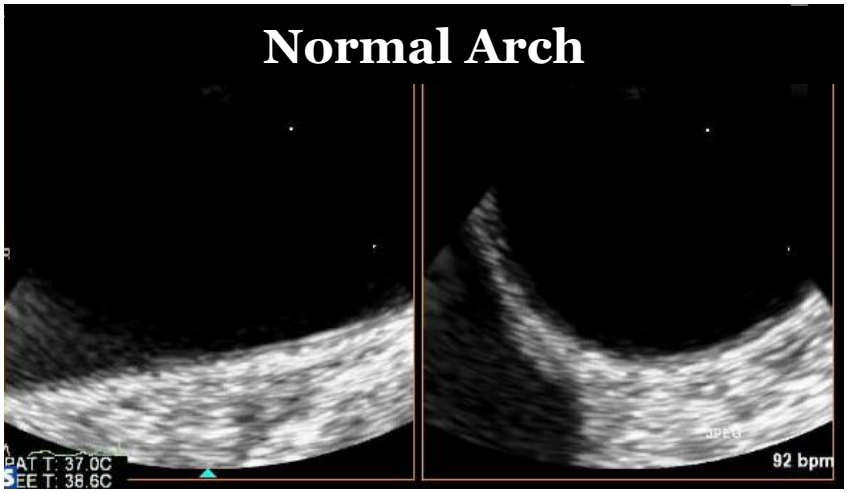
Basic Features

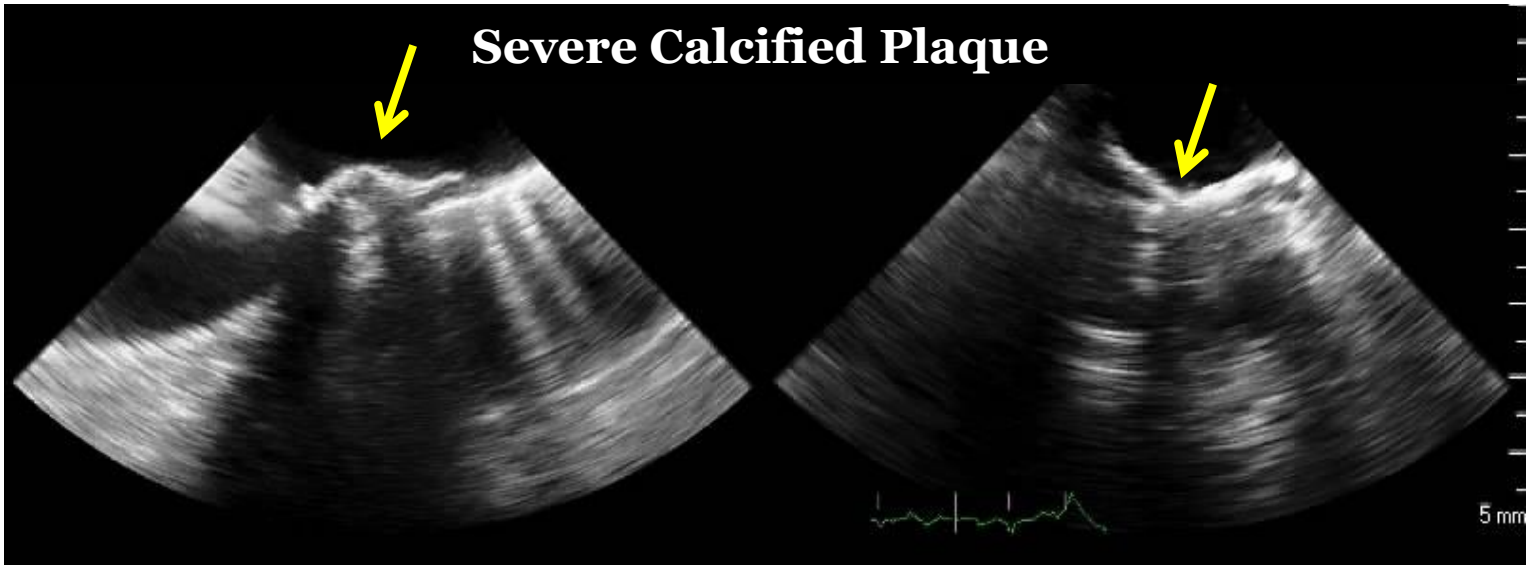
- Atheromatous plaque in ascending aorta and aortic arch is a well established source of systemic embolism
- The risk of embolism is related to plaque thickness and plaque complexity. High risk features include:
  - Plaque **thickness $\geq$ 4 mm**
  - Plaque **ulcerations**
  - **Mobile components** which represent superimposed thrombi
- Plaque from descending aorta can also embolize retrogradely into the neck vessels during diastolic flow reversal in the aorta

