Two-patch technique with BioGlue for ventricular septal rupture resulting from acute anterior myocardial infarction

Kenji Iino, MD, PhD, Yoshitaka Yamamoto, MD, PhD, Hideyasu Ueda, MD, and Hirofumi Takemura, MD, PhD, Kanazawa, Japan

From the Department of Cardiovascular Surgery, Kanazawa University, Kanazawa, Japan.

Disclosures: The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

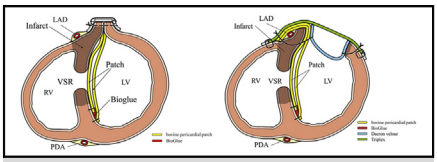
Received for publication Nov 6, 2021; accepted for publication Feb 16, 2022; available ahead of print Feb 26, 2022.

Address for reprints: Kenji Iino, MD, PhD, Department of Cardiovascular Surgery, Kanazawa University, 13-1 Takaramachi, Kanazawa 920-8641, Japan (E-mail: knj.iino@gmail.com).

JTCVS Techniques 2022;13:83-6

2666-2507

https://doi.org/10.1016/j.xjtc.2022.02.028



Two patches with BioGlue and free-wall repair with inner and prosthetic patches.

CENTRAL MESSAGE

Two-patch repair covering doubly the entire septum on the left side with BioGlue suture line reinforcement and additional LV free-wall repair for acute anterior post-myocardial infarction VSR ensures favorable outcomes.

See Commentary on page 87.

Video clip is available online.

Surgery for postinfarction ventricular septal rupture (VSR) remains associated with high mortality.[1-5] In cases of VSR resulting from acute myocardial infarction (AMI), we often encounter challenges in closing the VSR and the repair of the ventriculotomy made through the wide necrotic ventricular muscle. To simplify the procedure and reinforce the suture line, we perform VSR repair with 2 separate patches with BioGlue, which is applied on the suture line between 2 patches. If ventricular free-wall defect following excision of necrotic ventricular muscle becomes large, free-wall repair is performed using an inner patch covered by a prosthetic patch from the outside (Video 1).

This study was conducted in accordance with the guidelines of the ethics committee of our institution (institutional review board approval: 2020-177 [3525] October 2020). Informed consent was provided by all patients.

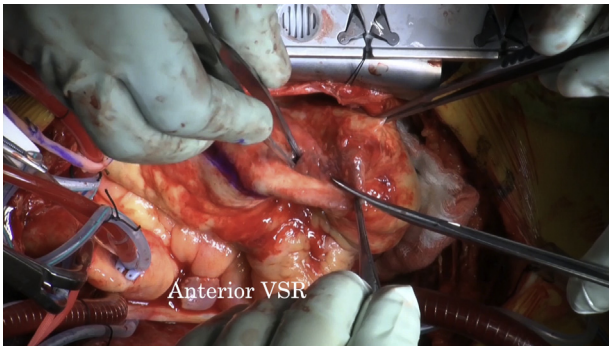
TECHNIQUES

Anterior VSR

For the left ventriculotomy, we perform a cut through the infarction area, 2 cm away from a left anterior descending artery (LAD). A properly tailored bovine pericardial patch is then sutured to the endocardium of left ventricle surrounding the VSR by running a 4-0 polypropylene suture. The suturing begins beyond the VSR margin, farthest away from the ventriculotomy, into the healthy area of the septum. The procedure is performed in both clockwise and anticlockwise directions and passed to the ventriculotomy edge, at the point where the septum joins the anterior wall. A second larger patch is sutured to the endocardium further out the first suture line in the same suturing fashion. After that, BioGlue (CryoLife Inc) is applied only to the suture line between the patches to reinforce it, not to fill up the cavity between patches. The left ventriculotomy is closed with mattress sutures buttressed with felt strips through the 2 patches, followed by an over and over running suture (Figure 1, *A*, and Figure 2, *A*).

Anterior VSR With Wide Necrotic Ventricular Muscle

The ventriculotomy is made at the lateral side of the identified infarcted lesion, and then the necrotic ventricular muscle is trimmed parallel to the LAD. VSR is repaired in the same fashion as described previously. Free-wall repair for large defects following the excision of the necrotic ventricular muscle is performed using an oval-shaped Dacron velour (Sauvage filamentous). This patch is placed on the septum and free wall over the



VIDEO 1. VSR repair with 2 separate patches with BioGlue, which is applied on the suture line between 2 patches. Free wall repair for large ventricular free-wall defect following excision of necrotic ventricular muscle. *VSR*, Ventricular septal rupture; *LV*, left ventricle; *LAD*, left anterior descending artery. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00140-7/fulltext.

ventriculotomy with 3-0 polypropylene interrupted sutures. Then, we suture on the septal side through the 2 bovine patches and septal wall to come out through the right ventricular wall and bovine patches. However, the sutures on the free-wall side are placed transmurally outward from the left ventricular (LV) cavity. A triplex (Terumo) is opened longitudinally, cut into an oval shape, and placed on the epicardial site covering the ventriculotomy and tied down with interrupted sutures. Then, a felt strip is placed on the epicardium around the edge of the triplex with a continuous 4-0 polypropylene suture. (Figure 1, *B*, and Figure 2, *B*).

