In the mid-1990s, the modified single-patch technique, which was introduced by various surgical approaches, has been developed since Lillehei et al. performed the first successful repair of complete atrioventricular septal defect (AVSD) in 1955 [1]. However, the technique used to close the interventricular communication is still debated. A primary characteristic of the modified single-patch technique, which was introduced in the mid-1990s [2, 3], is the obliteration of interventricular communication by direct closure of the bridging leaflet and septal crest. We compared different surgical techniques in terms of the postoperative surgical outcomes and evaluated the usefulness of the modified single-patch technique.

1. Introduction

Various surgical approaches have been developed since Lillehei et al. performed the first successful repair of complete atrioventricular septal defect (AVSD) in 1955 [1]. However, the technique used to close the interventricular communication is still debated. A primary characteristic of the modified single-patch technique, which was introduced in the mid-1990s [2, 3], is the obliteration of interventricular communication by direct closure of the bridging leaflet and septal crest. We compared different surgical techniques in terms of the postoperative surgical outcomes and evaluated the usefulness of the modified single-patch technique.

2. Materials and methods

Sixty-one patients who underwent the biventricular repair of complete AVSD from January 1997 to December 2006 at the Sejong General Hospital were analyzed retrospectively. In Seok Jeonga, Chang-Ha Leea,*, Cheul Leeb, Hong Gook Limb, In Sub Kimb, Hyo Chul Younb, Seong Wook Hwangc, Hong-Joo Seod

*Department of Thoracic and Cardiovascular Surgery, Chonnam University, College of Medicine, Kwangju, South Korea
bDepartment of Thoracic and Cardiovascular Surgery, Sejong Heart Institute, Sejong General Hospital, 91-121 Sosa Bon 2-dong, Sosa-gu, Bucheon-si, Gyeonggi-do 422-711, South Korea
cDepartment of Thoracic and Cardiovascular Surgery, Chosun University, College of Medicine, Kwangju, South Korea

Exclusion criteria included complete AVSD with tetralogy of Fallot (TOF). The patient population in our study was divided into two groups: the obliteration technique (OT) group underwent the modified single-patch technique (18 patients) and the patch technique (PT) group underwent the classical one-/two-patch technique (43 patients). The one-/two-patch techniques were categorized as the same technique because the interventricular defect was closed with the patch material. These patients were not randomized, but instead, each case was managed according to the individual patient’s anatomy and surgeon’s discretion.

All operations were performed with cardiopulmonary bypass (CPB), moderate hypothermia, aortic cross-clamp (ACC) application, and the infusion of antegrade cardioplegic solution. In the one-/two-patch technique, a glutaraldehyde (GA)-treated autologous pericardial patch or Dacron (C.R. Bard, Haverhill, Pennsylvania) patch were used to close the ventricular septal defect (VSD). When closing the VSD with the modified single-patch technique, a series of not-pledgeted, interrupted, horizontal mattress sutures (6/0 or 7/0 Polypropylene) was first placed on the right side of the ventricular septal crest. These sutures were passed through the midportion of the common atrioventricular (AV) valve leaflet and through a harvested...
autologous pericardial patch, after which they were tied off and obliterated the interventricular component. The degree of cleft closure depended on the anatomy of the AV valve. The primum atrial septal defect (ASD) was closed with a pericardial patch with a continuous suture. Routine intraoperative transesophageal echocardiography (TEE) evaluation was performed by pediatric cardiologists.

A statistical analysis was performed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). All results are expressed as the mean±S.D. or the median value plus a range. The statistical analysis was carried out using the Pearson’s χ²-test and Mann–Whitney U-test. The P<0.05 was considered as the statistical significance.

3. Results

The preoperative demographics, intraoperative data and in-hospital results of two groups are shown in Tables 1–3. No significant differences were observed between the two groups except ACC time, which was shorter in the OT group (OT: 110.8±27.5 min, PT: 134.4±42.5 min, P=0.03).

Complete follow-up data were available on 16 patients (88.9%) in the OT group and 38 patients (88.4%) in the PT group. The postoperative results are summarized in Table 4. One death (5.5%) occurred in the OT group. He died three months postoperatively. The cause of death was pneumonia. Three deaths (7%) took place in the PT group: one hospital death and two late deaths. In the case of hospital death, the patient died on the first postoperative day because of low cardiac output syndrome. In the case of late death, one patient died two months postoperatively from heart failure, and the other patient died suddenly five months postoperatively.

