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Minimally invasive surgery for correction of septal defects in pediatric patients

Cirugía de mínima invasión para corrección de defectos septales en pacientes pediátricos

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ABSTRACT

Objective: our aim was to investigate the safety, feasibility, and early outcomes of our initial experience in repairing atrial and ventricular septal defects using a right minithoracotomy. **Material and methods:** we conducted an observational retrospective study at a single center. The study included a total of 13 consecutive pediatric patients who underwent congenital cardiac surgery using this surgical technique from 2022 to 2023. **Results:** a total of 13 minimally invasive surgeries were performed to close septal defects, involving seven females and six males, aged between 2 and 11 years, with weights ranging from 11 to 40 kg. Cardiopulmonary bypass times ranged from 13 to 61 minutes (average 38.5 minutes), and aortic clamping times ranged from 12 to 37 minutes (average 30.5 minutes). The average ICU stay was 2.7 days (range 1 to 5 days), and the average postoperative hospital stay was 6.1 days (range 4 to 8 days). There were no postoperative deaths. Postoperative complications included one case of thoracic exploration for bleeding and one case of diaphragmatic paralysis. **Conclusions:** right lateral thoracotomy in cardiac surgery is a viable approach for correcting some well-selected intracardiac defects. It is a reproducible and safe technique. The small skin incision provides superior aesthetic results without increasing morbidity or mortality rates, offering psychological and social satisfaction to patients.

RESUMEN

Objetivo: *nuestro objetivo fue investigar la seguridad, viabilidad y resultados tempranos de nuestra primera experiencia en la reparación de defectos septales auriculares y ventriculares, mediante una minitoracotomía derecha.* ***Material y métodos:*** *realizamos un estudio observacional retrospectivo en un único centro. El estudio incluyó un total de 13 pacientes pediátricos consecutivos que se sometieron a cirugía cardíaca congénita utilizando esta técnica quirúrgica en un periodo de tiempo de 2022 hasta 2023.* ***Resultados:*** *se realizaron un total de 13 procedimientos de cirugía mínimamente invasiva para el cierre de defectos septales, involucrando a siete mujeres y seis hombres, con edades y peso entre los 2 y 11 años y 11 y 40 kg, respectivamente. Los tiempos de circulación extracorpórea variaron desde 13 hasta 61 minutos (promedio 38.5 minutos), los tiempos de pinzamiento aórtico fueron de 12 hasta 37 minutos (promedio 30.5 minutos). La estancia media en la unidad de cuidados intensivos (UCI) fue de 2.7 días (rango, 1-5 días) y la estancia hospitalaria media postoperatoria fue de 6.1 días (rango 4-8 días). No hubo muertes postoperatorias. Las complicaciones postoperatorias incluyeron: un caso de exploración torácica por sangrado y un caso de parálisis diafragmática.* ***Conclusiones:*** *la toracotomía lateral derecha en cirugía cardíaca es un abordaje viable para la corrección de algunos defectos intracardiacos bien seleccionados. Siendo una técnica reproducible y segura. La pequeña incisión en la piel proporciona resultados estéticos superiores sin aumentar las tasas*

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de morbilidad o mortalidad, ofreciendo satisfacción psicológica y social a los pacientes.

Keywords: atrial septal defect, congenital heart disease, minimally invasive cardiac surgery, thoracotomy, ventricular septal defect.

