

Experience of Repair Ventricular Septal Defect with Left Superior Vena Cava Through Right Axillary Thoracotomy

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ABSTRACT

Objective: To summarize the experience in the treatment of repair ventricular septal defect with left superior vena cava (LSVC) through right axillary thoracotomy. To explore the surgical strategy of treating VSD with LSVC through right axillary thoracotomy.

Methods: Right axillary thoracotomy and median sternotomy were performed in 73 cases of ventricular septal defect with LSVC in our center from 2018 to 2019. Perioperative data and surgical information were analyzed retrospectively.

Results: There were 54 cases of R-group and 19 cases of S-group with a median age of 0.8 years (0.5-1.6 years). In the 73 patients, 21 (38.9%) were male. The operation time of the R-group was shorter than the S-group ($P < 0.05$). The postoperative drainage in the R-group was less than the S-group ($P < 0.05$). The mechanical ventilation time was longer in the S-group than in the R-group ($P < 0.05$). The score of positive inotropic drugs was higher in the S-group than in the R-group ($P < 0.05$). There were no deaths, serious complications, or readmission in the follow-up 6 months (3-10 months).

Conclusion: Right axillary thoracotomy is a safe procedure with excellent cosmetic and clinical results for ventricular septal defect with left superior vena cava. It has the advantages of short operation time, less bleeding, and short postoperative time.

INTRODUCTION

Right axillary thoracotomy has been performed for correcting congenital heart disease for 26 years, and it was first used in clinical practice by Liu in 1994 [Liu 1998]. Right axillary thoracotomy reduced the surgical trauma of the patient. At the same time, its cosmetic results are more satisfying [Liu 2000; Heinisch 2018; Right Anterolateral Thoracotomy in the Repair]. This technique has been applied to repair some

simple congenital heart diseases and has achieved satisfactory clinical results.

However, the patients with persistent left superior vena cava (LSVC) were not considered suitable for right axillary thoracotomy, due to the blood return from the LSVC interfering with the surgical operation. In contrast, median incision was more frequently used. It would facilitate surgical operations through temporarily blocking LSVC or intubating drainage LSVC.

Our center has repaired many VSD patients with LSVC by temporarily blocking LSVC through right underarm thoracotomy in the past two years. In this study, we reviewed these cases and analyzed the characteristics of the operation to summarize the treatment experience.

METHODS

Patient selection: Between January 2018 and December 2019, 2,463 patients underwent the primary correction of VSD in our department. We selected 73 (3%) patients of VSD with LSVC. The inclusion criteria excluded the patients with complex cardiac malformation, isolated left superior vena cava, palliative surgery, and reoperation. We divided these patients into two groups: the right axillary thoracotomy group (R-group) with 54 (74%) patients and median sternotomy group (S-group) with 19 (26%) patients. Data concerning general patient characteristics, such as age, sex, weight, diagnosis, VSD size, LSVC size, associated cardiac anomalies, and functional status of the heart, were collected to analyze any differences between the two groups before the operation.

Operative technique: Surgery was performed under venous inhalation anesthesia and cardiopulmonary bypass (CPB). R-group patients were placed in the left lateral position with the right side raised 60° to 80°. A cloth roll was placed under the left armpit to bend the body upward. The right arm was suspended over the head and fixed to the frame. Three lines were marked with a pen on the body surface, including the anterior axillary line, middle axillary line, and posterior axillary line. The skin incision was made arcuate about 2-3cm from the intersection of the posterior axillary line and the third rib to the intersection of the axillary midline and the fifth rib. The 4th intercostal space was found along the muscle fiber and cut to enter in the pleura cavity. (Figure 1) The right lung was pushed back with a wet gauze to expose the pericardium. The pericardium was opened parallel

