https://doi.org/10.56871/PED.2025.65.59.005 UDC 616.37-007.43+616.329-002+616.1-089.844

Surgical treatment of types II–IV hiatal hernias: causes of failures and approaches to coping

Stanislav A. Skriabin[1, 2], Maria V. Korelskaya[1], Aram A. Manucharov[1, 2], Dmitrii I. Vasilevskii[3], Aida D. Baisekeyeva[3]

[1] Murmansk Regional Hospital by P.A. Bayandin, Murmansk, Russia
[2] Murmansk Arctic University, Murmansk, Russia
[3] Pavlov First Saint Petersburg State Medical University, Saint Petersburg, Russia

ABSTRACT

The review based on the analysis of domestic and foreign literature systematizes the causes and possible solutions to the problems of surgical treatment of hiatal hernias of types II–IV. Hiatal hernias of types II–IV are understood as diaphragmatic hernias, in which there is a displacement of abdominal organs into the mediastinum through the hiatus esophageus of the diaphragm parallel to the esophagus without or together with it (paraesophageal component), which is an absolute indication for surgical treatment, since it has anatomical features for the occurrence of life-threatening conditions (acute intestinal or gastric, esophageal obstruction, strangulation and further necrosis of organs located in the hernial sac). The mechanisms of development of this type of hernia are numerous and varied, caused by a whole complex of simultaneously or sequentially acting reasons, which should be taken into account in the subsequent choice of the method of surgical intervention. This approach minimizes the likelihood of surgical failures, relapses of hernias. The variety of types of hiatal hernias determines a large number of surgical interventions, types of modifications of individual surgical techniques, additional ways to improve the reliability of surgical treatment (hiatoplasty, including using various implants and fundoplication). A wide variety of surgical modifications and methods, absence a single tactic of surgical "action" in various anatomical situations, accordingly, increases the frequency of possible failures of surgical treatment.

Keywords: esophageal hernia, gastroesophageal reflux disease, diaphragmatic plastic surgery, crurorаphy, fundoplication

To cite this article
Skriabin S.A., Korelskaya M.V., Manucharov A.A., Vasilevskii D.I., Baisekeyeva A.D. Surgical treatment of types II–IV hiatal hernias: causes of failures and approaches to coping. *Pediatrician (St. Petersburg).* 2025;16(3):45–54. https://doi.org/10.56871/PED.2025.65.59.005

Submitted: 10.07.2025 **Accepted: 26.08.2025** **Published online: 30.09.2025**

ISSN 2587-6252 (Online)

https://doi.org/10.56871/PED.2025.65.59.005 УДК 616.37-007.43+616.329-002+616.1-089.844

Анализ причин неудач хирургического лечения хиатальных грыж II–IV типов и пути их преодоления

С.А. Скрябин[1, 2], М.В. Корельская[1], А.А. Манучаров[1, 2], Д.И. Василевский[3], А.Д. Байсекеева[3]

[1] Мурманская областная клиническая больница им. П.А. Баяндина, Мурманск, Россия
[2] Мурманский арктический университет, г. Мурманск, Россия
[3] Первый Санкт-Петербургский государственный медицинский университет имени акад. И.П. Павлова, Санкт-Петербург, Россия

