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OPTIMIZATION OF LAPAROSCOPIC INTERVENTION TACTICS FOR MECKEL'S DIVERTICULUM IN CHILDREN

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Abstract:

The article discusses the effectiveness of laparoscopic interventions (LI) for Meckel's diverticulum (MD) in children. A total of 174 patients were examined from 2006 to 2021. The pathology was observed mainly in children under 3 years of age (38.8%), in 58% of cases the patients were hospitalized with suspected appendicitis. The indication for laparoscopy was the picture of acute abdomen and gastrointestinal bleeding. 98 laparoscopies and 76 laparotomies were performed, with an increase in LI and a decrease in conversions, i.e. the transition from laparoscopies to open interventions, noted. When performing KD, there is a decrease in blood loss, relief of pain, rapid normalization of temperature, early activation of patients, and the duration of hospitalization decreased from 9 to 3 days. The results of the study show the high effectiveness of laparoscopic interventions in children.

Keywords: Meckel's diverticulum, children, laparoscopy, laparotomy, bleeding, patient mobilization.

RELEVANCE. Meckel's diverticulum (DM) is the most common congenital gastrointestinal pathology, detected in 2-3% of children, more often in boys. (1,4,8) In about 50% of cases, clinical manifestations are detected in children under 10 years of age, and in the rest - at the age of up to 30 (2, 7,8). DM in children is difficult to diagnose and can be asymptomatic throughout life. At the same time, in some children, it manifests itself with the clinic of acute abdomen already at an early age. Improving diagnostic and therapeutic algorithms for DM in children is an urgent task of pediatric abdominal surgery and paediatrics in general (2,4,7,10,11).

Characteristics of Meckel's diverticulum: abdominal pain (the most common symptom), intestinal obstruction, and gastrointestinal bleeding (3,5,10). The prevalence and severity of each of them depend on the anatomical features, the presence of ectopic tissues in the diverticulum wall with different morphofunctional characteristics, and the patient's age. But in most cases, they manifest in the order given.

Meckel's diverticulum is the cause of more than 50% of cases of small intestinal bleeding in children under 2 years of age. The possibilities of preoperative diagnostics of DM are minimal, not exceeding 12-25%. At the same time, a certain value is acquired by a set of special research methods (ultrasound of abdominal organs, radionuclide method, etc.), the diagnostic capabilities of which are different (3,8,12).

MATERIAL AND METHODS: Our report presents the examination and treatment results of 98 children admitted from 2006 to 2021 to the Department of Pediatric Surgery of the Russian Scientific Center for Emergency Medicine and Medical Care, who underwent surgical interventions for Meckel's diverticulum and its complications.

Retrospective analysis was performed on archival materials and case histories of children. The ages of children ranged from 1 month to 17 years (Table 1). Boys constituted the overwhelming majority (64.3%; 63 out of 98).

Table 1.
Distribution of examined patients by gender and age

Age/Gender	1 month – 1 year	1-3 years	3-7 years	7-13 years	13-17 years old	Total
Boys	6	23	14	10	9	63 (64.3%)
Girls	3	15	9	5	4	35 (35.7%)
Total	9	38	23	15	13	98

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%	9.2%	38.8%	23.5%	15.3%	13.2%	100%

Also, in terms of age, the relatively largest proportion were children of early childhood (1-3 years) – 38.8%, the next most frequent were children of preschool age (3-7 years) – 23.5%, children of school age (7-13 years) made up 15.3%, and the least in our study were infants (1 month – 1 year) – 9.2%.

RESULTS OF THE STUDY. The patients were referred to the clinic with the following preliminary diagnoses (Fig. 1): acute appendicitis was suspected in the majority of cases (58.2%), gastrointestinal bleeding was suspected in 26.5% of cases, Meckel's diverticulum was differentiated in only 10.2%, and the least number of patients (5.1%) were given a preliminary diagnosis of acute intestinal obstruction. It is interesting that during the initial examination, the diagnosis of Meckel's diverticulum was not confirmed in the vast majority of patients, or there was no suspicion of its possible presence.

