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# PERCUTANEOUS ENDOSCOPIC GASTROSTOMY IN PEDIATRICS. LITERATURE REVIEW

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**Abstract**

**Introduction**: Percutaneous endoscopic gastrostomy (PEG) is a common procedure performed worldwide in patients with a variety of comorbidities, with multiple indications. Although the procedure is considered generally safe, life-threatening complications can sometimes occur. The purpose of this review is to analyze endoscopic percutaneous access techniques and determine the frequency of associated complications.

**Methods**: analytical review of the literature on main complications associated with PEG in children. A literature search was conducted in PubMed, CyberLeninck, and Elibrary databases using the keywords “percutaneous endoscopic gastrostomy,” “complications,” and “children.” The depth of the search was 10 years.

**Results:** Thirteen articles with 2009 pediatric patients were analyzed. The most common PEG methods are Pull and Push. Pull method was performed in 29.9% of patients and Push method in 48.7%. In 21.4% of patients, the method of PEG was not specified in the publications. Dysphagia of neurologic origin was the main indication followed by the need for nutritional support in different diseases. A total of 1505 complications were reported, of which 1370 (91.0%) were minor complications and 135 (9.0%) were major complications. Hypergranulation was the most frequent minor complication, followed by leakage of gastric contents through the gastrostomy site, peristomal infections, dislocation and early exit of the gastrostomy tube. Among the serious complications, gastric heterotopia was the most frequent in one-stage Button PEG. Peritonitis, gastrointestinal bleeding, hidden bumper syndrome, gastrointestinal fistula and bowel obstruction were next in frequency. Perforation of esophagus, stomach and intestine occurred in 2 cases each. Fatal outcome was reported in 2 patients, the cause of death was sepsis after perforation of the esophagus and gastrointestinal fistula formation.

**Conclusion**: Children undergoing percutaneous endoscopic gastrostomy often have minor complications. PEG has a low incidence of major complications and mortality.

***Keywords:*** *children; complications; percutaneous endoscopic gastrostomy.*

***For citation:***

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**Резюме**

# ЧРЕСКОЖНАЯ ЭНДОСКОПИЧЕСКАЯ ГАСТРОСТОМИЯ В ПЕДИАТРИИ. ОБЗОР ЛИТЕРАТУРЫ

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**Введение:** Чрескожная эндоскопическая гастростомия (ЧЭГ) - распространенная процедура, проводимая во всем мире у пациентов с различными сопутствующими заболеваниями, с множеством показаний. Хотя процедура считается в целом безопасной, иногда могут возникнуть опасные для жизни осложнения. Целью данного обзора является анализ эндоскопических методов чрескожного доступа и определение частоты связанных с ними осложнений.

**Стратегия поиска:** аналитический обзор литературы по основным осложнениям, связанным с ЧЭГ у детей. Поиск литературы проведен в базах данных PubMed, КиберЛенинка и Elibrary с использованием ключевых слов «чрескожная/перкутанная эндоскопическая гастростомия», «осложнения» и «дети». Глубина поиска – 10 лет.

**Результаты:** Анализ охватил тринадцать научных работ, в которых участвовало 2009 детей. Самыми распространенными методами ЧЭГ являются Pull и Push. Метод вытягивани (Pull) выполнялся у 29,9% пациентов, метод проталкивания (Push) у 48,7%. У 21,4% пациентов метод ЧЭГ не указан в публикациях. Дисфагия неврологического происхождения была основным показанием, за которым следовала потребность в нутритивной поддержке при разных заболеваниях. Всего сообщено о 1505 осложнениях, из них 1370 (91,0%) – незначительные осложнения 135 (9,0%) – серьезные осложнения. Гипергрануляция была наиболее часто встречающимся незначительным осложнением, за ними следовали утечка желудочного содержимого через место наложения гастростомы, перистомальные инфекции, смещение и ранний выход гастростомической трубки. Среди серьезных осложнений гетеротопия желудка оказалась самым частым при проведении одноэтапной Button ЧЭГ. Далее по частоте распределились перитонит, кровотечения из ЖКТ, синдром скрытого бампера, гастрокишечнокожные свищи и непроходимость кишечника. Перфорация пищевода, желудка и кишечника встречались по 2 случая каждый. О летальном исходе сообщено у 2 пациентов, причина смерти была связана с сепсисом после перфорации пищевода и сформирования гастрокишечного свища.

