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CURRENT TRENDS IN THE DIAGNOSIS AND TREATMENT OF MECONIUM ILEUS IN PREMATURE INFANTS

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Abstract. Meconium ileus (MI) is an important cause of neonatal intestinal obstruction, and its incidence has been rising with advances in the survival of extremely preterm infants. Historically linked almost exclusively to cystic fibrosis, MI is now recognized as a predominantly non-cystic fibrosis condition in premature neonates, driven by functional immaturity of the gastrointestinal tract.

This review covers 43 publications (2000–2026) retrieved from PubMed, Scopus, Web of Science, eLibrary, and the Cochrane Library. Epidemiology, classification, aetiopathogenesis, clinical features, and current diagnostic strategies - including bedside abdominal ultrasound - are discussed. Conservative management options (water-soluble contrast enemas, N-acetylcysteine) and surgical techniques (enterotomy with lavage, primary resection and anastomosis, various enterostomy configurations) are analyzed. Compression-based technologies for intestinal reanastomosis – nickel-titanium clips and magnetic compression anastomosis – that shorten the stoma-bearing period and reduce metabolic losses are described.

The authors consider that multicentre prospective studies with adequate statistical power and long-term follow-up are needed before these techniques can be adopted as routine clinical practice.

Ключевые слова: *meconium ileus; preterm neonates; intestinal obstruction; N-acetylcysteine; compression anastomosis; review.*

Introduction. Meconium ileus (MI) is a form of congenital intestinal obstruction characterized by obstruction of the distal ileum with viscous, dehydrated meconium. This condition was first described by K. Landsteiner in 1905 in his work "Darmverschluss durch eingedicktes Meconium. Pankreatitis", published in the journal Centralblatt fur allgemeine Pathologie und pathologische Anatomie [1]. For over a century, MI was considered primarily as an early manifestation of CF, in which mutations in the CFTR gene lead to the production of abnormally thick intestinal secretions. However, clinical observations over the past two decades have significantly changed the understanding of this pathology: it has been established that the majority of cases of MI in extremely premature infants are not associated with CF, but develop as a result of functional immaturity of the gastrointestinal tract [2, 3].

Delayed meconium passage in extremely preterm, extremely low birth weight (ELBW) infants remains an unresolved problem in neonatology and pediatric surgery. MI in these infants is associated with an increased risk of necrotizing enterocolitis (NEC) and sepsis, complicates the initiation of enteral feeding, prolongs hospitalization, and worsens survival [2, 3]. According to various estimates, MI accounts for 9 to 33% of all cases of small bowel obstruction in newborns [4, 5]. According to the World Health Organization, the incidence of preterm births in 2020 reached 9.9%, which corresponds to 13.4 million premature babies born annually [6]. Improvements in perinatal care have increased the survival rate of ELBW newborns [7], and a natural consequence has been an increase in the absolute number of MI cases in this cohort. The choice of treatment tactics for MI in premature infants remains controversial: there are currently no generally accepted treatment protocols [4, 8].

The aim is to analyze literary data on the epidemiology, etiopathogenesis, diagnosis and treatment of meconium ileus in premature infants.

Materials and methods. A literature search was conducted in PubMed, Scopus, Web of Science, eLibrary, and the Cochrane Library for the period 2000–2026 using the keywords "meconium ileus," "meconium obstruction," "preterm neonate," "very low birth weight," "extremely low birth weight," "meconium-related ileus," "compression anastomosis," and their Russian-language equivalents. Inclusion criteria included original studies, systematic reviews, meta-analyses, case series, and clinical guidelines on the diagnosis and treatment of meconium ileus. Exclusion criteria included conference abstracts without full text, publications in languages other than Russian and English, and studies with

duplicate cohorts. Additionally, selected sources of historical significance published before 2000 were included. A total of 43 publications were selected.

Epidemiology. In the general live birth population, the incidence of meconium obstruction is approximately 1:25,000 [9]. Among very low birth weight (VLBW, less than 1500 g) and extremely low birth weight (ELBW, less than 1000 g) premature infants, this rate is significantly higher: according to systematic reviews, meconium obstruction is diagnosed in 3.9–11.3% of patients in this category [3, 10]. Historically, premature infants accounted for 5–12% of all cases of meconium obstruction [4, 11], but in the last 10–15 years, with improved care of extremely premature infants, the absolute number of cases has been steadily increasing [7].

