



Saline Contrast Echocardiography

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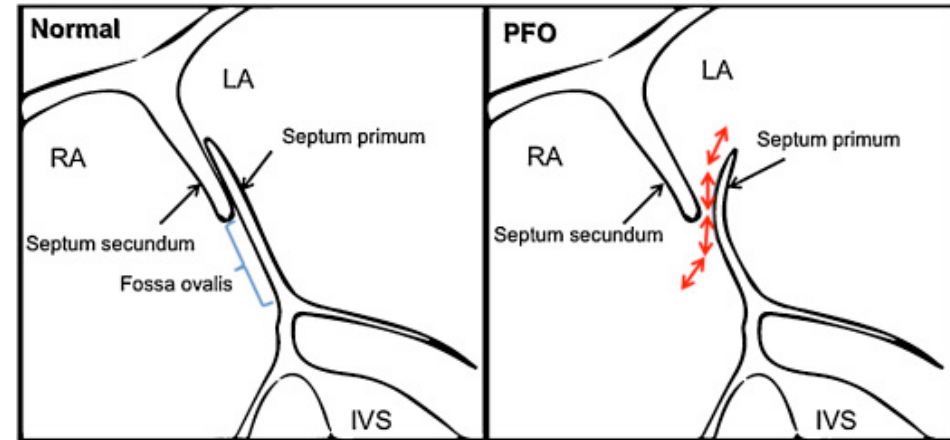
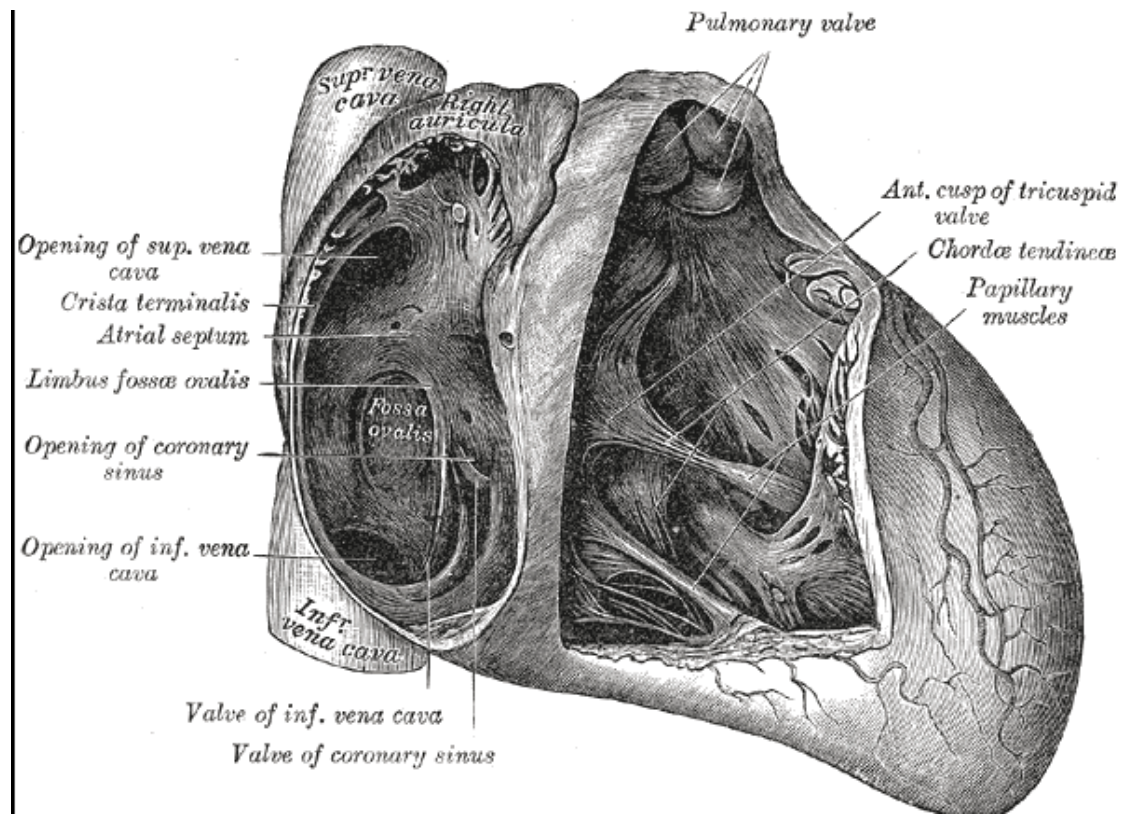
Detroit, MI

Relevant disclosures: None

Bubble Considerations

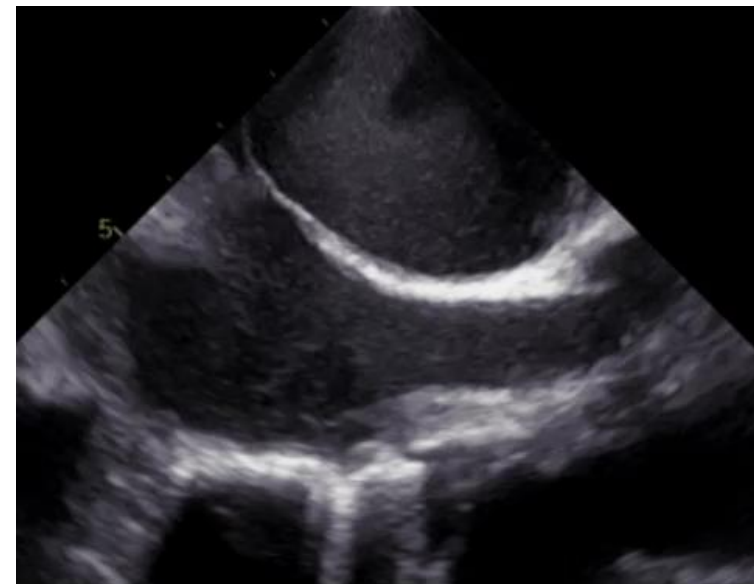
- Atrial septal anatomy
- Saline bubble administration
- Caveats and cases.

Anatomy of the Atrial Septum



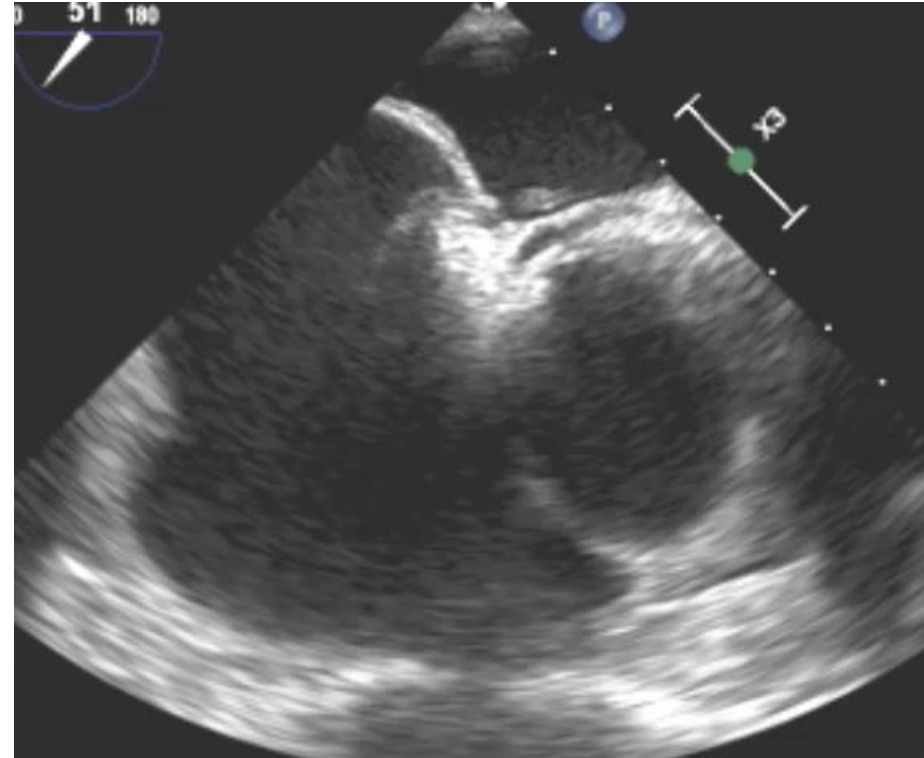
Diagnostic and Interventional Imaging

Volume 96, Issue 9, September 2015, Pages 891-899



[Henry Gray](#) (1918) *Anatomy of the Human Body*

Do this to prevent...



75 yo male with pulmonary embolism and acute kidney injury

Is there an age cut-off for bubble studies?

The Lancet. Neurology

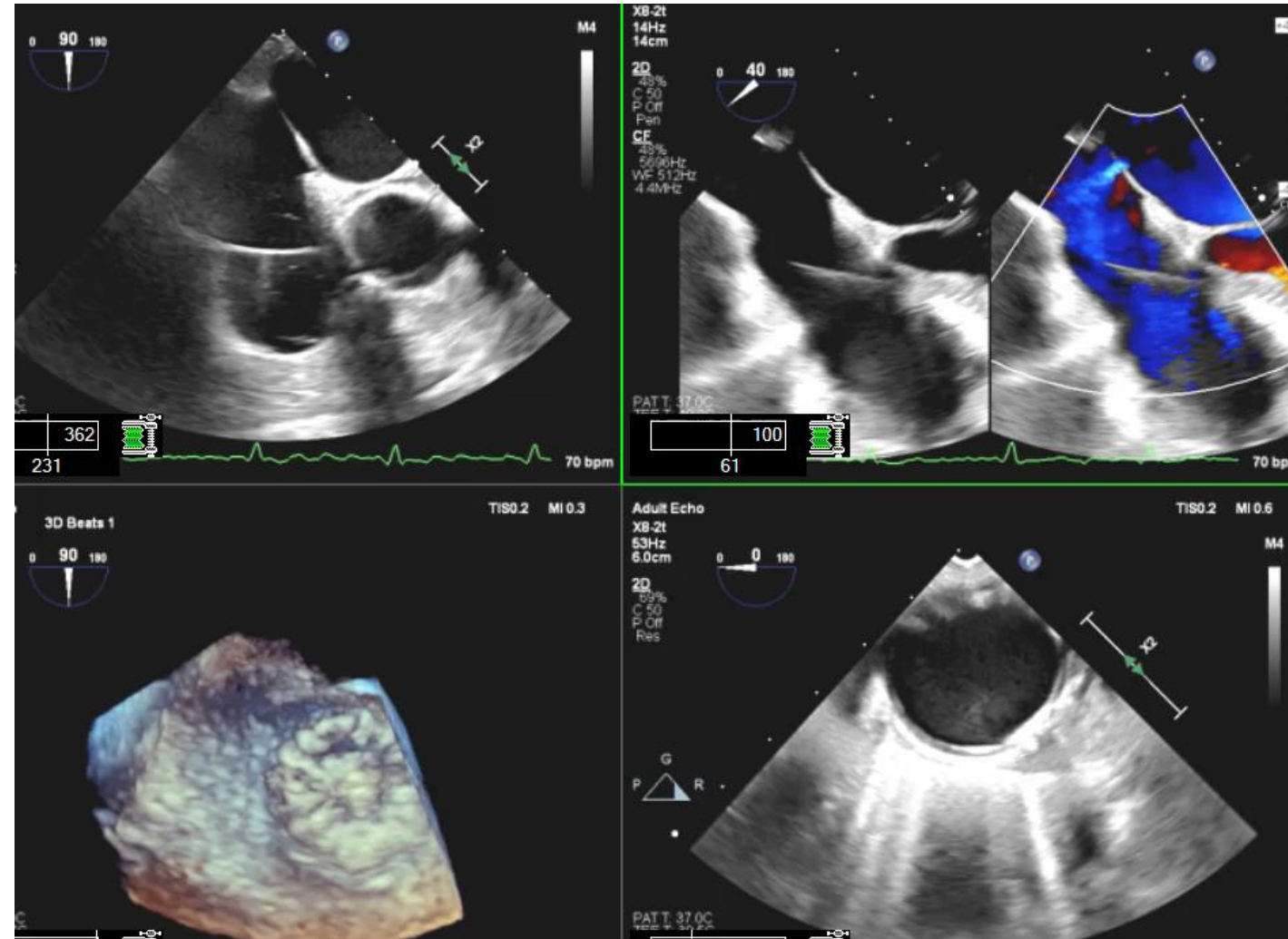
ELSEVIER

Prevalence of patent foramen ovale in cryptogenic transient ischaemic attack and non-disabling stroke at older ages: a population-based study, systematic review, and meta-analysis

Sara Mazzucco, MD, Linxin Li, DPhil, [...], and Oxford Vascular Study Phenotyped Cohort

85 year old male at risk for stroke

- AFIB with 4+ LA dilation.
- Appendage occlusion device
- Atheroma
- PFO with shunt during snoring



What is the best way to do a bubble study?

Importance of Abdominal Compression Valsalva Maneuver and Microbubble Grading in Contrast Transthoracic Echocardiography for Detecting Patent Foramen Ovale

Yoichi Takaya, MD, Nobuhisa Watanabe, RDCS, Madoka Ikeda, RDCS, Teiji Akagi, MD, Rie Nakayama, MD,
Koji Nakagawa, MD, Norihisa Toh, MD, and Hiroshi Ito, MD, *Okayama, Japan*

Study of 134 adults with cryptogenic stroke or migraine and suspected PFO

Gold standard: TEE and/or fluoroscopy

Patient characteristics (N = 134)	
Variables	Value
Age, y	42 ± 15
Sex, male	71 (53)
Cryptogenic stroke	62 (46)
Migraine	72 (54)
PFO diagnosis confirmed by TEE and/or cardiac catheterization	
Presence of PFO	80 (60)
Absence of PFO	54 (40)

TTE

3 injections of agitated saline into a 20 gauge antecubital vein :

MIX 1 mL air, 1 mL blood, and 8 mL saline

REMOVE LARGE BUBBLES BEFORE INJECTION

INJECT during Valsalva.

