American Journal of Medicine and Medical Sciences 2026, 16(4): 2114-2118
DOI: 10.5923/j.ajmms.20261604.113

Secondary Cosmetic Defects and Complications of Pectus Excavatum

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Abstract We reviewed the literature data in order to identify the coverage of the issues of diagnosis and treatment of children operated on with the pathology of pectus excavatum, identified types of secondary cosmetic defects and various types of complications in the outcome postoperative period. To date, there are enough supporters of both schools who solve the problems of PE themselves, setting different goals and providing information about complications and unsatisfactory results in the early and late postoperative period.

Keywords Pectus excavatum, Children, Secondary cosmetic defects

1. Introduction

Pectus excavatum deformity of the thoracic girdle (PE) is a congenital abnormality of the development of the chest, manifested in the form of immersion of the thoracic-rib complex into the chest cavity, over time leads to functional disorders of the vascular and respiratory systems and even persistent psychoemotional instability by adolescence [1,2,4,6,8,15,30]. According to the literature, PE ranks first among all congenital anomalies of the anterior chest wall, which account for 91% [1,3,5,22]. The primary description of this congenital malformation belongs to J. Schenk (1594), and the main notable work devoted to the problems of treatment belongs to L. Meyer (1911), after which most scientists from leading schools took up this pathology, offering more than 100 surgical methods of treatment in modern practice of thoracic surgery and pediatric orthopedics [2,4,9,12,25], and even a less invasive technology (Minimal Invasive Repair of Pectus Excavatum - MIRPE) by D. Nuss (1998), which at one time proved to be a revolutionary revolution and was aimed at significantly solving the problems of treating this congenital pathology [2,4,9,18,30,42].

At one time, the M Ravitch technique sought to solve this congenital pathology in a radical way, which became widely popular among specialists, and a number of modifications of this surgical method were developed [2,8,20,21,23]. To date, there are enough supporters of both schools who solve the problems of PE themselves, setting different goals and providing information about complications and unsatisfactory results in the early and late postoperative period [7,22,35].

According to scientists who conducted large–scale studies in the last century with this pathology, V.K. Urmonas, N.I. Kondrashin, (1983), M. Ravitch (1977), in principle 1/5 of existing patients will need surgical intervention, however, unsatisfactory results and the incidence of complications of various types is much higher - 40-50%. According to these scientists, the occurrence of complications at a high level is associated with errors in the development of indications for treatment methods and possibly the lack of consideration of the severity of connective tissue dysplasia in the body [10,15,24,25,28].

Currently, the treatment of PE is conducted mainly in two directions, as a conservative one using the "vacuum bell - VB" and a variety of surgical techniques proposed by most scientists. The disadvantages of the "Vacuum Bell - VB" method include: the occurrence of complications in most cases associated with skin and blood vessels; the appearance of discomfort among patients with improper installation and adaptation of endofixer stabilizers to the area of a funnel-shaped defect; in patients older than 9-10 years (when the frame of the anterior chest wall is rigid), very little is possible to get a good result, and in patients older than 9-10 years, the recurrence of the funnel-shaped defect is much higher; currently, the optimal age criterion for the use of the surgical method remains questionable [26]. In the practical activities of A.O. Shominova, Z.B. Mitupov and A.Y. Razumovsky (2022), the "vacuum bell - VB" method was used in 46 patients with PE and, due to the above conditions, this method was abandoned in 9 (19.5%) cases [26]. According to the analysis of the collected data on the surgical treatment of this pathology, PE is conditionally treated using 6 groups of thoracoplastic operations, these methods differ in relation to the methods of correction of the funnel-shaped

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Received: Mar. 28, 2026; Accepted: Apr. 23, 2026; Published: Apr. 28, 2026
Published online at http://journal.sapub.org/ajmms

defect and its stabilization:

1. Methods of correction of PE without the use of fixators (methods of M. Ravich (1949), N.I. Kondrashin and V.K. Urmonas (1960) [29,31,38];
2. Methods of correction of PE using external traction devices (external traction devices I.A. Marsheva, Gross (1950), G.A. Bairova (1960), Tashkent Pediatric and Andijan State Medical Institute (2000-2010);
3. Thoracoplasty methods performed on the basis of turning the resected sternocostal complex 180 degrees (Japanese scientists WADA and Jung A. (1967);
4. Thoracoplasty methods performed using bone grafts in PE;
5. Thoracoplasty methods performed using endofixers (Rebain-Wernicke methods (1957) and Paltia V-Sulamaa M. (1958);
6. Operation D. Nuss - MIRPE; [32].

A large number of traditional thoracoplastic methods have a positive effect on the functional state of the heart and lungs in case of their violation, but, to date, issues related to achieving an ideal external cosmetic result have not found a full-fledged solution. As the medical culture of mankind develops, aesthetic requirements for the results of treatment increase [25].

Postoperative complications include a specific group of secondary deformities of the ribs that occur after primary thoracoplasty of PE with particular complexity and difficulties in their diagnosis and surgical treatment [7,10,11].

It can be assumed that the above types of secondary cosmetic defects often occur in young (up to 6-7 years old) children and adolescents who have been diagnosed with severe connective tissue dysplasia in the body and especially in age periods when a feature of rapid growth of skeletal bones is observed [16,20,25].

2. Classification of Postoperative Complications

The classification of complications after surgical interventions is carried out by many scientists based on various criteria. Most of the scientists' research works are devoted to acute surgical complications arising after various types of thoracoplastic interventions and their elimination [33,38].

When analyzing complications associated with the methods of thoracoplastic PE corrections without the use of fixing devices (group 1 operations), these surgical procedures are highly traumatic, which leads to the addition of secondary infection with the risk of complications such as bedsores, pneumonia and even deaths in high frequency associated with prolonged bed rest (up to 60 days) after the procedure [34,36]. In addition, the recurrence rate of the funnel-shaped defect is high due to the lack of use of fixators to stabilize the corrected sternocostal complex [35,37].

Methods of correction of PE using external traction devices (group 2 operations) have a number of disadvantages:

- firstly, the presence of constant communication of the chest cavity with the external environment with the help of traction threads and concomitant mediastinitis and purulent complications occur;
- secondly, in the early stages after surgery, there is permanent damage and irritation of the sternum and ribs by traction threads, the development of coarse keloid scars in the long term after surgery, as well as secondary atypical and keel-shaped deformities on the anterior surface of the chest [5,17,37].
- thirdly, in as a result of short-term immobilization, PE deformation often recurs, and therefore it is very difficult to achieve the formation of an ideal relief of the anterior chest wall.

The main disadvantages of the 3 groups of thoracoplasty methods performed on the basis of a 180-degree reversal of the resected sternocostal complex are purulent complications and rejection of the reinstalled resected sternocostal complex, recorded up to 60% due to a sharp deterioration in blood circulation in the sternocostal complex [39,40,41].

Among patients in whom 4 groups of thoracoplasty methods were used and a bone graft was used as a fixator, resorption of the installed bone grafts and purulent complications with subsequent recurrence of the funnel-shaped defect occur [43].

In the 5th group of thoracoplasty methods performed using endofixers, complications such as inflammation of the area of attachment to the ribs of the fixator and purulent complications, fracture or migration of fixators with injury to internal organs, as well as difficulty in removing metal devices arise [27]. Taking into account the above circumstances and possible complications, most thoracoplasty methods are currently not used by surgeons and orthopedists, and have historical significance [26].

Currently, many scientists use various polymers to eliminate a cosmetic defect with mild degrees of funnel deformations. For example, Snel B. (2009) proposed filling the area of a minor funnel-shaped defect with silicone. In the long term after such operations, the proportion of complications, such as the occurrence of seroma, displacement and instability of the implant, constant pain in the field of practice was 43% [18,42].

