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MINI-FOCUS ISSUE ON VALVULAR HEART DISEASE

INTERMEDIATE

CASE REPORT: CLINICAL CASE

Stabbed Through the Heart

An Unusual VSD Presentation

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ABSTRACT

Traumatic ventricular septal defects due to penetrating cardiac injury are uncommon. Transthoracic echocardiography is an essential tool in diagnosis. Options for closure include either surgical or percutaneous repair. We present a case of a trauma-related ventricular septal defect in a young patient that was successfully repaired by using a percutaneous approach. (**Level of difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2020;2:559–64) © 2020 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/).

HISTORY OF PRESENTATION

A 21-year-old man presented to the emergency department trauma center at the University of Chicago following an altercation, at which time he incurred >20 stab wounds from a 5-inch blade. On arrival, his airway and breathing were intact, and his Glasgow Coma Score was 13. The patient remained hemodynamically stable with a blood pressure on arrival of 111/83 mm Hg, pulse of 97 beats/min, and respiratory rate of 18 breaths/min. The physical examination was notable for 1 penetrating stab wound to the anterior mid-sternum, 8 stab wounds to the posterior and lateral neck, 5 stab wounds to the posterior back, and 5 stab wounds to the left hand.

LEARNING OBJECTIVES

- To understand the importance of 2D and 3D echocardiography in diagnosing VSDs and guiding VSD closure procedures.
- To appreciate the differences between trauma-related and post-infarction VSDs, both in terms of structure and management.

MEDICAL HISTORY

The patient had no significant medical history.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis for this patient with a penetrating stab wound to the chest included cardiac contusion, pulmonary contusion, tracheobronchial injury, pneumothorax, cardiac tamponade, penetrating cardiac injury, hemothorax, diaphragmatic injury, esophageal injury, pneumomediastinum, pneumopericardium, and traumatic aortic dissection.

INVESTIGATIONS

A focused assessment with echocardiography revealed a pericardial effusion. The patient was tachycardic with a narrow pulse pressure. He was taken emergently to the operating room

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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 *JACC: Case Reports* author instructions page.

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ABBREVIATIONS AND ACRONYMS

2D = 2-dimensional

3D = 3-dimensional

LV = left ventricular

RV = right ventricular

TTE = transthoracic echocardiogram

VSD = ventricular septal defect

for sternotomy where a penetrating right ventricular (RV) wound was repaired and a large mediastinal hematoma was evacuated. Post-operatively, the patient remained persistently tachycardic, and thus a repeat transthoracic echocardiogram (TTE) was performed revealing a large ventricular septal defect (VSD) in the muscular portion of the intraventricular septum with significant left-to-right shunting, RV dilation, and reduced RV systolic function (Figure 1).

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MANAGEMENT

After a multidisciplinary evaluation involving cardiac surgery and interventional cardiology, a decision was made to attempt percutaneous closure of the VSD in the patient. He was brought to the catheterization laboratory on day 5 of hospitalization, at which time a transesophageal echocardiogram with 2-dimensional (2D) and 3-dimensional (3D) imaging was performed, showing a slit-like VSD in the muscular portion of the interventricular septum (Figure 2).

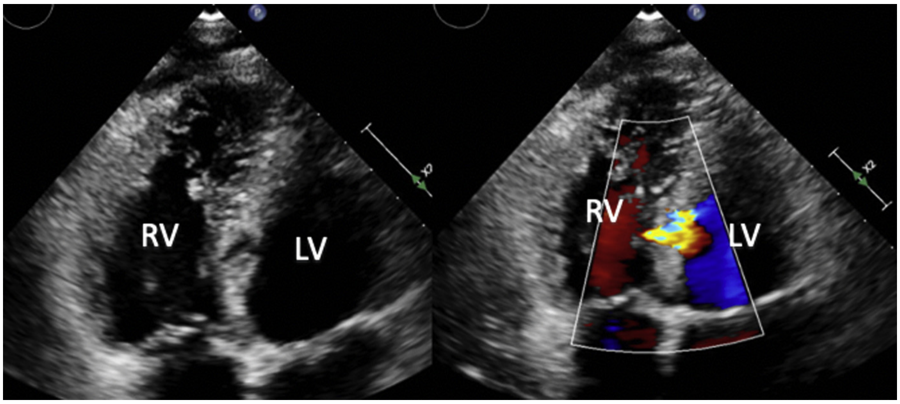
Right femoral arterial access and right internal jugular venous access were obtained. From the right femoral arterial sheath, a 6-F JR4 catheter was advanced over a 0.035-inch wire into the left ventricle. A 0.035-inch × 260 cm Glidewire Advantage (Terumo, Somerset, New Jersey) wire was used to cross the VSD and was advanced into the left pulmonary artery. A 10-mm Goose Neck Snare (Medtronic, Minneapolis, Minnesota) was used to snare the Glidewire via the right internal jugular, and the wire was externalized. A Navicross catheter (Terumo, Somerset, New Jersey) was loaded on the Glidewire and advanced via the right internal jugular and placed in the descending aorta. The Glidewire was removed and replaced with a 0.035-inch × 300 Amplatzer wire (Abbott Vascular, Santa Clara, California). A 9-F TorqVue catheter (Abbott Vascular) was advanced over the wire and placed in the left ventricle. An 18-mm muscular VSD occluder (Abbott Vascular) was deployed across the defect (Figure 3). Once adequate position was confirmed, the device was released (Figure 4).

