

A case of ruptured sinus of Valsalva aneurysm and reversible flow-induced pulmonary hypertension

Basil Al-Sabeq, Sabe De and Ryan Davey

Division of Cardiology, Department of Medicine, University of Western Ontario, London, ON, Canada

Abstract

Pulmonary hypertension (PH) in adults with congenital heart disease (CHD) and significant systemic-to-pulmonary shunting is a significant cause of morbidity and mortality. Its pathophysiology is incompletely understood, but involves a flow-induced pulmonary arteriopathy characterized by endothelial cell dysfunction and vascular remodeling that alters pulmonary arterial vasoreactivity. There is a paucity of literature linking PH with left-to-right shunting due to ruptured sinus of Valsalva aneurysms (SOVA). We present a unique case of reversible, flow-associated PH due to a ruptured congenital right SOVA fistulizing into the right atrium (RA), with emphasis on non-invasive and invasive assessment of pulmonary hemodynamics before and after surgical intervention.

Keywords

congenital, echocardiography, right atrium, shunt

Date received: 22 November 2017; accepted: 30 January 2018

Pulmonary Circulation 2018; 8(2) 1–5

DOI: 10.1177/2045894018760656

Introduction

Sinus of Valsalva aneurysm (SOVA) is a rare anomaly, accounting for 3.5% of congenital heart disease¹ (CHD) and reported in 0.1–3% of all cardiac surgeries.² It has a male predominance, involves the right coronary cusp most frequently,³ and can be congenital or acquired,⁴ the latter most commonly associated with connective tissue disorders or infectious etiologies such as infective endocarditis or syphilitic aortitis.⁵ Symptoms of a ruptured SOVA are protean but non-specific, a continuous precordial murmur on auscultation is suggestive, and the diagnosis is often made incidentally through non-invasive cardiac imaging. Patients with unruptured aneurysms may be asymptomatic. Echocardiography is an essential tool to confirm the diagnosis, search for evidence of rupture and intracardiac shunting, define the anatomical structures involved, and assess the impact on cardiac chamber size and function. Other imaging modalities, such as cardiac computed tomography (CT), cardiac magnetic resonance imaging (MRI), or ascending aortography may play a role in the diagnosis as well.⁶ The definitive treatment of a ruptured SOVA is surgical excision of the aneurysm and repair with either primary or patch closure.⁷

Pulmonary hypertension (PH) is a known and often ominous complication in adults with CHD and left-to-right shunting. While more common etiologies of left-to-right shunting such as atrial or ventricular septal defects (ASD, VSD) prevail,⁸ the literature associating ruptured SOVA with PH is scarce.^{9,10} Here, we present a case of a ruptured congenital right SOVA fistulizing into the right atrium (RA) and associated with reversible, flow-induced PH that resolved after surgical management.

Case description

A 30-year-old male construction worker with no notable past medical history presented to the emergency department with a background of two years of exertional chest discomfort and overnight nausea, diaphoresis, and chest pain at rest that was atypical for angina. Apart from a three pack-year cigarette

Corresponding author:

Ryan Davey, Division of Cardiology, Department of Medicine, University Hospital, London Health Sciences Centre, University of Western Ontario, 339 Windermere Road, London, ON N6A5A5, Canada.

Email: ryan.davey@lhsc.on.ca



Creative Commons Non Commercial CC-BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<http://www.creativecommons.org/licenses/by-nc/4.0/>)

which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

© The Author(s) 2018.

Reprints and permissions:
sagepub.co.uk/journalsPermissions.nav
journals.sagepub.com/home/pul



smoking history, he did not have risk factors for atherosclerotic coronary artery disease, nor did he have identifiable risk factors for infective endocarditis. Low-dose acetylsalicylic acid had recently been prescribed by his family physician and he was intermittently taking ibuprofen as needed for chest pain relief. He denied symptoms of dyspnea, orthopnea, paroxysmal nocturnal dyspnea, leg swelling, weight gain, abdominal discomfort, and increased abdominal girth, and constitutional symptoms were absent.

On initial examination, he appeared comfortable and could speak in full sentences. Vital signs revealed a temperature of 37.2°C, left brachial artery blood pressure of 136/74 mmHg with no significant difference contralaterally, regular pulse of 123 bpm, respiratory rate of 16/min, and peripheral oxygen saturation of 97% on room air. Physical examination was remarkable for a loud, continuous murmur across the precordium but best heard at the left lower sternal border. There were no signs of heart failure, breath sounds were vesicular and equal bilaterally, and there were no features consistent with Marfan or Ehlers-Danlos syndromes.

