Two- and Three-Dimensional Transesophageal Echocardiographic Detection of Aortic Dissection Rupture With Extension of Dissection Into the Pulmonary Artery

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INTRODUCTION

Combined aortic (AO) and main pulmonary artery (MPA) dissection is a very rare and highly lethal entity, with only 16 cases reported in the literature.[1-16] We report an elderly patient in whom two-dimensional (2D) and three-dimensional (3D) transesophageal echocardiography (TEE) performed intraoperatively showed rupture of the AO dissection false lumen into the pulmonary artery (PA) with the dissection flaps in the PA clearly noted to be continuous with and extending from the AO false lumen. Thus, we were able to make a definitive diagnosis of PA dissection resulting from AO dissection rupture by TEE in this patient.

CASE PRESENTATION

The patient was a 69-year-old man with a medical history of hypertension, hyperlipidemia, and coronary artery bypass surgery 4 weeks prior who presented at an outside hospital with severe chest and back pain and paraplegia. Computed tomography angiography (CTA) scan showed type A AO dissection involving the AO root extending through the arch and down into the descending aorta with near complete occlusion at the infrarenal level with distal reconstitution. The patient was emergently transferred to our hospital for further management and taken directly to the operating room. Vital signs were stable on admission, with a pulse rate of 82 beats per minute, blood pressure 160/42 mm Hg, and respiratory rate of 22 breaths per minute. Physical examination was notable for profound paraplegia. No murmurs were reported on cardiac examination. Transthoracic echocardiogram (TTE) was not done due to the emergent nature of the procedure.

VIDEO HIGHLIGHTS

Video 1: Two-dimensional TEE, midesophageal, AO valve short-axis view with color-flow Doppler, demonstrates the differing flows through true and false lumens of the dissected aorta. *FL*, False lumen; *LA*, left atrium; *RV*, right ventricle; *TL*, true lumen.

Video 2: Two-dimensional TEE, midesophageal, ascending AO short-axis view, demonstrates the intimal dissection in the aorta with continuity and extension into the MPA. The *red arrow* points to the dissection flap in MPA. *PV*, Pulmonary valve; *RPA*, right PA.

Video 3: Two-dimensional TEE, midesophageal ascending AO views, X-plane mode, demonstrates the rupture of false lumen of the aorta into the MPA from the short-axis (*left*) and long-axis (*right*) orientations. *AO*, Aorta.

Video 4: Two-dimensional TEE, midesophageal ascending AO short-axis view, demonstrates the intimal dissection flap in the aorta with continuity and extension (*yellow arrow*) into the MPA (*red arrow*).

Video 5: Three-dimensional TEE, midesophageal ascending AO short-axis, live mode display, volume-rendered image, demonstrates the intimal dissection in both the aorta and MPA (*red arrow*).

Video 6: Three-dimensional TEE, midesophageal ascending AO short-axis, live mode display, volume-rendered image with higher gain settings, demonstrates the likelihood of multiple dissection flaps seen within the MPA (*red arrows*) and the proximal right PA.

Video 7: Three-dimensional TEE, live mode display, midesophageal, volume-rendered reconstruction en face view of the intimal dissection of the MPA (*red arrow*), demonstrates the increased thickness of the tissue and helps distinguish this from a linear artifact.

