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RESEARCH ARTICLE

TREATMENT OF CONGENITAL DUODENAL OBSTRUCTION: FROM OPEN TO LAPAROSCOPIC APPROACH FOR DUODENO-DUODENAL ANASTOMOSIS.

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ABSTRACT

Conginental duodenal obstruction is a relatively rare malformation. Laparoscopic operation for this condition was described for the first time in 2001, but more than 20 years later, there is still debate over the preferred method of surgical correction. We believe that laparoscopic correction of conginental duodenal obstruction is a safe and feasible method and can be used in premature infants with low body weight.

Materials and Methods: From September 2017 to December 2021, 27 children with conginental duodenal obstruction were treated in our department. We were able to identify the diagnosis in 17 children during the antenatal period, while plain X-ray confirmed postnatal diagnosis. In doubtful cases the contrast fluoroscopy was performed. Four children underwent open correction of the defect via a circumbilical approach, while laparoscopic duodeno-duodenal anastomosis using the Kimura technique was performed in the remaining 23 children.

Results: Intraoperative complication in the form of duct injury was observed in 1 patient with an atypically located Wirsung duct. In the postoperative period, anastomotic failure was noted in 2 children, and perforation of the duodenum was detected in 2 patients. The mortality rate comprised 26%, which was partly attributed to severe concomitant pathologies. The use of prolonged epidural analgesia in combination with laparoscopic surgery provided early weaning from mechanical ventilation and transfer from the intensive care unit. Enteral feeding was initiated on postoperative day 5, and the average length of hospital stay was 29±10.5 days.

Conclusion: There are no limitations to performing laparoscopic correction of congenital duodenal obstruction. When there are accompanying congenital defects, minimally invasive technology allows to perform combined operations on organs of the thoracic and abdominal cavity, which reduces the overall surgical time. In combination with prolonged epidural analgesia, laparoscopic technique reduces the length of stay in the intensive care unit and the need for parenteral nutrition, which ultimately lowers the risk of inflammatory complications and treatment costs.

Keywords: conginental duodenal obstruction, duodeno-duodenal anastomosis, laparoscopic Kimura anastomosis, neonatal surgery, extended epidural analgesia.

Introduction

Congenital atresia and stenosis of the duodenum occur in 1 child per 5000-10000 live births.[1] For all the time of studying this problem, various methods for correcting this pathology have been proposed, including excision of the duodenal membrane, gastrojejunostomy, duodeno-duodenostomy, duodenojejunostomy and other bypass anastomoses in various modifications.[2] Nowadays, the gold standard for surgical treatment is considered to be the technique of diamond-shaped duodeno-duodenal bypass anastomosis, which was developed by Ken Kimura in 1977[3], and it is not dependent on the cause of the obstruction.[4] The development of laparoscopy, the emergence of tools and technologies that allow safe minimally invasive interventions in newborns, made it possible to introduce laparoscopic operations on the duodenum. The first experience of laparoscopic Kimura's duodeno-duodenoanastomosis was presented in 2001 by Nikolaas M.A. Bax et al.[5], and this method has become widely used. However, it took several years to develop surgical techniques to ensure the safety with a minimum proportion of complications and adverse outcomes.[6,7] And even now, despite the more than 20-year history of laparoscopic operations for congenital duodenal obstruction (CDO), laparotomy remains the preferred surgical approach in many countries.[8] The experience of laparoscopic Kimura's procedures at the leading of the Moscow Children's Hospital allowed us to implement this technique at the children's hospital of the Moscow Region. Our own experience allowed us to identify the causes of bad outcomes and propose technologies which can improve the quality of treatment for this group of children. The purpose of the article is to present our experience in implementing the laparoscopic Kimura operation. A detailed analysis of technical difficulties, intraoperative and postoperative complications with an assessment of the effectiveness of the introduced changes in the original technique allows us to speak of laparoscopic correction of CDO as a safe and reproducible technology.

The Level of Evidence: III.

ABBREVIATIONS:
CDO – Conginental duodenal obstruction
US – Ultrasound examination
TAT – Trans-anastomose tube

Materials and Methods

A retrospective analysis of the medical records of an inpatient at the Neonatal Surgery Department of the Moscow Regional Center for Maternity and Childhood Healthcare for the period from September 2017 to December 2021 made it possible to form a cohort of patients (27 children - 100%), the selection criterion for which was a CDO. To obtain the most detailed understanding of the relationship among surgical techniques, the impact of comorbid conditions on the outcome of the operation and treatment in general, we did not apply the exclusion criteria to the resulting cohort of patients. We analyzed the contribution of antenatal diagnosis and postnatal diagnosis to the timely provision of specialized care for children with CDO. We also analyzed the reasons for the late diagnosis

of the disease to form criteria for surgical alertness in pediatric conditions using this example. We analyzed the underlying and concomitant diseases and conditions in children with CDO in order to form risk groups, justified changes in the timing and extent of surgical correction. We analyzed the technological features of operations and their changes in the process of gaining experience. We also analyzed in detail the results and outcomes of diseases in this group.

Prenatal ultrasound revealed CDO in 17 children (63%) (Fig.1), and their mothers were referred to a specialized maternity hospital for delivery. In 10 children (37%), CDO was diagnosed after birth, mainly due to clinical symptoms that raised suspicion of a congenital defect, so the children were transferred to our in-patient clinic. Late admission (at the age of over 7 days) was observed in 3 cases (11%). Timely diagnosis was difficult in 2 cases due to severe somatic condition at birth in one patient and the clinical presentation of ulcerative-necrotizing enterocolitis in the other. The third child was hospitalized from home at the age of 38 days with partial intestinal obstruction (intraoperatively we found a duodenal membrane, which allowed the child to remain subcompensated for a long period). There were 16 males and 11 females in our series, the average age at hospitalization was 3.59±4.89 days (minimum 0, maximum 38 days).

