Korean J Thorac Cardiovasc Surg 2013;46:433-438 □ Clinical Research □
ISSN: 2233-601X (Print) ISSN: 2093-6516 (Online) http://dx.doi.org/10.5090/kjtcs.2013.46.6.433

Surgical Repair of Ventricular Septal Defect after Myocardial Infarction: A Single Center Experience during 22 Years

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Background: Surgical repair of post-infarct ventricular septal defect (VSD) is considered one of the most challenging procedures having high surgical mortality. This study aimed to evaluate the outcomes of the surgical repair of post-infarct VSD. ***Methods:*** From May 1991 to July 2012, 34 patients (mean age, 67.1±7.9 years) underwent surgical repair of post-infarct VSD. A retrospective review of clinical and surgical data was performed. ***Results:*** VSD repair involved the infarct exclusion technique using a patch in all patients. For coronary revascularization, 12 patients (35.3%) underwent concomitant coronary artery bypass graft, 3 patients (8.8%) underwent preoperative percutaneous coronary intervention, and 9 patients (26.5%) underwent both of these procedures. The early mortality rate was 20.6%. Six patients (17.6%) required reoperation due to residual shunt or newly developed VSD. During follow-up (median, 4.8 years; range, 0 to 18.4 years), late death occurred in nine patients. Overall, the 5-year and 10-year survival rates were 54.4%±8.8% and 44.3%±8.9%, respectively. According to a Cox regression analysis, preoperative cardiogenic shock (p=0.069) and prolonged cardiopulmonary bypass time (p=0.008) were independent predictors of mortality. ***Conclusion:*** The early surgical outcome of post-infarct VSD was acceptable considering the high-risk nature of the disease. The long-term outcome, however, was still dismal, necessitating comprehensive optimal management through close follow-up.

Key words: 1. Myocardial infarction
2. Ventricular heart septal defects
3. Surgery
4. Mortality
5. Risk factors

INTRODUCTION

The development of ventricular septal defect (VSD) is an uncommon complication following acute myocardial infarction (MI) occurring in 0.2% of patients with MI [1], but it is one of the most serious and life-threatening complications. Although surgical repair of post-infarct VSD is a challenging procedure having high surgical mortality of 19% to 60% in previous reports [1-16], there is still no alternative therapeutic option. For instance, the outcomes of medically treated patients are reported as extremely poor, having a mortality rate of 90% or more [1].

Recently, data regarding the outcomes of post-infarct VSD from two nationwide large-scale registries have been reported

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Received: April 12, 2013, Revised: July 16, 2013, Accepted: July 22, 2013
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in Europe and the United States [9,10]; however, there has been no report regarding this issue from a reasonably sized population consisting of other ethnic groups such as the Korean population. Therefore, the present study aimed to evaluate the early and late outcomes of the surgical repair of post-infarct VSD performed in Korea and to determine the predictive factors of mortality.

METHODS

1) Patients

Between May 1991 and July 2012, 34 adult patients underwent the surgical repair of post-infarct VSD at the Asan Medical Center, Seoul, Korea. From transthoracic echocardiography and coronary angiography (CAG) profiles, preoperative, operative, and postoperative variables were collected retrospectively. These included demographic characteristics, co-morbidities, preoperative hemodynamic status (presence of shock, requirements of intra-aortic balloon pump, extracorporeal membrane oxygenation [ECMO]), aortic cross clamp time, and cardiopulmonary bypass (CPB) time. The study was approved by the institutional ethics committee/review board of the Asan Medical Center, and the requirement for informed patient consent was waived in view of the retrospective nature of the study.

2) Surgical technique

The operations were performed by six cardiac surgeons. All of the VSD repairs were performed by using the infarct-exclusion technique first described by David and colleagues. The ventriculotomy incisions were made in the infracted area of the left ventricular or right ventricular free wall. Then, the interventricular septal defect was excluded using a Dacron (DuPont, Wilmington, DE, USA), Teflon (Impra Inc., subsidiary of LR Bard, Tempe, AZ, USA), or bovine pericardium patch. The patch was sutured to un-infarcted tissue to avoid dehiscence or recurrence of VSD. The ventriculotomy was closed and reinforced by Teflon strips beside the suture line. Concomitant coronary arterial bypass graft surgery (CABG) was performed in 21 patients.

