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Analysis Of Long-Term Outcomes of Esophageal Atresia Surgery in Newborns

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ABSTRACT

Annotation. In the modern pediatric surgical profile, esophageal atresia remains one of the most complex congenital pathologies requiring urgent surgery and long-term postoperative support. The progress of surgical methods, the development of new intensive care protocols and the improvement of resuscitation approaches have led to a significant increase in survival and an improvement in the direct results of treatment of esophageal atresia in newborns. However, data on long-term outcomes after discharge from the hospital are still often contradictory and require systematic analysis.

This study is aimed at a comprehensive assessment of the long-term results of surgical correction of esophageal atresia in newborns, identifying risk factors for complications and determining the optimal management of patients in the distant period.

The results of an extensive retrospective-prospective sample with many years of observation are presented, which make it possible to formulate conclusions about the role of modern methods of surgery and the importance of a multidisciplinary approach to the rehabilitation of children who have undergone such interventions.

Keyword: *esophageal atresia, surgical treatment, long-term results, newborns, complications, rehabilitation*

1. INTRODUCTION

Esophageal atresia in newborns is one of the most common severe congenital anomalies of the gastrointestinal tract and requires surgery in the first days of a child's life. This pathology is characterized by the absence or underdevelopment of part of the esophagus, which makes it impossible to adequately pass food from the oral cavity to the stomach and leads to serious consequences already in the early neonatal period.

In the absence of treatment, the outcome of the disease usually becomes fatal, but modern surgical methods allow correction with a high probability of restoring the anatomical integrity of the esophagus. Nevertheless, the quality of life of such patients, especially in the long-term period, directly depends not only on the initial type of atresia and the severity of concomitant malformations, but also on the timeliness and adequacy of postoperative rehabilitation, observation by specialists of related profiles, timely correction of emerging complications and comprehensive support for the child's family.

The improvement in survival rates was made possible largely due to progress in the field of neonatology and the improvement of newborn management protocols in the conditions of modern intensive care units. The factors that ensured this success include the emergence of new anesthetic technologies, the development of minimally invasive surgery and new methods of prenatal diagnostics, which make it possible to determine in advance the tactics of management even before the birth of a child. Despite high achievements, issues of long-term results in the form of gastro esophageal reflux, esophageal strictures, motor disorders, frequent respiratory infections, malnutrition and psychological problems in patients are not given enough attention in clinical practice, especially at the level of systematic multi-year studies.

This study aims to fill the data gap in the long-term outcomes of esophageal atresia surgery in newborns. The paper presents the results of many years of observation of patients who underwent surgical correction of esophageal atresia in one highly specialized center. Clinical, instrumental and laboratory parameters, as well as quality of life, frequency and nature of emerging complications were evaluated throughout the study period. The authors sought to determine the impact of risk factors on health outcomes and provide practical recommendations for optimizing the management of such patients.

Further systematization of knowledge about long-term outcomes will make it possible to develop more effective strategies for the prevention of late complications and develop uniform standards for dispensary observation, including a mandatory assessment of the digestive, respiratory and neuropsychiatric spheres [6]. Comparison of morphological and pathogenetic features of different types of esophageal atresia with clinical symptoms makes it possible to purposefully approach each group of patients and individualize treatment taking into account potential risks. The presence or absence of concomitant malformations also plays an important role in the outcomes, especially in VACTERL syndrome, where, in addition to esophageal atresia, there may be a combination with abnormalities of the spine, heart, kidneys and limbs [2].

The relevance of the topic is supported by the fact that the improvement of surgical approaches and neonatal intensive care has led to the emergence of an increasing number of children living to adulthood. Many of them face repeated reconstructive surgeries, long-term medical treatment, nutritional disorders and the need for special care in adolescence.

Meanwhile, systematic data on exactly what consequences can occur, how often they occur and what preventive measures are most effective are still underrepresented in the domestic and world literature. Therefore, a detailed study of the long-term results of surgical treatment of esophageal atresia has not only academic, but also significant practical interest for both pediatric surgeons and neonatologists, gastroenterologists, pulmonologists, rehabilitation specialists and other specialized experts.