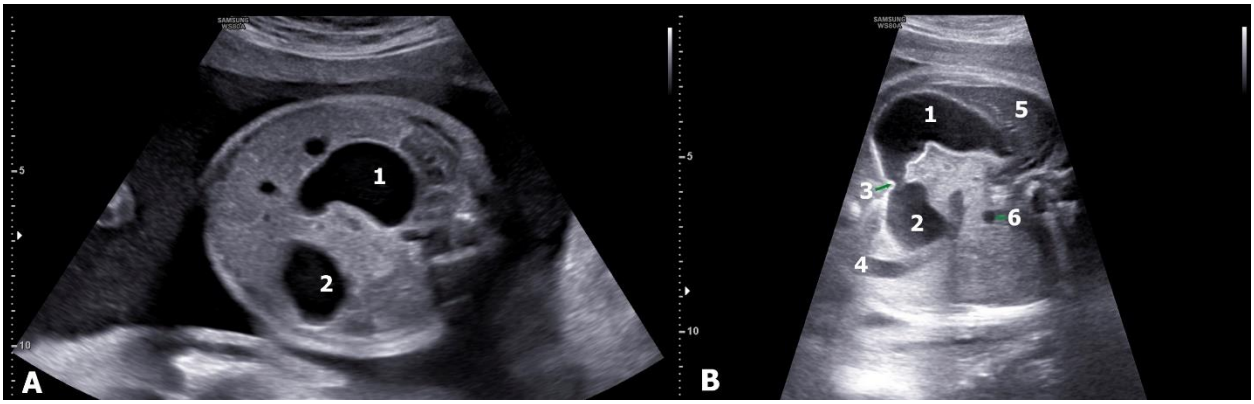

Figure:1 Prenatal US image with a "double-bubble" symptom: A – classical view, B – detailed image (1 – stomach, 2 – duodenum, 3 – pylorus, 4 – gallbladder, 5 – spleen, 6 – aorta).

The preoperative examination included a chest and abdomen X-ray (Fig.2) and ultrasound (US) examination, and in some cases, a fluoroscopy contrast study was required to assess evacuation (Fig.3). The cause of obstruction was a duodenal membrane in 13 cases (48%), annular pancreas in 10 patients (37%), and duodenal atresia in 4 cases (15%) (Fig.4). Multiple congenital malformations were found in 8 children: Down syndrome in combination with a congenital heart defect (n=3); Ivemark syndrome (reversed organs combined with an incomplete rotation of the intestine and duodenal obstruction) (n=2, one of whom also had a heart defect); esophageal atresia (n=2); hypospadias (n=1). Both children with esophageal atresia had both malformations detected in utero.

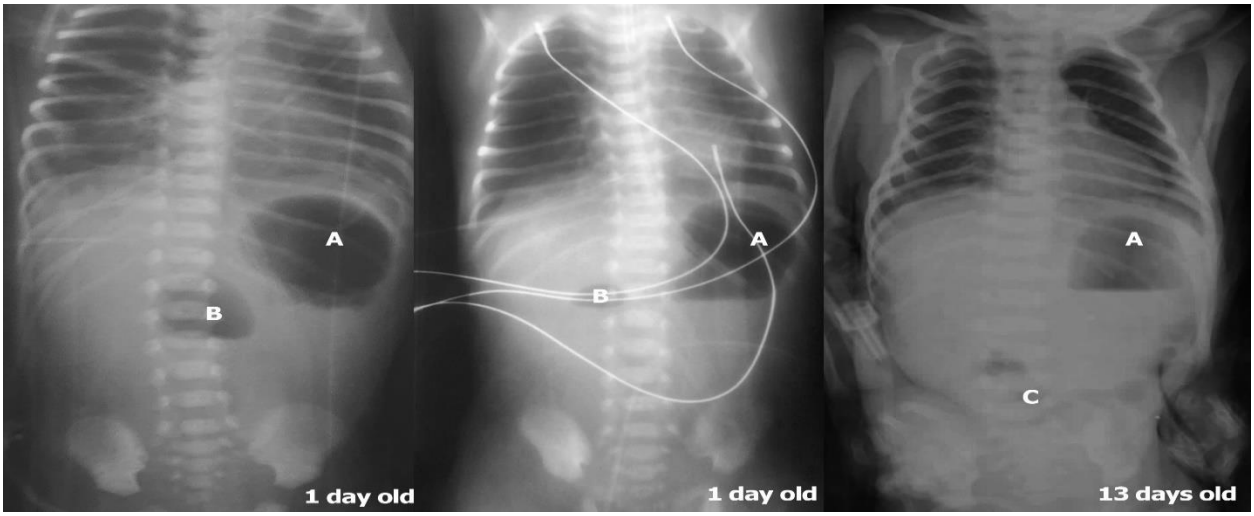

Figure 2. Plain radiography of the chest and abdomen in a direct projection in the vertical position: different types of gas in the the duodenum (A - stomach, B - duodenum, C - intestine).

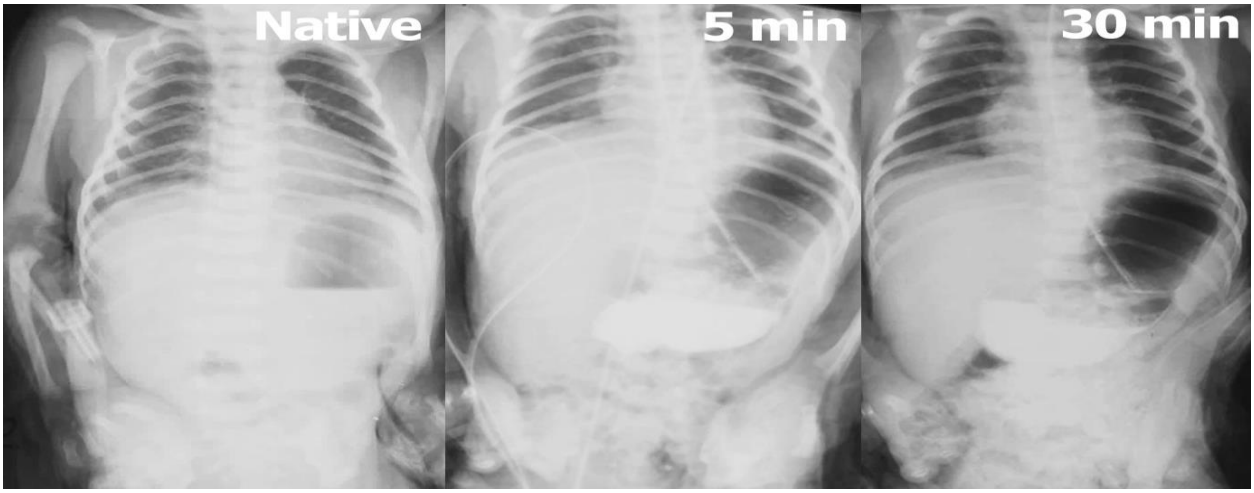

Figure 3. Fluoroscopic examination with water-soluble contrast in a child 13 days without gas in the duodenum: native and delayed images at 5 and 30 minutes after contrast given (contrast remains in duodenum).