Imaging Recommendations

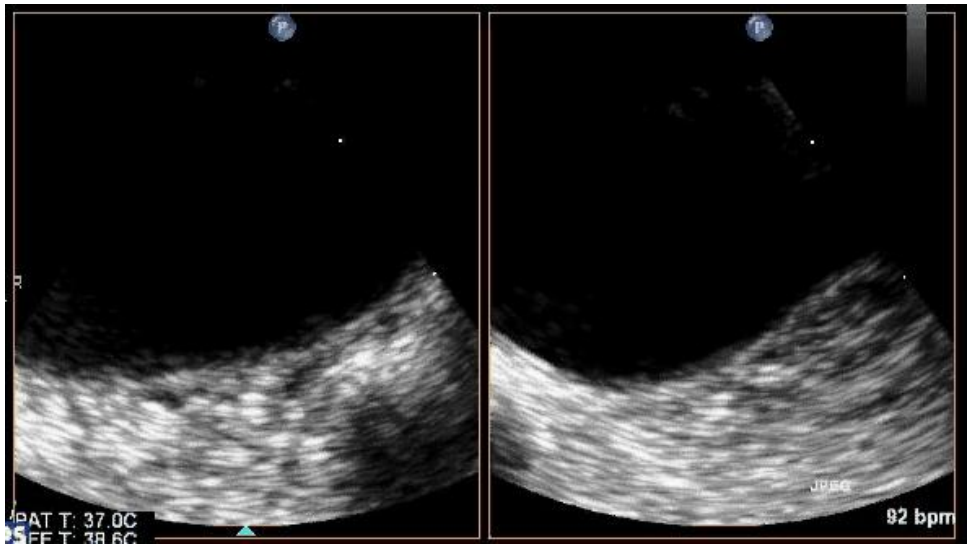
- Plaque in the ascending aorta and arch typically cannot be fully evaluated by transthoracic echocardiography
- **Transesophageal echocardiography** is the primary echocardiographic means of diagnosing and characterizing aortic plaques