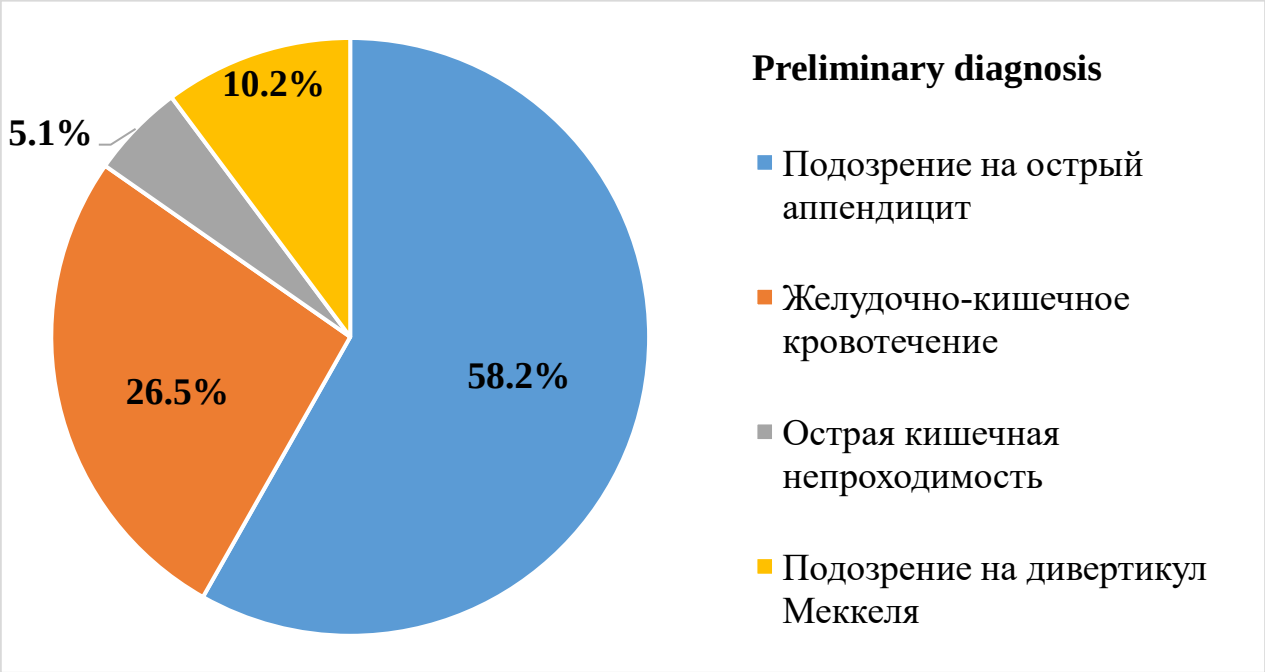

Fig. 1. Distribution of patients according to the referring diagnosis

The following clinical situations (Table 2) served as indications for laparoscopic surgery for Meckel's diverticulum: the presence of symptoms of acute abdomen (n = 60), gastrointestinal bleeding - GI (n = 26) and acute intestinal obstruction - AIO (n = 12).

Table 2.
Symptoms of Meckel's diverticulum

Syndrome	n	%
Acute abdomen	60	61.22%
Housing and communal services	26	26.53%
OK	12	12.25%
Total	98	100%

As minimally invasive abdominal surgery in children was introduced and the experience was accumulated, indications and contraindications for endoscopic diagnostic and treatment methods changed towards expanding the indications. Absolute contraindications to laparoscopy in children:

- the child's extremely serious condition,
- cardiovascular and respiratory failure,
- severe coagulopathy,
- conditions that prevent safe aseptic insertion of trocars.

Relative contraindications:

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- prediction of the total adhesive process in the abdominal cavity of a child based on the anamnesis, the intraoperative situation during previous interventions, and the results of instrumental diagnostics;
- pronounced swelling of the intestinal loops, which prevents laparoscopic manipulation due to the impossibility of achieving the required volume of the abdominal cavity.

DIAGNOSTIC LAPAROSCOPY.

It was performed under endotracheal anaesthesia. *Preoperative preparation* depended on the patient's condition and the choice of surgical intervention - emergency or planned surgery.

The patient's position on the operating table is horizontal, on his back.

Stages of diagnostic and laparoscopic diverticulectomy :

- Introduction of three trocars;
- Revision of the abdominal cavity;
- Revision of intestinal loops;
- Isolation and mobilization of the intestinal section with DM;
- Diverticulectomy (various methods);
- Performing simultaneous operations (as indicated);
- Sanitation and drainage of the abdominal cavity (as indicated)
- Suturing wounds of the anterior abdominal wall.

It should be noted that after the detection of Meckel's diverticulum, it was isolated and mobilized, and adhesions were cut. The situation was also assessed to determine the surgical tactics: open or invasive diverticulectomy. Laparoscopic diverticulectomy was performed with the application of Raeder's nodal sutures, resection of the ileum with the diverticulum and application of a side-to-side anastomosis, and resection of the small intestine with the application of a small-to-small intestinal anastomosis. If the laparoscopic intervention was impossible, a mid-midline laparotomy or mini-laparotomy with video assistance was used.