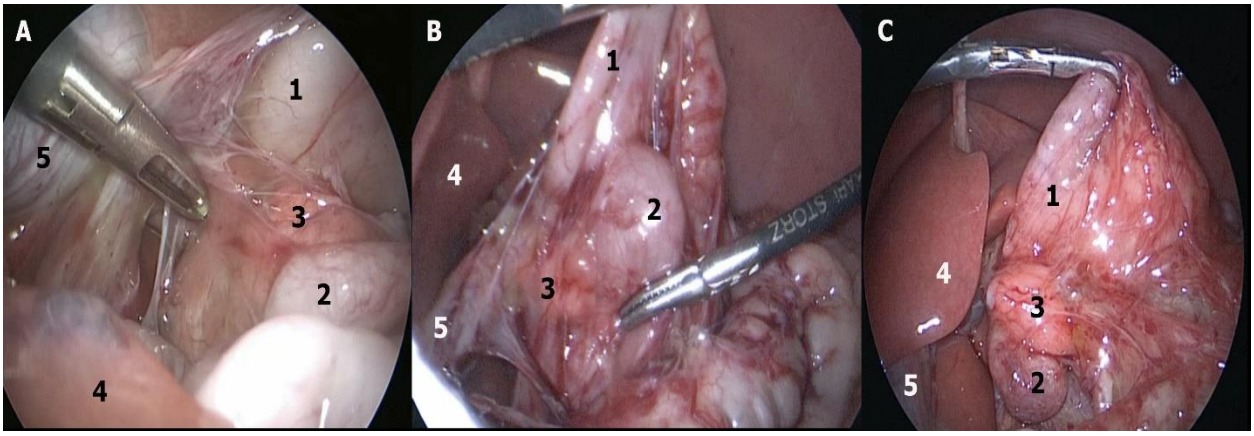

Figure 4. Intraoperative image of types of duodenal obstruction: A - atresia, B - membrane, C - annular pancreas (1 - proximal duodenum, 2 - distal duodenum, 3 - pancreas, 4 - liver, 5 - gallbladder).

The surgery was performed urgently after the patients' condition was stabilized, with an average preoperative preparation time of 4.2±1.4 days, except children with esophageal atresia who were operated within their first day of life. Laparotomy with anastomosis via circumbilical access was performed in 4 children (15%). For laparoscopic correction we used 4 mm 30-degree optics with a length of 18 cm, which is used in arthroscopy. In our opinion, the advantage of using 4 mm optics over 3 mm is the greater amount of light-conducting optical fiber. This greater illumination allows for an increased focal distance and therefore a larger operating field without losing the detail of the obtained image. Using longer optics (25-42 cm) in combination with 18 cm instruments disrupts the ergonomics of the operation.

We have started performing Kimura's operation using the laparoscopic method since 2018. During the reported period we have completed 23 (85%) laparoscopic duodeno-duodenal anastomoses in total. Dissatisfaction with the results of surgical treatment, the presence of anastomotic failure forced us to look for possible changes in the technique of laparoscopic surgery to minimize surgical risks. Analysis of technical intraoperative difficulties, intraoperative and postoperative complications revealed the main causes of their occurrence: inadequate visualization of the anastomosis line, tissue tension at the anastomosis, atypical anatomy of the Wirsung duct. Since September 2020, we have changed the technical approach to surgical intervention. The introduced changes made it possible to ensure safe mobilization of the duodenum, reduction of tension in the anastomosis zone, better visualization of the surgical site with a clear control of the anastomosis line around the entire circumference of the duodenum. Thus, patients operated on by laparoscopic access were divided into two groups: 13 children (48%) children operated on before September 2020 and 10 children (37%) operated on using a modified technique. We compared children in these two groups (Table 1). Since we analyzed small samples, we used the Wilcoxon-Mann-Whitney test to estimate the probability of an error-free forecast P by the main characteristics and t Student's test for assessing the relative values of the ratio of the causes of obstruction. This analysis showed that since the probability of an error-free prediction $p > 0.05$ when assessing all of the listed parameters, the differences between groups I and II were not significant. This allows us to compare both selected groups and obtain statistically significant data.

Table 1. Comparative characteristics of groups I and II.

	Group I			Group II			U_{emp}	p
Sex	Male 7 (26%)	Female 6 (22%)	Total 13 (48%)	Male 6 (22%)	Female 4 (10%)	Total 10 (47%)	65	>0.05
Age of admition	0.92±0.85 days (0 - 5 days)			7.9±10.26 days (0 - 38 days)			48	>0.05
Age of procedure	4.69±2.28 days (1 - 13 days)			11.6±10.84 days (0 - 44 days)			48.5	>0.05
Procedure after admition	3.91±1.93 days (1 - 8 days)			3.7±1.22 days (0 - 6 days)			59.5	>0.05
Weight after birth	2229±582 g (1120 – 3330 g)			2533±678 g (800 - 3660 g)			44.5	>0.05
Concomitant diseases	4 (15%)			4 (15%)			59	>0.05
The cause of obstruction							t	p
Atresia	2 (7%)			2 (7%)			0%	<95.5%
Membrane	7 (26%)			5 (19%)			66%	<95.5%
Annular pancreas	4 (15%)			3 (11%)			41%	<95.5%

(U_{emp} – U empirical, U critical for a sample of 23 observations is 27-37, t - t Student's test for the relative values)

Despite the fact that the restrictions of the Mann-Whitney U-test do not apply to a sample with more than 2 and less than 60 observations, we decided not to single out a group of children operated on by open surgery. Although the analysis of groups with different numbers of observations will give a statistical result, it will not be objective and this analysis does not meet the objectives of statistical analysis.

