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CASE REPORT

ADVANCED

DAVINCI CORNER

# Transcatheter Treatment of Ascending Aorta Pseudoaneurysm Guided by 3D-Model Technology

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## ABSTRACT

Ascending aorta pseudoaneurysm is a rare but potentially life-threatening complication of atherosclerosis, infections, chest trauma, transcatheter or surgical interventions. Due to high surgical risk, percutaneous closure is considered a valuable cost-effective therapeutic alternative. In this setting, 3D printing technology is emerging as a powerful tool to plan transcatheter repair. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2022;4:343–347) © 2022 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Ascending aorta pseudoaneurysm (AAP) is a rare but potentially life-threatening complication of atherosclerosis, infections, blunt chest trauma, transcatheter procedures, or, more frequently, surgical interventions.[1,2] It may remain clinically silent for a long time until compression of the surrounding structures, infection, distal embolization, mass fistulation, or life-threatening rupture ensue. Thus, symptoms or the potential for complications mandate emergent repair at the diagnosis.[3] Because surgical treatment is still burdened by high morbidity and mortality, the transcatheter option has emerged as a safer and cost-effective therapeutic alternative. However, this approach is still technically

## LEARNING OBJECTIVES

- To understand the incidence, pathogenesis, and potential transcatheter treatment of ascending aorta pseudoaneurysm.
- To show the usefulness of 3D technology in planning interventional (surgical or transcatheter) repair in patients in critical condition with challenging, life-threatening cardiac anomalies.
- To highlight the potentiality of 3D printing technology in guiding transcatheter repair of ascending aorta pseudoaneurysm in pre-procedure planning and device selection.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors’ institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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**ABBREVIATIONS AND ACRONYMS**

**3D** = 3-dimensional

**AAP** = ascending aorta pseudoaneurysm

**CT** = computed tomography

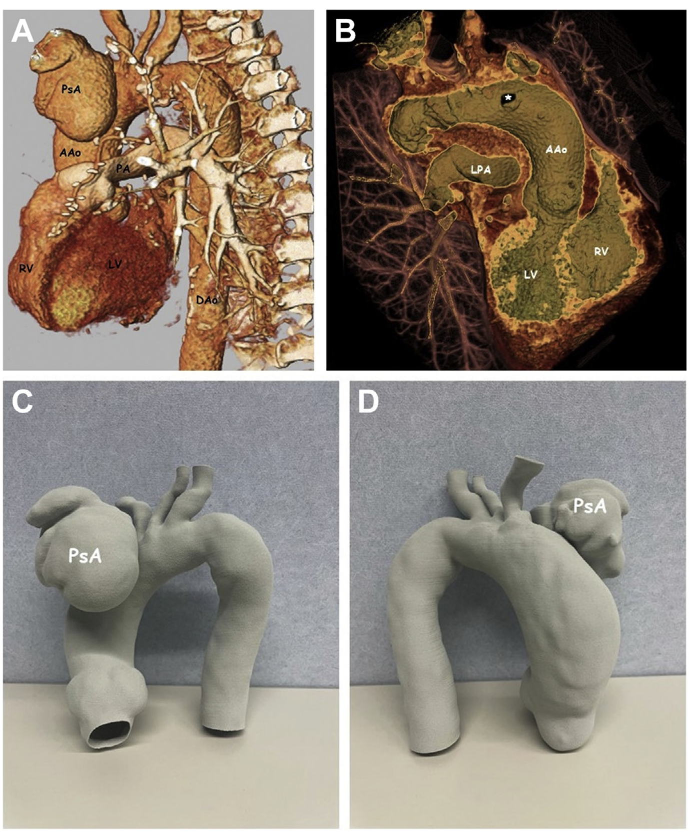
demanding and has not been standardized because of the unpredictability and complexity of local anatomy and the lack of dedicated devices.[4] In this setting, 3D printing technology has recently emerged as an invaluable tool in planning complex transcatheter interventions.[5,6]

This article reports on 3 cases of postsurgical AAP successfully treated by transcatheter closure based on 3D printed models.