In the literature of the 1980s–2010s, it was claimed that 80–90% of MI cases were associated with CF [12]. However, these data were obtained mainly in cohorts of full-term newborns. A multicenter cohort study by Rook J.M. et al. (2025), which covered more than 3.5 million live births and all forms of meconium obstruction (including preterm infants), showed that only 2.2% of 1844 infants with meconium obstruction had confirmed CF [13]. These results are supported by a review by L.E. de Jesus et al. (2024), which demonstrated that meconium obstruction of prematurity (MOP) in the vast majority of cases is caused not by genetic mutations of the CFTR gene, but by intestinal immaturity and impaired motility [14].

Recently, the genetic aspect of non-CF meconium ileus has attracted the attention of researchers. Romi H. et al. (2012) described homozygous loss-of-function mutations in the GUCY2C (guanylate cyclase 2C) gene as a cause of meconium ileus without CFTR mutations in infants from endogamous populations. These data were confirmed by Smith A. et al. (2019) and Bolia R. et al. (2021), who expanded the range of described populations and mutation variants. The role of GUCY2C-associated obstruction in a cohort of premature infants has not yet been studied, but the very existence of a genetically determined non-CF meconium ileus enhances our understanding of the pathogenesis of this pathology.

Meconium ileus (MI) is the most common autosomal recessive disorder among Caucasians. In Russia, its incidence, according to neonatal screening data, ranges from 1:8,000 to 1:10,000 newborns [15, 16]1, and meconium ileus (MI) develops in 15-20% of children with this disorder and is its earliest clinical manifestation [12, 17]. However, the presented epidemiological data indicate that among premature infants, meconium ileus is significantly more often an independent pathology unrelated to MI.

Classification. Clinically, MI is divided into simple (uncomplicated) and complicated, each of these forms occurring in approximately half of cases [5]. In the simple form, viscous meconium formed in utero obstructs the lumen of the small intestine, causing dilation of the proximal sections and the clinical picture of mechanical intestinal obstruction. In the complicated form, segmental volvulus, intestinal atresia, intestinal wall necrosis, perforation with the formation of meconium peritonitis, as well as giant meconium pseudocysts may develop [5]. Distinguishing between the forms is essential for tactics, since complicated MI always requires emergency surgical intervention, whereas in the uncomplicated course, conservative therapy is acceptable [4].

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Etiology and pathogenesis. The pathogenesis of MI in premature infants is multifactorial and differs from the mechanisms characteristic of CF. In patients with CF, obstruction is caused by mutations in the CFTR gene, leading to impaired chloride transport, dehydration of intestinal contents, and the formation of excessively viscous meconium [18]. In premature infants without CF, immaturity of the gastrointestinal tract comes to the fore [2, 3, 19]. The central link in the pathogenesis is weak intestinal motility. In extremely premature infants, intramural nerve plexuses are not fully formed: migration of neurons from the neural crest to the intestinal wall and maturation of ganglia continue throughout the gestational period [9, 20]. This leads to impaired coordination of peristaltic movements and a decrease in propulsive activity of the intestine, as shown in the works of Berseth C.L. [20]. Immaturity of smooth muscle cells, deficiency of interstitial cells of Cajal and imbalance of neurotransmitters (acetylcholine, nitric oxide, serotonin) further slow down the transit of contents through the distal ileum [2,

14].

Added to this is the immaturity of the enzymatic systems. In premature infants, the secretion of pancreatic enzymes–trypsin, lipase, and amylase–is reduced, leading to incomplete breakdown of the protein and lipid components of meconium. Insufficient secretion of water and electrolytes into the intestinal lumen, characteristic of this gestational age, gives meconium an excessively dense consistency [4, 19]. Increased mucin content and a deficiency of water in the intestinal contents hinder its passage [14].