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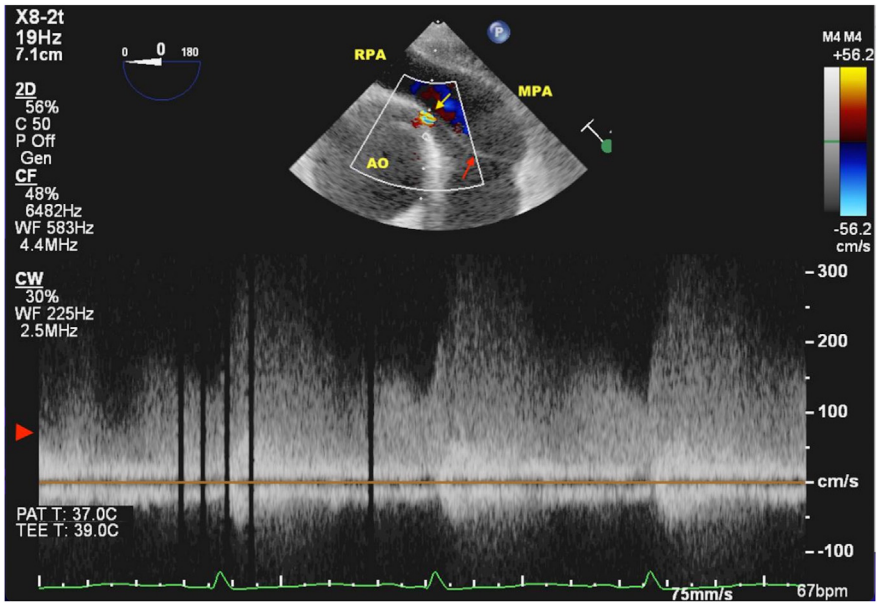

Figure 1 Two-dimensional TEE, midesophageal AO valve short-axis view with color flow–guided, continuous-wave Doppler interrogation of the fistulous communication (*yellow arrow*), demonstrates the continuous flow throughout the cardiac cycle (*red arrowhead*) and the MPA intimal dissection (*red arrow*). *AO*, Aorta; *RPA*, right PA.

Intraoperative 2D and 3D TEE showed AO root dissection extending into the arch and descending aorta (Videos 1 and 2), with moderate AO regurgitation (vena contracta width of 5 mm, pressure half time of 440 ms), normal left and right ventricular function by visual estimate, and essentially normal mitral, tricuspid, and pulmonary valves. A fistulous communication measuring 0.4 × 0.8 cm was delineated by 2D TEE color Doppler between the AO false lumen and the PA with continuous flow signals throughout the cardiac cycle demonstrated by continuous-wave Doppler (Video 3, Figure 1).

A linear mobile echo in the PA indicative of an intimal dissection was noted extending from and continuous with the AO false lumen wall in the region of the communication (Video 4, Figure 2).

The patient underwent successful axillary bilateral femoral artery bypass surgery with reconstitution of perfusion to the lower extremities. Due to severe lactic acidosis, a repeat CTA of chest, abdomen, and pelvis was done on postoperative day 1 to evaluate bowel ischemia. The CTA was routine and nongated, which resulted in cardiac motion–related artifacts. However, it did show type A AO dissection along with a linear filling defect in the PA in close proximity to the

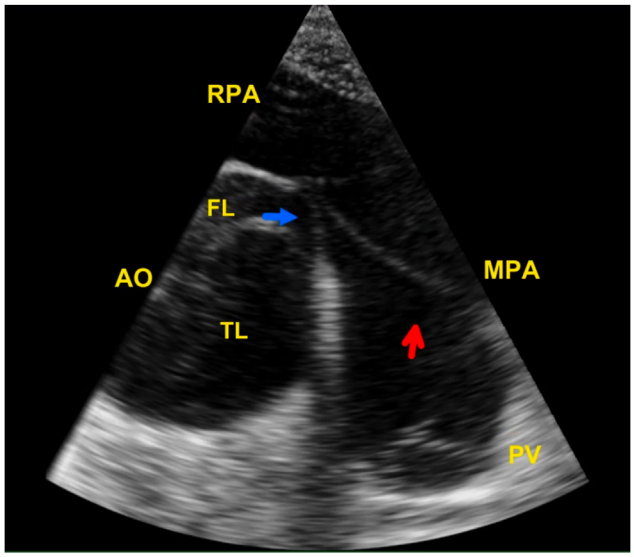

Figure 2 Two-dimensional TEE, midesophageal ascending AO short-axis view, demonstrates the intimal dissection within the aorta with continuity and extension into the MPA (*blue arrow*) where the intimal dissection is demonstrated (*red arrow*). *FL*, False lumen; *PV*, pulmonary valve; *RPA*, right PA; *TL*, true lumen.