АННОТАЦИЯ

В обзоре анализируются работы отечественных и зарубежных авторов с систематизацией причин и возможных путей решения проблем хирургического лечения хиатальных грыж II–IV типов. Под хиатальными грыжами II–IV типов понимаются диафрагмальные грыжи, при которых происходит смещение органов брюшной полости в средостение через хиатальное отверстие диафрагмы параллельно пищеводу без или вместе с ним (параэзофагеальный компонент), что является абсолютным показанием к хирургическому лечению из-за анатомических особенностей, способных привести к возникновению жизнеугрожающих состояний (острой кишечной или желудочной, пищеводной непроходимости, ущемления и дальнейшего некроза находящихся в грыжевом мешке органов). Механизмы развития данного вида грыж многочисленны и разнообразны, обусловлены целым комплексом одновременно или последовательно действующих причин, которые следует учитывать в дальнейшем выборе метода хирургического вмешательства, которое может минимизировать вероятность хирургических неудач, рецидивов грыж. Разнообразие видов хиатальных грыж определяет большое количество хирургических вмешательств, разновидностей модификаций отдельных хирургических техник, дополнительных путей улучшения надежности хирургического лечения (хиатопластики, в том числе с использованием различных имплантатов, фундопликации). Большое разнообразие хирургических модификаций и методов, отсутствие единой тактики хирургического «действия» при различных анатомических вариантах, соответственно, увеличивает частоту возможных неудач хирургического лечения.

Ключевые слова: грыжа пищеводного отверстия диафрагмы, гастроэзофагеальная рефлюксная болезнь, пластика диафрагмы, крурорафия, фундопликация

Для цитирования:
Скрябин С.А., Корельская М.В., Манучаров А.А., Василевский Д.И., Байсекеева А.Д. Анализ причин неудач хирургического лечения хиатальных грыж II–IV типов и пути их преодоления. *Педиатр*. 2025;16(3):45–54. https://doi.org/10.56871/PED.2025.65.59.005

Рукопись получена: 10.07.2025 **Рукопись одобрена: 26.08.2025** **Опубликована online: 30.09.2025**

ISSN 2079-7850 (Print)

Based on the specific anatomical defects, four types of hiatal hernias are recognized, encompassing all possible variants of the occurring changes [6, 22].

Type I is a sliding (axial) hiatal hernia, characterized by the axial displacement of the abdominal esophagus and the gastroesophageal junction (and potentially other parts of the stomach) into the thoracic cavity, most commonly into the posterior mediastinum. This type of displacement lacks a peritoneal sac and is typically sliding. Type I hiatal hernias account for 90–95% of all hiatal hernias [6, 22].

Type II is a paraesophageal hiatal hernia, which involves displacement of the gastric fundus (or less frequently, other parts of the stomach) into the mediastinum through the diaphragmatic hiatus alongside the esophagus. In this type, the gastroesophageal junction maintains its normal abdominal position. These hernias always have a peritoneal (hernial) sac and constitute approximately 1% of cases [6, 22].

Type III is a mixed hiatal hernia, combining the anatomical alterations of the first two types: axial displacement of the gastroesophageal junction and paraesophageal displacement of other parts of the stomach into the thoracic cavity. They always possess a hernial sac, with a reported incidence of 5–8% [1, 22].

Overall, hiatal hernias of types II–III account for only 5–10% of all cases, with mixed (type III) hernias being the most prevalent among them, representing up to 90% of these cases.

Type IV hiatal hernias are characterized by the displacement of abdominal organs other than the stomach (such as the small or large intestine, omentum, spleen, or liver) into the mediastinum through the hiatal orifice, as well as organs of the retroperitoneal space (e.g., the left kidney or pancreas) [1, 22]. This type is quite rare, constituting up to 1% of cases.

The presence of a paraesophageal component, which is characteristic of types II–IV hiatal hernias and involves displacement of abdominal organs into the mediastinum alongside the esophagus, represents an absolute indication for surgical treatment. This indication is due to the anatomical predisposition of these hernias for life-threatening conditions, such as acute intestinal, gastric, or esophageal obstruction, strangulation, and subsequent necrosis of organs within the hernial sac [1, 2, 12, 20, 24]. The pathogenesis of these hernias is multifactorial and diverse, resulting from a complex of simultaneously or sequentially acting causes that must be considered when selecting a surgical approach [1, 3, 5, 11, 15].

