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Transesophageal Echocardiography-guided Minimally Invasive Surgical Device Closure of an Unusually Shaped Residual Ventricular Septal Defect in a Child

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ABSTRACT

Closure of residual ventricular septal defect with an occluder is traditionally performed by a percutaneous transcatheter approach under radiographic guidance. However, this procedure may be of limited use in cases with unusually shaped defects and in patients with low body weight. Here, we report minimally invasive surgical device closure of a 6 mm residual ventricular septal defect under transesophageal echocardiographic guidance, in a patient weighing 10 kg that had previously undergone surgical correction of a double outlet right ventricle. The defect was positioned in the suture line between the Gore-Tex vascular graft and the remnant ventricular septum, and was unusual in that it formed a 135° angle with the Gore-Tex graft. The defect was closed successfully with a 10 mm asymmetric occluder. To the best of our knowledge, this is the first report of transesophageal echocardiography-guided minimally invasive surgical device closure of an unusually shaped residual ventricular septal defect after surgical correction of a double-outlet right ventricle.

INTRODUCTION

Residual ventricular septal defect (R-VSD) is a recognized complication after surgical correction of a double-outlet right ventricle (DORV) [Brown 2001]. Percutaneous transcatheter closure of R-VSD has been reported but remains problematic in cases involving unusually shaped defects and in patients with low body weight [Dua 2010]. Here we describe the use of a new method, transesophageal echocardiography (TEE)-guided minimally invasive surgical device closure, to close an unusually shaped R-VSD after surgical correction of a DORV in a child weighing 10 kg.

CASE REPORT

A 34-month old child weighing 10 kg presented at our hospital with a systolic murmur after surgical correction of a DORV with a 16-mm Gore-Tex vascular graft (G-TVG) between the left ventricle (LV) and aorta. Transthoracic echocardiography revealed an R-VSD measuring 6 mm in diameter positioned in the suture line connecting the G-TVG to the VSD (Figure 1A). Atypically, the R-VSD formed an angle of approximately 135° with the G-TVG.

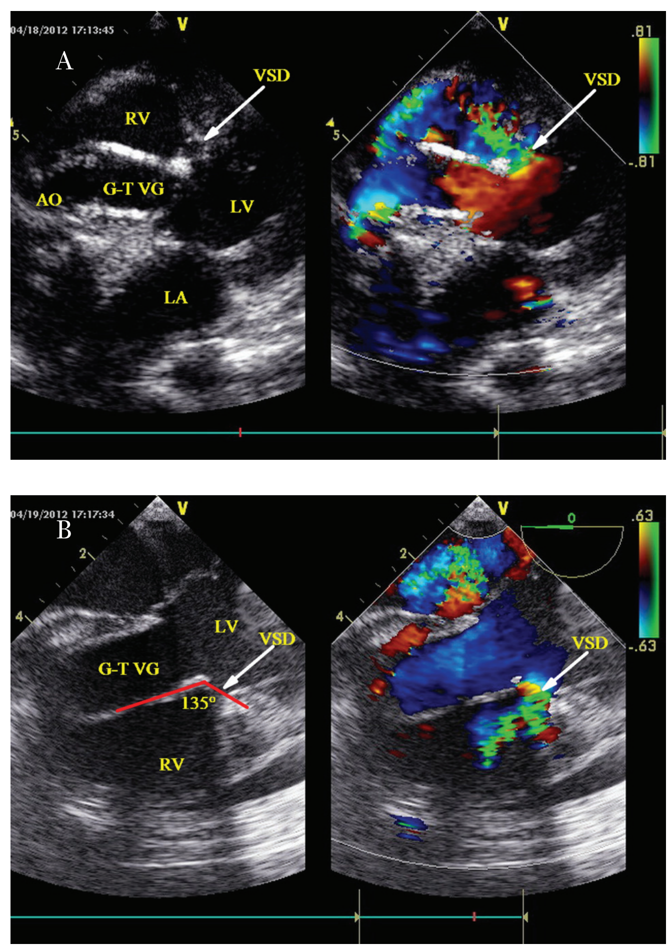

Figure 1. A, Left: Transthoracic echocardiography showing R-VSD after surgical correction of double-outlet right ventricle (arrow). Right: Transthoracic echocardiography showing a significant left-to-right shunt of R-VSD (arrow). B, Left: TEE showing an angle of 135° between the G-T VG and the R-VSD. Right: TEE showing a significant left-to-right shunt of R-VSD (arrow). TEE, transesophageal echocardiography; R-VSD, residual ventricular septal defect; LV, left ventricle; RV, right ventricle; LA, left atrium; G-T VG, Gore-Tex vascular graft; AO, aorta.

