Midterm Results of the “Sandwich Technique” via a Right Ventricle Incision to Repair Post-Infarction Ventricular Septal Defect

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Introduction

A post-infarction ventricular septal defect (VSD) is a life-threatening complication of a transmural acute myocardial infarction; there is poor survival with medical therapy.1,2) Problems of the current surgical techniques are residual shunting, uncontrolled bleeding, and technical difficulty.3,4) We have developed a new technique to solve these problems.5) Using direct echocardiography to view the VSD and trabecula in the right ventricle enables a right ventricular (RV) approach. By contrast, an RV incision without any guidance presents an uncertain view of the right ventricle. Gelatin-resorcin-formalin (GRF) glue (Cardial; Technopole, Sainte-Etienne, France) used in the “sandwich technique” enabled us to diminish the risk of leakage. The entire procedure avoided excessive downsizing of the left ventricle. This report describes the mid-term results of the sandwich technique, performed via a right ventricle incision, to repair a post-infarction ventricular septal defect.

Materials and Methods

From June 25, 2001 to December 29, 2010, we had seven surgical cases of post-infarction VSD. The patients’ characteristics were collected, which included age; sex; clinical presentation; laboratory data; operative...
parameters; residual leak; postoperative bleeding; major complications; thirty-day postoperative mortality; and long-term survival. The data were presented as the mean +/- standard deviation (SD) or by ranges.

**Surgical technique**

Epicardial direct ultrasonography is applied to the right ventricular wall under extracorporeal circulation. This enables the surgeon during cardiac arrest to visualize the lesion, perform the appropriate incision into the right ventricle, and to perform a trabecula resection. (The trabecula impedes the surgical view.)

The fragile necrotic myocardium around the VSD is resected (Fig. 1A), and the edge of the defect is trimmed (Fig. 1B). The left ventricular (LV)-side patch is introduced into the left ventricle through the space produced by the trimmed defect. The surgical bite should be 1.0 cm from the edge of the trimmed defect. After adding an outer margin that extends 0.5 cm from the stitch, the length and width of patches are 3.0 cm larger than the size of the trimmed defect. The LV-side and RV-side patches are composed of Teflon felt and equine pericardial patch. They are attached using fibrin glue or GRF glue. (In the first two patients, equine pericardial patches were not applied to the RV patches.)

Eight to ten 4-0 polypropylene mattress sutures are first applied to the LV-side patch and then to the edge of the defect. The LV-side patch is introduced into the left ventricle chamber (Fig. 1C). After the introduction of the LV-side patch, the sutures are lifted to make the LV-side patch fit the ventricular septum (Fig. 1D). The GRF glue is applied three or four times into the defect, while taking care that the glue does not enter the LV chamber (Fig. 1E).

To prevent the presence of residual aldehyde from the hardener, the ratio of the adhesive to the hardener in the GRF glue is controlled at 10:1.6. The amount of adhesive is measured using a syringe, and the amount of the hardener is controlled by counting drips from a 27 gauge needle with a 1 ml syringe (Fig. 1E).

The LV-side and RV-side patches pinch the ventricular septum tissue. This generates friction between the myocardium and the patches, thereby eliminating the possibility of the sutures tearing the tissue and the development of leaks (Fig. 1F). The right ventricle is closed either with or without equine pericardial reinforcement.

**Results**

Preoperative data are displayed in Table 1. The mean age of patients was 70.9 years old. The perforation was located at the anterior wall or the posterior wall. A cardiac rupture occurred in two patients. The duration from the onset of the infarction to the operation was from zero to 17 days. Most patients had received preoperative treatment with an intra-aortic balloon pump (IABP), and one patient had received preoperative treatment with percutaneous cardiopulmonary support (PCPS).