Hiatal hernias of types II–IV are predominantly acquired conditions. The development of this pathology is caused by structural degradation of connective tissue fibers (elastin) in the phrenoesophageal ligament, weakening of the ligamentous apparatus of the stomach and other organs, and general weakness of the visceral ligaments [6, 7, 14]. The occurrence of acquired hernias is associated with involutional anatomical changes in the tissues forming the esophageal hiatus [1, 2, 20, 24], as well as a range of additional factors. These contributing factors include pulmonary emphysema affecting diaphragmatic descent [13, 20] and age-related involution of the diaphragm alongside the development of atherosclerosis [13, 17, 20]. Furthermore, key anatomical alterations involve relaxation of the esophageal fascial connections and stretching of the phrenoesophageal ligament [2, 6, 7, 13, 17, 20], as well as reduction or absence of the subdiaphragmatic fat ring surrounding the esophagus. Another significant factor is atrophy of the left hepatic lobe with disappearance of the subdiaphragmatic adipose tissue, which disrupts organ relationships in the hiatal region [7, 13, 17, 20, 24]. Finally, a constitutional predisposition is evidenced by connective tissue weakness, frequently associated with hernias of other localizations, flatfoot, and varicose veins of the subcutaneous and hemorrhoidal plexuses [1, 24].

The development of hiatal hernias is initiated by the pressure gradient between the thoracic and abdominal cavities, specifically its increase due to elevated intra-abdominal pressure. Conditions that lead to increased intra-abdominal pressure include obesity, coughing, overeating, constipation, flatulence, ascites, large intra-abdominal tumors, pregnancy, heavy lifting, and sudden abdominal straining, among others [1, 24].

Another significant group of causes comprises recurrent longitudinal spastic shortening of the esophagus, esophageal dyskinesias, and reflex or symptomatic esophagospasms — a common condition that develops secondary to various pathologies of the esophagus, gastrointestinal tract, gallbladder, cervical and thoracic spine, and other organs. Therefore, a subset of hiatal hernias should be considered secondary to other diseases affecting the vagus nerve innervation zone, which explains their frequent co-occurrence with peptic ulcer disease, cholelithiasis, cholecystitis, and other disorders involving digestive tract dyskinesia [24].

Surgical management of types II–IV hiatal hernias is almost invariably technically challenging. It necessitates fulfilling several essential conditions to prevent postoperative complications and adhering to a consistent surgical principle [14, 22]. These procedures, often referred to collectively as diaphragmatic plastic surgery, encompass both hiatoplasty (repair of the hiatus) and fundoplication (antireflux component). To date, no clear, definitive indications exist for selecting a specific surgical approach for these hernias, the type of fundoplication, or the technical details of hiatal repair in various clinical scenarios [4, 22].

The mandatory requirements for the surgical procedure are:

- adequate mobilization and excision of all elements of the hernial sac;

- mobilization of the anatomical structures surrounding the hernial sac to ensure proper visualization and mobilization of the esophagus thereby reducing the risk of iatrogenic injury — failure to achieve this significantly increases the risk of recurrence and hinders the creation of a competent fundoplication wrap [4, 11];
- restoration of the natural anatomy among the esophagus, stomach (or other organs), and the diaphragm;
- reduction of the stomach and abdominal segment of the esophagus (or other organs) into the abdominal cavity;
- calibration of the hiatal opening;
- performance of the antireflux component — fundoplication [6, 7, 22].

The choice of both the reconstruction technique for the esophagogastric junction and the type of fundoplication in types II–IV hiatal hernias depends on esophageal length, the integrity of the hiatal crura, and the size of the hiatal opening [5–7].

The incidence of complications directly related to the surgical repair is relatively low, approximately 1%, with a mortality rate of 0–0.1% [22]. However, the long-term recurrence rate of hiatal hernias is substantial, ranging from 10–15% to 30–40%, and reaching up to 60% in some studies [11, 22]. The causes of failed surgical repair can be broadly categorized into several groups. The first group encompasses technical errors in performing the operation, while the second involves insufficiently appreciated anatomical variations and physiological characteristics of the diaphragm, esophagus, and stomach that necessitate a specific, tailored surgical strategy [4, 25].