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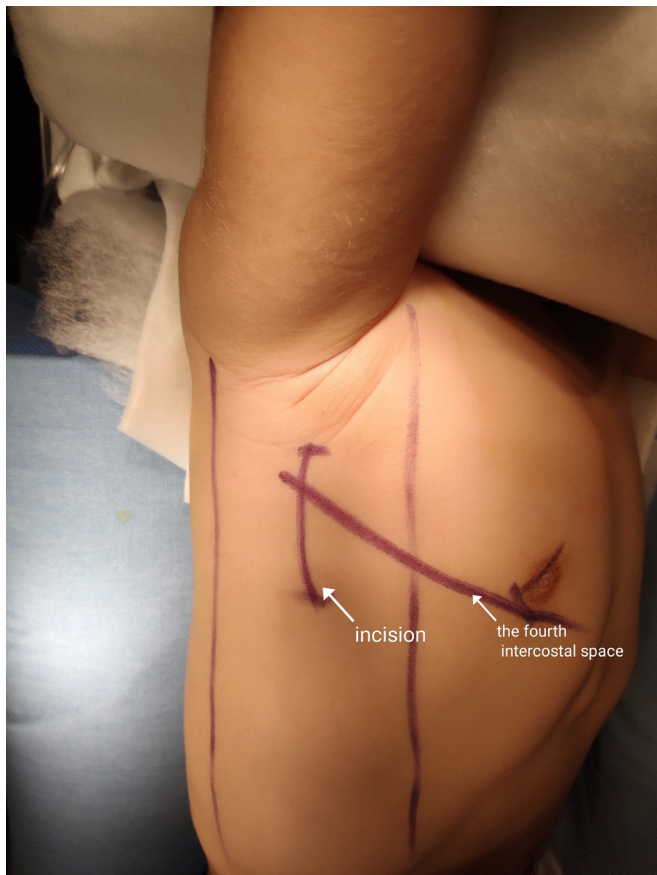


Figure 1. Right axillary thoracotomy incision

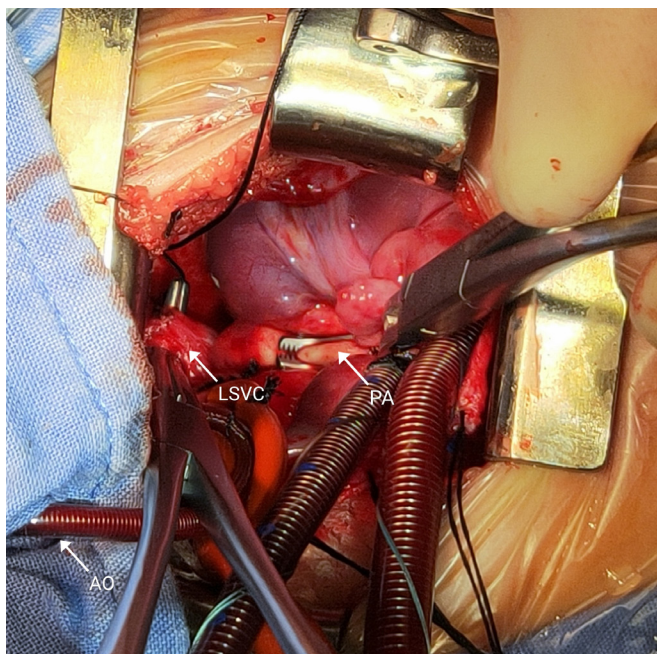


Figure 2. Operative field exposure during right axillary thoracotomy

2 cm anterior to the phrenic nerve. The right edge of pericardial incision was hanged with 3 sutures. The pericardial edge of the pulmonary artery, aorta and superior vena cava also were hanged with suture. The field can be viewed more easily by elevating the mediastinal structures. In the S-group, the heart was exposed through a classic midline sternotomy. After heparinization, the ascending aorta was first cannulated, followed by both venae cava. When the body temperature was between 24°C and 32°C after the start of cardiopulmonary bypass, the aorta was cross-clamped and cold crystalloid cardioplegic solution was infused into the ascending aorta. The techniques of correcting the cardiac defects between the two groups were identical. Acceptable exposure of the intracardiac anatomy could be obtained with a standard oblique right atriotomy or a vertical right ventricular incision.