Aortic Arch: Normal vs. Severe Plaque



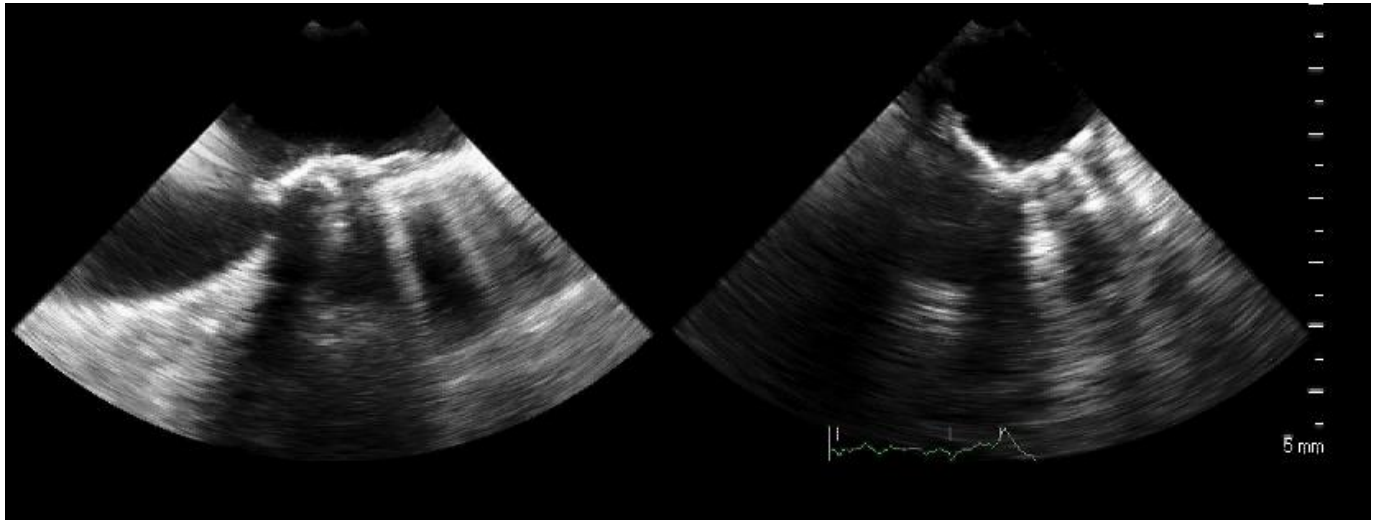


Aortic Arch: Normal vs. Severe Plaque

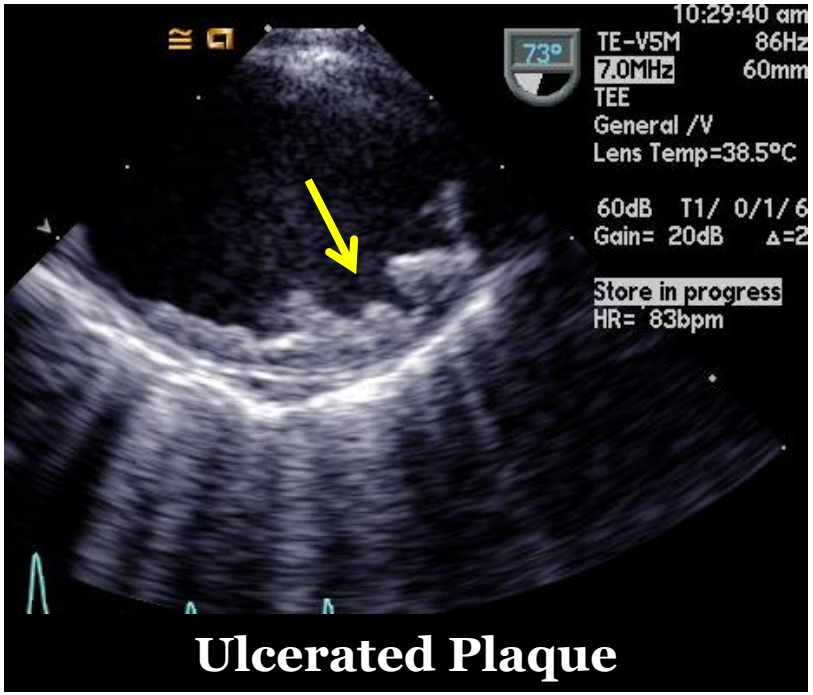


<<< Normal Arch

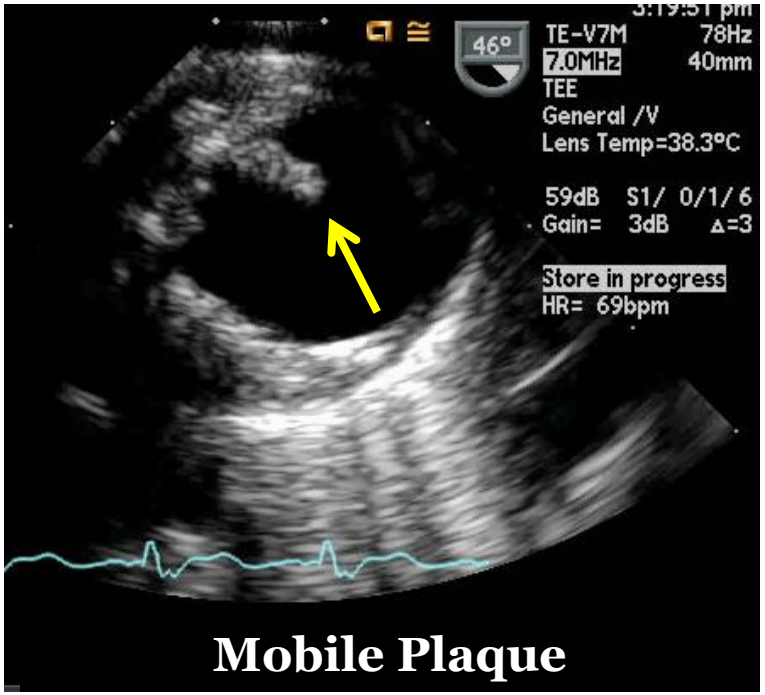
Severe Plaque >>>