Laboratory investigations revealed a borderline neutrophil-predominant leukocytosis, while hemoglobin, platelet count, electrolytes, urea, and creatinine were within normal limits. High sensitivity troponin T was minimally elevated but did not follow an acute coronary syndrome infarct pattern with serial testing. Blood cultures and serum VDRL serology were negative. A 12-lead surface electrocardiogram showed sinus tachycardia and met criteria for right atrial enlargement. Initial chest radiography revealed an enlarged cardiac silhouette and a focal right upper lobe opacification that resolved with repeat imaging before hospital discharge.

Transthoracic echocardiography revealed normal left ventricular systolic and diastolic function with an ejection fraction of 57% by the modified Simpson's method. The right ventricle (RV) was moderately dilated with qualitatively reduced systolic function, though tricuspid annular plane systolic excursion (TAPSE) and peak systolic excursion velocity (S') were within normal limits at 2.2 cm and

13 cm/s, respectively. Interventricular septum flattening was observed throughout the cardiac cycle (Fig. 1a) but predominantly during systole. Tricuspid regurgitation was severe (Fig. 1b), with a Doppler signal suggestive of severe PH. Right atrial pressure was severely elevated as estimated by inferior vena cava assessment (Fig. 1c). An agitated saline “bubble” contrast study demonstrated a large right SOVA that produced a filling defect in the RA (Fig. 2). Color Doppler established communication of this SOVA with the RA, suggesting rupture, with the color jet entering the RV through the tricuspid valve, likely contributing to contamination of the tricuspid regurgitation Doppler signal and overestimation of the peak velocity of 5.2 m/s (Fig. 1b). There was no associated aortic regurgitation, ASD, VSD, or valvular vegetations. A contrast-enhanced cardiac gated multidetector CT scan showed a bicuspid aortic valve and a ruptured right SOVA with aorto-atrial communication immediately proximal to the tricuspid valve (Fig. 3). In addition, right atrial and right ventricular enlargement was

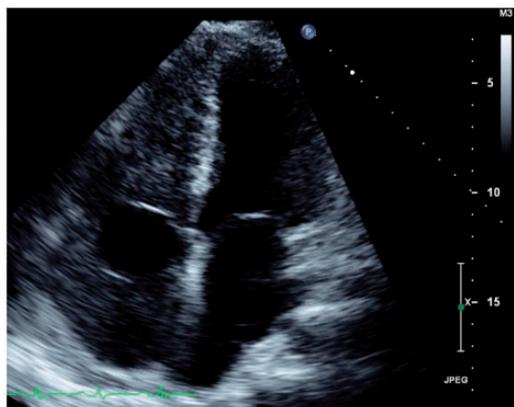


Fig. 2. Apical four-chamber view after intravenous injection of agitated saline contrast demonstrating opacification of the right atrium and ventricle and sinus of Valsalva aneurysm represented by a right atrial filling defect.

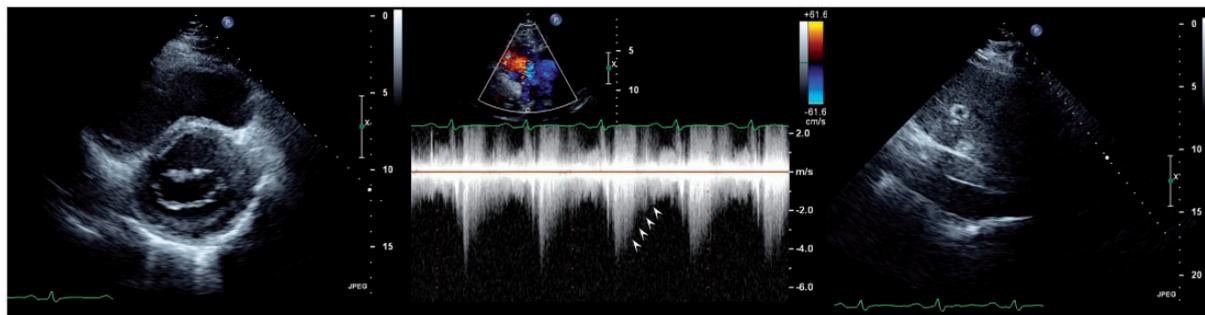


Fig. 1. Echocardiogram illustrating (a, left panel) a “D-shaped” interventricular septum in parasternal short-axis view at the mitral valve level, (b, middle panel) severe tricuspid regurgitation suggested by “V-wave cutoff sign” (arrowheads) in parasternal long-axis right ventricular inflow view with continuous wave spectral Doppler, and (c, right panel) subcostal view of dilated inferior vena cava (2.9 cm) that did not collapse > 50% with sniff (not shown), all consistent with PH.

