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THE COMPARISON OF SURGICAL CORRECTION OF RECURRENT PECTUS EXCAVATUM WITH CROSSING WIRE CONSTRUCTION AND RAVITCH TECHNIQUE

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Aim of the study. The article compares the method of surgical treatment using a crossing wire construction with the modified Ravitch operation for recurrent pectus excavatum.

Methods. Between 2010 and 202, in our center twenty-four patients with recurrent pectus excavatum were operated. 15 patients underwent modified Ravitch technique with sternocostal plate and 9 patients were operated by open toracoplasty with crossing wire construction. The primary end point was Haller index change after operation. The secondary end points included length of stay after operation, short-term and long-term complications.

Results and discussion. The mean patient age was 19.1±2.87 years. The mean Haller index was 4.45±2.78, the Gizhitskaya index – 0.7±0.1. A toracoplasty with cross wire construction was performed in 9 patients. There was no perioperative death. The Haller index reduced to 2,9±1,76 after the operation. During the follow-up, there were 1 patient who developed wound marginal necrosis; hemothorax in 2 patients and pneumothorax in 1 patient.

Conclusions. Reoperation for recurrent pectus defects is a challenging undertaking. The results of our study showed that patients with recurrent pectus excavatum can safely undergo reoperation by toracoplasty with cross wire construction, and achieve satisfactory results

Key words: thoracoplasty; pectus excavatum; Ravitch operation; crossing wire construction

INTRODUCTION

Pectus exavatum (PE) is the most common anomaly of the anterior chest wall. This anomaly is characterized by depression of the sternum and adjacent ribs. The main method of correcting this deformity is surgical treatment. Nowadays a huge number of surgical techniques have been described, the main of which are the open Ravitch «technique», the Nuss procedure and their modifications [9]. The frequency of recurrence of pectus excavatum after operative interventions is about 5-37% [4, 10, 11, 12]. Currently there are no guidelines regarding the management of recurrent PE. The most common causes of recurrence of chest deformity are insufficient mobilization of the sternocostal complex during the Ravitch operation, displacement of the plate, as well as excessively early removal of the bar after the Nuss procedure. In case of recurrence of PE 2 or more sternocostal plates are placed substernally for better stabilization. Which leads to excessive tension of the anterior sternocostal panel and associated pain syndrome. Open operation according to Ravitch, although it is the optimal method of surgical treatment for complex deformity of the rib cage, nevertheless, this operation is not aesthetic. When using a wire construction to stabilize the sternum and ribs during the open thoracoplasty, one of the possible complications can be a breakdown of the wire structure with its further migration.

In this study, we review our institutional experience in the surgical treatment of recurrent PE in adults with the modified Ravitch operation and crossing wire construction.

Aim of the study – the comparison of the method of surgical treatment using a crossing wire construction with the modified Ravitch operation for recurrent pectus excavatum.

MATERIAL AND METODS

Retrospective review of 302 patients undergoing repair of recurrent PE in our hospital between 2010 and 2022 was performed. Included in the

