

Shunt Evaluation to Guide Patent Foramen Ovale Closure

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Disclosures

I have no relevant relationships with commercial interests to disclose.



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Patient History

- 51yo gentlemen with a history of orthodeoxia-platypnea syndrome with a large patent foramen ovale (PFO) on echocardiogram and multiple small pulmonary arteriovenous malformations (AVMs) by CT presenting with severe hypoxemia on minimal exertion who was referred for PFO closure.
- PMHx:
 - Liver failure s/p liver transplant
 - Hepatopulmonary hypertension
 - CAD s/p PCI to the right PDA
 - DVT s/p 6 months of warfarin



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Vitals and Physical Examination

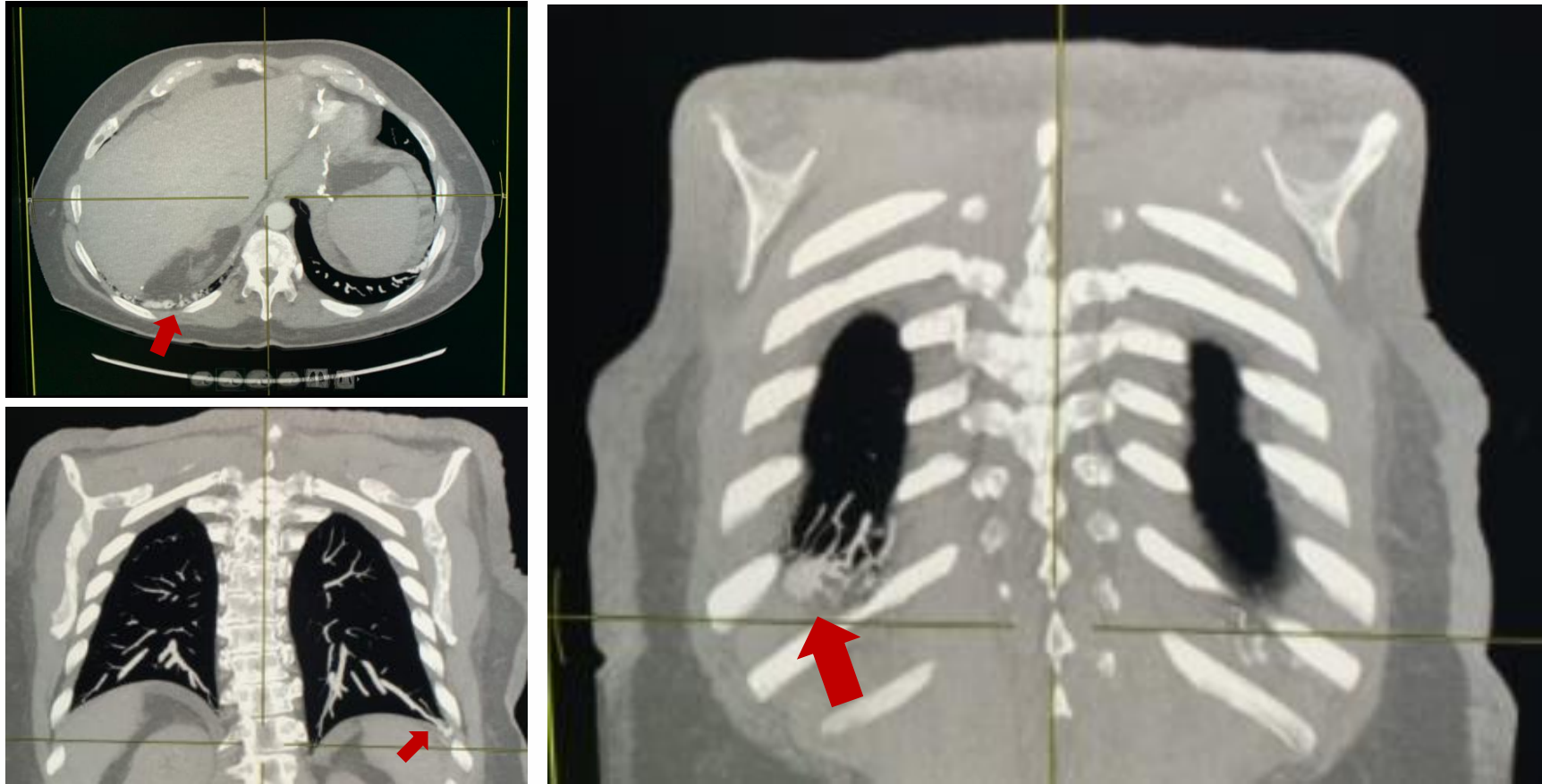
- Vitals: Afebrile, HR- 73, BP-105/68 mmHg, RR-18/min, Saturation of 85% supine and 72% sitting
- Exam
 - General: Alert and awake
 - Neck: No JVD
 - Lungs: Clear to auscultation, SpO2 88 on 10L high flow.
 - Heart: Regular heart rate and rhythm.
 - Extremities: No clubbing or edema.
 - Skin: Warm and dry.