DISCUSSION

This case illustrates an example of penetrating trauma resulting in a defect in the muscular portion of the intraventricular septum, in this case secondary to a stab wound, which was successfully closed by percutaneous repair. Traumatic VSDs comprise a small percentage of total VSD cases, with an incidence of 1% to 5% of cases of penetrating cardiac injury (1). Other etiologies of acquired VSD include complications of acute myocardial infarction, surgical and transcatheter aortic valve replacement, and septal myectomy.

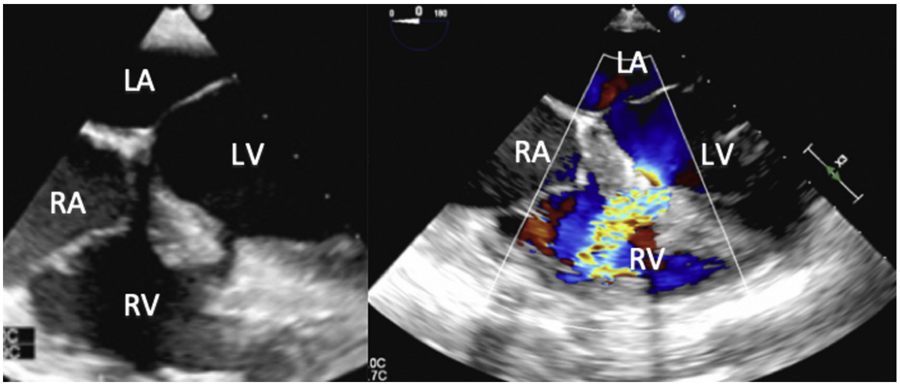
The treatment for traumatic VSD has historically been based on a combination of heart failure symptoms, hemodynamics (most commonly a pulmonary flow/systemic flow ratio ≥1.5), and defect size. A large VSD of >10 mm in diameter requires closure as soon as possible because of the high likelihood of developing congestive heart failure (2). In the case of our patient, the size of the VSD orifice was 1.2 × 0.6 cm,

FIGURE 1 **2-Dimensional Transthoracic Echocardiogram**



Two-dimensional transthoracic echocardiogram from apical 4-chamber view demonstrating a slit-like muscular ventricular septal defect **(left)** with color Doppler demonstrating left-to-right shunt **(right)**. LV = left ventricle; RV = right ventricle.

FIGURE 2 **2-Dimensional Transesophageal Echocardiogram With and Without Color Doppler**



Two-dimensional transesophageal echocardiogram from modified 4-chamber view demonstrating a slit-like muscular ventricular septal defect **(left)** with color Doppler demonstrating left-to-right shunt **(right)**. LA = leftr atrium; RA = right atrium; other abbreviations as in Figure 1.

thus meeting criteria for a large VSD. Given the patient's critical illness, a pulmonary flow/systemic flow ratio was not obtained; however, the gradient across the VSD was 55 mm Hg, and there was evidence of RV dilation (RV:left ventricular [LV] ratio of 1.2:1), suggesting a hemodynamically significant left-right shunt.

Options for VSD closure include either surgical or percutaneous repair. Percutaneous transcatheter closure of muscular and post-infarct VSDs has been previously shown to be an effective treatment option for selected patients with VSD and suitable anatomy; this is specifically true for those with a location remote from the tricuspid and aortic valves with an adequate amount of surrounding tissue to avoid interaction with the subvalvular apparatus (3).

Echocardiography is an essential tool in diagnosing the presence of a VSD, as well as in categorizing the type, location, and degree of severity. 2D TTE is the most frequently used modality for diagnosis of VSDs, with an estimated 85% of cases diagnosed according to echocardiography (4). The parasternal long-axis window allows one to distinguish between muscular, membranous, and infundibular VSDs. The apical views are particularly useful in visualizing inlet VSDs and Gerbode defects. In addition, color and spectral Doppler help to determine the degree of shunt severity, the presence or absence of volume overload and chamber enlargement, and complications related to VSDs, including aortic regurgitation and pulmonary hypertension.