The surgery was performed under general combined anesthesia with tracheal intubation and epidural analgesia. The age at the time of the operation was 7.33±5.53 days (ranging from 0 to 44 days), and the weight was 2299±661 g (ranging from 800 to 3660 g). A simultaneous operation was performed in two children for esophageal atresia. In both cases, the first stage of the procedure was thoracoscopic esophago-esophageal anastomosis, which allowed to place a gastric tube into the stomach for decompression. Due to the fact that one of these children was found to have a persistent cloaca with a Meckel's diverticulum and an incomplete rotation of the intestine, in addition to the duodeno-duodenal anastomosis, embryonic adhesions were separated and Meckel's diverticulum resection was performed. This operation was completed by a separate sigmoid colostomy through a mini-laparotomy incision.

Our experience, as well as the use of modifications published by local and foreign surgeons, helped us to determine the features of laparoscopic surgery that distinguish it from the original technique[5,9] These technological changes have become the criterion for dividing into groups.

Initially, we placed the optical trocar in the right mesogastrium, abandoning the infraumbilical position. The position of the laparoscopic ports for the manipulators was adjusted relatively to the first trocar, placing them in the right hypochondrium and along the lower semicircle to the left of the umbilicus (Fig.5). This arrangement of the optics

together with transabdominal fixation of the upper horizontal branch of the duodenum to the anterior abdominal wall allowed adequate inspection of the right wall of the anastomosis (Fig.6). Pneumoperitoneum was created depending on the child's weight. For children weighing more than 3000 g we used the pressure of 10 mmHg and the flow of 5 L/minute. For children weighing more than 1500 g, the safe pressure was 8 mmHg, and the flow could be 4-5 L/minute. For children weighing less than 1500 g, the carbon dioxide pressure was set at 6 mmHg with a flow of 3 L/minute. The parameters of insufflation were adjusted according to the indicators of lung ventilation: when the inspiratory pressure or the amount of carbon dioxide gas in the exhaled mixture increased, the insufflation pressure was decreased. We performed precise blunt division of the transverse duodenal ligament with the evaluation of all suspicious tubular structures within it to identify any possible atypical positioning of the Wirsung duct. After mobilizing the proximal and distal parts of the duodenum, in case of a large diastasis between the ends or a limited mobility of the distal end, we conducted additional mobilization of the lower horizontal branch through the ligament of Treitz up to the jejunum. The next step was to use sharp-pointed scissors to cut the proximal part along the transverse muscle fibers and the distal part along the longitudinal ones. We created the diamond-shaped anastomosis using a continuous intracorporeal suture with biodegradable monofilament threads with a diameter of 6/0 or 5/0, which separately formed the posterior and anterior lips of the anastomosis (Fig.7). We did not insert a gastric tube beyond the anastomotic line nor use a safety drainage.

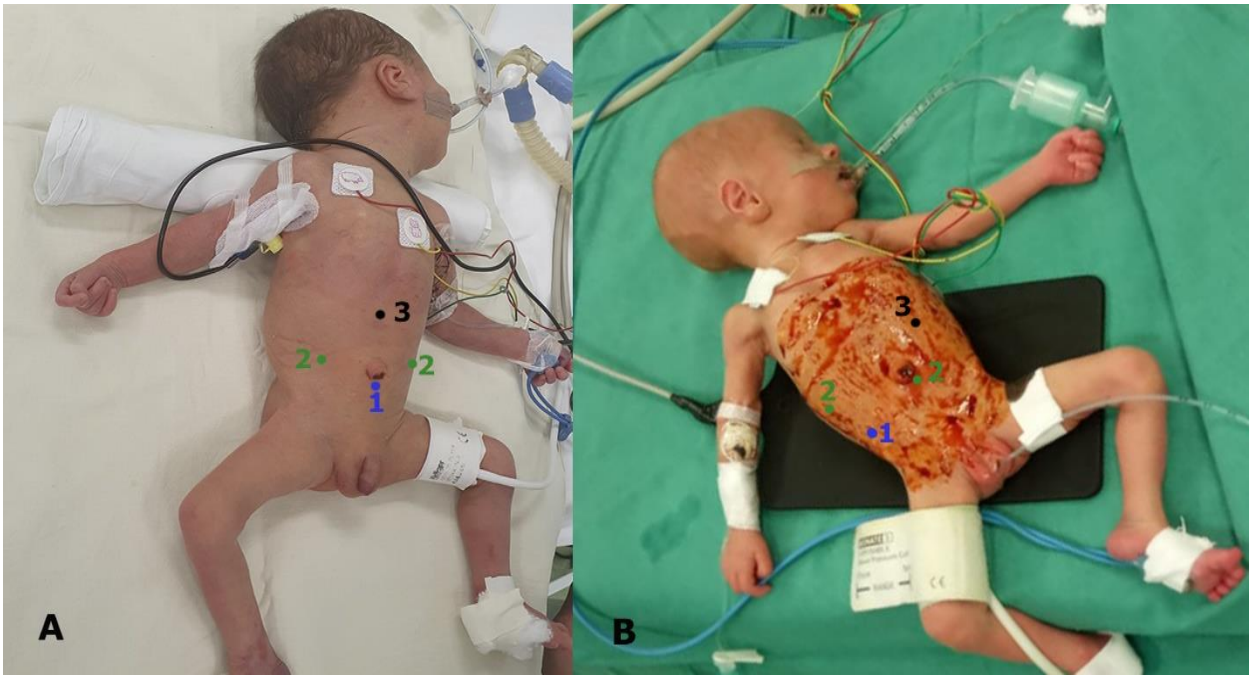

Figure 5. Patient position and placement of trocars: A - position across the table, B - position across the table with a 45° counterclockwise rotation (1 - place for the optical trocar, 2 - places for manipulators, 3 - place for fixing the duodenum).