Common errors during the reconstructive phase include the use of absorbable suture material for hiatal closure; inadequate, superficial incorporation of the diaphragmatic crura tissue in sutures; and leaving an excessively large hiatal opening [4, 22].

Highly significant causes of failed surgical repair of hiatal hernias are related to patient behavior in the early postoperative period. Due to intense pain, coughing, vomiting, and excessive physical activity, the mechanical stress on the tissues increases substantially. This leads to suture cut-through before the formation of strong connective tissue adhesions, as well as dislocation of a prosthetic mesh (if one was placed) and early re-herniation of the stomach into the mediastinum [6, 22].

Excess body weight is also considered an unfavorable prognostic factor for long-term outcomes in this surgical field, necessitating adequate patient selection and preoperative preparation, along with a careful choice of surgical strategy [22].

Many authors regard large hiatal hernia size as one of the significant factors for recurrence. The significant tension on the sutures during approximation of the muscular crura in cases of substantial diastasis, and the excessive strain on the tissues in the suture area, lead to gradual suture cut-through and re-formation of the hernial orifice [6, 22]. Currently, there are no precise data indicating which dimensions of the esophageal hiatus — specifically, what excess size and in which measurement — should be considered a high risk for repair failure. Most researchers regard a threshold of 5 cm in any dimension as critical, but there is evidence from clinical and experimental studies suggesting an increased probability of recurrence with hiatal dimensions of 3.5 cm and even 2.5 cm [6, 22].

The mechanical weakness of the diaphragmatic crura — such as hypotrophy or fibrosis — is also regarded as a critical factor in the failure of crural repair. This is primarily due to the lack of objective criteria for intraoperative assessment of the crura's mechanical integrity, which necessitates reliance on the surgeon's subjective judgment and experience [4, 6, 22].

Several key physiological factors significantly increase the mechanical stress on the reconstructed hiatus: the constant motion of the crura during respiration, esophageal peristalsis, and the propulsive wave of food bolus transport, the latter causing brief, subtle, but frequently repeated changes in esophageal length. Furthermore, the unique anatomy of the esophageal hiatus, which functions as a muscular loop, results in force application along at least three distinct vectors during its constriction and relaxation, rather than a single one. This multidirectional stress substantially compromises the durability of the hiatal repair [6, 22].

Finally, inadequate repair of a large hiatal defect (greater than 5–7 cm) leads to a high rate of gastric re-herniation into the thoracic cavity, accounting for failed surgical outcomes in 40–50% of types II–III hiatal hernia cases [7, 8, 19].

The use of prosthetic materials for hiatal repair has become increasingly common [8].

Nevertheless, several key aspects remain debated, including the criteria for utilizing a mesh graft to reinforce the crural repair, the definition of clear indications for its application, and the optimal surgical technique and methodology for its placement [8, 22, 25].

While persistent concerns exist about frequent complications associated with mesh hiatoplasty for types II–IV hiatal hernias, there is also considerable evidence highlighting a high rate of recurrence and postoperative complications when mesh prostheses are not used [2, 4, 7, 8]. Consequently, the choice of material and technique for closing the hernial defect remains a subject of ongoing discussion.

Various approaches to selecting the appropriate mesh material for hiatoplasty continue to be actively investigated [9, 10].

Polypropylene mesh implants (e.g., Prolene, Ethicon) provide superior tensile strength and facilitate the

formation of robust, reliable scar tissue. Despite these advantages, reported anatomical recurrence rates following their use demonstrate considerable variation, ranging from 0.8% in some series to 22.7% in others [9, 10]. In early postoperative follow-up within the first year, anatomical recurrences have been observed in 8.0% of cases [9, 10]. Specifically, the recurrence rate was 1.8% after onlay mesh repair compared to 2.4% after inlay technique [9, 10]. A primary disadvantage of these meshes is their excessive rigidity. When placed in close proximity to the esophagus, they can provoke significant periesophageal fibrosis. This may result in prolonged dysphagia (lasting more than three months) without overt stricture formation, or in the development of fibrotic strictures, esophageal erosion, and mesh migration into the esophageal lumen. Each of these complications carries a risk of implant infection, which can progress to abscess formation [8]. A further drawback is the potential for mesh shrinkage, with a volume reduction of 15.0–20.0% over time. When a mesh is positioned circumferentially around the esophagus, this contraction significantly increases the risk of the aforementioned complications [9]. The incidence of dysphagia one year postoperatively with these implants stands at 4.0% [9, 10].

