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A Sandwich Technique Employing Right Ventricular Incision to Repair Posterior Ventricular Septal Rupture with Right Ventricular Wall Dissection: A Case Report

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Abstract

Background: Ventricular septal rupture (VSR) leading to right ventricular (RV) wall dissection is an extremely rare and life-threatening complication of inferior myocardial infarction (MI) with posterior VSR. Its rare incidence and complex pathology make it difficult to select the appropriate surgical procedures to prevent fatalities. **Case Presentation:** A 68-year-old woman was transferred to our hospital because of a post-infarction VSR 12 days after symptom onset. Short-axis image obtained using transthoracic echocardiography demonstrated a large posterior VSR. Moreover, the VSR was continuous, with a large echo-free space in the posterior wall of the right ventricle. Color echocardiography showed blood flowing into the echo-free space through the septal defect and blood flowing out into the RV lumen. Coronary angiography revealed complete occlusion of the second segment of the right coronary artery. Thus, dissection of the posterior wall of the right ventricle that continued into the RV lumen was considered to have been caused by the posterior VSR caused by an inferior MI. The patient underwent urgent surgery to repair the VSR using the sandwich double-patch technique by making a posterior RV incision that was repaired using a third patch. No additional procedure was required to block the flow from the cavity of the RV wall dissection into the RV lumen. Postoperative echocardiography and contrast-enhanced computed tomography demonstrated that the VSR was closed securely and the RV wall dissection was almost completely thrombosed. **Conclusion:** In this case, a patient with a posterior VSR and RV wall dissection was successfully treated using the sandwich double-patch technique with a posterior RV incision. No additional procedure may be needed for RV wall

dissection when a secure VSR repair is complete; however, close follow-up is essential to improve the long-term prognosis.

Keywords

Ventricular Septal Rupture, Right Ventricular Wall Dissection, Surgery, Sandwich Technique, Right Ventricular Incision

1. Introduction

Ventricular septal rupture (VSR) is a life-threatening complication of a transmural acute myocardial infarction (MI). Although surgery is the treatment of choice, it is challenging to perform and is associated with high mortality [1]. In patients with inferior MI, septal rupture generally involves the basal inferoposterior septum, and the communicating tract between the left and right ventricles is often serpiginous with a variable degree of right ventricular (RV) wall extension [2]. Furthermore, as posterior VSR with RV wall dissection is a rare and complicated condition, many of which are diagnosed postmortem, an optimal surgical strategy has not yet been established [3] [4] [5] [6]. Therefore, a simple and easy-to-perform treatment is desirable. Herein, we report a patient who underwent a sandwich double-patch technique using a posterior RV incision to treat posterior VSR with RV wall dissection.

2. Case Presentation

In May 2021, a 68-year-old woman experienced neck pain and dyspnea after receiving her first vaccine for coronavirus disease (COVID-19). Five days after vaccination, the dyspnea worsened with new onset chest pain. The family doctor observed the patient for 7 days. However, the symptoms did not improve and an electrocardiogram showed abnormal Q waves in leads II, III, and aVF. Transthoracic echocardiography revealed a VSR. The patient was immediately transferred to our hospital. On admission, her blood pressure and pulse rate were 118/56 mmHg and 97 beats/min, respectively. Her oxygen saturation level was 99% at an oxygen flow rate of 2 L/min, administered via nasal prongs. Additionally, there was no lung murmur; however, a grade IV pansystolic heart murmur was heard in the fourth intercostal space along the left sternal border. Blood test results revealed a serum blood urea nitrogen concentration of 107 mg/dL; serum creatinine of 1.44 mg/dL; total bilirubin of 5.3 mg/dL; aspartate aminotransferase level of 3100 U/L; alanine aminotransferase level of 2591 U/L; creatine kinase level of 103 U/L; troponin T of 1.02 ng/dL; and N-terminal pro-B-type natriuretic peptide of 1823 pg/mL. Chest radiography showed a cardiothoracic ratio of 69% and mild lung congestion. Moreover, a short-axis image of the left ventricle obtained using transthoracic echocardiography demonstrated severe hypokinesis of the inferior wall, pericardial effusion, and a large defect in the