Palabras clave: *comunicación interauricular, cardiopatía congénita, cirugía cardíaca mínimamente invasiva, toracotomía, comunicación interventricular.*

Surgical repair in cardiovascular surgery traditionally involved a midline sternotomy due to procedure complexity and improved surgical field exposure. However, over the last two decades, this approach has evolved to include minimally invasive techniques, offering aesthetic benefits. One drawback of these methods is the visible scar on the chest, which can be psychologically burdensome for children.[1,2] Minimally invasive cardiac surgery (MICS) can utilize various approaches, including midline ministernotomy, right anterior minithoracotomy, and right lateral or subaxillary thoracotomy.[3,4] Among the benefits observed are improved aesthetics, shorter ICU and hospital stays, reduced blood product usage, decreased trauma, less surgical pain, and faster recovery.[5,6] A right anterior minithoracotomy yields favorable cosmetic results and avoids sternum division, reducing the risk of deformities like scoliosis compared to ministernotomy.[4] At our center, we initially performed repairs for atrial septal defects in patients weighing less than 20 kg. As experience grew, we expanded to include a wider range of pathologies and became more flexible with patient weights, gradually minimizing incisions.[5]

MATERIAL AND METHODS

We conducted a single-center, observational, retrospective study. The study included a total of 13 patients diagnosed with congenital heart disease with pulmonary overcirculation from February 2022 to February 2023, eligible for total correction, diagnosed via echocardiography. Patients with diagnoses of secundum atrial septal defect (ASD), primum ASD, ventricular septal defect (VSD), and partial anomalous pulmonary venous connection (PAPVC) were included. Exclusions were patients with patent ductus arteriosus (PDA), weight greater than 40 kg, and those who had undergone previous surgery. The procedures were performed by two surgeons. Demographic and clinical data are summarized in *Table 1*. We analyzed intraoperative and postoperative outcomes, including cardiopulmonary bypass time and aortic cross-clamp time, postoperative complications, mechanical ventilation duration, Intensive Care Unit (ICU) stay, and in-hospital stay *(Table 2)*.

Surgical technique

With general anesthesia and invasive monitoring, the patient is placed in a left lateral decubitus position at a 45° angle, and the right arm is fixed over the head. A line is traced from the xiphoid appendix to the scapular angle, subsequently identifying the anterior and mid-axillary lines. An incision is made at the convergence of these lines *(Figure 1)*, typically encountering only the serratus anterior and intercostal muscles. The incision is no more than 5 cm. Access is gained at the 4th intercostal space, using two thoracic spreaders *(Figure 2)*. Subsequently, a 1 to 2 cm pericardiotomy is performed above the phrenic nerve. Anterior and posterior traction stitches are placed on the pericardium, the thymus is displaced (usually preserved), and cannulation is performed-aortic and bicaval with angled cannulas. Occasionally, a second incision less than 1 cm below is made for inferior vena cava cannula placement, later used for pleuromediastinal drainage. Antegrade cold cardioplegia is administered, aortic clamping is performed, and correction of the heart defect is carried out conventionally. After completing the repair, deaeration

Table 1: Demographic data.

Age (years) [range]	6.1 [2-11]
Weight (kg) [range]	21 [11-40]
Sex, n (%)	
Males	6 (47)
Females	7 (53)
Diagnosis	ASD (9)
	ASD + PS
	ASD VS + device
	Embolism
	VSD
	TAPVC

ASD = atrial septal defect. PS = pulmonary stenosis. VS = vein stenosis. VSD = ventricular septal defect. TAPVC = total anomalous pulmonary vein connection.

Table 2: Results.

CPB time (min) [range]	38.5 [13-61]
Cross-clamp (min) [range]	30.5 [12-37]
Extubation in OR, n (%)	11 (84)
Lactate (max) [range]	4.2 [1.6-9.6]
ICU stay (days) [range]	2.7 [1-5]
Hospital stay [range]	6.1 [4-8]
Complications	1 Diaphragmatic paralysis
	1 Contralateral hemothorax

CPB = cardiopulmonary bypass. ICU = intensive care unit. OR = operating room.