Polytetrafluoroethylene (PTFE) implants, such as DualMesh and Gore, are composite prostheses comprising two layers: a base of either polypropylene or polyester and an anti-adhesive PTFE layer. This PTFE component is specifically designed to prevent adhesion formation and subsequent scarring upon contact with abdominal viscera. Originally developed for laparoscopic intraperitoneal ventral hernia repair, these meshes are now also employed in the reconstruction of large and giant hiatal hernias, predominantly via the onlay technique. It is estimated that between 23% and 30.7% of surgeons utilize these prostheses in such procedures [8, 14]. Study data indicate anatomical recurrence rates ranging from 2.2% to 5.7% with their use [9, 10, 14]. A significant limitation, however, is their considerable rigidity and thickness, which can predispose patients to postoperative complications. The reported incidence of cicatricial esophageal strictures is 0.3%, while esophageal erosion occurs in 0.5% of cases [9]. When a mesh of this type is fixated circumferentially around the esophagus, the rate of dysphagia is 62.0% [9, 10]. In cases of giant hiatal hernias where an inlay repair technique was performed using Grurasoft and Bard (USA) meshes — which feature a soft, V-shaped anterior edge — long-term follow-up data (at an average of 16 months) showed anatomical recurrence rates of 1.9–4.7% and dysphagia rates of 24.0–38.0%.

Low-weight and absorbable mesh implants are currently regarded as the most promising category. Low-weight implants can be manufactured from non-absorbable fibers like polypropylene or polyester, featuring a specialized weave with large pores, as exemplified by Mersilene and Ethicon (USA) **polyester** meshes. Partially absorbable implants are composite by nature, meaning they consist of a combination of absorbable and non-absorbable fibers. For example, Ultrapro and Ethicon (USA) implants are composed of 50% polypropylene and 50% polyglecaprone. Such meshes are often considered optimal because they offer not only high tensile strength inherent to the polymer but also a low-weight structure — characterized by thin, soft fibers and large pores. Additionally, their partial absorption promotes the formation of pliable connective tissue scars and minimizes the risk of tissue erosion. Clinical experience with Ultrapro implants suggests that their favorable efficacy-safety profile is also attributable to the fixation method, specifically the original sublay repair technique [9, 10]. In the corresponding study, with a mean follow-up of 28 months (range 10–47 months), the symptomatic anatomical recurrence rate for large hernias was 4.9%, and the incidence of prolonged dysphagia was only 2.1%, with no observed cases of cicatricial strictures or esophageal erosion [9, 10]. When a different technique employing polyester mesh with cruroraphy was used, the symptomatic anatomical recurrence rate demonstrated a statistically significant advantage for mesh augmentation (1.4% vs. 7.4%), although detailed data on postoperative complications were not available in the abstract [8, 15, 23]. Other studies involving mesh repair with a mean follow-up of 34 months reported no anatomical recurrences, but a dysphagia rate of 11.0% was documented [15]. Results from further research on onlay repair with this implant (mean follow-up 26 months) revealed no cases of dysphagia, strictures, or erosion; however, recurrence rates reached 10–11% [15]. Regarding fully absorbable synthetic meshes, such as **polyglactin-based** Vicryl and Ethicon (USA), the potential for long-term mesh-related complications is virtually eliminated. Nonetheless, recurrences attributable to complete absorption are more frequent, with studies reporting anatomical recurrence rates of 9.5 to 18.5% at a mean follow-up of 30 months [23].