**Заключение**: У детей, перенесших чрескожную эндоскопическую гастростому, часто возникают незначительные осложнения. ЧЭГ имеет низкую частоту серьезных осложнений и смертности.

***Ключевые слова:*** *дети; осложнения; чрескожная/перкутанная эндоскопическая гастростомия.*

***Для цитирования:***

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**Түйіндеме**

# ПЕДИАТРИЯДАҒЫ ПЕРКУТАНДЫ ЭНДОСКОПИЯЛЫҚ ГАСТРОСТОМИЯ. ӘДЕБИЕТТІК ШОЛУ

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**Кіріспе**: Перкутанды эндоскопиялық гастростомия (ПЭГ) - әртүрлі сырқаты бар науқастарға, әртүрлі көрсеткіштерге байланысты әлемде кеңінен орындалатын процедура. Процедура жалпы қауіпсіз деп саналғанымен, кейде өмірге қауіп төндіретін асқынуларға әкелуі мүмкін. Бұл шолудың мақсаты тері арқылы эндоскопиялық гастростомия әдістерін талдау және онымен байланысты асқынулардың жиілігін анықтау болып табылады.

**Әдістер**: Бұл зерттеуде балалардағы теріарқылы эндоскопиялық ассистенция арқылы гастростома орнатумен байланысты асқынулар бойынша әдебиет талданды. Әдебиет іздеуі PubMed, КиберЛенинка және Elibrary дерекқорларында жүргізілді, іздеу сөздері ретінде «теріарқылы/перкутанды эндоскопиялық гастростомия», «асқынулар» және «балалар» қолданылды. Іздеу тереңдігі – 10 жыл.

**Нәтижелер**: ізденіске сай 13 мақала таңдалып алынып, 2009 науқас бала мәліметтері талданды. Теріарқылы эндоскопиялық ассистенция арқылы гастростомия әдістерінің ең кең таралғандары Pull және Push болып табылады. Pull әдісі 29,9%, Push әдісі 48,7% науқаста қолданылды. 21,4% науқаста ПЭГ әдісі мақалаларда көрсетілмеген. Неврологиялық себептерге байланысты дисфагия, одан кейін әртүрлі сырқаттарға байланысты нутритивтік қолдау ПЭГ орнатудың негізгі көрсеткіштері болды. Мақалаларда 1505 асқыну туралы хабарланған, оның ішінде 1370 (91,0%) – жеңіл асқынулар, 135 (9,0%) – ауыр асқынулар. Гипергрануляция ең жиі кездескен жеңіл асқыну болды, одан кейін гастротүтікше орнатылған жерден асқазан ішіндегі сұйықтықтың ағуы, перистомалық инфекциялар, гастротүтікшенің орнынан ығысуы немесе ерте шығып кетуі байқалған. Ауыр асқынулардың арасында асқазан гетеротопиясы бірқадамды Button ПЭГ әдісінің ең жиі асқынуы болған. Одан кейінгі орындарда перитонит пен асқазан-ішек жолдарынан қан кетулері, жасырын бампер синдромы, асқазан-ішек-тері жыланкөздері және ішек өтпеушілігі орналасқан. Өңеш, асқазан және ішек перфорациясы әрқайсысы 2 науқаста кездескен. 2 науқаста өлім жағдайы хабарланған, өлім себебі өңеш перфорациясынан кейінгі сепсис пен гастроинтестинальды жыланкөздің қалыптасуы болған.

**Қорытынды**: Перкутанды эндоскопиялық гастростомия жасалған балаларда жеңіл асқынулар жиі кездеседі. Теріастылық эндоскопиялық ассистенция арқылы гастростомия ауыр асқынулар мен өлімнің төмен деңгейімен сипатталады.