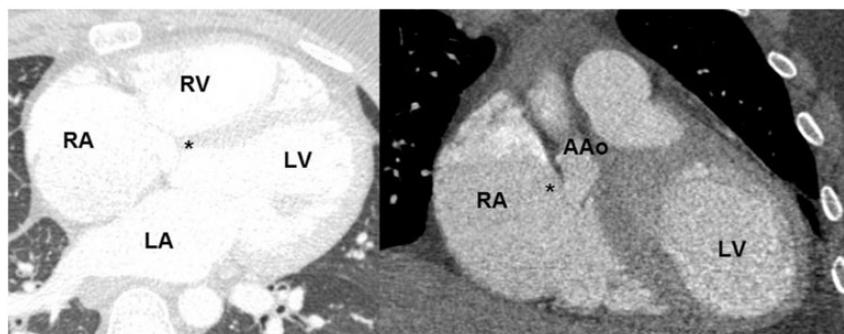


Fig. 3. CT cross-sections showing fistulization of right SOVA into the right atrium (asterisk) in (a, left panel) transverse and (b, right panel) coronal planes. RA, right atrium; RV, right ventricle; LA, left atrium; LV, left ventricle; AAo, ascending aorta.

again noted, and coronary anatomy was normal with no evidence of luminal coronary artery disease.

The patient was referred to cardiothoracic surgery, who requested a right heart catheterization (RHC) due to perioperative concerns regarding the severity of PH suggested by echocardiography. Invasive hemodynamic assessment performed via right heart Swan-Ganz catheterization at end expiration revealed a mean RA pressure of 17 mmHg (v-wave 27 mmHg), RV systolic pressure of 52 mmHg, RV end diastolic pressure of 17 mmHg, pulmonary artery pressure (PAP) of 52/32 mmHg, with a mean PAP (mPAP) of 38 mmHg, mean pulmonary capillary wedge pressure (PCWP) of 23 mmHg (v-wave 28 mmHg), and cardiac output (CO) of 4.81 L/min by assumed Fick determination. Transpulmonary gradient was 15 mmHg, diastolic pressure gradient was 9 mmHg, and calculated pulmonary vascular resistance (PVR) was 1.0 Wood units (WU) using the calculated pulmonary flow (Q_p) of 14.5 L/min. An oximetry run demonstrated the following oxygen saturations: inferior vena cava 61%, superior vena cava 61%, high RA 75%, mid RA 73%, low RA 72%, high and mid RV 85%, low RV 86%, and main pulmonary artery 82%. Assumed systemic arterial saturation was 93% and pulmonary to systemic flow ratio (Q_p/Q_s) was 3.0 with the caveat that assumed systemic arterial saturation introduced a potential source of error in the shunt ratio calculation.

The patient subsequently underwent pericardial patch repair after excision of the ruptured aneurysm and its associated windsock deformity. Perioperative transesophageal echocardiography (Figs. 4 and 5) demonstrated aneurysmal dimensions of 35 × 28 mm in the major and minor axes and a maximum fistula neck dimension of 11 mm, concordant with prior CT imaging. Color flow Doppler post intervention did not demonstrate flow into the RA from the sinus of Valsalva.

When assessed in clinical follow-up three months post-operatively, the patient was entirely asymptomatic despite maintaining an active lifestyle, and repeat transthoracic echocardiography revealed normal RV size and function and normal RA size and pressure estimate. Only trace

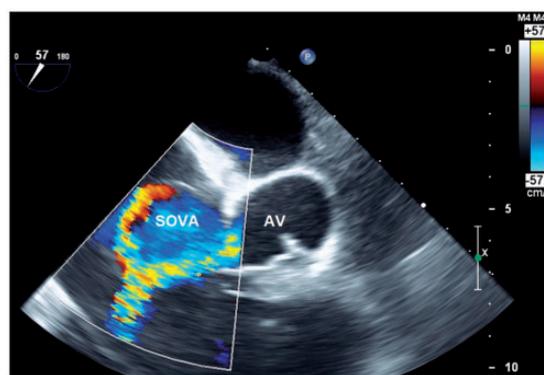


Fig. 4. Transesophageal echocardiogram in mid-esophageal aortic valve short axis view with color flow Doppler imaging depicting right SOVA communicating with the right atrium.