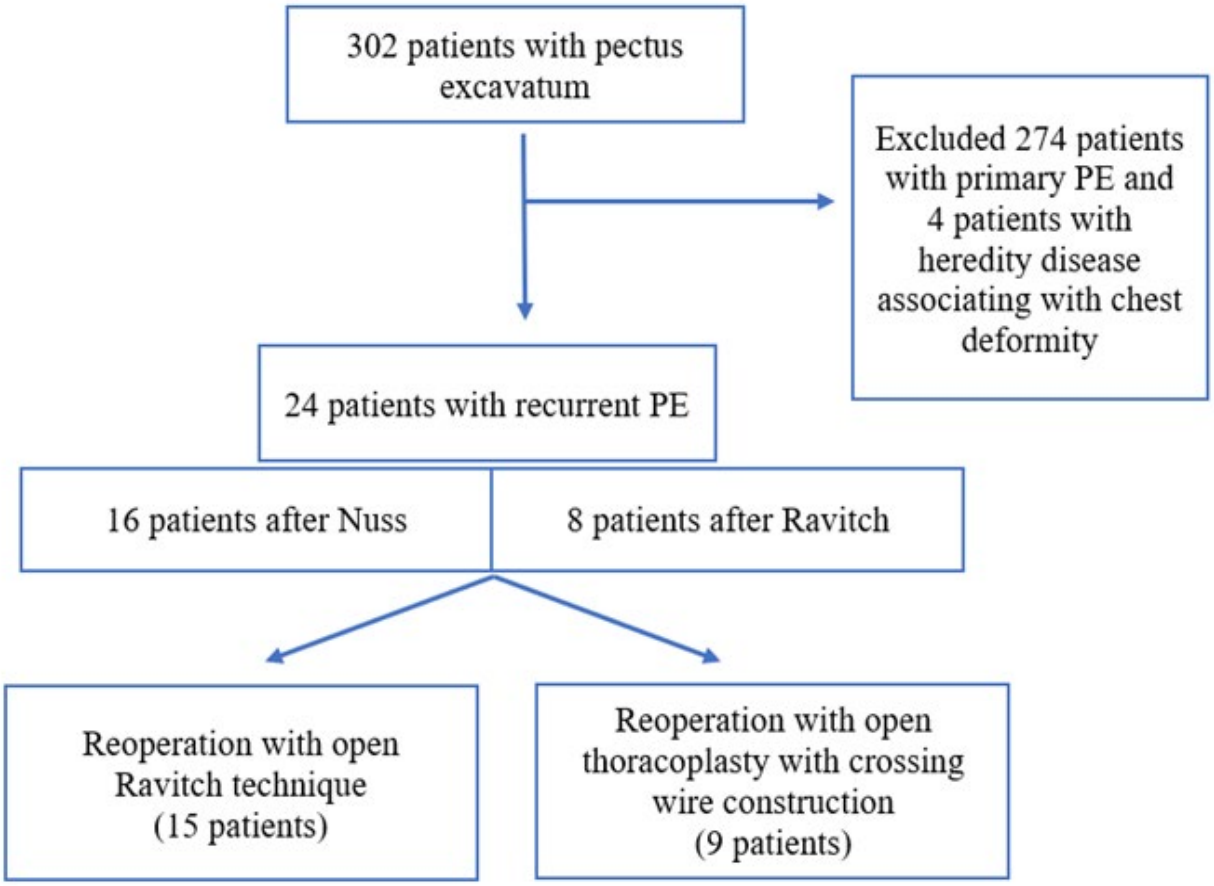

Figure 1 – Distribution of patients by groups

analysis were patients requiring surgical revision of recurrent PE who had their initial repair during childhood or adolescence. Excluded were patients with recurrent another chest deformity, patients with heredity disease associating with chest deformity (Poland syndrome, Marfan syndrome, Ehlers-Danlos syndrome). According to the inclusion and exclusion criteria, 24 patients with recurrent pectus exavatum chest deformity were selected from them (fig. 1). All 24 patients were divided into 2 groups: 15 patients underwent modified Ravitch technique with sternocostal plate and 9 patients were operated by open toracoplasty with crossing wire construction.

Preoperative workup. Preoperative examination of patients with relapses is similar to that of patients undergoing primary thoracoplasty. Examination includes chest X-ray, chest CT, lung spirography.

Surgical procedure. Regardless of the group, the onset of surgery was the same: the patient was placed in the supine position using general anesthesia and orotracheal intubation. After routine disinfection a three-ray skin incision was made for better visualization. The soft tissues were mobilized to the outer boundaries of the deformation. After skeletonization from III to VII of the rib on both sides to the outer boundaries of the deformity, parasternal resection and mandatory costotomy of the same ribs are performed. The sternum is corrected in the III intercostal space by an incomplete transverse sternotomy with a fracture of the posterior plate.

After elevation and mobilization of the sternum, the patients of the first group underwent a forming a tunnel under the sternum, through which the sternocostal plate is then passed, the ends of which are brought out through the intercostal spaces and placed on the bone parts of the ribs, where 2 transverse plates are fixed on the plate with locking screws to avoid bar rotation (fig. 2).

