

Case Report


Surgical Closure of Iatrogenic Atrial Septal Defect and Tricuspid Valve Replacement in a Patient With Moderate Right Heart Failure


Takehiro Inoue, MD,^a Takuma Satsu, MD,^a and Hitoshi Kitayama, MD^a^aDepartment of Cardiovascular Surgery, Mimihara General Hospital, Sakai, Osaka, Japan

A clinically significant right-to-left shunt due to an iatrogenic atrial septal defect (iASD) is a rare complication of catheter ablation using a transseptal puncture approach for atrial arrhythmias.^{1,2} Furthermore, surgical closure of the iASD carries a high risk in redo patients with severe tricuspid regurgitation (TR) due to moderate right ventricular (RV) dysfunction.³ We present a successful case of redo cardiac surgery including closure of an iASD and tricuspid valve replacement (TVR) without dissection of the patent internal mammary artery.

Case

A 66-year-old man was admitted for catheter ablation of symptomatic atrial flutter. He had previously suffered from inferior and RV infarction and had undergone percutaneous coronary intervention for right coronary artery occlusion 6 years earlier. Two months later, he underwent coronary artery bypass grafting of the left internal mammary artery to the left anterior descending artery. However, he had recently gradually developed chronic heart failure, with a brain natriuretic peptide level of 878 pg/mL. Color Doppler echocardiography demonstrated severe TR with a markedly dilated right atrium (RA) and right ventricle (Fig. 1A). The severe TR presumably was caused by annular dilatation with impaired RV function (echocardiographic tricuspid annular plane systolic excursion: 12 mm; RV fractional area change: 20%; tricuspid annulus: 48 mm). His left ventricular ejection fraction was 50%, with no pulmonary hypertension. For the management of chronic heart failure, tricuspid valve replacement (TVR) was necessary. However, due to the high risk of redo sternotomy after coronary artery bypass grafting, we opted for catheter ablation of atrial flutter.

The patient underwent radiofrequency catheter ablation using a transseptal puncture approach for the symptomatic atrial flutter. However, soon after the catheter ablation, his systemic oxygen saturation decreased to 83%, and his clinical condition deteriorated, with dyspnea and fatigue. Even after appropriate medical management with noninvasive positive pressure ventilation and moderate doses of dobutamine, his percutaneous oxygen saturation remained at 86%–93%, with peripheral cyanosis clinically. Transesophageal echocardiography identified an iASD with a right-to-left shunt (Fig. 1B; Video 1 , view video online). The cause of the refractory hypoxemia was the presence of a persistent right-to-left shunt across the iASD. As medical management was unable to control the refractory hypoxemia and due to the severe TR with moderate RV failure (echocardiographic tricuspid annular plane systolic excursion: 10 mm; RV fractional area change: 18%), we determined that surgery for closure of the iASD and TVR was required. Preoperative right heart catheterization demonstrated an elevated mean RA pressure of 18 mm Hg, a normal pulmonary artery (PA) pressure (PA: 25/11 [mean: 15] mm Hg), and a mean PA wedge pressure of 10 mm Hg.

Via full redo sternotomy, dissection of the patent left internal mammary artery graft was not attempted. Under cardiopulmonary bypass, following placement of an aortic cross-clamp, antegrade cold blood cardioplegia was administered. Additionally, potassium was given systemically, targeting a serum level of more than 6 mEq/l for achieving cardiac arrest even in the presence of a patent left internal mammary artery graft that was not manipulated.⁴ Under systemic hyperkalemia with mild hypothermia (bladder temperature: 30.3 °C), the iASD was identified on the superior side of the fossa ovalis, and its direct suture closure was performed (Fig. 2; Video 2 , view video online). After aortic declamping, TVR with a 33-mm Carpentier-Edwards Perimount pericardial prosthesis (Edwards Lifesciences, Irvine, CA) was performed on-pump on a beating heart. The patient was weaned from cardiopulmonary bypass with the use of an intra-aortic balloon pump, in addition to moderate doses of dobutamine. The aortic clamp time and cardiopulmonary bypass time were 19 and 128 minutes, respectively. The

Received for publication December 25, 2022. Accepted December 6, 2023.

