



## Results Of Surgical Treatment Of Pectus Excavatum In Children And Adolescents

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### ABSTRACT

This study was performed on the results of surgical treatment of 183 patients with various forms of PE at the age of 3 to 18 years. All operated children were divided into three groups. The first group consisted of 76 (41.5%) patients who underwent thoracoplasty with fixation of the mobilized sternal-rib complex on an external traction splint. The second group included 77 (42,1%) patients operated by the developed method of thoracoplasty. The third group of 30 (16.4%) patients operated on the classical Nuss-method. Short and long term results were compared between the groups.

The operation time was significantly shorter in third group (55 min) and the volume of blood loss was higher in the first group (46,4±12,5 ml). Pleural effusion and atelectasis were observed 4 and 3 patients and atelectasis or pneumonitis was observed 3 and 2 patients in first and third groups respectively. The duration of postoperative pain syndrome was significantly shorter in second group with intercostal blockade. Pneumothorax was established 4 and 3 patients in first and third groups. Partial relapse and complete relapse were observed 3 (4.1%) and 2 (2.7%) patients in the first group. The best cosmetic result was observed in the second group (modified thoracoplasty) and third group (Nuss method), respectively (p<0.05).

Short and long-term results were excellent for modified thoracoplasty and Nuss procedures with low complication rates.

**Keywords:** *pectus excavatum, sternum, surgical treatment, long-term results*

### INTRODUCTION

Congenital pectus excavatum (PE) takes the first place among the deformation of the chest, accompanied by violations of the cardiorespiratory system and various cosmetic defects [1,2,3,4].

A radical way to eliminate the deformation of the chest is surgical correction-thoracoplasty. Of the many methods of thoracoplasty of funnel-shaped

deformation of the chest, currently the most widespread are minimally invasive methods based on the plastic properties of the sterno costal complex using special plates for stabilization [5,6,7]. One of the terrible complications is damage to the intercostal vessels and pericardium with the development of bleeding. In adolescents older than 15 years, there are fractures of the sternum and plate migration[7].

To prevent secondary changes in the spine and the development of psycho-emotional disorders in adolescents, surgical treatment of all types of chest deformities is recommended to begin as early as possible [8,9,10,11,12]. With this study, we wanted to share the short and long term results of patients who were operated with 3 different methods due to PE deformity in different time periods.

The aim of this study is to review the surgical experiences with pectus excavatum (PE) deformities regarding to three different methods.

### MATERIAL AND METHODS

This study was based on the results of surgical treatments for 183 patients with various PE deformities aged 3 to 18 years old. They were operated in the Department of Orthopedics and Traumatology of the Regional Children's Clinical Hospital of the Health Department of Turkestan region from 1997 to 2018 and in the Department of Traumatology of Shymkent City Children's Hospital №1 from 2016 to 2018. All operated children were divided into three groups.

The first group consisted of 76 (41.5%) patients who underwent Ravitch thoracoplasty with fixation of the mobilized sternal-rib complex on an external traction tire from 1997 to 2008.

The second group included 77(42.1%) patients operated from 2008 to 2018 by the modified method of thoracoplasty (Eurasian patent No. 028328 of 30.11.2017).

The third group consisted of 30 (16.4%) patients operated on the classical Nuss method from 2016 to 2018 inclusive.

Clinical examination of children was carried out according to the generally accepted scheme. The degree of deformation in Pectus excavatum was determined by the sternal depression on the lateral projection of the chest x-ray, in severe forms of deformation, the Haller index was used based on the results of computed tomography. Indications for surgical correction of pectus excavatum were, Haller index of 3.25 or more, as well as gross violations of the function of the cardiorespiratory system [13,14].

In the first group, a traditional Ravitch operation was performed with the fixation of the sternocostal complex on the external traction tire of the Marshev. Before applying a traction tire to the chest, a pre-made plaster frame is applied in the shape of the chest, with a window formed according to the boundaries of the deformation. The traction tire was placed on a plaster frame in order to evenly distribute the transmitted load on the chest outside the zone of resected rib cartilage and sternum. Marshev's traction tire was removed after 30-45 days, depending on the age.

In the second group used a modified thoracoplasty consisting in resection of the rib cartilage from the outer edge of the deformation from the parasternal chondrotomy, the sternum was correction "T" shaped on level III intercostal interval by the front transverse wedge-shaped sternotomy with break rear cortical plate of the sternum is mobilized Sterno-costal complex is stabilized by osteosynthesis of the body of the sternum in the bone part needle Illizarov, with the creation of an oval support platform at the ends of the needles in order to fix them in the bony part of the rib with a resorption suture material, beyond the mobilized sternocostal complex. Depending on the age and degree of deformation, one or two needles were used in parallel to each other. The needles were removed after 12-18 months.