***Түйінді сөздер:*** *балалар; асқынулар; теріарқылы эндоскопиялық ассистенция арқылы гастростомия.*

***Дәйексөз үшін:***

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***Introduction***

Nutritional deficiency in children associated with various diseases is a pressing problem in childhood and has been the subject of numerous foreign studies. The importance of this problem is due to its widespread prevalence, confirmed negative impact on the course of the underlying disease and the immune system, as well as the risk of developing infectious complications, prolonged hospital stays, and increased treatment costs [45,46]. Providing nutritional support plays a key role in the treatment of this category of patients. Temporary enteral nutrition can be provided via a nasogastric tube, but it needs to be replaced every four to six weeks. It is also important to note that nasogastric tubes can cause complications such as aspiration pneumonia, gastric ulcers, and bleeding [25,26]. If long-term enteral feeding is necessary, gastrostomy may be considered instead of a nasogastric tube [8,33]. Experts from the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) indicate that it is advisable to perform a gastrostomy if enteral feeding is expected to be necessary for more than three to six weeks [24].

According to ESPGHAN recommendations, gastrostomy is usually indicated for children with concomitant chronic nutritional needs, in whom oral intake is insufficient to maintain growth. Although the specific indications for gastrostomy are numerous and varied, the most common indications are related to insufficient oral fluid and nutrient intake and/or swallowing disorders in central nervous system disorders, either as the primary cause or in combination with chromosomal or metabolic disorders. In addition, renal disorders, congenital heart disease, cancer, chronic respiratory diseases such as cystic fibrosis, and gastrointestinal disorders such as Crohn's disease and intestinal failure may require feeding through a gastrostomy to correct nutritional deficiencies. Gastrostomy tubes are also placed for congenital or acquired conditions such as esophageal atresia and craniofacial surgery, when eating through the mouth may be anatomically difficult. Furthermore, they may be necessary for children who require nutritional restoration to achieve a recommended weight that is appropriate for certain surgical procedures, such as infants with congenital heart defects [22,24].

Gastrostomy is also sometimes indicated for children with unsafe swallowing, at risk of recurrent aspiration during oral feeding, and when gastric drainage and decompression are required in cases of anterior intestinal motility disorders. Another rare but recognized indication is the delivery of therapeutic formulas to patients with certain metabolic disorders, which are usually unpleasant to taste. It can also be offered to patients who require multiple medications due to diseases of other organs, to improve compliance and medication effectiveness [8,14,23,24].

The decision to perform a gastrostomy should be made on a case-by-case basis, taking into account the patient's needs, primary diagnosis, and life expectancy. The first gastrostomy was used to feed an adult with obstruction in the cardia or above. It was first proposed by Egeberg in 1837, but after numerous attempts and failures, it was only successfully performed in 1876 by Verneuil [12] using an open surgical method [40]. In pediatrics, this procedure was the main treatment for early-stage esophageal atresia, and the first successful results of treating these patients were reported in the works of Leven [32] and Ladd [31] in the early 1940s. In subsequent years, researchers expanded the surgical conditions for which open gastrostomy was performed.

Less invasive percutaneous endoscopic gastrostomy (PEG) was introduced in 1980 by *M.W. Gauderer et al.* [18]. The inspiration for the development of this procedure came from the glow in the stomach of a newborn baby undergoing endoscopy. The first PEG was performed in a pediatric operating room on June 12, 1979, at Cleveland University Hospital (USA) on a four-month-old child with insufficient oral intake of neurological etiology under sedation. During and after the operation, no complications were noted in the early period, but after three weeks, migration of the probe from the stomach was observed, associated with the use of a thin probe with a distal end in the form of a mushroom, as well as, most likely, the use of excessive force when pulling the anterior wall of the stomach to the anterior abdominal wall. The author subsequently improved the probe by adding an internal limiter and avoiding excessive pressure on the tissue between the internal and external limiters, using thicker probes [19]. In subsequent years, PEG became a popular method of enteral nutrition among adults as well. In 2001, 20 years after its invention, more than 216,000 operations were performed annually in the United States [20]. Later, gastrostomy began to be used for non-surgical indications, for example, to meet the nutritional needs of patients with severe neurological disorders and developmental delays.