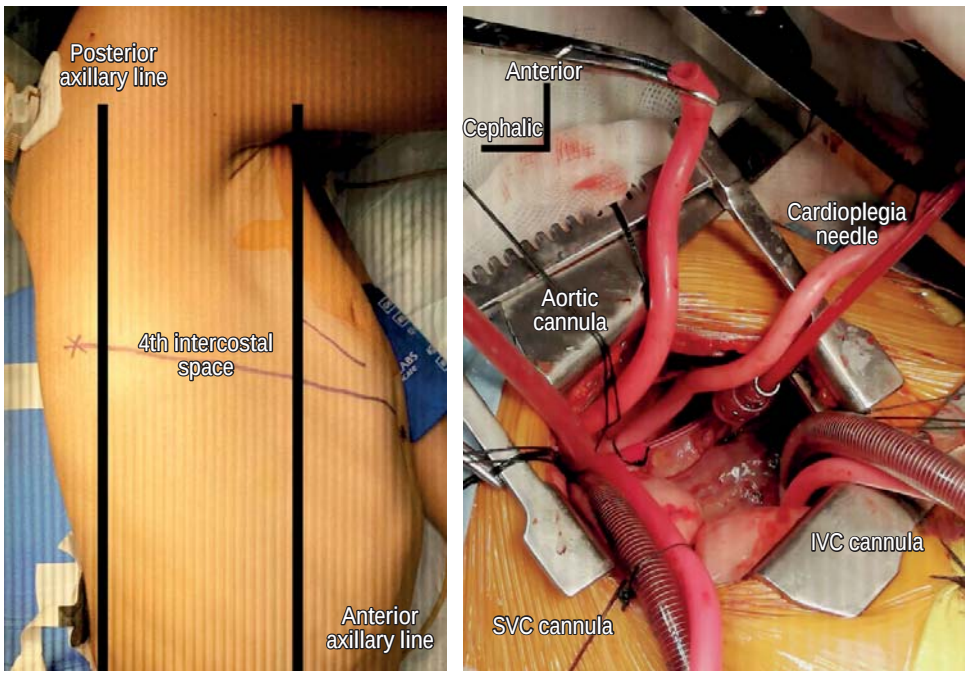

Figure 1:

Patients were positioned with the right side elevated 75 degrees, aligning the incision along the anterior axillary line, posterior axillary line, and the 4th intercostal space. We utilized conventional cardiac surgical instruments.
IVC = inferior vena cava.
SVC = superior vena cava.

Figure 2:

The excellent cosmetic result of the right subaxillary thoracotomy.

is achieved through continuous suction via the cardioplegia, and the patient is routinely weaned off extracorporeal circulation. A postoperative echocardiogram is conducted for cardiac evaluation. The pericardium is partially closed, a pleuromediastinal chest drain tube is placed, temporary epicardial pacemaker leads are positioned, and the chest wall is closed in the usual manner.

RESULTS

A total of 13 minimally invasive surgical procedures for septal defect closure were performed using the previously described technique. The procedures involved seven girls and six boys, aged between 2 and 11 years, with weights ranging from 11 to 40 kg. The congenital heart defects repaired

included atrial septal defects such as superior vena cava, inferior vena cava, ostium secundum, fenestrated defects, and perimembranous ventricular septal defects. The perioperative data for atrial septal defects showed that 8 were corrected with primary closures and 4 with double velour patches. Cardiopulmonary bypass times ranged from a minimum of 13 minutes to a maximum of 61 minutes (average 38.5 minutes), while aortic cross-clamp times ranged from 12 minutes to 37 minutes (average 30.5 minutes). No significant residual defects were reported in the postoperative echocardiograms. There were no intraoperative deaths. Ten patients were successfully extubated in the operating room, although two required reintubation after arriving in the Intensive Care Unit (ICU) due to increased respiratory rate and elevated serum lactate levels. Mechanical ventilation time did not exceed 24 hours in any case. The average ICU stay was 2.7 days (range 1 to 5 days), and the average hospital stay post-surgery was 6.1 days (range 4 to 8 days). There were no postoperative deaths. Postoperative complications included one case of thoracic exploration for bleeding and one case of diaphragmatic paralysis. No associated thoracic deformities were reported.

