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Percutaneous Transthoracic Treatment of Ascending Aortic and Root Pseudoaneurysms: Procedural Aspects and Guidance with the Use of Multimodality Imaging

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ABSTRACT

Open repair of ascending aortic pseudoaneurysms (AAPs) is currently the standard of care, but it is associated with high morbidity and mortality. A single-center retrospective experience of 4 patients after cardiac surgery undergoing 5 percutaneous transthoracic embolization procedures is presented. In 3 of the 4 patients, the primary outcome of complete thrombosis was achieved after the first procedure, with a mean follow-up time of 11.5 months. In all 5 procedures, the patients tolerated the procedure well without associated acute complications. Percutaneous transthoracic embolization of AAPs offers an alternate minimally invasive treatment pathway for prohibitive-risk candidates.

ABBREVIATIONS

AAP = ascending aortic pseudoaneurysm, PsA = posterior pseudoaneursym, TEE = transesophageal echocardiography

Ascending aortic pseudoaneurysms (AAPs) may arise in the setting of trauma, mycotic infections, and following cardiac surgery or aortic arch replacement (1,2). Open repair is currently the standard of care. Reoperation, however, requires repeat sternotomy and cardiopulmonary bypass, frequently in patients with multiple comorbidities. Reported mortality rates range from 7 to 41% (1,3,4). Expansion of AAPs is unpredictable and rupture can be fatal (5). There have been a few cases published regarding endovascular approaches to treating AAPs including coil embolization, endovascular stent-graft placement, and implantation of occluder devices (6,7), however not all lesions are suitable for endovascular management. We report our experience utilizing a multimodality imaging based approach for transthoracic percutaneous embolization of AAPs.

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MATERIALS AND METHODS

This was a retrospective study with Institutional Review Board approval that waived requirement for informed consent. A total of 4 patients underwent transthoracic percutaneous embolization for AAPs from January 2015 to December 2016. The decision to intervene percutaneously was made by a multidisciplinary team consisting of interventional radiology, cardiology, and cardiothoracic surgery and was based on perceived high preoperative risk factors and suboptimal traditional transvascular access to the AAP. Imaging modalities used consisted of computerized tomography (CT), transesophageal echocardiography (TEE), and fluoroscopy for guidance.

CASE REPORTS

Case 1

A 55-year-old man presented with a recurrent posterior AAP after attempted reoperative repair after a Bentall procedure for a type A aortic dissection (**Fig 1a**, **b**). Preprocedural

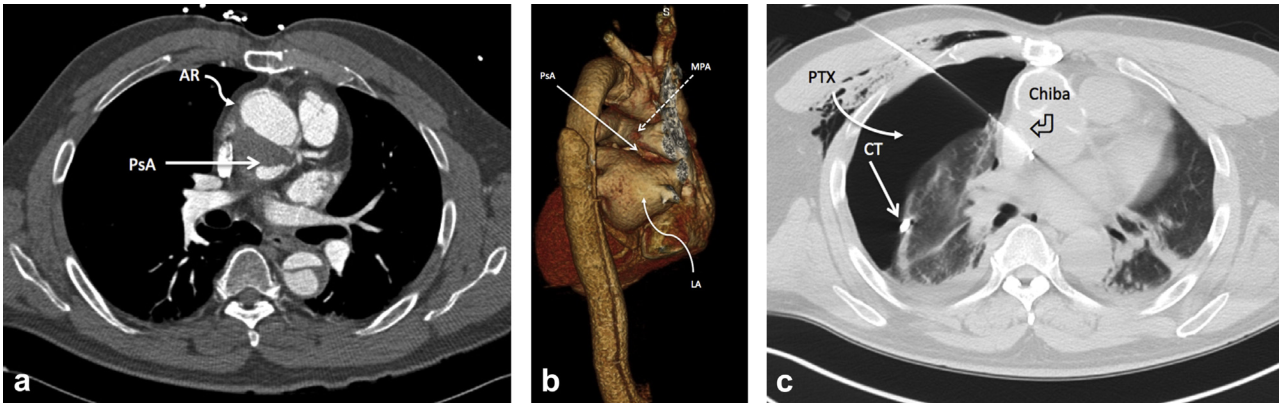

Figure 1. (**a**) CT angiogram in the axial plane, demonstrating a PsA (straight arrow) arising posterior to the AR (curved arrow). Residual descending thoracic aortic dissection is present. (**b**) CT 3-dimensional reconstruction of the heart and vessels. Posterior and lateral view. PsA (straight arrow) arising posterior to the ascending aorta in close approximation to the left atrium (curved arrow; *LA*) and main pulmonary artery (dotted arrow; *MPA*). (**c**) Noncontrast axial slice through the upper chest. Iatrogenic right pneumothorax (curved arrow; *PTX*) with a chest tube (straight arrow; *CT*) in place. Chiba needle (outlined arrow) traversing minimal lung due to the induced pneumothorax.

evaluation revealed poor transvascular access into the pseudoaneurysm due to proximity to the coronary arteries, a 1 mm neck, and perceived inability to maintain stable transvascular access in the AAP.