Research materials and methods. The study is based on a retrospective and prospective evaluation of clinical data from 128 newborns diagnosed with esophageal atresia who were operated on in the pediatric surgery department of a specialized medical center from 2012 to 2024. The retrospective part includes patients who underwent surgery from 2012 to 2019, the prospective part includes patients who underwent surgery from 2020 to 2024.

The study did not include children born with extremely low body weight less than 1000 g and having severe comorbidities incompatible with life, as well as patients whose parents refused to participate in long-term follow-up.

The diagnosis was verified on the basis of the clinical picture, data from radiological methods of examination with contrast, as well as ultrasound and endoscopic examinations. If necessary, computed tomography of the chest organs was carried out to clarify the anatomical relationships and identify concomitant defects.

The preoperative management plan included correction of water-electrolyte disorders, prevention of aspiration complications, and stabilization of hemodynamics and advisory examinations of related specialists. Types of surgery were selected on the basis of the type of esophageal atresia, which was determined by Gross classification and refined according to preoperative diagnostics. The study took into account the features of operational equipment (open access or thoracoscopic

correction), the type of anesthesia, the presence of cardiac surgical risks and the severity of the child's condition at the time of the intervention according to the APGAR scale and a number of other indicators of neonatal status.

In the postoperative period, all children underwent intensive therapy and long-term follow-up, which included endoscopic monitoring of the esophagus, abdominal ultrasound, chest X-ray, if necessary, as well as consultations with a gastroenterologist, pulmonologist and pediatric surgeon. A single observational study was established to assess quality of life, functional outcomes, and incidence of complications. Both paper medical records and electronic medical records were used to analyze the data, which made it possible to collect detailed information about each patient.

Statistical processing included descriptive statistics, assessment of the distribution of signs, calculation of means and standard deviations, medians, as well as the use of multiple regression analysis methods to assess the impact of various factors on the outcome of the disease.

Student's, Mann-Whitney or ANOVA tests were used to test hypotheses of significant differences in group means depending on the nature of the distribution and the number of groups compared. Spearman and Pearson coefficients were used to calculate the correlation of complications and long-term outcomes. $P < 0.05$ was considered statistically significant.

All patients or their legal representatives signed an informed consent to participate in the study, which was conducted in compliance with ethical standards and principles consistent with the Declaration of Helsinki. The study protocol was approved by the institution's local ethics committee. Personal data was recorded anonymously, in accordance with the requirements of the current legislation.

2. RESULTS AND DISCUSSIONS OF THE STUDY.

In the study group, boys were 51%, girls - 49%. 25% of the sample (32 children) revealed concomitant congenital defects, which is consistent with world statistics on combined anomalies in esophageal atresia (VACTERL syndrome and other defects of the heart, spine and genitourinary system). The type of atresia according to the Gross classification was distributed as follows.

Table 1. Patient disposition by esophageal atresia type

Gross atresia type	Number of patients (n = 128)	Percentage of sample
I (without fistula)	9	7%
II (upper fistula)	5	4%
III A (lower fistula)	23	18%
III B (both fistulas)	70	55%
IV (other options)	21	16%

Drawing conclusions from the table, we can say the following. She demonstrates that the bulk (about 55%) of children have the most typical atresia variant (III B) when both proximal and distal fistulas are present. Fewer patients with other types confirm the overall clinical trend of one or two fistulas. The table helps to link the morphological features of the disease with surgical tactics: in the most common variant (III B), certain types of complications are more common, including failure of sutures in the fistula zone.

Most patients were operated on in the first 72 hours of life, which is an important factor in the success of treatment. In the early postoperative period, respiratory complications (pneumonia, bronchitis) remained the main problem, which indicated micro breathing or aspiration due to an unformed adequate anti-reflux barrier. About 12% of children needed repeated surgery in the next three months after discharge, mainly due to the formation of strictures or failure of stitches [7].

Catamnesis was carried out on average from 6 months to 12 years. Part of the data was obtained as a result of regular dispensary examinations, part - by purposefully calling the patient to the hospital or during outpatient consultations.