Record at least 20 cardiac cycles per injection

1) At rest with **no Valsalva** to assess for pulmonary AV shunt

2) During Valsalva which was released immediately when bubbles opacified the RA.

3) Repeat **Valsalva and abdominal compression**, releasing both with RA opacification

Study compared 2 thresholds for positive PFO shunt:

- 1) 1+ bubble
- 2) 5+ bubbles



Note abdominal contraction.

Clinical Investigation

Patent Foramen Ovale

Inferior Vena Cava Compression as a Novel Maneuver to Detect Patent Foramen Ovale: A Transesophageal Echocardiographic Study

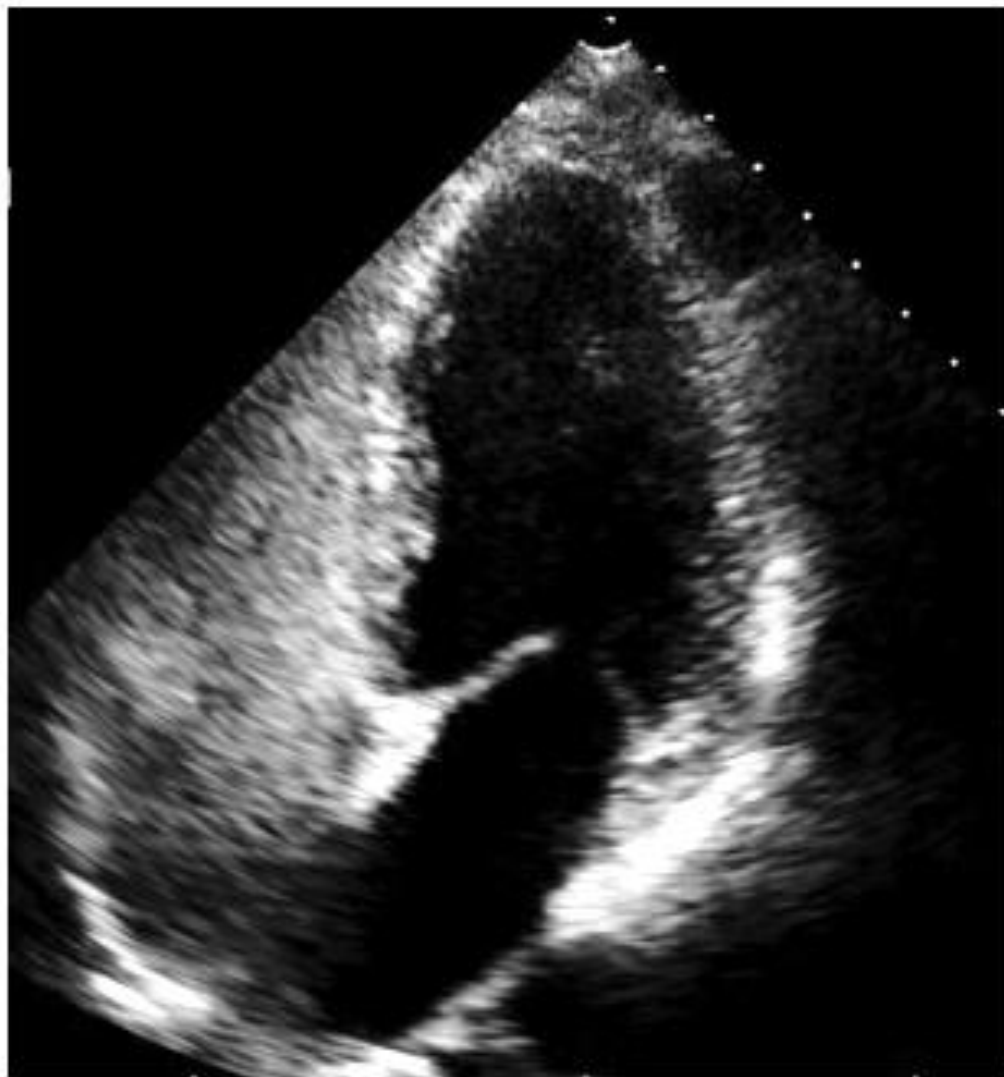
Eiji Yamashita MD^a, Tomoyuki Murata MD^a, Eri Goto MD^a, Takeshi Fujiwara MD^b, Takehito Sasaki MD^a, Kentaro Minami MD^a, Kohki Nakamura MD, PhD^a, Koji Kumagai MD, PhD^a, Shigeto Naito MD, PhD^a, Kazuomi Kario MD, PhD, FESC, FACC, FAHA^b, Shigeru Oshima MD, PhD^a

Method:
**Compress the right upper abdomen
by 5 cm for 30 seconds**

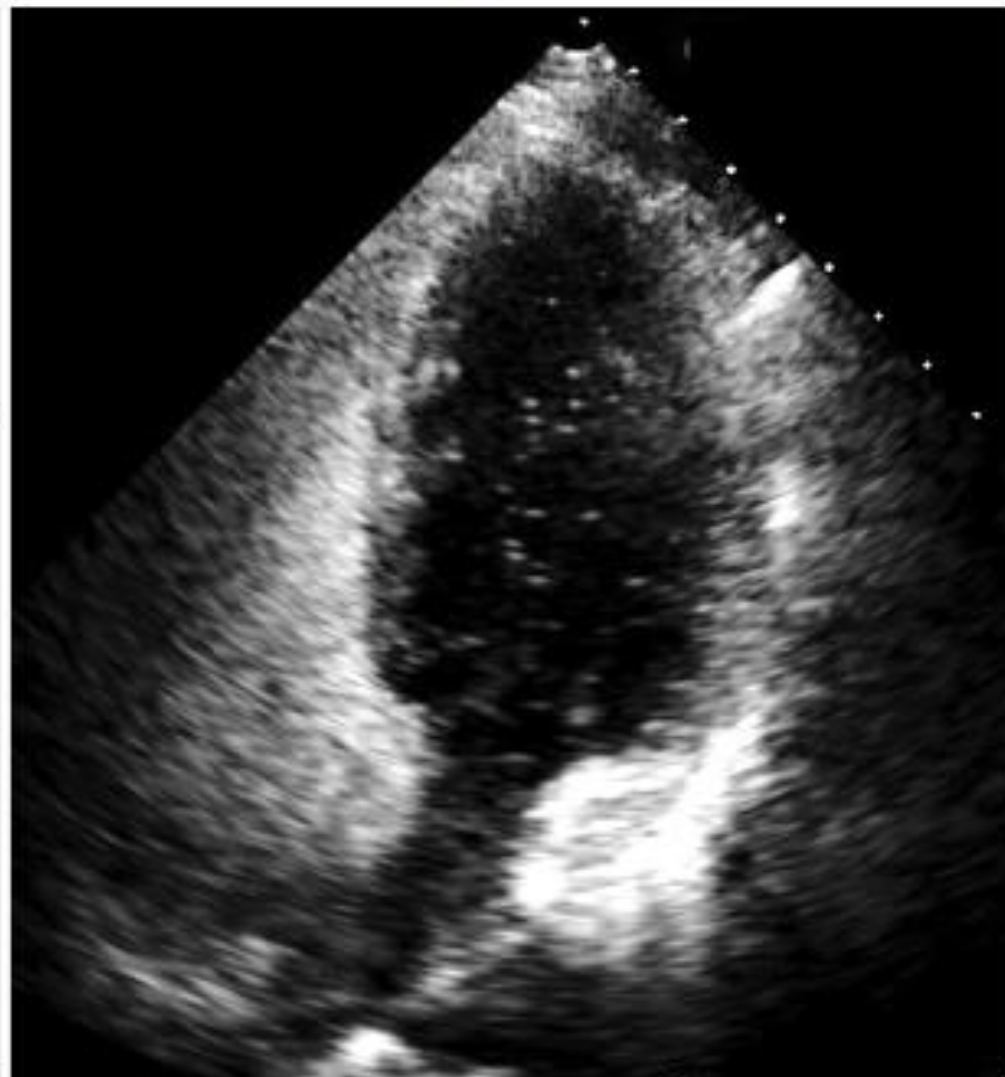
COMPRESS WITH CAUTION:

- 1. PREPARE THE PATIENT.**
- 2. DO NOT PRESS IF ABDOMINAL SYMPTOMS OR DISEASE ARE PRESENT.**
- 3. STOP IF CAUSING DISCOMFORT**
- 4. LOOK AT THE PATIENT'S FACE TO RECOGNIZE DISCOMFORT.**

Valsalva Maneuver



Valsalva and Abdominal Compression



Contrast TTE for PFO detection

	Sensitivity, %	Specificity, %	Accuracy, %
Spontaneous Valsalva maneuver, at least one microbubble	93	76	86
Spontaneous Valsalva maneuver, at least five microbubbles	85	89	87
Abdominal compression Valsalva maneuver, at least one microbubble	99	57 ←	82 ←
Abdominal compression Valsalva maneuver, at least five microbubbles	99	89 →	95 →

Importance of Abdominal Compression Valsalva Maneuver and Microbubble Grading in Contrast Transthoracic Echocardiography for Detecting Patent Foramen Ovale

Yoichi Takaya, MD, Nobuhisa Watanabe, RDCS, Madoka Ikeda, RDCS, Teiji Akagi, MD, Rie Nakayama, MD,
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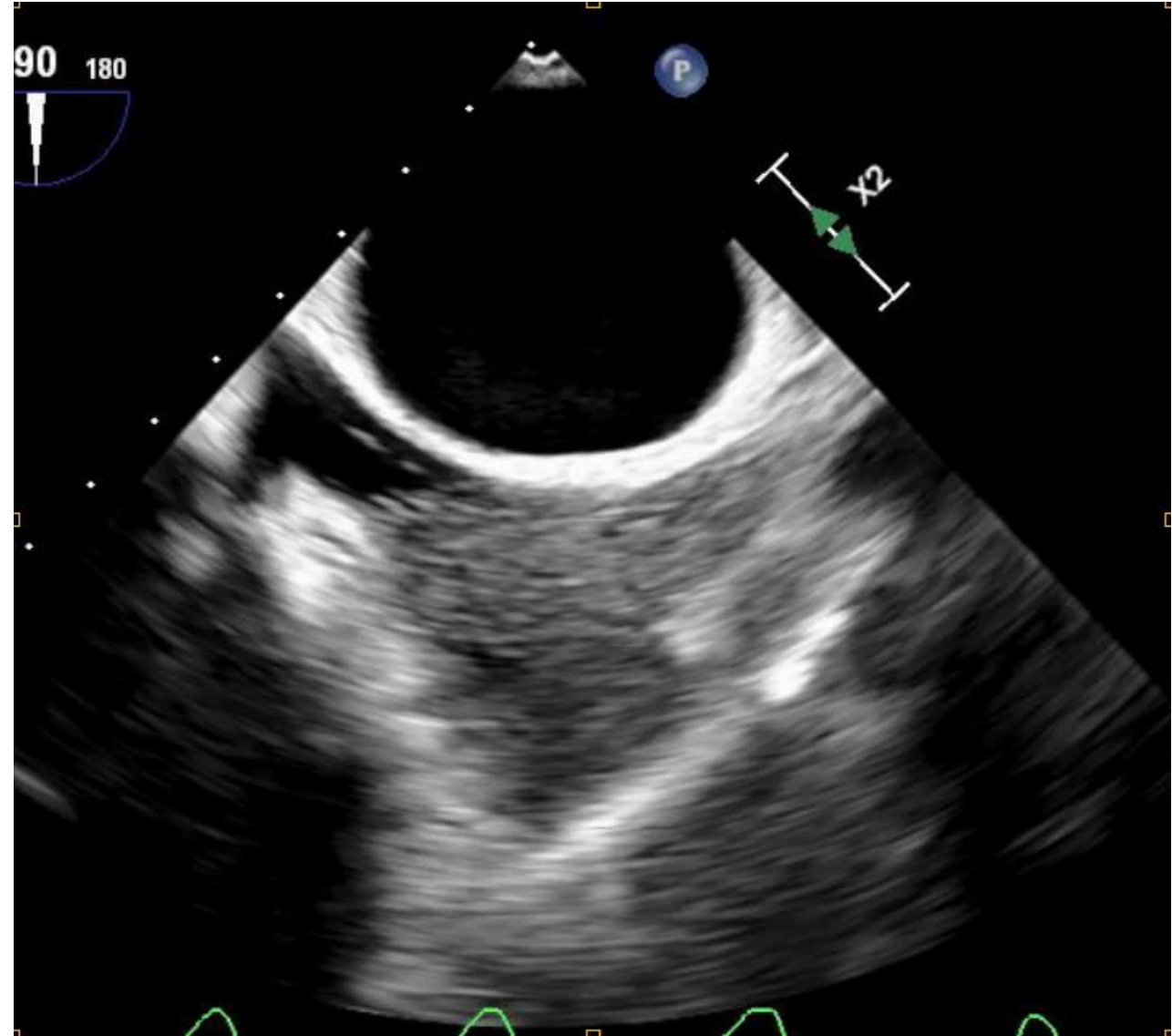
Findings:

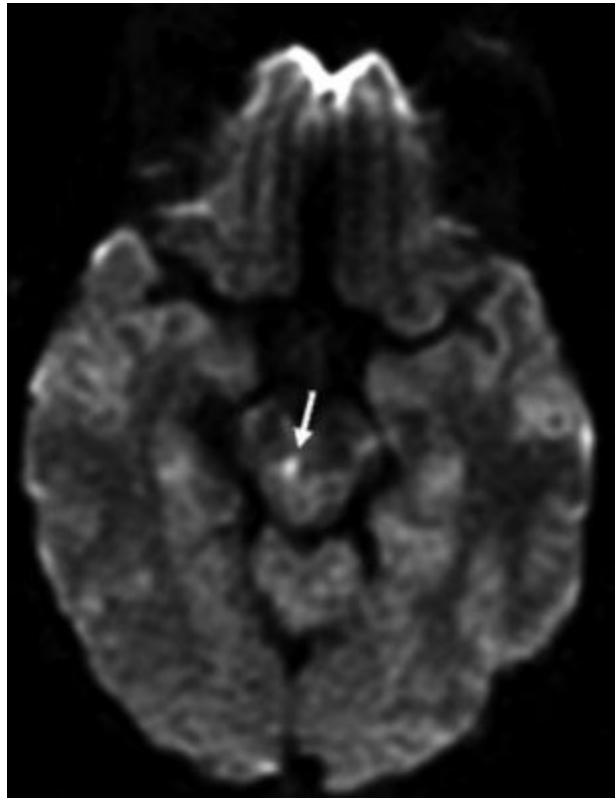
**Increased sensitivity by requiring
5 bubbles in the left heart.**

**Abdominal compression during Valsalva
maximizes accuracy.**

Methodolgy Caveats:

- Color Doppler is useful though less sensitive.
- Harmonic imaging. Increase gain.
- Septal shift is more important than the 3/6 rule
- Better bubbles with blood
- Coughing is a second option
- **DO NOT INJECT NON-AGITATED BUBBLES**
- **DO NOT INJECT WITH SIGNIFICANT RA→LA SHUNT ON COLOR DOPPLER**





Cerebral Ischemic Events Associated With ‘Bubble Study’ for Identification of Right to Left Shunts

José R. Romero, James L. Frey, Lee H. Schwamm, Bart M. Demaerschalk, Hari P. Chaliki, Gunjan Parikh, Robert F. Burke, and Viken L. Babikian

Originally published 4 Jun 2009 | <https://doi.org/10.1161/STROKEAHA.109.549683> | Stroke. 2009;40:2343–2348

[Other version\(s\) of this article](#) ✓

Abstract

Background and Purpose—Detection of an intracardiac shunt is frequently sought during the evaluation of patients with cryptogenic ischemic stroke and agitated saline intravenous injection, or “bubble study” (BS), is performed in most cases. We present the first attempt to identify the clinical features in patients who had cerebral ischemic events with BS.