PEG has become widely used by both adult and pediatric physicians to provide enteral nutritional support to patients who, despite maintaining gastrointestinal absorption and motility functions, are unable to consume solid or liquid food due to various diseases. Due to its effectiveness, safety, ease of use, and relatively low cost, PEG has become an increasingly popular method. Compared to open gastrostomy, PEG is easily performed by experienced endoscopists. The success rate of tube placement is 99.5%, with a mortality rate of 0.5% to 2% [27,39]. A PEG tube can remain in place for at least six months.

Although the placement of a percutaneous endoscopic gastrostomy (PEG) tube is a minimally invasive procedure, like any surgical intervention, it carries a risk of complications [34]. ESPGHAN suggests classifying complications by severity (minor and major complications) or by time of occurrence (early or late postoperative). Early complications include bleeding associated with endoscopy, damage to internal organs (colon and small intestine, in rare cases - liver and spleen damage), pneumoperitoneum, cellulitis, and minor wound infections.

Late complications include: impaired wound healing (granulation, peristomal infection, edge separation), intraperitoneal leakage of gastric contents, gastric perforation, transhepatic and transpancreatic placement, incorrect placement of the gastrostomy tube in the abdominal wall, aspiration pneumonia, exacerbation of GERD, postpyloric migration with possible dumping syndrome, mucosal damage, ulceration, luminal obstruction, pancreatitis, hidden bumper syndrome, mechanical problems with the tube: displacement, clogging, porosity, kinking or fracture, gastric paresis [24].

**The aim** is to analyze endoscopic methods of percutaneous access and determine the frequency of associated complications.

***Search strategy***

For the literature review, the first step was to select keywords: "percutaneous endoscopic gastrostomy," "children," "complications." Based on the keywords, a literature search was conducted to identify articles published in the PubMed, CyberLeninka, and Elibrary databases. The search covered a period of 10 years.

Only original full-text articles reporting the results of observational studies involving children under the age of 18 were included. Reviews, meta-analyses, systematic reviews, editorial articles, letters, lecture notes, and clinical case reports were excluded. In the first stage of the literature search, articles were selected based on their titles and abstracts. The full texts were then analyzed to select articles for inclusion. In accordance with our objective, a total of 13 publications were selected for analysis, containing data on 2,009 patients.

**Search results**

Methods of performing the PEG procedure:

In the PEG surgical technique, there are two fundamentally different ways of performing the procedure: "pull" and "push."

The pull technique according to Gauderer–Ponsky is the most commonly used in modern practice. The site for gastrostomy insertion is determined using a transabdominal impulse/finger pressure and transillumination on the anterior abdominal wall. Local anesthesia is administered into the abdominal wall and skin.

The puncture cannula is inserted through the anterior abdominal wall into the stomach cavity under endoscopic guidance, while the stomach is distended to ensure that the stomach wall is opposed to the abdominal wall. The needle is removed from the cannula and an introducer containing a double thread is inserted through the cannula. The thread is pushed through the cannula until it is visible endoscopically in the stomach cavity. The thread is then grasped and secured through the endoscope using forceps. The endoscope with biopsy forceps/clips and the attached thread is pulled out through the mouth as a single unit. The thread is then connected to the PEG, the PEG is lubricated, and the guide thread, which has been brought out through the abdominal wall, is pulled through the cannula while the PEG is pulled through the mouth, esophagus, and into the stomach. The PEG tube is pulled through the abdominal wall, with the inner disc fitting snugly against the stomach lining. Finally, the PEG is secured to the anterior abdominal wall by adjusting the external bumpers that come with the gastrostomy device used [10].