After the incision soft tissues (skin, subcutaneous fat, muscles and perichondrium and periosteum) exfoliate from the ribs and sternum by blunt way to the outer boundaries of the deformation. The xiphoid process of the sternum is cut off and the sternum is mobilized in a blunt way with the help of sebsternal hydropreparation (0.25% solution of 20.0 ml of Novocaine is first introduced into the retrosternal space). Then, segmental wedge-shaped resection of the deformed costal cartilages, parasternal resection of the same ribs for 20-30 mm is performed along the outer boundaries of the deformation. The sternum is corrected by an incomplete transverse wedge osteotomy in the second intercostal space,

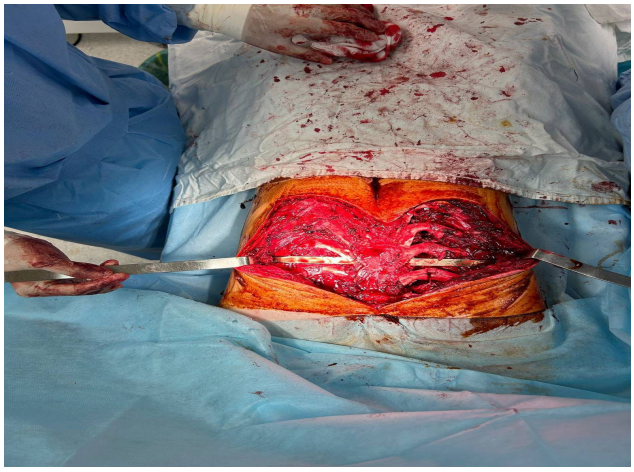

Figure 2 – Sternocostal plate under sternum. Intraoperative view

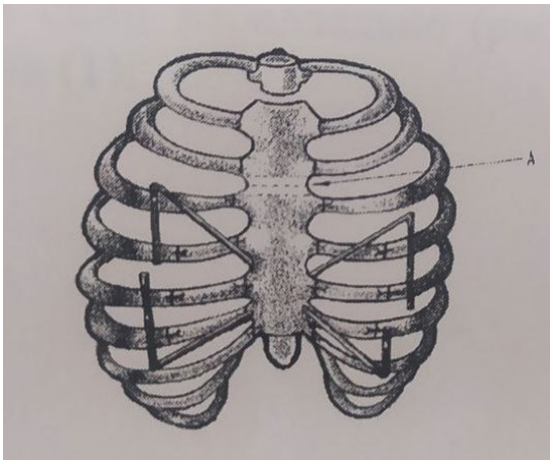

Figure 3 – Crossing wire construstion

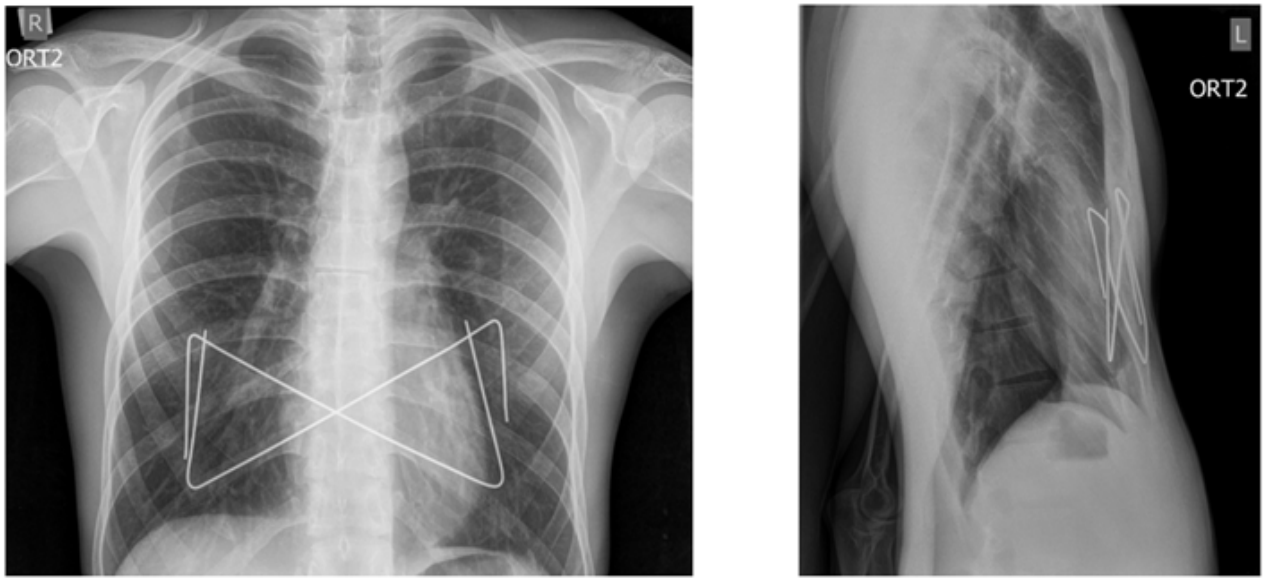

Figure 4 – The X-rays of patient with crossed wire construction

the posterior cortical plate is partially fractured. To stabilize the sternocostal complex, 2 thick wires with a diameter of 2-2.5 mm are used, which are held under the sternum, crossing at the top of the deformity. The ends of the spokes are brought out through the intercostal spaces to the surface of the ribs beyond the limits of the mobilized rib-sternal panel. The ends of each spoke are bent at right angles in opposite directions, immersing them in the thickness of the soft tissues so that the spokes rest on the above and underlying ribs (fig. 3).

Finally, the operation was the same in both groups: rib stumps are sutured to the sternum with interrupted sutures. The wound was washed and sutured tightly in layers leaving a drainage tube.

Rehabilitaton. Drainage tubes were removed on the second day after the operation. The next day after the surgical intervention, rehabilitation measures began to be carried out (verticalization and activation of the patient, breathing exercises, inhalations).