Corresponding author: Dr Takehiro Inoue, Department of Cardiovascular Surgery, Mimihara General Hospital, 4-465, Sakaiku Kyowacho, Sakai, Osaka 590-8505, Japan. Tel.: +81-72-241-0501; fax: +81-72-244-3577.

E-mail: rtcryo@hotmail.co.jp

See page 626 for disclosure information.

Novel Teaching Points

- Clinically important iASDs are relatively rare. Severe right-to-left shunt across an iASD is even rarer.
- Severe TR due to impaired RV dysfunction might contribute to the development of significant right-to-left shunt across an iASD after transseptal approach procedures.
- Awareness of the risk of significant right-to-left shunt after creation of an iASD, when severe TR and/or a large interatrial pressure gradient is present, is important. In our case, moderate RV systolic dysfunction was present, but surgical repair of the iASD, along with TVR in our case resolved the right-to-left shunt and restored normal oxygen saturations and hemodynamics.

postoperative peak creatine kinase-MB level was 34 UI/L. After surgery, postoperative right heart catheterization revealed that RA pressure was decreased (mean RA: 5 mm Hg), and PA pressure was somewhat elevated but almost normal (PA: 28/10 [mean: 17] mm Hg), with normalization of systemic arterial oxygenation of 98%.

The patient was successfully weaned from the intra-aortic balloon pump the next morning, and he was extubated without hypoxemia on postoperative day 2. The patient was discharged uneventfully 3 weeks postoperatively. However, because of sick sinus syndrome, he subsequently underwent implantation of a pacemaker 4 months after the surgery. He is presently asymptomatic, at full activity at a 3-year follow-up.

Comment

iASDs were detected in 3.7%-26.0% of patients 3-12 months after a transseptal puncture approach for atrial

arrhythmias.^{1,2} Furthermore, all iASDs were left-to-right shunts, and overall, only 2% of patients required device closure.² Although iASDs were likely underreported, iASDs could be encountered more frequently in the future, due to single transseptal puncture with double cannulation, an increase in cryoballoon ablation, and use of large devices, such as with percutaneous mitral valve repair. Refractory hypoxemia due to a persistent right-to-left shunt across an iASD is even rarer; its incidence has been reported previously in only small series and case reports. Morikawa et al. reported that the incidence of right-to-left shunt through an iASD after the MitraClip (Abbott Vascular, Santa Clara, CA) procedure was 5% and was associated with acute deoxygenation (35%).⁵ In that study, the presence of right-to-left shunt was associated with major adverse cardiovascular events at follow-up.

Risk factors for right-to-left shunt with iASDs include creation of a larger defect, RV dysfunction, a severely dilated RA, more severe TR, a higher RA pressure, as well as an increased interatrial pressure gradient.^{1,2,5} The persistent right-to-left shunt is more likely to develop in the presence of moderate right heart failure with relatively preserved left-sided cardiac function, such as RV cardiomyopathy, a large RV infarction, sarcoidosis, or adult congenital heart disease.¹ In our case, although the patient suffered from inferior and RV infarction, left-sided cardiac function was relatively preserved, resulting in the absence of pulmonary hypertension. In this rare condition, a right-to-left shunt seemed more likely to occur after a transseptal approach for catheter ablation because of the increased interatrial pressure gradient.^{5,6} Although left atrial pressure was not directly measured in our case, the difference between the RA pressure of 18 mm Hg and the PA wedge pressure of 10 mm Hg provided a large interatrial pressure gradient. On the other hand, Morikawa et al. suggest that the combination of elevated right-sided pressures and a significant reduction in left atrial pressure after the MitraClip procedure may be related to the occurrence of right-to-left