For patent ductus arteriosus (PDA), dissection and ligation via the aortic-pulmonary septum under parallel circulation was performed. The assistant stretched the pulmonary artery with auricular forceps. After this, the surgeon could isolate the aortic-pulmonary septum with right angle forceps and ligate the PDA.

Technical points: When the CPB was started, the superior vena cava and inferior vena cava were not cross-clamped. The superior vena was inserted into the right atrium to ensure adequate drainage. The purpose is to make the heart smaller and the surgical field clearer. And then, when the assistant pulled down the stabilization of the main pulmonary artery with auricular forceps, the surgeon pulled the aorta to the right side with tweezers with their left hand and separated the LSVC from the left pulmonary artery with scissors in their right hand. The LSVC was separated from the gap with right angle forceps and banded with 10# silk. In sequence, the surgeon started to repair the defects and other intracardiac malformations. (Figure 2)

The choice of incision was determined by the surgeon's habits and the patient's request and was not related to LSVC. It is noteworthy that the surgeon needed to intermittently relax the banding of LSVC, according to the color of the patient's face and the venous drainage. If the patient's face was still dark or the venous drainage was insufficient, it needed to be increased through cannulation of the coronary sinus.

Statistical analysis: All data were analyzed using SPSS 24.0 software. An unpaired t-test was used to compare continuous variables with a normal distribution between groups, and if the continuous variables or the differences did not conform to the normal distribution, a Wilcoxon signed-rank test was used. The associations between qualitative variables were analyzed by chi-square, continuity correction, or Fisher's exact test. All tests were two-sided, and a probability level less than 0.05 was used as a criterion of significance.

RESULTS

Study populations: The diagnostic data of the study groups are detailed in Table 1. (Table 1) The perioperative results of patients in both groups are listed in Table 2. (Table 2) There was no significant difference in the two groups, in terms of preoperative data.

Operative data: It is statistically significant that the time of operation was clearly longer in the S-group than that of in the R-group ($P = 0.029$). No statistical difference was observed in bleeding, CBP time, and aortic cross clamp time.

Clinical outcomes: In the postoperative period, amount of chest drainage ($P = 0.048$) and mechanical ventilation time ($P = 0.02$) were found to be less in the R-group than S-group.

Follow up: The mean follow-up duration was 17.2 ± 7.6 months (range, 3–38 months). No cases of early and late death or hospital readmission were reported in either group. There was no significant difference in residual lesions between the two groups.

DISCUSSION

The method of repairing ventricular septal defect combined with LSVC through right axillary thoracotomy is safe and effective. LSVC is a relatively frequent finding in congenital cardiac malformation. This anomaly is thought to be due to the persistence of the left anterior cardinal vein, which normally involutes to give the ligament of Marshall or the ligament of the LSVC [Erdoğan 2007; Ramos 2005]. The incidence of persistent LSVC is 0.3–0.5% in the general

population and between 3% and 10% in patients with congenital heart disease. The majority of LSVC drains into the right atrium through the coronary sinus and would not need

Table 1. Associated malformations of the patients

| Associated malformation | R-group (N = 54) | S-group (N = 19) |
|-------------------------|------------------|------------------|
| PFO | 14 | 3 |
| ASD | 11 | 6 |
| RVOTO | 4 | 2 |
| PDA | 6 | 5 |
| SAS | 6 | 3 |
| PS | 1 | 0 |
| DCRV | 0 | 1 |
| MS | 0 | 1 |

PFO, patent foramen ovale; ASD, atrial septal defect; RVOTO, right ventricular outflow tract obstruction; PDA, patent ductus arteriosus; SAS, subaortic membrane; PS, pulmonary stenosis; DCRV, double-chambered right ventricle; MS mitral stenosis