The "from oneself" or push technique according to the Sacks–Vine method was proposed in 1983 by V.A. Sacks and others [13]. Under endoscopic control, gastropexy is performed using a one-step fixator with three fixators. The puncture site is determined in the center of the gastropexy, and a trocar is inserted into the stomach lumen under the direct supervision of an endoscopist. A guidewire is passed through the trocar, which is then used to insert the dilator. After sequential dilation of the future gastrostomy, a feeding tube is inserted into the stomach and the dilator is removed. The balloon is inflated [29].

The introducer insertion technique is a modified push technique using an introducer, proposed in 1984 by T.R. Russell and co-authors, developed on the basis of the Seldinger technique used to insert a subclavian catheter into the central vein [38]. The technique is performed by inserting a gastric tube through a transcutaneous puncture to avoid passing it through the mouth. Long curved needles are used to place two parallel sutures during gastropexy under gastroscopic control.

These sutures secure the front wall of the stomach. A metal trocar designed for PEG is inserted through a percutaneous incision. The membrane is removed and the balloon with the gastric tube is inflated. This method prevents peristomal infections and implantation of tumors in the pharynx and esophagus [9,11,15].

Image-guided technique – PEG is performed under visual control using fluoroscopy in two projections. It was first described in 1981 by R.V. Preshaw [37]. An oral suspension of barium sulfate is administered to the patient on the eve of the procedure to localize the colon. Ultrasound is used to visualize the liver. The loop is inserted through the mouth, and the guidewire is inserted into the stomach under fluoroscopic guidance and removed through the mouth. The mesh catheter is pulled retrograde from the abdominal wall to the mouth, and then the PEG is pulled through the esophagus [9,35]. Similar methods have been described using computed tomography, but these techniques have not found widespread use in practice [6].

Laparoscopically assisted CHG insertion – this procedure requires both endoscopic and laparoscopic techniques, so both an endoscopist and a pediatric surgeon are needed. A 5-millimeter optical tube for the laparoscope is inserted through the navel. The procedure requires both endoscopic and laparoscopic techniques, so both an endoscopist and a pediatric surgeon are needed. A 5-millimeter optical tube for the laparoscope is inserted through the navel. A pneumoperitoneum at a pressure of 8-12 mmHg is recommended. At the same time, gastroscopy and visualization of the stomach lumen are performed. After purging the stomach, the optimal location for the gastrostomy is selected by external finger pressure and direct visualization. Gastropexy is performed using 3 fixators, a needle is inserted into the stomach lumen, through which a guide wire is passed, which is then used to guide the dilator. After sequential expansion of the canal, the GT is inserted, the balloon is inflated, and the tube is fixed to the skin at the appropriate length. The gastrostomy is performed under direct laparoscopic and endoscopic visualization [9,10,44,47].

Researchers continued to work on improving techniques, and in 1984, *M.W. Gauderer and J.L. Ponsky* proposed a device to prevent gastric contents from leaking during the pull method, which was called the "gastric button" [19]. In 1993*, D.R. Ferguson et al.* reported on the use of the "one-step button" device, which is a "gastric button" and is initially installed during PEG [6,16]. A modification of this device is the low-profile gastrostomy tube, which is used in practice.

There are two main types of gastrostomy tubes: standard gastrostomy tubes and low-profile gastrostomy tubes. A standard gastrostomy tube is a long silicone tube.

The distal end of the gastrostomy tube, located in the lumen of the stomach after insertion, has a wide disc-shaped funnel-shaped extension called an internal bumper. When traction is applied, it ensures close contact between the stomach wall and the peritoneum of the anterior abdominal wall. To ensure constant tight contact between the bumper and the outer part of the abdominal wall, a disc-shaped device similar in structure, called an anti-bumper, is mounted on the gastrostomy. The stable position of the gastrostomy is ensured by compression of the tissues in the area where the gastrostomy tube passes through the thickness of the anterior abdominal wall using an anti-bumper, which is fixed with removable plastic clips [3].