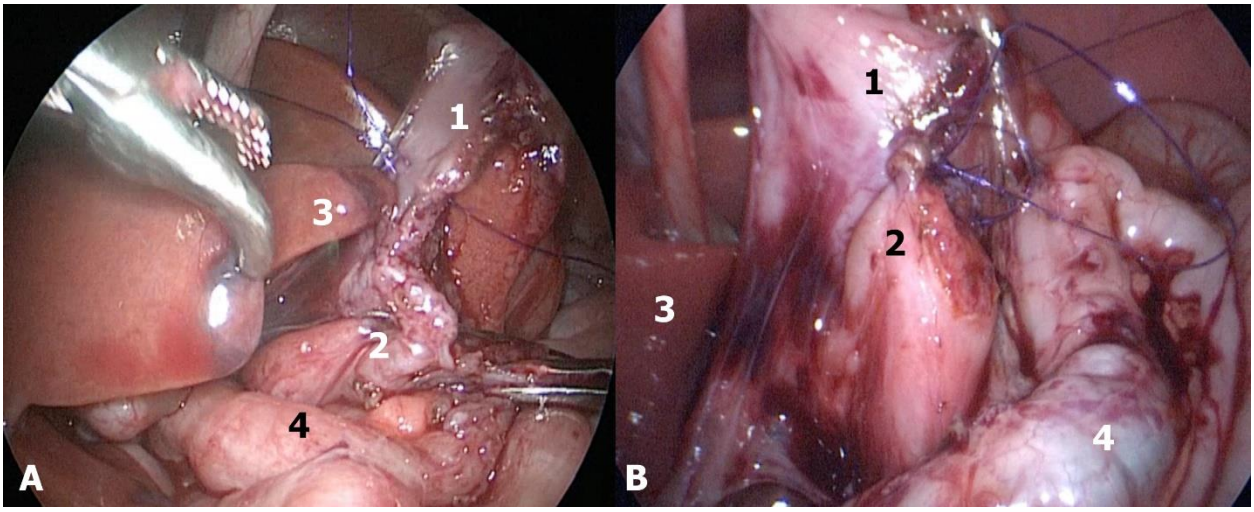

Figure 6. Intraoperative view of the right wall of the anastomosis: A – optics in umbilical region, B – optics in right mesogastrium (1 - proximal duodenum, 2 - distal duodenum, 3 - liver, 4 – transverse colon).

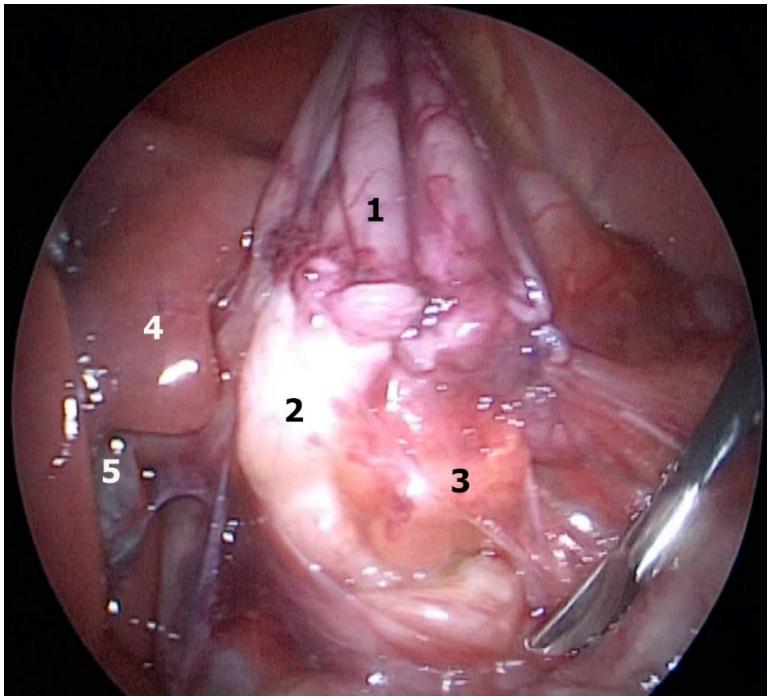

Figure 7. Final view of the anastomosis (1 - proximal duodenum, 2 - distal duodenum, 3 - pancreas, 4 - liver, 5 - gallbladder).

Results

Surgery was performed in all 27 patients in our cohort. The operation time for open surgery was 155±24 minutes (135-165 minutes), no intraoperative complications were noted. Postoperative complication was noted in 1 (3%) child who had an anastomotic failure. He was an infant with a weight of 2124 g with the anastomotic failure detected on the 6th postoperative day. After a repeat reconstruction 6 days later, the anastomotic failure recurred. Thirteen days after the third operation, this child died due to the development of respiratory, cardiovascular, and renal failure.

Another child who underwent open procedure and finally died was a baby with Down syndrome, heart defect, and perinatal contact with Human immunodeficiency viruses. He died on the 18th day after the operation due to a severe infection.

Comparative results of the treatment of children with the laparoscopic technique are presented in Table 2.

Table 2. Comparison of the results of treatment of children in groups I and II.

	Group I	Group II	U_{emp}	U_{cr}	p
Operation time (min)	115±17,3 (75 - 165)	91±4,4 (85 - 100)	15	27-37	<0,05
Intraoperative complications (n)	1 (4%)	0 (0%)	60	27-37	>0,05
Postoperative complications (n)	3 (11%)	0 (0%)	50	27-37	>0,05
Lethal outcome (n)	4 (15%)	1 (4%)	51,5	27-37	>0,05
The use of narcotic analgesics (n)	2 (7%)	0 (0%)	31,5	14-21	>0,05
The use of epidural analgesia (n)	7 (26%)	10 (37%)	31,5	14-21	>0,05
Duration of inotropic support (days)	3,8±0,55 (3 - 5)	0	13,5	14-21	<0,05
Duration of lung ventilation (days)	3,6±1,70 (1 - 6)	1±0,44 (0 - 2)	13,5	14-21	<0,05
Stay at intensive care unit (days)	12,9±3,65 (6 - 22)	5,8±2,1 (3 - 13)	6	14-21	<0,05
Starting enteral feeding after procedure (days)	9,7±2,67 (6 - 18)	6,3±0,74 (5 - 7)	11	14-21	<0,05
Discharge from the hospital after procedure (days)	30,1±10,12 (14 - 58)	23,3±4,72 (18 - 35)	18,5	7-13	<0,05

(U_{emp} – U empirical, U critical for a sample of 23 observations is 27-37, and then decreases to 14-21 as we exclude from further analysis children who died, the last range is 7-13 as we exclude premature children who stayed in neonatal department for a long time after surgery and their time of hospital stay was not related to the operation).