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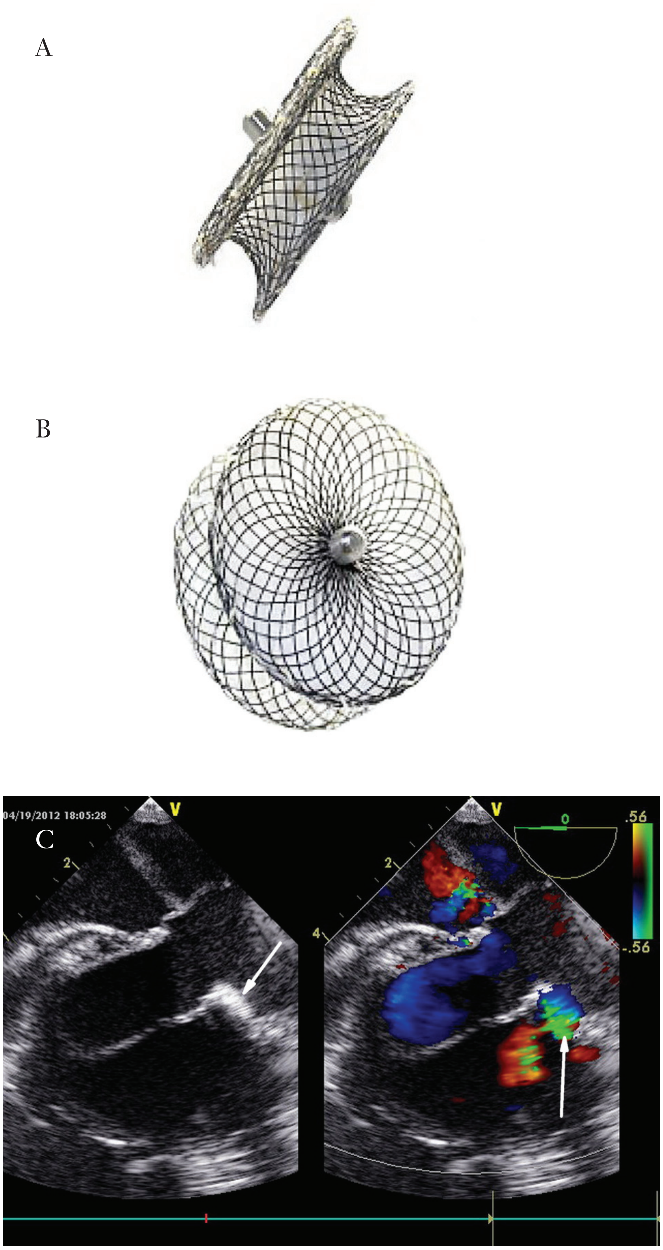

Figure 2. A, Symmetric occluder, side view. B, Symmetric occluder, top view. C, Left: TEE showing the 9 mm ordinary symmetric occluder (arrow). Right: TEE showing a residual shunt at the upper edge of the 9 mm ordinary symmetric occluder (arrow).

