ORIGINAL ARTICLE

Right anterior minithoracotomy with preservation of the vascular bundle for correction of congenital ventricular septal defects

Serzhan Kuramys[1], Berik Bolatbekov[2], Seythan Joshibayev [3], Berikbai Yessenbekov[4]

ABSTRACT

Introduction

Congenital VSDs require early correction to avoid serious complications. For many years, the gold standard was the median longitudinal sternotomy, but given the gross cosmetic effect, mini-approaches were developed, but right anterior mini-thoracotomies gained popularity. We modified the method of anterior right-sided minithorcatomy by preserving a. et v. mammaria interna and the purpose of the study was to evaluate its effectiveness.

Material and Methods

The design of the study was prospective with historical control. A total of 82 patients who underwent VSD correction were included in the study. All patients were divided into three groups: group 1 operated by median sternotomy (MS) – 15 patients; Group 2 operated by right anterior minithoracotomy (RAMT) – 38 patients; and the 3rd main group operated on by right antero-lateral thoracotomy (RLMT) with preservation of the artery and vein of the internal mammary artery - 29 patients.

Results

We revealed the older age in RAMT group. Cardio pulmonary bypasstime and total operation time were shorter in RLMT group, but the time of aortic cross-clamping is shorter than in RAMT group, but longer than in MS group. The length of the skin incision is also the shortest in RLMT group, which enhances the cosmetic effect. Also there were revealed a shorter mechanical lung ventilation time and ICU stay, moreover we observed reduced amount of drainages, as well as quick discharge home.

Conclusion

Therefore, improved and modificated right antero-lateral minithoracotomy method with preserving a et v mammaria interna is feasible, has a good cosmetic effect, and short hospitalization stay, but should perform with careful preparation of the entire cardiac team.

Keywords

ventricular septal defect, mini-thoracotomy, minimal invasive surgery, congenital heart disease

INTRODUCTION

Congenital Ventricular Septal Defect (VSD) is one of the most common congenital septal heart defects, which requires correction as early as possible upon detection, due to early disability and mortality in the natural course without surgical correction[1,2]. For a long time, the gold standard for the correction of congenital VSDs was median longitudinal sternotomy, which showed good results with nearly zero mortality, but the bad cosmetic effect forced many cardiac surgeons to think about mini-approaches. As a result, several mini-approaches have been developed for the correction of VSD - lower ministernotomy, transxifoidal access and mini-thoracotomy[3]. Minithoracotomy, which had several modifications, such as anterior (lateral) minithoracotomy or subaxillary minithoracotomy, became very popular. In each clinic, the technique and technology

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of minithoracotomy differed, but nevertheless, the majority preferred anterior minithoracotomy, since the subaxillary approach was complicated by the depth of work on a dry heart[4,5].

Since 2007, our clinic has been conducting anterior minithoracotomies. However, starting in 2019, we have enhanced the technique by preserving the artery and vein of the mammaria. This involves making an incision between the 4th intercostal space to provide direct access to the heart and facilitate central cannulation. This modification is particularly beneficial in children, where peripheral cannulation poses various difficulties and complications. Consequently, the aim of this study is to assess the outcomes of anterior minithoracotomy with the preservation of the mammary artery and vein, comparing it to both median sternotomy and anterior minithoracotomy without preservation of the vascular band.

METHODS

Study design

The design of the study was prospective with historical control. The study included children ageing from 3 till 18 years old with isolated congenital VSDs from 2019 to 2023. Adults above 18 years old with isolated congenital VSD or children with combined congenital heart defects (VSD with ASD, AVSD, tetralogy of fallot, hypoplasia or stenosis of the pulmonary artery, etc.) were exluded.

The study was conducted in accordance with all the rules of the Declaration of Helsinki with the written consent of the parents at the Scientific and Clinical Center for Cardiac Surgery and Transplantology in Taraz, Kazakhstan and Cardiomed clinic in Shymkent, Kazakhstan.