Low-profile gastrostomy tubes are individually selected in size depending on the thickness of the anterior abdominal wall. The gastrostomy tube is fixed by carefully selecting its length during installation and inflating the internal balloon, which resembles a Foley catheter device. The outer part of the tube is equipped with a lock, which allows for the airtight connection of standard enteral feeding systems during feeding.

Between feedings, the external opening in the gastrostomy tube is closed [3]. A low-profile gastrostomy has a number of advantages. Due to its small size, the external part of the gastrostomy practically does not protrude above the surface of the body and is invisible under clothing, thereby improving the quality of life for pediatric and adult patients who lead an active lifestyle.

***Results***

Table 1 lists the publications included in this literature review. The most common methods are Pull and Push. The Pull method was performed in 587 (32.9%) patients, and the Push method in 908 (45.2%). In 441 (21.9%) patients, the PEG method was not specified in the publications.

*Table 1.*

**Publications analyzed in this literature review / Table 1. Publications analyzed in this literature review.**

| № | Authors, year of publication, reference to literature | Period analyzed | Number of patients | Technique TEG |
|---|---|---|---|---|
| 1 | Franco Neto J.A. et al .(2021) [17] | 2003-2018 | 152 | Pull – 140<br>Push - 12 |
| 2 | Szlagatys-Sidorkiewicz A. et al. (2015) [41] | 2000-2009 | 350 | PEG |
| 3 | Takalo M. et al. (2024) [43] | 2002-2020 | 217 | Push – 138<br>Pull - 79 |
| 4 | Gothberg G. et al. (2015) [21] | 2005-2012 | 168 | Pull |
| 5 | Jacob A., et al. (2015) [29] | 2007-2010 | 128 | Button peg - 73<br>Pull - 55 |
| 6 | Karaseva O.V. et al. (2016) [1] | 2010-2015 | 45 | Push |
| 7 | Shamanskaya T.V. et al. (2014) [7] | 2012-2014 | 9 | Push |
| 8 | Rachkov V.E. et al. (2015) [4] | 2014 | 20 | Push |
| 9 | Ryzhov E.A. et al. (2014) [5] | 2012013 | 7 | Pull |
| 10 | Lozovaya V.V. et al. (2024) [2] | 2022 | 13 | Pull – 8<br>Push - 5 |
| 11 | Özçelik Z. et al (2023) [36] | 2013-2020 | 130 | Pull |
| 12 | Jean-Bart C. (2022) [30] | 2009-2020 | 679 | Push |
| 13 | Işık I. et al. (2021) [28] | 2014-2019 | 91 | PEG |

In Table 2, patients are grouped according to the reasons for gastrostomy placement. We divided the reasons into four groups: neurological dysphagia, mechanical dysphagia, nutritional support, and gastric decompression.

*Table 2.*

**Distribution of patients by reasons for gastrostomy [1,2,4,5,7,17,21,28-30,36,41,43].**

| № | Causes | Numbers | % |
|---|---|---|---|
| 1 | Neurological dysphagia | 1264 | 62.9 |
| 2 | Need for nutritional supplements | 664 | 33.1 |
| 3 | Mechanical dysphagia | 79 | 3,9 |
| 4 | Gastric decompression | 2 | 0,1 |

The group with neurological dysphagia included patients with cerebral palsy, neuromuscular and genetic diseases, central nervous system disorders, and chronic neurological diseases. The group of patients requiring nutritional supplements consisted of patients with cancer, cystic fibrosis, chronic diseases of the gastrointestinal tract, heart, lungs, kidneys, immunodeficiency conditions, metabolic disorders, and palliative patients with various nosologies. The group with mechanical dysphagia included patients with neck lymphangioma, esophageal stricture, stomach and neck tumors, adenobuccal dystrophy, and ENT diseases. Patients with visceral myopathy formed a group with gastric decompression. In Table 3, we have grouped the complications mentioned in the publications under review that are associated with the placement of a pacemaker.