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Noncontrast Chest CT



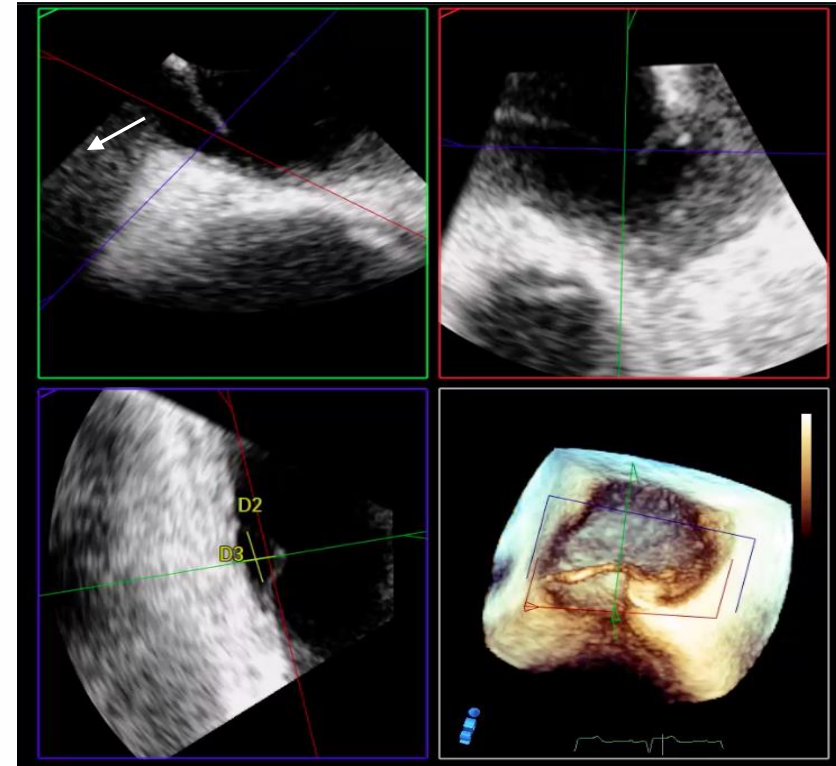
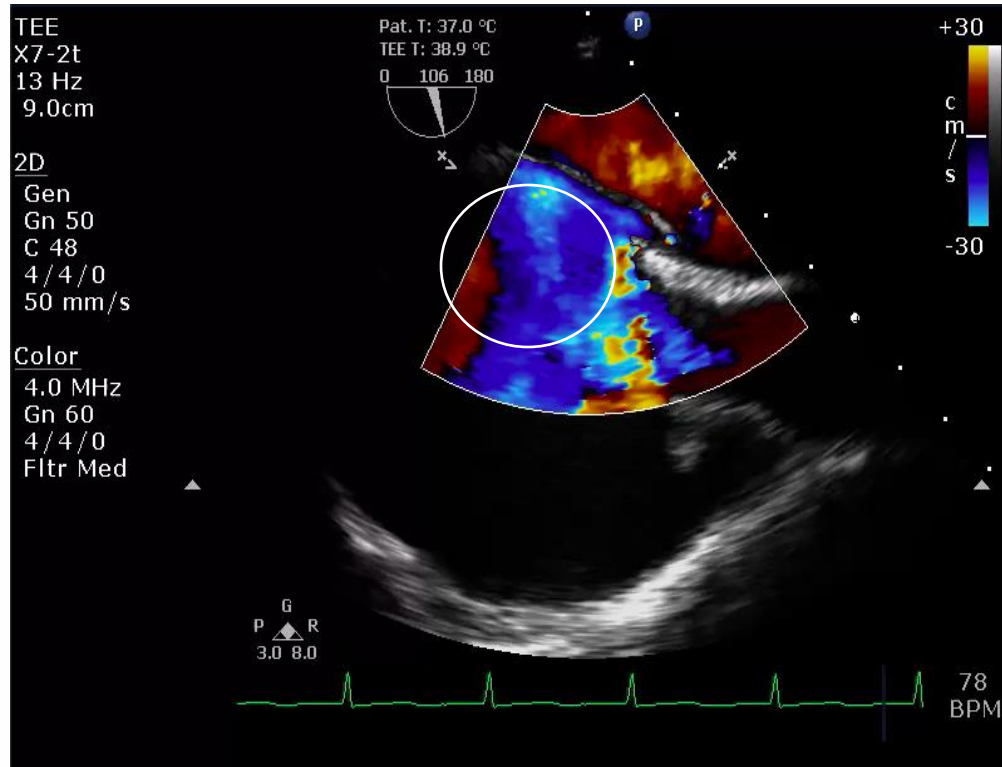
Multiple small AVMs (red arrows) are noted on chest CT.