Aortic Arch: Complex Plaque

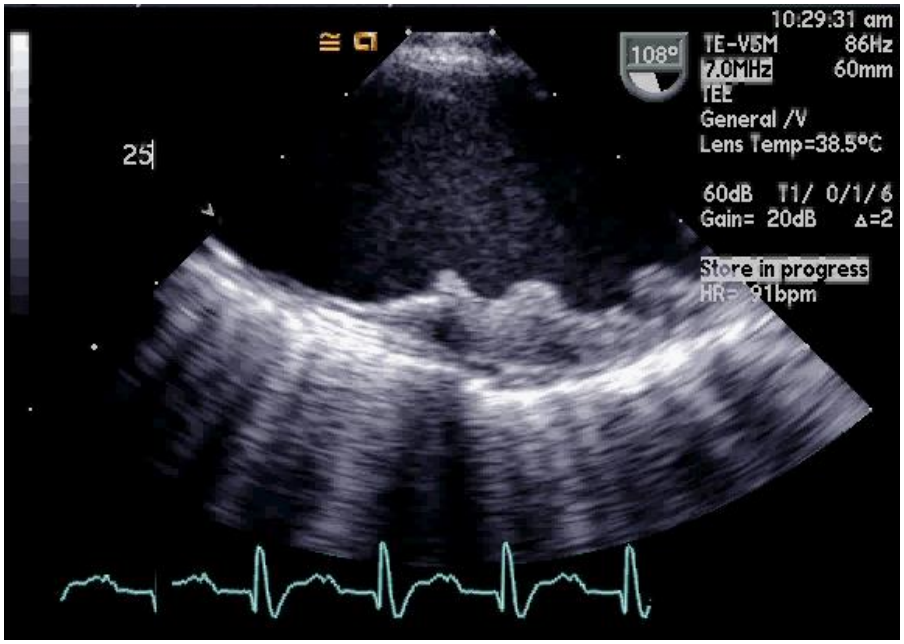


Ulcerated Plaque

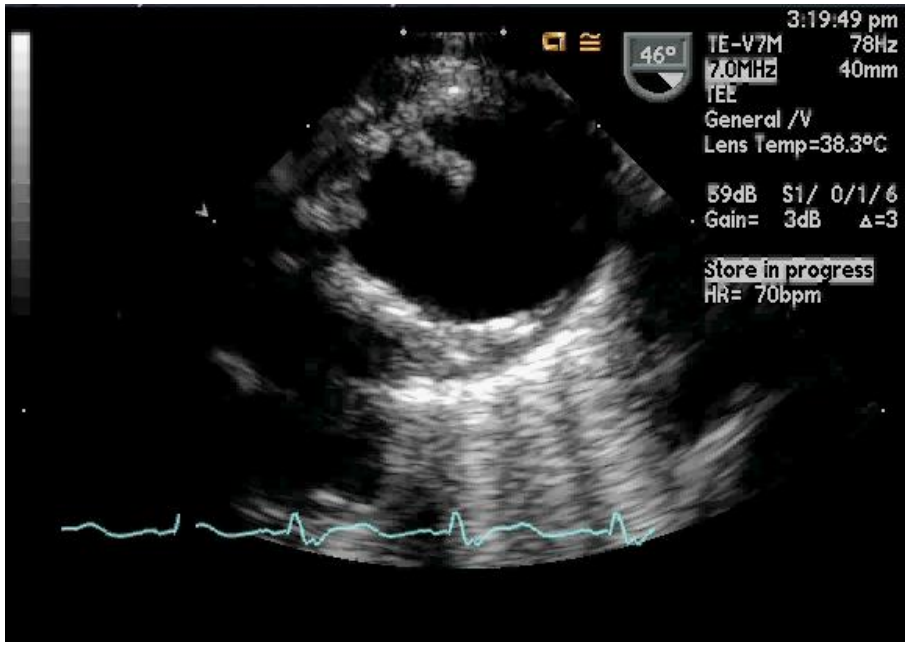


Mobile Plaque

Aortic Arch: Ulcerated vs. Mobile Plaque

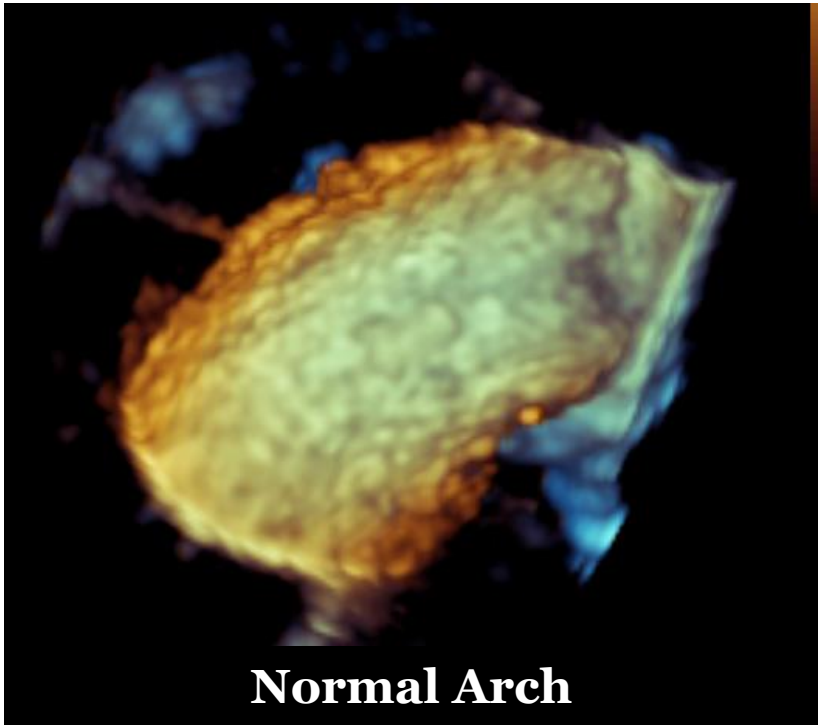


Ulcerated Plaque