## CASE REPORTS

**CASE 1.** A 70-year-old asymptomatic man was admitted in critical conditions 3 months after surgical coronary artery revascularization for severe anemia and refractory heart failure. Diagnostic workouts for hidden bleeding or abscesses showed a huge AAP (58 × 69 × 83 mm) at the site of surgical cannulation. The angio-CT scan measured an aneurysmal neck of about 9 × 7 mm (Figures 1A and 1B, Video 1) and showed compression of the main pulmonary artery and complete occlusion of the venous graft. Owing to the patient's high surgical risk (EuroSCORE 17.3%), the percutaneous approach was deemed the therapeutic option with the highest risk-benefit profile. The patient gave informed consent for the procedure. A CT scan-based 3D model of the aortic arch was printed (Figures 1C and 1D), the careful evaluation of which made us conscious that the left subclavian artery provided the straightest vascular course to the lesion. Using this 3D model, we could fully mimic ex vivo the entire procedure (Video 2). The procedure was performed via the left brachial artery. The pseudoaneurysm was easily probed with an Amplatzer left coronary catheter and completely occluded with a 14-mm Amplatzer septal occluder device (Abbott) (Figures 2A and 2B), with sudden improvement of the patient's hemodynamic stability. Thereafter, we were able to treat the heart failure, and the patient was discharged in good clinical condition after 18 days. The predischarge CT scan showed complete occlusion of the pseudoaneurysmal mass (Figure 2C).

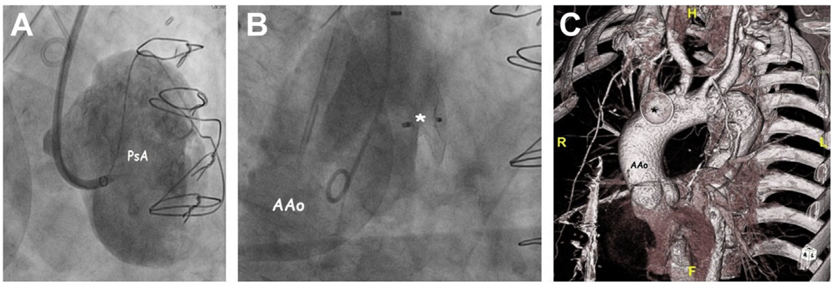
**FIGURE 1 3D Computed Tomography Scan and Printed Model of the Huge Pseudoaneurysm Compressing the Anterior Surface of the Ascending Aorta**




Ascending aorta pseudoaneurysm as imaged at computed tomography scan 3D reconstruction from outside **(A)** and by cut-plain internal views **(B)**. Using the cut-plain internal view, it is possible to precisely size the feeding breach of the pseudoaneurysm **(asterisk)**. Printed 3D model of the ascending aorta and pseudoaneurysm as viewed en face **(C)** and from behind **(D)**. AAo =ascending aorta; Dao = descending aorta; LPA = left pulmonary artery; LV = left ventricle; PA = main pulmonary artery; PsA = pseudoaneurysm; RV = right ventricle.

**CASE 2.** A 67-year-old asymptomatic woman was referred for expanding AAP and severe aortic valve regurgitation several years after repair of a Stanford type A acute aortic dissection. During follow-up, progressive worsening of the aortic valve regurgitation and enlargement of the pseudoaneurysm of the anterior portion of the ascending aorta had been shown (Figures 3A and 3B). Owing to her high surgical risk (EuroSCORE 35.9%), a 2-step percutaneous approach of pseudoaneurysm closure and transcatheter aortic valve implantation was deemed the best cost-effective therapeutic option. The patient gave informed consent for the procedure. Thus, as is routinely done in complex cases,[6] a CT scan-based 3D model of the aortic arch was printed (Figures 3C and 3D) to mimic ex vivo the entire procedure. The procedure was performed with the patient under general anesthesia, via the right femoral artery (Video 3). The pseudoaneurysm was probed with a steerable sheath (Agilis NXT steerable introducer) (Figure 4A) and completely occluded with a 12-mm Amplatzer vascular plug type II (Abbott) (Figures 4B and 4C). The patient was discharged 2 days after the procedure in good clinical condition and underwent successful transcatheter aortic valve implantation (Edwards Sapien3 #29) a few months later.

