

# Ventricular Septal Defect Occluder Device causing Left Ventricular Outflow Tract Obstruction

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## Abstract

The American Heart Association recommends percutaneous transcatheter device closure in patients with muscular or perimembranous ventricular septal defects (VSDs) who have suitable anatomy and a hemodynamically significant left to right shunt with left heart volume overload. Device related complications may include vascular injury, infection, conduction disturbances, residual shunt, hemolysis, and device embolization. Left ventricular outflow tract (LVOT) obstruction after percutaneous VSD closure is a known but less common complication, occurring when the occluder device or surrounding tissue narrows the LVOT. Treatment options for significant LVOT obstruction include percutaneous strategies, such as device repositioning or balloon dilation, as well as surgical revision. Surgical strategy for occluder-associated LVOT obstruction is to remove the occluder and close the VSD. We describe here a novel technique to relieve the LVOT obstruction when removal of the occluder device was not possible.

**Key Words:** subaortic ventricular septal defect; device closure; left ventricular outflow tract obstruction

## Introduction

Ventricular septal defect (VSD) is a common congenital heart defect, and among its various types, the perimembranous (or subaortic) type accounts for about 70%, followed by muscular, inlet, and outlet septal defects. The American Heart Association (AHA) recommends percutaneous transcatheter device closure in patients with muscular or perimembranous VSD, who have suitable anatomy, hemodynamically significant left to right shunt (Qp: Qs  $\geq$  2) with left heart volume overload. [1] Defects considered for transcatheter closure must be anatomically favorable for device implantation, with adequate space to avoid injury to surrounding structures such as the aortic and atrioventricular valves.

Device-related complications may include vascular injury, infection, conduction disturbances, residual shunt, hemolysis, and device embolization. Left ventricular outflow tract (LVOT) obstruction after percutaneous VSD closure is a known but less common complication, occurring when the occluder device or surrounding tissue narrows the LVOT. Echocardiography is essential for visualizing the occluder device, measuring LVOT dimensions, and assessing pressure gradients. Surgical strategy for occluder-associated LVOT obstruction is to remove the occluder and close the VSD. In this case, the removal of the occluder device without damaging the neighboring structures was not possible because of the extensive adhesions around the occluder. We describe here a novel technique to relieve the LVOT obstruction.

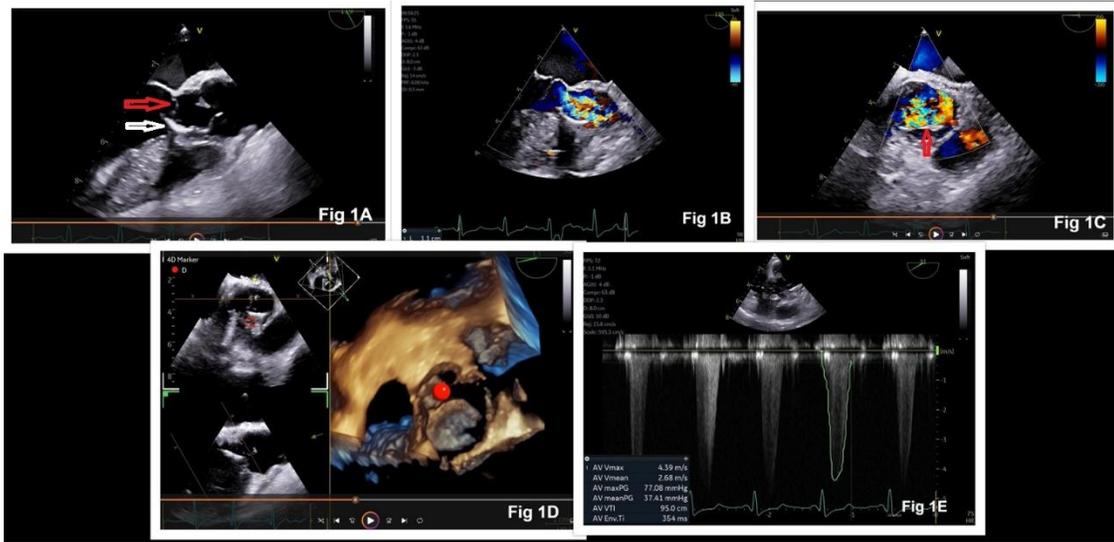
## Case Report

A 22-year-old female presented with a two-year history of shortness of breath and chest pain radiating to the left arm (New York Heart Association class III). Her past history included device closure of a large subaortic VSD 9 years ago, by using the Amplatzer Duct Occluder II device (St. Jude Medical, St. Paul, MN). Further details of the occluder device and the procedure were not available. All laboratory tests and chest X-ray were normal. Echocardiography showed situs solitus, levocardia, normal systemic and pulmonary venous drainage, atrioventricular and ventriculo-arterial concordance, an intact interatrial septum, and a VSD occluder device seen in the subaortic position. The left disk of the occluder device was causing severe LVOT obstruction. The aortic valve was trileaflet with mildly thickened aortic cusps, mild aortic regurgitation, and no valvular aortic stenosis. Additionally, there was membranous tissue seen below the aortic valve, causing turbulent blood flow. The peak and mean pressure gradients at the LVOT (subvalvular) level were 108/71 mmHg, respectively. The LV had mild concentric hypertrophy with normal systolic function. The rest of the valves and cardiac structures were normal.