DISCUSSION

In recent decades, significant advances have been made in MICS. Despite these advancements, the acceptance and practical implementation of MICS remain limited in developing countries due to various challenges.[7,8]

Surgical correction of atrial and ventricular defects has traditionally shown excellent results with routine median sternotomy.[8] With improvements in cardiac surgery safety, there has been a growing emphasis on reducing procedural trauma and enhancing cosmetic outcomes, particularly for children, adolescents, and young women.[6] Right lateral thoracotomy presents a viable alternative to median sternotomy, offering advantages such as reduced surgical trauma, faster recovery, and improved aesthetic results, especially for women.[8,9] This technique has been increasingly adopted for simple coronary disease repairs and has gained growing popularity.[6,10]

The successful establishment of cardiopulmonary bypass is essential for performing MICS. The arterial cannulation site is typically deep, and aortic cannulation often presents the greatest challenge. Some studies have reported using forceps to grasp the tip of the curved arterial cannula, which can facilitate this process.[11] In certain cases, the inferior vena cava cannula was placed through the sixth intercostal space, and this site was subsequently used for chest tube placement at the end of the surgery. A literature review found few comparisons of minimally invasive techniques for congenital heart defects, with no significant differences in operative time, duration of cardiopulmonary bypass, or blood transfusion volume, suggesting that different incisions did not complicate the procedure.[12]

In our series, we have not yet compared traditional median sternotomy with MICS to identify significant differences in intraoperative or postoperative outcomes. Nevertheless, our results indicate a reduction in the length of stay in the cardiovascular intensive care unit and overall hospital stay.

Yu Qing et al. reported in their study involving 665 patients that there were no significant differences in success rates (OR: 0.23; 95% CI 0.05-1.07) or rates of severe complications (OR: 1.46; 95% CI 0.41-5.22) between the MICS and sternotomy groups. MICS demonstrated an advantage in cosmetic outcomes, with a significant reduction in incision length by 8.97 cm. Further follow-up is needed to assess the psychological impact of the incision on our patient group.[13]

Unlike other emerging technologies, the right lateral thoracotomy approach does not require specialized instruments, and most of the procedure resembles conventional cardiac surgery. This means there is no significant increase in hospital costs, resulting in shorter hospital stays.[14,15] At our center, we successfully adapted conventional surgical instruments for MICS, which reduced costs related to hospital stay.

The success of all procedures is highlighted, with no conversions to full sternotomy and no recorded perioperative adverse events. The absence of deaths, low cardiac output syndrome, arrhythmias, reoperations for residual defects, complete atrioventricular block, or cerebrovascular events during postoperative follow-up underscores the safety and efficacy of this approach.[13,15] An et al. reported one early hospital death (2.1%) following total correction in a 4-month-old child. The patient died from low cardiac output syndrome and multiorgan failure on the seventh postoperative day.[16] In our study, the average ICU stay was 2.7 days (ranging from 1 to 5 days), and the average post-surgery hospital stay was 6.1 days (ranging from 4 to 8 days). There were no postoperative deaths. Postoperative complications included one case of chest exploration for bleeding, one case of diaphragmatic paralysis, and two cases of sternal costal dislocation.

This study has the following limitations: first, it is a retrospective study rather than a randomized controlled trial, which introduces some selection bias in the patient groups, though the results remain clinically relevant. Second, the study was conducted at a single center with a small sample size, so results may vary in other cardiac units. Additionally, long-term follow-up results need to be summarized in more detail.

CONCLUSIONS

We can conclude that MICS approach for atrial and some ventricular defects can be a reproducible surgical alternative that does not require changes to the infrastructure used in traditional approaches. However, further comparative studies

are needed to determine if there are significant differences compared to traditional methods. Nevertheless, some studies suggest that the smaller skin incision provides superior aesthetic results without increasing morbidity or mortality rates, offering psychological and social satisfaction to patients.

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