In the third group, the correction of PE deformity was performed using the classic Nuss technique using thoracoscopy and consisted of a C-shaped bar with support on the transverse plates on both sides along the anterior axillary line. Postoperative thoracic catheter not used. The bar was removed after 24 months.

Surgical intervention in all groups was performed under intubation anesthesia with minimal trauma and hemostasis. The children stayed in the intensive care unit first day, they received a full volume of infusion and antibacterial therapy, as well as narcotic analgesics. On the second day, the children were transferred to the Department of traumatology and orthopedics, they treated for pain relief and prevention of pulmonary complications. They were allowed to sit for 2-3 days and move independently for 5-6 days. The most important point in the postoperative period

is the improvement of pulmonary ventilation, and the relief of pain. For this purpose, the developed modified thoracoplasty performed intercostal Novocain blockade of resected costal cartilage along the middle axillary line on both sides. This made it possible to reduce the use of narcotic and non-narcotic analgesics in comparison with patients who were not blocked. Thus, children who were blocked received analgesics only in the intensive care unit, and those children who were not blocked continued to receive analgesics for 3 days after thoracoplasty. An epidural catheter for pain relief was not used, only an intravenous analgesic in the intensive care unit.

Short time results (up to 10 days) were evaluated according to the following criteria: duration of the operation, volume of blood loss, duration of pain, wound seroma, pleural effusion, atelectasis or pneumonitis, pneumothorax requiring pleural puncture.

Long-term results (up to 2 years) were evaluated according to the following criteria: migration of metal structures with pain requiring removal, keloid scar with ligature fistulas, partial relapse, complete relapse, and lethal outcome. The outcomes were classified as excellent (complete resolution of the deformity), good (close to complete correction), fair (partial correction of the deformity), poor (any recurrence or residual deformity), or slight overcorrection [15]. Prior to surgery, all parents signed an informed consent form for the operation.

### Statistical Analyses

Statistical analyses were performed using SPSS software (version 24; SPSS; Chicago, Illinois, United States). Student's t-test was used to assess the validity of the differences. At  $p < 0.05$ , the differences were considered statistically significant.

### Ethics statement

Written informed consents were obtained from the patients for publication of this article.

## RESULTS

The study was consisting of 124 (67.8%) male and 59 (32.2%) girls. Patients were between 3-5 years old 51 (27.9%), 6-8 years old 56 (30.6%), 9-11 years old 44 (24%) and 12 years old 32 (17.5%). Asymmetric form 92 (50.3%), symmetrical form 76 (41.5%) and flat-funnel form 15 (8.2%) were detected in the patients with PE. There was no difference between groups in terms of age and gender distribution.

Short time postoperative results were observed in all patients in the study groups. The operation time is significantly shorter when using the classic Nuss technique (55 min), and the volume of blood loss is greater when using Ravitch thoracoplasty ( $46,4 \pm 12,5$  ml) due to procedure of the method. Pleural effusion and atelectasis was observed 4 and 3 patients and atelectasis or pneumonitis was observed 3 and 2 patients in first and third groups respectively but  $p > 0.05$  Table 1.

**TABLE 1:** Short and long-term results of treatment groups in the study.

	Ravitch thoracoplasty	Modified thoracoplasty	Nuss procedure	p
Number of patients	76	77	30	-
Average age of patients (years)	$7,3 \pm 1,4$	$8,5 \pm 2,3$	$9,8 \pm 2,5$	$>0,05$
The duration of hospital stay (days)	$8 \pm 2,2$	$7 \pm 1,1$	$7 \pm 1,4$	$>0,05$
Duration of surgery (min)	$96 \pm 8,6$	$75 \pm 8,9$	$55 \pm 5,8$	$<0,05$
Volume of blood loss, ml	$46,4 \pm 12,5$	$30,43 \pm 9,6$	$21,2 \pm 5,3$	$>0,05$
Duration of pain syndrome (day)	$5,2 \pm 1,3$	$2,1 \pm 0,7$	$5,32 \pm 1,5$	$<0,05$
Wound seroma	2(2,6%)	-	-	$>0,05$
Pleural effusion	4	-	3	$<0,05$
Atelectasis or pneumonitis	3	-	2	$>0,05$
Pneumothorax	4(5,2%)	-	3(10%)	$<0,05$

Keloid scar of an operating wound with suture fistulas	7(9,2%)	3(3,9%)	-	<0,05
Cosmetic results - excellent	56(73.5%)	73(94.8%)	28(93.3%)	<0.05
-Good	16(21.0%)	3(3.9%)	2 (6.7%)	
-poor	5(6.5%),	1(1.3%)		
Migration of metal structures	-	-	1(3,3%)	<0,05
Relapse(% ) - partial	3(4,1%)	1(1,3%)	1(3,3%)	
- complete	2(2,7%)	-	-	

The duration of postoperative pain syndrome is only less when using modified thoracoplasty, which is associated with intercostal blockade of resected costal cartilages ( $p < 0.05$ ). Pneumothorax (requiring pleural puncture) developed in 4 (5.2%) patients after Ravitch thoracoplasty ( $p < 0.05$ ).