Mobile Plaque

Aortic Arch on 3D TEE: Normal vs. Ulcerate Plaque



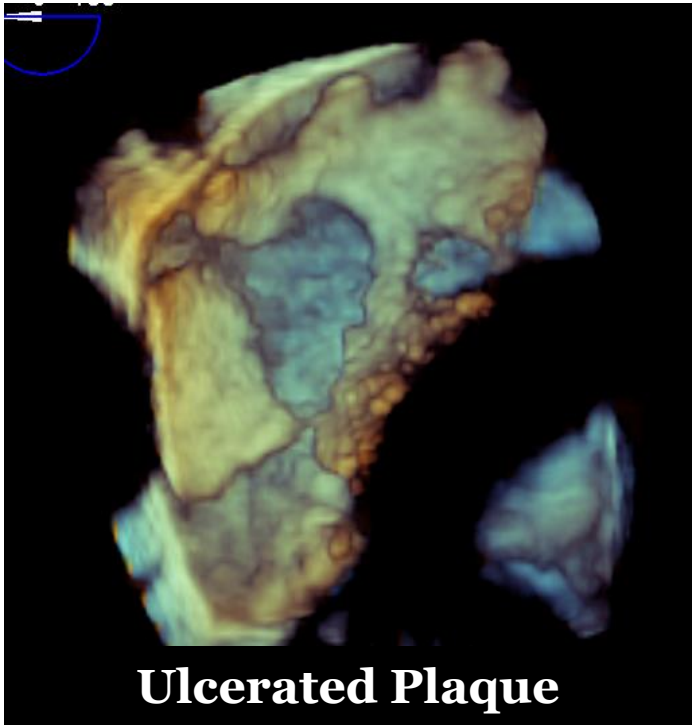


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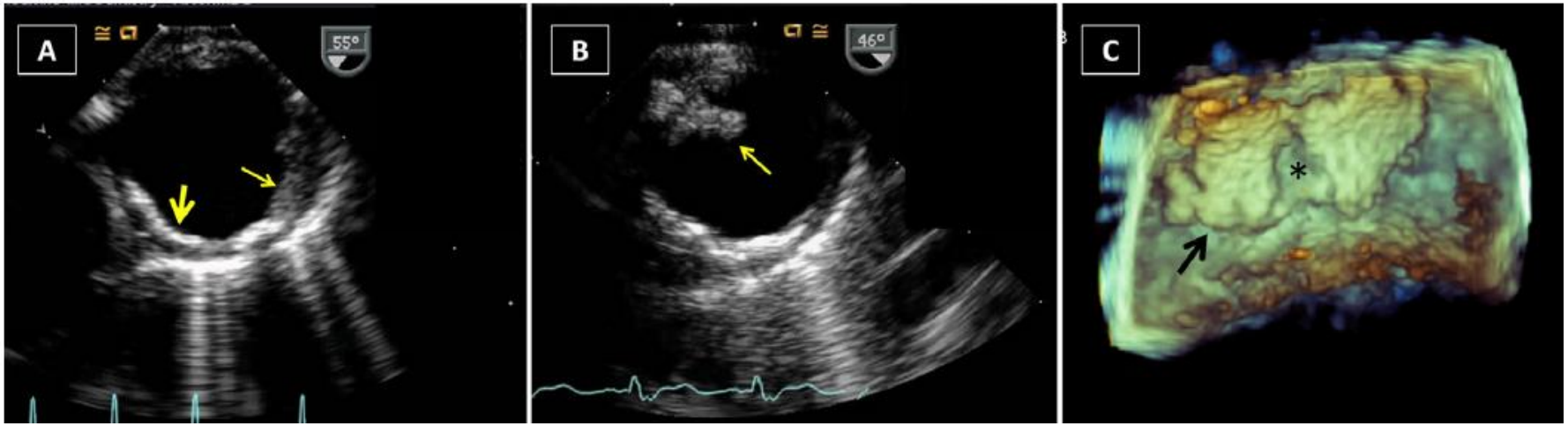
Table 9 Classification of atherosclerotic plaques

