

*Original article*

**Comparing clinical course and patients out comes in patients undergoing Open surgical Versus Thoracoscopic closure of the atrial and ventricular septal defects in children**

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**Abstract:**

The current study is aimed at evaluation of the impact of different surgical approaches while correcting congenital heart diseases (CHD). Clinical outcomes like; operative time, complications, hospital stay were evaluated in children undergoing surgical repair of atrial septal defect (ASD) and ventricular septal defect (VSD). **Patients and methods:** Between 2015 and 2019, a total of 111 patients surgically managed for CHD with male: female ratio of.... and mean age 10.42±3.24 years. Two surgical approaches: open either right anterolateral thoracotomy or sternotomy and thoracoscopic were used. The study conducted to determine the operative time, ICU stay, complications, recovery period and long term follow up of the patients in both the groups. **Results:** 67 patients with ASD and 44 patients with VSD underwent cardiac surgery. Mean operation time was significantly longer in TS patients in comparison with TT and ST groups. However, mean intensive care unit (ICU) stay and hospital stay were significantly shorter in TS group in comparison with TT and ST patients. **Conclusion:** TS approach in repair of congenital heart defects not only resulted of good cosmetic effect, but also reduces time in ICU and hospital stay in comparison with “classical” operational techniques. In this article we tried to show the whole results of research.

**Keywords:** congenital heart disease (CHD); atrial septal defect (ASD); ventricular septal defect (VSD); thoracoscopy; thoracotomy

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**Introduction:**

Congenital heart disease (CHD) is the most common cause of major congenital anomalies, representing a major global health problem, with a high incidence of 9 to 13 of 1000 births per year<sup>1,2</sup>. However, birth prevalence of CHD are vary among different studies. Therefore, in the recently published GBD 2017 Congenital Heart Disease Collaborators' study new information on the burden of CHD throughout the world was presented. They demonstrated that the global prevalence of CHD at birth, in 2017, is estimated to be nearly 1.8 cases per 100

live births, while annual global mortality of CHD is estimated to be 261247 cases<sup>3</sup>.

Therefore, early and adequate treatment of the CHD in children is required. Several approaches/methods have been implicated for repair of atrial septal defect (ASD) and ventricular septal defect (VSD) by cardiac surgery, starting with successful closure of ASD by Lewis and Taufic in 1953<sup>4</sup> and continued with “classical” closure of an ASD and ventricular septal defect (VSD) via sternotomy or minimal invasive thoracotomy. Both surgical methods are effective and showed relatively low incidences of mortality and

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morbidity<sup>5,8</sup>. However, recent advances in cardiac surgery suggested that the endoscopic repair of the CHD in children is safe and can be performed with or without robotic assisted technique. Several studies demonstrated that endoscopic repair of the ASD or VSD by using robotic technologies is a feasible and safe procedure with good clinical and cosmetic results<sup>9-11</sup>. However, usage of robotic technique to repair congenital heart defects is expensive and not available in many centres, particularly in low-income countries. Besides, thoracoscopic closure of congenital heart defects in children is technically challenging and limited to a small number of experienced centres. Therefore, total closure of the ASD or VSD without a robotically assisted surgical system is a good alternative. It was reported that the thoracoscopic closure of ASD or VSD without a robotically assisted surgical system appears feasible and safe in children<sup>12,13</sup> and associated with a reduced total operation time and a shorter intensive care and hospital stay than “classical” repair through a sternotomy<sup>14,15</sup>. Indeed, decreasing the days of hospital stay of patients with CHD is one of the primary goals, it increases hospital bed turnover and consequently decreases the hospital resources consumption. In our centre we have successfully established thoracoscopic closure of ASD and VSD in children without using robotically assisted surgical system<sup>16</sup>. We aimed to evaluate the impact of different surgical approaches in correction of CHD on postoperative hospital stays in children either with ASD or VSD.

In the current manuscript we have investigated if thoracoscopic correction of the heart defects in comparison with “classical” sternotomy or mini-invasive right anterolateral approaches will reduce the length of hospital stay in children with ASD or VSD.

