Transesophageal Echocardiography Guidance for Percutaneous Closure of Ascending Aortic Pseudoaneurysm

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INTRODUCTION

A pseudoaneurysm is a focal arterial outpouching resulting from an injury to the vascular wall, which leads to a contained rupture with a collection of blood between the media and the adventitia.[1]

Although it is unusual to find pseudoaneurysms in the ascending aorta, this particular location represents a potentially life-threatening condition as it is associated with an increased risk of thrombosis, embolization, and even complete arterial rupture.[2] Unfortunately, there are no clinical or imaging features that can accurately predict such catastrophic complications, and, therefore, aggressive treatment is recommended.[3,4]

Currently, surgical repair holds its place as the standard of care and is the preferred treatment for most patients, but it can be technically challenging and carries significant risk in some cases.[5] This has led to the development of several endovascular techniques, and percutaneous closure of ascending aortic pseudoaneurysms has been successfully performed in selected patients with high surgical risk.[4,6] For these cases, a multidisciplinary discussion with multimodality imaging is critical to plan the interventional approach and avoid procedural complications.[7,8] While transesophageal echocardiography (TEE) is traditionally considered a secondary and optional imaging mode during these procedures, it can be a valuable tool and serve as the primary intraprocedural imaging modality in specific cases.

CASE PRESENTATION

A 52-year-old woman was referred for treatment of chronic sternal osteomyelitis and ascending aortic pseudoaneurysm after coronary artery bypass graft surgery (CABG). The patient's medical history was also notable for chronic kidney disease associated with left renal atrophy due to severe renal artery stenosis.

With the diagnosis of ascending aortic pseudoaneurysm, first noted 3 months after CABG, serial computed tomography (CT) scans were done and reported stable size for several months. However, around 8 months after the initial diagnosis, the surveillance scan suggested an increase in the pseudoaneurysm size associated with surrounding soft tissue thickening and sternal osteomyelitis (Figure 1). These findings raised concern regarding the potential risk of rupture, and the patient was referred to our institution for further evaluation and management. A multidisciplinary heart team discussion was held, and while it was believed that surgery would be required for further debridement, the risk of a surgical intervention was considered high in the setting of aortitis and active infection. One critical factor was the presence of an in situ right internal mammary artery graft to the left anterior descending artery, with the graft coursing anterior to the aorta, adjacent to the pseudoaneurysm and just underneath the sternum (Figure 2); therefore, an open approach would carry a high risk of graft injury. In this regard, the possibility of percutaneous coronary intervention was discussed in case the graft needed to be sacrificed; however, the patient's coronary anatomy was not optimal for this. Moreover, waiting for the ideal time for surgery would pose a risk of pseudoaneurysm rupture and potentially devastating consequences. After a careful evaluation, the decision was made to attempt a percutaneous closure with fluoroscopy and TEE guidance to avoid the administration of a large amount of iodinated contrast during the procedure given the renal disease.

Since the pseudoaneurysm was located in the distal ascending aorta, a high upper esophageal view was required to keep it in the view (Figure 3). By TEE, the pseudoaneurysm had a neck of 7×8 mm and the sac measured $31 \times 26 \times 18$ mm, with a partially thrombosed cavity (Figure 4, Video 1). Of note, measurements of the pseudoaneurysm size were consistent among CT, TEE, and fluoroscopy. Pulsed-wave Doppler at the neck of the lesion demonstrated bidirectional flow, consistent with the "to-and-fro" pattern classically seen in pseudoaneurysms (Figure 5). Under TEE guidance, a delivery catheter with a 6-4 Amplatzer Duct Occluder II, which has 12 mm disks, was placed at the neck of the pseudoaneurysm (Figure 6, Videos 2 and 3). Initial placement appeared adequate angiographically, but TEE highlighted that a portion of the aortic disk may have been deployed into the pseudoaneurysm neck (Video 4), prompting us to reposition the device and deploy once properly placed. At the end of the procedure, the device appeared well seated, with a slight disk motion from compression of the nitinol wire mesh by the systolic aortic movement, which is an expected finding (Videos 5 and 6). The pseudoaneurysm cavity was almost completely thrombosed (Figure 7, Videos 5 and 6), and there was no significant residual leak noted by TEE, although fluoroscopy demonstrated a faint amount of contrast inside the pseudoaneurysm sac, suggesting a trivial leak (Figure 8, Video 7). In addition, a small mobile echodensity was noted on the aortic surface of the device, which was thought to be consistent with thrombus (Videos 5 and 6). Initiation of therapeutic anticoagulation was discussed, but given the small size and the impending need for surgical intervention, it was decided to manage this with aspirin alone. The patient underwent sternal debridement a few days later,