To compare the results, the data were taken into account before surgery, also intra- and postoperative results.

Description of medical intervention

The skin incision (Picture 1.)for right anterior minithoracotomy began at the right edge of the sternum at the level of the 4th intercostal space, preserving a. et v. mammaria interna. The length of the skin incision varied from 5 to 8 cm depending on the age of the patient. The direction of the skin incision in girls continued, going around the mammary gland from below along the skin fold. Then the skin and subcutaneous tissue were dissected, and in women it is often necessary to move the mammary gland upward along with the capsule. Next, part of the pectoralis major muscle and intercostal muscle were dissected along the upper edge of the underlying rib. The lateral incision of the intercostal muscles was continued longer than the previous tissue dissection, i.e. close to the level of the anterior axillary line. Hemostasis was performed more carefully to avoid areas of hemorrhage. After installing the retractor, the edges of the wound were separated. The right lung was retracted laterally with two loose swabs and a large damp cloth. The pericardium was opened longitudinally 2 cm above the phrenic nerve, a patch was cut out, and to improve visibility, the right atrium (RA) was pulled toward the wound using thread holders on the pericardium. After placing sutures on the aorta and appendage of the RA, bypassing the vena cava began to connect with cardio-pulmonary bypass (CPB). (Picture 2.) Aortic cannulation was the best performed with a straight tip cannula. When connecting with CPD, the cannula for the Inferior Vena Cava (IVC) was passed through a separate stab wound at the level of the VI-VIIth intercostal space along right anterior axillaris linea, which was subsequently used for drainage of the pleural cavity after correction. The main stage of heart surgery was performed and the bypass was turned off once hemodynamics was stabilized. An accurate hemostasis was carried out. The ribs were tightened with sutures and layer-by-layer suturing the soft tissues (muscles and subcutaneous tissue) was performed with drainage of the right pleural cavity with one drainage tube. (Picture 3.)

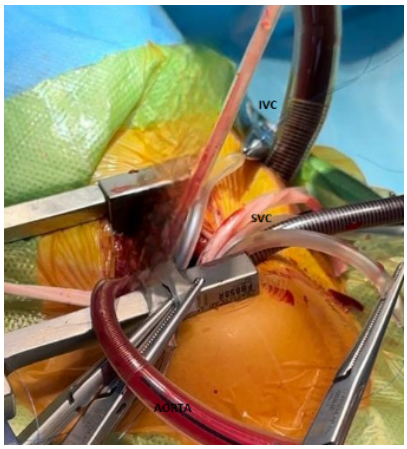
Variables

To compare the results, we assessed ECHO parameters (LVEF – left ventricle ejection fraction; LV EDS – left ventricle end diastolic size; LV ESS - left ventricle end systolic size; RV – right ventricle; PAP – pulmonary artery pressure); the duration of time on cardio-pulmonary bypass (CPB) and aortic cross-clamping time in minutes, the duration on mechanical lung ventilation in minutes and staying in intensive care unit (ICU) in hours and total hospitalization in days.

Statistical analysis

Statistical analysis was performed using Microsoft Excel 2007-2010 software and the SPSS application statistical software package. Qualitative indicators are presented

Picture 1. Marking



Picture 2. Cannulation

Picture 3. Final cut

as absolute frequencies and percentages. Quantitative markers were normally distributed as mean ± standard deviation (m ± SD). Non-normally distributed numerical signs are denoted as median (first and third quartile) - Me (Q1-Q3). Normal distribution of numerical data was evaluated using the Kolmogorov-Smirnov test with Bonferroni correction. When comparing two different groups or following the law of normal distribution, the comparison of pre- and post-treatment results by quantitative characteristics was carried out according to the t-test (Student's test) for unrelated groups. In the case of non-normal distribution, the comparison of two different groups according to their quantitative characteristics was carried out according to the Mann-Whitney U-test. Comparison of two different groups according to qualitative characteristics was carried out according to the Pearson test. If there were three or more groups, or multiple treatments the analysis of variance (ANOVA) was performed under normal distribution conditions for quantifications conducted at multiple stages, which was also used to compare continuous data. All reported values at $p < 0.05$ were considered significant.