Under CT guidance, an iatrogenic pneumothorax was performed with displacement of the lung from the projected transthoracic trajectory. An 18-gauge Chiba needle (Cook, Bloomington, Indiana) was advanced across the thoracic cavity from the right chest wall into the AAP between the right atrial appendage, aorta, and inferior vena cava under CT guidance (Fig 1c).

The patient was then transported to the angiography suite with the needle stabilized in position, where TEE demonstrated blood flow within the partially thrombosed pseudoaneurysm. A Renegade STC microcatheter (Boston Scientific, Marlborough, Massachusetts) was advanced through the needle under fluoroscopic and TEE guidance and the AAP was embolized to stasis with the use of a total of 0.4 cc ethylene-vinyl alcohol copolymer (EVOH; Medtronic, Irvine, California). No nontarget embolization or residual flow was noted on final aortography or TEE.

Post-procedure CT angiography at 10 months' follow-up, however, demonstrated partial recanalization. The patient was brought back and similar access was obtained with a repeated transthoracic percutaneous approach into the AAP. Coil embolization was performed with the use of Concerto microcoils (Medtronic) under fluoroscopic and TEE guidance. CT angiography performed 5 months later showed complete thrombosis of the AAP.

Case 2

A 70-year-old man developed an anterior AAP arising from the innominate arterial suture line after an endovascular stent graft repair of an enlarging descending thoracic aortic aneurysm. The neck of the pseudoaneurysm measured 1.9 mm. An 18-gauge Chiba needle was advanced from the right parasternal space, medial to the right internal mammary artery and vein, into the retrosternal pseudoaneurysm sac under direct fluoroscopic guidance with the use of bony and sternal wires as landmarks. A Renegade STC microcatheter in conjunction with a Transend microwire (Stryker Neurovascular, Kalamazoo, Michigan) was passed through the needle into the AAP. The AAP sac was then embolized with a combination of coils (Interlock; Boston Scientific) and EVOH. Post-embolization aortography showed no filling of the AAP. CT performed after 8 months demonstrated complete hemostasis.

Case 3

A 58-year-old woman with a history of Marfans syndrome status after aortic valve replacement, Bentall procedure, and single-vessel coronary artery bypass grafting was noted to have an enlarging 9 mm pseudoaneurysm (PsA) adjacent to the aortic sinus, with a maximal diameter of 3.2 cm on CT angiography (Fig 2a).

An 18-gauge Chiba needle was advanced from the right chest wall through the right atrial appendage under CT guidance into the AAP (Fig 2b). The patient was then moved to the angiography suite, where TEE demonstrated bidirectional flow in the PsA sac and appropriate positioning of the needle (Fig 2c). With the use of bimodal fluoroscopic and echocardiographic guidance, the aneurysm sac was coil embolized to stasis (Fig 2d, e). Follow-up CT angiography and cardiac magnetic resonance imaging after 8 months showed complete hemostasis.

Case 4

A 58-year-old woman was noted to have a persistent AAP after multiple aortic valve replacements for bicuspid aortic valve, and a previous attempt at AAP closure with the use of an Amplatzer Muscular ventricular septal defect occluder (AGA Medical Corp, Plymouth, Minnesota) was unsuccessful. Post-procedure aortography showed a residual leak seen at the inferior aspect of the AAP. The leak was seen