Methods—Using a list serve established by the American Academy of Neurology, a member posted a question regarding the safety of BS in patients with patent foramen ovale. A standardized questionnaire was used to gather data about patients with cerebral ischemic events, details of each case were reviewed, and the findings pooled.

Results—Five patients with ischemic complications of BS (all female, aged 42 to 90 years) were identified from 4 institutions, 3 ischemic strokes and 2 transient ischemic attacks. Events occurred either during or within 5 minutes of BS. Early brain MRIs confirmed acute infarction in 3, including one who had transient symptoms. MRI infarct volumes were small, and deficits were mild in those who developed stroke. Diagnostic evaluation revealed a patent foramen ovale alone in one case, a pulmonary arteriovenous malformation in one case, and a patent foramen ovale and/or pulmonary shunt in 3 cases.

Conclusions—Ischemic cerebrovascular complications can occur in patients who undergo BS and are associated with the presence of cardiac or pulmonary shunts. The true incidence and degree of disability remains unknown, and further study is indicated to assess the impact of technical differences in BS methodology. Novel methods to promote physician communication such as the use of electronic list serves may reduce barriers to reporting of drug, technique, or device complications and should be explored to identify rare complications that otherwise will likely go unappreciated.

Stroke

Volume 40, Issue 7, 1 July 2009; Pages 2343-2348

Increase accuracy by

- 1) Opacifying the RA
- 2) Observing the atrial septum shift → LA
- 3) Visualizing bubbles cross the septum
- 4) Detecting bubbles within 6 beats or with the septal shift

Note:

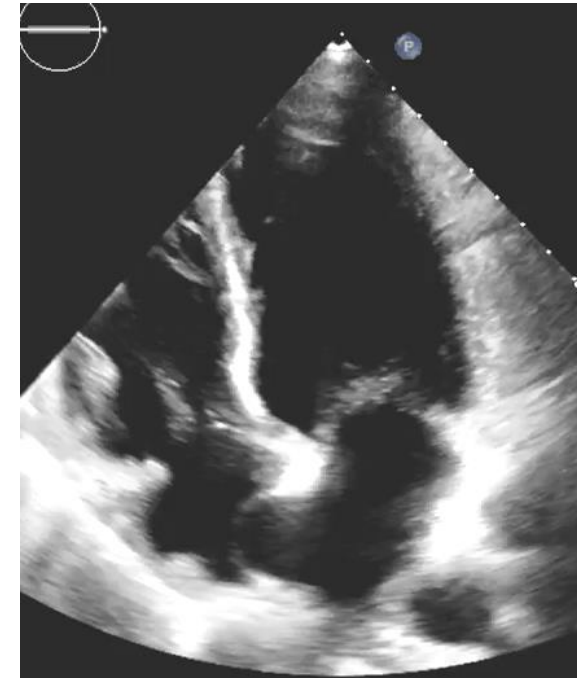
- 1) No shunt with good septal shift = No SHUNT
- 2) Transpulmonary shunting is more likely if
 - a) shunt is >3-6 beats after septal shift
 - b) bubbles exit the pulmonary veins

False Negatives:

- 1) Suboptimal RA opacification
- 2) The septum is shielded by IVC flow
- 3) Inadequate increase in RA pressure or septal shift
- 4) High LA pressure from left heart pathology

False Positives:

- 1) Transpulmonary shunting (may be physiologic)
- 2) Confusion with chordae or trabeculation.
- 3) Smoke confused as bubbles
- 4) Cavitation



Criteria for Grading the Shunt

<i>Grade</i>	<i>Bubbles*</i>
0 (<i>none</i>)	0
1 (<i>small</i>)	1 – 9
2 (<i>moderate</i>)	10 – 30
3 (<i>large</i>)	> 30 >20



Grade 1 (*small*)



Grade 2 (*moderate*)



Grade 3 (*large*)

ANATOMICAL NUANCES AND TEE

Cryptogenic stroke versus migraine patients undergoing PFO closure

ECHOCARDIOGRAPHIC ASSESSMENT OF PATENT FORAMEN OVALE

Identification of High-Risk Patent Foramen Ovale Associated With Cryptogenic Stroke: Development of a Scoring System

Rie Nakayama, MD, Yoichi Takaya, MD, Teiji Akagi, MD, Nobuhisa Watanabe, RDCS, Madoka Ikeda, RDCS, Koji Nakagawa, MD, Norihisa Toh, MD, and Hiroshi Ito, MD, *Okayama, Japan*

Comparison of 57 pts with CS (on MRI) to 50 migraine pts without CS undergoing transcatheter PFO closure.

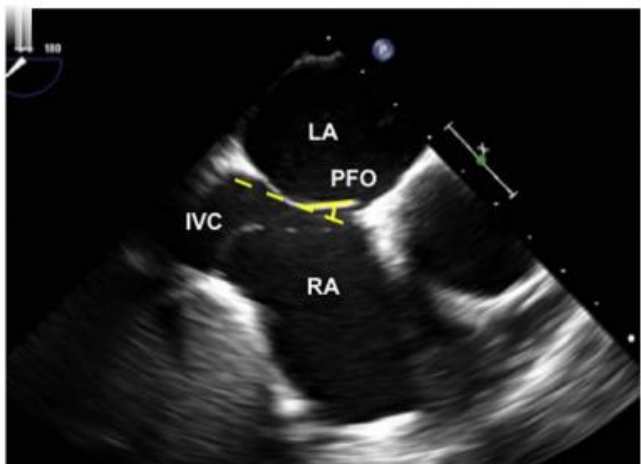
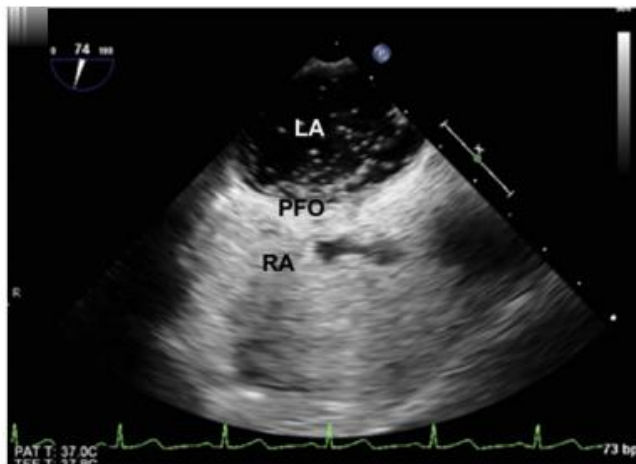
PFO HEIGHT - MAXIMUM SEPARATION



MAXIMUM PFO OVERLAP LENGTH



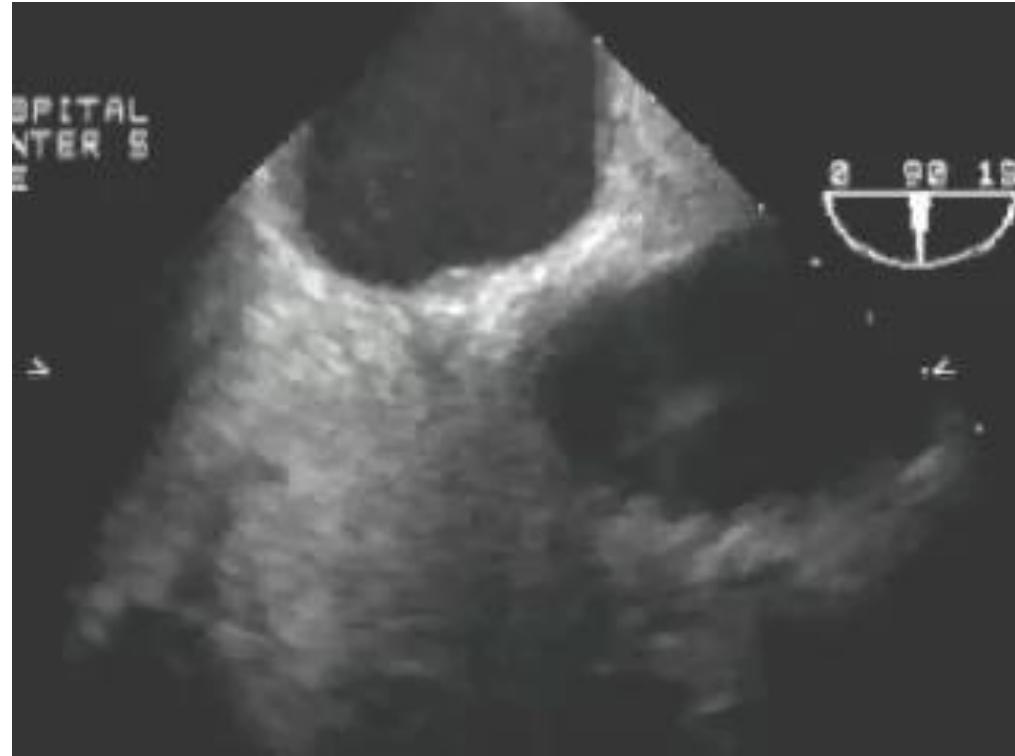
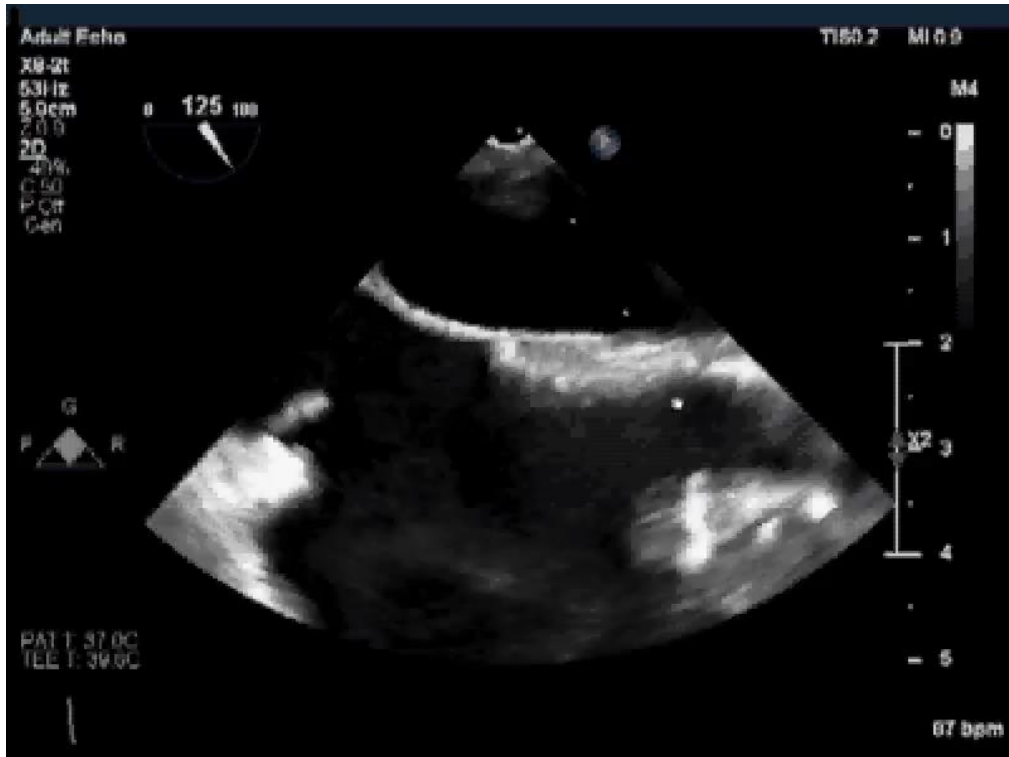
FOSSA OVALE MOBILITY