Materials

A total of 82 patients who underwent VSD correction were included in the study. All patients were divided into three groups: group 1 operated by median sternotomy (MS) – 15 patients; Group 2 operated by right anterior minithoracotomy (RAMT) – 38 patients; and the 3rd main group operated on by right antero-lateral thoracotomy (RLMT) with preservation of the artery and vein of the internal mammary artery - 29 patients. Randomization was carried out according to the type of operation and the consent of parents or trustees.

RESULTS

When comparing the three groups according to Table 1, the older age in RAMT group, and the dilatation of the LV and RV EDS, as well as secondary pulmonary hypertension during natural following of the congenital VSDs, returned to normal after surgery, which shows a good postoperative effect. CPB time and total operation time were shorter in RLMT group, but the time of aortic cross-clamping is shorter than in RAMT group, but longer than in MS group - which may be due to the experience of the cardiac team and visions of open-heart access. The length of the skin incision is also the shortest in RLMT group, which enhances the cosmetic effect. Due to preserving a. et v. mammaria interna we revealed faster recovery and rehabilitation, which was confirmed by shorter mechanical lung ventilation time and ICU stay, moreover we observed reduced amount of drainages, as well as quick discharge home.

Adverse events

After the operation, not an any patient had neurological disorders, AV blocks, suppuration or non-healing of the wound, and there were no deaths. After correction of congenital VSDs there were residual shunts 2 cases in group MS, 3 cases in group RAMT and 1 case in group RLMT, which closed on their own within 6-8 months.

DISCUSSION

The correction of congenital ventricular septal defect (VSD) through the conventional median sternotomy approach demonstrates favorable long-term outcomes.

Table 1. Patient's characteristics

Category	MS group (n=15)	RAMT group (n=38)	RLMT group (n=29)	p value
Age, years	8.3±5.5 (3-18)	13.7±2.6 (7-18)	8.1±3.1 (3.4-15)	<0.01
Weight, kg	25.6±15.1 (11.9-54)	35.8±6.5 (15-47.2)	26.1±10.2 (11.4-47)	<0.01
ECHO				
LVEF, %	53.3±3.3 (48-58)	54.5±3.1 (50-61)	58.7±2.6 (52-64)	<0.01
*LV EDS, cm	4.3±0.5 (3.3-5.1)	4.2±0.3 (3.6-5.1)	4.3±0.3 (3.8-4.9)	0,82
*LV ESS, cm	3.3±0.4 (2.4-4.0)	3.4±0.3 (2.7-3.9)	3.2±0.2 (2.7-3.8)	0,29
*RV, cm	2.6±0.3 (2.1-3.1)	2.5±0.2 (2.1-2.9)	2.5±0.2 (2.1-2.9)	0,48
PAP, mm Hg	35±4.6 (29-43)	35.6±3.2 (31-44)	40±5.6 (29-54)	<0.01
Defects, mm	7.4±1.3 (5.5-10)	6.5±1.5 (4.0-10)	7.9±2.0 (1.1-10.9)	<0.01
Operational values				
CPB time, min	50.5±13.1 (27-80)	56±7.7 (40-70)	33.3±5.2 (24-49)	<0.01
Cross clamp time, min	16.1±0.2 (14-22)	21.3±3.3 (12-23)	18.4±3.6 (11-26)	<0.01
Hole operation time, min	167.8±30.3 (122-215)	156±16 (120-195)	131.1±11.7 (115-160)	<0.01
Incision length, cm	13.4±1.0 (12-15)	7.7±0.5 (6.5-9)	5.8±0.5 (5-7.1)	<0.01
Postoperative				
ICU time, hours	44.4±7.4 (32-60)	34.1±4.1 (25-42)	24±3.5 (14-30)	<0.01
Mechanical lung ventilation time, hours	23.5±5.6 (14-36)	15.3±2.1 (11-20)	9.3±2.7 (5-16)	<0.01
Drainage, ml	160.9±16.7 (120-180)	136.7±16.6 (110-190)	82.2±16.5 (50-115)	<0.01
Hospitalization days	10.1±2.7 (7-14)	8.7±3.3 (6-11)	7.6±1.9 (5-9)	<0.01
Postoperative ECHO				
LVEF, %	56.1±2.4 (52-60)	57.8±2.2 (54-62)	60.1±2.3 (55-64)	<0.01
*LV EDS, cm	4.0±0.4 (3.1-4.7)	4.0±0.3 (3.4-4.8)	3.9±0.2 (3.5-4.5)	0,29
*LV ESS, cm	3.0±0.3 (3.2-3.5)	3.7±0.8 (2.6-3.7)	2.9±0.3 (2.4-3.5)	0,74
RV, cm	2.4±0.3 (1.9-2.8)	2.5±0.2 (2.0-3.1)	2.2±0.1 (1.9-2.6)	<0.05
PAP, mm Hg	27.7±2.2 (24-31)	20.9±1.6 (18-24)	25.0±3.1 (21-31)	<0.05