3) Statistical analysis

Categorical variables were presented as frequencies and percentages, and were compared using the chi-squared test or Fisher's exact test. Continuous variables were expressed as mean±standard deviation and compared using the Student unpaired t-test. To determine the predictors of mortality, a Cox regression model was used for multivariable analyses. Variables with a p-value of ≤ 0.20 in the univariable analyses were candidates for the multivariable models. The multivariable analyses involved a backward elimination technique, and only variables with a p-value of ≤ 0.10 were used in the final model. Results were expressed as a hazard ratio (HR) with 95% confidence intervals (CI). All reported p-values were two-sided, and p-values of < 0.05 were considered to indicate statistical significance. Statistical analyses were performed with PASW SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

1) Baseline characteristics

The baseline characteristics of the patients are summarized in Table 1. Preoperative cardiogenic shock was present in 25 patients (73.5%). The cardiogenic shock was defined as a systolic blood pressure of < 90 mmHg for at least 30 minutes or the need for inotropic drugs to maintain a systolic blood pressure of ≥ 90 mmHg. The median time interval from the MI to the operation was 8.5 days (range, 0 to 187 days), and the median time interval from the VSD diagnosis to the operation was 3 days (range, 0 to 187 days). Nine patients (26.5%) underwent emergency surgical repair within 24 hours of the VSD diagnosis, 16 patients (47.1%) between 2 days and a week, and 9 patients (26.5%) after a week.

A preoperative CAG was performed in all of the patients with post-infarct VSD. Twenty-three patients (67.6%) were revascularized of culprit vessels. Twelve patients (35.3%) underwent concomitant CABG during surgical repair of VSD, three patients (8.8%) underwent preoperative percutaneous coronary intervention (PCI), and nine patients (26.5%) underwent both preoperative PCI and concomitant CABG.

Table 1. Baseline characteristics of the patients who underwent surgical repair of post-infarct VSD (n=34)

Variable	Value
Age (yr)	67.1±8.0
Male gender	13 (38.2)
Body surface area (m^2)	1.62±0.14
Hypertension	12 (35.3)
Diabetes mellitus	10 (29.4)
Previous myocardial infarction	1 (2.9)
Preoperative cardiogenic shock	25 (73.5)
Preoperative intraaortic balloon pump	23 (67.6)
Preoperative extracorporeal membrane oxygenation	1 (2.9)
Echocardiographic data	
LV end-systolic dimension (mm)	36.8±7.28
LV end-diastolic dimension (mm)	52.9±11.6
LV ejection fraction	43.7±8.6
LV mass (g)	210.3±57.1
Myocardial infarction to operation (day)	8.5 (0–187)
VSD diagnosis to operation (day)	3 (0–187)
Aorta cross clamp time (min)	85.2±45.2
Cardiopulmonary bypass time (min)	165.0±88.3
No. of diseased vessels	
One-vessel disease	16 (47.1)
Two-vessel disease	11 (32.4)
Three-vessel disease	7 (20.6)
Left main coronary artery disease	2 (5.9)
Anatomy of culprit lesion	
Left anterior descending artery	28 (82.4)
Right coronary artery	6 (17.6)
Location of VSD	
Anterior	28 (82.4)
Posterior	6 (17.6)
VSD size (mm)	13.9±7.3

Values are presented as mean±standard deviation, number (%) or median (range).
VSD, ventricular septal defect; LV, left ventricle.

Table 2. Early operative outcomes (n=34)

Variable	Value
30-day mortality	7 (20.6)
In-hospital mortality	10 (29.4)
No. of patients with major complications	
Residual shunt or recurrent ventricular septal defect	9 (26.5)
Left ventricular free wall rupture	1 (2.9)
Re-exploration for bleeding	1 (2.9)
New dialysis	3 (8.8)
Low cardiac output syndrome[a)]	7 (20.6)

Values are presented as number (%).
[a)]Postoperative requirement of mechanical support such as intra-aortic balloon pump or extracorporeal membrane oxygenation.

2) Early outcomes

The early operative outcomes are summarized in Table 2. Postoperative ECMO was required in three patients; one of them also required renal replacement therapy. Further, all three of them died of low cardiac output syndrome (LCOS).

Residual shunt or recurrent VSD was observed in nine patients (26.5%) in the postoperative echocardiography follow-up. Among them, five patients required reoperation because of a large hemodynamically significant defect, and two patients underwent concomitant tricuspid valve (TV) replacement during reoperation because of TV papillary muscle infarct necrosis in one patient and infective endocarditis of TV in the other. Among the nine patients with residual VSD, three patients died in hospital and another three patients died after discharge during the follow-up period.

Another patient underwent reoperation on the day after the first operation due to left ventricular free wall rupture. The left ventricular free wall rupture was newly developed, not a consequence of ventriculotomy dehiscence.

The 30-day mortality rate was 20.6% (n=7), and the cause of death was profound cardiac failure in all these cases. The patients in these cases were in cardiogenic shock at the time of operation. The other three patients died in hospital more than 30 days after the operation, and the causes of death were sepsis in two patients and subdural hemorrhage in the third patient. This resulted in the in-hospital mortality rate of 31.2% (n=10).