Keloid scar with suture fistulas was found in 7(9.2%) cases in the first group, and 3 (3.9%) cases in the second group. The formation of ligature fistulas is not related to the surgical technique that can be avoided by using a resorption suture material (vicryl). Migration of the metal structure requiring its removal was observed in 1 (3,3%) patient in the third group.

Partial relapse was characterized by the transition of the third degree of deformation and complete relapse were observed 3(4.1%) and 2 (2.7%) patients in the first group ( $p < 0.05$ ). Partial relapse was observed in one patient in the second and third groups, whereas complete relapse did not develop in this groups. The main cause of relapses is a gross violation of the mode in the deformation of the needles in the second group, the third group this was in strong pain behind the sternum, which served to remove the last 8 months. The best cosmetic result was observed in the second group (modified thoracoplasty) and third group (Nuss method), respectively ( $p < 0.05$ ).

## DISCUSSION

Ravitch technique, which has been applied since the 1950s, has revolutionized PE deformity with its minimal morbidity and good cosmetic results [16]. The Nuss method, which has been applied since 1998, has been an alternative to open standard treatment with less morbidity and scar results [17]. The modified thorocaplasty method in this study is an alternative method for PE.

Proposed to our method of thoracoplasty, which consists in osteosynthesis "T"-shaped osteotomies sternum Ilizarov needle technical simple to implement, requires no special metal for stabilization of the sternum-costal complex, complications like bleeding, hemopneumothorax, migration of metal is not observed in 94.8% of cases, there is a good result that can be recommended for surgical treatment of congenital PE deformation. While patients in the Ravitch and Nuss group needed more narcotic analgesic for pain, less pain medication was needed in the modified thoracoplasty group.

In the study of Molik et al. compared the Ravitch method ( $n = 68$ ) and Nuss ( $n = 35$ ) method. The epidural catheter was inserted for pain control 25 patients in the Nuss group but the catheter were used only 3 patients in the open method. In addition, for postoperative pain management, patient controlled intravenous analgesic (PCA) device was used in the open surgery group in half of the patients and almost all (except 4 cases) in Nuss group[18]. In this study, postoperative pain management was best done in the second group. Novocain blockade of resected rib cartilage along the middle axillary line on both sides reduces the duration of the pain syndrome and reduces the use of narcotic and non-narcotic analgesics in the postoperative period in comparison with patients who did not undergo blockages.

There is similarly length of stay times in this work, when other studies have lessing time in the Nuss group. Even this stay time is twice the literature [19]. The reason for more hospitalization of patients is hospital stay is economically inexpensive in our country and the distance of the patients from the hospital. Overall, the postoperative complications were higher in the first group. Postoperative atelectasis and pneumonia were not detected in second

group. It may also be considered to better the pain control.

Cosmetic is the most important reason for surgery and postoperative long-term success indicator. An excellent cosmetic results in the literature is between 75 %- to 95% [15,19,20]. Given the excellent results in this study, the most successful groups were the second (94.8%) and third groups (87.5%), respectively. In Gibreel et al. 75% excellent results and 12% good results were obtained in Nuss series including 313 patients, while the same results were found above 95% and 3% in another series of 406 cases from Shu et al. Study [15,21]. More than 97% good and excellent results were obtained in 375 patients for open surgery [21]. Relapse and poor results were dominantly seen in the Ravitch group. Although the re-operation rate of the series was between 0.75% and 11.6%, this rate decreases over the years [19,22,23]. Reoperation rate was found 1.1% in this study.

### CONCLUSION

Proposed to us the method of thoracoplasty, which consists in osteosynthesis "T"-shaped osteotomies sternum Ilizarov needle technical simple to implement, requires no special metal for stabilization of the sternum-costal complex, complications like bleeding, hemopneumothorax, migration of metal is not observed in 94.8% of cases, there is a good result that can be recommended for surgical treatment of PE deformation.

Short and long-term results were excellent for modified thoracoplasty and Nuss procedures with low complication rates. Novocain blockade of resected rib cartilage reduces the duration of the pain syndrome and reduces the use of narcotic and non-narcotic analgesics.

### CONFLICTS OF INTEREST

None to declare

### *Institutional Review Board Statement*

Not applicable.

All participants gave written informed consent before study entry.

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