Note: data presented as mean± SD (min, max)

Abbreviations: LVEF – left ventricle ejection fraction; LV EDS – left ventricle end diastolic size; LV ESS - left ventricle end systolic size; RV – right ventricle; PAP – pulmonary artery pressure; CPB – cardio-pulmonary bypass; ICU – intensive care unit; * - not significant

However, the sternotomy scars associated with this procedure can lead to significant cosmetic and psychological issues [6]. Our technical advancements, specifically preserving the internal mammary artery and vein (a.et v. Mammaria interna), in the right lateral minithoracotomy (RLMT) have successfully averted unsightly surgical scars, thereby minimizing both physical and psychological trauma, as well as reducing hospitalization time. Utilizing RLMT for the correction of VSD in children presents an alternative that yields more acceptable cosmetic results.

The incision made for RLMT, originating from the fourth intercostal space, is in close proximity to the heart, and the surgical appearance closely resembles that of a sternotomy. However, when dealing with patients having a VSD, the surgical correction is more intricate compared to patients with an atrial septal defect (ASD) because the VSD is deeper and obstructed by tricuspid valve tissue[7].

Guariento A. et al. conducted a large-scale analysis of the correction of congenital heart disease between February 1996 and March 2019, which included 1002 patients which were operated by miniinvasive methods as median inferior mini-sternotomy in 45% of patients (n = 455), right anterior mini-thoracotomy in 36% (n = 356), and right lateral mini-thoracotomy in 19% (n = 191). Procedures included repair of atrial septal defect (n = 575, 57%), repair of ventricular septal defect (n = 218, 22%), and repair of atrioventricular defect (n = 82, 8%) or partial anomalous pulmonary venous return (n =70.7%). They didn't find any differences in terms of complications and perioperative outcomes, regardless of the approach used. In our study wasn't any complications and mortality[4].

Beşir Y., et al., when comparing minithoracotomy with sternotomy, did not find a significant difference in the time of cardiopulmonary bypass and aortic clamping between above groups, although the duration of the operation was shorter in the minithoracotomy group (p = 0.001). The mean time of mechanical ventilation, length of stay in the intensive care unit and hospital stay were statistically significantly shorter, and the amount of drainage bleeding was statistically significantly lower in the mini-thoracotomy group (p=0.001). The same data were found in our study[8].

The right axillary transverse (horizontal) minithoracotomy incision has been advocated as an alternative approach to right minithoracotomy for the repair of congenital ventricular septal defects. Surgical correction of congenital VSDs through axillary minithoracotomy is difficult due to limited space and the tricuspid valve (TV) leaflets obstructing the surgical view. In most cases, cardiac surgeons usually solve this problem by temporarily cutting the anterior or septal (or both) valve leaflets at the base of the TV ring[9-12].