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Echocardiogram



A) Color doppler showing flow across the PFO. B) 3D dimensions of large PFO.

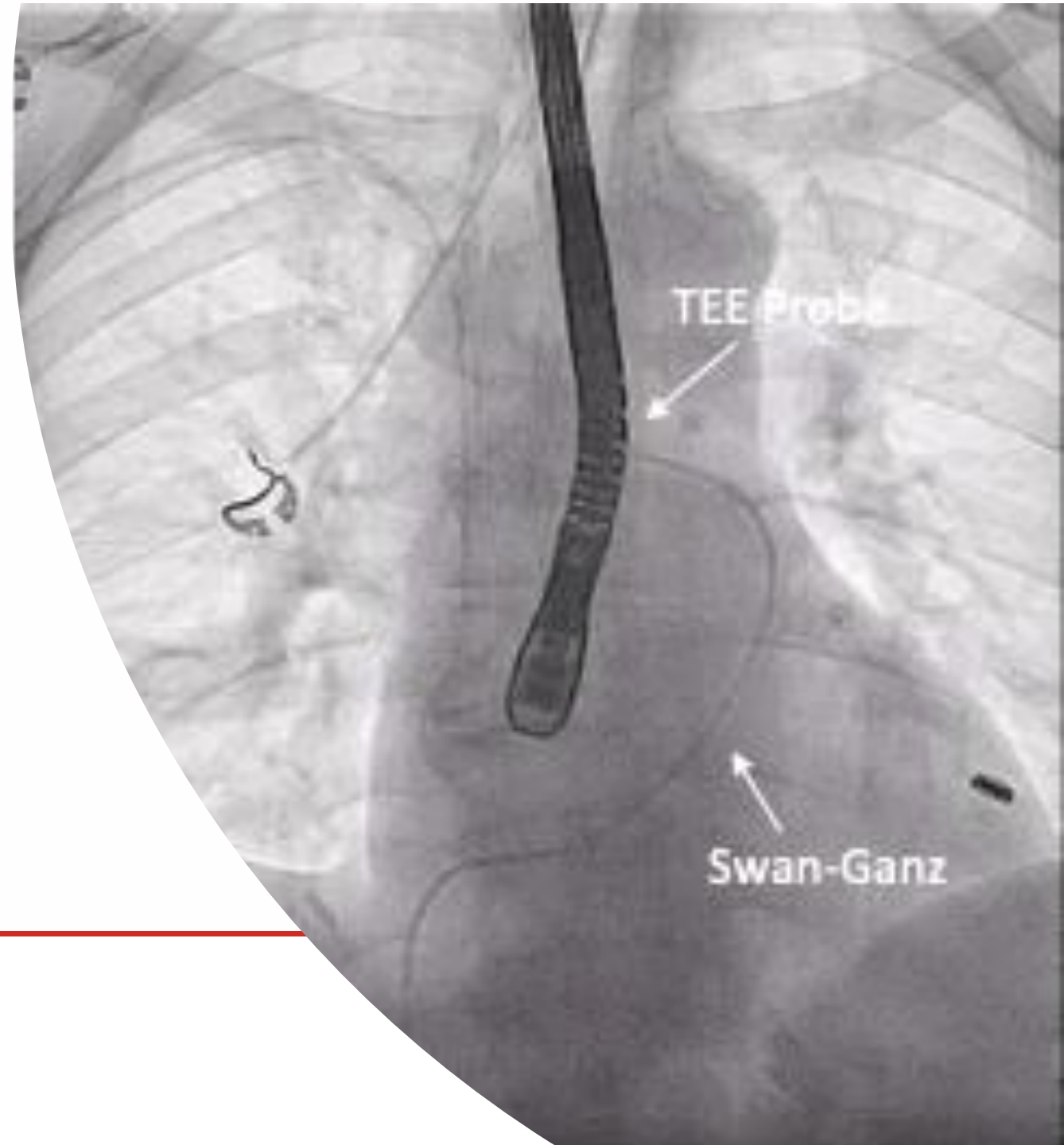


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Diagnostic Right Heart Catheterizations

- Initial pressures:
 - RA: 10
 - RV: 37/10
 - PA: 37/17 (25)
 - PCWP: 11
- Initial O2 Saturation (on 50% FiO2):
 - IVC: 67.8 %
 - RA: 74.5 %
 - PA: 71.2 %
 - LUPV: 84.8 %
 - Ao: 85 %