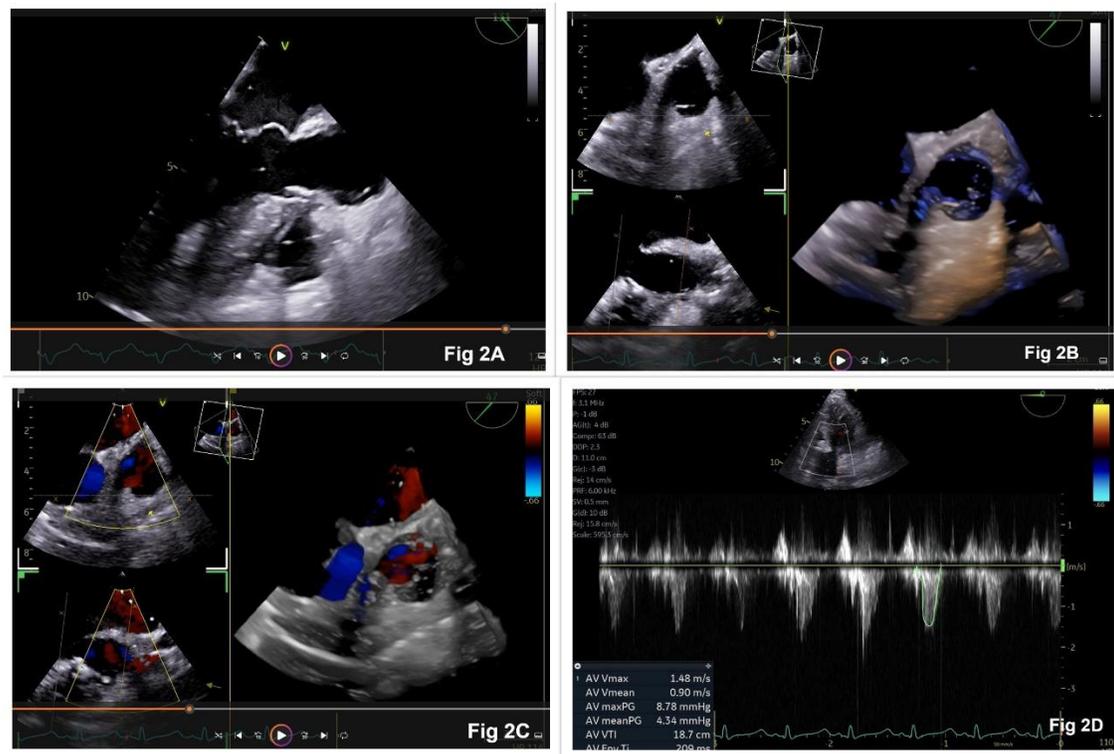
The surgical plan was the extrusion of the VSD occluder device and closure of the VSD using cardiopulmonary bypass (CPB). Informed consent was obtained. Under standard cardiac monitoring, general anesthesia was

induced and a transesophageal echocardiography (TEE) probe (6 VT-D transducer, Vivid E95 GE) was inserted. Intraoperative TEE confirmed the preoperative echocardiographic findings and showed significant narrowing of the LVOT (Figure 1A-1D). LVOT gradient measured during intraoperative TEE was 77/37 mmHg (Figure 1E). The surgical procedure consisted of a midline sternotomy, systemic heparinization, bicaval and aortic cannulation, and institution of CPB. During surgery, the VSD occluder device was found to be tightly adherent to the LVOT and the interventricular septum. A forceful extrusion of the device could have led to damage to the

aortic valve, the LVOT, the interventricular septum, and other neighboring structures. It could even have led to the formation of an iatrogenic VSD. Therefore, the surgeons decided to remove the left disk of the VSD occluder device by performing its debulking with Rongeur forceps and reassess the relief of LVOT obstruction. The subaortic membrane was resected. After coming off CPB, TEE showed LVOT pressure gradients of 8/4 mmHg (peak/mean), trace aortic regurgitation, a VSD device in situ, and no residual VSD shunt (Figure 2A-2D). The remaining surgical procedure and the postoperative course were unremarkable.