posterior septum at the papillary muscle level (**Figure 1(a)**). The VSR was continuous with a large echo-free space in the posterior wall of the right ventricle (**Figure 1(a)**), and color echocardiography showed blood flowing into the echo-free space through the septal defect and blood flowing out into the RV lumen (**Figure 1(b)**). Two different speeds of blood flow were observed: slow blood flow in the posterior wall of the right ventricle (**Figure 1(c)**) and accelerated blood flow into the RV lumen (**Figure 1(d)**). Furthermore, severe tricuspid regurgitation was observed, and the pulmonary to systemic flow ratio was estimated as 2.8. The left ventricular ejection fraction was 60%. Coronary angiography revealed complete occlusion of the second segment of the right coronary artery (**Figure 2(a)**), with no abnormal findings in the left coronary artery (**Figure 2(b)**). Right heart catheterization showed pulmonary artery and right ventricular pressures of 35/15 mmHg and 42/7 mmHg, respectively. Thus, the posterior VSR after the inferior MI was considered to have dissected the posterior wall of the right ventricle and penetrated the RV lumen. In the preoperative plan, we decided to treat heart failure first and wait for severe hepatic dysfunction to improve before performing surgery. We planned to perform the sandwich technique using an RV incision for VSR and no additional procedure for RV wall dissection. This was because we considered that RV wall dissection could be naturally absorbed by controlling the left-to-right shunt with a secure VSR repair [3] [4] [5]. Continuous dobutamine infusion using non invasive positive pressure ventilation and volume management ensured maintenance of circulatory stability in this patient. After the hepatic dysfunction improved, urgent surgery was performed 3 days after admission. Additionally, after general anesthesia was induced, an intra-aortic balloon pump was inserted prophylactically to support circulation after -a cardiopulmonary bypass. When the pericardium was incised, a large amount of dark blood containing cardiac fluid was discharged. Extracorporeal circulation was established by withdrawing blood from the upper and lower vena cavae and returning it to the ascending aorta. The posterior surface of the right ventricle was covered with a red edematous fibrin membrane that was soft and elastic to the touch (**Figure 3(a)**). An aortic cross-clamp was placed inducing an antegrade blood cardioplegic arrest. The RV posterior wall was incised approximately 7 cm parallel to the posterior descending artery to reach the cavity produced by dissection of the RV wall. A 4 × 2 cm VSR was observed on the septal side of the dissection wall; on the opposite side, the RV wall dissection was connected to the RV lumen (**Figure 3(b)**). The fragile tissue around the VSR was debrided. Subsequently, two 8 × 6 cm-sized bovine pericardial patches, lined with felt pieces, were created by adding a 2-cm seam allowance to the size of the VSR on the margin. The patches were fixed in the form of a sandwich from the left septal wall and RV wall dissection sides with eight 3-0 monofilament mattress sutures that closed the VSR by passing through all the layers around it (**Figure 3(c)**). No procedure was performed to block flow from the cavity of the RV wall dissection to the RV lumen. A new bovine pericardial patch reinforced with felt strips was used to repair the RV incision (**Figure 3(d)**) because it was

difficult to suture the incision line directly owing to the tension applied by the double patch on the right side. Tricuspid valve annuloplasty was performed using a 28-mm physio-tricuspid annuloplasty ring (Edwards Lifesciences, Irvine, CA, USA). A schematic diagram of this procedure is shown in Figure 3(e). The durations of aortic cross-clamping, cardiopulmonary bypass, and surgery were 174, 250, and 477 minutes, respectively. Postoperative transthoracic echocardiography showed moderate tricuspid regurgitation; however, left-to-right shunt flow was not observed. Contrast-enhanced computed tomography revealed that the dissected part of the posterior wall had some blood inflow from the RV lumen (Figure 4(a)); however, the cavity of the RV wall dissection was almost thrombosed (Figure 4(b)). The patient was discharged 71 days after the

