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Impairment of Venous Drainage Due to Atrial Septal Aneurysm During Open-Heart Surgery

Sanghun Kim, MD, and Hong Liu, MD

IT IS NOT UNCOMMON to encounter inadequate venous drainage during cardiopulmonary bypass. Some common causes include poor positioning and obstruction of the venous cannula, increased resistance due to the small diameter of the venous cannula, and kinks in the tubing that connects the venous cannula to the venous reservoir. We report a case of atrial septal aneurysm (ASA) impairing venous drainage from a 2-stage venous cannula in right atrium during a routine cardiac surgery case requiring cardiopulmonary bypass (CPB). Intraoperative transesophageal echocardiogram (TEE) was instrumental in diagnosis and treatment of the decreased venous drainage.

CASE REPORT

A 70-year-old male with a history of aortic stenosis presented with worsening dyspnea on exertion. His past medical history was notable for hypertension and hyperlipidemia. Transthoracic echocardiogram (TTE) revealed worsening of aortic stenosis with the aortic valve area about 0.9 cm^2, transaortic valve mean pressure gradient of 42 mmHg, peak pressure gradient about 80 mmHg, trace aortic regurgitation, and diastolic dysfunction with preserved biventricular systolic function (ejection fraction: 58%). ASA was not specifically noted on TTE report. TTE videos reviewed at a later time confirmed the initial report. Cardiac catheterization showed severe coronary artery disease involving left anterior descending artery, left circumflex artery, and right coronary artery. He presented to the operating room for aortic valve replacement and coronary artery bypass grafting.

After induction of general anesthesia, intraoperative TEE showed a large ASA of 20 mm base that moves equal distance towards both right and left atria by 15 mm (Figs 1 and 2 and Video Clips 1 and 2). A 3D TEE midesophageal bicaval view also clearly demonstrated the aneurysm (Fig 3). There was no evidence of patent foramen ovale (PFO) by color flow Doppler interrogation. A saline contrast test was not specifically done to look for PFO. After heparinization and placement of an arterial cannula in ascending aorta and a 2-stage venous cannula in the right atrium, CPB was initiated without incident. Within a few minutes, however, venous drainage was noted to be sluggish. Due to inadequate venous drainage, full flow could not be achieved on CPB. Because manipulation of the venous cannula and the tubing failed to improve venous drainage adequately, a vacuum was applied to the venous tubing to augment its drainage. However, the venous drainage became significantly worse after adding the vacuum. Upon investigation with TEE in midesophageal bicaval view, a portion of ASA was noted to be "sucked" into proximal ports of the venous cannula (Fig 4). The right atrium did not appear to be markedly enlarged indicating there is some venous drainage through distal ports of venous cannula. To relieve worsening of venous drainage, the vacuum was removed and venous tubing was clamped to fill the right atrium and allow separation of the aneurysm from the venous cannula. After readjustment of the venous cannula, there was no evidence of adherence of ASA to the proximal port on TEE. There were no further difficulties with venous drainage during cardiopulmonary bypass. The patient received a 25 mm St. Jude Epic porcine bioprosthetic valve (St. Jude Medical, Minneapolis, MN) and coronary artery bypass graft times 3 without repair of the aneurysm. Weaning from cardiopulmonary bypass was uneventful. Post bypass TEE showed the bioprosthetic valve in good position with no paravalvular leak, unchanged mitral valve, preserved ventricular function, and intact ASA.

DISCUSSION

Atrial septal aneurysm is described as a saccular deformity of the interatrial septum that bulges into the right or left atrium with a prevalence of 1% based on an autopsy study.[1] By echocardiogram, it is defined as protrusion of the aneurysm greater than 10mm beyond the plane of the atrial septum.[2] With widespread use of TTE in the 1980s, several studies found its prevalence to be ranging from 0.2% to 1.9%.[3,4] A recent study based on TEE put its prevalence at 4.3%[5] and suggests that it is a more sensitive diagnostic tool than TTE.[5,6] Although 3D TEE clearly showed the aneurysm in this case, 2D TEE is sufficient to make a diagnosis of ASA. Several studies have classified ASA based on morphology and movement of the aneurysm.[3,4,7] Based on the most recent study on a classification by morphology and movement during the cardiorespiratory cycle,[4] this patient has a type 5 ASA that moves equal distance to both right and left atria (Table 1).