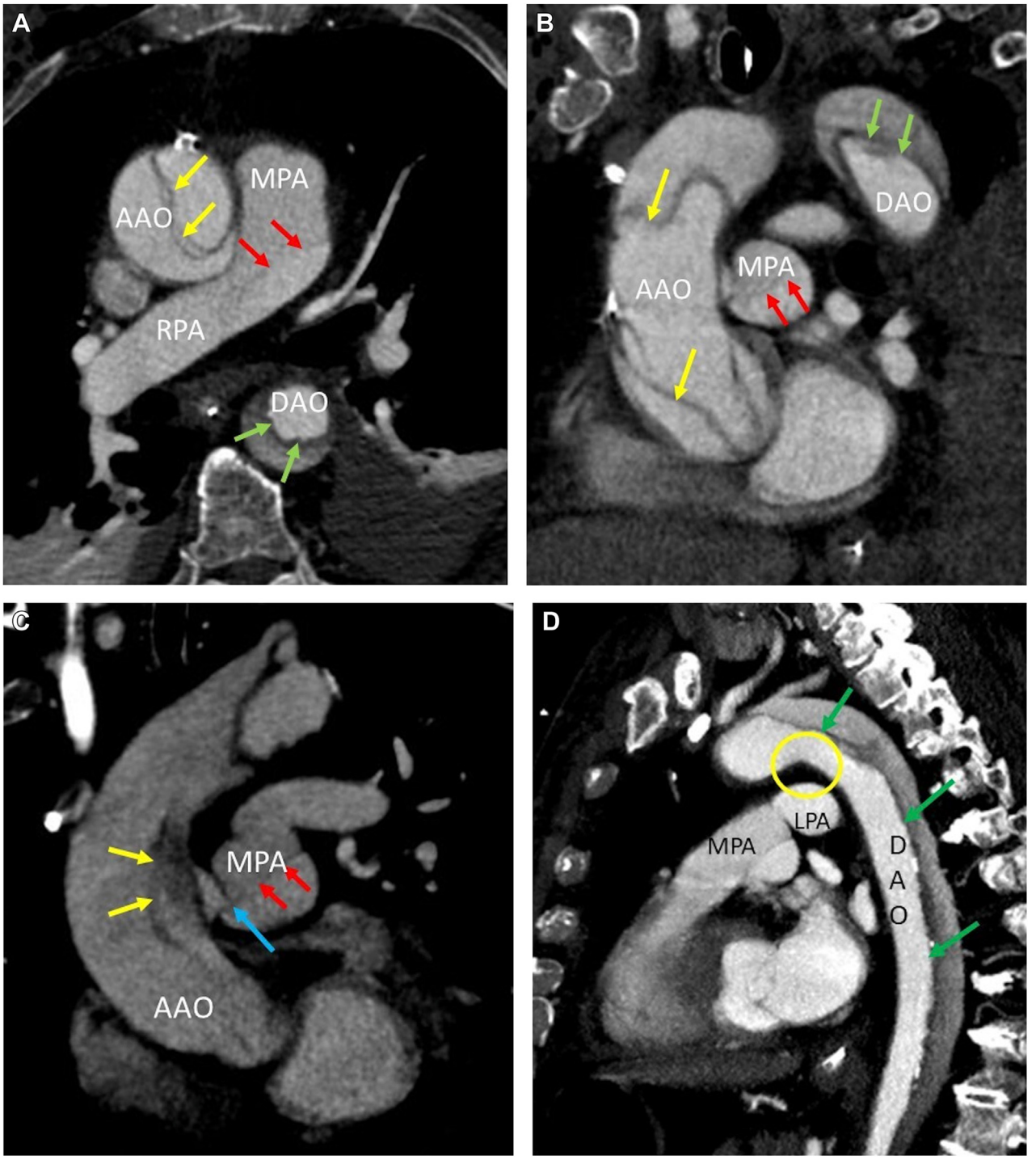

Figure 3 Computed tomography angiography multiplanar reconstructions (MPR) in the axial **(A)**, coronal **(B)**, and oblique **(C)** displays demonstrate the ascending AO (*yellow arrows*), MPA (*red arrows*), and descending thoracic aorta dissections (*green arrows*). A suspected small area of communication (*blue arrow*) between the aorta and MPA is highlighted in panel **C**, where the ascending AO dissection (*yellow arrows*) and MPA dissection (*red arrows*) are also noted. The MPR view from the oblique sagittal orientation **(D)** at the level of ligamentum arteriosum (*yellow circle*) could not demonstrate a focal AO wall irregularity or pseudo aneurysm. The AO dissection (*green arrows*) is seen involving the entire descending thoracic aorta. *AAO*, Ascending aorta; *DAO*, descending aorta; *LPA*, left PA; *RPA*, right PA.

Table 1 Combined AO and PA dissection cases from the literature

#	Authors	Age/sex	Presentation	2D TTE	CT scan	Mechanism	Surgery	Outcome
1	Revels *et al.* (2020)	40/M	Back and leg pain	Not mentioned	Ao diss (type B) + PA diss through PDA	Diss through PDA	Surgery	Died
2	Bakir *et al.* (2006)	74/F	SOB, peripheral edema	Not mentioned	Type B Ao diss + PA diss. Origin of flow in PDA from desc Ao false lumen	Diss through PDA	Surgery	Recovered
3	Shiraya *et al.* (2018)	76/M	Back pain, SOB	Not mentioned	Desc Ao diss (type B) + PA diss through thrombosed PDA	Diss through PDA	No surgery	Recovered
4	Cui *et al.* (2015)	42/F	SOB, cough	Asc Ao diss + PA diss + PDA	Asc Ao diss (type A) + diss extending from desc Ao to PA through PDA	Diss through PDA	Surgery	Recovered