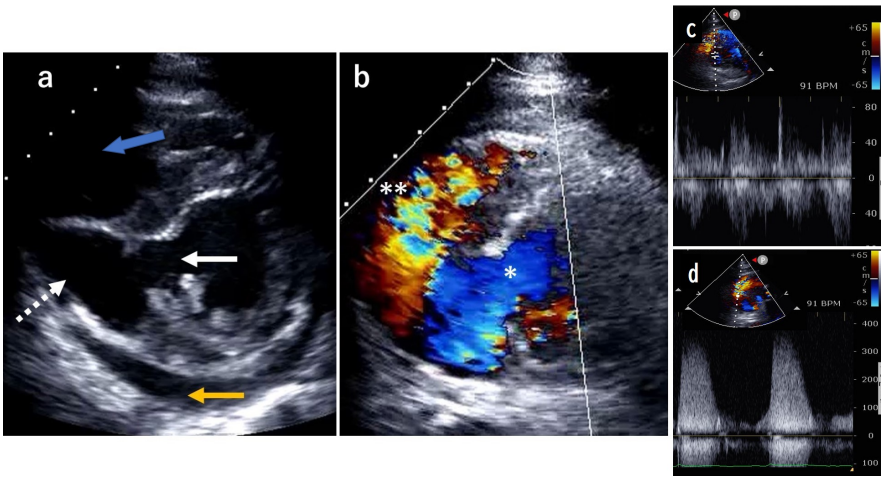

Figure 1. Short-axis transthoracic echocardiogram of the left ventricle shows pericardial effusion (yellow arrow) and a large defect in the posterior septum (white arrow). The ventricular septal rupture is continuous with the large dissected space (dotted arrow) in the posterior wall of the right ventricle. The large dissected space is also continuous with the true lumen of the right ventricle (blue arrow) (a). The color echocardiogram shows blood flowing into the echo-free space through the septal defect (*) and blood flowing out (**) into the right ventricular lumen (b). Two different speeds of blood flow are observed: slow blood flow in the former (c) and accelerated blood flow in the latter (d).

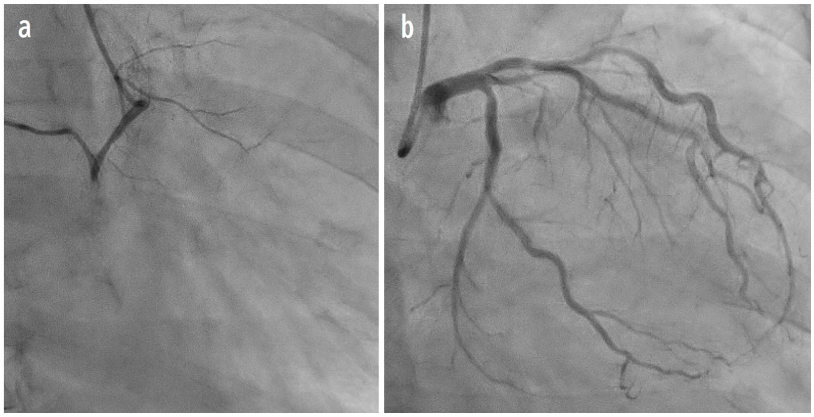

Figure 2. Coronary angiography revealed complete occlusion of the second segment of the right coronary artery (a) with no abnormal findings in the left coronary artery (b).