*Table 3.*

**Distribution of complications following CHD implantation [1,2,4,5,7,17,21,28-30,36,41,43].**

| Types of complications | Absolute quantity | % |
|---|---|---|
| Minor complications | | |
| Hypergranulation | 479 | 23,8 |
| Local peristomal infection | 220 | 10,9 |
| Leakage | 229 | 11.4 |
| Premature tube exit | 120 | 5,9 |
| Tube migration | 176 | 8,7 |
| Tube clogging and obstruction | 23 | 1,1 |
| Tube degradation | 28 | 1,2 |
| Pneumoperitoneum | 39 | 1,9 |
| Subcutaneous emphysema | 10 | 0,5 |
| Esophagitis | 4 | 0,2 |
| Ulcer | 7 | 0,4 |
| Others | 35 | 1,7 |
| Serious complications | | |
| Abdominal abscess | 4 | 0,2 |
| Hidden bumper syndrome | 9 | 0,5 |
| Peristomal cellulitis | 4 | 0,2 |
| Gastrointestinal fistula | 11 | 0,5 |
| Intestinal obstruction | 10 | 0,5 |
| Peritonitis | 16 | 0,8 |
| Bleeding associated with endoscopy (bleeding from the upper gastrointestinal tract) | 16 | 0,8 |
| Gastric atony | 5 | 0,2 |
| Esophageal perforation | 2 | 0,1 |
| Small bowel perforation | 2 | 0,1 |
| Gastric perforation | 2 | 0.1 |
| Gastric heterotopia | 44 | 2.2 |
| Pulmonary aspiration, pneumonia | 4 | 0,2 |
| Sepsis | 8 | 0,4 |

**Discussion**

This review analyzes endoscopic methods of percutaneous gastrostomy and determines the frequency and types of complications associated with gastrostomy tube placement. Percutaneous endoscopic gastrostomy is considered the method of choice when long-term enteral feeding is necessary in children with malnutrition due to various diseases, even in low-weight and premature infants. In this review, the youngest patient who had a PEG tube placed was 1 month old (body weight 2800 g), and the oldest patient was 17 years and 7 months old.

We divided the reasons for the need for a gastrostomy tube into four groups. The most common reason for PEG placement was neurological dysphagia, with a predominance of patients with cerebral palsy. The second most common reason for PEG placement was nutritional support for patients due to catabolic conditions associated with various pathologies. Cancer patients accounted for 9.3% (188) of all patients included in the second group. Patients with chronic heart, kidney, and lung diseases, cystic fibrosis, and metabolic disorders were also more likely to undergo gastrostomy. The proportion of patients with mechanical dysphagia was 4%; PEG was performed on 2 patients (0.1%) due to gastric decompression.

When analyzing the techniques used to perform PEG, it was found that in 21.9% (441) of patients included in the analysis, the method of surgical intervention was not specified. The traction technique was used in 32.9% (587) of cases (including 73 patients who underwent button PEG), and the pushing technique was used in 45.2% (908) of cases. We intended to evaluate the frequency of complications for each EGS method. However, not all publications covering both methods separately describe complications. Therefore, we were unable to achieve this goal. However, previous studies indicate that each method has its own advantages and disadvantages.

The pull method is relatively simple for the endoscopist to perform. The doctor can directly visualize the stomach and surrounding structures, which reduces the risk of displacement. The number of immediate complications, such as bleeding and perforation, is relatively low. However, the disadvantage is that the pull method is more invasive, as the endoscope must pass through the abdominal wall, creating a risk of infection around it. Patients may experience greater discomfort during the procedure due to tissue manipulation. This method is not suitable for all patients, especially if there are certain anatomical abnormalities or previous surgeries that make access difficult. The Pull method allows large-diameter PEG tubes to be inserted. However, two stages of endoscopy are required to remove the guide wire and insert the PEG tube [6,42].