Perinatal hypoxia and chronic placental insufficiency, which often accompany preterm birth, cause reduced intestinal blood flow, mucosal hypoperfusion, and impaired water absorption, which increases meconium viscosity [10, 21]. An immature microbiota also contributes: abnormal intestinal colonization in premature infants can disrupt the microbiota-enteric nervous system axis, affecting motility [17].

Postnatal factors include insufficient enteral nutrition in the first days of life, prolonged parenteral nutrition without an early enteral component, and the use of sedatives (opioids and muscle relaxants) that inhibit peristalsis [7, 21]. Additional risk factors include maternal hypertension, oligohydramnios, chronic fetoplacental insufficiency, gestational diabetes mellitus, and the use of magnesium sulfate [10]. The use of magnesium sulfate ($MgSO_4$) in the antenatal period for tocolysis or neuroprotection of the fetus deserves special attention. Transplacental transfer of magnesium to the fetus causes inhibition of immature intestinal motility, which has been demonstrated in a number of studies and is mentioned as one of the modifiable risk factors for MI [10, 14]. In addition, functional immaturity of CFTR channels (not a mutation, but insufficient expression) has been described in premature infants, reducing fluid secretion into the intestinal lumen and further increasing the viscosity of meconium [14].

Clinical picture. The clinical picture of MI typically manifests itself in the first days of life. However, premature infants differ from full-term infants in that the onset of symptoms often occurs on the 4th to 7th day of life, and in very premature infants it may be delayed until the 7th to 14th day, while in full-term infants, signs of obstruction typically appear within the first 24-48 hours [8, 14]. The delayed onset is explained by the immaturity of the gastrointestinal tract and more pronounced inhibition of motility.

The main manifestations of MI include abdominal distension, ineffective passage of meconium, gas retention, vomiting mixed with bile, and visible intestinal peristalsis through the anterior abdominal wall. On physical examination, the abdomen is distended and tense, with dilated intestinal loops often visible through the thinned anterior abdominal wall. Peristalsis is weakened or absent upon auscultation, and viscous meconium or a "rosary"-like conglomeration may also be palpated [5, 8].

In extremely premature infants, the clinical picture may be subtle, requiring increased vigilance [8]. In complicated forms of MI, signs of peritonitis are added: pronounced tension of the anterior abdominal wall and its hyperemia, complete absence of peristalsis, as well as hemodynamic instability - hypotension, tachycardia, desaturation [4, 5].

Laboratory changes in uncomplicated cases of MI may be minimal, although concomitant sepsis, common in premature infants, can mask and aggravate the manifestations of obstruction. In complicated cases, leukocytosis over 15×10^9/L with a left shift in the white blood cell count, elevated C-reactive protein and procalcitonin levels, metabolic acidosis, and electrolyte disturbances—primarily hyponatremia and hypokalemia associated with vomiting and fluid sequestration—are typically recorded [5, 8].

Diagnostics

Prenatal diagnostics. During ultrasound screening of the fetus in the second and third trimesters of pregnancy, echogenic bowel is visualized with a frequency of 0.2–1.4% of all pregnancies [22]. This sign may indicate the development of MI, especially when combined with polyhydramnios, dilation of intestinal loops over 7 mm, the presence of intra-abdominal pseudocysts or calcifications [22]. If echogenic bowel of the fetus is detected, genetic counseling (to exclude chromosomal abnormalities and CF), examination for intrauterine infections and dynamic observation with repeat ultrasound every 2–3 weeks are indicated [22].

The diagnosis of MI in premature infants consists of clinical assessment, laboratory, and instrumental data. Generally accepted international diagnostic criteria have not yet been developed; the criteria presented below are based on a summary of literary data [8].

Radiological diagnostics. Plain abdominal radiography in the frontal and lateral projections remains the basic method for visualizing intestinal changes in MI. Typical radiological signs of MI include multiple dilated loops of the small intestine with horizontal fluid levels, a "soap foam" or "ground glass" appearance in the right iliac region, corresponding to gas penetration into the thickness of compacted meconium masses, as well as gas depletion of the distal intestine [5, 8]. In premature infants with

ELBW, interpretation of radiographs can be difficult due to insufficient gas filling of the intestine, which often requires repeated dynamic examinations [8]. In complicated MI, pneumatosis of the intestinal wall is detected (18-21% of cases), free gas in the abdominal cavity during perforation (6-7%), as well as abdominal calcifications indicating previous intrauterine perforation and meconium peritonitis [4].