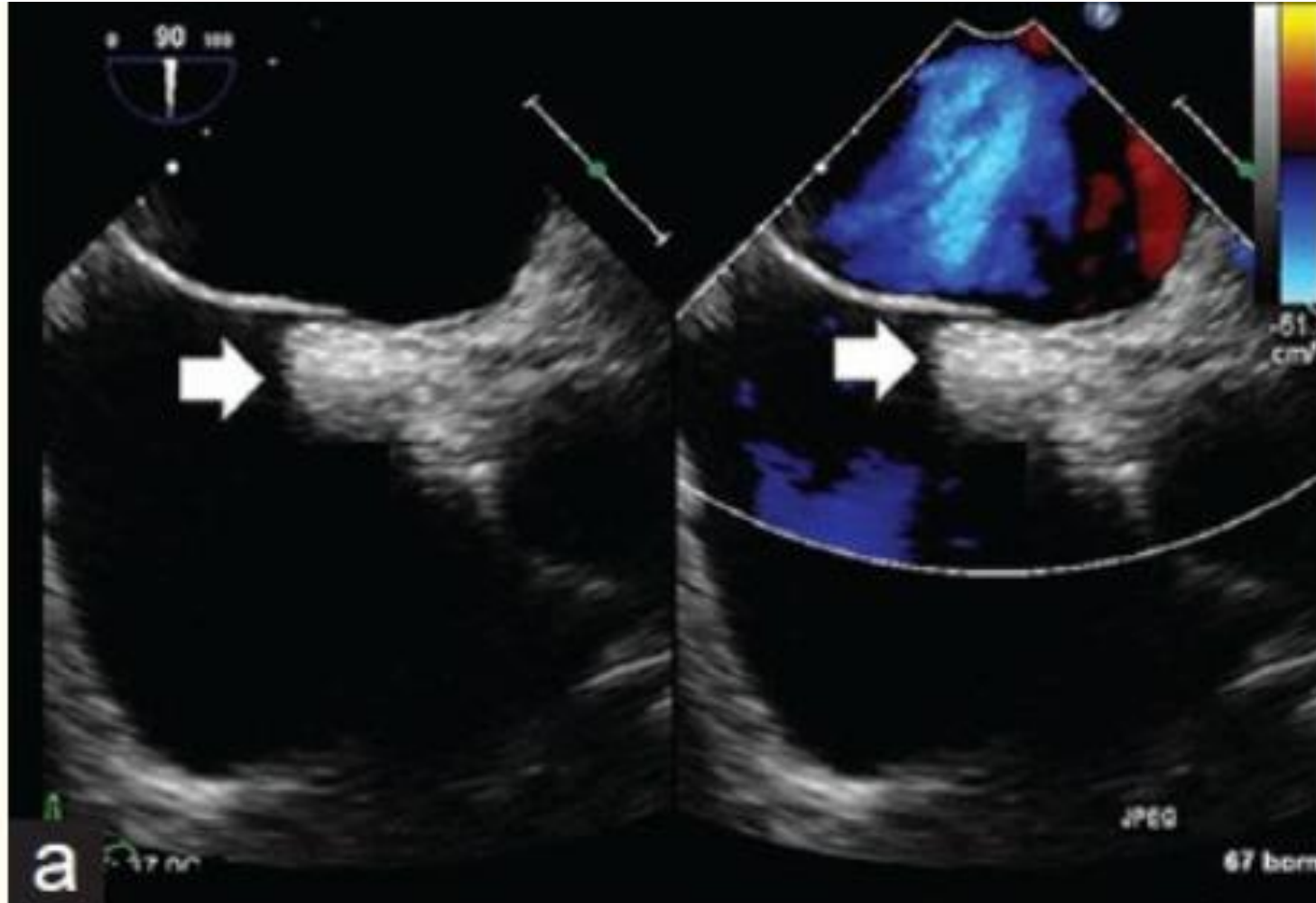
2D morphology complements bubble study.

- PFO Height: maximum septum primum - secundum separation in end-systole. ↑ height > 2 mm.
- PFO tunnel length: maximum overlap length between the septum primum –secundum. ↑ length > 10 mm.
- ASA: >10 mm of septal excursion from the RA:LA midline or >15 mm total excursion.
- **Hypermobile septum** > 5 mm septal excursion in every heartbeat.
- Prominent Eustachian valve: >10 mm protrusion into RA.
- **Large shunt: > 20 bubbles in the LA in a single frame.**
- Low angle PFO: < 10 degree difference in the IVC-septal plane.

Be wary of washout:



Lipomatous Shielding of the Fossa Oval



**A LT to RT shunt may
result in a negative
bubble study.**

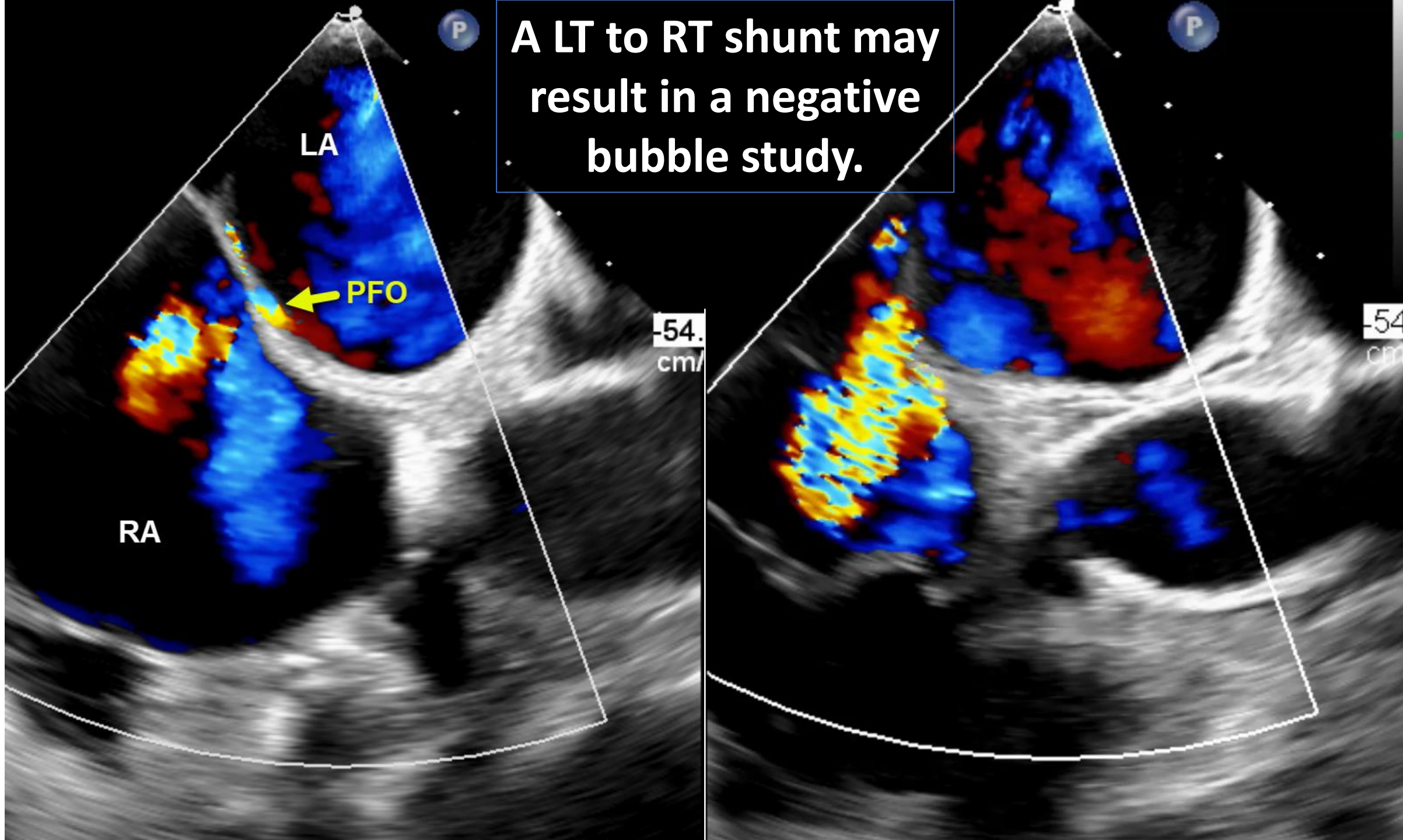
LA

PFO

RA

-54.
cm/

-54.
cm/



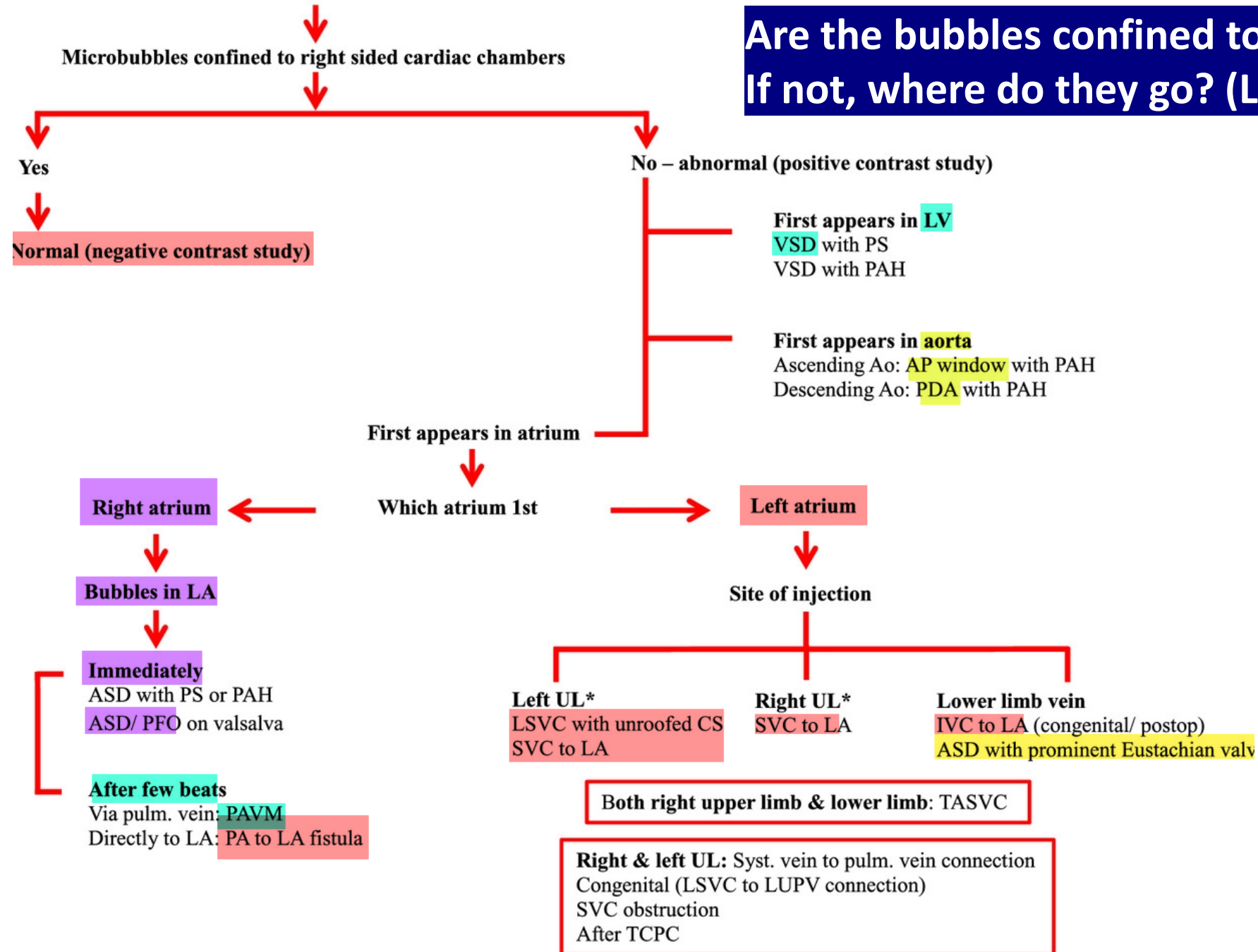
Agitated Saline Contrast Echocardiography in the Identification of Intra- and Extracardiac Shunts: Connecting the Dots

Samuel Bernard, MD, Timothy W. Churchill, MD, Mayooraan Namasivayam, MBBS, PhD,
and Philippe B. Bertrand, MD, PhD, *Boston, Massachusetts*

Applications:

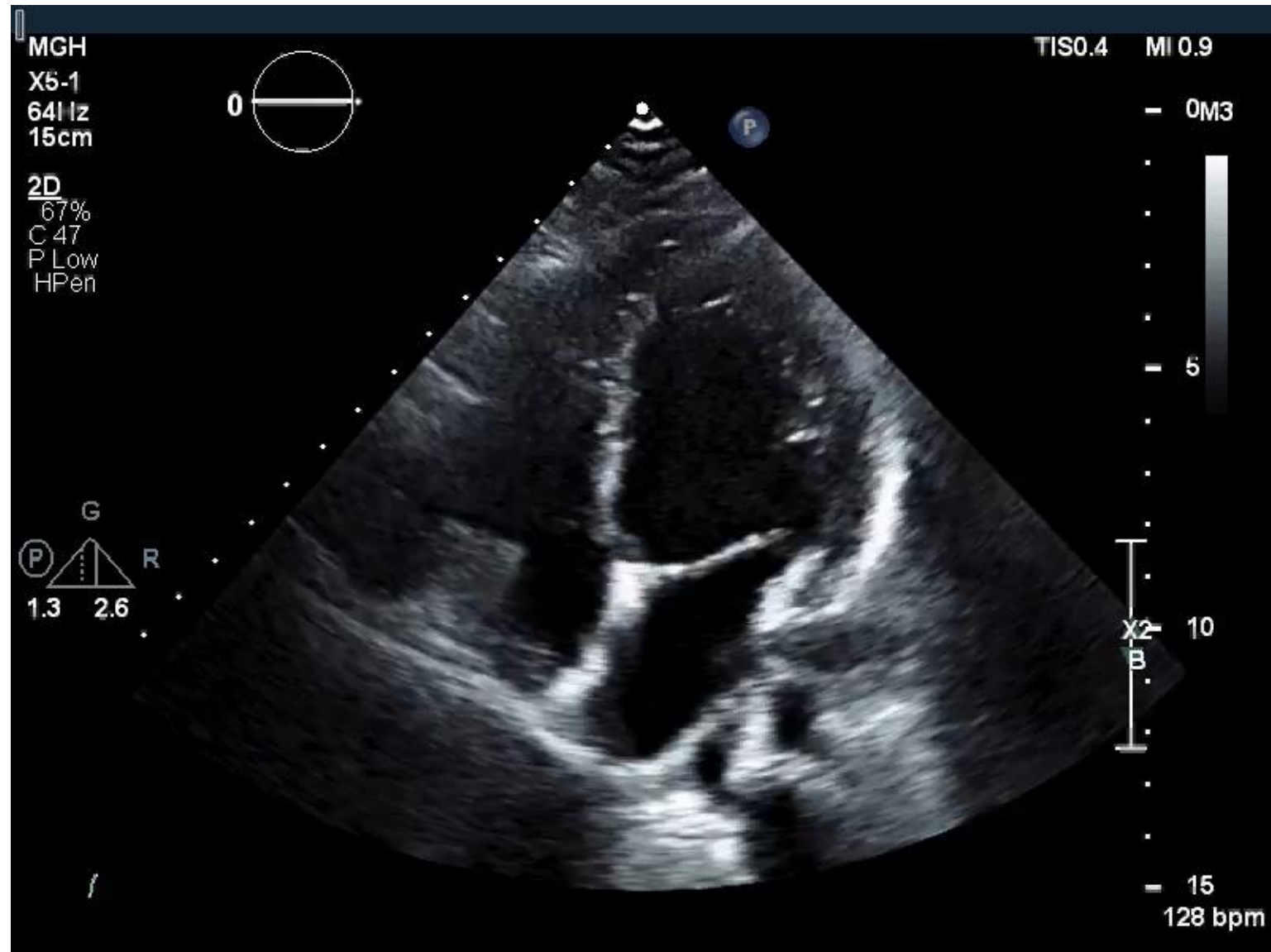
- Cryptogenic STROKE
- Migraine headaches
- RV dilation/dysfunction
- Hypoxemia
- Intra-/Extracardiac shunts
- Platypnea-orthodeoxia
(dyspnea and deoxygenation when upright; example \uparrow RA \rightarrow LA shunt)
- Decompression sickness; paradoxical air embolism

Are the bubbles confined to the RA/RV?
If not, where do they go? (LA, LV, AO, PA)

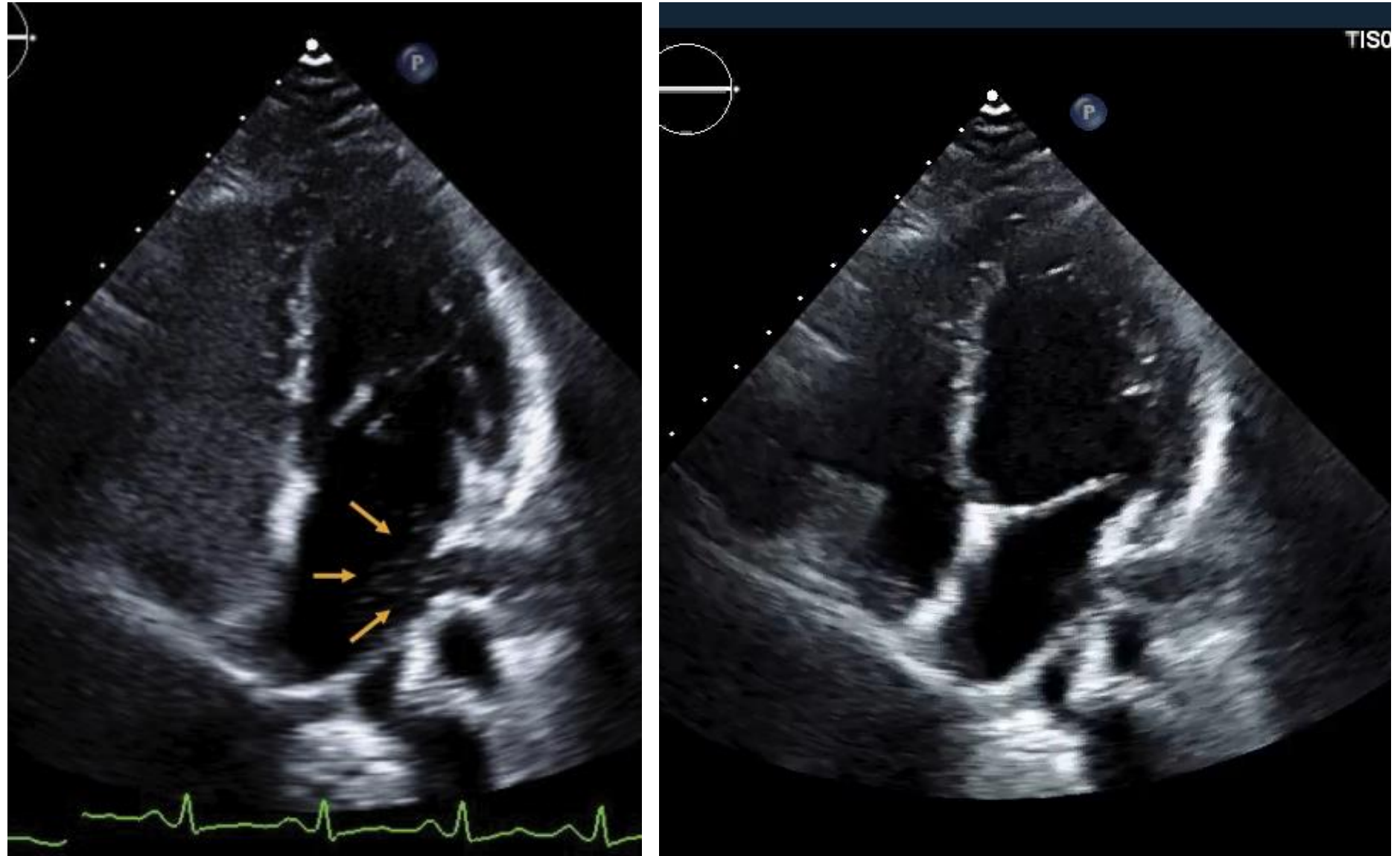


* In presence of ASD or connecting cava bubbles may appears in RA

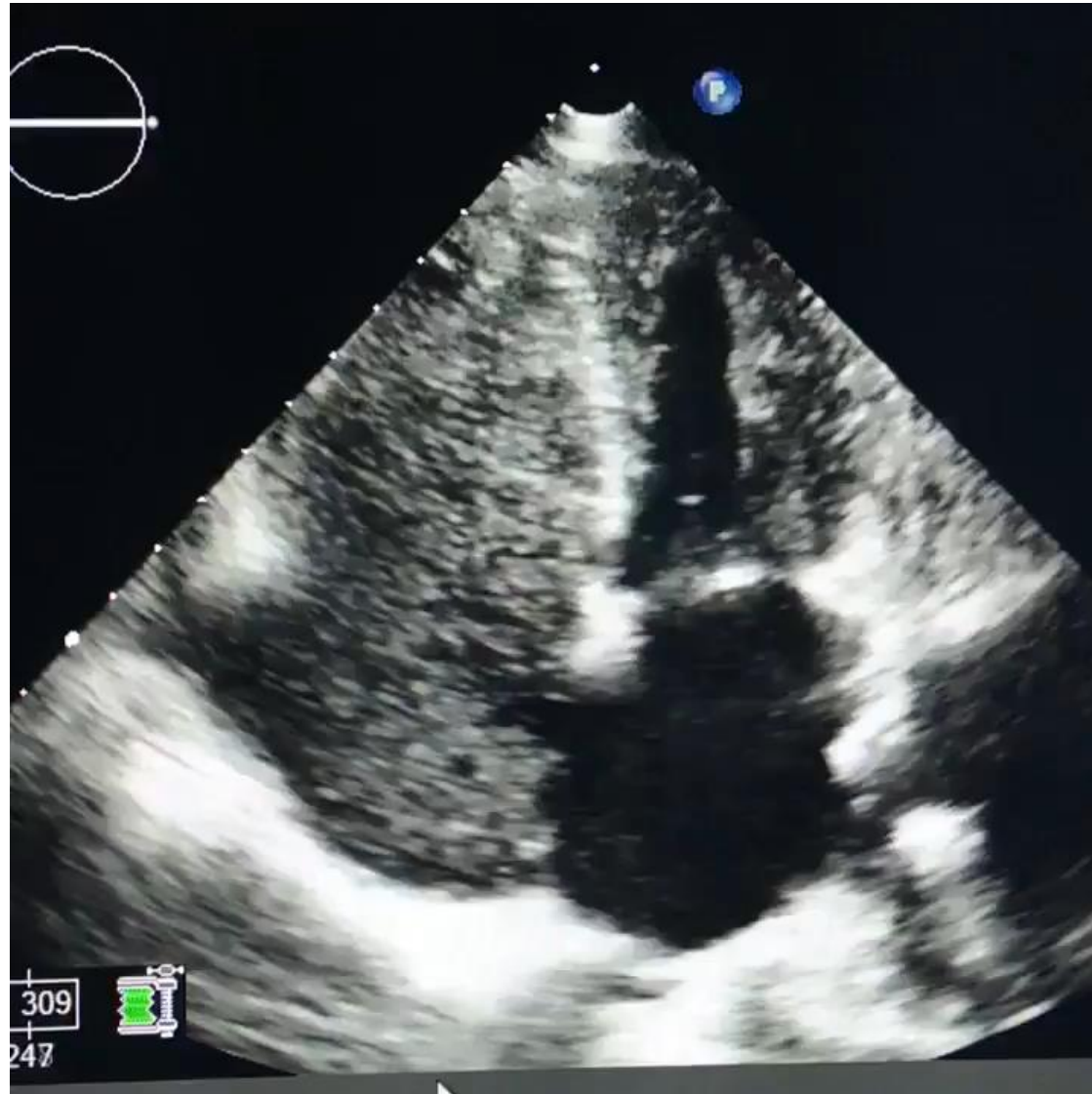
What are you seeing?



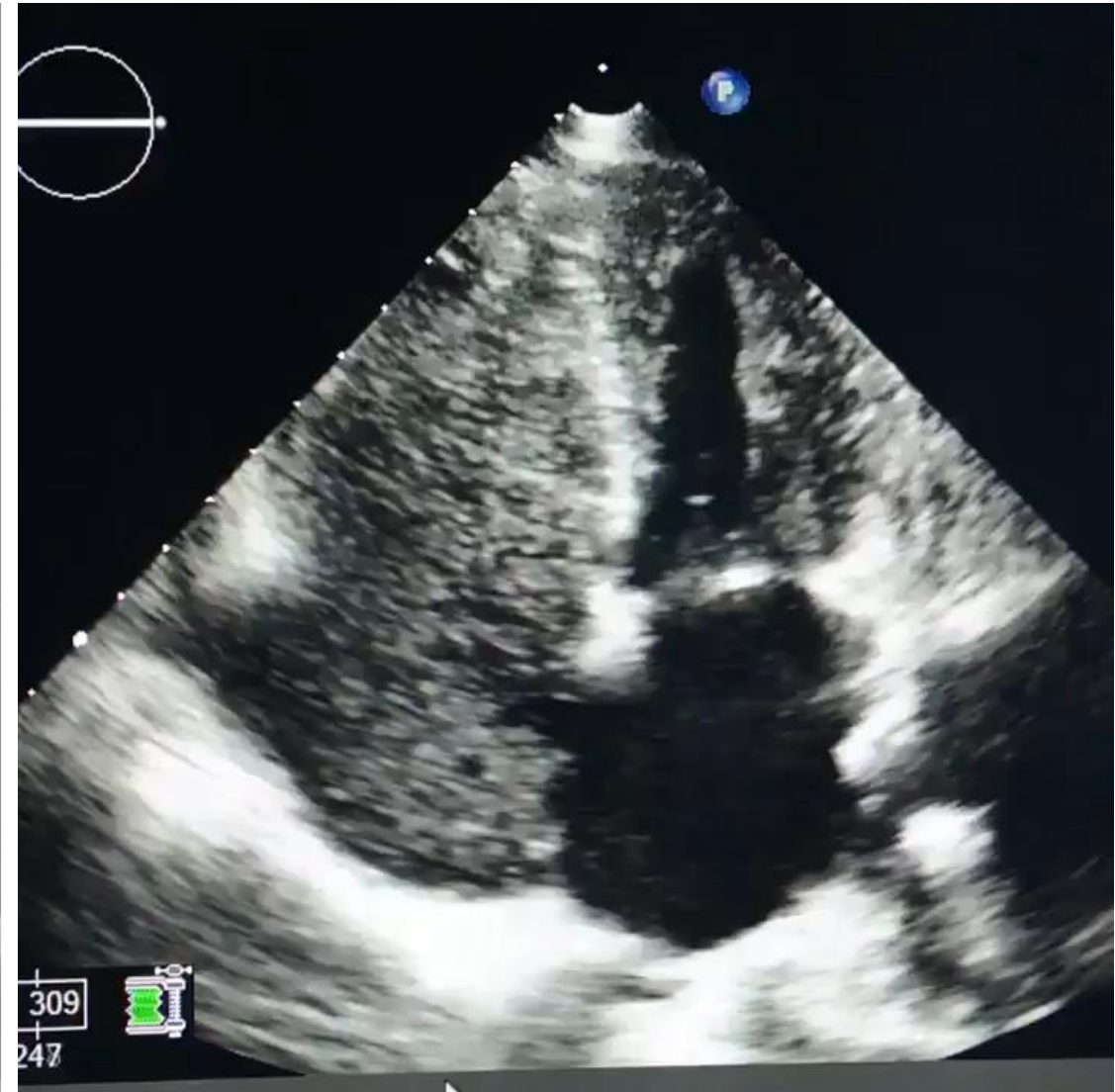
Answer: transpulmonary shunting (hereditary hemorrhagic teangiectasia)



What are you seeing?