In recent years, 3D echocardiography has helped to visualize VSDs more accurately by using 3D full volume with cropping and narrow-sector live 3D imaging with color. The feasibility of both transthoracic and transesophageal 3D echocardiography to demonstrate diagnostic-quality en face views of VSDs was reported in 100 patients with a wide variety of VSD types (including muscular, peri-membranous, and acquired). In all patients, the type, size, and location of the VSD were shown accurately with 1 of 3 protocols: full-volume mode with iCrop, full-volume standard mode, or narrow-sector live 3D mode, with success

FIGURE 3 **Percutaneous VSD Occluder**

Amplatzer Muscular VSD Occluder (Abbott Vascular, Santa Clara, California).

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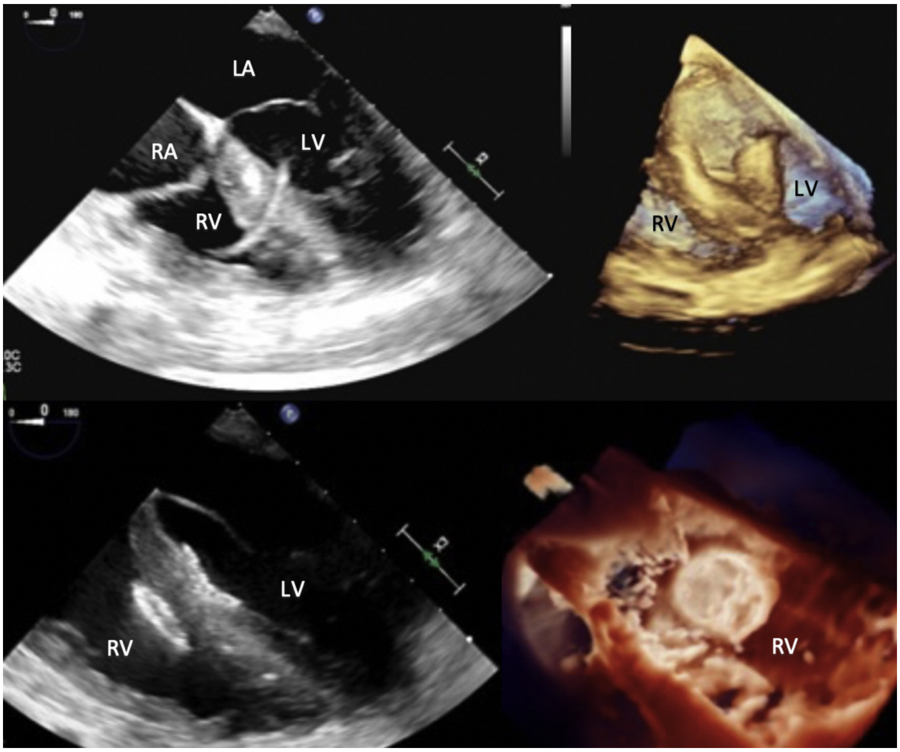
FIGURE 4 Intraprocedural Transesophageal Echocardiogram



Intraprocedural transesophageal echocardiogram (TEE) from a modified 4-chamber view showing the Amplatzer delivery catheter across the ventricular septal defect **(top left)**; 3D echocardiography showing deployment of the Amplatzer VSD Occluder **(top right)**; TEE showing the Amplatzer occluder device post-deployment **(bottom left)**; 3D TEE with transillumination showing the post-procedure Amplatzer device from the perspective of the RV **(bottom right)**. Abbreviations as in Figures 1 and 2.

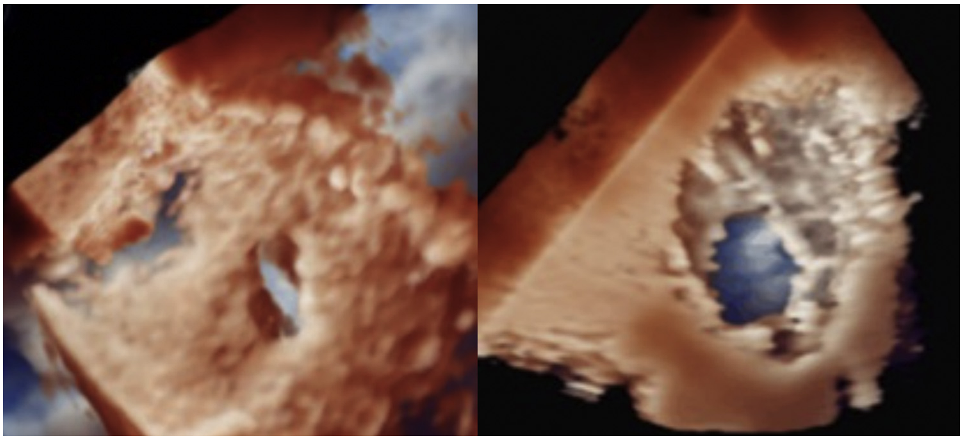
rates between 94% and 100% (5). Transillumination is a new 3D rendering tool (Philips, Amsterdam, the Netherlands) that uses a freely movable virtual light to enhance image details and depth perception; this tool was useful in the visualization of our patient's VSD (**Figure 4**, Video 1) (6). The VSD was also visualized by using the transparent glass feature on 3D echocardiography, with color Doppler showing a significant left-right shunt (Video 2).