Guba A.D. (2007) using an endofixer developed by him in order to fix the resected sternum of deformed cartilaginous sections of the ribs in his 70 cases divided postoperative complications conditionally into 2 groups:

- General surgical complications (hemothorax, pneumothorax, damage to internal organs, etc.);
- Complications associated with incorrectly chosen tactics;

There are 2 recognized group of complications, such as displacement of a metal device in 6 (8.95%) cases, the presence of residual deformation in 4 (5.98%) cases and recurrence of a funnel-shaped defect of varying severity in 12 (17.92%) clinical cases, the occurrence of which is associated with tactical errors, such as resection of deformed

ribs in large sizes, recommendations of thoracplastic surgery in patients under 5 years of age and a short period of immobilization [7].

In our review, we wanted to note that our goal was to study only that part of the complications associated with the surgical method of deformation of the ribs of the chest, which arose in the long-term periods after the operations performed. Since the diagnosis of these complications is difficult from an orthopedic point of view, choosing treatment tactics and, moreover, predicting the expected results is a difficult task.

Most scientists in their research papers describe the following atypical secondary cosmetic changes after thoracoplastic surgery:

- in some cases, after thoracoplastic operations performed with sternotomy and rib resection and the absence of fixing devices, a flat anterior chest wall may form;
- in thoracoplastic surgery using an external fixation device, secondary cosmetic changes may develop after sternotomy and rib resection, such as the unevenness of the operated area of the thoracic-rib complex by a combination of exfoliated and submerged areas;
- when using various methods of endofixation in combination with sternotomy and rib resection, such a complication arises, reminiscent in literature as hypercorrection of the sternocostal complex and immersion of the fixation site of endofixers to the ribs into the chest cavity;
- the authors involved in D. Nuss surgery using endofixers without stabilizers comment on cases such as secondary displacement of the endofixer, twisting at different degrees and the subsequent occurrence of complications such as recurrence of a funnel-shaped defect [40,43].

3. The Mechanism of Complications in the Long-Term Period After Surgical Interventions

Based on the analysis of literature data, the mechanisms of complications after all surgical interventions are conditionally divided into two groups:

- related to the methods of correction of funnel-shaped deformation;
- related to the types of fixators used to stabilize the sternocostal complex;

An analysis of the literature shows that the mechanism of development of complications is most often among adolescent patients, when their thoracic-rib complex area is in a sufficiently firmly ossified (rigid) state, sternotomy and rib resection are performed to eliminate the funnel-shaped defect, which means that the proportionality of the opposite forces between the sternum and ribs is violated. Therefore, after thoracoplastic operations by Ravich, Bairov, Gross and Kondrashin, performed by sternotomy and rib resection, secondary cosmetic defects occur more often.

The development of the second mechanism of complications is based on such an explanation as the high physical rigidity of the endofixers used in order to stabilize and disrupt their adaptation to the area of the corrected sternocostal complex. At the same time, at the heart of the change in the anthropometric parameters of the chest in the stages of child growth and the absence of a change in the arched shape of the fixator, the plate negatively affects and changes the shapes of the sternum and fixed ribs with the development of secondary cosmetic defects.

V.N. Stalmakhovich and co-authors (2017, 2019) carried out research work on 202 patients treated surgically for PE. As a result, only 4 patients had the following rare complications: fracture of the sternum at the level of the handle and the body of the sternum after installation of the endofixer, the appearance of a hematoma in the fibrous capsule around the metal endofixer, crushing of part of the latissimus dorsi muscle under the shoulders of the metal device and compression of the vessels of the armpit due to the spreading of the ribs after installation of the plate [19,20].

Alzhanova Zh.S. (2008) analyzed the long-term results of 61 patients with PE after surgical treatment, noting various complications in only 2 cases: hypercorrection (bulging) of the sternocostal complex on the anterior wall of the chest – in 1 case and recurrence of a funnel–shaped defect to a mild degree – 1.5 cm - in 1 case [1].