3) Overall outcomes and predictors of mortality

During the follow-up period (median, 4.8 years; range, 0 to 18.4 years), nine patients died after discharge. Overall, the 5-year and 10-year survival rates were 54.4%±8.8% and 44.3%±8.9%, respectively (Fig. 1).

Multivariable analyses revealed that the prolonged CPB time (HR, 1.07; 95% CI, 1.02 to 1.13; p=0.008) is an independent factor associated with the overall mortality. Preoperative cardiogenic shock (HR, 3.91; 95% CI, 0.90 to 17.01; p=0.069) also showed an association with the overall mortality; however, it was not statistically significant (Table 3). Fig. 2 shows higher survival rates of patients who were

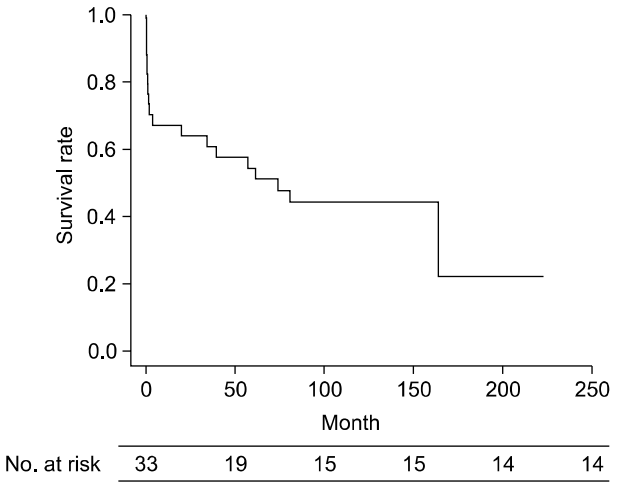

Fig. 1. Kaplan-Meier survival curve. Five-year survival rate, 54.4%± 8.8%; ten-year survival rate, 44.3%±8.9%.

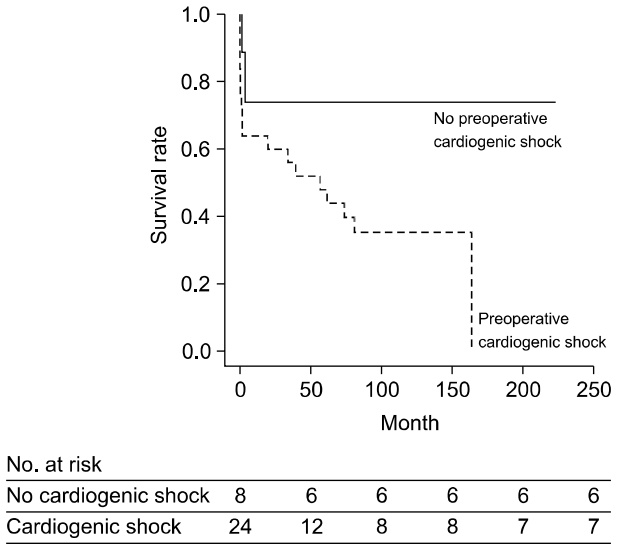

Fig. 2. Kaplan-Meier survival curve according to the presence of cardiogenic shock at the time of the operation.

not in preoperative cardiogenic shock at the time of operation than of the patients who were in cardiogenic shock.

DISCUSSION

After the introduction of reperfusion therapy such as early PCI or thrombolysis, the incidence of VSD development following MI significantly decreased by 5- to 10-fold [1,17]; however, the outcomes of medically treated patients are reported as extremely poor, having a mortality rate of 90% or more [1]. Thus, surgical repair is the only option to treat post-infarct VSD. Surgical repair of post-infarct VSD is still one of the most challenging cardiac procedures, despite recent advancements in surgical techniques, cardiac anesthesia, and myocardial protection during cardiac surgery.

Table 3. Multivariable risk factors analyses for overall mortality

	Hazard ratio	95% confidence interval	p-value
Preoperative cardiogenic shock	3.91	0.90–17.01	0.069
Prolonged cardiopulmonary bypass time	1.07	1.02–1.13	0.008