RESULTS

From January 2015 to March 2021, 7 patients underwent the procedure (mean age, 73 ± 6 years). Among them, 2 underwent concomitant free-wall repair. Later, 4 patients were weaned off cardiopulmonary bypass using intraaortic balloon pump (IABP) and percutaneous cardiopulmonary support whereas 2 used only IABP. Nonetheless, 4 patients underwent percutaneous coronary intervention (PCI) in LAD at the onset of AMI. Two patients underwent PCI in LAD at the onset of AMI and staged PCI for another territory during the same hospitalization. Three patients were in Killip class III, and the other 4 patients were in Killip class IV. Furthermore, 6 patients needed IABP support preoperatively. Five patients underwent an emergency operation on the same day of VSR diagnosis. Two patients were referred to our hospital for surgery from the initial hospital at several days' standing after diagnosis of VSR as a result, they underwent an urgent operation. One patient underwent concomitant coronary artery bypass grafting in the left circumflex coronary artery. Overall, the mean time of the aortic crossclamp procedure was 101 ± 37 minutes. However, it was 75 ± 13 minutes in septal infarction exclusion and 152 ± 6 minutes if there was additional LV free-wall repair. In contrast, in general, the mean time of cardiopulmonary bypass time was 145 ± 42 minutes. Moreover, it was 118 ± 20 minutes in septal infarction exclusion and 201 ± 5 minutes if there was additional LV free-wall repair. The overall rate of in-hospital mortality was 0%. None of the patients manifested low output syndrome (LOS) or residual shunt. The mean follow-up period was 37 ± 24 months with no death or reoperation cases. There were no signs of residual VSR or aneurysm formation of the LV according to echocardiographic follow-up (Table 1).

DISCUSSION

Daggett and colleagues[1] introduced a technique characterized by a transinfarct LV incision, infarctectomy, and direct or patch closure of VSR. In contrast, David and Armstrong's technique[2] included infarct exclusion using endocardial patch repair without removal of the infarcted ventricular muscle.

Even with Daggett and colleagues' and David and Armstrong's technique, we still have a residual leak, uncontrolled bleeding, low cardiac output, and technical difficulty, higher mortality, and the recurrence of VSR after a postinfarction VSR repair.

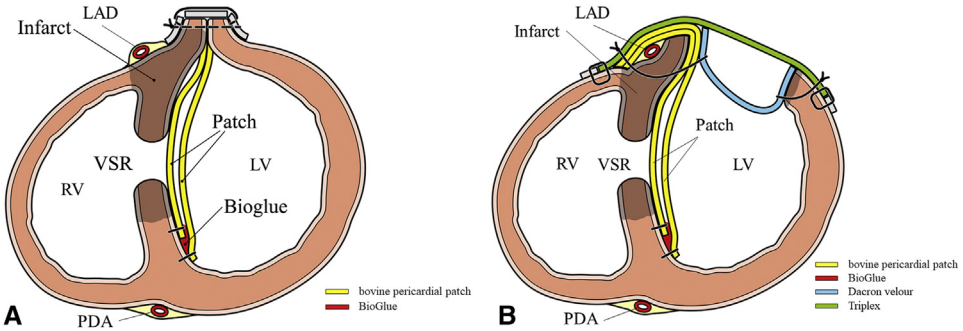


FIGURE 1. Cross-sectional view of ventricles. A, Anterior VSR repair by 2 separate patches with BioGlue applied on the suture line between 2 patches. B, Anterior VSR extended repair of the septum and free walls with an inner patch covered by a prosthetic patch from outside for the anterior left ventricular free-wall defect created by infarctectomy. *LAD*, Left anterior descending artery; *VSR*, ventricular septal rupture; *RV*, right ventricle; *LV*, left ventricle; *PDA*, posterior descending artery.

FIGURE 2. Postoperative computed tomography showing repaired ventricular septum by 2 separate patches with BioGlue (*arrow*) for anterior VSR (A) and anterior VSR and free-wall repair (B) without a residual shunt. *VSR*, Ventricular septal rupture; *LV*, left ventricle; *RV*, right ventricle.

Many surgeons have tried to improve the previous techniques and reduce the risk of postoperative leak.[3-5] However, the weakness of a single suture line, using of one patch and tension could lead to a residual leak, patch dehiscence, and recurrence of VSR.

The concept of our procedure is to deal with septal infarction and free-wall infarction separately. For the septal infarction, we performed the exclusion with 2 bovine pericardium patches, which cover doubly the entire septum on the left side with a running suture. This method could reduce the tension on the inner patch.

BioGlue was applied to the suture line between the patches to prevent blood from leaking through the suture line. However, BioGlue is known for its high strength and good tensile. Therefore, we didn't see the complications related to BioGlue such as embolization and dislodgement.