A comparative analysis showed a statistically significant reduction in the time of surgery, the duration of inotropic support of the cardiovascular system, mechanical ventilation, stay in the intensive care unit and the time to start enteral feeding in the second group. We can attribute these differences to, of course, the accumulation of experience of the surgical, anesthetic and resuscitation team, but technical features make a significant contribution to this result as well. We can also note the absence of intraoperative and postoperative complications in the second group; however, these observations were not statistically confirmed. Further research is needed to obtain statistically reliable data.

Intraoperative complication was noted in 1 child in the form of injury of the atypically located Wirsung duct. During the blunt division of the transverse duodenal ligament, the duct located outside the pancreatic

parenchyma was ruptured because it was impossible to differentiate it within the ligament tissue during mobilization (Fig.8). It was decided intraoperatively to create an anastomosis by suturing the end of the duct into it[10].

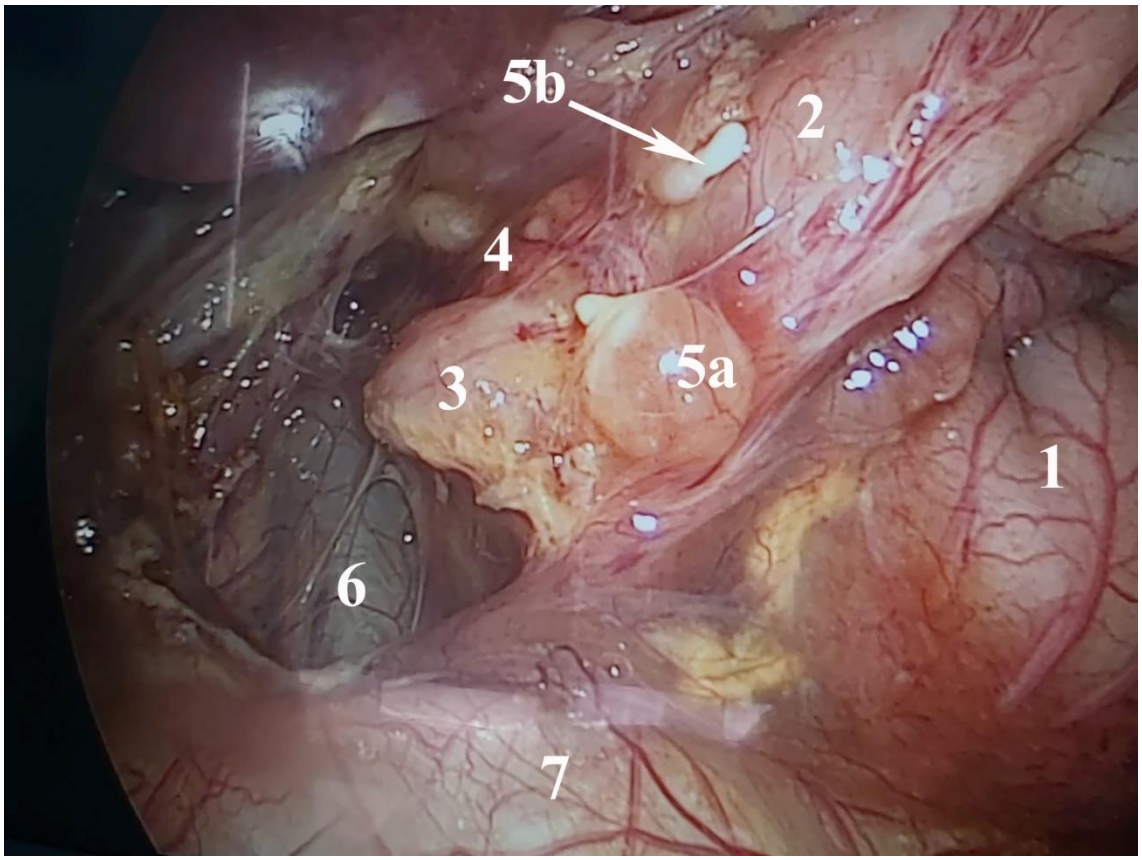

Figure 8. Intraoperative picture after damage of the pancreatic duct: 1 – stomach, 2 – proximal duodenum, 3 – distal duodenum, 4 – annular pancreas, 5a – proximal (extended) part of the Wirsung duct, 5b – distal (narrow) part of the Wirsung duct, 6 – inferior vena cava, 7 – transverse colon.

During the postoperative period, the children were on extended epidural analgesia for 3 days, which, in combination with laparoscopic surgery, allowed us to avoid the use of narcotic analgesics and, therefore, there was no need for hemodynamic support with inotropic drugs. All of that, in turn, allowed for early weaning from mechanical ventilation, and in 2020 and 2021 most patients were extubated immediately after the end of the surgery. This approach provided an opportunity for early transfer from the intensive care unit to the surgical department. Bowel passage was mostly restored on the 4th day after surgery, and enteral feeding was started on the 5th day after surgery with high hydrolyzed protein formulas. Subsequently, a gradual transition to breast milk was possible.

Postoperative complications were observed in 3 children from the group I. One child with Wirsung duct trauma described above had an anastomotic failure and two more children had a perforation of the distal segment of the duodenum. A premature infant at 26 weeks of gestation with a weight of 1137 g had a

perforation occurred on the 2nd day after the surgery. The second child with Down syndrome and a heart defect presented perforation on the 9th day after laparoscopic anastomosis. All re-operations were performed using the laparotomy access. There were 7 (26%) lethal outcomes in our series: 2 after open surgery; 5 after laparoscopic surgery: 3 children with the complications described above and two more children. One premature infant with a very low body weight with Ivemark syndrome and a heart defect died on the 28th day after the operation due to a severe course of intrauterine infection complicated by ulcerative-necrotizing enterocolitis, pneumonia, respiratory, and cardiovascular failure. And a girl with VATER-association with cystic dysplasia of the kidneys developed renal failure, which was complicated by pulmonary hypertension led to death on the 30th day after surgery.