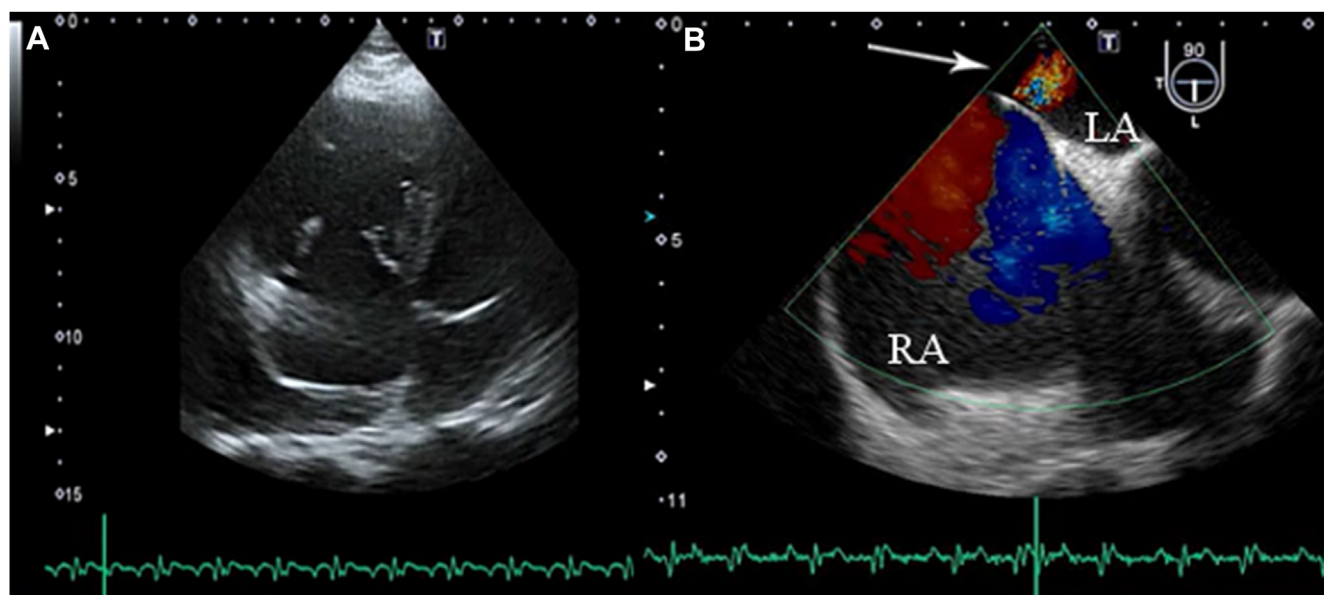


Figure 1. (A) Transthoracic echocardiography showed a markedly dilated right atrium (RA) and ventricle. (B) Transesophageal echocardiography with color Doppler showed a continuous right-to-left shunt through an iatrogenic atrial septal defect (arrow). LA, left atrium.

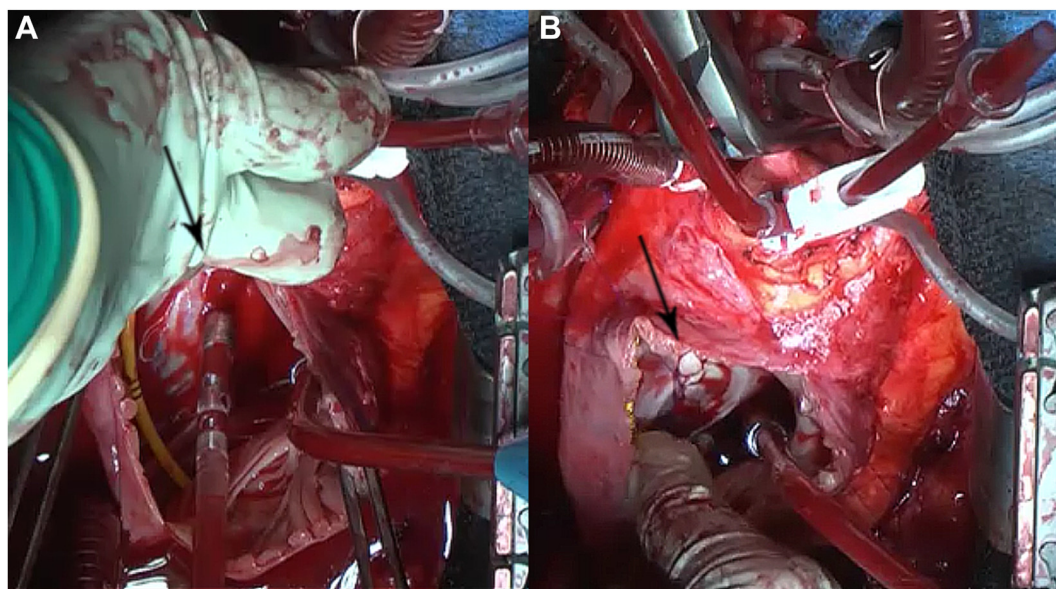


Figure 2. (A) Intraoperative view of the iatrogenic atrial septal defect (arrow). (B) Direct suture closure of the iatrogenic atrial septal defect (arrow).