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VIDEO HIGHLIGHTS

Video 1: Intraprocedural TEE images showing the ascending aorta and the pseudoaneurysm in short axis from an upper esophageal view. To the *left*, the two-dimensional mode shows the location of the PSA; to the *right*, color Doppler reveals flow into the PSA cavity, which is partially thrombosed.
Video 2: Intraprocedural TEE images showing the ascending aorta and the pseudoaneurysm in long axis from an upper esophageal view. To the *left*, two-dimensional mode with delineation of the PSA and the catheter; to the *right*, color Doppler enhances the demarcation of the thrombosed portion and helps guide catheter placement.
Video 3: Intraprocedural three-dimensional TEE with photo-realistic imaging and a virtual light source that highlights the structure of the pseudoaneurysm and the catheter.
Video 4: Intraprocedural TEE images showing the ascending aorta and pseudoaneurysm in 2 orthogonal views from the upper esophagus. With initial deployment, the aortic disk displays an asymmetric shape with an elevated border, suggestive of suboptimal position.
Video 5: Intraprocedural three-dimensional TEE image after repositioning showing optimal device deployment with no evidence of residual leak by color Doppler.
Video 6: Intraprocedural three-dimensional TEE image after device deployment with echogenic material below the device consistent with thrombus formation.
Video 7: Aortic angiography in the left anterior oblique view showing the device with a trivial residual leak.

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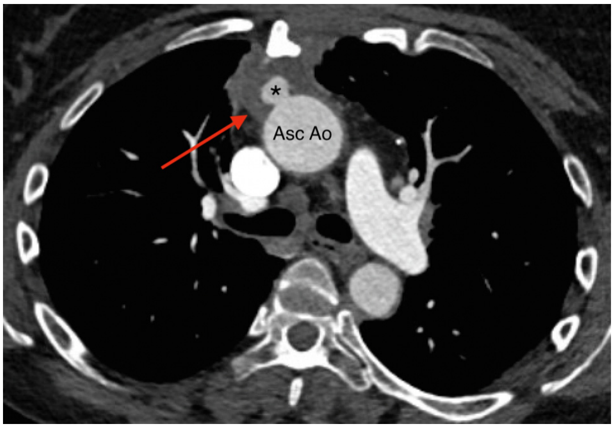

Figure 1 Chest CT with transverse view showing the pseudoaneurysm *(asterisk)* in the ascending aorta with surrounding soft tissue thickening *(arrow)*. *Asc Ao*, Ascending aorta.

with excision of infected bone with bilateral pectoralis major muscle flaps for wound closure. No additional intervention of the pseudoaneurysm was performed. Surveillance CT performed 3 days after the percutaneous intervention revealed a stable closure device with decreased pseudoaneurysm size and no residual leak (Figure 9). Furthermore, given the patient's chronic sternal osteomyelitis and the concern for an ongoing infectious process playing a role in the development of the pseudoaneurysm, she was treated with broad-spectrum intravenous antibiotics for 6 weeks with the plan to continue oral doxycycline as chronic suppressive therapy.

DISCUSSION

Ascending aortic pseudoaneurysms can develop as a complication from surgery, typically at the site of graft anastomosis or cannulation,