5	Hong *et al.* (2015)	41/F	Chest discomfort, SOB, cough,	Asc Ao (type A) diss + PA diss + PDA	Ao diss (type A) + PA diss through a PDA	Diss through PDA	Surgery	Recovered
6	Rittoo *et al.* (2012)	72/F	Chest pain, PDA closed 4 years ago, AV + Ao root replaced 7 years ago	Diss flap in desc Ao and PA	Diss of desc Ao (type B) + PA diss. Transcatheter closed PDA rendered patent by diss.	Diss "involved" PDA	No surgery	Died
7	Zhu *et al.* (2016)	26/F	Chest pain, SOB	Not mentioned	Type B Ao diss + PA diss associated with PDA.	Diss through PDA not mentioned.	Surgery	Recovered
8	Zhang *et al.* (2022)	32/F	Chest pain	Moderate AR, Ao sinus and PA aneurysms. No mention of diss. Only 2D TEE done.	Ao diss (type A) + PA diss following transcatheter PDA occlusion 6 years before. Ao sinus and PA aneurysms.	?Iatrogenic, related to previous PDA closure.	Surgery	Recovered
9	Antunez *et al.* (2021)	81/F	Chest pain radiating to back, hemodynamic collapse	Ao (type A) and PA diss	Ao diss (type A) and PA diss displacing PDA occluder device creating shunt between Ao and PA. Interval between transcatheter PDA closure and Ao diss not mentioned.	?Iatrogenic, related to previous PDA closure.	Surgery	Died
10	Jing *et al.* (2011)	45/M	Chest pain radiating to abdomen, SOB	Diss in arch + left subclavian artery diss	Ao diss (type B) + PA diss + tube like structure connecting Ao and PA.	?Diss not through PDA but possibly through lacerated ligamentum arteriosum (thin, filled with blood)	Surgery	Recovered

(*Continued*)

