Interventricular Septal Dissection with Perforations Following Takotsubo Cardiomyopathy

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PII: S2666-2507(23)00373-5
DOI: https://doi.org/10.1016/j.xjtc.2023.09.026
Reference: XJTC 1522

To appear in: JTCVS Techniques

Received Date: 14 August 2023
Accepted Date: 21 September 2023


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Title

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Disclosure Statement: All the authors declare that they have no information to disclose.

Funding Statement: All the authors declare that they have no information to disclose.
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Word count: 775
**Glossary of Abbreviations**

CT = computed tomography

IABP = intra-aortic balloon pump

IVS = interventricular septum

IVSD = interventricular septal dissection

LV = left ventricle

PCPS = percutaneous cardiopulmonary support

RV = right ventricle

TC = takotsubo cardiomyopathy

VSP = ventricular septal perforation

**Central Picture Legend**

Ventricular septal perforation with dissection following takotsubo cardiomyopathy.

**Central Message**

The timing of surgery for interventricular septal dissection complicated by perforation should be carefully considered because of the fragile interventricular septum.
Main manuscript

1. Introduction

Interventricular septal dissection (IVSD) is a rare condition of the interventricular septum (IVS) that mainly occurs following an aneurysm of the sinuses of Valsalva, bacterial endocarditis, trauma, cardiac surgery, endomyocardial biopsy, congenital myocardial developmental anomalies, or myocardial infarction.[1] IVSD following takotsubo cardiomyopathy (TC) is rare.[2] The IVS is sometimes perforated, creating a shunt.

We report a case of IVSD complicated by ventricular septal perforation (VSP) following TC ((IRB 1158 and August 14, 2023). Written informed consent could not be obtained from the patient because of the operative death.

2. Case report

An 82-year-old woman, with a history of mechanical mitral valve replacement for infective endocarditis 7 years earlier, was transferred to our hospital with complaints of chest discomfort and nausea.

Electrocardiography revealed ST segment elevations in V1-6. However, coronary angiography revealed no lesions, and acute coronary syndrome was ruled out (Supplementary Fig 1). Left ventriculography revealed apical akinesis (Supplementary Fig 2) even though her
echocardiography 9 months earlier showed normal function of left ventricle (LV). The patient was diagnosed with apical ballooning-type TC and admitted to the intensive care unit.

The following day, lactic acidosis progressed and contrast-enhanced computed tomography (CT) revealed an extensive IVSD (Fig. 1A). Transthoracic echocardiography revealed IVSD with a shunt from the LV to the right ventricle (RV) through the VSP (Fig. 1B). Percutaneous cardiopulmonary support (PCPS) with an Impella CP (Abiomed, Inc. Danvers, Massachusetts, USA) was initiated because the patient was in shock.

Re-sternotomy was performed 12 days after diagnosis. We removed the Impella CP and inserted an intra-aortic balloon pump (IABP) 1 h preoperatively to prevent postoperative bleeding. Under cardiopulmonary bypass with moderate hypothermia, the RV was longitudinally incised 1 cm away from the left anterior descending coronary artery. The ventricular septal wall was dissected with a single tear (1 × 1 cm) into the LV (Fig. 2A). The dissected septum was sufficiently stiff to sew double patches. We performed the “sandwich technique” via an RV incision to repair the VSP. [3] We inserted a tailored 1.85-mm Bard polytetrafluoroethylene felt (Becton Dickinson, Sunnyvale, CA, USA) into the LV. BioGlue Surgical Adhesive (CryoLife, Kennesaw, GA, USA) was inserted into the defect. Bard polytetrafluoroethylene felt (1.65 mm) and an Edwards bovine pericardial patch (Edwards Lifesciences, Irvine, CA, USA) were pasted together. The sheet was cut to use on the RV side.
Cardiopulmonary bypass was smoothly weaned off using IABP. Transesophageal echocardiography performed during the surgery revealed no residual shunts.

