

# Evaluation of PFO with Agitated Saline: Best Practices

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# Learning Objectives

- Indications for bubble study
- Correct technique to perform a bubble study
- Interpretation

# Indications

- Intracardiac or pulmonary shunt.
- Augment TR dopplers.

# Why use bubbles?

- Agitated saline injection contains microbubbles with diameter ranging from 16-38 $\mu\text{m}$ .
- Average diameter of pulmonary capillaries is 8 $\mu\text{m}$ .
- Microbubbles smaller than 8 $\mu\text{m}$  dissolve in approximately 190ms in blood.
- The median red blood cell transit time through the pulmonary circulation is approximately 1.2s.
- 2D TTE with color Doppler is 89-100% sensitive for ostium secundum ASD and 100% sensitive for ostium primum ASD.
- Only 22% sensitive for PFO.

# Technique

- $\geq 20$ -gauge IV in large antecubital or forearm vein.
- Typically right-sided vein with patient in left lateral decubitus position.
- Apical four-chamber or a subcostal view.
- Harmonic imaging.
- No adjustment of mechanical index is needed.
- 9mL saline with 1mL room air agitated between two empty syringes using a three-way stopcock.
- Addition of 1mL blood increases number of microbubbles.
- 50% glucose, 50% saline solution has longer duration of opacification and peak signal intensity but not necessarily better for PFO detection.
- Always perform with provocative maneuvers.

# Physiological Maneuvers to Provoke Right-Left Shunting

- Inspiration followed by forceful expiration against close airway for 15 to 20 seconds followed by release of expiratory effort.
- With release of strain, decrease in intrathoracic pressure and elevation of RA pressure relative to LA pressure.
- ASC injection performed during strain phase of Valsalva maneuver.
- Abdominal compression can be performed, epigastric pressure with subsequent release on appearance of bubbles in RA.
  - Compression of IVC in patients sedated during TEE may be more effective.

# Optimizing ASC Study on TTE

- Complete opacification of RA.
- Bulging of IAS to the left.
- Repeat injections or lower extremity injection may be considered.
- Direct visualization of bubbles crossing IAS increases specificity.
- Appearance of left atrial bubbles within 3 to 6 beats after appearance of right atrial bubbles is current standard.
- TEE is gold standard.

# False Negatives

- Inadequate augmentation of RA pressure above LA pressure.
- Inability to opacify the RA.



# False Positives

- Intrapulmonary shunting
- Anomalous venous shunts.
- Very large Eustachian valve/cor triatriatum dexter(misidentification of IAS)
- Incomplete clearance of ASC from prior injection.
- Pseudocontrast effect- appearance of weakly echo-dense material(snowstorm contrast) from the pulmonary vein following a Valsalva or cough maneuver.
- Alternative causes of shunting (sinus venosus ASD, coronary sinus ASD)

# Nontraditional Causes of Positive ASD study

Cause of shunting	Order of chamber opacification	Other echocardiographic findings	Abnormal shunting seen when injected by		
			RUE	LUE	Lower extremity
Superior sinus venosus ASD	LA simultaneous with (or before) RA	<ul style="list-style-type: none"> <li>SVC ↔ RUPV by 2D echocardiography/ color Doppler (typically difficult to visualize in adults)</li> <li>ASC seen in pulmonary veins before LA opacification</li> </ul>	Yes	Yes	No
Inferior sinus venosus ASD	LA simultaneous with (or before) RA	<ul style="list-style-type: none"> <li>IVC/RA junction ↔ right-sided pulmonary vein by 2D echocardiography/ color Doppler (typically difficult to visualize in adults)</li> </ul>	No	No	Yes
Persistent left-sided SVC with <ul style="list-style-type: none"> <li>Unroofed CS</li> <li>Drainage via pulmonary vein</li> <li>Direct LA drainage</li> </ul>	LA simultaneous with (or before) RA	<ul style="list-style-type: none"> <li>2D visualization of persistent left-sided SVC</li> <li>If CS is unroofed               <ul style="list-style-type: none"> <li>Dilated CS (2D)</li> <li>ASC seen in CS before LA</li> </ul> </li> </ul>	No	Yes	No
IVC-to-LA shunting <ul style="list-style-type: none"> <li>Congenital</li> <li>Postoperative (ASD closure)</li> </ul>	LA opacification before RA	<ul style="list-style-type: none"> <li>May have a residual ASD if a postoperative complication</li> </ul>	No	No	Yes
VSD (with pulmonary hypertension)	LV after RV opacification (before LA)	<ul style="list-style-type: none"> <li>Exact type of VSD can be localized by 2D and color Doppler assessment</li> </ul>	Yes	Yes	Yes
PDA (with pulmonary hypertension)	Descending Ao after RV opacification (before LA)	<ul style="list-style-type: none"> <li>Continuous color flow Doppler during PA and Ao assessment</li> </ul>	Yes	Yes	Yes

# Conclusion

- ASC is a powerful tool in the detection of intra and extra-cardiac shunt.
- Meticulous technique is essential to take full advantage of this inexpensive and easy to perform test.

Thank you