Statistical analysis. X-ray assessment of the results was carried out by calculating the Haller and the Gizhitskaya indecies. The Mann – Whitney U-test was applied for comparing the two groups. IBM SPSS Statistics 20.0 and STATISTICA 10 were used for statistical analysis of the research results. A p-value less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The average age of patients with PE was 19.1±2.87 years. Among them were 18 men (75%) and 6 women (25%). Surgical interventions for primary deformity of the chest were as follows: Nuss operation – in 16 patients (66.6%), Ravitch operation – in 8 patients

Table 1 – Demographic and hospitalization information of all group

Index		After Nuss	After Ravitch	Total
Number of patients		16	8	24
Age		17±2,74	20±2,45	19,1±2,87
Gender	male	75%	80%	75%
	female	25%	20%	25%
Haller index		4.59 ± 1.25	4.21 ± 1.12	4,45±2,78
Gizhitskaya index		0.7±0.2	0.7±0.1	0,7±0,1
Time after first thoracoplasty		3.1±1.52	3.5±1.02	3,2±1,43

Table 2 – Hospitalization information of two group

Operation technique	Open Ravitch		Crossing wire construction	
Number of patients	15		9	
Haller index	before	after	before	after
	3,8±1,24	2,7±1,84	3,7±1,19	2,9±1,76
Gizhitskaya index	before	after	before	after
	0,7±0,18	0,9±0,08	0,7±0,15	0,9±0,07
Intraoperation blood loss	428±70,63		428±75,46	
Duration of operation	126±10,3		124±12,4	
Hemothorax	20%		22%	
Pneumothorax	13,3%		11,1%	
Wound complication	6,7%		11,1%	
Day of hospitalisation	7,6±0,98		7,4±0,88	

(33,3%). The mean Haller index was 4.45±2.78, the Gizhitskaya index – 0.7±0.1 (table 1).

All patients were followed up for 29.32±12.45 months (range 24 to 43 months). The Haller index in first group was 3,8±1,24 before operation and 2,7±1,84 after operation, in second group the Haller index was 3,7±1,19 before operation and 2,9±1,76 after operation. The early complications and Haller index are shown in table 2.

Patients were followed up every 6 months after the operation. A general examination of the patient and a chest X-ray are performed (figure 4).

Removal of metal structures was performed in the interval from 2 to 4 years from the moment of the last surgical intervention (fig. 5, 6).