During laparoscopy, the anatomical features were clarified intraoperatively and the localization options of the DM were determined. Thus, we found that in the vast majority of cases (95.9%) the length of the diverticulum was from 2 to 8 cm and only in 4 cases (4.1%) the length was more than 10 cm, the conical shape of the diverticulum was detected in 54 (55.1%) children, cylindrical in 38 (38.8%); and pear-shaped was observed in 6 (6.1%) cases.

The base of the diverticulum was more than 2 cm wide in 53.1% of cases, and in the remaining (46.9%) cases the base width was less than 2 cm.

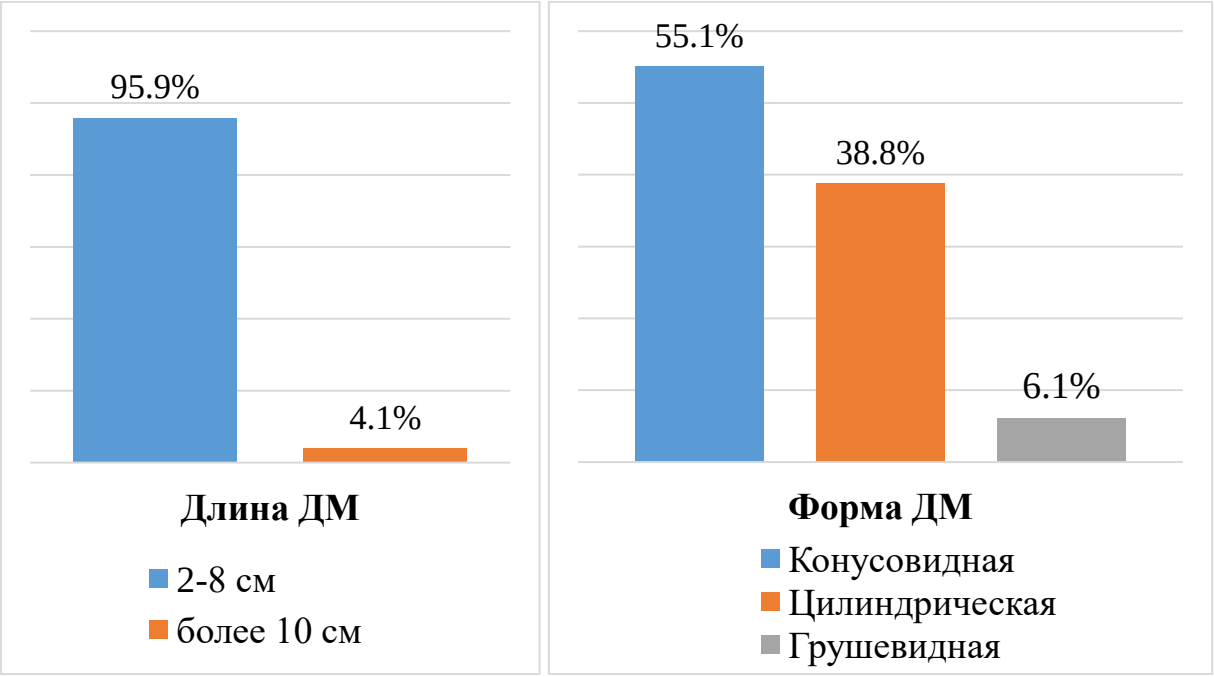

Fig. 2. Variations in the size and shape of Meckel's diverticulum itself

The next feature of the anatomical location of the diverticulum is the ileocecal angle, which was located at a distance of 20 to 100 cm from the diverticulum itself in the overwhelming majority of patients - 94.9%.

Also, a feature of the localization of DM was that it could be located along the antimesenteric edge (52.1%), on the lateral surface (41.8%) and on the mesenteric edge (6.1%).