The average length of postoperative hospitalization in other cases was 29±10.5 days. Currently, the follow-up period is 34±11.2 months, and a pediatric surgeon in the follow-up clinics monitors the children. Weight gain, the presence of gastritis and gastro-duodenitis due to the slow passage through the anastomosis are evaluated. No such disturbances were detected in our series.

Discussion

The detection of CDO during antenatal diagnosis is quite high. The classic ultrasound antenatal criterion is a "double bubble sign", which is confirmed in the postnatal period on X-ray as two levels of fluid.[6] The ultrasound sign of "neutrophil nucleus" is also known, indicating a combination of duodenal obstruction and esophageal atresia[11]. According to different authors, the antenatal defect was detected in 55-71% of patients[6,8] Late hospitalization of children with CDO is mainly associated with an atypical clinical picture in the absence of an antenatal diagnosis. Significant partial obstruction of the duodenum may present with vomiting in the neonatal period. Some authors suggest that if the duodenal membrane has a hole large enough to allow liquid food to pass through, or elastic and can stretch over time, this will lead to late manifestations of intestinal obstruction, already when switching to solid food. The most common symptoms in these cases indicate partial obstruction, food regurgitation, dyspepsia, pain, malabsorption due to bacterial overgrowth. CDO with annular pancreas can be detected even later, in adulthood manifesting with signs and symptoms of gastroesophageal reflux disease, peptic ulcer, pancreatitis, gastric outlet obstruction, recurrent duodenal obstruction, and gastric cancer[2].

The use of additional diagnostic methods during the preoperative stage is not frequently required, in most cases indications for surgery are based on X-ray examination. However, in doubtful cases, the most informative method is a contrast study of the gastrointestinal tract[8].

All authors describe the combination of duodenal obstruction and other congenital malformations. The most commonly encountered are chromosome 21 trisomy and congenital heart defects[6,8,12] The authors also agree that surgery should be performed on newborns after the stabilization of their condition[2,8].

The method of operation largely depends on the surgeon's preferences. For example, S. Rothenberg et al[6] presented their experience

of mastering the Kimura laparoscopic operation they describing the stages of technology implementation. After experiencing a large number of complications initially, surgeons abandoned laparoscopy for duodenal obstruction for 5 years. During this time, they made changes to the surgical technique, which allowed them to introduce it into practice in an improved form and achieve good reproducible results. On the contrary, other authors do not see the particular benefit of laparoscopy for correcting CDO. In their article, Bethell and colleagues summarized a four-year experience of correcting this defect in the United Kingdom, where open surgery was performed in 97 cases compared to 5 laparoscopic procedures[8].

The presence of combined developmental defects necessitated the need for simultaneous operations, such as Ladd procedure or colostomy in case of anorectal malformation.[6] According to some data, combined correction was required in almost half of the children in the series.[12] Esophageal atresia was found in 2-7% of cases and it required mandatory radical or staged correction.[7,8,12]

Data on operative time in different articles vary, and some authors do not provide it at all.[7,8] In articles with such a comparison, we found statistical evidence of the predominance of the time of laparoscopic surgery over open surgery. A more detailed analysis made it possible to estimate the size of the compared groups, and in these articles the group operated on openly was significantly larger than with laparoscopic operations.[12,13] On the one hand, it would be more promising to conduct studies in which surgeons with great experience in open surgery could compare their results with surgeons who predominantly operate laparoscopically. It would help us to understand how the operation time is influenced by such parameters as surgical access and suturing the wound, mobilization of the duodenum and its adaptation for anastomosis, suturing of the anastomosis with continuous or interrupted suture, intubation of the distal duodenum or not. Then a detailed analysis would be informative when compared with the results of treatment. But on the other hand, operative time is just time to work, there is no competition and no surgeon will sacrifice the quality of their work in favor of shortening the operation time.

The use of epidural analgesia in the intraoperative and postoperative period is not evaluated in most surgical articles, sometimes one can find data on the timing of the use of narcotic analgesics.[12] These data are mainly presented in the articles of anesthesiologists-resuscitators. In their paper, Zeev Shenkman et al[14] presented data on the use of epidural analgesia in small-weight premature babies during surgical interventions are presented. The authors proved that, in combination with epidural anesthesia, light general anesthesia was possible with minimal doses of muscle relaxants and without systemic opioids. It allowed for early tracheal extubation and therefore required less intensive care unit resources. Tracheal extubation in their observations was usually performed in the operating room. Epidural infusion provides excellent postoperative analgesia. It attenuates the hormonal-metabolic stress response to surgery[15,16,17], may improve lung function earlier, allows for earlier recovery, and bowel

function may recover earlier.[14] From our point of view, it is also worth noting several important advantages. The use of systemic opioid analgesics leads to a decrease in blood pressure, which in newborns and premature babies requires the introduction of vasopressor drugs. Periodic use of opioids for pain breakthroughs creates conditions for the development of stress conditions in the patient, which will provoke a response of their own hormonal system with an uncontrolled release of adrenaline or noradrenaline, which in turn also negatively affects the blood supply to the gastrointestinal tract in general and the anastomosis zone as well.