## Material and Methods:

### Study design

The study involved 111 patients with congenital heart disease (67 with ASD and 44 with VSD), who have been operated on at the Research-clinical center for cardiac surgery and transplantology (Taraz, Kazakhstan) over the period from 2015 to 2019. All patients were divided into the three groups: in group 1 – all patients underwent ASD (n=23) or VSD (n=15) closure by thoracoscopic (TS) surgery, in group 2 – cardiac surgery in ASD (n=24) and VSD (n=13) patients operated via anterolateral thoracotomy (TT)

and in group 3 – cardiac surgery. This study approved by the Ethics Committee at the Asfendiyarov Kazakh National Medical University and has been conducted in accordance with the principles of the Helsinki Declaration. The written informed consent was obtained from all patients’ parents or legal guardians for the participation in the current research study.

### Pre-surgical assessment and echocardiography

Pre-surgical assessment includes physical examination, chest X-ray, blood analyses and transthoracic echocardiography to evaluate the size and type of ASD and VSD, right ventricular internal diameter (RV) and systemic (Qs) and pulmonary (Qp) flows were acquired to estimate the size of intra-cardiac shunt as described previously<sup>17</sup>.

### Thoracoscopic closure of the ASD and VSD

Thoracoscopic operation in children with CHD was performed as described previously<sup>12</sup>. The anterolateral thoracotomy or sternotomy for repair of ASD or VSD were performed as described elsewhere<sup>8,13</sup>. Routine perioperative transesophageal 2D-echo monitoring (TEE) was performed. After the operation, patients were monitored in a surgical intensive care unit (ICU) and after hemodynamic stabilisation were transferred to the postoperative department. In addition to chest X-ray, blood gas analysis and transthoracic echocardiography were routinely performed to assess the postoperational condition.

**Statistical analyses.** All the statistical calculations were performed using GraphPad Prism 8 (GraphPad, San Diego, CA, USA). All data are expressed as mean value  $\pm$  standard deviation (SD) of the mean value; multiple comparisons were analysed by one-way ANOVA corrected by Tukey’s tests.  $P < 0.05$  was considered statistically significant.

Before surgery all patients underwent clinical examination, including ECG, chest x-ray and routine echocardiography. The patients’ characteristics before cardiac surgery presented in Table 1 and 2. Our pre-operational data showed that there were no significant difference between studied groups in the most of parameters. There were no inpatient deaths or surgery complications in either group.

### Thoracoscopic Repair of the Atrial Septal Defect (ASD) in Children

A total of 67 patients with ASD were included in this study. Baseline examination revealed that in a children with ASD the size of RV measured by

echocardiography was slightly, but significantly bigger ( $p=0.03$ ) in comparison with thoracotomy, but not with sternotomy group of patients (Table 1).

Our operational data demonstrate that TS procedure in an ASD repair employed longer time in comparison with TT ( $p=0.01$ ) and ST ( $p=0.0001$ ) groups (Figure 1B). However, we have found that the patients operated via TS approach stayed in ICU significantly shorter time ( $16.0\pm 2.1$  hours) in comparison with patients operated via TT ( $21.0\pm 1.8$  hours,  $p=0.0001$ ) and ST ( $22.1\pm 2.8$  hours,  $p=0.0001$ ) approaches (Figure 1E). Similarly, the total postoperative stay

of patients after ASD repair by TS operation was significantly shorter ( $5.6\pm 1.1$  days) in comparison with TT ( $7.0\pm 0.8$  days,  $p=0.01$ ) and ST ( $8.1\pm 1.3$  days,  $p=0.0001$ ) groups. Nevertheless, patients operated via TT spent significantly less days in the hospital in comparison with ST group ( $p=0.01$ ) of patients (Figure 2B). Thus, our data demonstrated that TS operation in patients with ASD was associated with reduced total postoperative stay in ICU as well as in postoperative department, suggesting faster recovery after less-invasive approach in comparison with traditional ST.