Surgical repair of pectus deformities is most commonly performed during childhood, early adolescence and rarely in adult in order to minimize cardiac or respiratory impairment, as well as to diminish significant psychological consequences. The standard open repair for PE has been the Ravitch technique for long time [13], which involves extensive resection of deformed costal cartilages, anterior osteotomy and stabilization of the sternum. In spite the success of the techniques described above some patients still face recurrent deformity [2]. The reasons for recurrence were varied: age at the time, extensive resection of ribs cartilage, displacement or premature removal of the metal support bar and local infection [8, 13]. During Nass surgery, there is a higher frequency of relapses due to migration of the sternocostal plate, as well as the age of patients (in adult patients, the results of correction are less satisfactory) [1, 6]. Most recurrences are seen within the first 1-3 years after operation [5]. Patients with connective tissue disorders such as Marfan syndrome have a higher incidence of recurrence after repair [10]. Most of our patients required reoperation because they presented with symptoms such as psychosocial reasons for repair, assassinating with psychological inferiority. We thought the indications for reoperation should be based on the patient's age, symptoms, chest wall appearance and psychosocial impairments. Correction of recurrent pectus is much more difficult and complex than primary repair. With the first procedure of

Figure 5 – Two years postsurgery photo

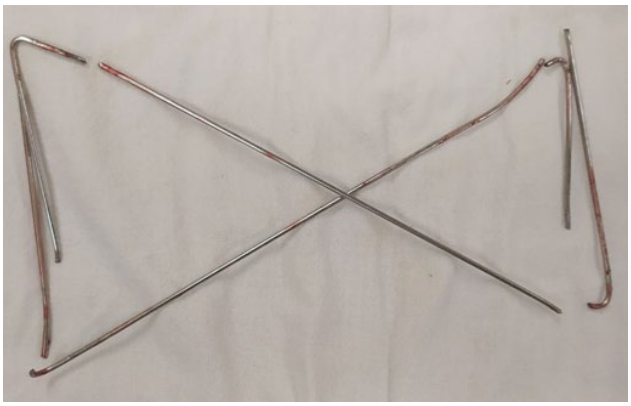

Figure 6 – Removed crossed wire construction

correction, the irregular fusion and ossification of the regenerated costal cartilages often adhered to the pericardium and lung. The intrathoracic dense adhesions between the sternum and mediastinal structures increase both the difficulty and the potential risks of reoperative procedures [7]. Blood loss and postoperative hospitalization were similar between groups. The disadvantage is the location, being a cosmetic visible anterior incision, but the subxiphoid incision is small and worthwhile compared with the cardiac complications.

The recurrence rate in our research center was 7.94%. According to the authors, the frequency of recurrences of pectus excavatum after the Ravitch operation and the minimally invasive Nass technique ranges from 2 to 37% [3]. Thus, the frequency of recurrence of PE is within the reference values.

Early postoperative complications of both groups are presented in table 2. One patient of second group had a pneumothorax (11,1%) requiring a chest tube aspiration at the time of the operation. Two patients on second group (22%) had a hemothorax postoperatively and one patient had (11,1%) wound complication (marginal necrosis). No one of the patients had pericarditis postoperatively and pneumonia. There were no deaths or cardiac perforations.

Some studies reported a slight increased rate of early complications such as pleural effusion requiring drainage (6%), hemothorax (8%), pericarditis (4%), and increased rate of pulmonary parenchymal laceration and myocardial injuries.

We think that recurrence of PE may present mainly due to either technical faults during the primary surgical correction (incomplete mobilization of anterior chest wall, insufficient rib cartilage resection and costotomy, bar displaysment) or early bar removal. Also we think that the rate of recurrence of the PE after Nuss procedure more higher than Ravitch operation.

We believe that the method of surgical correction of pectus excavatum recurrence using a crossing wire construction is a worthy alternative to the Ravitch operation. This method is simple and cheap to use. Along with the advantages, there are also disadvantages, such as, for example, the lower rigidity of the metal structure compared to the sternocostal plate.

CONCLUSIONS

Reoperation for recurrent pectus defects is a challenging undertaking. The results of our study showed that patients with recurrent pectus excavatum after open repair can safely undergo reoperation by modified Ravitch procedure with cross wire construction, and achieve satisfactory results.

Authors' contributions:

O. S. Bekarisov, M. T. Abilmazhinov – concept and design of the study.

K. B. Tazhin – collection and processing of the material.

M. T. Abilmazhinov, A. B. Kazbekov – statistical processing.

A. B. Kazbekov – text writing.

K. B. Tazhin – editing.

Conflict of interest. No conflicts of interest have been declared.