Caimmi and colleagues[5] reported a technique in which they fixed a septal patch to the posterior LV free wall with a transmural suture. When the VSR is funnel-shaped myocardial necrosis characterized by a small ostium at the right ventricle side, septal infarction area could be removed to place anchoring suture through the septal remnant from right side to the left side. In contrast, our concept is about performing septal infarction exclusion from the LV side without removal of septal infarction area regardless of VSR shape. We believe that it is a simple reproducible procedure to perform septal infarction exclusion using 2 pericardial patches with a running suture reinforced BioGlue.

We decided whether LV free-wall repair was accomplished or not, based on LV pathologies at ventriculotomy. We basically perform ventriculotomy closure through the usual technique of buttressing the suture lines with 2 Teflon strips, which are placed on either side of the incision. However, as the LV closure line is subjected to LV pressure, the suture must be placed on the healthy ventricular muscle. However, when ventricular muscle at the edge of ventriculotomy has intramyocardial hematoma, the boundary between healthy and necrotic muscle will be ill-defined from outside, leading surgeons to underestimate the necrotic area. Therefore, the ventricular muscle at both sides of the incisions should be resected until intramyocardial hematoma is removed. In addition, conventional ventriculotomy closure such as the previous one may lead to postoperative LOS, which highlights the importance of LV free-wall repair. In our study, 2 patients required LV

TABLE 1. Patient data

Patient	Sex	Age, y	Preoperative NYHA	Preoperative Cr, mg/dL	Preoperative IABP	Killip classification	VSR surgery, d	Early death	Postoperative residual shunt	Postoperative EF, %	Late death	Follow-up, mo	Residual shunt at latest follow-up	EF (%) at latest follow-up	NYHA at latest follow-up
1	F	80	4	0.81	+	IV	0	–	–	35	–	71	–	54	2
2	M	63	4	1.34	+	IV	0	–	–	40	–	68	–	45	2
3	M	68	4	0.66	+	III	5	–	–	32	–	47	–	46	2
4	F	81	4	0.78	–	III	10	–	–	48	–	36	–	51	2
5	F	75	4	1.79	+	IV	0	–	–	45	–	21	–	47	2
6	M	70	4	0.99	+	III	0	–	–	35	–	12	–	48	1
7	F	73	4	0.95	+	IV	0	–	–	30	–	7	–	30	2

"VSR surgery" indicates period from VSR onset to operation (days). *NYHA*, New York Heart Association functional class; *Cr*, creatinine; *IABP*, intra-aortic balloon pumping; *VSR*, ventricular septal rupture; *EF*, ejection fraction; *F*, female; *M*, male.

free-wall repair; however, the defect after resection of intramyocardial hematoma at LV free wall was oval with approximate width and length of 4 cm and 7 cm, retrospectively.

We used the Triplex graft for the secondary closure of the anterior infarct because it consists of inner and outer layers of uncoated knitted polyester graft fused with a central layer of self-sealing elastomeric membrane. In addition, it has high intrinsic impermeability, which could reduce oozing from suture holes. As a result, the water leakage value was 0.68 mL/cm^2/min, significantly lower than the mean value (15 mL/cm^2/min) of the standard coated vascular grafts. Moreover, we placed Teflon felt around the Triplex patch to close the gap between the triplex graft and the epicardium to seal the gap between triplex and epicardium.

This free-wall repair technique is more time-consuming than conventional ventriculotomy closure. Furthermore, crossclamp time for this technique is slightly longer. However, this approach facilitates ventricular closure without burdensome hemostasis and postoperative LOS. Although initial results seem encouraging, it is quite difficult to provide a comparison with other proposed techniques because of the various other factors that can influence the outcome in these patients, such as preoperative comorbidities, clinical status, and preoperative or postoperative management.

Although all our operations were done on an emergency basis, there has been no mortality, residual shunt, or LOS. Thus, this paper offers surgeons a new surgical technique for VSR repair tailored to a range of postinfarcted myocardial pathologies.

References

1. Daggett WM, Guyton RA, Mundth ED, Buckley MJ, McEnany MT, Gold HK, et al. Surgery for post-myocardial infarct ventricular septal defect. *Ann Surg*. 1977;186:260-71.
2. David TE, Armstrong S. Surgical repair of postinfarction ventricular septal defect by infarct exclusion. *Semin Thorac Cardiovasc Surg*. 1998;10:105-10.
3. Labrousse L, Choukroun E, Chevalier JM, Madonna F, Robertie F, Merlico F, et al. Surgery for post infarction ventricular septal defect (VSD): risk factors for hospital death and long term results. *Eur J Cardiothorac Surg*. 2002;21:725-31; discussion 731-2.
4. Lundblad R, Abdelnoor M. Surgery of postinfarction ventricular septal rupture: the effect of David infarct exclusion versus Daggett direct septal closure on early and late outcomes. *J Thorac Cardiovasc Surg*. 2014;148:2736-42.
5. Caimmi PP, Grossini E, Kapetanakis EI, Boido R, Coppo C, Scappellato F, et al. Double patch repair through a single ventriculotomy for ischemic ventricular septal defects. *Ann Thorac Surg*. 2010;89:1679-81.