Ultrasound diagnostics. Ultrasound of the abdominal organs is increasingly used in the examination of premature infants with suspected meconium ileus, primarily due to the absence of radiation exposure and the ability to perform it at the patient's bedside [23, 24]. Ultrasound characteristics of meconium ileus include dilation of small intestinal loops, thickening of the intestinal wall over 2-3 mm, decreased or absent peristalsis, the presence of free fluid in the abdominal cavity, and hyperechoic contents in the intestinal lumen [8, 23]. The absence of signs of inflammation and pneumatosis of the wall during sonography helps to differentiate meconium ileus from necrotizing enterocolitis [23]. In addition, ultrasound allows for dynamic monitoring of the effect of therapy and early detection of complications.

Differential diagnosis of MI is carried out with other causes of low intestinal obstruction in newborns: ileal atresia, intestinal volvulus, necrotizing enterocolitis, Hirschsprung's disease and meconium plug syndrome [23]. In all cases, it is advisable to exclude MI by determining immunoreactive trypsin in dried blood spots, sweat test (upon reaching a body weight of 2 kg) and genetic testing [5, 8].

The diagnosis of MI in premature infants is based on a combination of signs: absence or scanty passage of meconium in the first 48-72 hours of life; abdominal distension and vomiting with bile; characteristic radiographic signs – dilation of the loops of the small intestine, fluid levels, a "soap foam" pattern; ultrasound criteria – dilation of the loops and thickening of the intestinal wall; exclusion of other causes of intestinal obstruction [8].

Conservative treatment. In simple meconium ileus – without perforation and peritonitis–the method of choice is conservative tactics [4, 5].

General events. Treatment begins with gastric decompression using a permanently open feeding tube to reduce intra-abdominal pressure and prevent aspiration. Simultaneously, infusion therapy is administered to correct hypovolemia, electrolyte imbalances, and metabolic acidosis; the volume and composition of the solutions are selected individually. Antibacterial therapy is prescribed if NEC or intestinal perforation is suspected, as well as in the case of a concurrent infectious process; parenteral nutrition is continued until intestinal passage is restored [5, 8].

Contrast enemas. Conservative therapy is based on enemas with water-soluble contrast agents. Gastrografin is a radiopaque agent containing sodium amidotrizoate and meglumine amidotrizoate with an osmolarity of approximately 1900 mOsm/L. Due to its osmotic and detergent effects, it attracts water into the intestinal lumen, softening viscous meconium and stimulating peristalsis [5, 8]. The procedure is performed under X-ray control: the agent is diluted in a ratio of 1:3 or 1:4 with saline solution to reduce hyperosmolarity and administered through a rectal catheter in a volume of 15–30 ml under low pressure [8]. If the response is positive, meconium passage begins within 24-48 hours.

The effectiveness of conservative treatment of MV using contrast enemas, according to systematic reviews from 2014 to 2024, varies widely–from 22 to 85% [5, 8, 14]. The average effectiveness over the past 10 years, according to Donos M.A. et al. (2024), is 28.5% – however, this concerns a cohort of patients with confirmed MV [5], which limits extrapolation to premature infants without MV. Effectiveness depends on gestational age: in more mature newborns, success is achieved more often, while in extremely premature infants it is significantly less frequent [7, 8]. It is assumed that in the absence of MV, conservative therapy is more effective due to the lower viscosity of meconium [8].

The risk of perforation with contrast enemas is 2.7–23.0% [5]. When the dilution protocol and pressure control are followed, the incidence of complications is minimal [25]. Careful monitoring of water and electrolyte balance is necessary during the first 6–12 hours after the procedure. Nephrotoxicity and thyrotoxicity of iodine-containing contrast agents in premature infants dictates the need to monitor renal and thyroid function during the first year of life [25].