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ ЭФФЕКТИВНОСТИ ТОРАКОПЛАСТИКИ С ИСПОЛЬЗОВАНИЕМ КОНСТРУКЦИИ СКРЕЩИВАЮЩИХСЯ СПИЦ И ОПЕРАЦИИ РАВИЧА У ПАЦИЕНТОВ С РЕЦИДИВАМИ ВОРОНКООБРАЗНОЙ ДЕФОРМАЦИИ ГРУДНОЙ КЛЕТКИ

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Цель исследования. сравнить эффективность торакопластики с использованием конструкции перекрещивающихся спиц и модифицированной операции Равича при рецидиве воронкообразной деформации грудной клетки.

Материалы и методы. В период с 2010 по 2022 годы в «Национальном научном центре травматологии и ортопедии имени академика Н. Д. Батпенова» (Республика Казахстан, г. Астана) были прооперированы 24 пациента с рецидивом воронкообразной грудной клетки. 15 пациентам была выполнена модифицированная методика Равича с использованием грудино-реберной пластины, 9 пациентам проведена торакопластика с использованием спицевой конструкции. Первичной конечной точкой было изменение индекса Галлера после операции. Вторичные конечные точки включали в себя продолжительность пребывания в стационаре, краткосрочные и долгосрочные осложнения.

Результаты и обсуждение. Средний возраст пациентов составил 19,1±2,87 г. Средний индекс Галлера составил 4,45±2,78, индекс Гижицкой – 0,7±0,1. Периоперационной смерти не было. После операции индекс Галлера снизился до 2,9±1,76. За время наблюдения у 1 пациента развился краевой некроз раны, у 2 пациентов был зарегистрирован гемоторакс, у 1 пациента возник пневмоторакс.

Выводы. Коррекция рецидивов воронкообразной деформации грудной клетки является сложной задачей. Результаты исследования показали, что торакопластика с использованием конструкции с перекрещивающимися спицами позволяет добиться удовлетворительных результатов у пациентов с рецидивами воронкообразной деформации грудной клетки.

Ключевые слова: торакопластика; воронкообразная деформация грудной клетки; операция Равича; спицевая конструкция

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КЕУДЕ ҚУЫСЫНЫҢ ШҰҢҚЫР ТӘРІЗДІ ДЕФОРМАЦИЯСЫ ҚАЙТАЛАНҒАН НАУҚАСТАРДА АЙҚАСПАЛЫ СПИЦ ДИЗАЙНЫ МЕН РАВИЧ ОПЕРАЦИЯСЫН ҚОЛДАНА ОТЫРЫП, ТОРАКОПЛАСТИКАНЫҢ ТИІМДІЛІГІН САЛЫСТЫРУ

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Зерттеудің мақсаты. Торакопластиканың тиімділігін қиылысатын спиц дизайнын және кеуде қуысының шұңқыр тәрізді деформациясының қайталануында өзгертілген Равич операциясын қолдана отырып салыстырыңыз.

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Нәтижелер және талқылау. Пациенттердің орташа жасы 19,1±2,87 жасты құрады. Галлердің орташа индексі 4,45±2,78, Гижицкая индексі 0,7±0,1 болды. Периоперативті өлім болған жоқ. Операциядан кейін Галлер индексі 2,9±1,76 дейін төмендеді. Бақылау кезінде 1 пациент шеткі жара некрозын дамытты; 2 пациент гемоторакс алды және 1 пациент пневмоторакс алды.

Қорытындылар. Кеуде қуысының шұңқыр тәрізді деформациясының қайталануын түзету қиын. Біздің зерттеу нәтижелеріміз торакопластика айқаспалы спиц дизайнын қолдана отырып, кеуде қуысының шұңқыр тәрізді деформациясының қайталануы бар науқастарда қанағаттанарлық нәтижелерге қол жеткізуге мүмкіндік беретінін көрсетті.

Кілт сөздер: торакопластика, кеуде қуысының шұңқыр тәрізді деформациясы, Равич операциясы, сөйлеу құрылымы