While there were occasional case reports of cerebrovascular embolic events in patients with ASA, its clinical significance was not appreciated until routine use of echocardiogram found high prevalence of stroke of embolic origin in those patients.[5,9,10] Although not definitively proven, mechanism is presumed to be due to paradoxical interatrial shunting of thrombus since a high percentage of patients with ASA has PFO.[5,6] Presence of spontaneous echo contrast in the aneurismal cavity has been previously reported and thought to be a precursor to thrombus formation.[8] In a patient who presented for routine coronary artery bypass graft surgery, massive thrombus was noted within the aneurismal cavity that subsequently caused intraoperative embolic stroke.[11] These findings suggest that source of emboli could be cardiac in origin due to thrombus formation within the aneurysm. It is also not uncommon that thrombus within ASA has been mistaken as an atrial mass preoperatively and found out to be an aneurysm encasing thrombus during surgery for excision of the mass.[12,13] In this case, ASA was not surgically repaired given that it was an incidental finding with no prior neurological events and evidence of PFO. Other associated congenital cardiac abnormalities shown through echocardiogram include patent foramen ovale, atrial septal defect, mitral valve prolapse, and ventricular septal defect.[2,14]

This is the first case report describing decreased venous drainage due to ASA during a routine cardiac case requiring CPB. Venous drainage during cardiopulmonary bypass is determined by a cross sectional area of the lumen of the venous cannula, volume of blood in the cannulated vessel or chamber providing central venous pressure, and hydrostatic pressure difference between the cannula location and the

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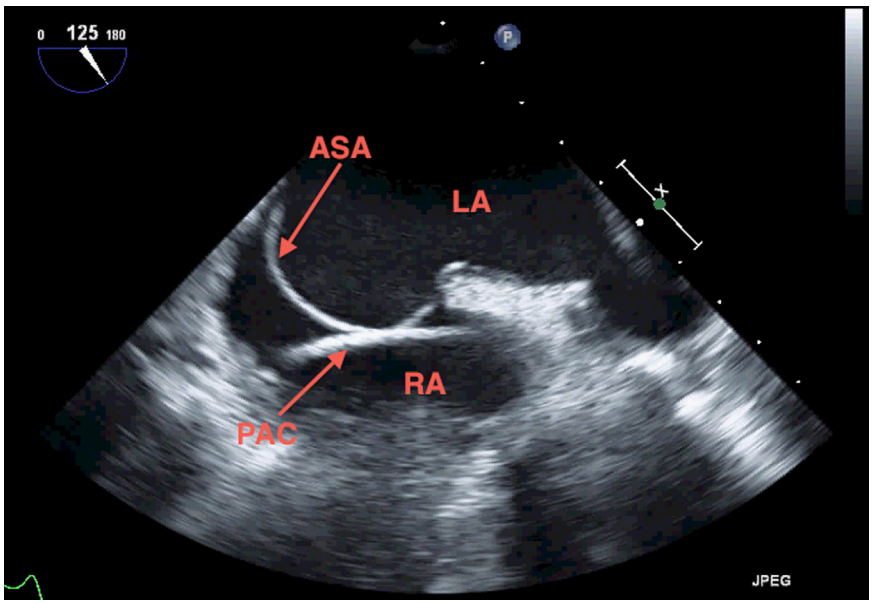

Fig 1. A modified transesophageal echocardiography bicaval view shows atrial septal aneurysm (ASA) protrudes toward the right atria (RA). LA, left atria; PAC, pulmonary artery catheter. (Color version of figure is available online.)

venous reservoir. Therefore, impaired venous drainage can be seen with obstruction or compromise of any of the parts creating a venous conduit between the patient and the venous reservoir. Increased resistance from small cannula, obstruction of cannula or tubing, airlocks, inadequate blood volume, and drug-induced venodilation can cause inadequate venous drainage. Once the venous cannula is confirmed to be appropriately placed and tubing is noted to be without obstruction from airlocks and extrinsic compression, vacuum-assisted venous drainage can be attempted to improve the drainage especially if a small diameter cannula was used. In this patient, venous drainage was inadequate due to adherence of the aneurysm to proximal ports of the venous cannula and worsened with vacuum assistance.