Table 2. Long-term health outcomes

Indicator	Value/Frequency
Body mass index (BMI) at 3-7 years of age	15.7 ± 2.1 kg/m ² (deficiency in 14% of children)

Strictures requiring bugging or re-operation	19%
Verified gastroesophageal reflux	23%
Recurrent bronchopulmonary disease	16%

A correlation was found between the presence of gastro esophageal reflux and the occurrence of strictures in the postoperative period. It turned out that in children whose parents reported regular episodes of regurgitation and heartburn, the likelihood of repeated interventions for esophageal strictures was statistically higher compared to those patients whose reflux was not diagnosed or manifested in a mild form ($p < 0.05$). An important factor in long-term prognosis was active and timely rehabilitation, including dietary correction, drug therapy with anti-reflux drugs, and endoscopic observation. In patients who consistently followed the recommendations on nutrition, feeding regimen, as well as in those who underwent regular physiotherapy courses, the number of complications was lower [2].

Significant attention in the study was paid to the assessment of psychomotor development and quality of life, which is often overlooked in the analysis of purely surgical outcomes. Parents reported some difficulties in shaping the eating behavior of children associated with unpleasant memories of pain when solid food passes through the narrowed lumen of the esophagus.

These data are illustrated in Figure 1, which schematically represents the main factors influencing the process of food behavior formation.

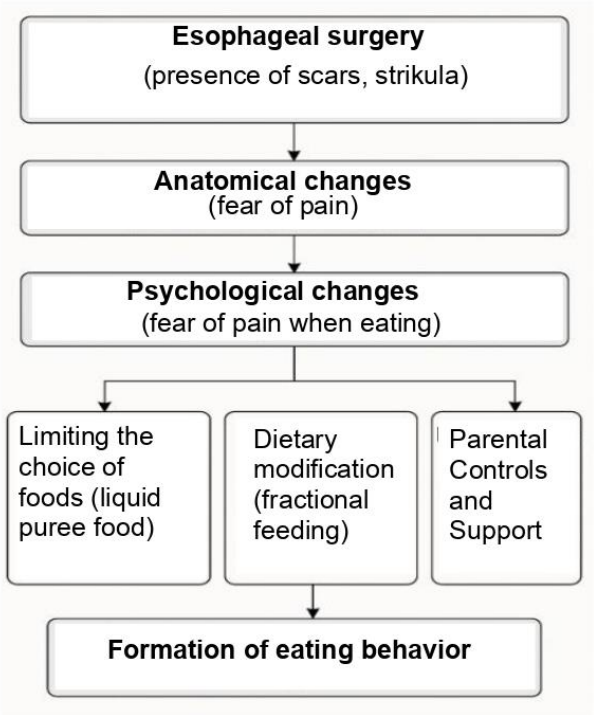

Figure 1. Diagram of factors influencing the formation of eating behavior in children with esophageal atresia (description)

The scheme includes the interaction of the anatomical features of the esophagus after surgical correction, psychological factors (fear of pain), social support (parental control, psychological consultations) and external circumstances (the need for special diets, regular medical procedures). The representation in the form of a diagram shows how each of these factors together forms the child's attitude to eating, affects his appetite and choice of foods [1].

In addition to nutritional disorders, some children had recurrent episodes of respiratory diseases, including pneumonia and bronchitis, associated with potential aspiration or micro breathing of the contents of the esophagus with motor disorders. These data confirm the importance of dynamic observation of the pulmonologist and early diagnosis of respiratory complications [10].

Figure 2 shows a simplified diagram of the pathogenetic mechanisms underlying respiratory complications in the presence

of gastro esophageal reflux and esophageal motility disorders.

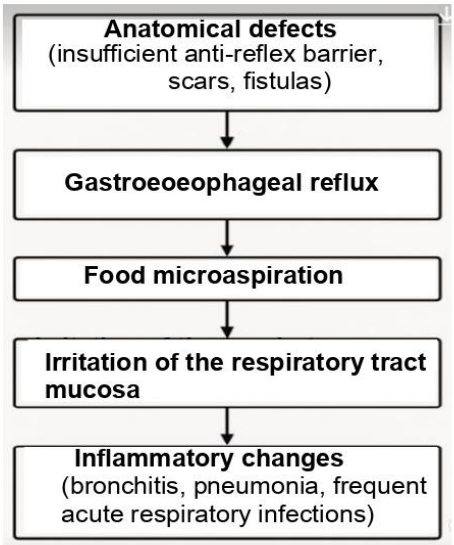

Figure 2. Scheme of pathogenesis of respiratory complications (description):