11	Khaja *et al.* (2017)	25/M	Chest pain, SOB, right eye blindness, leg weakness	Bicuspid AV, ?asc Ao + arch + PA diss with communication from left sinus of Valsalva to PA, hemopericardium	Bicuspid AV, Ao coarctation, asc Ao + arch (type A) + PA diss + fistula from left sinus of Valsalva to PA.	Diss extended through fistula, not clear whether preexisting or created by Ao diss rupture.	Surgery	Recovered
12	Guo *et al.* (2019)	38/M	SOB, cough	Not mentioned	Asc Ao and arch diss (type A) + PA diss + AO-PA fistula.	Diss through fistula not mentioned, not clear if fistula preexisting.	Surgery	Recovered
13	Itoh *et al.* (2009)	71/M	Back pain	Not mentioned	Ao (type A) + PA diss associated with Ao-PA window.	Diss through Ao-PA window not mentioned	Not mentioned	Not mentioned
14	Song *et al.* (2021)	53/F	Chest pain, SOB; AVR 18 months ago.	Normal AVR. Diss not mentioned	Asc Ao (type A) + PA diss "combined" by Ao-PA fistula, not clear if preexisting.	Diss through fistula not mentioned. ? Iatrogenic from manipulation during previous AVR.	Surgery	Died
15	Khatchatourian *et al.* (2005)	55/M	Not mentioned	Ao diss	Ao diss (type I) repair, hematoma lateral to Ao + PA diss.	?Hematoma infiltrating PA ?Iatrogenic from manipulation during surgery	Surgery	Recovered
16	Hsu *et al.* (2007)	63/M	Chest pain radiating to back, SOB, cardiogenic shock	Not mentioned	Ao (type A) + PA diss with rupture of PA diss into pericardium/ mediastinum.	Not clear	No surgery	Died

Ao, Aorta; *AR*, AO regurgitation, *asc*, ascending; *AV*, AO valve; *AVR*, AO valve replacement; *desc*, descending; *diss*, dissection; *F*, female; *M*, male; *SOB*, shortness of breath; *type A*, Stanford type A AO dissection; *type B*, Stanford type B AO dissection; *type I*, Debakey type I AO dissection; *?*, possible.

AO dissecting intimal flap and a suspected communication between the AO and the PA (Figure 3A–C). There was no AO wall irregularity or pseudo aneurysm formation at the site of ligamentum arteriosum (Figure 3D). The patient did not do well after surgery and gradually deteriorated with septic shock and multiorgan failure and subsequently expired. Autopsy was not performed.

DISCUSSION

There have been 16 adult cases reported in the literature with combined AO and PA dissection confirmed by CTA (Table 1). Six of these cases showed the dissection directly propagating from the AO into the PA through a patent ductus arteriosus (PDA) by CTA.[1-6] In these cases, the presence of a PDA appears to act as a conduit that facilitates extension of the dissection into the PA. In another patient,[7] the PDA was an associated finding, but no mention was made regarding extension of the dissection through its lumen. In 2 additional patients,[8,9] associated PA dissection was suspected to be related to manipulations during transcatheter closure of the PDA. Jing *et al.*[10] described a patient wherein a tube-like bloated structure with thin walls, not typical of a PDA, was noted during surgery and was suspected to be a lacerated ligamentum arteriosum that may have acted as a conduit for extension of the dissection. Thus, in the majority of patients (10/16, 62.5%), combined AO and PA dissection was associated with a congenital PDA or possibly a lacerated ligamentum.

Extension of an AO dissection into the PA through a fistula from the left AO sinus of Valsalva into the PA by CTA was visualized in 1 patient.[11] However, it is not clear whether the fistula preexisted or was formed by the AO dissection rupture. In 2 other patients, an associated AO-PA fistula and AO-PA window were described, but no specific mention was made about whether they served as conduits for propagation of dissection into the PA.[12,13]

Possible AO manipulation and/or cannulation during open heart surgery was suspected as the cause of combined AO and PA dissection in 2 patients, 1 of whom underwent AO valve replacement 18 months earlier and the other of whom had AO dissection repair in which PA dissection was found by CTA in the postoperative period.[14,15] The mechanism of combined AO and PA dissection was not clear in 1 patient who presented with cardiogenic shock from PA rupture into the mediastinum.[16]

Ten of the reported cases had a Stanford type A AO dissection, with the rest of the cases showing Stanford type B dissection. Two-dimensional TTE was reported to have made the diagnosis of concomitant AO and PA dissection in 5 of these cases,[4-6,9,11] but dissection flaps in both the great vessels were demonstrated in only 2 of the reported cases.[5,9] Also, none of the patients demonstrated continuity of the intimal dissection from the AO into the PA by either 2D TTE or 2D TEE. Three-dimensional TEE was not reported in any patient.