Jiaquan Zhu et al. described comparison between the right anterolateral minithoracotomy (RALMT) and The right axillary minithoracotomy (RAMT). As a result, it was revealed that the time of aortic clamping in the RAMT group was 35.8 ± 7.5 (11–67) minutes and in the RALMT group 40.1 ± 10.2 (12–68) minutes; CPB time in the RAMT group was 64.9 ± 10.2 (21–105) minutes and in the RALMT group 71.2 ± 12.3 (33–132) minutes; the time spent in intensive care in the RAMT group was 2.0 ± 1.1 (1–5) days and in the RALMT group 1.9 ± 1.0 (1–6) days; the drainage volume after surgery in the RAMT group was 7.4 ± 2.1 (3.6–10.3) ml/kg and in the RALMT group 6.7 ± 2.1 (3.3–15.5) ml/kg; ; hospitalization time in the RAMT group was 6.0 ± 1.4 (5–13) days and in the RALMT group 6.5 ± 1.2 (5–19) days. According to the above data, the advantages of RAMT are visible, however, we believe that this is due to the age grades, because in the RAMT group age was 2.4 ± 0.9 (0.8–17) years and in the RALMT was group 17.5 ± 4.8 (11–68) years. Also they described in their study that in patients with VSD, the distance from the incision to the defect was too deep for adequate vision; to solve this problem, they placed a wet ice sponge behind the heart in the pericardial cavity, thereby raising the heart and closer to the surgeon[13].

Zhou K. et al studied the safety and effectiveness of total thoracoscopic repair of ventricular septal defects (VSD). The study included 36 patients aged 29 ± 9.52 years, the results revealed that the time of artificial circulation was 112 ± 23.16 minutes and the time of aortic clamping was 65 ± 19.94 minutes, the time of postoperative hospital stay was 5.11 ± 2 .48 days, according to drainages 139.86 ± 111.71 ml. Compared to the data in our study group, there is a higher age, longer bypass time and longer aortic cross-clamping time than in our study[14].

In our study, we used only central cannulation, since there were descriptions of thrombosis after peripheral cannulation[15]. Dixit S. described the results of correction of congenital VSDs with central cannulation as in our study. Over the course of 2 years, 54 operations were

performed on patients with congenital VSD using the anterolateral thoracotomy method. The mean incision length was 7.16 ± 02.08 cm (range, 5 to 9 cm); the mean duration of cardiopulmonary bypass (CPB) was 61.72 ± 14.20 min (range 48–78 min); mean aortic cross-clamp time was 38.51 ± 13.08 min (range 26–56 min); the mean length of postoperative intensive care unit (ICU) stay was 1.83 ± 1.32 days (range, 1–3 days); the average total hospital stay was 4.92 ± 1.82 days (range 4–7 days), which is also comparable to our results[16].

According to KUINOSE, M. et al. the right anterolateral minithoracotomy has its advantages, but also has its complications as: Damage to the aorta or vena cava due to cannulas, incomplete clamping of the ascending aorta, air embolism, unexpected blood loss, temporary aeration of both lungs, Pneumothorax - which may lead to serious consequences. To avoid these complications, careful preparation and a surgical plan is recommended in conjunction with the anesthesiologists, perfusionist and nurses who prepare the medical instruments and devices for the operation and we absolutely agree with these postulates[17].

Study limitations

The small number of patients in all groups does not allow full interpretation of the results in a larger population, but the initial results of a modification of the anterior right minithoracotomy showed good results.

CONCLUSION

Therefore, improved and modificated right antero-lateral minithoracotomy method with preserving a et v mammaria interna is feasible, has a good cosmetic effect, and short hospitalization stay, but should perform with careful preparation of the entire cardiac team.

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