shunt across an iASD.⁵ Although the mechanism of clinically significant iASD development after a transeptal approach differs somewhat between patients undergoing catheter ablation and those undergoing the MitralClip procedure, high RA pressure and severe TR are important predictors of right-to-left shunt. We think that the severe TR was also a contributing factor to the persistent right-to-left shunt across the iASD. Chiam et al. postulate that the right-to-left shunt was facilitated by the severe TR jet across the iASD into the left atrium in their case.²

In addition to iASD closure, adequate management of severe TR may improve the prognosis of patients with impaired RV dysfunction. Most centres would close the iASD percutaneously, and manage the TR separately. Percutaneous closure is the treatment of choice because it is minimally invasive and avoids the risks of redo cardiac surgery. However, due to our limited experience with percutaneous closure of the iASD, we opted for simultaneous surgical repair. Redo surgery including closure of the iASD and TVR might have carried a significant risk of harm to our patient. In the presence of significant RV systolic dysfunction, complete defect closure and TVR potentially could lead to inability to maintain cardiac output and as a consequence, mortality.⁷ In our case, closure of the iASD was achieved successfully under cardiac arrest even in the presence of a patent left internal mammary artery graft that was not manipulated. Additionally, after aortic declamping, the patient underwent TVR with an on-pump beating-heart technique, which aided in minimizing myocardial damage. Furthermore, difficulty in weaning off cardiopulmonary bypass is anticipated when RV infarction is accompanied by left ventricular failure. Therefore, in addition to afterload reducing agents, we introduced an intra-aortic balloon pump at the time of weaning from cardiopulmonary bypass. As a result, the simultaneous surgical repair resolved the right-to-left shunt and restored normal oxygen saturations and hemodynamics without untoward consequences.

Conclusion

Clinically significant right-to-left shunt across an iASD, causing refractory hypoxemia, may develop and persist due to severe TR and severe right heart failure. If the intra- and postoperative stage is uneventful, surgical repair of the iASD, along with TVR in patients with impaired RV systolic dysfunction could improve the late prognosis, although careful management of redo surgery is required.

Ethics Statement

The research reported has adhered to the relevant ethical guidelines.

Patient Consent

This is a retrospective case report using de-identified data; therefore, the IRB did not require consent from the patient.

Funding Sources

The authors have no funding sources to declare.

Disclosures

The authors have no conflicts of interest to disclose.

References

1. Lee A, Mahadevan VS, Gerstenfeld EP. Iatrogenic atrial septal defect with right-to-left shunt following atrial fibrillation ablation in a patient with arrhythmogenic right ventricular cardiomyopathy. *Heart Rhythm Case Rep* 2018;4:159-62.
2. Chiam PTL, Lim CP, Hsu LF, Liew R. Iatrogenic atrial septal defect after catheter ablation-to close or not to close? *Ann Acad Med Singap* 2022;51:441-3.
3. Eshcol J, Wimmer AP. Hemodynamically significant iatrogenic atrial septal defects after cryoballoon ablation. *HeartRhythm Case Rep* 2018;5:17-21.

4. Fujita T, Kobayashi J, Nakajima H, Toda K. Systemic hyperkalemia and mild hypothermia for valve surgery in patients with patent internal mammary artery graft. *Interact Cardiovasc Thorac Surg* 2010;11:3-5.
5. Morikawa T, Miyasaka M, Flint N, et al. Right-to-left shunt through iatrogenic atrial septal defect after MitraClip procedure. *JACC Cardiovasc Interv* 2020;13:1544-53.
6. Bassi S, Amersey R, Andrews R. Right ventricular infarction complicated by right to left shunting through an atrial septal defect: successful treatment with an Amplatzer septal occluder. *Heart* 2005;91:e28.
7. Kietz MF, Prihada EA, van der Bijl P, et al. Prognostic implications of right ventricular remodeling and function in patients with significant secondary tricuspid regurgitation. *Circulation* 2019;140:836-45.

Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at <https://www.cjopen.ca/> and at <https://doi.org/10.1016/j.cjco.2023.12.005>.