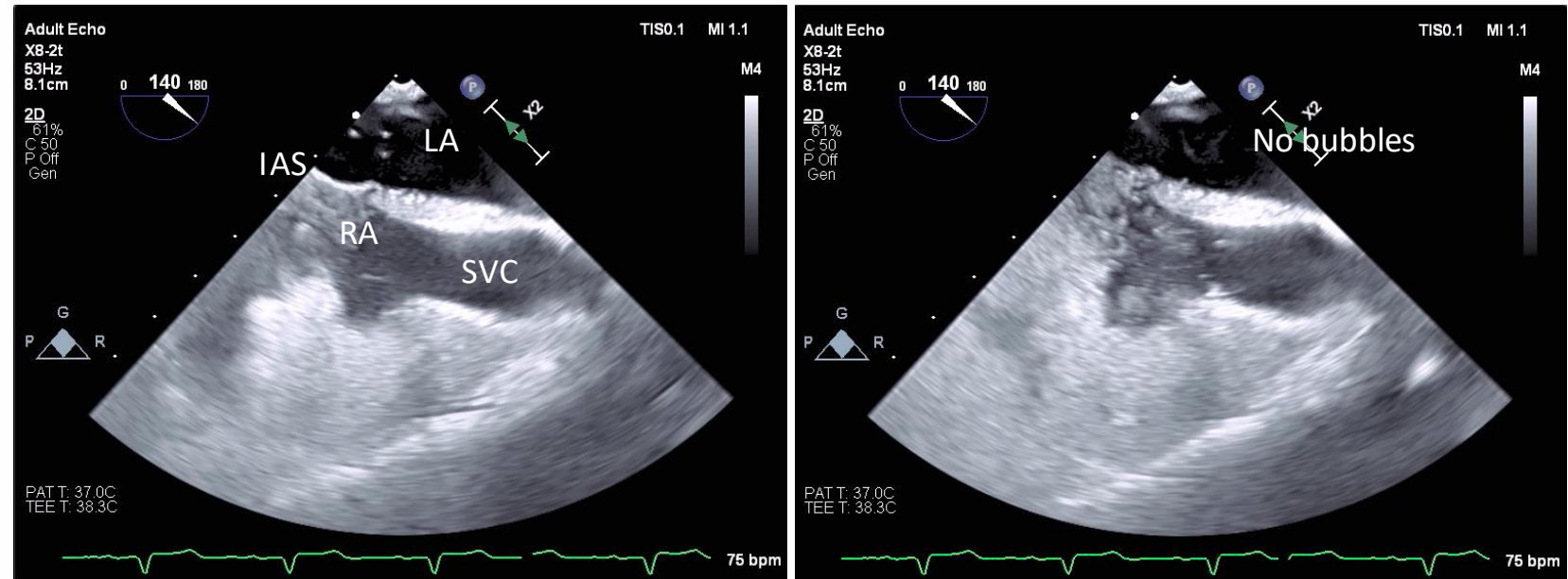


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Transesophageal Echocardiogram (TEE)

- Four serial agitated saline bubble studies were performed.
- Only a few bubbles are noted in the left atrium within less than 3 heart beats.



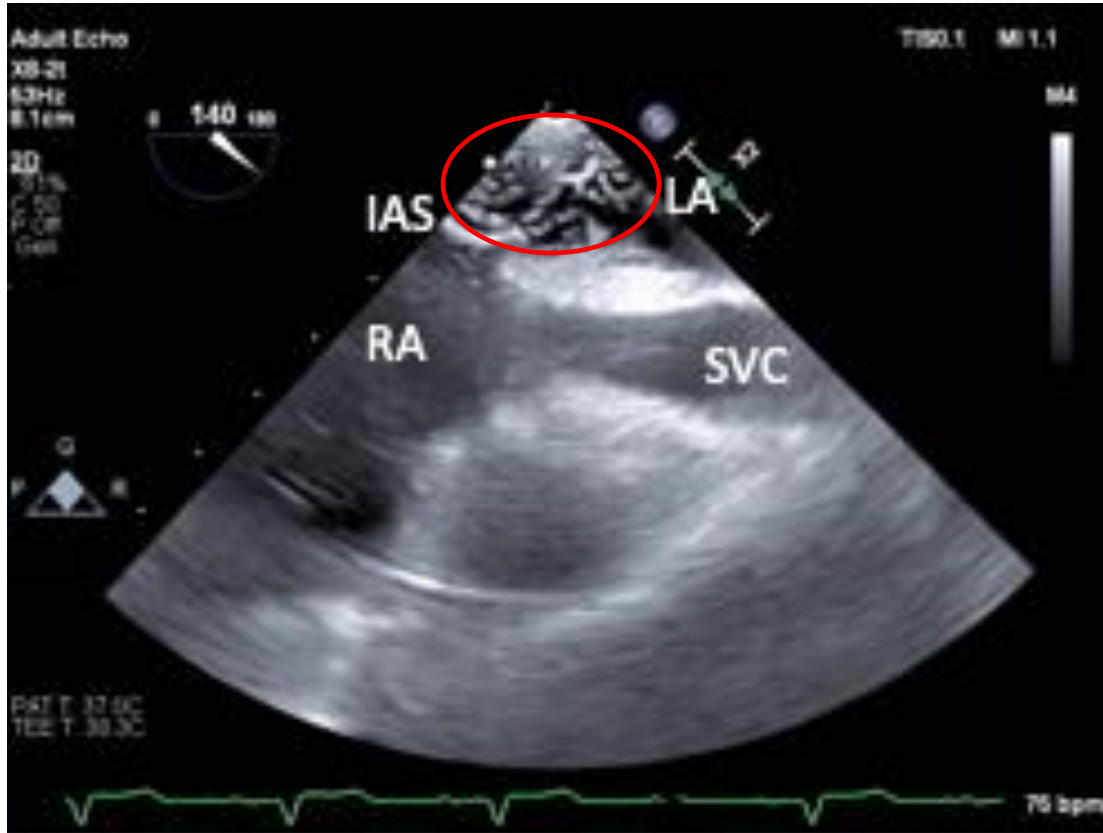
Interatrial septum (IAS), left atrium (LA), right atrium (RA), superior vena cava (SVC).