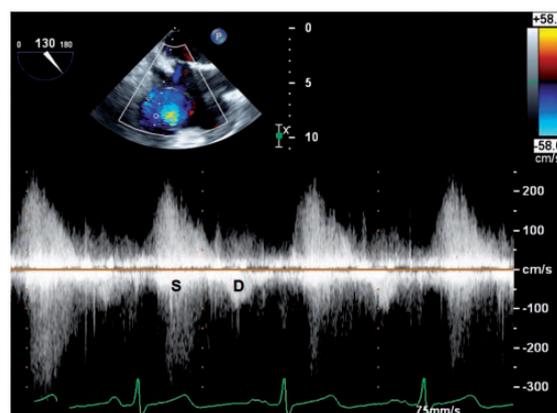


Fig. 5. Continuous wave spectral Doppler demonstrating continuous flow into the right atrium due to a persistent trans-aneurysmal gradient throughout the cardiac cycle. S, systole; D, diastole.

tricuspid regurgitation was observed, systolic PAP was estimated at 25 mmHg, no interventricular septum flattening was noted, and there was no residual aorto-atrial shunting. Repeat RHC demonstrated a mean RA pressure of 7 mmHg, RV systolic pressure 33 mmHg, RV end diastolic

pressure 7 mmHg, PAP of 30/16 mmHg with a mPAP of 22 mmHg, mean PCWP of 12 mmHg, and normal CO by assumed Fick (6.17 L/min). Calculated PVR was 1.62 WU. Blood oximetry showed oxygen saturations of 78–79% in the superior vena cava, RA, RV, and pulmonary artery, an assumed systemic arterial saturation of 100%, and calculated Q_p/Q_s was 0.99.

Informed consent was obtained for publication of this case report.

Discussion

Patients with CHD who develop PH are known to develop characteristic histopathologic changes in the pulmonary vasculature, including neointimal fibrosis, medial hypertrophy, and plexiform lesions,¹¹ the latter considered pathognomonic for pulmonary arterial hypertension. Though the molecular mechanisms are incompletely understood, increased pulmonary blood flow has been identified as a key mediator in this process.¹² Experimental animal data have revealed detrimental effects of increased pulmonary blood flow on morbidity and mortality that are independent of increases in PAP. Using rats injected with monocrotaline as models for an isolated increase in PAP, Van Albada et al.¹³ showed that monocrotaline-treated rats with iatrogenic aortocaval shunts had worse outcomes than their non-shunted counterparts with similar PAP. Shunted rats displayed increased RV hypertrophy, pulmonary-to-systemic artery pressure ratios, and rates of sacrifice due to debilitating dyspnea or significant weight loss. It is unknown whether increased pulmonary blood flow, independent of PAP, is similarly a negative prognosticator in humans.

Although calculated PVR was < 3 WU, preoperative hemodynamic assessment was consistent with the 2015 European Society of Cardiology/European Respiratory Society hemodynamic definition of combined pre- and post-capillary PH,¹⁴ as supported by a mean PCWP > 15 mmHg and diastolic pressure gradient > 7 mmHg in the setting of a mPAP > 25 mmHg. Because our case involved significant systemic-to-pulmonary shunting, CO determination by thermodilution technique and use in PVR and left-to-right shunt calculations is inappropriate due to its potential for CO overestimation. Moreover, the presence of significant concomitant tricuspid regurgitation introduces another potential source of inaccurate thermodilution CO measurements. For these reasons, the assumed Fick method for CO determination was utilized for PVR and shunt flow ratio calculations.

The absence of identifiable left-sided heart disease and normalization of PCWP on repeat assessment postoperatively confirm augmented pulmonary venous return as the cause of the elevated PCWP. Interestingly, while our “shunt run” suggested a significant oxygen saturation step-up at both the level of the RA and RV, this is most likely explained by incomplete arterio-venous mixing in the RA as the shunt flow was directed towards the RV at its entry point just proximal to the tricuspid valve. The striking

increase in oxygen saturation between RA and RV would have been challenging to reconcile without precise anatomic correlation, highlighting the importance of multimodality imaging in this case.