Operative and postoperative data are displayed in Table 2. Two patients received a simultaneous coronary artery bypass graft (CABG). LV rupture in one case was wozzing type, and was repaired with equine pericardium.
The mean aortic clamp time was 126 minutes (with a range of 74 to 173 minutes). The mean extracorporeal circulation time was 207 minutes (with a range of 119 to 251 minutes). The mean operation time was 399 minutes (with a range of 302 to 449 minutes). The mean postoperative use of IABP was for 2.9 days (with a range of one to five days). We observed some leakage, but it was very minor. By the thirtieth post-operative day, there was no mortality. However, one patient died of congestive heart failure on the thirty-second post-operative day. His surgery was a redo operation that was performed four days after the first surgery (which had been the Komeda type of surgery with a single patch repair through an LV incision). Hospital mortality was 14.3% (1/7 cases). Another patient died of arrhythmia three months after surgery. Five of seven patients (71%) survived for longer than a year and are currently alive. The longest patient survival time was nine years. Mild left ventricular aneurysmal formation was seen in a case with preoperative percutaneous cardiopulmonary support. No patient required left ventricular plasty in follow-up period.

### Discussion

A post-infarction ventricular septal defect (VSD) occurs in 1% to 2% of transmural acute myocardial infarction cases. Medical therapy provides poor results—around 10% of patients survive past three months with medical therapy.

Residual shunting, uncontrolled bleeding, and technical difficulty are problems of current surgical techniques. Deja et al. reported the results of 110 patients who had undergone Dagget’s surgical technique, the Komeda exclusion technique, or other surgical techniques. There was residual shunting in 40% of patients; reoperation in 12% of patients; operative mortality in 35% of patients; and a five-year survival in 45% of patients. The Dagget technique provides excessive strong tension at the suture, and the result is often residual shunting and bleeding. A reduction in the size of the left ventricle and a change in the geometry of the left ventricle can sometimes deteriorate LV function. The exclusion technique involves stitching a rather healthy myocardium. This prevents further tearing of the VSD, but residual shunting and potential change in LV geometry cannot be fully avoided. GRF glue reinforcement helps to prevent leaks. The double patch technique, in which the patch is reinforced with GRF glue, seems to prevent shunting, but the potential problem of LV geometry change still remains.

The sandwich technique described in this report (Fig. 2) is simple and technically easy to perform, compared with techniques previously reported. Our data showed less residual shunting, no reoperation, and low postoperative mortality. However, our experience is limited. The sandwich technique consists of the following elements, which improve surgical results:

1. Direct echocardiography allows a surgeon to visualize the VSD. It provides information about the trabecula in the right ventricle. By contrast, an RV approach without any guidance, gives an uncertain view of the right ventricle.

2. Two patches pinch the ventricular septum and provide some friction between the myocardium and...
patches. This generates less tearing force at the sutures, compared with the single patch technique.

3. The GRF glue prevents leaks at the VSD and suture holes and strengthens the edge of the VSD by cross-linking the fragile necrotic myocardium.

4. The LV geometry is not changed.

5. The degree of technical difficulty of the sandwich technique is similar to that of valve replacement, and its technical ease should be promoted.

There are several points of concern with the sandwich technique, although it has good surgical results. The first concern is thrombus formation at the patches. In our early experience, one patient presented with thrombus at the RV patch. In this patient, an equine patch was not initially applied on Teflon felt, but it was applied afterwards. Another patient presented with a brain infarction. In this patient, an equine pericardial patch was attached to Teflon felt with GRF glue. GRF glue may accelerate thrombus formation. For recent patients, we used fibrin glue to attach equine pericardial patches to the felt and then put the patients on warfarin for three months while monitoring for the degradation product of fibrin. The second concern is the possibility of right heart failure after the surgery. The RV incision and the patch at the ventricular septum can affect RV function. For example, an excessively large patch may prevent ventricular septal motion, but a patch that is too small may result in leaks. Reinforcement of the RV incision with felt may impede the motion of the RV free wall. The third concern is the possible presence of residual aldehyde and the formation of a pseudoaneurysm at the repair site. When using GRF glue, care should be taken to use the correct ratio of the adhesive to the hardener. Our in vitro test indicated that a 10 to 1 volume ratio of adhesive to hardener provides the best force and minimal residual aldehyde.6)

In conclusion, the sandwich technique seals the post-infarction VSD between two patches with GRF glue and is performed via a RV approach. This technique is technically easy to perform and results in less change in the LV size, fewer leaks, less bleeding, improved accessibility to the anterior and posterior wall VSD, and good midterm survival.

References