**Table 1. Characterization of the patients with atrial septal defect (ASD) before cardiac surgery**

	Thoracoscopy (TS, n=23)	Thoracotomy (TT, n=24)	Sternotomy (ST, n=20)	TSvsTT	TSvsST	TTvsST
Age, year	11.83±3.33	10.38±3.49	11.35±3.31	0.31	0.89	0.61
Gender, m/f	7/16	12/12	8/12			
Height, cm	145.0±17.43	137.7±13.75	137.1±16.80	0.278	0.21	0.98
Weight, kg	36.87±12.62	33.08±10.02	34.15±11.41	0.49	0.71	0.94
BSA, m <sup>2</sup>	1.23±0.31	1.11±0.23	1.13±0.28	0.29	0.48	0.95
HR, bpm	86.57±11.88	94.04±13.50	95.90±13.30	0.12	0.054	0.88
BP <sub>syst</sub> , mmHg	101.30±8.29	95.42±6.58	96.00±7.53	0.02	0.06	0.96
BP <sub>diast</sub> , mmHg	64.57±7.22	59.62±1.38	61.50±3.66	0.09	0.18	0.96
LV EF, %	65.57±3.41	64.71±4.45	65.80±6.07	0.80	0.98	0.72
Qp/Qs	2.05±0.46	1.98±0.22	1.95±0.33	0.78	0.61	0.94
RV, cm	2.84±0.76	2.35±0.49	2.57±0.71	<b>0.03</b>	0.38	0.53

BSA – body surface area; HR – heart rate; BP – systemic blood pressure; LV – left ventricle; EF – ejection fraction; Qp – pulmonary flow; Qs – systemic flow; Qp/Qs – ratio of the pulmonary to systemic flow, describes the magnitude of a cardiovascular shunt; RV – right ventricle; Data presented as mean  $\pm$  standard deviation of the mean value (SD); All statistics were performed using GraphPad Prism version 8.00 for Windows. The treatment groups were compared using one-way analysis of variance and the Tukey's multiple comparisons test.

#### Ethical approval

This study approved by the Ethics Committee at the Asfendiyarov Kazakh National Medical University and has been conducted in accordance with the principles of the Helsinki Declaration. The written informed consent was obtained from all patients' parents or legal guardians for the participation in the current research study.

#### Results:

##### Thoracoscopic Repair of the Ventricular Septal Defect (VSD) in children

A total of 44 patients with VSD were included in this study. There were no difference between studied groups in all parameters, except Qs/Qp ratio, which was significantly higher in TS group in comparison with children operated by ST approach, but not TT surgery (Table 2).

Similarly to ASD patients, TS procedure in a VSD repair employed longer time in comparison with TT ( $p=0.01$ ) and ST ( $p=0.01$ ) groups (Figure 1C). For now, we have demonstrated that the patients operated via TS approach stayed in ICU significantly shorter time ( $18.0\pm 1.3$  hours) in comparison with patients operated by ST ( $20.9\pm 1.7$  hours,  $p=0.0001$ ), but not in comparison with patients operated via TT approach ( $19.0\pm 1.8$  hours,  $p=0.2$ , Figure 1F). Similarly to ICU stay, the total postoperative stay

of patients after VSD repair by TS operation was significantly shorter ( $6.9 \pm 1.3$  days) in comparison with patients operated via ST ( $8.1 \pm 1.1$  days,  $p=0.05$ ), but not via TT ( $6.5 \pm 0.5$  days,  $p=0.01$ ) approaches (Figure 2C). At the same time, postoperative stay of the patients from TT group was significantly

shorter in comparison with ST group ( $p=0.01$ ). Thus, similarly to ASD patients, our data demonstrated that TS repair of VSD associated with faster recovery and reduced total postoperative stay in ICU as well as in the hospital in comparison with ST group of patients.