**Figure 1:** Intraoperative transesophageal echocardiographic images showing occluder device obstructing the left ventricular outflow tract {LVOT} (white arrow), subaortic membrane (red arrow, Figure 1A), narrow LVOT (1.1 cm, Figure 1B), turbulent blood flow in aortic valve (Figure 1C), occluder device in LVOT in 3D view (Figure 1D), and pressure gradient across LVOT (Figure 1E)



**Figure 2:** Postoperative transesophageal echocardiographic images showing wide open left ventricular outflow tract (LVOT, Figure 2A), absence of occluder device in LVOT (Figure 2B), no turbulence in LVOT (Figure 2C), and low pressure gradient across LVOT (Figure 2D)

## Discussion

LVOT obstruction after percutaneous VSD closure is a known but less common complication, occurring when the occluder device or surrounding tissue narrows the LVOT, leading to symptoms like chest pain, shortness of breath, fatigue, dizziness, or syncope. This obstruction often happens due to the device's placement near the septum or increased septal wall thickness, but it can also relate to the anatomical location of the VSD, like subaortic defects, as seen in this patient. VSD is a common congenital heart defect, and among its various types, the perimembranous (or subaortic) type accounts for about 70%, followed by muscular, inlet, and outlet septal defects. The American Heart Association (AHA) recommends percutaneous transcatheter device closure in patients with muscular or perimembranous VSD, who weigh > 5 kg and have a hemodynamically significant left-to-right shunt ( $Q_p: Q_s \geq 2$ ) with left heart volume overload. [1] Though there has also been a considerable growth in understanding, techniques, and devices for percutaneous VSD closure, significant limitations still exist, and surgery remains the preferred treatment strategy in the majority of cases. Defects considered suitable for transcatheter closure must be anatomically favorable for device implantation, with adequate space to avoid injury to surrounding structures such as the aortic and atrioventricular valves. The only FDA-approved transcatheter device is for muscular defects. Transcatheter closure of perimembranous defects is often technically feasible, but has been limited by the risk for conduction abnormalities. Inlet and outlet septal defects are not considered appropriate for device closure. [2]

Device-related complications may include vascular injury, infection, conduction disturbances, residual shunt, hemolysis, and device embolization. [3] Perimembranous VSDs may be in close proximity to the aortic valve; there is also a risk for valve distortion, causing aortic insufficiency. For safe VSD closure using devices, an adequate distance ( $\geq 2$  mm) from the aortic valve ought to be secured. [4] Though LVOT obstruction is an uncommon complication of VSD device closure, it can be attributed to one of the following mechanisms: (i) malposition or protrusion of the device into the LVOT, (ii) an improperly sized device causing impedance to the blood flow at the LVOT, (iii) bulging of the device or septal tissue toward the LVOT, (iv) aortic cusp distortion caused by tension from the device, leading to narrowing of the LVOT, and (v) excessive septal hypertrophy near the VSD device causing narrowing of the LVOT, or (vi) hyperdynamic septal motion in response to device placement, mimicking a dynamic obstruction. LVOT obstruction can also result from the expansion of the anterior-superior region of the occluder's left disk in the LVOT. Anatomic predisposition is another mechanism for causing LVOT obstruction. Certain VSD types, especially those in the subaortic area, such as doubly-committed subarterial VSDs, have a higher inherent risk for causing LVOT obstruction.

Diagnosis of LVOT obstruction must be suspected if there are signs and symptoms of heart failure or the presence of a new murmur. Echocardiography is essential for visualizing the occluder device, measuring LVOT dimensions, and assessing pressure gradients. Preoperative and intraoperative use of TEE is helpful in many ways. In the preoperative period, it is useful (i) to confirm the diagnosis, (ii) to assess the degree of

LVOT obstruction, (iii) to assess any residual VSD shunt, and (iv) to assess any associated congenital heart diseases. Intraoperatively, TEE is useful (i) to guide the surgeons in debulking the VSD device to relieve the LVOT obstruction, (ii) to assess the adequacy of LVOT obstruction relief, and (iii) to confirm the absence of any new or residual shunts.

Treatment options for significant LVOT obstruction include (i) percutaneous strategies such as device repositioning or balloon dilation, or (ii) surgical revision. Surgical strategy for occluder-associated LVOT obstruction is to remove the occluder and close the VSD. In this case, the removal of the occluder device without damaging the neighboring structures was not possible because of the extensive adhesions around the occluder. For this reason, debulking of the left disk of the occluder device was done. In a similar case report, *Topcuoglu et al* found that the VSD device had caused perforation of the right aortic cusp, leading to moderate aortic regurgitation, and surgery was performed by partial occluder resection and the closure of VSD by autologous pericardial patch.<sup>5</sup> *Hosseinsabet* has also reported a case of right ventricular outflow tract (RVOT) obstruction after percutaneous VSD device closure. [6] Accordingly, when VSD closure by device is planned, the possibility of stenosis in a narrowed RVOT should be taken into account. Some devices, like specific patent ductus arteriosus occluders, are designed not to cause LVOT obstruction due to their single-disk structure, making them preferred for certain VSDs.

In conclusion, while percutaneous VSD closure is effective, LVOT obstruction remains a potential concern, particularly with subaortic defects. Careful patient selection, precise device sizing, and thorough post-procedure monitoring with echocardiography are crucial to prevent or manage this complication. With extensive adhesions around the occluder device, debulking of the LV disk can be used to relieve LVOT obstruction.

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