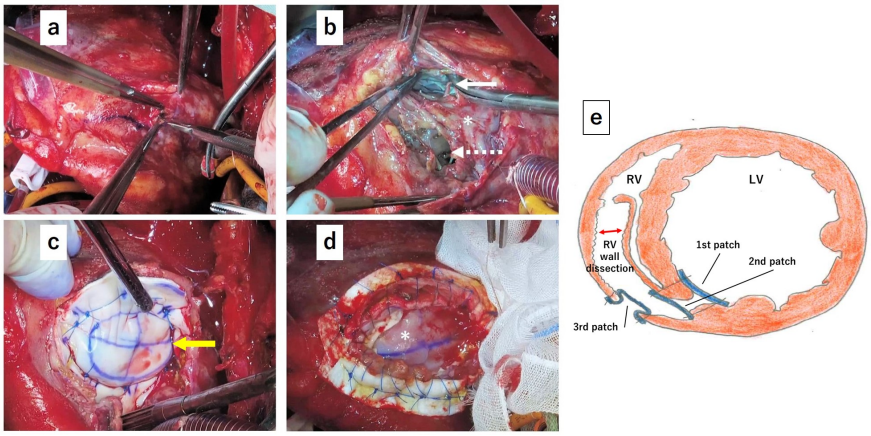

Figure 3. Intraoperative view showing the posterior surface of the right ventricle (a) and the interior of the right ventricular wall dissection (b). A 4 × 2 cm-sized ventricular septal rupture (solid white arrow) is observed on the septal side of the dissected wall (*), and on the opposite side, the right ventricular wall dissection is connected to the right ventricular lumen (dotted white arrow). The right-side patch (yellow arrow) after closing the ventricular septal rupture using the sandwich double-patch technique (c) and the posterior right ventricular wall surface (*) after repairing with another bovine pericardial patch (d). The schema of this procedure is shown (e).

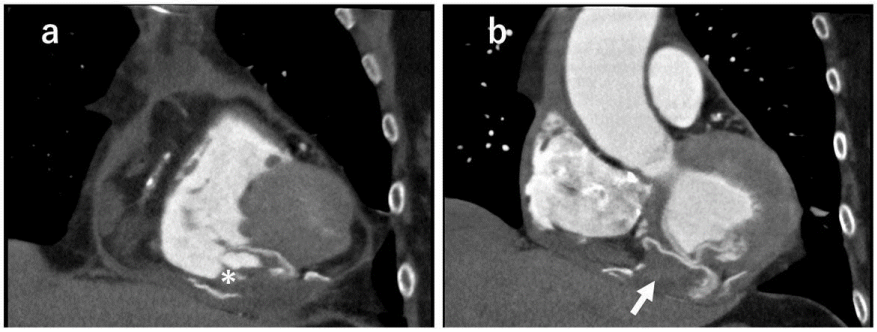

Figure 4. Postoperative contrast-enhanced computed tomography shows some blood inflow in the dissected part of the right ventricular posterior wall (*) from the right ventricular lumen (a), but the cavity of the right ventricular wall dissection has almost thrombosed (arrow) (b).

surgery. At the 12-month postoperative follow-up, the patient had a class II New York Heart Association functional status. However, during this period, she was unable to visit our hospital for social reasons and, accordingly, had not undergone any imaging evaluations such as echocardiography or CT. Unfortunately, 13 months after the operation, her heart failure suddenly worsened and she visited our hospital again. The patch-sealed ventricular septal defect had ruptured again, and the patient died of heart failure, as treatment had no effect.

3. Discussion

VSR is a serious mechanical complication that develops after transmural MI and requires surgery to prevent mortality. However, the surgical results remain unsatisfactory because of the low frequency and severity of the condition [1].

Moreover, VSR with RV wall dissection is an even rarer pathological condition associated with posterior VSR. Therefore, there is a lack of knowledge regarding the selection of an appropriate surgical procedure to prevent deaths [3] [4].

Although the mechanism by which RV wall dissection occurs is not well understood, posterior VSR after inferior MI develops into a complex VSR, wherein the left-to-right shunt tract meanders through the ventricular septum. Conversely, anterior VSR tends to develop as a simple septal rupture with a direct connection at the same level in the left and right ventricles [2]. In cases of complex VSR, the septal rupture may extend to the RV wall, reaching the interstitium between the superficial and deeper layers and causing dissection of the RV wall [7]. RV wall dissection can be classified into the following types: re-entry (RV wall dissection results in rupture that extends into the RV lumen), rupture into the pericardial sac (RV wall dissection results in rupture into the pericardial sac), and intramural hematoma without any exit [7]. The current case was classified as a re-entry type with a VSR based on preoperative echocardiographic examination and intraoperative observation findings. Appropriate echocardiographic evaluation is important for the diagnosis and treatment of this rare condition [3] [4] [5].