While our case is typical in terms of its anatomic features, patient demographics, classic precordial murmur, and associated aortic valve morphologic abnormality,¹⁵ flow-induced PH in this context is exceptionally rare. PH has been reported in a patient with ruptured SOVA and Gerbode defect⁹ and separately in a case of Shone’s complex with an unruptured SOVA, subaortic VSD with left-to-right shunt, bicuspid aortic valve, patent ductus arteriosus, and persistent left superior vena cava.¹⁰ To our knowledge, however, our case is the first to report PH solely attributed to systemic-to-pulmonary shunting and a hyperdynamic pulmonary circulation from a ruptured SOVA. Moreover, while reversibility of PH with improvement in functional status after cessation of excessive pulmonary blood flow has been demonstrated in CHD patients with percutaneously occluded ASDs,¹¹ our report showcases this reversibility with a unique pathology. Although we could not find an obvious date or precipitant for SOVA rupture or monitor its hemodynamic effects over time, the duration of symptomatology suggests a prolonged process. Similar to what has been shown with ASD shunt closure, our case showed reversibility, and indeed normalization, of PAP in flow-induced PH following shunt repair, though we are hindered by our single example and lack of histopathologic correlation.

Acknowledgments

The authors thank Dr. Ian Chan from the Division of Radiology, Department of Medical Imaging, University of Western Ontario, for his assistance in the selection of CT images.

Conflict of interest

The authors declare that there is no conflict of interest.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

References

1. Bass D and Bhimji SS. Aneurysm, sinus of Valsalva. StatPearls [Internet]. Treasure Island, FL: StatPearls Publishing, 2017.
2. El-Ashry A and Estrera AL. Patch repair of an isolated right sinus of Valsalva aneurysm. *Ann Thorac Surg* 2016; 101: e199–201.
3. Rosero-Britton BR, Nguyen A, Warsame I, et al. Incidental finding of an aorto-right atrial fistula in a patient undergoing repair of a sinus of Valsalva aneurysm. *Front Med* 2017; 4: 95.
4. Perera NK, Galvin SD, Farouque O, et al. Aortic to right atrial fistula secondary to chronic ruptured sinus of Valsalva aneurysm. *Heart Lung Vessel* 2015; 7: 260–262.
5. Ott DA. Aneurysm of the sinus of Valsalva. *Semin Thorac Cardiovasc Surg Pediatr Card Surg Ann* 2006; 9: 165–176.

6. Abdelsalam M, Bachinsky W, Pawlusch D, et al. Noncoronary sinus of Valsalva aneurysm rupture into right atrium. *Tex Heart Inst J* 2013; 40: 493–494.
7. McGregor P, Temtanakitpaisan Y, Hiltbolt A, et al. A spectrum of sinus of Valsalva aneurysm-from the young to the old. *Echocardiography* 2017; 34: 1524–1530.
8. Giannakoulas G and Gatzoulis MA. Pulmonary arterial hypertension in congenital heart disease: current perspectives and future challenges. *Hellenic J Cardiol* 2016; 57: 218–222.
9. Coelho R, Pannu HS, Thakurta SG, et al. Ruptured aneurysm sinus of Valsalva and Gerbode defect with severe tricuspid and aortic regurgitation: a case report and its surgical correction. *J Cardiovasc Surg* 1997; 38: 531–533.
10. Ganju NK, Kandoria A, Thakur S, et al. A constellation of cardiac anomalies: beyond Shone's complex. *Heart Views* 2016; 17: 23–26.
11. Hsu CH, Roan JN, Wang JN, et al. Hemodynamic, biological, and right ventricular functional changes following intraatrial shunt repair in patients with flow-induced pulmonary hypertension. *Congenit Heart Dis* 2017; 12: 533–539.
12. Van Albada ME, Bartelds B, Wijnberg H, et al. Gene expression profile in flow-associated pulmonary arterial hypertension with neointimal lesions. *Am J Physiol Lung Cell Mol Physiol* 2010; 298: L483–L491.
13. Van Albada ME, Schoemaker RG, Kemna MS, et al. The role of increased pulmonary blood flow in pulmonary arterial hypertension. *Eur Respir J* 2005; 26: 487–493.
14. Galiè N, Humbert M, Vachiery JL, et al. 2015 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Heart J* 2016; 37: 67–119.
15. Budts W, Moons P, Mertens L, et al. Ruptured aneurysm of the sinus of Valsalva into the right atrium. An uncommon congenital heart defect. *Acta Clinica Belgica* 2003; 58: 94–96.