Table 2. Characteristics of patients in both groups

| Items | N = 73 | R-group (N = 54) | S-group (N = 19) | P |
|---|------------------|------------------|------------------|------|
| Male | 27 (37.0%) | 21 (38.9%) | 5 (26.3%) | .482 |
| Age (years) | 0.8 (0.5-1.6) | 0.8 (0.5-1.6) | 0.6 (0.3-1.7) | .339 |
| Weight (kg) | 7 (5.5-9.1) | 7.1 (6.0-9.4) | 5.8 (5-8.3) | .106 |
| Height (cm) | 72 (64-79) | 72 (64.8-79.3) | 65 (60.5-76.5) | .107 |
| Intraoperative bleeding (ml) | 64.6±23.7 | 64.4±24.5 | 65.3±21.5 | .898 |
| Before aortic cross-clamping time (min) | 38.5±9.4 | 38.2±9.7 | 39.1±8.7 | .74 |
| Operative time (hour) | 2.5±0.4 | 2.4±0.4 | 2.7±0.4 | .029 |
| CPB time (min) | 73.8±17.7 | 72.4±16.5 | 78.4±21.1 | .230 |
| Aortic cross-clamping time (min) | 39.0±13.0 | 37.9±12.4 | 42.5±14.6 | .208 |
| LSVC (mm) | 5.6±1.4 | 5.5±1.4 | 5.7±1.4 | .643 |
| VSD size (mm) | 9.4±2.2 | 9.1±2.2 | 10.3±2.1 | .054 |
| EF% (preoperative) | 67.8±9.6 | 67.7±10.6 | 67.9±5.2 | .928 |
| Cardiothoracic ratio | 0.58 (0.56-0.61) | 0.57 (0.55-0.6) | 0.6 (0.57-0.64) | .11 |
| EF% (postoperative) | 67.0±9.8 | 66.9±10.7 | 67.4±6.6 | .857 |
| Postoperative 2 days draining (ml) | 85 (60-120) | 70 (59-115) | 100 (65-155) | .048 |
| Drug score | 4.6±2.9 | 4.0±2.5 | 6.9±3.7 | .001 |
| Mechanical ventilation time (hour) | 23 (8-48) | 22 (6.5-31.3) | 50 (19-74) | .002 |
| ICU stay (day) | 3 (1-4) | 3 (1-4) | 4 (2-8.5) | .108 |
| Residual shunt | 7 | 5 | 2 | .764 |

LVEF, left ventricular ejection fraction; drug score: dopamine 1ug/kg/min=1score, adrenaline 0.01 ug/kg/min=1score, Norepinephrine 0.01 ug/kg/min=1score, milrinone 1ug/kg/min=1score

surgery [Bosch 2013]. But the LSVC needed to be temporarily blocked or intubated drainage in operation. So, many surgeons choose the median incision to facilitate surgical repair. This retrospective study suggested that LSVC also could be temporarily blocked in some simple congenital heart disease through right axillary thoracotomy.

Right axillary thoracotomy has been performed in simple congenital heart disease. Especially the postoperative pain, thoracic deformity, unsightly, children's psychological impact and other problems caused by median sternotomy gradually attracted the attention of patients and their families [Yaliniz 2015; Yoshimura 2001]. (Figure 3) At the same time, right axillary thoracotomy also has been used in complex congenital heart disease after more 20 years development, such as tetralogy of fallot, pulmonary stenosis, partial endocardial cushion defects or partial unroofed coronary sinus syndrome [Liu 2000; Heinisch 2018], event in adult congenital heart disease and so on [Yang 2019]. Congenital heart disease coexisting with LSVC are not contraindications to the right axillary thoracotomy [Erdoğan 2007; Yang 2019].