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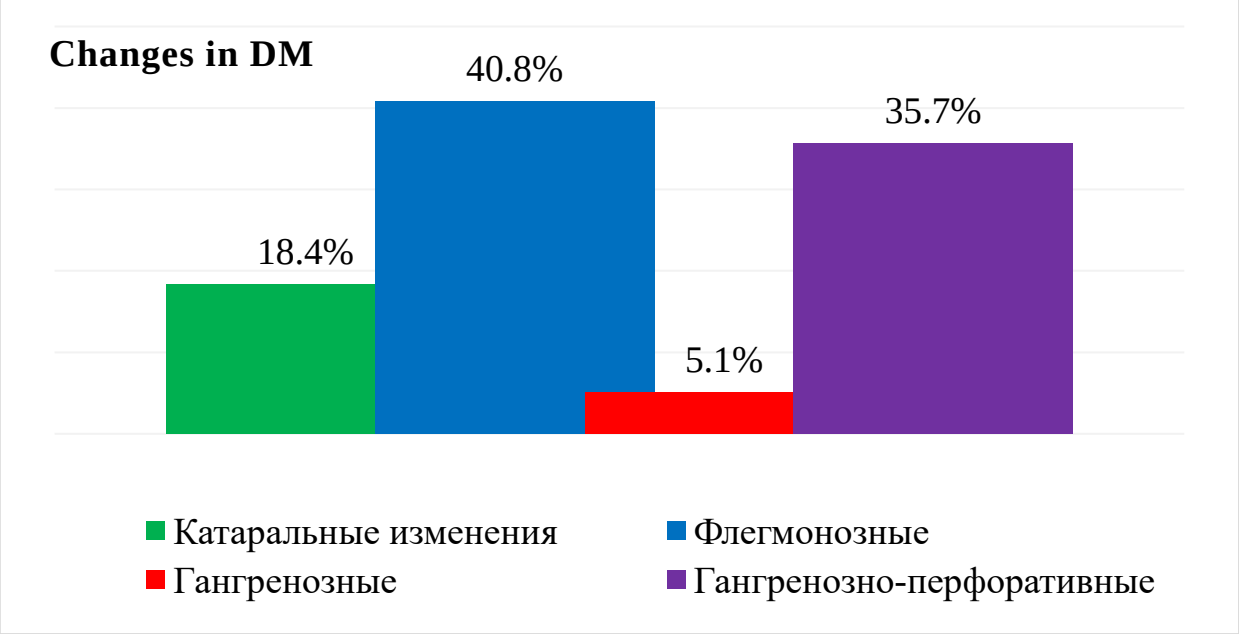

Fig. 3. Variants of pathological changes in Meckel's diverticulum

During the laparoscopic procedure, the visual assessment revealed catarrhal (40.8%), phlegmonous (18.4%), gangrenous (35.7%), gangrenous -perforative (5.1%) changes in the diverticulum (Fig. 4).

The relationship between the frequency of laparoscopy and the reduction in the proportion of unjustified open surgeries for DM in children (Fig. 5.7) changed with a statistically significant difference in different periods of the study and the introduction of minimally invasive surgery in pediatric practice. Thus, if in the period from 2006 to 2013, the proportion of laparoscopy was only 36.9%, then by the present period this figure has increased to 74.4%.

	2006-2013	2014-2021	Total
Laparoscopy	31 (36.9%)	67 (74.4%)	98 (56.3%)
Laparotomy	53 (63.1%)	23 (25.6%)	76 (43.7%)
Total	84 (100%)	90 (100%)	174 (100%)

Table 3. The proportion of laparoscopies for Meckel's diverticulum in different periods of the study

Laparoscopic diverticulectomy with the application of Raeder's interrupted sutures was performed in 32 (32.7%), i.e. in one-third of patients. This intervention was supplemented by appendectomy in 11.2% of cases with concomitant inflammation of the appendix. Application of extracorporeal sutures was performed in 16 (16.3%) patients, and single-row sutures - in 3 (3.1%). Laparoscopic resection of the ileum together with the diverticulum and application of a side-to-side anastomosis (6.1%) was performed in destructive forms of DM involving the ileal wall - due to the discrepancy in the diameter of the proximal and distal parts of the small intestine after resection. In 8.2% (8 of 98) of cases, it was possible to perform a resection of the small intestine with the application of a small-to-small intestinal anastomosis. Conversion to mid-midline laparotomy was performed in 5 (5.1%) patients, and mini-laparotomy with video assistance was performed in 17 (17.3%) children (Table 5.3).