According to Croitoru D.P. (2002) and Hosie S. (2002), the proportion of postoperative complications remains high and it has been shown that the recurrence of funnel deformity reaches 3-30% [30,42].

Komissarov I.A. and co-authors (2013) recognized that surgical treatment of thoracic girdle deformity in the early stages (before school age) led to recurrence of funnel-shaped deformity in 2 clinical cases [13].

Continuing to study the problem of recurrence of funnel-shaped deformity in the long-term postoperative period, Ruzikulov U.S. and co-authors (2010) reported that there was a recurrence of PE in 29.6% of cases after surgical treatment among 96 patients with PE of varying severity treated by G.A. Bairov and in the same place it should be noted that another mechanism of the factors of recurrence of PE It is a short-term fixation using external ventilation devices (up to 2 months) [17].

Dzhenalaev D.B. and co-authors (2020) noted that a recurrence of I. Gyzicka grade II-corresponding PE was observed in 10 (3.5%) patients requiring repeated surgical correction [8].

The timing of obtaining metal fixators in the long term after surgery can also serve as one of the main criteria for the recurrence of funnel-shaped deformation of the anterior chest wall. In this direction, Zlotnikov E.N. and co-authors (2010), according to the results of their scientific research, the minimum period of immobilization should be 2 years. This period is considered sufficient for a complete reorganization of the sternum tissue during its sternotomy and resected ribs, and this is proved by a significant decrease in the titer of oxyproline in the blood [9].

Ibragimov Ya.Kh. and co-authors (2012) in their scientific studies, 4 (9.5%) of 42 patients who used their proposed external fixation device had a recurrence of funnel-shaped chest deformity, while the remaining 4 (9.5%) had cosmetic defects of various manifestations, one of which was hypercorrection areas of the sternocostal complex [10,11].

According to the scientific work of Mirzakarimov B.H. (2010), in 78 patients using external fixation devices, such as external traction devices of Bairov and Ravich Grosso, it was noted that recurrence of the funnel-shaped defect occurs in the long term after thoracoplasty - in 33% and hypercorrection of the anterior sternocostal complex – in 45% of cases [14].

Plyakin V.A. and co-authors (2013) showed the results of two large thoracoplastic schools, namely M. Ravitch and D. Nuss. After analyzing the finished results of these two methods, it was concluded that after the M. Ravitch method it is 5% and D. Nuss surgery is 10% [15,16].

D. Nuss reported an unsatisfactory proportion of results of 8%, based on 10 years of observations of her minimally invasive thoracoplasty method, while surgeons and orthopedists using the D. Nuss method reported an increase of up to 21% [32].

A.Y. Shchur and co-authors (2007) reported that the recurrence of funnel-shaped deformity in the long term after various surgical interventions in patients with funnel-shaped chest deformity is 9% with the Ravich Gross method and 2.5% after D Nuss surgery [27]. Razumovsky A.Yu., Alkhasov A.B., Mitupov Z.B. (2019) reported a large number of operations in more than 100 patients with PE per year with fewer cases of recurrence of PE less than 2% after D. Nuss surgery [26].

Based on the data from the review of the numerous literature presented above, it should be noted that there are few scientific papers on secondary cosmetic complications after practice, and the causes, pathomechanism and timing of these complications, the problems of their diagnosis and elimination do not have a sufficient solution. In addition, the optimal timing for the elimination of secondary cosmetic defects that occur after surgery is also not yet known in our available literature.

4. Conclusions

Thus, the section devoted to the issues of secondary postoperative deformities of the anterior chest wall after thoracoplastic operations for funnel-shaped deformity of the chest in modern thoracic surgery and pediatric orthopedics is one of the least studied areas. Given its numerous unsolvable problems that explain its relevance and demand, it is a promising direction to conduct fundamental research work on the development of optimal timing of these consequences, pathomechanisms of their occurrence, diagnosis and rational treatment.

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