In our case, although the finding of PA dissection continuity with AO dissection through a fistulous communication was visualized by 2D TEE, it was more comprehensively demonstrated by 3D TEE (Video 5, Figure 4).

Unlike 2D TEE, multiple dissection flaps were noted in the PA by 3D TEE (Video 6). Three-dimensional TEE in contrast to 2D TEE also allowed en face views of the PA intimal dissection. This was useful in differentiating the intimal dissection flap from a linear echo due to reverberation artifact, which may mimic dissection and result in misdiagnosis. Dissection results from splitting of a vessel wall and therefore has a certain width to it when viewed en face in contrast to an artifactual echo (Video 7).[17] In addition, cropping of the 3D TEE color Doppler data set enabled en face views of the fistulous communication, which permitted more accurate dimensional measurements (0.5 × 1.2 cm) as well as measurements of the circumference (3.95 cm) and area (0.38 cm^2; Figure 5).

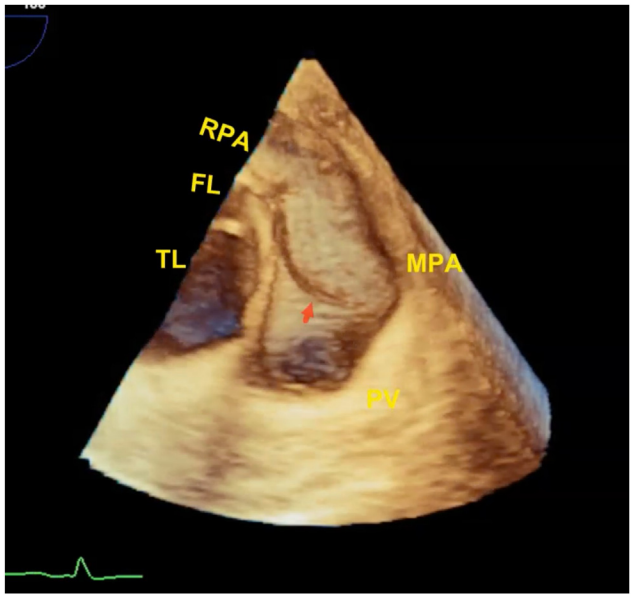

Figure 4 Three-dimensional TEE, midesophageal ascending AO short-axis view, live mode, volume-rendered display, demonstrates the intimal flap in both the aorta and MPA (*red arrow*). *FL*, False lumen; *PV*, pulmonary valve; *RPA*, right PA; *TL*, true lumen.