In recent years, there has been increasing interest in low-osmolar contrast agents–iopromide (Ultravist® 300) and iogexol (Omnipaque®)–as a potentially safer alternative to Gastrografin in extremely premature infants with ELBW [5, 8]. The advantages of these agents include a lower risk of hyperosmolar diarrhea and the possibility of repeated administration. However, according to Piloyan et al. (2024), the use of iogexol (whose osmolarity corresponds to blood plasma – 322 mOsm/kg) failed to achieve success in any infant, whereas sodium amidotrizoate was effective in 73% of cases [8]–lower osmolarity also means a weaker osmotic effect.

Ultrasound-guided enemas. Ultrasound-guided contrast enemas have emerged as a promising approach to conservative treatment of MI [26]. This approach reduces radiation exposure, visualizes

contrast distribution in real time, and enables early detection of perforation. According to available data, the success rate of ultrasound-guided procedures reaches 68.3% with a perforation rate of 2.3% [26], indicating acceptable safety, including in neonates with ELBW.

N-acetylcysteine (NAC) – A mucolytic drug that breaks disulfide bonds in mucins and proteins of meconium, thereby reducing its viscosity [27, 28]. NAC can be administered either orally (via a nasogastric tube) or rectally as microenemas. However, systematic reviews emphasize that NAC does not replace surgical consultation and remains an adjunct to standard therapy [7, 27].

Other conservative methods. Glycerol enemas, historically used as the first step in conservative therapy for MI, are currently being critically reviewed due to limited efficacy and the risk of mechanical damage to the rectal mucosa in extremely premature infants [28]. Enemas with breast milk are being studied in several centers in a randomized study by Zheng L. et al. (2024), which included 286 premature infants with a gestational age of 23–30 weeks; enemas with breast milk demonstrated an acceleration of meconium evacuation compared to saline; the effect was most pronounced in the subgroup of 29–30 weeks of gestation [29].

Surgical treatment. Surgical treatment is indicated in cases of complicated meconium ileus (perforation, intestinal necrosis, volvulus, atresia, meconium peritonitis), as well as in cases of ineffectiveness of repeated contrast enemas with increasing obstruction, peritonitis, or multiple organ failure [4, 5]. In extremely premature infants, the threshold for transition to surgery may be lower due to a higher risk of perforation during expectant management [30].

Types of surgical interventions. There is no single standard for surgical tactics; the choice is determined by the form of the disease, the child's condition, and intraoperative findings [4, 5, 9, 30–36]. According to a retrospective analysis by Farrelly et al. (2014), included in the systematic review by Donos et al. (2024), of 24 operated patients with simple and complicated MI, a separate stoma was formed in 41% of cases, enterotomy with lavage was performed in 13%, and resection with primary anastomosis was performed in 15% [5]. In a prospective cohort study by Long et al. (2021), which included 56 newborns with MI and CF, an intestinal stoma was formed in 24 of 44 (55%) patients who underwent laparotomy; The most common option was the double-barreled enterostomy according to Mikulicz [31].

Enterotomy with lavage of the intestinal lumen with warm saline (with or without the addition of NAC) is the least invasive intervention, allowing for the preservation of the entire length of the intestine. However, in infants with ELBW, the technique is associated with technical difficulties: a pronounced disproportion between the dilated afferent and collapsed efferent loops complicates suturing. Karimi et al. (2011) in a retrospective study of 41 patients reported the development of peritonitis in 2 of 4 newborns after enterotomy with lavage (purse-string ileotomy), associating this with a decrease in the viability of the dilated intestine in combination with the previous administration of a hyperosmolar solution and mechanical effects on the wall during the passage of meconium [9]. In the same study, resection with double-barreled enterostomy was not associated with anastomotic leakage in either the simple or complicated MI group [9]. Patwardhan U.M. et al. (2026) described a technique for intraoperative administration of NAC through a 27G needle directly into the obstructed ileal loop at several points, which in most cases allowed for the evacuation of meconium without opening the intestinal lumen [32]. This technique requires further multicenter studies.