The management of the aforementioned case of a traumatic VSD secondary to penetrating cardiac injury differs from the recommended treatment for a post-infarction VSD. Historically, the recommended treatment for post-infarction VSDs has been emergent primary surgical repair with concurrent coronary artery bypass grafting, regardless of hemodynamic status (7). However, because of the soft and friable nature of the post-infarct tissue, it has been proposed that delayed surgical repair is preferred to allow the tissue edges surrounding the VSD to undergo myocardial fibrosis, which results in more favorable surgical conditions (8).

Although there is limited literature about the optimal timing for traumatic VSD closure, several patients with knife-related VSDs have undergone successful percutaneous closure in the days following surgical repair of the right ventricle due to large VSD size or hemodynamically significant shunt (9). Large VSDs (>10 mm in diameter) such as that seen in our patient require closure as soon as possible to prevent further hemodynamic complications (2).

The difference in the nature of the surrounding myocardial tissue in a traumatic VSD compared with a post-infarction VSD is illustrated in **Figure 5**, where 3D echocardiography is used to contrast the intact surrounding myocardium in our patient compared with the friable and spongy tissue surrounding the post-infarction VSD.

FIGURE 5 **Traumatic Versus Post-Infarction VSD**



Three-dimensional echocardiography with transillumination demonstrating the slit-like ventricular septal defect (VSD) and intact surrounding myocardium of our patient with traumatic VSD from a stab wound **(left)** contrasted with the friable and spongy tissue of a post-infarction VSD **(right)**.

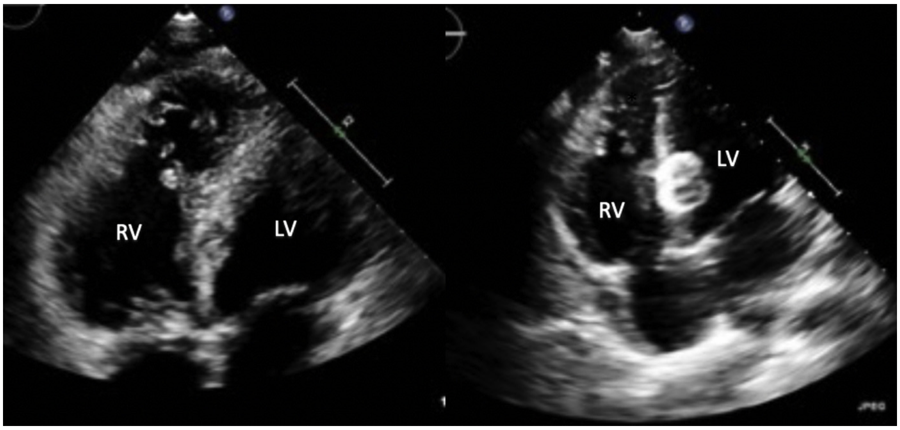
FOLLOW-UP

A follow-up TTE depicted a well-positioned occluder device with no evidence of peri-device flow. Of note, the patient's RV dilation improved after percutaneous closure compared with his initial presentation 2 weeks earlier (Figure 6). The patient was subsequently discharged home in stable condition.

CONCLUSIONS

Traumatic VSDs should be ruled out with TTE in all cases of penetrating cardiac injury. Percutaneous VSD closure with a muscular VSD occluder device is a feasible treatment option for patients with suitable anatomy, as shown in the case of our patient. TTE remains the primary method for diagnosing VSDs. 3D

FIGURE 6 **Transthoracic Echocardiogram Pre- and Post-Percutaneous VSD Occluder**



Transthoracic echocardiogram at presentation from the apical 4-chamber view showing muscular VSD with moderately dilated RV **(left)** compared with the post-procedural transthoracic echocardiogram with the Amplatzer VSD Occluder in place. A smaller, mildly dilated RV after successful VSD closure and improvement in degree of left-right shunting **(right)** can be seen. Abbreviations as in Figures 1 and 5.

echocardiography and transillumination are useful tools in delineating the shape and size of VSDs and serve as useful adjuncts to 2D TTE and trans-esophageal echocardiogram in providing intra-procedural echocardiographic guidance for percutaneous VSD closure.

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KEY WORDS echocardiography, imaging, occluder, three-dimensional imaging, ventricular septal defect

APPENDIX For supplemental videos, see the online version of this paper.