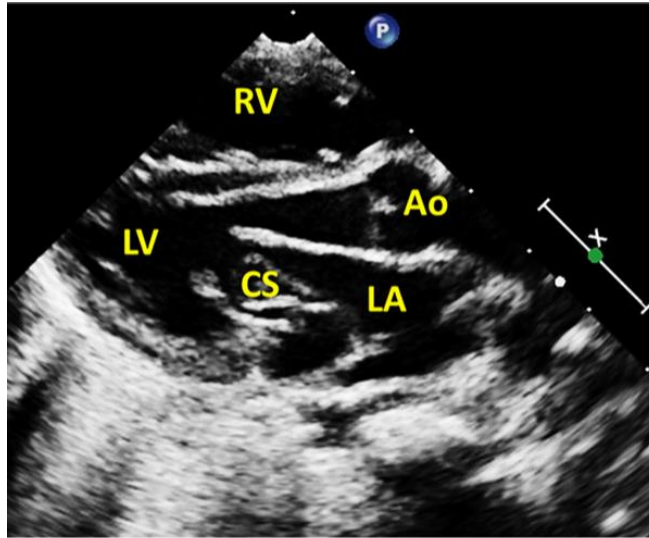


Answer: negative contrast effect through an ASD

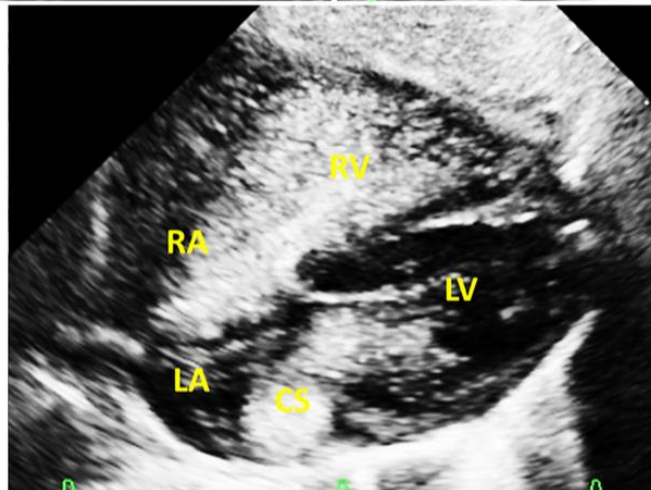
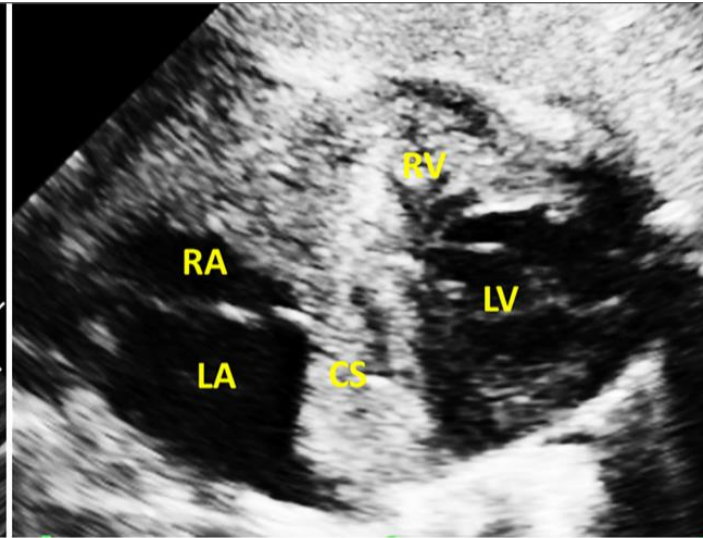


3 month old baby with cyanosis from a persistent left SVC → RA and LA shunt because of an unroofed coronary sinus

PLX: floppy CS



Subcostal view CS → RA

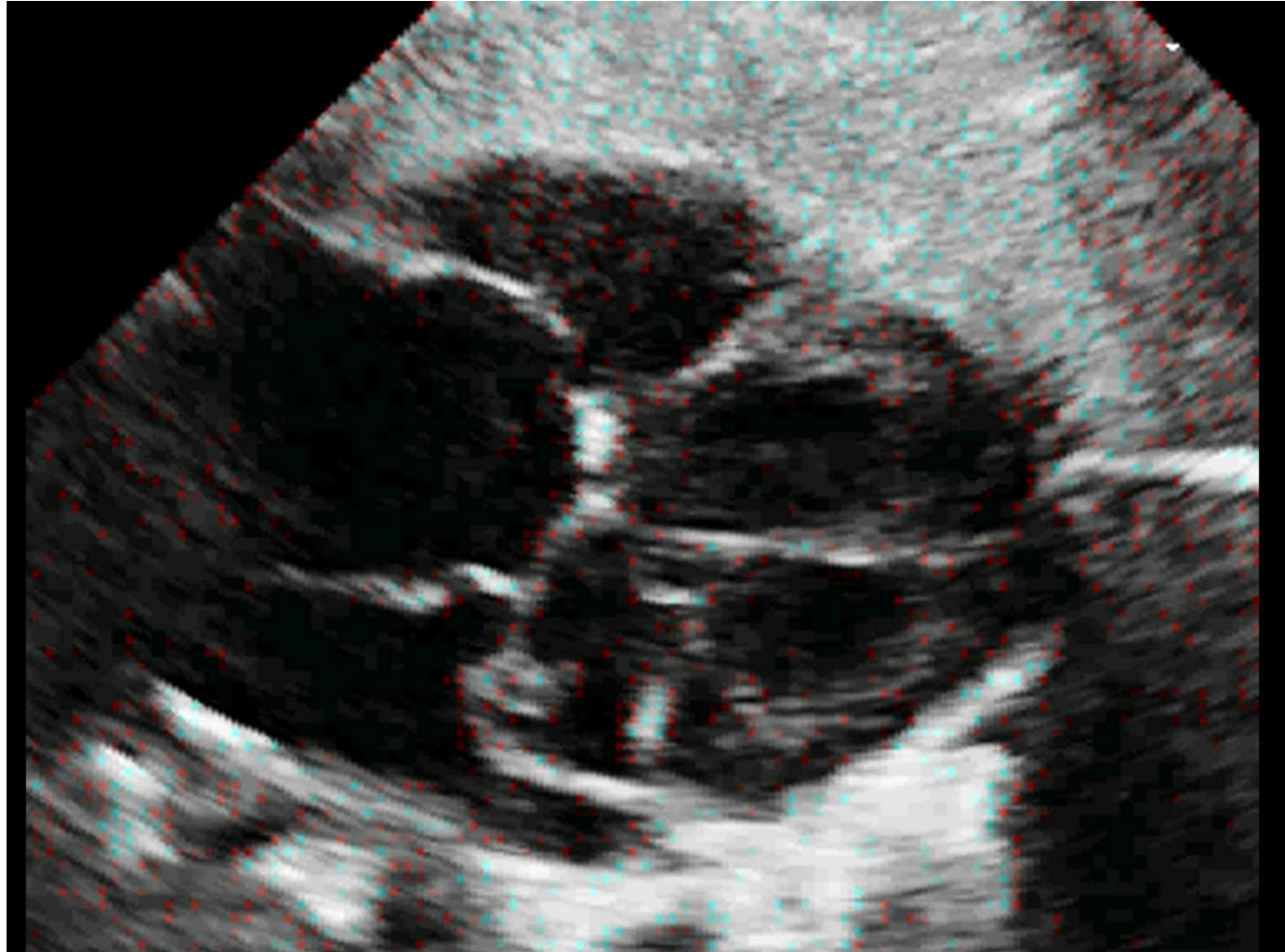


Subcostal view
CS → LA and RA

Important tip: Always inject in the left arm to rule out left sided SVC in patients with coronary sinus dilation.

3 month old baby with cyanosis from a persistent left SVC → RA and LA shunt because of an unroofed coronary sinus

Subcostal view CS
contrast shunts to
RA and then LA

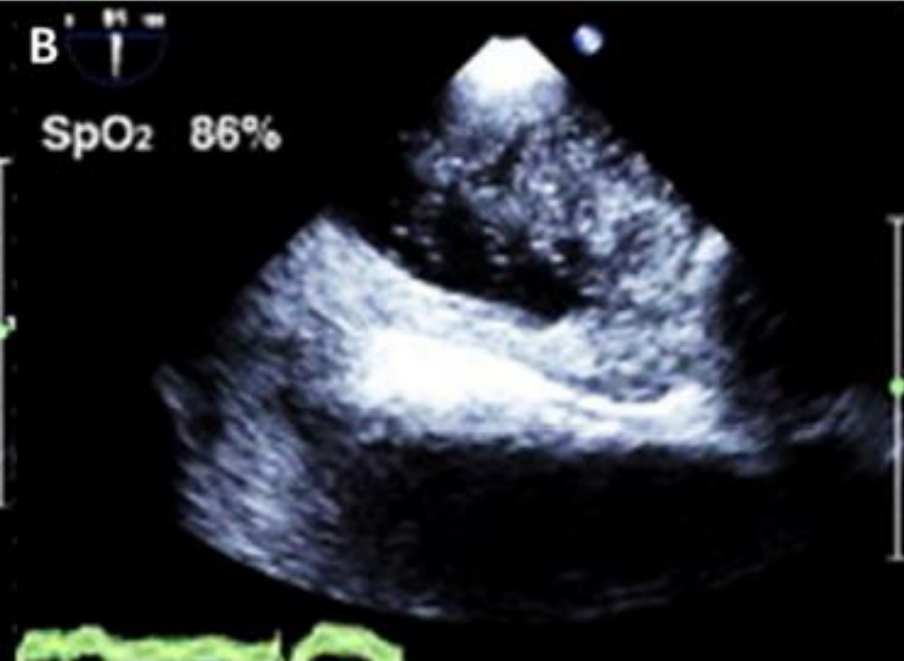


Platypnea orthodeoxia syndrome—Dyspnea and hypoxia in upright posture Bicaval TEE View