**FIGURE 2** **Angiographic and 3D Computed Tomography Scan Imaging of the Pseudoaneurysm Submitted to Device Closure**

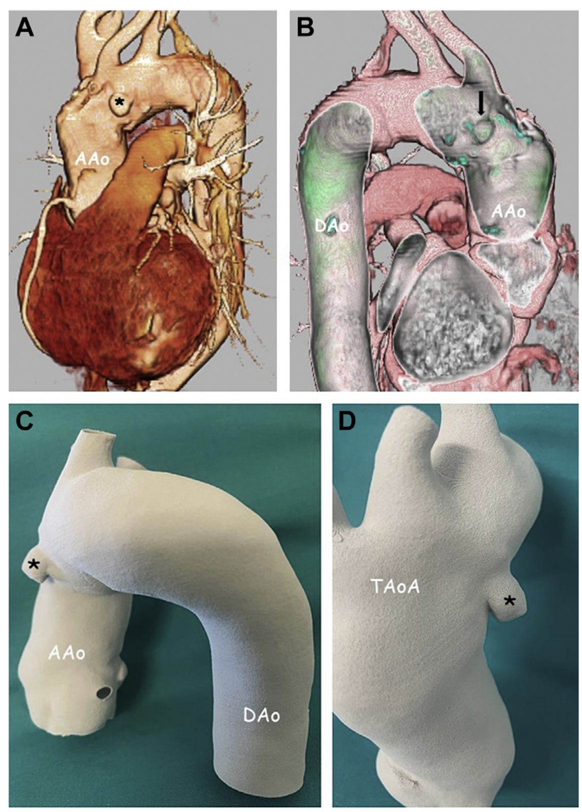



Angiographic appearance of the pseudoaneurysmal sac at the "in-situ" angiography **(A)**. Angiographic **(B)** and computed tomography scan 3D reconstruction **(C)** of the ascending aorta after occlusion with the ASO device **(asterisk)**. AAo = ascending aorta; PsA = pseudoaneurysm.

**CASE 3.** A 76-year-old man with a history of coronary artery disease, ascending aortic aneurysm, and severe aortic regurgitation was referred for progressive anemia about 2 weeks after surgical aortic valve replacement with a biologic prosthesis, ascending aorta replacement with vascular graft, and aorto-coronary bypass graft. The CT scan showed severe aortic arch dilation (53 × 55 mm) and a dissecting pseudoaneurysm (1.8 × 1 × 0.7 cm, with a feeding mouth of 0.6 $cm^2$) located at the posterolateral side of the conduit anastomosis (**Figures 5A and 5B**). Based on the patient's hemodynamic instability and the high risk of surgical re-intervention (EuroSCORE 8.8%), the percutaneous approach was considered the best therapeutic option. The patient gave informed consent for the procedure. A CT scan-based 3D model of the aortic arch was printed (**Figures 5C and 5D**). The procedure was performed with the patient under general anesthesia, via the right femoral artery and left axillary artery. The pseudoaneurysm was probed with an Amplatzer left coronary guiding catheter and completely occluded with simultaneous implantation of 2 controlled-release coils (Cook Medical) and a 6-6 mm Amplatzer duct occluder type II device (Abbott) (**Figures 6A to 6C,** Video 4). The patient's clinical condition suddenly improved, and he was discharged 4 days after the procedure with complete closure of the pseudoaneurysmal sac as shown by a control CT scan (**Figure 6D**).

**COMMENT.** The transcatheter option is increasingly emerging as a safer and cost-effective alternative to surgical repair of AAP. However, this approach is still technically demanding because of the unpredictability and complexity of local anatomy and the lack of dedicated devices. Using 3D printing technology to

**FIGURE 3** **3D Computed Tomography Scan and Printed Model of the Pseudoaneurysmal Pouch Located at the Anterior Surface of the Transverse Aortic Arch**




Angio-computed tomography scan 3D reconstruction of the ascending aorta showing a small pseudo-aneurysm **(asterisk)** as viewed from outside **(A)**. Using the cut-plain internal view **(B)**, it is possible to image shape and size of its feeding mouth **(arrow)**. Printed 3D model of the ascending aorta pseudoaneurysm as viewed en face **(C)** and from behind **(D)**. AAo = ascending aorta; Dao = descending aorta; TAoA = transverse aortic arch.