The scheme reflects anatomical prerequisites (shortened esophagus, the presence of fistula remnants, failure of the sphincter apparatus), functional disorders (weakened peristalsis), leading to the ingress of acidic gastric contents into the lower respiratory tract, as well as systemic factors (reduced immunity, concomitant malformations). The diagram visualizes the relationship between reflux episodes, micro aspiration and inflammatory changes in the bronchi and lungs.

A separate area of research was the assessment of differences in the long-term period in children who underwent the traditional open method of surgical correction and in those who underwent thoracoscopy [4]. The analysis showed a tendency towards fewer adhesions in the chest cavity and less severity of postoperative pain syndrome in patients from the thoracoscopic group, but a statistically significant difference in the incidence of late complications, such as strictures, reflux and eating disorders, was not recorded ($p > 0.05$).

Table 3 shows comparative indicators for the sample of children, taking into account the type of operation.

Table 3. Comparison of long-term results in open and thoracoscopic access

Parameter	Open access (n = 67)	Thoracoscopy (n = 28)	p-value
Average operation time, min	120 ± 35	180 ± 45	<0,05
Distant stricture frequency	18%	20%	>0,05
Signs of GER in patients older than 3 years	22%	25%	>0,05
Recurrent bronchitis/pneumonia	14%	15%	>0,05
Postoperative pain syndrome (parental assessment)	Moderate severity	Light/medium	<0,05

Thus, the choice of surgical technique was determined mainly by the initial condition of the child, the experience of the surgeon and the availability of technical equipment. The minimally invasive technique is potentially better tolerated by the child and provides an indirect reduction in the risk of adhesion disease, but does not provide a radical advantage in relation to late complications associated with the features of the pathology itself [10].

Discussing the results obtained, it can be stated that the long-term outcomes of surgical treatment of esophageal atresia are largely determined by comprehensive rehabilitation and observation by specialized specialists. The risk of severe strictures and respiratory complications remains noticeable even several years after surgery, and problems with eating behavior can have a negative impact on the overall development of the child [7].

By analyzing the entire data set, three key factors can be identified that determine a good forecast.

Firstly, early surgical correction using optimal methods of anesthesia and high-quality neonatal resuscitation gives the highest possible survival rate and reduces the risk of gross anatomical disorders.

Second, comprehensive multidisciplinary follow-up includes gastroenterological and pulmonological control, regular endoscopic examinations, and correction of emerging nutritional disorders.

Thirdly, long-term psychological support and work with the family form a positive attitude towards medical procedures in the child, which significantly reduces the risk of social maladjustment.

The combination of these approaches can significantly improve long-term results and minimize the risk of severe complications during adulthood.

3. CONCLUSIONS

The study demonstrated that the long-term outcomes of surgical treatment of esophageal atresia in newborns directly depend on the timeliness of surgical correction, adequate neonatal support, a multidisciplinary approach to rehabilitation and careful monitoring of potential complications. A high level of success of the operation in the acute period does not guarantee the absence of problems in the long term. Common complications include strictures, gastro esophageal reflux and respiratory diseases that can manifest themselves at different stages of child development.

The use of minimally invasive methods can reduce the trauma of the intervention and improve early postoperative indicators, however, prolonged catamnesis did not reveal significant differences in the structure of late complications between open and thoracoscopic access. The key factors in the prevention of severe consequences are regular endoscopic examinations, timely correction of anatomical disorders, individualized nutrition and targeted psychological support for the child and his family.

The data obtained indicate the need for long-term follow-up of patients who underwent surgical treatment of esophageal atresia. Early diagnosis and correction of emerging problems can reduce the frequency of repeated interventions and ensure more complete development of children, including successful adaptation in society and school.

The development of uniform national surveillance protocols, including regular assessment of the digestive and respiratory systems, as well as mandatory quality of life testing, seems extremely important to reduce the burden of the disease and improve prognostic indicators

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