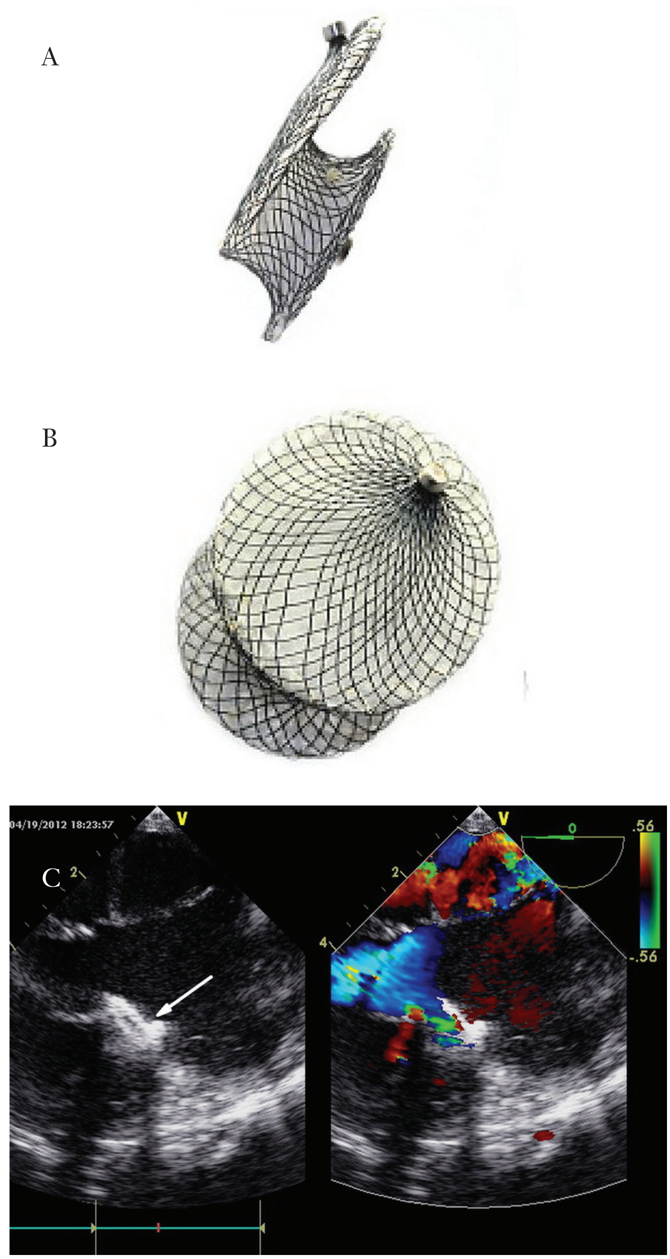

Figure 3. A, Asymmetric occluder, side view. B, Asymmetric occluder, top view. C, Left: TEE showing the 10 mm asymmetric occluder (arrow). Right: TEE confirming that shunting through the R-VSD diminished immediately after deployment of the 10 mm asymmetric occluder.

Informed consent was obtained from the parents, and TEE-guided minimally invasive surgical device closure of the R-VSD was attempted.

General anesthesia was established and the patient placed in a supine position. TEE confirmed the R-VSD formed a 135° angle with the G-T VG (Figure 1B). The right ventricle (RV) was exposed via a 3 cm incision in the inferior sternum. Antibiotic prophylaxis was administered and the patient fully heparinized (1 mg/kg). Under real-time guidance and monitoring by TEE (GE, Vivid 7 Dimension, Horten, Norway), the free wall of the RV was palpated to locate the defect and a purse-string suture placed at this location. A trocar was introduced into the RV within the purse string, and a 0.035 inch guide wire was passed through the trocar into the LV. A 9 Fr delivery sheath was fed over the wire and inserted into the LV. The guide wire was withdrawn and a 9 mm ordinary symmetric occluder, which is concentric with both disks 2 mm larger than the waist (Shanghai Shape Memory Alloy Co., Ltd, Shanghai, China) (Figures 2A and 2B), was deployed

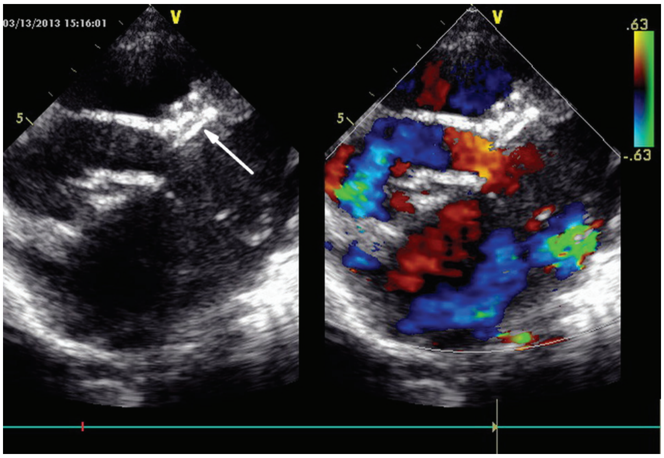

Figure 4. Left: Follow-up transthoracic echocardiography showing that the occlude was stable (arrow). Right: Follow-up transthoracic echocardiography showing no R-VSD shunt.