Our study found that the CPB time, aortic occlusion time, open thoracic-aortic occlusion time and blood loss had no statistical significance in two groups. It showed that the difficulty to repair the defects of patients with LSVC through right axillary thoracotomy did not increase. It is safe and effective in these VSD patients with LSVC. At the same time, right axillary thoracotomy is better than median sternotomy in the operation time and postoperative drainage. In addition, the mechanical ventilation time was longer in the S-group than in the R-group. It was because the increased drainage made the mechanical ventilation time extend.

Surgeons need to deal with various emergencies caused by the left superior vena cava. Although many patients preoperatively were diagnosed through improvements in echocardiography, some patients still escaped diagnosis, such as unroofed coronary sinus, partially unroofed coronary sinus, or coronary sinus ostial atresia. In all cases, surgeons should be aware of different signs that may raise the suspicion of persistent LSVC. When the diameter of the superior vena cava is smaller than normal, the right atrium expands after vena cava cross-clamped, the venous drainage is not good, or venous blood flows from the left atrium, the surgeon should consider the possibility of LSVC. If the LSVC was found when the right atrium was cut open, cannulation from the coronary sinus was used to increase drainage [Salve 2017]. If the surgical field was still affected by bleeding, the surgeon can close the right atrium and start again separate LSVC under parallel

circulation. Also, the cardiopulmonary bypass time may be prolonged, but the operation was more uneventful.

CONCLUSION

In conclusion, right axillary thoracotomy is a safe procedure with excellent cosmetic and clinical results for simple congenital heart defects with LSVC. However, it was still necessary to perform comprehensive preoperative imaging in all patients with persistent LSVC to avoid unexpected complications. We can make use of right axillary thoracotomy to repair more patients in our department in the next few years.

REFERENCES

- Bosch B, Stockman A, Beelen R. 2013. Persistent Left Superior Vena Cava in Cardiac Congenital Surgery. *Acta Cardiol.* Dec;68(6).
- Erdoğan M, Karakaş P, Uygur F. 2007. Persistent left superior vena cava: the anatomical and surgical importance. *West Indian Med J.* Jan;56(1).
- Heinisch PP, Wildbolz M, Beck MJ. 2018. Vertical Right Axillary, et al: Mini-Thoracotomy for Correction of Ventricular Septal Defects and Complete Atrioventricular Septal Defects. *Ann. Thorac. Surg.* 10;106(4).
- Liu Y, Zhang J, Sun HS, et al. 1998. Correction of cardiac defects through a right thoracotomy in children. *Zhonghua Wai Ke Za Zhi.* Jul;36(7).
- Liu YL, Zhang HJ, Sun HS, et al. 2000. Repair of cardiac defects through a shorter right lateral thoracotomy in children. *Ann. Thorac. Surg.* Sep;70(3).
- Ramos N, Fernández-Pineda L, Tamariz-Martel A. 2005. Absent right superior vena cava with left superior vena cava draining to an unroofed coronary sinus. *Rev Esp Cardiol.* Aug;58(8).
- Right Anterolateral Thoracotomy in the Repair of Atrial Septal Defect: Effect on Breast Development.
- Salve GG, Jain SA, Thakkar BM, et al. 2017. Right Posterior Thoracotomy for Open-Heart Surgery in a Rare Morphology. *Ann. Thorac. Surg.* Jan;103(1).
- Yaliniz H, Topcuoglu MS, Gocen U, et al. 2015. Comparison between minimal right vertical infra-axillary thoracotomy and standard median sternotomy for repair of atrial septal defects. *Asian J Surg.* Oct;38(4).
- Yang M, Su J, Liu A, et al. 2019. Correction of simple congenital heart defects by right axillary thoracotomy in adults *J Card Surg.* Nov;34(11).
- Yoshimura N, Yamaguchi M, Oshima Y. 2001. Repair of atrial septal defect through a right posterolateral thoracotomy: a cosmetic approach for female patients *Ann. Thorac. Surg.* Dec;72(6).