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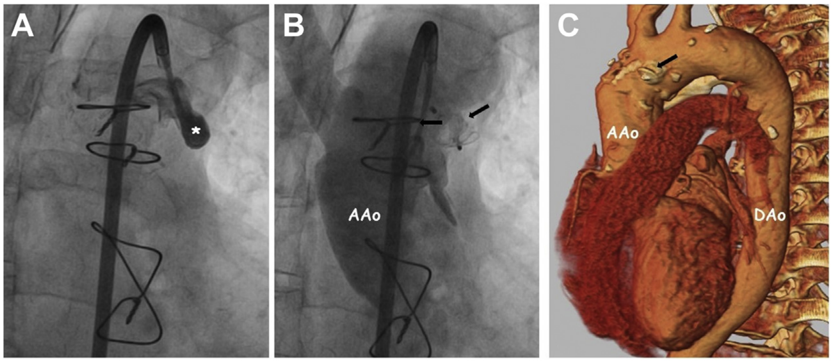
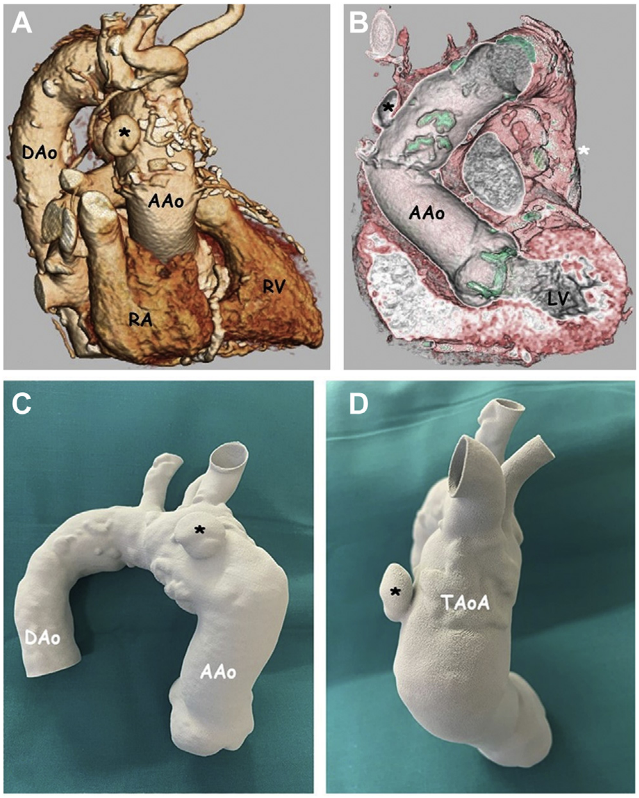
**FIGURE 4 Angiographic and 3D Computed Tomography Scan Imaging of the Pseudoaneurysm Submitted to Device Closure**




Pseudoaneurysmal sac **(asterisk)** as imaged by in situ angiography **(A)**. Complete occlusion of the pseudoaneurysm after device implantation **(arrow)** as imaged at aortic angiography **(B)** and pre-discharge computed tomography scan 3D reconstruction **(C)**. AAo = ascending aorta; DAo = descending aorta.

**FIGURE 5 3D Computed Tomography Scan and Printed Model of the Pseudoaneurysmal Sac Located at the Posterolateral Surface of the Ascending Aorta**




Pseudoaneurysm **(asterisk)** of the posterior side of the ascending aorta as imaged at computed tomography scan 3D reconstruction from outside **(A)** and by cut-plain internal view **(B)**. Printed 3D model of the ascending aorta pseudoaneurysm as viewed from behind **(C)** and above **(D)**. AAo = ascending aorta; DAo = descending aorta; LV = left ventricle; RA = right atrium; RV = right ventricle; TAoA = transverse aortic arch.

finely detail the site, size, and shape of the feeding breach and its spatial relationship with the neighboring structures may be crucial for the success of the procedure.[5] This approach adds several advantages to simple 3D digital reconstruction. It allows a more tangible understanding of the spatial relationship between the cardiac and extracardiac structures, making it easier to plan vascular access, entry angle to the target lesion, and device manipulation. In addition, the use of 3D printed models allows the surgeon to entirely mimic ex vivo the planned interventional procedure by testing different types of devices, decreasing procedure time, x-ray exposure, and overall risk of the treatment.