Acellular dermal matrix implants, such as Allograft and LifeCell (USA), possess all three advantages of the previously described meshes for preventing postoperative complications: anti-adhesive properties, a soft structure, and absorbability. The implantation technique reported in all literature sources is consistent—onlay repair reinforced with posterior cruroraphy. In patients with larger hiatal defects where this material was used, follow-up at an average of 18–20 months demonstrated anatomical recurrence rates of 3.6 to 8.8% and dysphagia rates of 1.8 to 4.3% [8]. However, data indicate insufficient long-term effectiveness of biological implants in preventing recurrences, with recurrence rates increasing with longer follow-up periods: at a mean follow-up of 43 months after surgical treatment, the hiatal hernia recurrence rate averaged 27.0%, requiring reoperation in most cases — up to 20% [21].

Prosthetic hiatal repair can be performed using four main techniques. The widespread onlay technique involves reinforcing the posterior crurorаphy by suturing a rectangular, triangular, or V-shaped mesh to both diaphragmatic crura after their approximation behind the esophagus. Postoperative follow-up at a mean of 17 months showed an anatomical recurrence rate of 18.0% [21, 27]. The advantage of this method is its superior recurrence prevention outcomes, as it is considered the most physiologically appropriate approach biomechanically. Its disadvantages include contact between the mesh's anterior edge and the esophagus, the development of postoperative complications (particularly when using a rigid polypropylene implant), and the inability to repair defects located anterior to the esophagus [8, 27].

The second common technique is inlay — a tension-free repair where a triangular-shaped implant is placed behind the esophagus between the diaphragmatic crura without suturing them. Its advantage is the capability to repair giant hiatal defects when atrophic and widely separated crura cannot be reliably approximated. The disadvantages of this repair include a greater potential for direct contact between the mesh's anterior edge and the esophagus compared to onlay; an increased recurrence risk due to the less durable single-layer reconstruction; and prolapse of the implant's free anterior edge. Therefore, the SAGES (Society of American Gastrointestinal and Endoscopic Surgeons) clinical guidelines for hiatal hernia management state that this technique should not be used [21, 27].

The third technique is a modification of the first one and involves onlay reinforcement of the crurorаphy using either a single square or round mesh with a keyhole-shaped opening around the esophagus, or separately sutured semicircular mesh segments positioned anterior and posterior to the esophagus. Its advantage is the ability to address defects both posterior and anterior to the esophagus, while its disadvantage is the higher frequency of postoperative complications due to circumferential contact between the implant and esophagus. According to observational data, the dysphagia rate was 62.0% [21, 27].

Another surgical technique is the sublay method — reinforcement of the posterior crurorаphy through two-layer mesh repair. In this approach, a triangular-shaped implant is sutured behind the esophagus to both diaphragmatic crura, which are then approximated to completely isolate the mesh from esophageal contact [16].

Unresolved issues in the surgical management of types II–IV hiatal hernias include the necessity of fundoplication and the selection of its type.

The procedure of choice is complete fundoplication, with its various modifications, particularly the classic Nissen fundoplication. This technique provides optimal control of gastroesophageal reflux and was first described in 1956 by one of the pioneers of antireflux surgery [12, 16].

The principle involves reinforcing the gastroesophageal junction with a circumferential gastric wrap that prevents spontaneous relaxation of the cardia and creates an additional high-pressure zone between the stomach and esophagus. The key element and distinctive feature of the Nissen fundoplication's valvular mechanism is the direct correlation between the wrap's compressive effect and intraluminal gastric pressure. This characteristic enables reliable control of disease manifestations even in cases of significant gastroduodenal hypertension, establishing it as the "gold standard" of surgical treatment [12]. A limitation of this complete fundoplication is that the rigid, tightly-fitted wrap may cause severe mechanical dysphagia in patients with impaired esophageal motility, restricting its routine application.