Table 1

<table>
<thead>
<tr>
<th>Preoperative demographics</th>
<th>OT (n=18) (%)</th>
<th>PT (n=43) (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>18</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Median age at operation (months)</td>
<td>3.5 (range: 1–28)</td>
<td>5 (range: 1–117)</td>
<td>0.06</td>
</tr>
<tr>
<td>Gender (males/females)</td>
<td>6:12</td>
<td>15:28</td>
<td>0.91</td>
</tr>
<tr>
<td>Mean weight at operation (kg)</td>
<td>5.02±2.09</td>
<td>6.20±3.42</td>
<td>0.15</td>
</tr>
<tr>
<td>Down syndrome</td>
<td>9 (50)</td>
<td>22 (51)</td>
<td>0.93</td>
</tr>
<tr>
<td>Intractable CHF</td>
<td>5 (28)</td>
<td>23 (54)</td>
<td>0.07</td>
</tr>
<tr>
<td>Rastelli type (A/B/C/not classified)</td>
<td>15/1/1/1/1</td>
<td>26/4/12/1/1</td>
<td>0.20</td>
</tr>
<tr>
<td>Mean size of VSD (mm)</td>
<td>6.36±0.47</td>
<td>8.50±0.52</td>
<td>0.09</td>
</tr>
<tr>
<td>More than moderate LVAVR</td>
<td>6 (33)</td>
<td>5 (12)</td>
<td>0.07</td>
</tr>
<tr>
<td>LVOTO</td>
<td>0</td>
<td>2 (5)</td>
<td>0.35</td>
</tr>
<tr>
<td>AVV anomalies</td>
<td></td>
<td></td>
<td>0.86</td>
</tr>
<tr>
<td>Hypoplastic LVAV</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Single left-sided papillary muscle</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Strawdell</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Double-orifice LVAV</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Double-orifice RAV</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

OT, obliteration technique; PT, patch technique; CHF, congestive heart failure; VSD, ventricular septal defect; LVAVR, left atrioventricular valve regurgitation; LVOTO, left ventricular outflow tract obstruction; AVV, atrioventricular valve; LAVR, left atrioventricular valve regurgitation; AV, atrioventricular valve; PDA, patent ductus arteriosus; ASD, atrial septal defect; SVC, superior vena cava; VSD, ventricular septal defect; PAPVR, partial anomalous pulmonary venous return.

The left AV valve regurgitation worsened during the follow-up period in two patients (11.1%) in the OT group vs. five patients (11.6%) in the PT group. At the last follow-up, two patients (11.1%) had more than moderate left AV valve regurgitation in the OT group vs. four patients (9.3%) in the PT group and no significant difference was observed between the two groups. Two patients in the OT group (11.1%) and three patients in the PT group (7%) required reoperation for AV valve dysfunction after the initial repair. No prosthetic valve replacements were performed in either group. No correlation was detected between reoperation and mortality (Table 5).

In the OT group, four patients (22.2%) had trivial leak (<2 mm) in the interventricular communication on intraoperative TEE and 12 patients (28.0%) in the PT group.
Almost residual VSD healed spontaneously within several months in follow-up transthoracic echocardiography (TTE). However, one patient in the OT group had the residual VSD at follow-up TTE. This patient underwent the reoperation for both residual VSD and right AV valve regurgitation. None required the operation for left ventricular outflow tract obstruction (LVOTO) and pacemaker implantation in either group.

### 4. Discussion

Excellent short- and mid-term results of the modified single-patch technique have been reported [4–6]. The expected advantage of the modified single-patch technique is the simplicity that results from avoiding the VSD patch. However, concern exists that any left AV valve deformity, LVOTO, or residual VSD would deteriorate after repair with the modified single-patch technique. Some studies have claimed that the ratio of reoperation for late left AV valve regurgitation with the modified single-patch technique was lower than that with the classical-patch technique [5, 6]. Our results were similar to this assertion. Moreover, a study reported that while the proportion of potential LVOTO was up to 70% in autopsied hearts with an AVSD, the actual rate of LVOTO was only about 7% [7]. Although the LVOTO would be expected to arise from morphologic obstruction due to the scooping of the bridging leaflet, hemodynamic obstruction developed in rare cases. Our results were also consistent with this finding.