**Table 2. Characterization of the patients with ventricular septal defect (VSD) before cardiac surgery**

	Thoracoscopy (TS, n=15)	Thoracotomy (TT, n=13)	Sternotomy (ST, n=16)	TSvsTT	TSvsST	TTvsST
Age, year	8.73±2.91	9.69±3.19	9.25±2.01	0.62	0.85	0.90
Gender, m/f	10/5	5/8	8/8			
Height, cm	130.5±12.32	129.50±18.85	128.40±13.77	0.98	0.92	0.97
Weight, kg	26.53±6.31	28.81±11.20	26.13±6.57	0.74	0.98	0.65
BSA, m <sup>2</sup>	0.97±0.17	0.99±0.27	0.92±0.17	0.91	0.80	0.57
HR, bpm	99.20±5.75	91.38±12.47	92.00±12.75	0.14	0.16	0.98
BP <sub>syst</sub> , mmHg	95.33±6.11	95.38±9.67	95.94±6.63	0.99	0.97	0.97
BP <sub>diast</sub> , mmHg	60±0	59.62±1.38	61.25±5.91	0.95	0.61	0.46
LV EF, %	64.73±2.79	65.77±4.41	66.94±3.82	0.74	0.23	0.67
Qp/Qs	1.97±0.24	1.83±0.19	1.75±0.11	0.16	<b>0.006</b>	0.43
RV, cm	1.86±0.17	2.07±0.40	1.87±0.15	0.08	0.99	0.09

BSA – body surface area; HR – heart rate; BP – systemic blood pressure; LV – left ventricle; EF – ejection fraction; Qp – pulmonary flow; Qs – systemic flow; Qp/Qs – ratio of the pulmonary to systemic flow, describes the magnitude of a cardiovascular shunt; RV – right ventricle; Data presented as mean  $\pm$  standard deviation of the mean value (SD); All statistics were performed using GraphPad Prism version 8.00 for Windows. The treatment groups were compared using one-way analysis of variance and the Tukey's multiple comparisons test.

### Discussion:

Congenital heart disease is an important contributor to morbidity and mortality in children and a global problem in child health. According to the GBD 2017 Congenital Heart Disease Collaborators' study CHD caused 261 247 deaths in 2017, with 180 624 deaths in infants within the 1<sup>st</sup> year of life. Authors reported that the mortality in a patients with CHD mainly occurred in countries in the low and low-middle income<sup>3</sup>.

As suggested surgical repair in an early childhood is often mandatory especially in patients with a complex heart defects<sup>18</sup>. However, choice of the surgical procedure may impact on postoperative patient's stay in ICU, postoperative department

and influences on a hospital bed turnover, hospital resources consumption and therefore on the total cost of therapy. Many factors can affect the patient's length of stay in the hospital after surgical procedure, which also includes the type of surgical procedure and perioperative complications. In fact, more invasive surgical procedure require longer stay in the hospital than minimally invasive approaches.

Consequently, length of stay in a hospital can indicate the speed of recovery and how well the operation was carried out. The total thoracoscopic repair of the ASD, VSD with or without robotic techniques have been well described. However, as we have mentioned above, robotic technique required more resources and it's difficult to establish in a low-income countries. It was reported that the thoracoscopic repair of CHD was associated with a shorter time of returning to school and with a better postoperative quality of life than in patients who underwent ASD repair via sternotomy [15]. In our university hospital we have successfully established thoracoscopic closure of the ASD and VSD in children. Despite the fact that the total operational time was significantly longer in TS group of patients in comparison with TT and ST groups, an intensive care stay and postoperative hospital stay in the TS group were markedly shorter than in the groups operated via

TT and ST approaches. According to the published reports the total operational time is vary from one to another centre and highly depending on the skills of operators. Hence, in an earlier published study Ma and colleagues reported that the total operation time was considerably shorter in patients subjected to VSD closure by thoracoscopic approach in comparison with traditional sternotomy<sup>14</sup>. Thereafter, several studies reported that the operational time for ASD or VSD closure were shorter in comparison with conventional surgery<sup>12,13</sup>. Moreover, Liu and co-authors reported that the operation time can be decreased with improvement of the surgical technique by operators. They conclude, that the surgeons could master this technique quickly, resulted of the total operation time reduction and subsequently intensive care stay and overall hospital stay<sup>13</sup>.

During, surgery we have performed TEE and as it was suggested the intraoperative TEE cost-effective and provides valuable information in assessment of CHD repair<sup>19</sup>. We have performed all operation with intraoperative TEE and able to control successfulness of the ASD and VSD closure and we believe that it impacts on duration of postoperative stay in ICU and total postoperative hospital stay<sup>20</sup>.

### Conclusion

Thus, in our centre the totally thoracoscopic surgery was feasible and more importantly safe for the closure of ASD and VSD in children. This technique is associated with a reduced intensive care and hospital stay compared to conventional VSD repair using sternotomy.

**Conflict of interest:** not declared

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