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Bubble Study Continued



- However, following 3 heart beats very brisk flow of bubbles is seen into the left atrium via all four pulmonary veins.

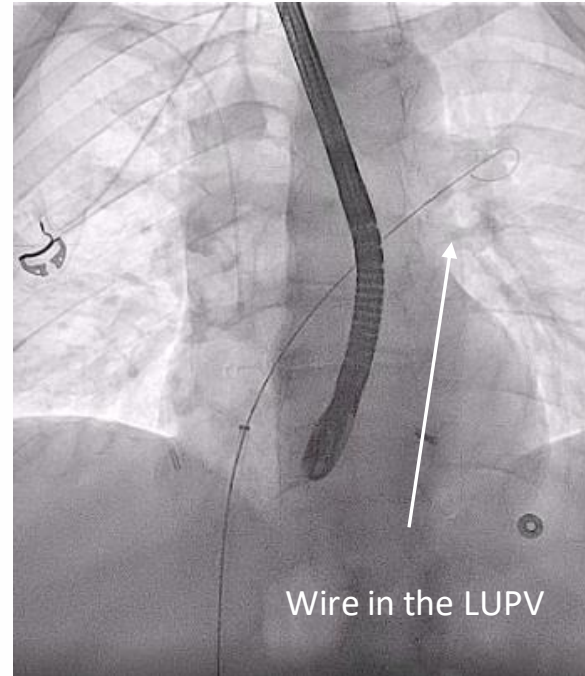


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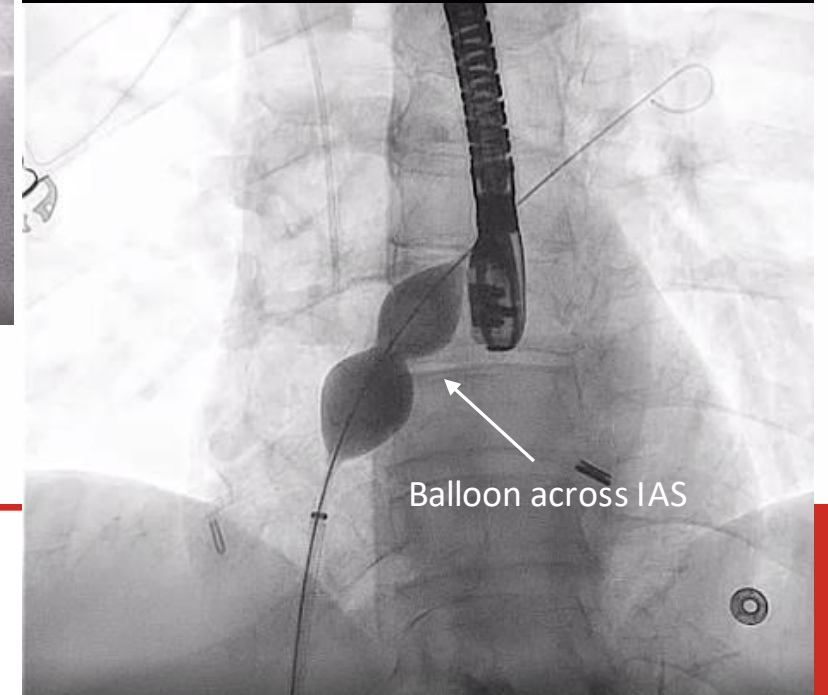
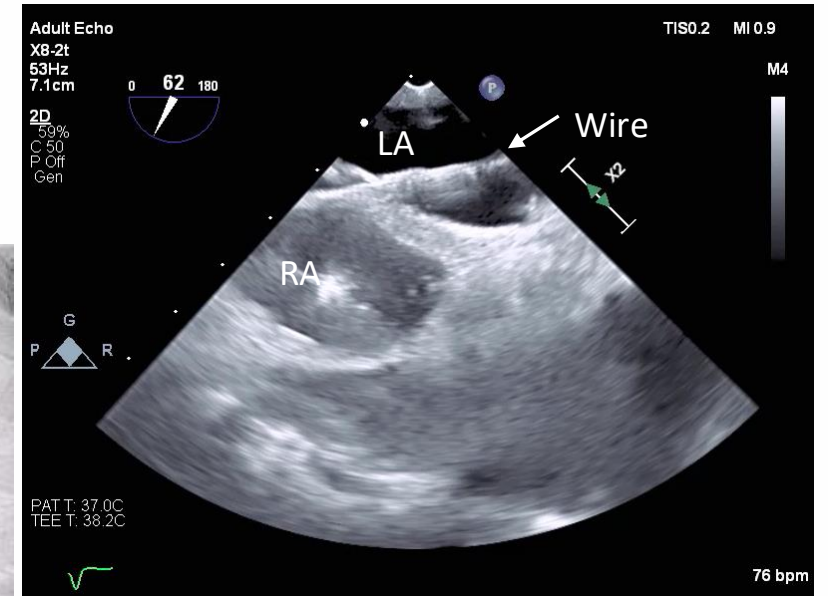
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PFO Closure Device Delivery