Supine

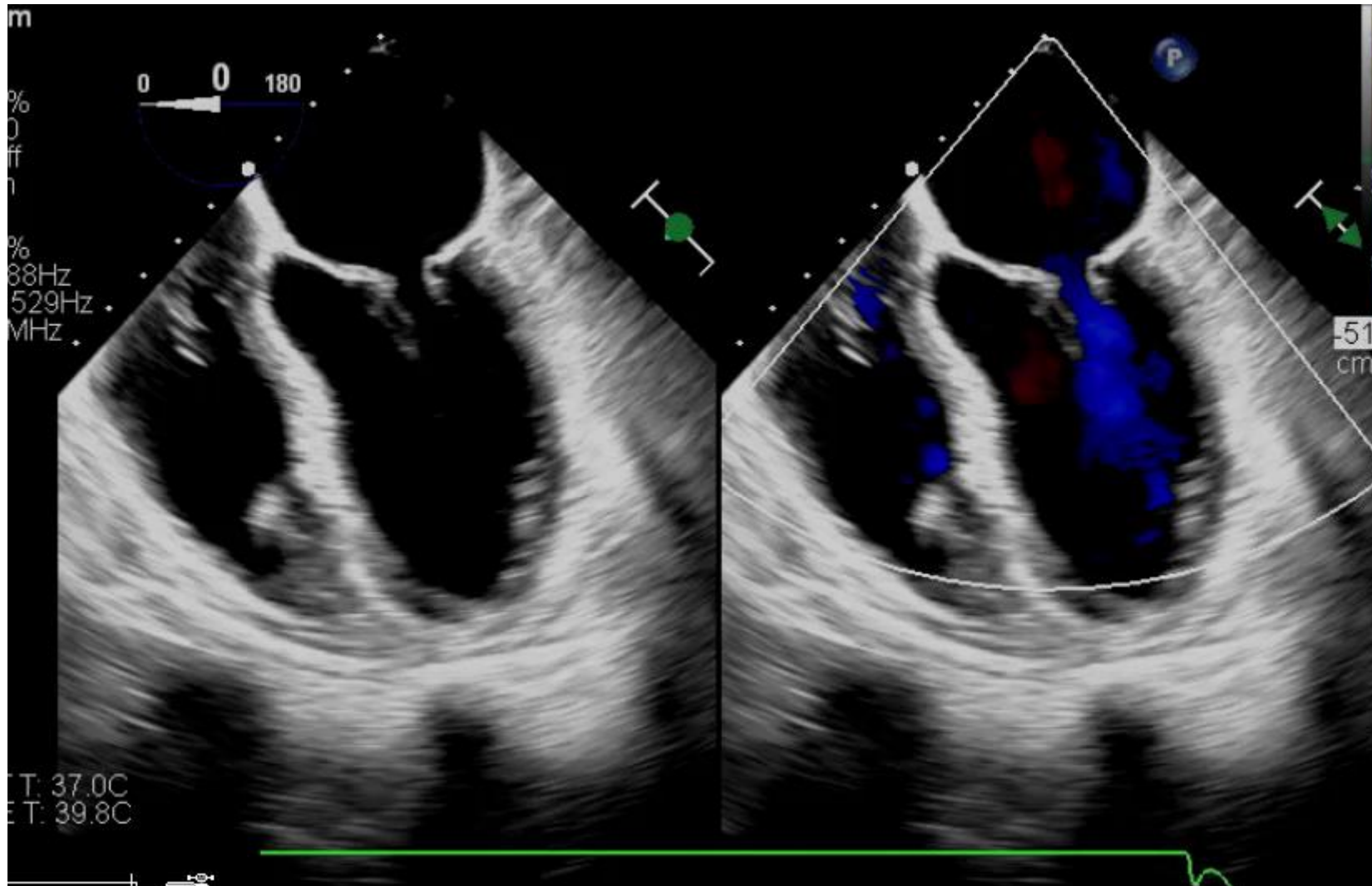


Sitting

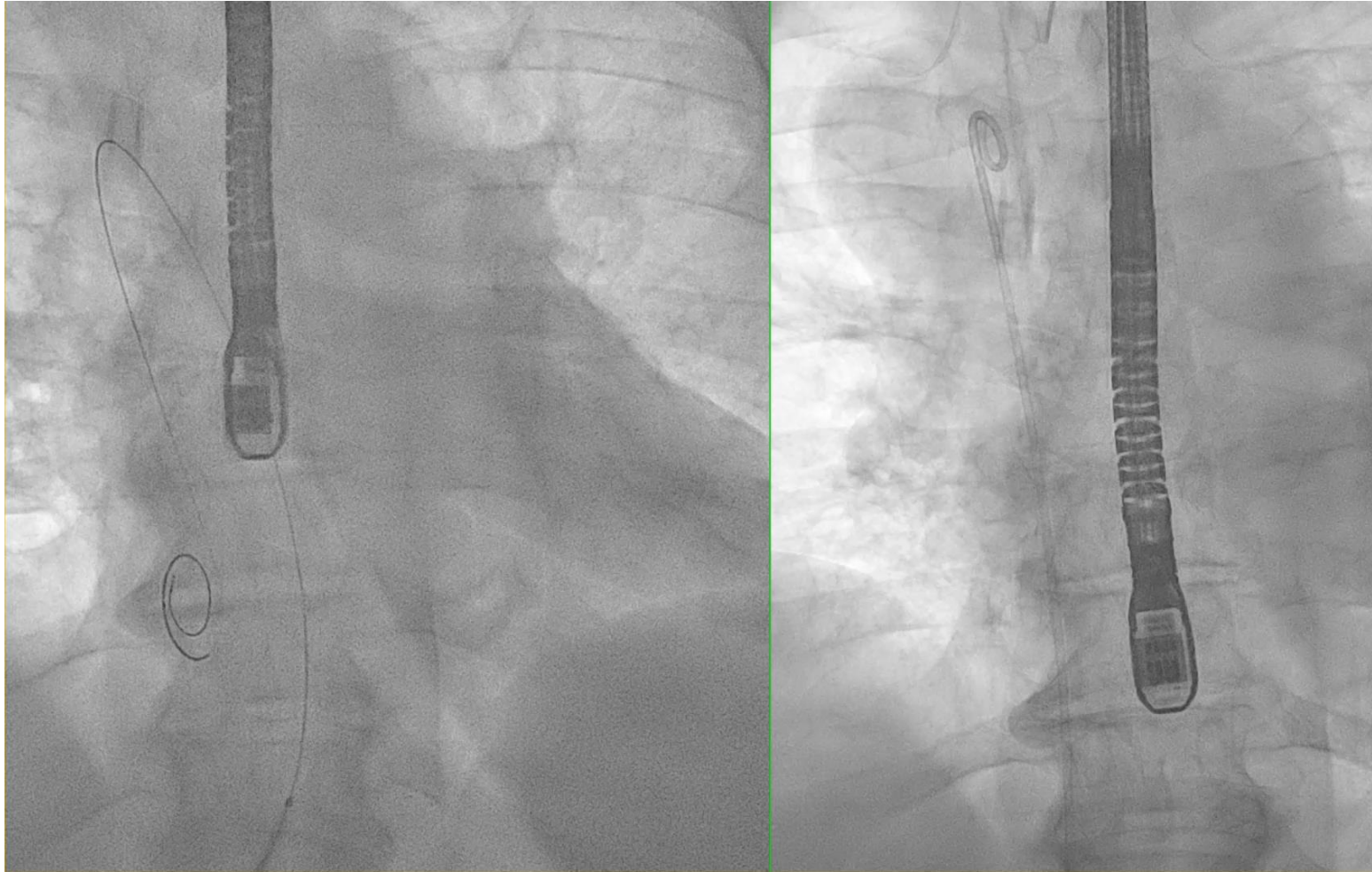


SCE using TEE approach in supine position **A**. shows minimal right-to-left shunt through PFO (arrow) in supine position which gets exaggerated while sitting **B**. Adapted with permission from Shirashi et al.²¹

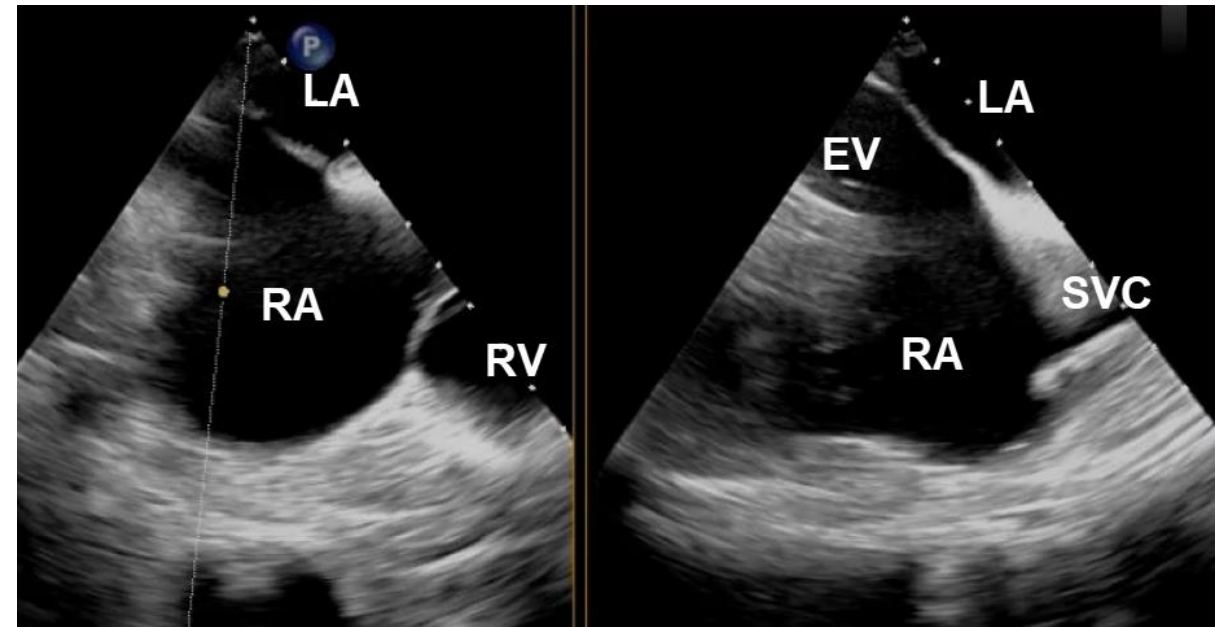
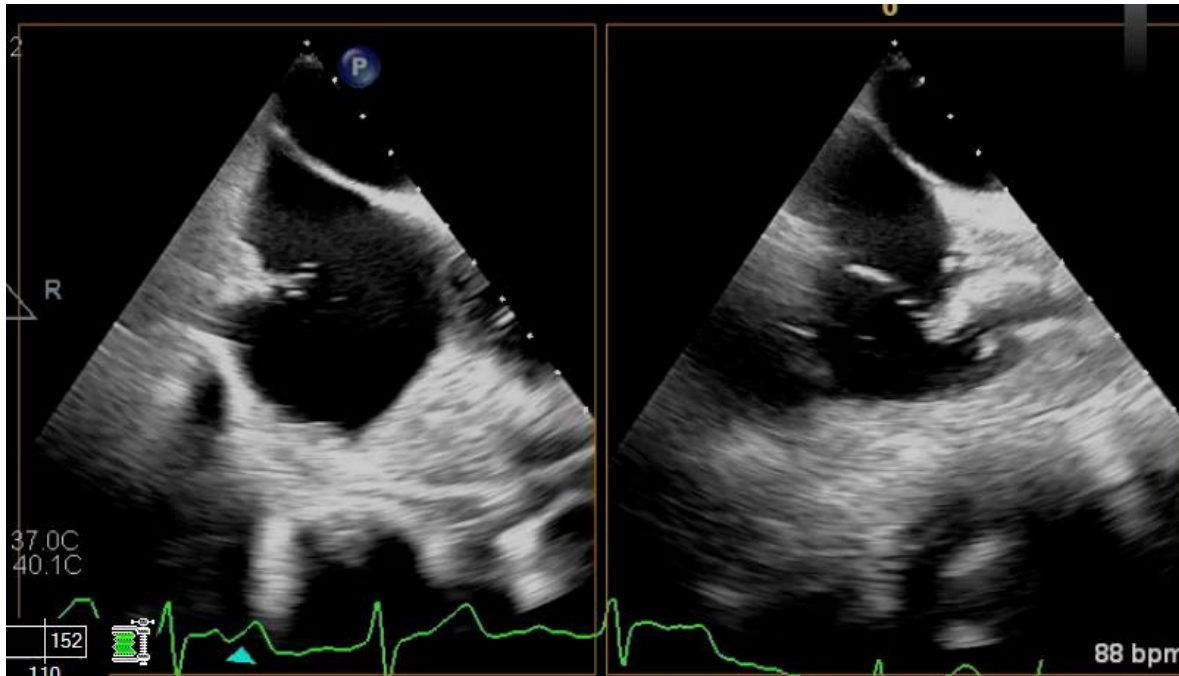
65 year old female referred for left atrial
appendage occlusion for atrial fibrillation.

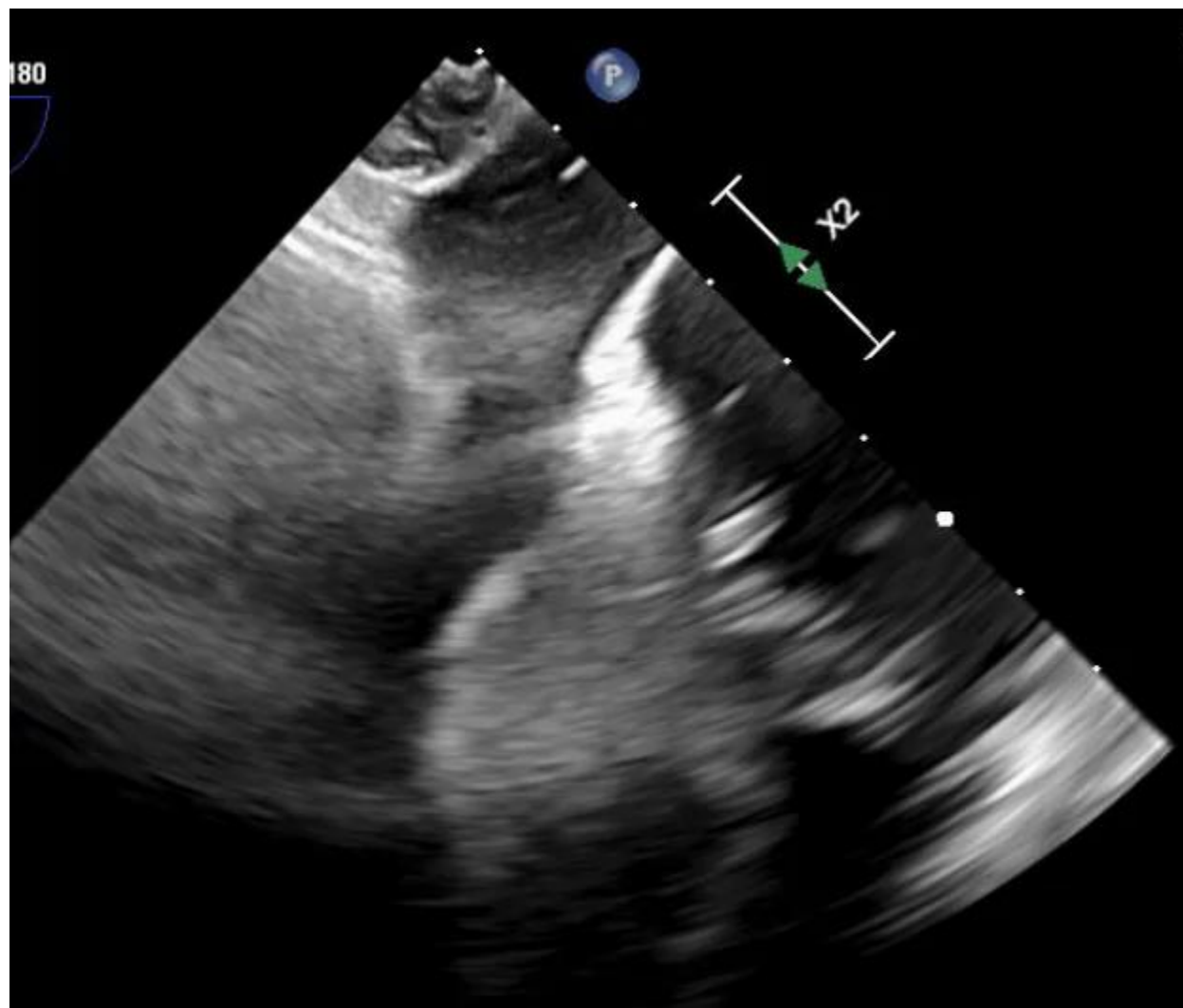
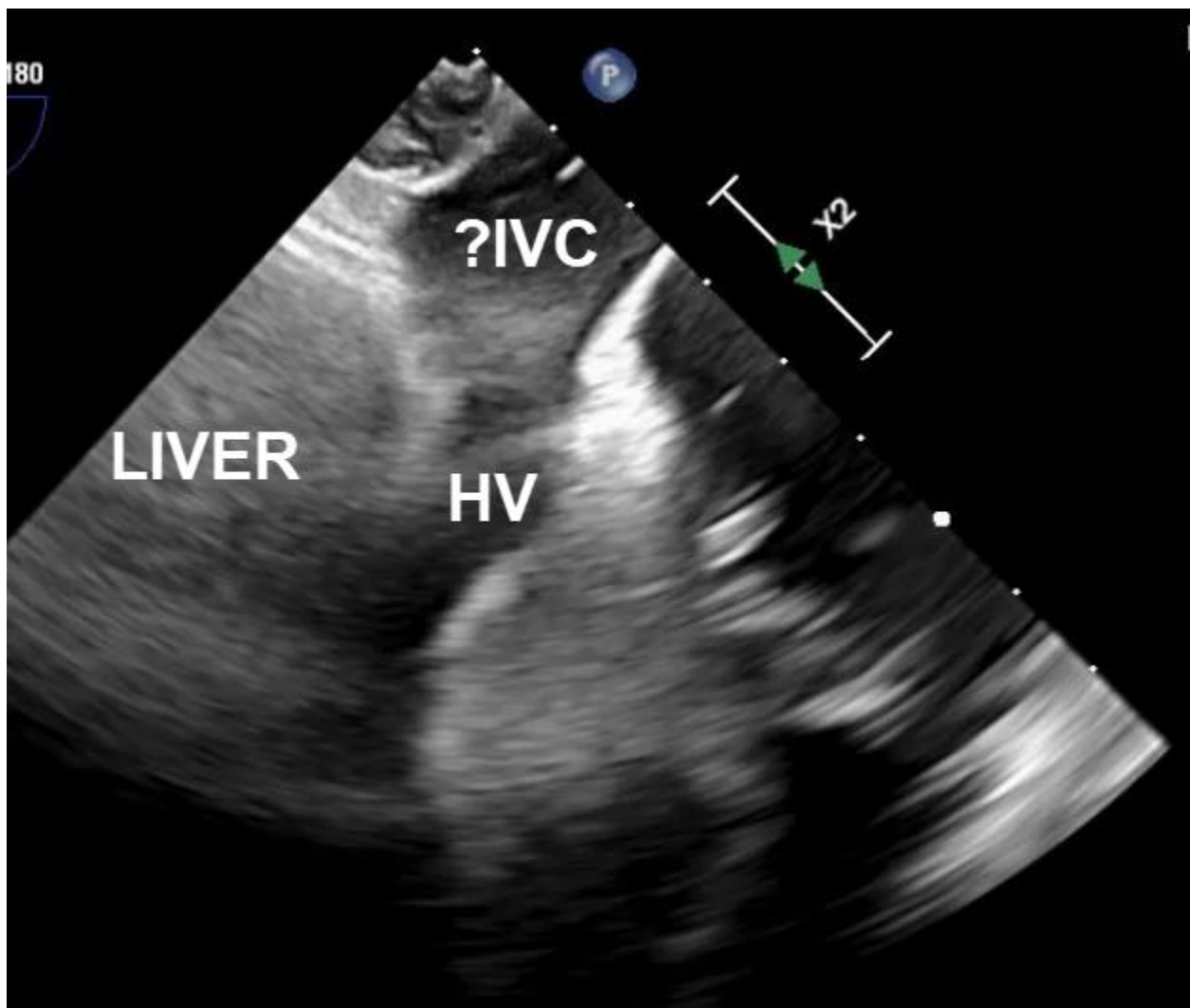