A recent guideline on perioperative TEE published by the Society of Cardiovascular Anesthesiologists (SCA) and American Society of Anesthesiologists (ASA) Task Force on TEE states that "TEE should be used in all open heart procedures and … should be considered in coronary artery bypass graft surgeries" for adults without contraindications.[15] There is no

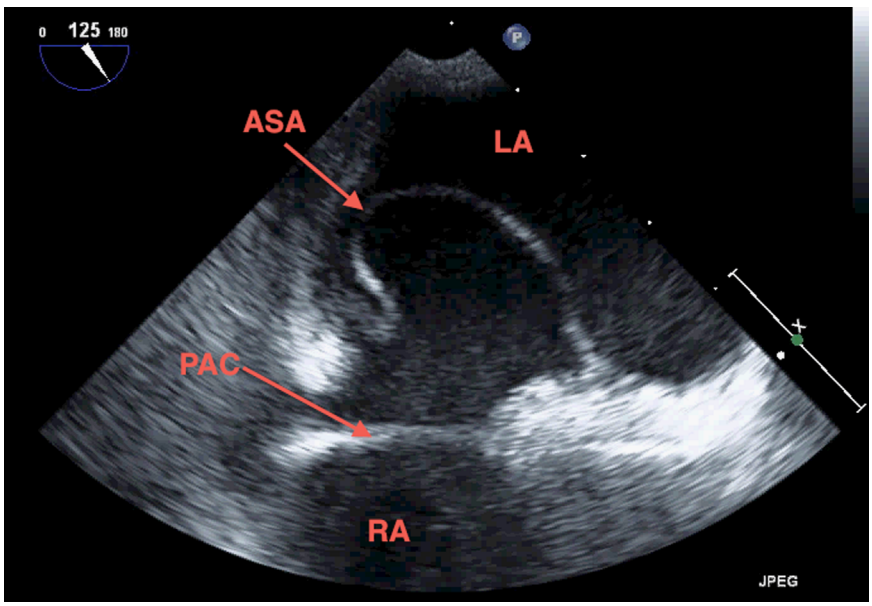

Fig 2. A modified transesophageal echocardiography bicaval view shows atrial septal aneurysm (ASA) protrudes toward the left atria (LA). PAC, pulmonary artery catheter; RA, right atria. (Color version of figure is available online.)

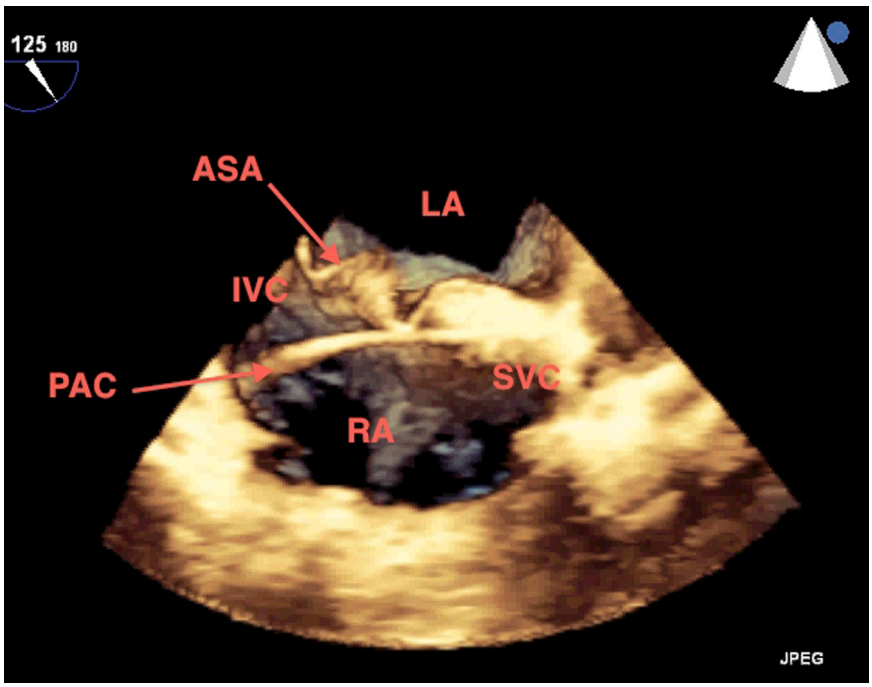

Fig 3. A modified 3D full volume transesophageal echocardiography bicaval view shows atrial septal aneurysm (ASA) moves bilaterally toward the right atria (RA) and left atria (LA). IVC, inferior vena cava; PAC, pulmonary artery catheter; SVC, superior vena cava. (Color version of figure is available online.)