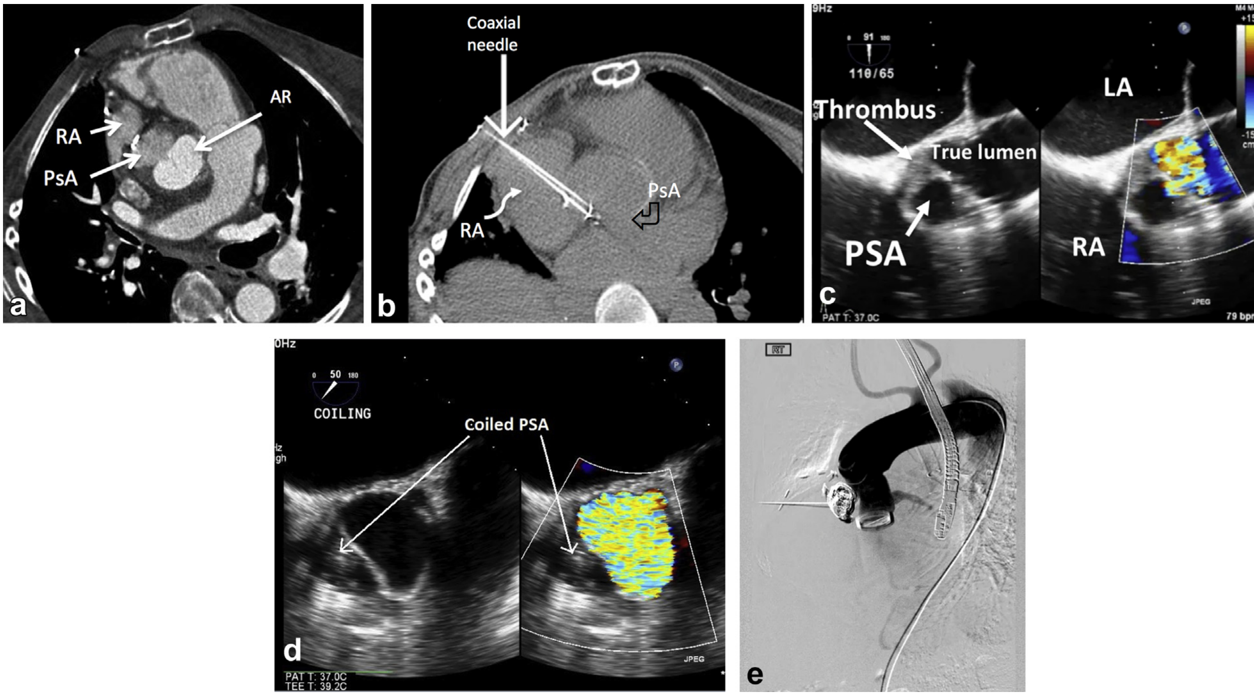

Figure 2. (**a**) CT angiogram. Anterior PsA sac (medium arrow) posterior to the right atrium (short arrow; *RA*) and anterior to the AR (long arrow). (**b**) Coaxial needle (large arrow) traversing the RA (curved arrow) with the distal tip in the PsA sac (outlined arrow). Motion artifact from cardiac motion is present. (**c**) 2-dimensional TEE, midesophageal short axis view of the aortic pseudoaneurysm (short arrow) at 90 degrees. Color Doppler flow through the AR shows a small connection between the PsA and the ascending aorta. (**d**) 2-dimensional TEE, midesophageal short-axis view at 50 degrees of the aortic PsA after coiling (arrows). Color Doppler is used to show no evidence of residual flow between the PsA and the ascending aorta. (**e**) Post embolization aortography, demonstrating no residual flow into the PsA. TEE probe is noted.

Table. Case Details

Patient	Age (y)/Sex	Location	Diameter (cm)	Immediate Success (Aortography/TEE)	Procedural Complications	Follow-Up (mo)	Recurrence
1	56/M	Posterior	4.7	Achieved	None	8	Yes
2	70/M	Anterior	3.5	Achieved	None	8	No
3	58/F	Anterior	3.2	Achieved	None	13	No
4	56/F	Anterior	4.7	Achieved	None	17	No

TEE = transesophageal echocardiography.

again on a follow-up CT angiography 2 weeks later, measuring 3 cm in diameter and a neck measuring 8 mm.

Under CT guidance, a 19-gauge Chiba needle was advanced to the inferior aspect of the AAP through which a Renegade STC microcatheter and V-18 wire (Boston Scientific) were placed. The AAP sac was then coil and hemostatic foam (Avitene; CR Bard, Murray Hill, New Jersey) embolized under fluoroscopic and TEE guidance. Repeated aortography demonstrated complete stasis, and 17-month follow-up CT angiography showed no persistent filling.

RESULTS

In 3 of the 4 patients, the primary outcome of complete thrombosis was achieved after the first procedure, with a mean follow-up time of 11.5 months (range 8–17 months; Table). The other patient achieved complete thrombosis after a second percutaneous treatment. In all 5 procedures, the patients tolerated the procedure well without hemodynamic or electrical instability. There were no incidences of nontarget embolization or associated acute complications.

DISCUSSION

AAPs are most often seen after cardiothoracic surgery (1,2). Aggressive treatment should be pursued because rupture can be fatal and the rate of expansion is unpredictable (5).

The current standard of care is open surgical repair, but patients are often poor repeated surgery candidates owing to medical comorbidities and resulting high perioperative mortality (1,3,4). Furthermore, anatomic and physiologic challenges to accessing AAPs in the high-flow, pulsatile, and capacious aortic root (AR) and ascending aorta can limit endovascular options with the use of a traditional endovascular approach.

Case reports have described endovascular techniques for repair of AAPs with catheter-directed endovascular thrombin injection, stent grafts, septal occluder devices, and vascular plugs to bypass repeated sternotomy (8,9). A case series of ten patients who underwent AAP repair with the use of Amplatzer septal occluders and vascular plugs through a transfemoral approach demonstrated that 2 patients required reintervention owing to device malposition. Four patients had complete AAP exclusion in imaging follow-up (mean 29 months) (8). A smaller series of 3 patients showed no recurrence after a 5-year follow-up after treatment by means of a transfemoral approach and placement of a 0.052-in coil (5). Direct access through a transthoracic approach has been previously described in the management of peripheral pulmonary arterial pseudoaneurysms and in an endoleak of the descending thoracic aorta after thoracic aortic repair (7,9). However no case reports were found in which an ascending aortic pseudoaneurysm was embolized via a transthoracic approach.

In conclusion, multimodality image-guided transthoracic percutaneous treatment of ascending thoracic aortic pseudoaneurysms led to complete stasis after a single intervention in 3 of 4 patients. Because treatment options for AAPs are limited, especially in the recent postoperative setting, the percutaneous transthoracic embolization procedure may be a minimally invasive option for repair.

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