The push method may cause less trauma to surrounding tissues, which may lead to faster recovery. However, there is a high risk of incorrect tube insertion, which can lead to complications such as aspiration or

perforation. The Push method requires a single endoscope insertion and has a low risk of infection. However, due to the small diameter of PEG tubes, they can easily become clogged. In addition, damage to the fixing balloon can cause displacement of the PEG tube [42].

*M. Takalo and co-authors* described the advantages of the Russell modification of the Push balloon technique. Thus, the installed gastrostomy slightly rises above the skin surface and has a valve that prevents the release of gastric contents into the external environment, it is much more convenient to care for and does not require specialized medical involvement when replacing it.

Replacement of a gastrostomy tube inserted using the Russell method can even be performed at home, whereas the Pull method requires hospitalization of the child [42]. However, the initial insertion of a low-profile gastrostomy tube is technically more difficult with the Push method and is contraindicated in a number of cases in patients with anatomical features. One of the reasons that may contribute to complications with the Push method is the method of gastropexy. To date, none of the existing methods of fixing the gastrostomy tube allows for the achievement of tightness of the external gastric anastomosis, accompanied by leakage of stomach contents to the outside.

The choice between these two methods often depends on the specific condition of the patient, the qualifications of the endoscopist, and clinical conditions. Proper assessment and consideration of the potential risks and benefits are crucial in determining the most appropriate approach for each individual patient.

Despite the minimally invasive nature of PEG, complications associated with PEG tube placement remain common. In our analysis of 13 publications, there were 1,505 complications, of which 1,370 (91.0%) were minor complications and 135 (9.0%) were serious complications. Hypergranulation (n = 479; 23.8%) was the most common minor complication. In 229 (21.4%) patients, gastric contents leaked through the gastrostomy site. Peristomal infections were reported in 220 (10.9%) patients, gastrostomy tube displacement in 176 (8.3%) patients, and early tube exit in 120 (5.9%) patients. Serious complications developed in 135 (9.0%) patients. As for the distribution of serious complications, 44 (2.2%) patients developed gastric heterotopia during a single-stage Button PEG.

Next in frequency were peritonitis (0.8%) and gastrointestinal bleeding (0.8%). Hidden bumper syndrome, gastrointestinal-skin fistulas, and intestinal obstruction occurred in 0.5% of patients each. In our review, perforation of the esophagus, stomach, and intestines occurred in 2 cases each (0.1%). Fatal outcomes from the procedure were reported in 2 patients (0.1%), with the cause of death related to sepsis following esophageal rupture and the formation of a gastrointestinal fistula [40]. Repeat surgery was performed in 1.2% (24) of patients.

The work of *Balogh et al.,* published in 2018, is one of the largest meta-analyses, which reviewed 18 articles with a total of 4,631 patients who underwent gastrostomy between 1994 and 2017. The incidence of serious complications was 10%, and minor complications were 33%.

However, it should be noted that in 5.8% of cases, image-guided techniques and laparoscopically assisted CHG administration were used, which were not applied in the publications we analyzed. In their meta-analysis, serious complications were mainly represented by cellulitis (1.5%), peritonitis (1.5%), sepsis or surgical wound dehiscence (1.5%), hidden bumper syndrome (1.0%), severe pneumoperitoneum (0.7%), and gastrointestinal fistula (0.45%) [9].

The frequency of complications is related to the duration of patient follow-up. Due to the retrospective nature of the publications included in this analysis, it was not possible to establish the median follow-up time, as it was not reported by all authors. To reduce complications and mortality, ESPGHAN recommends individualizing the indications for PEG and making the decision to insert a PEG by a multidisciplinary team, taking into account all relevant circumstances in children. Adequate planning and preparation before the procedure, follow-up observation of patients, treatment of any complications, and optimal timing for PEG removal are important.

***Conclusion***

Summarizing the analysis of the literature, it can be stated that percutaneous endoscopic gastrostomy is a practical and safe method of nutritional support for children with various health problems, regardless of the child's weight. Children who have undergone percutaneous endoscopic gastrostomy often experience minor complications. Percutaneous endoscopic gastrostomy has a low incidence of serious complications and mortality.

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