- PFO was crossed with a multipurpose catheter.
- Over an Amplatz SuperStiff wire, the 6 Fr sheath was exchanged for 9 Fr 70 cm sheath which was advanced to the right atrium.
- A 25mm PTS sizing balloon was placed across the PFO and inflated to stop flow by TEE.
- Right atrial pressure with balloon occlusion of PFO: 10 mmHg (unchanged).



Left upper pulmonary vein (LUPV)

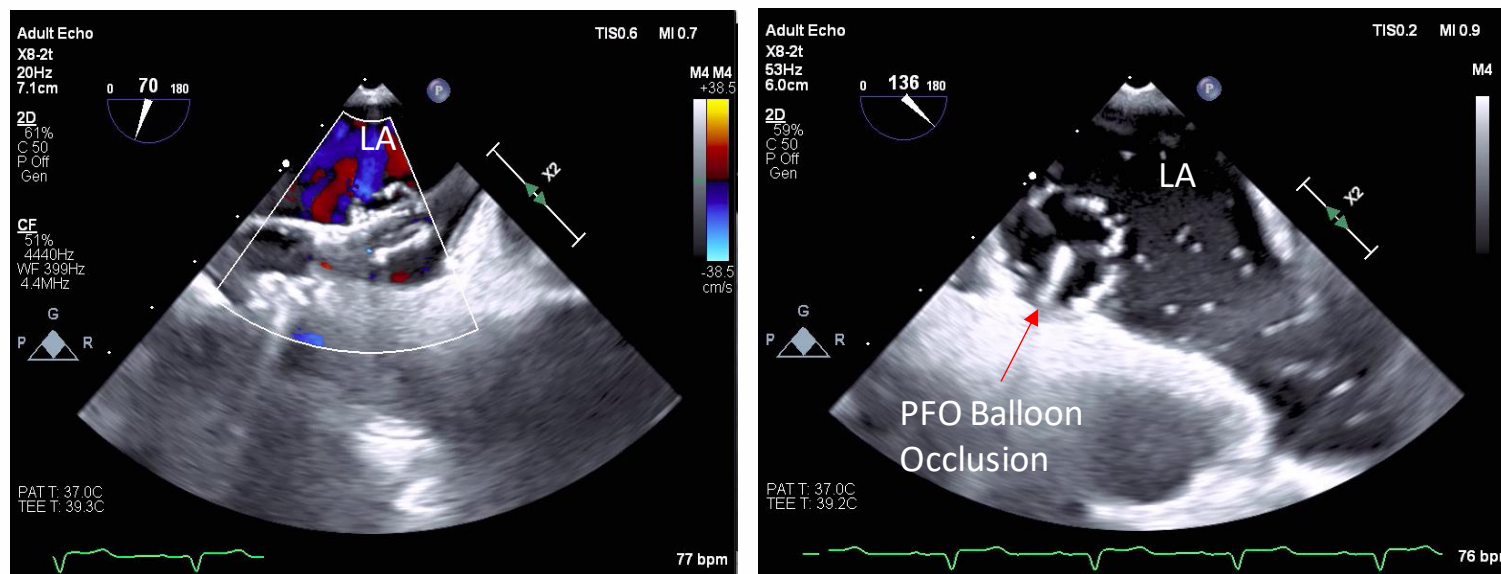


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Bubble Study w/ PFO occlusion

- Repeat bubble study with balloon occlusion demonstrated continued bubbles in the LA