doubt that patients undergoing valve repair or replacement would benefit from intraoperative TEE to determine adequacy of the valve placement and function. What is not so clear is whether those patients with intact biventricular systolic function needing coronary revascularization with CPB would benefit from having an intraoperative TEE examination. It is presumed that monitoring of volume status, contractility, and regional wall motion abnormality would provide essential information to guide perioperative management of patients receiving coronary artery bypass graft surgery. Unlike a

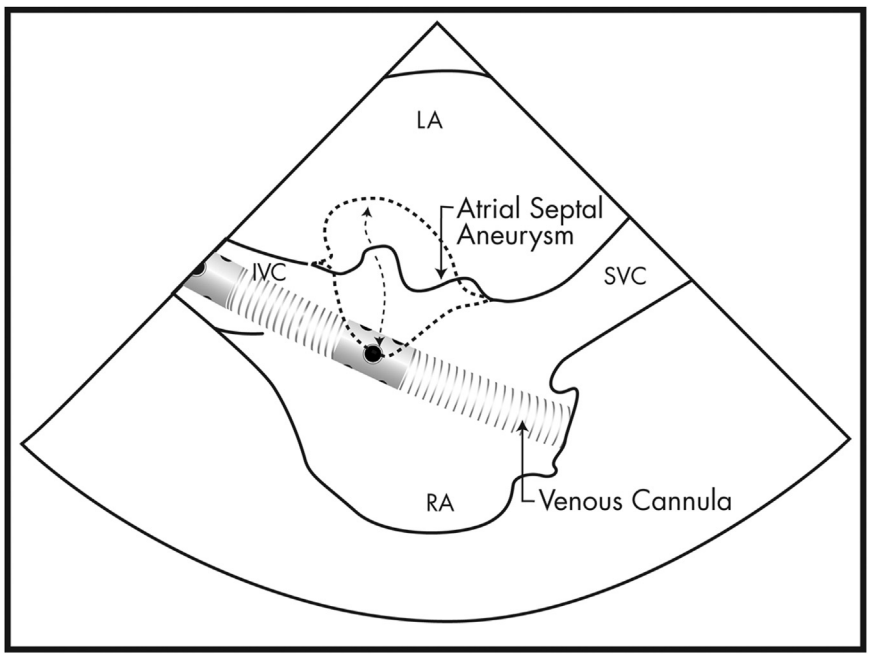

Fig 4. A schematic drawing illustrates how atrial septal aneurysm (ASA) blocks the venous drainage. The ASA was sucked into the proximal holes of a 2-stage venous cannula when vacuum was applied to the venous drainage tubing. The dotted line demonstrated the motions of ASA towards both right atria (RA) and left atria (LA). IVC, inferior vena cava; SVC, superior vena cava.

Table 1. Atrial Septal Aneurysm Classification

1R	Protrudes from midline to right atrium throughout the cardiorespiratory cycle
2L	Protrudes from midline to left atrium throughout the cardiorespiratory cycle
3RL	Maximal excursion to right atrium with lesser excursion to left atrium
4LR	Maximal excursion to left atrium with lesser excursion to right atrium
5	Bidirectional and equidistant to the right atrium and left atrium during cardiorespiratory cycle

previous report,[16] intraoperative TEE clearly made a difference and changed clinical management in this case and shows that there is a role in routine cardiac surgery cases requiring CPB. Not only was TEE able to diagnose the cause of decreased venous drainage, but also, it was able to show resolution of the problem. Although it is not a common finding, ASA should be considered as a possible cause of decreased venous drainage after common causes are ruled out in patients with this pathology.

In summary, diagnosis of ASA has been made more frequently with routine use of 2-dimensional echocardiogram especially with TEE. Initially noted as an incidental finding with uncertain clinical relevance, it is now recognized as a risk factor for stroke of embolic origin especially when associated with PFO. TEE is superior to TTE for both diagnosis of ASA and confirmation of interatrial shunting from PFO. In this case, intraoperative TEE was instrumental in diagnosis and treatment of decreased venous drainage from adherence of aneurismal tissue to venous cannula. ASA should be considered as a possible cause of decreased venous drainage after other more common causes are ruled out. To reiterate, the recent guideline on perioperative TEE by SCA and ASA states, "TEE … should be considered in coronary artery bypass graft surgeries" for adults without contraindications.[16]

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary material cited in this article is available online at http://dx.doi.org/10.1053/j.jvca.2013.09.001.

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