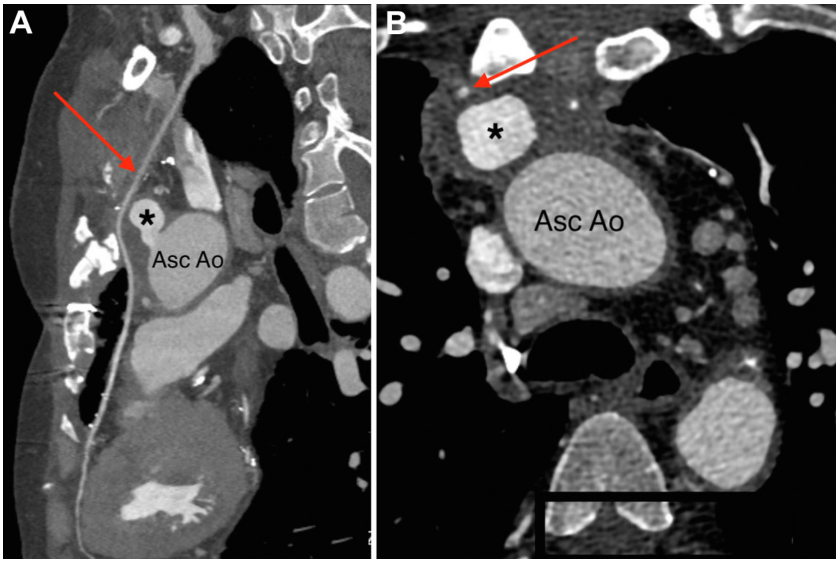

Figure 2 Chest CT with **(A)** curved planar reformat reconstruction of the RIMA graft and **(B)** transverse view showing the close proximity of the graft *(arrow)* to the pseudoaneurysm *(asterisk)* and the sternum. *Asc Ao*, Ascending aorta; *RIMA*, right internal mammary artery graft.

Figure 3 Aortic digital subtraction angiography in left anterior oblique view showing the pseudoaneurysm *(asterisk)* in the ascending aorta. *Asc Ao*, Ascending aorta.

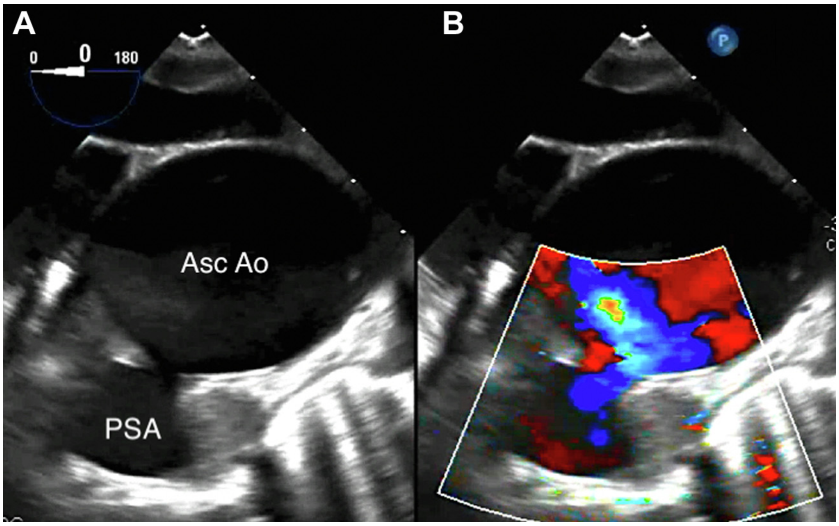

Figure 4 Intraprocedural TEE images showing the ascending aorta and the pseudoaneurysm in short axis from an upper esophageal view. **(A)** Two-dimensional mode shows the location of the PSA; **(B)** color Doppler reveals systolic flow into the PSA cavity, which is partially thrombosed. *Asc Ao*, Ascending aorta; *PSA*, pseudoaneurysm.

or they can be related to trauma, infection, various inflammatory processes, and, rarely, complicated penetrating ulcers in the presence of severe atherosclerotic disease.[9,10] In the case of our patient, it is likely that the lesion originated from a focal injury at the cannulation or cardioplegia catheter site during CABG surgery, although a contribution from an active infection is also possible.

From an imaging standpoint, it is important to recognize the key echocardiographic features of a pseudoaneurysm. Typically, color Doppler shows a bidirectional, swirling blood pattern, often referred to as the "yin-yang" sign (Figure 4, Video 2). Similarly, by placing the sample volume at the neck of the pseudoaneurysm and interrogating this area with pulsed-wave Doppler, we get a "to-and-fro" pattern (Figure 5), in which the "to" corresponds to blood entering the pseudoaneurysm in systole and the "fro" represents blood exiting the pseudoaneurysm during diastole.[11]

Different techniques for percutaneous closure have been described, including placement of septal occluder devices, vascular plugs, endovascular covered stents, coil embolization, and thrombin injection.[1,2,4,12] Ultimately, the optimal procedure is selected according to the location and size of the pseudoaneurysm, as well as the clinical presentation and comorbidities.[3] These procedures are regularly planned with multimodality imaging, and they are performed under