Another technical consideration involves esophageal rotation along the frontal axis when using the main part of the gastric fundus to create the posterior portion of the wrap. This occurs when the gastric fundus is insufficient for tension-free reconstruction or has limited mobility [6, 7, 12, 22].

When the gastric fundus measures less than 5 cm or has limited mobility, the modified Rossetti fundoplication is employed, where anterior and posterior parts of the wrap are formed from equal portions of the gastric fundus. If additional mobility is required to create a symmetrical wrap, the gastrosplenic ligament is mobilized with division of two to three upper short gastric vessels. This prevents esophageal rotation and helps minimize the risk of functional dysphagia [5–7, 12].

For patients with a small gastric fundus (less than 3 cm), fundoplication is performed using the Hill technique [18]. This procedure involves creating a 2.0–2.5 cm duplication plication along the right semi-circumference of the esophagogastric junction from its anterior and posterior walls. Using the same or separate sutures, this construction is then fixed to the pre-approximated diaphragmatic crura and the median arcuate ligament [5, 6, 18].

The Donahue fundoplication, introduced in 1977 and commonly known as the short floppy Nissen, was specifically developed to prevent postoperative dysphagia in patients with esophageal motility disorders. Unlike the classic Nissen technique, this «soft» circular reconstruction requires extensive mobilization of the gastric fundus with obligatory division of the short gastric vessels. The resulting short (2 cm) gastric wrap loosely encircles the esophagogastric junction without causing compression or obstructing food passage [5–7]. A relative drawback of this technique is the "delayed action" phenomenon, where the antireflux effect is only achieved under significant gastroduodenal hypertension. In cases of lower esophageal

sphincter incompetence with moderate increases in intraluminal gastric pressure, the risk of harmful content reflux into the esophagus remains.

The Toupet fundoplication, described in 1963, involves reinforcing the esophagogastric junction with a partial (270°) gastric wrap. Positioned posteriorly and along both lateral aspects of the esophagus, the wrap leaves the anterior esophageal surface free, thereby avoiding obstruction to food bolus transit. Simultaneously, this elastic framework created from the gastric fundus prevents excessive dilation of the cardiac sphincter and stretching of the abdominal esophagus [6, 7].

The Dor fundoplication, first described in 1962 as an adjunct to cardiomyotomy and subsequently modified, involves anterior displacement of the gastric fundus over the esophagogastric junction with fixation to the right wall of the abdominal esophagus. The antireflux mechanism of this procedure results from several factors: lengthening of the abdominal esophagus, recreation of the acute angle of His, and tensioning of the oblique muscle fibers of the cardiac sphincter through left-to-right fundic displacement. A similar valvular mechanism is achieved with the 90° Watson fundoplication during reconstruction of the esophagogastric junction [26].

Therefore, the main causes of failed surgical treatment for types II–IV hiatal hernias include violation of essential operative principles — specifically, inadequate mobilization of hernial sac structures and failure to restore normal anatomy — coupled with technical execution errors. Additionally, insufficient appreciation of anatomical variations in the diaphragm, esophagus, and stomach that demand specific surgical approaches (various hiatoplasty and fundoplication techniques) contributes to poor outcomes.

Overcoming these failures requires appropriate selection of safe prosthetic repair techniques for large and giant hiatal hernias, establishing clear indications for hiatal reconstruction (with careful material and technique selection) based on hernia size, and defining precise criteria for fundoplication choice. Further research in these areas, particularly the pursuit of surgical methods with unequivocally demonstrated efficacy and safety based on long-term treatment outcomes, will enable minimization of surgical failures for this condition.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

Funding source. This study was not supported by any external sources of funding.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

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AUTHORS INFO

* **Stanislav A. Skriabin**, thoracic surgeon, oncologist, Head of the Thoracic Surgery Department, Murmansk Regional Clinical Hospital by P.A. Bayandin; address: 6 Pavlova str., Murmansk, 183032, Russia; Associate Professor, Clinical Medicine Department, Murmansk Arctic University; address: 15, Kapitana Egorova str., Murmansk, 183038, Russia;
ORCID: 0009-0003-7801-4007; eLibrary SPIN: 8669-7786;
e-mail: stas911@mail.ru