The recurrence rates of VSD after the initial surgical repair of post-infarct VSD have been reported to range from 10% to 44% [3,9,14,18]. In the present study, nine patients (26.5%) had complications of residual shunt or recurrent VSD after surgery at postoperative echocardiogram, and five of them required reoperation because of a large hemodynamically significant defect. The myocardial fragility and vague margin of the infracted tissue may be attributable to the relatively high incidence of residual shunt. A study suggests that residual VSD occurrence would be reduced with a double patch technique as compared to a single patch technique [14]. However, the operative periods were distinct between the two operative techniques in the study: the single patch technique in the first half and double patch technique in the second half period. Moreover, the study could not show a statistically significant difference between the two techniques. A comparison of the recurrence rate according to surgical methods was not conducted in most of the studies reported thus far because of the small number of subjects considered and the long study period owing to the rare incidence of post-infarct VSD. In this present study, a comparison of surgical techniques for the recurrence of VSD was also not conducted because all of the VSD repairs were performed using a uniform surgical technique. Nevertheless, we believe that achieving complete exclusion of the fragile-infarcted myocardial tissue by fixing the patch on the healthy, viable myocardium may be the best way to reduce the risk of residual VSD.

Although a recent report demonstrated a significant im-

provement of surgical outcomes in the second half of the 25-year study period [6], there were no remarkable changes in the surgical outcomes of post-infarct VSD in the other previous studies [1-5,7-18]. The dismal outcomes may be attributable to the disease nature of post-infarct VSD: the surgical outcomes of post-infarct VSD are predominantly affected by the preoperative patients' hemodynamic stability. Most of the studies on post-infarct VSD showed a strong association of shock at the time of operation and early mortality [3,13-16]. It has been commonly believed that if patients are hemodynamically stable, surgical repair should be delayed until the formation of the myocardial scar tissue and the development of the margins of the infracted muscle because the myocardium is considerably fragile; this may facilitate technical aspects of the surgical procedure. However, a majority of the studies demonstrated no association of the surgical timing of VSD and the surgical outcomes [3,6,11-13], and the current guideline of American College of Cardiology/American Heart Association recommends immediate repair of post-infarct VSD after diagnosis without delay, irrespective of the hemodynamic status because rapid deterioration can occur in many patients [19]. The association of the earlier surgical timing and operative mortality in some reports may be mostly attributable to the hemodynamic status requiring earlier surgery, not to the technical difficulty. Our findings also suggest associations between preoperative cardiogenic shock and early and overall outcomes, whereas there were no associations between the surgical timing and the outcomes.

The posterior location of VSD has been found to be associated with poor prognosis in most of the previous studies [3,9,18,20]. Surgical difficulties in the exposure of the septal rupture site and the right heart failure are mainly attributed to poor prognosis. However, David et al. [7] and a recent report [8] showed a different result; they revealed that posterior VSD is significantly associated with improved surgical outcomes. The authors suggest that the infarct exclusion technique may address the difficulties of posterior VSD repair and prevent right heart failure by the physiologically sound character of the technique. In the previous two studies, however, the sample size was small, involving only 44 patients and 32 patients, respectively; thus, the sample size may have been too small to evaluate the casual relationship between the VSD location and operative risk. Considering the relatively small sample size of 34 patients in the present study, it can be understood in the same context that the location of the VSD was not associated with the surgical outcomes in the present study.

The present study showed an early mortality rate of 20.6% and in-hospital mortality of 31.2%. The results are comparable to the previous reports of post-infarct VSD that reported early mortality ranging from 19% to 60% [1-16]. Consistent with other studies [3,13-16], our current findings suggest a strong association between preoperative cardiogenic shock and early and overall mortality. All of the patients who died within the first 30 days after the operation were in cardiogenic shock at the time of operation. However, because of a small sample size, the statistical significance was marginal ($p=0.069$).

Prolonged CPB time was found to be a risk factor of overall mortality in several previous studies [5,6]. However, prolonged CPB time was not a predictor of cumulative mortality in 30-day survivors in the cited study [6], and the authors suggested that the prolonged CPB might have been confounded by underlying factors. In our study, prolonged CPB time was an independent factor associated with overall mortality in the multivariable analysis. We also believe that the result cannot be attributed to the effect of CPB itself, but the underlying clinical situations of prolonged CPB such as difficulty in weaning from CPB might have contributed to the mortality. For instance, two patients required more than 400 minutes of CPB time; these patients were given ECMO as a result of CPB weaning failure and died of LCOS.

This study is subject to the limitations inherent in the retrospective studies of observational data from a single center. The study results might have been affected by unmeasured confounders, procedure bias, or detection bias. Although the number of subject patients was not small compared with previous studies on post-infarct VSD, the absolute number of patients enrolled was small to draw robust conclusions.

In conclusion, using the infarct exclusion technique, we found that the early surgical outcome of post-infarct VSD was acceptable considering the high-risk nature of the disease. However, the long-term outcome was still dismal, necessitating comprehensive optimal management through close

follow-up. Preoperative cardiogenic shock and prolonged CPB time were significant and independent predictors of the overall mortality.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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