Onset	Stage	Clinical manifestations	Lesion name	Description
Early lesions	I	Typically silent	Initial lesion	Small amounts of intracellular lipid deposits
	II		fatty streak	Larger amounts of intracellular lipid deposits
	III		intermediate lesion	Small extracellular lipid deposits
Late lesions	IV	Silent or clinically overt	Atheroma	Extracellular lipid core
	V		Fibroatheroma	Lipid core with fibrotic changes
	VI		Complex plaque	Surface defects such as ulcerations, hemorrhage and thrombus; mobile plaque, a marker of severe atherosclerosis, is mostly made of thrombi

AORTIC ATHEROMA
2D & 3D TEE



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Recommendations for Echocardiographic Evaluation of Aortic Sources of Embolism

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

Recommendations for Echocardiography in Patients Referred for Cardiac Surgery or Percutaneous Intervention

Echocardiography Recommended

- TEE or intracardiac echocardiography is recommended in all patients before intracardiac percutaneous intervention to exclude potential cardiac sources of emboli that might be dislodged during intervention.
- The routine preoperative use of TEE to identify and manage aortic atheromatous disease is recommended in patients with increased risk for embolic stroke, including those with histories of cerebrovascular or peripheral vascular disease and those with evidence of aortic atherosclerosis or calcification by other imaging modalities, including preoperative or intraoperative MRI, CT, or chest radiography. TEE may allow the surgeon to individualize the surgical technique and potentially reduce the incidence of embolic stroke.

GUIDELINES AND STANDARDS

Multimodality Imaging of Diseases of the Thoracic Aorta in Adults: From the American Society of Echocardiography and the European Association of Cardiovascular Imaging

Endorsed by the Society of Cardiovascular Computed Tomography and Society for Cardiovascular Magnetic Resonance

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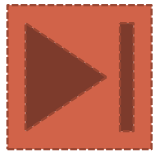
(J Am Soc Echocardiogr 2015;28:119-82.)