Resection of the affected intestinal segment with the creation of a primary anastomosis is permissible in stable newborns in the absence of peritonitis and hemodynamic instability [4, 5]. This tactic allows to avoid the formation of a stoma and repeated operations, however, the frequency of surgical complications of primary anastomosis ranges from 21% to 31% according to general reviews [4]. In particular, Jawaheer et al. (2007) in a series of 13 patients with complicated MI recorded surgical complications after resection with primary anastomosis in 4 patients (31%): two anastomotic strictures with an adhesive process, one adhesive intestinal obstruction and one retraction of intra-abdominal drainage [33]. Karimi et al. (2011) described anastomotic leakage in 2 of 14 patients (14%) with complicated MI after resection with primary anastomosis and in 1 of 2 (50%) in the simple MI group [9]. These data justify a clearly differentiated selection of patients for primary anastomosis.

The formation of a double-barreled enterostomy according to Mikulich is considered by a number of authors as a preferred option in unstable patients with peritonitis, multiple zones of questionable intestinal viability, and in neonates with ELBW [4, 9]. The advantages of the technique include the absence of an intra-abdominal anastomosis, minimal intestinal trauma, and the possibility of retrograde enemas after surgery [9]. The disadvantages include significant fluid and electrolyte losses, parastomal dermatitis and skin maceration (according to the Tomsk Perinatal Center, skin maceration was

observed in 43.2% of neonates with enterostomies), as well as the need for repeated intervention to restore intestinal continuity [9, 37].

In children with a higher body weight and satisfactory somatic status in the absence of intestinal ischemia, the Bishop-Coupe procedure can be performed - the formation of an anastomosis between the afferent and efferent loops with the withdrawal of the distal end as a decompression stoma. According to Boczar et al. (2015), included in the systematic review by Donos et al. in a retrospective study of 10 patients with MI, the Bishop-Coupe stoma was described as a safe method, not accompanied by electrolyte imbalances, excessive fluid loss or weight loss [5]. Martynov et al. (2019) in a comparative study of 102 newborns (MI, intestinal atresia, NEC) confirmed the safety of the Bishop-Coupe procedure with a low complication rate and a shorter operative time compared to a separate stoma [34].

Comparison of the Santulli and loop ileostomy techniques. Askarpour et al. (2020) in a retrospective study of 53 newborns with MI (Santulli ileostomy – n = 28, loop ileostomy – n = 25) demonstrated statistically significant advantages of the Santulli technique: the frequency of skin maceration was 21.4% versus 84% ($p < 0.001$), stoma prolapse – 0% versus 28% ($p = 0.003$), wound infection – 7.1% versus 28% ($p = 0.044$), the volume of losses through the stoma in the first week was 70.5 ± 15.1 ml versus 144.6 ± 20.0 ml ($p < 0.001$), the duration of hospitalization was 12 ± 2.3 versus 14.2 ± 1.5 days ($p < 0.001$) [35]. However, the study was single-center and preterm and low birth weight infants were excluded from the sample, which limits the extrapolation of the results to very preterm infants.

The Bishop-Coupe operation (1957) and Santulli ileostomy are widely used and provide the possibility of intestinal lavage and irrigation in the postoperative period [5, 9]. However, intra-abdominal anastomosis in extremely premature infants carries an increased risk of leakage, as shown by Karimi et al. (2011): with resection with primary anastomosis, the incidence of peritonitis due to leakage was 14% in complicated MI, whereas with double-barrel enterostomy this complication was not recorded [9]. H. Till et al. (2021) described the successful formation of a loop ileostomy in a newborn weighing 273 g – the smallest boy in Europe at that time, which confirms the technical feasibility of ostomy even in extreme immaturity [36].

According to Ivanov S.D. et al. (2021) from the Tomsk Perinatal Center, among 79 newborns with intestinal stomas (including 14 with MI, 72.8% premature), T-shaped anastomosis was associated with longer parenteral nutrition ($p=0.018$), an increased incidence of liver failure ($p=0.018$) and anastomosis dysfunction ($p=0.046$) compared with double-barrel enterostomy with a compression clip [37]. The authors concluded that double-barrel enterostomy with a NiTi compression device is a safe alternative to T-anastomosis in newborns with contraindications to primary anastomosis [37].