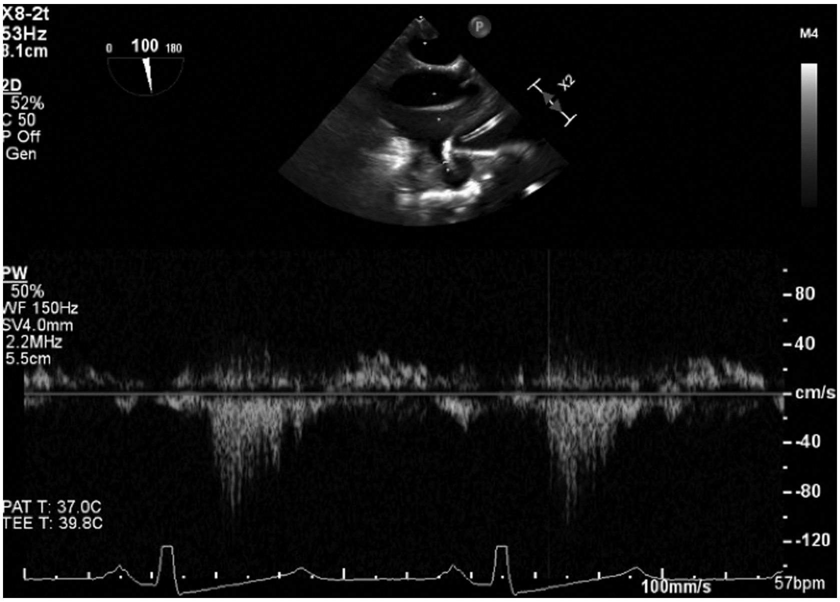

Figure 5 Pulsed-wave Doppler at the neck of the pseudoaneurysm shows the "to-and-fro" waveform representing blood going in and out of the cavity during the cardiac cycle.

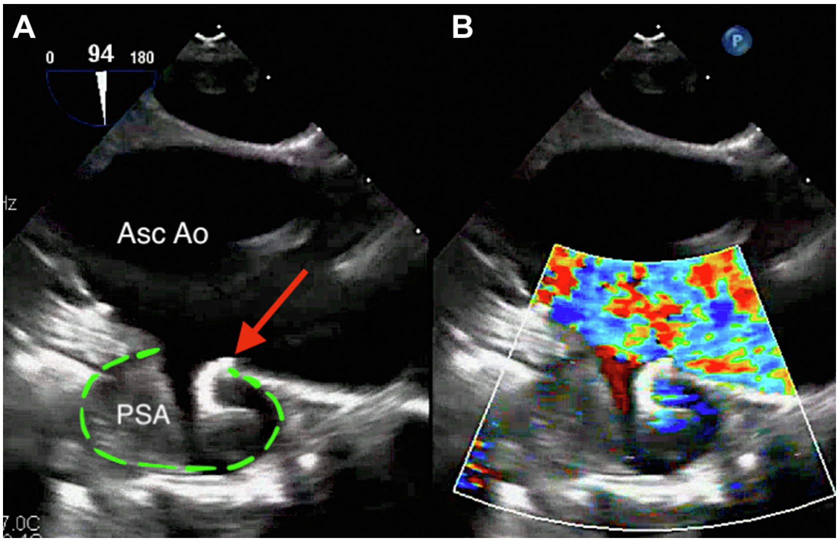

Figure 6 Intraprocedural TEE images showing the ascending aorta and the pseudoaneurysm in long axis from an upper esophageal view. **(A)** Two-dimensional mode with delineation of the PSA and the catheter *(arrow)*; **(B)** color Doppler enhances the demarcation of the thrombosed portion and helps guide catheter placement. *Asc Ao*, Ascending aorta; *PSA*, pseudoaneurysm.

fluoroscopic guidance, with TEE added as a secondary tool when available.[7]

This case highlights the instrumental role of TEE as a primary intraprocedural modality. It can provide crucial information including location, morphology, and size of the pseudoaneurysm, as well as guide catheter placement and device positioning.[2,8] In addition, imaging immediately postprocedure facilitates early identification of complications, such as device instability, residual leak, thrombus formation, and aortic dissection. In this case, 145 mL of iodinated contrast were used, and utilizing TEE for intraprocedural guidance gave our patient with chronic kidney disease the opportunity to reduce the amount of contrast by an estimated 75 mL that would have been needed for additional ascending aortograms.