Postoperative hemodynamics were stable; the IABP was removed on postoperative day 2, and CT revealed pneumonia; broad-spectrum antibiotics were immediately initiated. However, 3 days later, CT showed deterioration of pneumonia, a new pulmonary abscess, and fistula due to abscess rupture. Postoperative echocardiography revealed improved contractility of the LV apex and no shunt (Fig.2B). Contrast-enhanced CT revealed successful VSP repair (Fig.2C). Despite antibiotic treatment, the patient developed septic shock and died on postoperative day 8.

3. Discussion

The optimal surgical timing for VSP complicated by extended IVSD following TC is unknown because of limited reports. A VSP with dissected IVS is more fragile than an isolated VSP. Miyake et al. reported fragile and necrotic tissues around the VSP area in an emergency surgical case, whereas relatively firm tissues were observed around the VSP area in an elective surgery case. [4] Furthermore, in most patients with TC, cardiac function improves with conservative therapy. They performed elective surgery 13 days after VSP onset following TC, and the result was uneventful, with no residual shunt. [4] In their case, onset of VSP with IVSD
was occurred 1 day after diagnosing apical ballooning-type TC and the rupture site was anterior type. However, their patient had not needed catecholamines or mechanical circulatory support until the surgery.

In our case, we were apprehensive that a secure repair would be extremely difficult because the dissected area extended to almost the entire IVS. Additionally, LV function was severely impaired because of TC. Although the patient developed cardiogenic shock at VSP onset, she remained stable after introducing PCPS and Impella CP. The LV function improved 4 days after VSP onset. However, surgery was delayed until the dissected IVS was sufficiently durable to enable secure repair.

Furui et al. reported that delayed surgeries for VSP were associated with low reoperation rates for residual shunt, recurrent VSP, LV pseudoaneurysm, and hospital mortality. [5] Conversely, there is a high risk of preoperative intravenous catheter infections, atelectasis, and pneumonia resulting from prolonged immobility. [5]

Our surgical repair was completed because of sufficient durable tissues around the VSP. However, perioperative infections could not be controlled. Surgery could be delayed for an optimal timing, considering this infection as a comorbidity of delayed surgery. The timing of surgery should be decided based on the advantages of ensuring a secure repair, depending on the etiology, and the disadvantages associated with surgery delay.
Figures

Fig.1: (A) Contrast enhanced CT demonstrating extensive IVSD complicated with VSP. (B) Transthoracic echocardiography showing the dissection of the IVS in color Doppler indicating plural flows through the VSP, near the apex.

CT, computed tomography; IVSD, interventricular septal dissection; VSP, ventricular septal perforation; IVS, interventricular septum; RV, right ventricle; LV, left ventricle.

Fig.2: (A) Intra-operative image of a single tear (1 cm × 1 cm) of the ventricular septal wall just under the incision (arrow). The left ventricular septum around the ostium of the dissection tract is not fragile and reveals no ischemic change. (B) Postoperative echocardiography showing no shunt after VSP repair. (C) Contrast enhanced CT showing successful VSP repair.

CT, computed tomography; VSP, ventricular septal perforation; RV, right ventricle; LV, left ventricle.
Supplementary Fig. 1: Coronary angiography of (A) the left coronary artery and (B) the right coronary artery revealing no lesions.

Supplementary Fig. 2: Left ventriculography of (A) systole and (B) diastole showing apical akinesis.

Supplementary Fig. 3: Sequence of events from the admission to postoperative death

IABP, intra-aortic balloon pump; ICU, intensive care unit; IVSD, interventricular septal dissection; PCPS, percutaneous cardiopulmonary support.
References


<table>
<thead>
<tr>
<th>Day</th>
<th>Event</th>
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<tbody>
<tr>
<td>Day 1</td>
<td>Admission to our hospital due to chest discomfort and nausea</td>
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<tr>
<td></td>
<td>Transfer to ICU with diagnosis of Takotsubo cardiomyopathy</td>
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<td>Day 2</td>
<td>Diagnosis of IVSD with perforations</td>
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<td>PCPS with an Impella because the patient was in shock</td>
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<td>Day 12</td>
<td>Removal of Impella and insertion of IABP one hour before the surgery</td>
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<td>Removal of PCPS during surgical repair for IVSD with perforations</td>
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<td>Day 14</td>
<td>Removal of IABP</td>
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<td>Death caused by sepsis</td>
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