Titanium nickelide (NiTi) compression clips with shape memory. The principle of restoring intestinal continuity in a double-barreled enterostomy according to Mikulicz is based on the formation of a delayed compression junction between the afferent and efferent loops through the interstomal spur. The clip consists of two parallel-oriented branches (30 x 6 mm, wire cross-section 1 mm, TH-10 alloy) with shape memory in the operating temperature range of 0–40 °C. When the clip, pre-cooled to 0 °C, is applied to the interstomal spur of a double-barreled enterostomy, the branches close upon heating to body temperature, compressing the adjacent walls of the afferent and efferent sections. As a result of the adhesive-necrotic process, an interintestinal anastomosis is formed, and the device is evacuated outward together with a section of necrotic tissue without migrating along the intestine on the 3rd-7th day. A compression suture, unlike a ligature suture, is devoid of such disadvantages as the formation of coarse scar tissue, contamination of the suture channel and leaving foreign bodies in the suture area [37, 38]. In a cohort of 79 children in the first year of life with small intestinal stomas for the period 2000-2021, double-barreled enterostomies according to Mikulicz were formed in 44 (55.7%), of which a NiTi compression clip was applied in 18 (40.9%); T-shaped anastomoses according to Bishop-Koop - in 12 (15.2%). Indications for clip placement were pathological losses of intestinal chyme (more than 20 ml/kg per day) when radical closure of the stoma was impossible due to the severity of the somatic status. The clip was applied on the 9th-58th day after surgery (median 23 days), was rejected spontaneously on the 5th day (3rd-7th), and stool through the rectum appeared on the 1st-3rd day after clip rejection. Compression anastomosis was achieved in 15 of 18 children (83.3%), and stoma closure without resection of the anastomosis zone (suturing the external part) was achieved in 11 of 15 (73.3%) [37].

Magnetic compression interintestinal anastomosis (MCIA). An alternative method for restoring intestinal transit in double-barreled enterostomies is the use of permanent magnets (Sm-Co or Nd-Fe-B) in a silicone housing, inserted through the stoma lumen into the afferent and efferent loops. The magnetic elements create a pressure of approximately 200 g/cm² on the adjacent intestinal walls, caus-

ing staged ischemia and necrosis with the formation of a lateral opening over 5-7 days; the magnetic plates are removed or rejected spontaneously [39].

Gatkin E. Ya. et al. (2015, Moscow) reported the use of magnetic plates (induction 300-360 mT, energy density ≥255 k/Jm³, attractive force between the plates about 600 g, which corresponds to ~200 g/cm²) in 48 children with double-barreled enterostomies aged from 1 month to 14 years. Magnetic elements were installed on the 6-7th day after enterostomy formation. Complete interintestinal anastomosis was formed within 5-7 days; the plates were removed, after which 45 of 48 children (93.8%) normalized stool (1-3 times a day), and discharge through the stoma decreased to a minimum. Irregular bowel movements due to adhesive stenosis were observed in 2 children; In 1 child, magnet placement was impossible due to severe adhesions. The hospitalization period was 10-25 days for 41 children; the remaining 7 were discharged for outpatient observation at a later date [39].

In a multicenter Kazakh-Russian study, Bisaliev B.N. et al. (2020) compared the treatment outcomes of children with enterostomies who underwent MCMA (n=16) with the control group of traditional stoma closure (n=18). The MCMA group demonstrated a reduction in the total bed-day by 13.1 days (p=0.004), intensive care unit stay by 13.5 days (p<0.001), and the duration of total parenteral nutrition by 12.7 days (p<0.001). Complications developed in 1 of 16 in the MCMA group and 4 of 18 in the control group (p=0.340); mortality was 0 of 16 versus 2 of 18 (p=0.487) – the differences are statistically insignificant due to the small sample size [40].

The advantages of compression methods include minimal invasiveness of the procedure, early restoration of intestinal transit with reduced fluid and electrolyte losses, reduced severity of parastomal dermatitis, accelerated rehabilitation, and the possibility of final closure of the stoma by suturing the external part without resection of the anastomosis zone [37, 39–41].