Reviewing the literature did not reveal any information about the presence of the abnormally located Wirsung duct in the observations of other authors. Discussing this variant of the anomaly with colleagues, both pediatric surgeons and specialists in pancreatic surgery in adulthood, allowed us to be convinced of the uniqueness of this observation. We additionally presented this case in a separate article.[10]

Among postoperative complications, anastomotic insufficiency currently is not the most common. Surgeons mainly describe wound infections, suture dehiscence, and ventral hernia formation[8,12]. However, David van der Zee, who was the first to perform laparoscopic Kimura anastomosis, stated that from 2005 to 2008 they were even forced to stop performing laparoscopic duodeno-duodenal anastomoses due to an "unprecedented" number of insufficiencies. In the group before 2005 the occurrence of insufficiencies was 23%. However, accumulating experience and improving the surgical technique allowed them to return to laparoscopy for the correction of CDO and avoid conversions, complications, and repeated surgeries.[7]

At the time of the first correction of CDO by Ladd in 1931[18], the mortality rate was 40%.[6] The development of neonatal resuscitation, parenteral nutrition, and the ability to manage concomitant conditions has reduced mortality to 5-10%. In addition, in most cases, fatal outcomes are due to concomitant pathology, primarily the cardiac one.[7] In our study, the mortality rate was 26%. In 6 cases lethal outcomes occurred on average 17.3±8 days after surgery due to respiratory and cardiac failure because of a severe septic process or cardiac failure. In 1 child with Down syndrome and a heart defect lethal outcome occurred on the 13th day after repeated surgery for ulcerative necrotizing enterocolitis.

The severity of the postoperative period and the development of systemic disorders were mainly associated with a long enteral pause and the inability to compensate for the nutritional needs of newborns using parenteral supplementation. To overcome this limitation, various techniques for intubation of the jejunum with the passage of a feeding tube beyond the anastomosis zone and drainage systems of the stomach and proximal duodenum have been proposed. Trans-anastomose tube (TAT) feeding resulted in earlier feeding initiation and faster achievement of full nutrition compared to oral gastric drainage alone.[2] Kimura et al. reviewing their experience with diamond-shaped anastomosis, demonstrated earlier recovery of anastomotic function in their patients.[19] For many surgeons, this has

become a reason to abandon the routine practice of intubation of the anastomotic site and has led to different approaches to the early initiation of enteral feeding[20] Nevertheless, Bethell et al. in their article noted that TAT feeding was used quite actively in combination with parenteral nutrition or even isolated.[8] Our observations showed a significant reduction in the time to start enteral feeding in the group with a modified surgical approach of Kimura's laparoscopic procedure. We believe that both the reduction in postoperative complications and the absence of the use of opioids in combination with epidural analgesia play a role here. Thus, we can avoid intestinal intubation in children, which is very important in children with low and extremely low body weight, in which an additional intraluminal tube can create unwanted compression on both the anastomotic wall and the intestinal wall, which can provoke the development of perforation in compression site.

The length of postoperative hospital stay is an important economic indicator of the effectiveness of the proposed technique, and it often becomes another parameter for speculating on the topic of open versus laparoscopic surgery. In our series, the main contribution to the increase of this parameter was made by premature babies who were no longer under the surgeon's supervision, but still needed to be cared for in neonatal departments. Bethell also noted in his findings that 25% of children stayed in the clinic longer than 28 days.[8] Therefore, we believe the parameters described above fully allow us to compare various methods for correcting CDO at the present time.

We consider the tactics of postoperative follow-up in the long-term period to be an important issue. Unfortunately, regular long-term follow-up examinations are not available either for the surgeon or for the patient. The follow-up of such patients is carried out by a pediatrician or a general practitioner, depending on the characteristics of the healthcare system in the region. In order to ensure a full-fledged dispensary observation with timely detection of signs of long-term complications of surgical intervention, surgeons need to offer an accessible algorithm for identifying known and hypothetical complications. In our series, we did not observe any long-term complications. Though, in these children could be observed such complications as a delay in weight gain, the presence of gastritis and gastroduodenitis, excessive bacterial growth due to slow passage through the anastomosis, and adhesive obstruction. Several authors describe gastroesophageal reflux that occurs in a significant number of patients after CDO. It is thought to be exacerbated by gastric emptying dysfunction and can be treated medically, although 5% of patients have been reported to require surgery. Aside from the above, technical complications such as anastomotic leak, ductal injury, pancreatic fistula, or a missed atresia in a patient with multiple disorders are fortunately rare.[2]

Conclusion

Conginental duodenal obstruction is a defect detected antenatally, genetic abnormalities and associated developmental defects also can be found in such patients. Giving birth in a specialized maternity hospital allows to avoid transportation of the newborn and

provides timely surgical treatment even in severe conditions. In all cases of ulcerative necrotizing enterocolitis consultation of a pediatric surgeon is necessary to exclude any malformations of the gastrointestinal tract. X-ray is the most reliable method to verify the diagnosis, and in doubtful cases, fluoroscopy with water-soluble contrast can be used to determine the indications for surgery. In cases of duodenal obstruction when gastric drainage is adequate through a gastric-tube, the operation can be delayed until the patient's general condition is stabilized. However, it should be noted that the presence of esophageal atresia in combination with duodenal obstruction is an indication for urgent surgery, as the risk of aspiration or stomach rupture is very high. There are no restrictions on performing laparoscopic correction of CDO. This minimally invasive technology allows for combined operations on the organs of the thoracic and abdominal cavity and reduces the duration of surgery. This method of correction, combined with prolonged epidural analgesia, reduces the length of the patient's stay in the intensive care unit and the need for parenteral nutrition, which ultimately reduces the risks of inflammatory complications and treatment costs.

Conflicts of Interest Statement:

The authors have no conflicts of interest to declare.

Author Contribution:

N.S. and E.E. are responsible for study concept and design. N.S., E.E. and S.S. are responsible for acquisition of data. A.M. is responsible for conducting anesthesiologic date, its interpretation and analysis. N.S. and D.K. are responsible for data interpretation and analysis. N.S., D.K. and E.E. are responsible for editing. E.E. and S.Sh. are responsible for critical revision of the manuscript for important intellectual content. N.S., E.E. and S.S. are responsible for statistical analysis. N.F., D.K. and S.Sh. are responsible for administrative, technical, or material support. N.S. has full access to all the data and takes responsibility for its integrity, accuracy, analysis and so is the guarantor of content.

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Highlights

Antenatal diagnosis of Congenital duodenal obstruction with subsequent delivery in a specialized maternity hospital allows for timely surgical treatment even in severe conditions.

The laparoscopic Kimura anastomosis can be performed in all newborns even with low weight and it allows for combined operations on the organs of the thoracic and abdominal cavity if necessary.

The use of prolonged epidural analgesia reduces the length of stay in the intensive care unit and allows for early enteral nutrition.

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