Femoral vein catheters emerged from SVC rather than IVC



Femoral injection of saline bubbles emerged from the SVC rather than the IVC





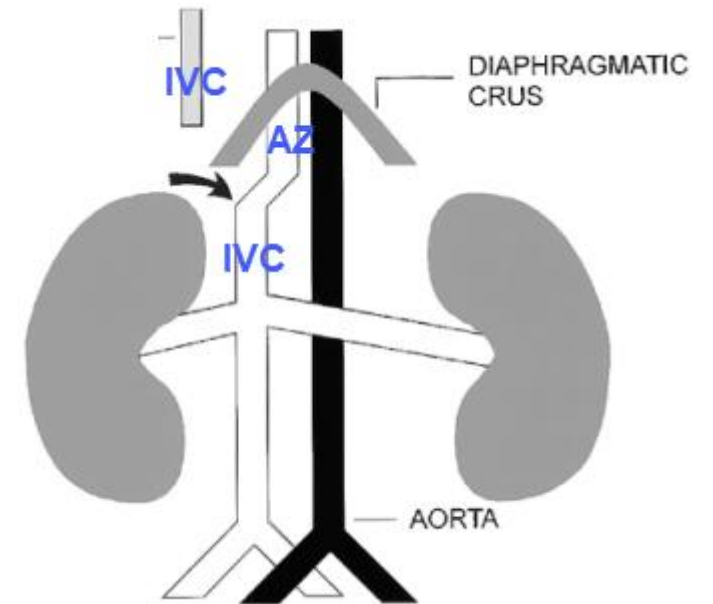
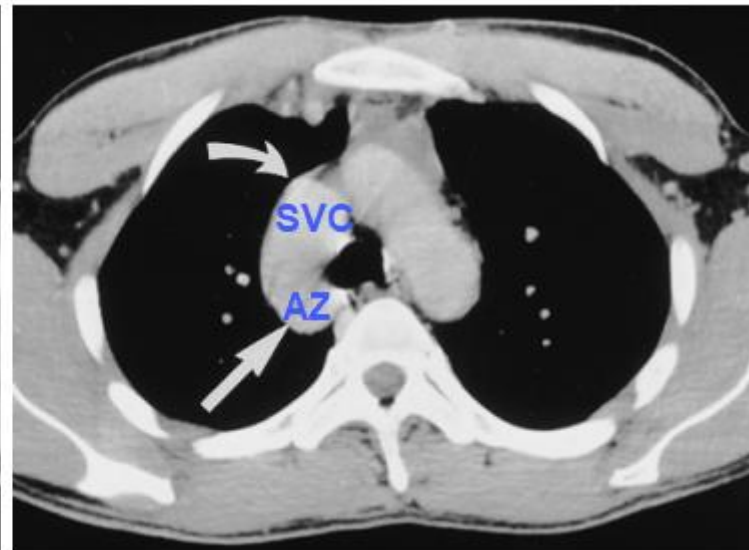
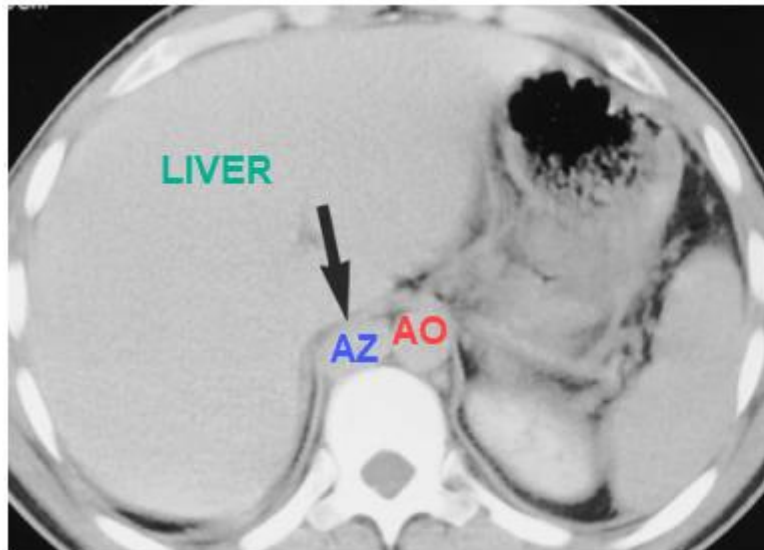
What going on????

Spectrum of Congenital Anomalies of the Inferior Vena Cava: Cross-sectional Imaging Findings¹

(CME available in print version and on RSNA Link)

LEARNING
OBJECTIVES
FOR TEST 2

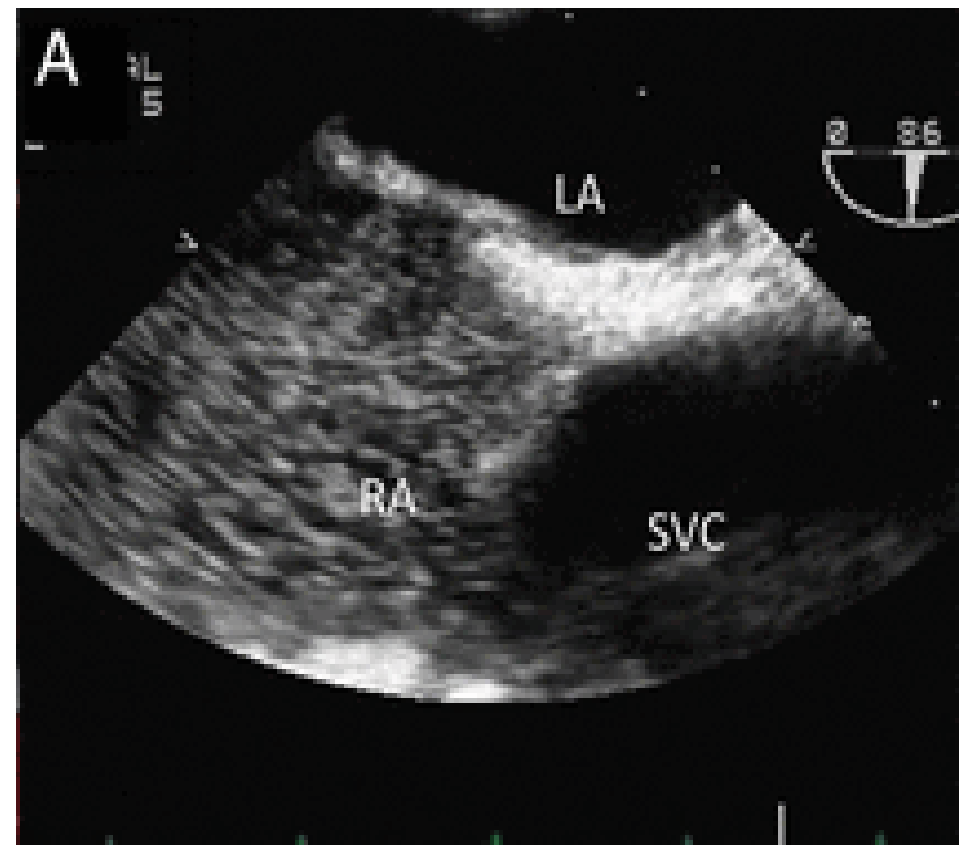
J. Edward Bass, MD • Michael D. Redwine, MD • Larry A. Kramer, MD
Phan T. Huynh, MD • John H. Harris, Jr, MD, DSc



Acquired systemic to pulmonary venous shunt

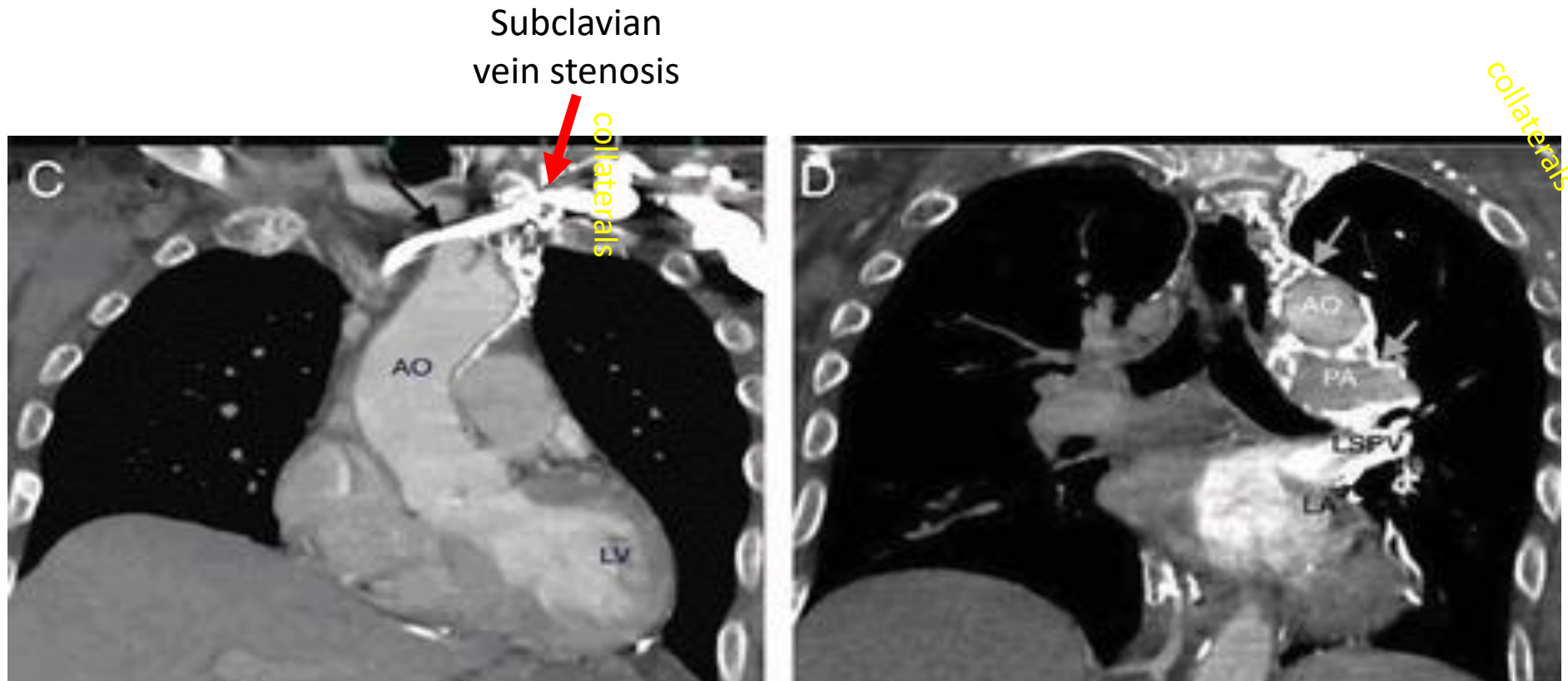
- **68 year old male, DM, HTM, admitted for CVA**

**6 years before, negative TEE for endocarditis.
Saline bubbles in RA only.**



Developed ESRD and LT subclavian thrombosis from catheter.

• **CT: subclavian vein stenosis increased venous pressure
→ collateral channels to LT upper pulmonary vein and LA.**



6 years before, **RA bubbles only.**



Repeat bubble study after subclavian vein thrombosis opacified the **LA first**



Take-aways

- Atrial septal anatomy is nuanced (esp w/ TEE)
- Consider adjusting bubble administration
 - Give during Valsalva and abdominal compression
 - Release when bubbles enter the RA
 - Go for 5
- There are many indications for bubble studies.
- Age cut-off should be nuanced with other findings.