CONCLUSION

Optimal management of ascending aortic pseudoaneurysms remains challenging, although experience is currently accumulating with percutaneous closure as an alternative for selected patients with high surgical risk. An individualized approach should be undertaken

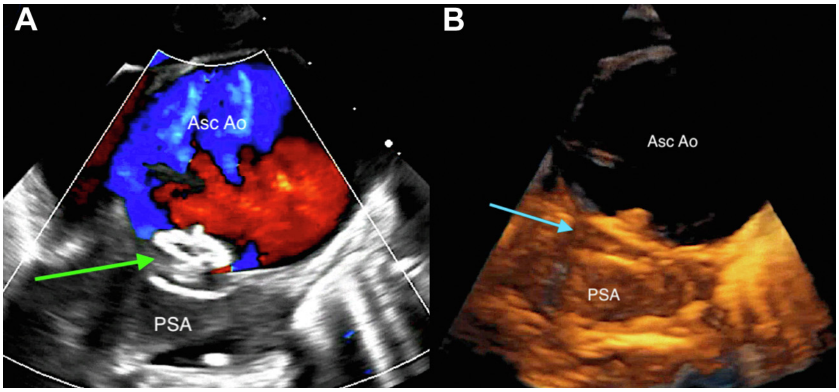

Figure 7 Intraprocedural TEE image after device deployment *(arrow)*. **(A)** Color Doppler with no evidence of residual leak; **(B)** three-dimensional view with echogenic material below the device consistent with thrombus formation. *Asc Ao*, Ascending aorta; *PSA*, pseudoaneurysm.

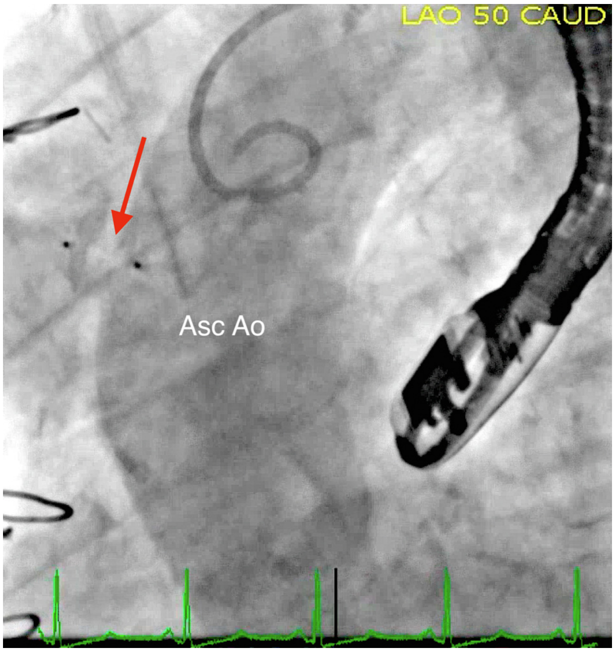

Figure 8 Aortic angiography in left anterior oblique view showing the device *(arrow)* with a trivial residual leak. *Asc Ao*, Ascending aorta.

when planning these interventions, and intraprocedural TEE guidance should be considered as a primary imaging modality, in conjunction with fluoroscopy, when the pseudoaneurysm location and image quality allow an optimal study to grant a contrast-sparing and radiation-minimizing option.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

CONSENT STATEMENT

The authors declare that informed patient consent was not provided for the following reason: The authors declare that since this was a case report utilizing de-identified data and entirely anonymized images from which the individual cannot be identified, informed consent was not required.

FUNDING STATEMENT

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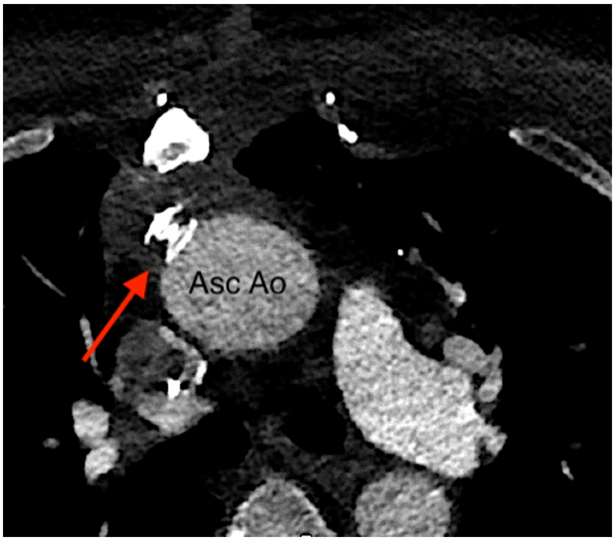

Figure 9 Follow-up chest CT with transverse view showing the device *(arrow)* in a well-seated position in the ascending aorta with a completely thrombosed cavity. *Asc Ao*, Ascending aorta.

DISCLOSURE STATEMENT

The authors report no conflict of interest.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.case.2022.09.009.

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