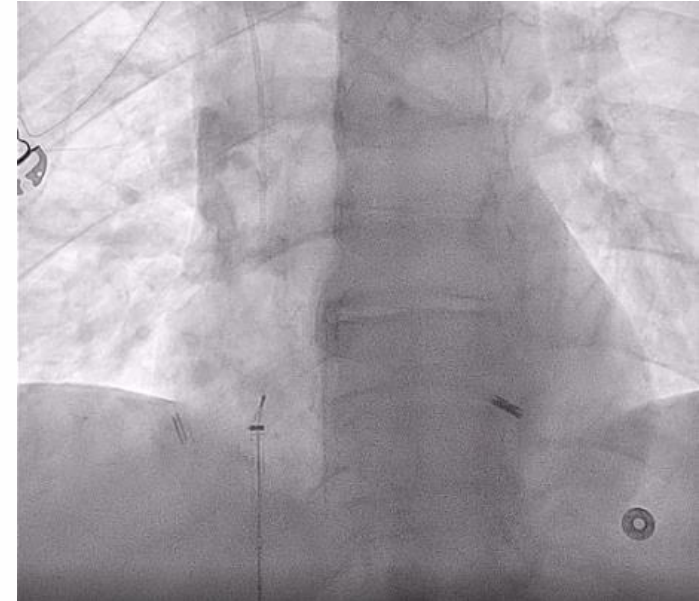
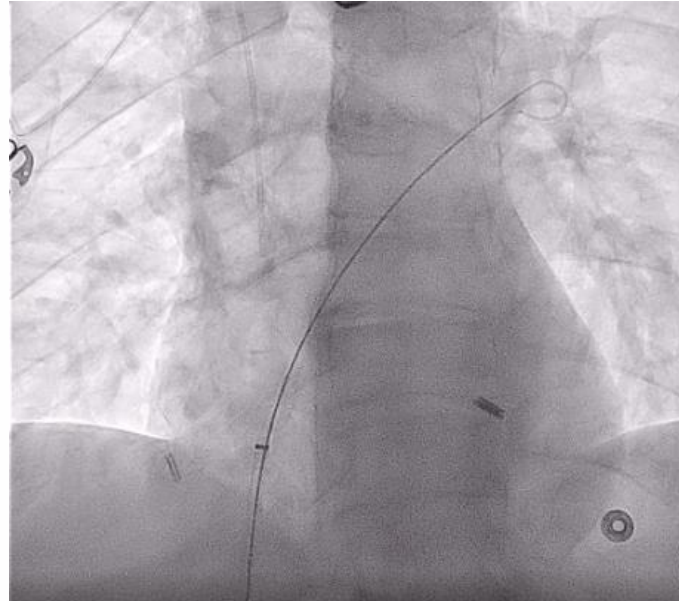


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Case Conclusion

- Given the PFO was not the principal source of shunting, no PFO closure device was placed.