In conclusion, the advantage of the 3D printing technology mainly lies in preprocedure planning of challenging percutaneous interventions. It allows prediction of any potential difficulty of the interventional procedure by giving a better knowledge of local anatomy and also testing ex vivo the performance of different off-label devices.

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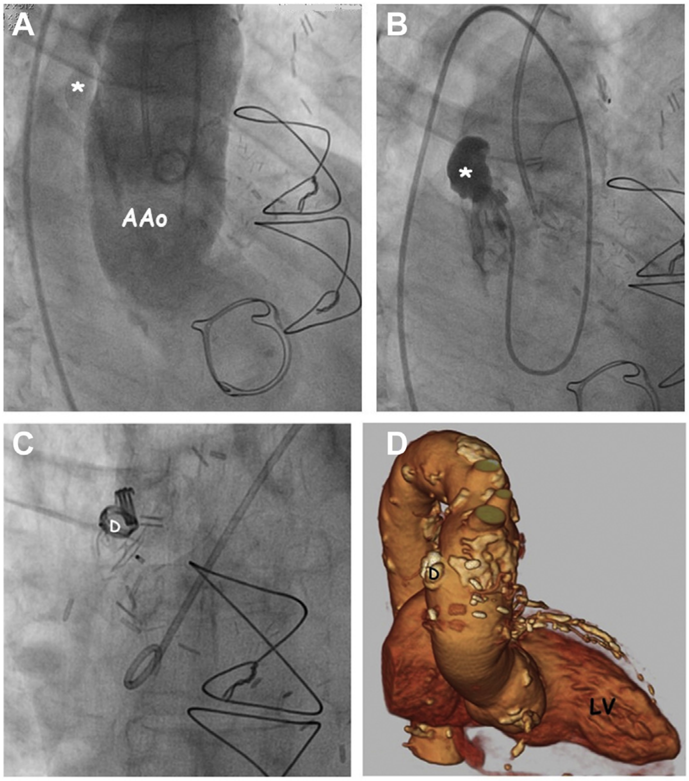
**FIGURE 6** Angiographic and 3D Computed Tomography Scan Imaging of the Pseudoaneurysm Submitted to Device Closure




Aortic angiography in right oblique view before **(A, B)** and after **(C)** closure of the pseudoaneurysmal sac with multiple devices. Complete occlusion of the pseudoaneurysm after device implantation as imaged at the predischarge computed tomography scan 3D reconstruction **(D)**. AAo = ascending aorta; D = devices; LV = left ventricle.

## REFERENCES

**1.** Belkin RN, Kalapatapu SK, Lafaro RJ, Ramaswamy G, McClung JA, Cohen MB. Atherosclerotic pseudoaneurysm of the ascending aorta. *J Am Soc Echocardiogr*. 2003;16:367-369.

**2.** Razzouk AA, Gundry S, Wang N, et al. Pseudoaneurysms of the aorta after cardiac surgery or chest trauma. *Am J Surg*. 1993;59:818-823.

**3.** Navaravong L, Saab F, Cook JR, Peterman M, Flack J. Ascending aortic pseudoaneurysm, a ticking bomb after cardiac surgery. *Cardiovasc Revasc Med*. 2011;12:177-180.

**4.** Bashir F, Quaife R, Carroll JD. Percutaneous closure of ascending aorta pseudoaneurysm using Amplatzer septal occluder device: the first clinical case report and literature review. *Cathet Cardiovasc Interv*. 2005;65:547-551.

**5.** Vukicevica M, Mosadeghb B, Minb JK, Little SH. Cardiac 3D printing and its future directions. *J Am Coll Cardiol Img*. 2017;10:171-184.

**6.** Santoro G, Pizzuto A, Rizza A, et al. Transcatheter treatment of "complex" aortic coarctation guided by printed 3D model. *J Am Coll Cardiol Case Rep*. 2021;3:900-904.

**KEY WORDS** 3D printing, aorta, device, pseudoaneurysm

**APPENDIX** For supplemental videos, please see the online version of this article.