across the R-VSD through the sheath. After the occluder was released, TEE revealed a 2 mm residual shunt at the upper edge of the occluder (Figure 2C) and the 9 mm symmetric occluder was removed. The decision was made to use a 10 mm asymmetric occluder to close the defect. The asymmetric occluder has a right disk 2 mm larger than the waist, and an asymmetric left disk with the longer (marked) edge 5 mm wider than the waist, and the shorter edge flush with the waist (Shanghai Shape Memory Alloy Co., Ltd, Shanghai, China) (Figures 3A and 3B). The occluder was placed with the marker upward to ensure that the longer edge of the left disk was directed upward to cover the residual defect; appropriate placement of the occluder was then confirmed by TEE. After occlusion, TEE revealed that the device was stably positioned and that the shunt had been eliminated (Figure 3C). The surgery was uneventful and no blood transfusions were required. Treatment with aspirin (40 mg/day for 6 months) was initiated after the procedure.

At the 18-month follow-up examination, the patient was asymptomatic and had no major arrhythmias. Transthoracic echocardiography revealed that the occluder remained stable and that no R-VSD shunting was present (Figure 4).

DISCUSSION

At some hospitals post-operative TEE is used routinely following complex cardiac surgery. However, in our institution this is not the case. The surgeon in this case was satisfied that no R-VSD was present after correction of the DORV, so TEE was not used for either intra-operative or post-operative evaluation; thus, any residual shunt that may have been present after the surgery was not detected. It may have also been the case that the residual shunt developed gradually over time, and hence would have been difficult to detect immediately after surgery.

R-VSD is usually treated surgically or by percutaneous transcatheter closure. It would have been difficult to use conventional percutaneous transcatheter closure in this patient for two reasons: the unusual shape of the R-VSD (at a 135° angle with the G-T VG) would have complicated the placement and adjustment of an appropriate occluder by the usual transcatheter route; and second, the femoral artery in a low body weight child, such as this patient, is too small and thin to accommodate a large sheath. Furthermore, repeat thoracotomy surgery imposes significant trauma, and is not without risk [Kirshbom 2009]. Therefore, a TEE-guided minimally invasive surgical device closure was planned.

During occlusion, the surgeon may need to adjust the type and size of the occluder to achieve closure of the residual shunt; the present case illustrates this point well. In general, the size of the first occluder chosen is determined by adding 1 to 2 mm to the dimension of the defect [Zhao 2012]. In this case, because of the special shape of the defect, we initially chose a larger 9 mm ordinary symmetric occluder. After release of this occluder, TEE revealed a 2 mm wide residual shunt at the upper edge of the occluder. We removed this occluder and replaced it with a 10 mm asymmetric occluder – since the residual shunt was located at the upper edge, we predicted that orienting the longer edge of the left disk upward would occlude the residual shunt. The result, as we expected, was the disappearance of the shunt.

It is worth noting that for transventricular placement of a device for correction of an apical defect, the relatively small amount of space between the free wall and the defect can make it challenging to orient the heart appropriately in order to place the wire through the defect. The location of the defect in this patient, in an area with more space, may have made it somewhat easier to carry out this procedure.

The advantages of this technique over conventional open heart surgery are the avoidance of cardiopulmonary bypass and a much smaller incision. TEE guidance is also preferable to percutaneous transcatheter closure in that it avoids exposure to radiation. In addition, this technique enables easy and accurate handling because of the short performance distance and relatively commodious operating space. Detailed TEE guidance of the entire procedure is important for the success of minimally invasive surgical device closure [Bai 2012]. The limitation of this method is that a chest wall incision is required.

To the best of our knowledge, this is the first report of TEE-guided minimally invasive surgical device closure of an unusually shaped R-VSD. This case demonstrates the potential of this procedure as a feasible and efficacious alternative to open heart surgery and percutaneous transcatheter closure for treatment of irregular shaped R-VSDs.

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