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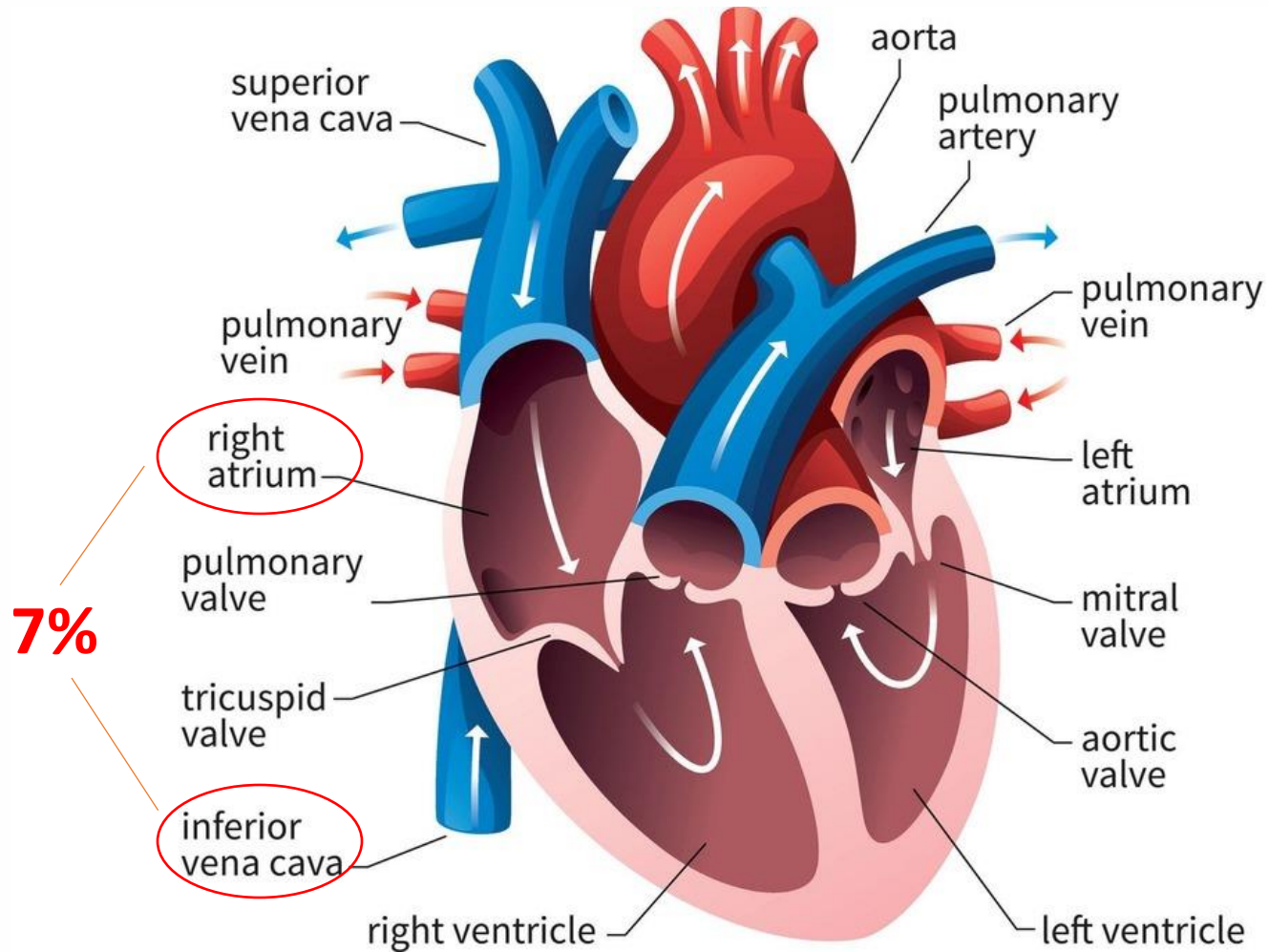
Oxygen step up of what percentage from the IVC to RA is indicative of left to right shunting?

- a. 7%
- b. 5%
- c. 3%
- d. 9%



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- The correct answer: 7% step up in oxygen saturation from the IVC to the RA.
- Left to right shunts allow oxygenated blood to mix with deoxygenated blood.
- Normally there is a decrease in oxygenation saturation as venous blood travels closer to the pulmonary vascular bed. An increase in oxygen saturation suggests the presence of a shunt.
- Antman *et al* as well as other investigators have outlined specific cutoffs of oxygen saturation that are more suggestive of the presence of a shunt.

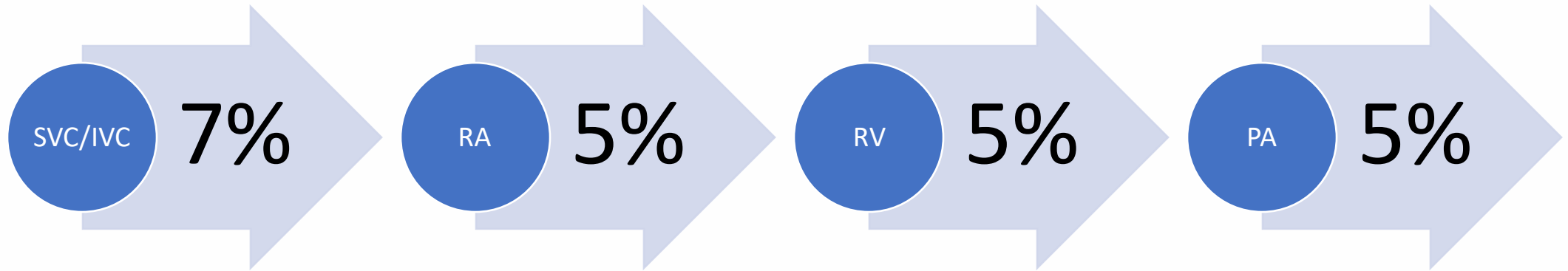


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Antman *et al*. Blood oxygen measurements in the assessment of intracardiac left to right shunts: A critical appraisal of methodology. The American Journal of Cardiology. [VOLUME 46, ISSUE 2](#), P265-271, AUGUST 01, 1980

Criteria for detection of Left-to-Right Shunt by Oximetry



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Conclusions and Learning Points

- Extra-cardiac shunting should be ruled out prior to PFO closure.
- This can be accomplished by performing an echocardiogram with bubble study along with a right heart catheterization to obtain oxygen saturations at several levels to assess for a step-up in oxygenation which would suggest a left to right shunt.
- If a shunt exists, the presence of an extra-cardiac shunt may be assessed further by repeating the bubble study while occluding the intracardiac lesion and degree of shunting will determine the principal source of shunting as demonstrated in our patient.



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