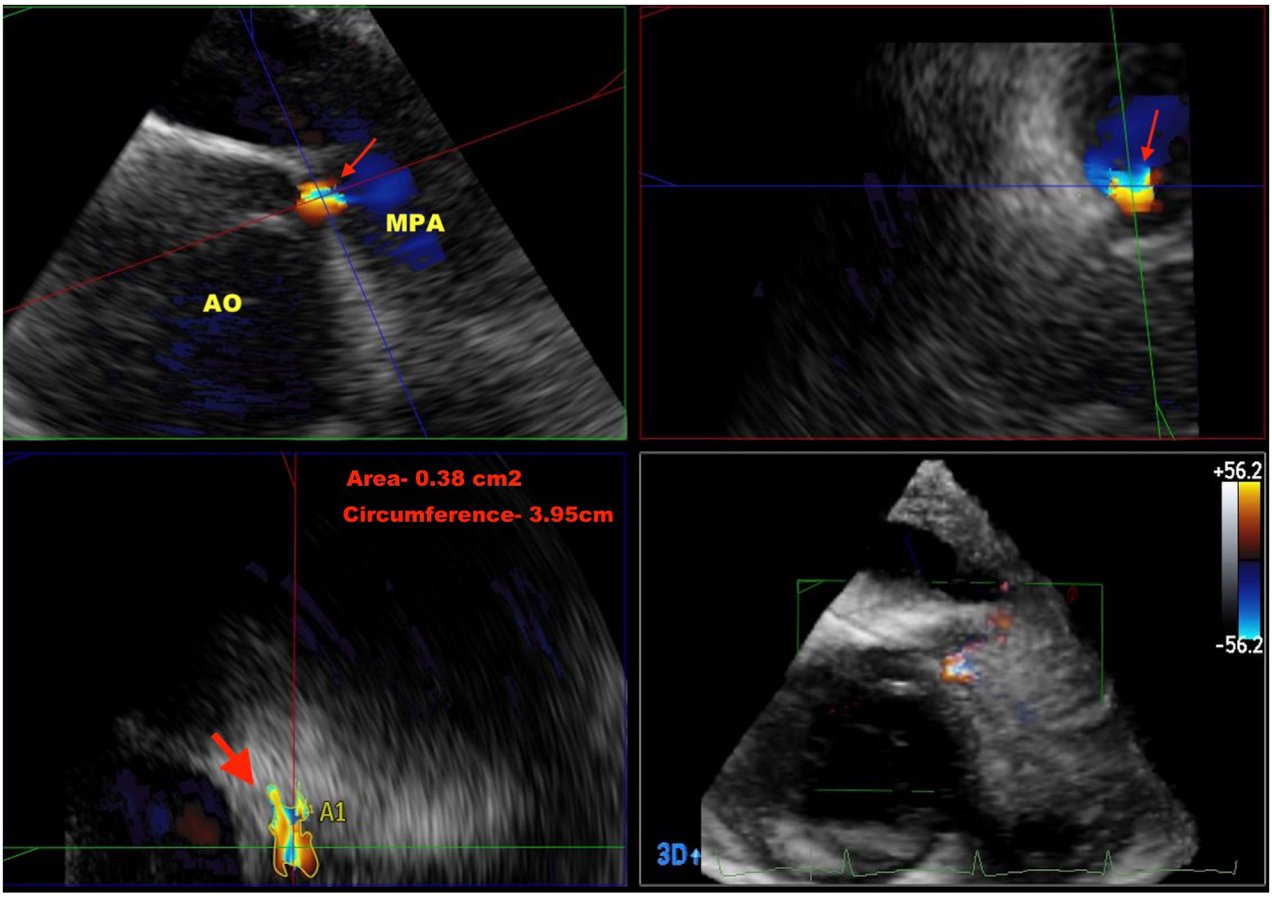

Figure 5 Three-dimensional TEE, midesophageal, 2D reconstructions with color-flow Doppler in multiplanar orthogonal views, live mode, demonstrates the en face view of the fistulous communication (*left lower panel*) enabling measurement of its area and circumference. *Red arrows* point to the fistulous communication noted in all 3 planes.

Three-dimensional TEE also showed that the PA dissection extended into the proximal right PA. Thus, 3D TEE was a useful supplement to 2D TEE and helped in making a more comprehensive assessment of the findings. Use of both 2D TEE and 3D TEE helped us make a confident and definitive diagnosis of extension of dissection from the AO into the PA through rupture of the AO false lumen into the PA.

Although we cannot be certain, it is possible the AO dissection with rupture and extension into the PA was related to trauma during the patient's previous coronary artery bypass surgery and the dissection extended a few weeks later further along the aorta (possibly due to uncontrolled hypertension) resulting in severe chest and back pain accompanied by paraplegia. There was no history of PDA or other preexisting abnormalities such as an AO-PA shunt or window.

CONCLUSION

We present a unique case of combined AO and PA dissection in whom both 2D and 3D TEE convincingly showed AO dissection rupture into the PA with continuity and extension of the dissection from the AO into the PA. Presumably, this resulted from trauma during previous coronary artery bypass surgery.

CONSENT STATEMENT

The authors declare that since this was a noninterventional, retrospective, observational study utilizing deidentified data, informed consent was not required from the patient under an IRB exemption status.

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.

FUNDING STATEMENT

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

SUPPLEMENTARY DATA

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