Maria V. Korelskaya, thoracic surgeon, oncologist, resident of the Thoracic Surgery Department, Murmansk Regional Clinical Hospital by P.A. Bayandin, Murmansk, Russia;
e-mail: mary_cat06@mail.ru

Aram A. Manucharov, MD, PhD, surgeon, Deputy Chief Physician for Surgery, Murmansk Regional Clinical Hospital by P.A. Bayandin, Murmansk, Russia; Associate Professor of the Clinical Medicine Department, Murmansk Arctic University, Murmansk, Russia;
e-mail: manucharov@mokb51.ru

ОБ АВТОРАХ

*** Станислав Анатольевич Скрябин**, врач, торакальный хирург, онколог, заведующий отделением торакальной хирургии, ГОБУЗ «Мурманская областная клиническая больница им. П.А. Баяндина»; адрес: Россия, 183032, г. Мурманск, ул. Павлова, д. 6; доцент, кафедра клинической медицины, ФГАОУ ВО «Мурманский арктический университет»; адрес: Россия, 183038, г. Мурманск, ул. Капитана Егорова, д. 15; ORCID: 0009-0003-7801-4007;
eLibrary SPIN: 8669-7786; e-mail: stas911@mail.ru

Мария Владимировна Корельская, врач, торакальный хирург, онколог, ординатор отделения торакальной хирургии, ГОБУЗ «Мурманская областная клиническая больница им. П.А. Баяндина», г. Мурманск, Россия;
e-mail: mary_cat06@mail.ru

Арам Альбертович Манучаров, канд. мед. наук, врач, хирург, заместитель главного врача по хирургии ГОБУЗ «Мурманская областная клиническая больница им. П.А. Баяндина», г. Мурманск, Россия; доцент кафедры клинической медицины, ФГАОУ ВО «Мурманский арктический университет», г. Мурманск, Россия; e-mail: manucharov@mokb51.ru

AUTHORS INFO

Dmitrii I. Vasilevskii, MD, PhD, Dr Sci (Medicine), Professor, surgeon, Head of the Department of Surgical Diseases of the Dental Faculty named after prof. A.M. Ganichkin, Pavlov First Saint Petersburg State Medical University, Ministry of Health of the Russian Federation, Saint Petersburg, Russia; ORCID: 0000-0001-7283-079X; eLibrary SPIN: 7598-6339; e-mail: vasilevsky1969@gmail.ru.

Aida D. Baisekeyeva, Assistant of the Department of Clinical Anatomy and Operative Surgery by prof. M.G. Prives, Pavlov First Saint Petersburg State Medical University, Ministry of Health of the Russian Federation, Saint Petersburg, Russia; ORCID: 0009-0001-2928-7362; e-mail: aida.baysekeeva@gmail.com

ОБ АВТОРАХ

Дмитрий Игоревич Василевский, д-р мед. наук, профессор, врач, хирург, заведующий кафедрой хирургических болезней стоматологического факультета им. проф. А.М. Ганичкина, ФГБОУ ВО «Первый Санкт-Петербургский государственный медицинский университет имени акад. И.П. Павлова» Минздрава России, Санкт-Петербург, Россия; ORCID: 0000-0001-7283-079X; eLibrary SPIN: 7598-6339; e-mail: vasilevsky1969@gmail.ru

Аида Джолдошбековна Байсекеева, ассистент кафедры клинической анатомии и оперативной хирургии им. проф. М.Г. Привеса, ФГБОУ ВО «Первый Санкт-Петербургский государственный медицинский университет имени акад. И.П. Павлова», Санкт-Петербург, Россия; ORCID: 0009-0001-2928-7362; e-mail: aida.baysekeeva@gmail.com

* Автор, ответственный за переписку / Corresponding author