The Dagget and Komeda-David techniques are typically used to surgically repair VSR [8] [9]. Balkanay *et al.* described a sandwich double-patch-type repair via a left ventricular incision that avoided the RV incision [10]. However, concerns remain regarding the limited field exposure from the left ventricular incision to the posterior VSR and bleeding due to the left ventriculotomy [11]. The benefit of the sandwich technique in which two patches are placed via an infarcted RV incision has recently been reported [11] [12]. This method is simpler and more technically feasible than previously reported techniques, and favorable surgical outcomes have been reported regardless of the VSR location [11] [12]. Therefore, this technique has recently been adopted by our institution as a first-line surgical procedure for VSR.

In cases of VSR with RV wall dissection, closure is essential for improving the patient's condition and preventing death. However, the importance of RV wall reconstruction remains unclear. Repair of the dissected RV wall may prolong cardiopulmonary bypass and operative times, and worsen surgical outcomes [3] [4]. However, the risks of prolonging the surgical procedure and cardiopulmonary bypass must be weighed against the benefits of repairing the dissected RV wall on a case-by-case basis [3]. Therefore, we repaired the VSR using the sandwich double-patch technique with a posterior RV incision, which was subsequently repaired using a third patch. No additional procedure to block the flow from the cavity of the RV wall dissection to the RV lumen was performed. Postoperative echocardiography and contrast-enhanced computed tomography revealed secure closure of the VSR and the RV wall dissection was almost completely thrombosed. Li *et al.* reviewed 17 previous case reports of VSR with RV wall dissection in the context of acute ischemia. Their echographic findings were characterized by including the starting point at the infarcted left ventricular in-

ferior wall, progression across the basal septum to the RV wall, and re-entry into the RV lumen. The disease has a poor prognosis, and its clinical outcomes are almost always dismal. According to their summary, VSR closure with an uncorrected left RV wall could improve survival and reduce the ultimate mortality rate compared with no surgery or VSR closure with RV reconstruction [4]. We arrived at the same conclusion.

However, the suitability of the posterior RV incision approach for acute posterior VSR with RV wall dissection remains unclear. Previously, the RV incision approach was used in cases of VSR with RV wall dissection wherein a certain amount of time had elapsed since the onset of VSR [13] [14]. In our case, we estimated that approximately 10 days had passed since the onset of the VSR. The repair of damaged heart muscles by connective tissue proliferation occurs as early as the 6th or 7th day after MI has been reported [15]. Therefore, the positive results in this case and in previous ones may be attributed to the intentional surgical delay, which might have promoted some degree of myocardial fibrosis and helped achieve successful VSR repair with hemostasis [13] [14]. Moreover, successful repair of the VSR without a residual shunt result in the exertion of only RV blood pressure on the RV wall. In addition, controlling bleeding from the RV incision by using patch repair with suture reinforcements and surgical glue may be an easier surgical procedure, especially in acute situations.

Although the detailed reason for the re-rupture of the interventricular septum 13 months postoperatively is unknown, a sandwich double-patch technique involving manipulation from the RV side may be insufficient to eliminate the weakness of the infarcted area of the left ventricular septum. It is possible that a pseudo-ventricular septal aneurysm developed and ruptured. This could have been prevented by using an extended sandwich closure, which covers a wider area of the ventricular septal wall [16]. However, it is possible that VSR surgery from the RV side may have resulted in sufficient exclusion of the infarcted area on the left ventricular septal side, thus requiring careful follow-up.

4. Conclusion

We report a case of successful VSR repair in a patient who underwent posterior VSR and RV wall dissection using the sandwich double-patch technique through a posterior RV incision. No additional procedure may be needed for RV wall dissection if secure VSR closure is achieved; however, close follow-up, including imaging evaluations, is important to achieve long-term prognosis.

Consent for Publication

Informed consent was obtained from the patient's family to publish this case report and associated images.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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List of Abbreviations

Ventricular septal rupture (VSR), myocardial infarction (MI), right ventricular (RV)