Cardiac Source of Embolism

PEDIATRIC POPULATION

STROKE IN THE PEDIATRIC POPULATION

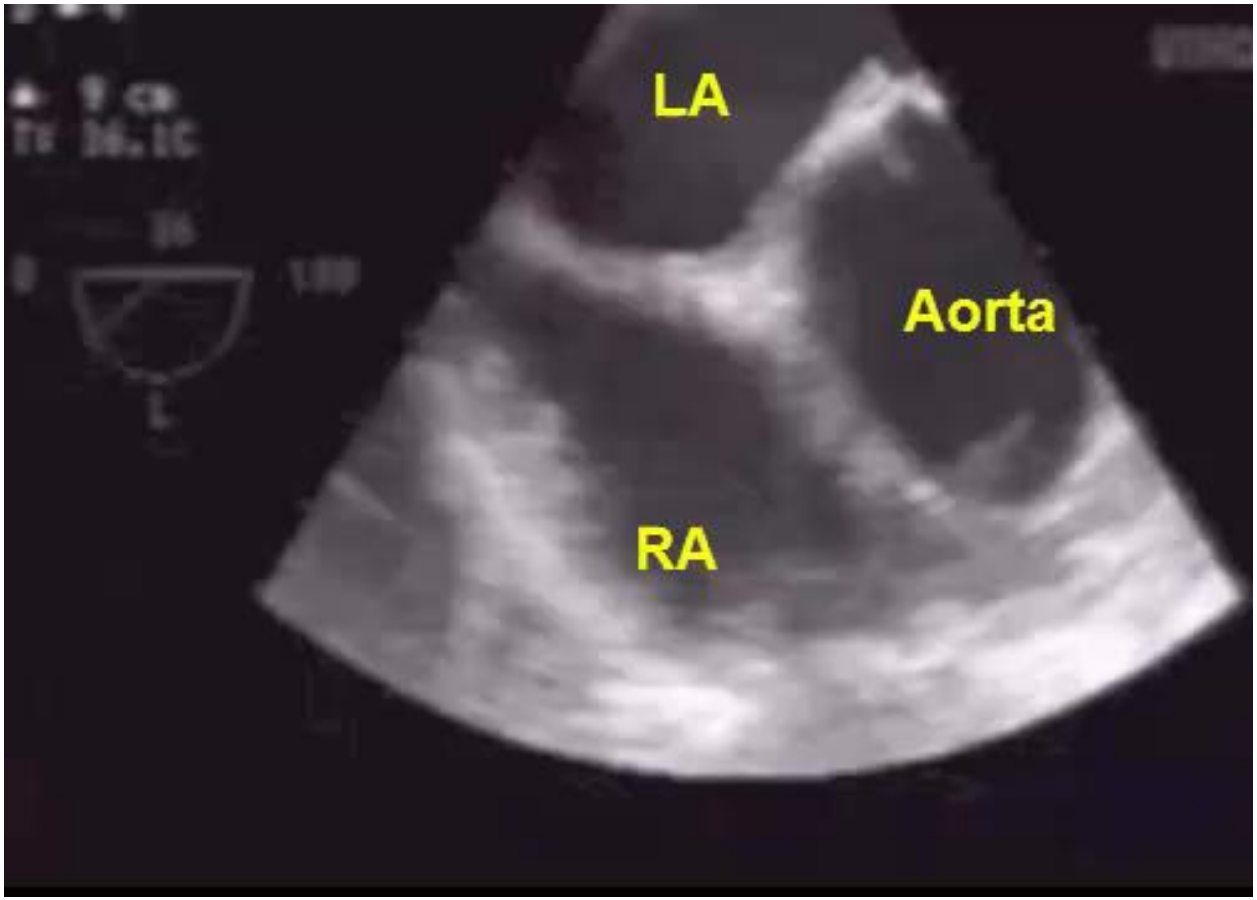
Stroke is rare in young adults (<50 years of age) and even less common in the pediatric population. Studies have shown that the annual incidence of stroke in young adults ranges from 10 to 23 cases per 100,000 persons per year.[216,217] In children, after excluding stroke due to perinatal trauma, the incidence is lower at about two or three cases per 100,000 persons per year.[218] Of these cases, 24% to 57% are thought to have embolic causes.[219] Embolic stroke in children can be due to hypercoagulable conditions or paradoxical embolus due to intracardiac or intravascular shunt. As in adults, strokes in pediatric patients may also be due to left-heart lesions with embolic potential, such as vegetations, tumors, and thrombi.

Many diseases predispose to hypercoagulability in children. Among the most common is sickle-cell disease, which has a 220 times higher annual incidence of stroke than the normal population.[220] Others include protein C deficiency, homocysteinuria, thrombotic thrombocytopenia purpura, and hyperlipidemia.

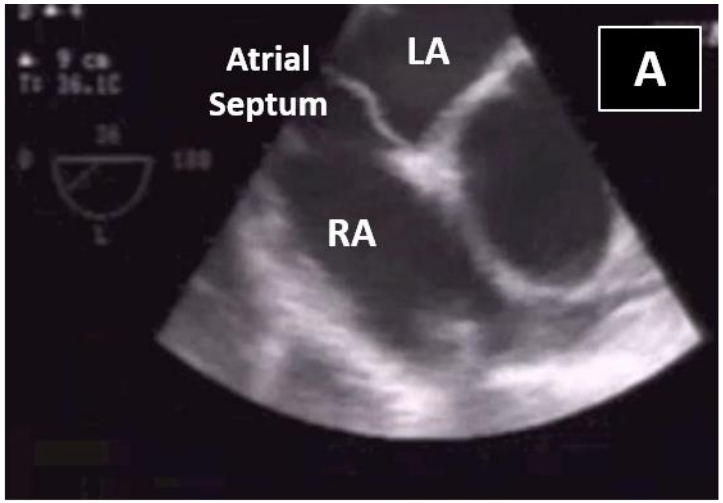
Certain congenital heart defects with intracardiac or intravascular shunt lesions predispose children to embolic stroke. Paradoxical embolism is discussed elsewhere in these guidelines, so the focus here is on the anatomic factors predisposing to embolic stroke in children. Among these, ASD and PFO receive the most attention.