Limitations of both methods: the need for patency of the distal sections of the intestine and the formation of a common platform when forming an intestinal stoma; the risk of migration with unsatisfactory fixation [37, 39, 40].

The use of MCMA or NiTi clips in the second stage of surgical treatment of MI can shorten the duration of stoma placement and reduce metabolic losses, thereby accelerating weight gain. The flow of chyme into the "disconnected" sections of the intestine during double-barreled enterostomies, analyzed in detail by Bhat S. et al. (2020) in a systematic review, confirms the importance of early restoration of passage for nutritional status [41]. In our opinion, compression technologies deserve more active implementation in the practice of neonatal surgical units; however, the available data are obtained mainly from single-center retrospective studies with small sample sizes; multicenter prospective studies involving leading pediatric surgical centers are needed to determine optimal algorithms [37, 40]. Indications for various types of intestinal anastomoses in newborns and young children, including compression techniques, were discussed at the Russian Symposium of Pediatric Surgeons in 2023 and were reflected in the draft resolution, which emphasized the need for a differentiated approach taking into account body weight, gestational age and the condition of the intestinal wall [42].

Outcomes and forecast. Historically, mortality in MI has reached 50–67% [30], but the situation has improved significantly over the past three decades: in modern prospective cohort studies and systematic reviews, mortality in MI associated with CF is 0–8% [5, 31, 43]. In a multicenter study by Padoan et al. (2019), which included 85 newborns with MI and CF from 13 Italian centers, 84% of children (n=71) required surgical treatment [43]. According to a prospective population-based study by Long et al. (2021), mortality was 4%, and stoma-related complications were noted in 9 of 24 (38%) [31]. Mortality in very preterm infants, however, is significantly higher: Kim et al. (2015) reported a postoperative mortality rate of 31.3% in ELBW (<1000 g) and 27.2% in VLBW (1000-1500 g) infants, although the difference did not reach statistical significance (p=0.824) [30]. The main causes of death are sepsis and multiple organ failure due to extreme prematurity [30, 43].

Early postoperative complications of MI include anastomotic leakage (21-31% in resection with primary anastomosis according to general reviews [4]; 31% in the series of Jawaheer et al. [33]), adhesive intestinal obstruction, wound infections, and cholestasis due to long-term parenteral nutrition [9, 33]. In complicated MI, the need for repeat operations reaches 20-38% [5, 31].

Long-term outcomes in preterm infants without CF are concerning: Kim et al. (2015) demonstrated that at 12 months of corrected age, 61.1% of survivors had weight and height below the 10th percentile; "catch-up growth" (above the 10th percentile) was achieved in only 57.1% of VLBW infants and 27.3% of ELBW infants, necessitating intensive nutritional support [30]. In infants with CF and MI, the long-term prognosis is determined by the course of the underlying disease [43].

Unfavorable prognostic factors for MI include ELBW at birth (<1000 g), complicated MI, the need for extensive bowel resection, the development of sepsis in the postoperative period, and long-term

dependence on parenteral nutrition [4, 9, 30, 43]. Favorable factors include successful non-surgical treatment with contrast enemas (associated with a shorter time to full enteral feeding - median 6 days versus 15 with laparotomy), the use of minimally invasive techniques, and early enteral nutrition [5, 31].

Conclusion. An analysis of 43 publications from 2000 to 2026 confirms that meconium ileus in preterm infants without meconium cystitis is a problem that is becoming more common as survival rates for very premature infants increase. Recent data confirm that in the vast majority of cases, this pathology is not associated with meconium cystitis in premature infants and deserves to be identified as a distinct clinical syndrome. The effectiveness of conservative treatment varies widely and depends on gestational age, requiring an individualized approach. Low-osmolar contrast agents, NAC, and ultrasound-guided enemas expand the possibilities of conservative management. When conservative therapy is ineffective and complicated cases arise, surgical treatment remains the primary method, and compression technologies–titanium nickelide clips and MKMA–offer a promising approach for restoring intestinal continuity in patients with enterostomies. According to the authors, multicenter prospective studies with sufficient statistical power and long-term follow-up are necessary for the integration of compression methods into routine practice and standardization of treatment protocols.

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