Nevertheless, we experienced that the modified single-patch technique was not applicable in all patients of complete AVSD. Application of this technique to patients with various intracardiac anomalies, such as a huge size VSD, complete AVSD with TOF pathology, and AV valve anomalies, is still a challenging problem. In our experience, two patients required the conversion of the modified single-patch technique to the patch technique due to severe left AV valve regurgitation on intraoperative TEE.

Our study has several limitations: it was a non-randomized design, with a small study group and a short follow-up period. In addition, the operations were performed by several surgeons who used slightly different surgical techniques. Consequently, a larger group of patients, longer follow-up, and randomized studies are required to demonstrate that the modified single-patch technique is indeed an effective procedure.

### 5. Conclusions

Our study focused on whether the surgical technique influences the postoperative outcome and evaluated the usefulness of the modified single-patch technique. There were no differences in surgical outcomes between the modified single-patch technique and the classical one- or two-patch techniques. Therefore, the modified single-patch technique can be done with a low mortality and morbidity and easily applicable in complete AVSD because of the simplified surgical technique. However, the wide application of this technique remains a challenging problem.

### References


### Conference discussion

**Dr. A. Kalangos** (Geneva, Switzerland): This is an interesting multi-institutional clinical study despite its limitations because you are trying to evaluate the outcomes of three different techniques we actually use to repair the complete AV septal defect. A similar comparative study of modified single-patch technique vs. two-patch technique was already published by Backer et al., from Chicago, in the Annals of Thoracic Surgery 2007, who concluded, as you, that the modified single-patch technique produced results comparable with those of the 2-patch technique in younger patients with similarly sized ventricular septal defects.
That being said, I'm a little bit concerned about the fact that you divided your patient population into 2 groups, the modified single-patch and the patch technique group in which you included all the patients who underwent the classic single-patch or 2-patch technique. The classic single-patch technique which requires division of the bridging leaflets has practical and theoretical disadvantages in terms of residual or recurrent mitral insufficiency due to the dehiscence of the leaflets from the patch reconstruction as well as due to the shortening which may also appear during this reconstruction.

My first question is, how many of the four patients in your patch technique group who had more than moderate left AV valve regurgitation at the last follow-up initially underwent the classic single-patch technique? You can reply and then I will continue.

Dr. Jeong: We repaired 14 patients with single-patch technique in our hospital. In this case there was poor exposure of VSD anatomy due to chordal crowding on the bridging leaflet or hypoplasia of the left AV valve. We regarded this condition is the state of division of bridging leaflet. We have always tried to divide the bridging leaflet and more tissue on the left side.

Dr. Kalangos: Sorry, I would like to know exactly what is the number of patients with the classic single-patch technique and 2-patch technique.

Dr. Jeong: Single-patch technique in 14 patients.

Dr. Kalangos: And in how many of those patients did you have more than moderate degree residual left AV valve regurgitation or recurrent AV valve regurgitation?

Dr. Jeong: I'm sorry, I don't understand your question.

Dr. Kalangos: Despite the fact that there is no significant difference between your 2 groups in terms of median age, mean weight, mean size of VSD and Rastelli-type classification, there are clearly more younger patients with smaller VSDs and fewer patients with Rastelli type C that are in your modified single-patch technique group. As you mention in your article, each case was managed according to the individual patient's anatomy and surgeon's preference, and you also noted that the modified single patch was not applicable in all patients with complete AV septal defect. I want to expand on my comments. Do you think that the sizes of the VSD and Rastelli classification are enough to select the modified single-patch technique over the classic single or 2-patch technique, or do you also include in your preoperative echocardiographic evaluation the discrepancy between the inlet and outlet dimensions of the ventricles?

The other question is, despite the fact that your VSD sizes are not indexed with the body surface area of the patients, what should be the critical VSD size below which the modified single-patch technique would be more appropriate?

And finally, what was the VSD size and Rastelli type in the 2 cases you converted intraoperatively from the modified single-patch technique to the 2-patch technique because of the presence of severe left AV valve regurgitation?

Dr. Jeong: In our experience, the result of modified single-patch technique was not critical. Two patients required conversion of modified single-patch technique to 2-patch technique. These patients showed more than moderate degree of regurgitation. The cause of failure was probably technical error. Both were finally repaired successfully with patch technique. We will try to gain more experience in modified single-patch technique.