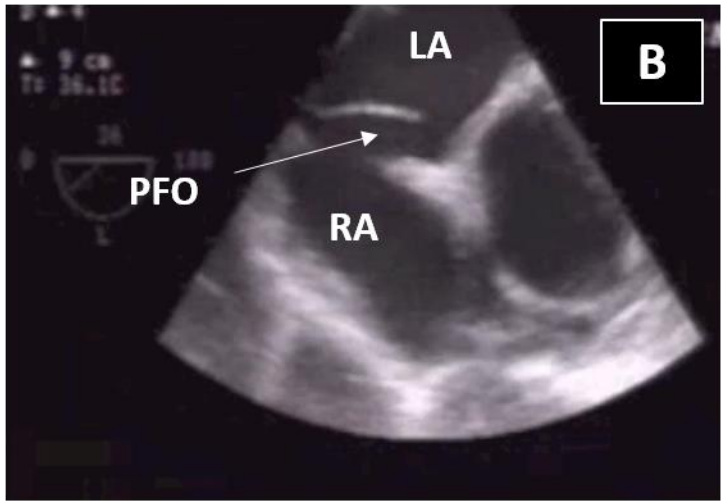
PATENT FORAMEN OVALE

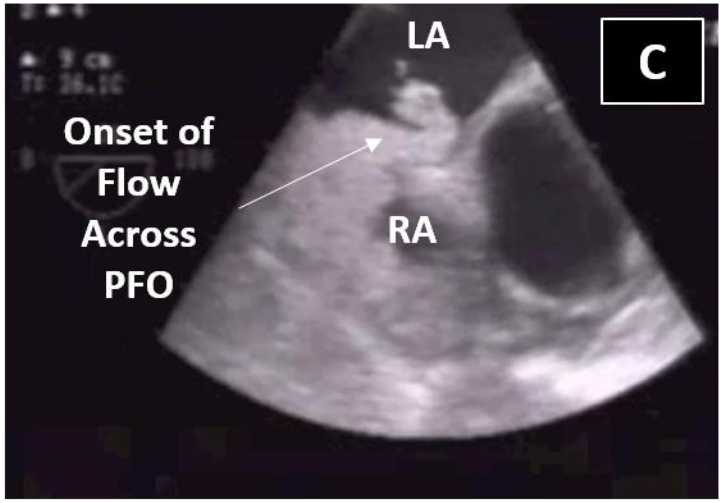
PEDIATRIC 2D TEE | AGITATED SALINE INJECTION

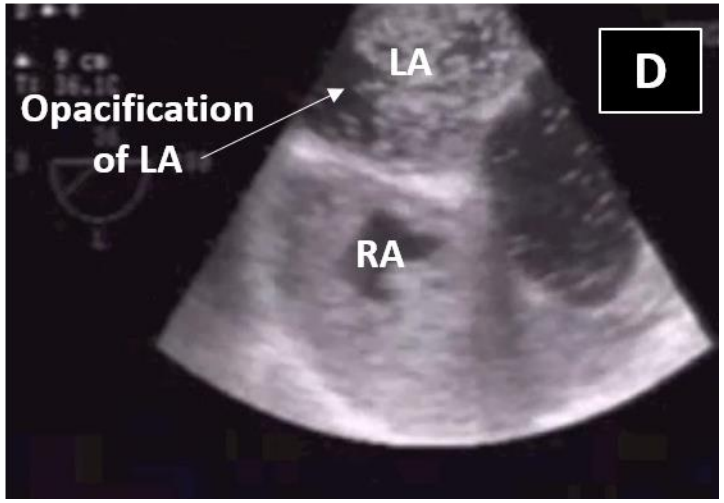


PATENT FORAMEN OVALE
PEDIATRIC 2D TEE | AGITATED SALINE INJECTION









PARADOXICAL EMBOLUS ACROSS INTERATRIAL SEPTUM
PEDIATRIC 2D TEE

Recommendations for Echocardiography in Pediatric Patients with Suspected Systemic Embolism

Echocardiography Recommended

- TTE is recommended in all children in whom embolic stroke is suspected.
- Agitated saline contrast bubble study may be necessary to determine right-to-left shunt pathway.
- Echocardiographic imaging in children with suspected cardiac source of embolism should be performed at a pediatric laboratory.

Echocardiography Potentially Useful

- TEE for evaluation of embolic stroke should be rare in children and is recommended only when TTE windows are poor.

ASE GUIDELINES & STANDARDS

Guidelines for the Echocardiographic Assessment of Atrial Septal Defect and Patent Foramen Ovale: From the American Society of Echocardiography and Society for Cardiac Angiography and Interventions

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Thank you

New York University Medical Center