Table 4.
Summary distribution of patients by type of surgical treatment in the group of laparoscopic diverticulectomies

Type of intervention a	Laparoscopy in DM (n=98)	
	n	%
with the imposition of Raeder's nodal sutures	32	32.7%
with the imposition of Reder's nodal sutures + appendectomy	11	11.2%
with the imposition of extracorporeal sutures	16	16.3%
with the imposition of single-row sutures	3	3.1%

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Laparoscopy. Minilaparotomy with video assistance. Wedge resection	17	17.3%
Laparoscopy, mini-laparotomy with video assistance, ileal resection together with DM with side-to-side anastomosis	6	6.1%
Laparoscopy with small bowel resection and small-to-small bowel anastomosis	8	8.2%
Conversion to laparotomy	5	5.1%
Total	98	100.0%

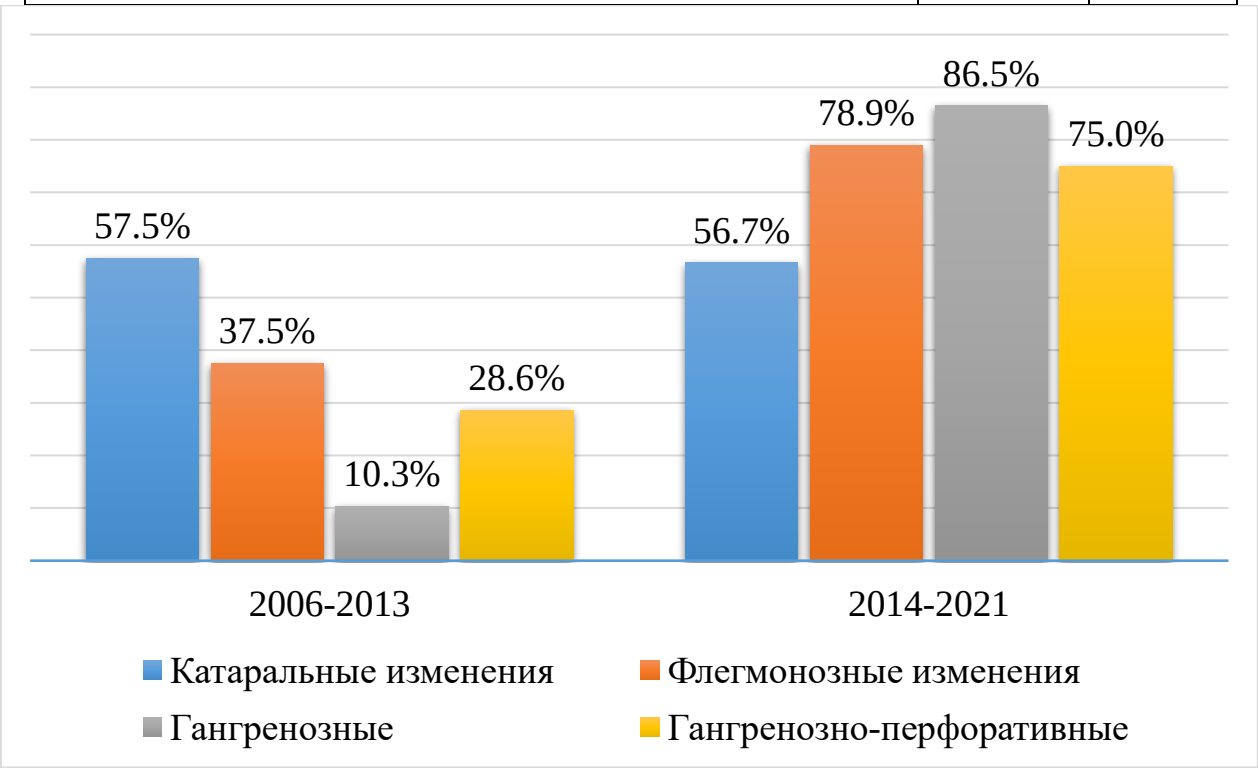

Fig. 4. The rate of use of laparoscopic technique for various forms of Meckel's diverticulum

The level of development of minimally invasive surgery for DM in children can be determined by the indicator of the use of laparoscopic techniques in complex cases (Fig. 8).

As can be seen from Fig. 5, the frequency of using laparoscopy in the gangrenous form increased from 10.3% to 86.5% ($\chi^2 = 34.8$, $p < 0.001$), in the phlegmonous form - from 37.5% to 78.9% ($\chi^2 = 4.23$, $p = 0.037$), gangrenous - perforative form - from 28.6% to 75% ($\chi^2 = 2.3$, $p = 0.13$).

The conversion rate to open surgery was reduced from 9.7% (3 of 31) to 3.0% (2 of 67), and the conversion to mini-laparotomy access with video assistance from 35.5% (11 of 31) to 8.9% (6 of 67) with a statistically significant difference ($\chi^2 = 11.59$, $p = 0.0005$) as the indications expanded and the laparoscopic technique of diverticulectomy was introduced (Fig. 6).

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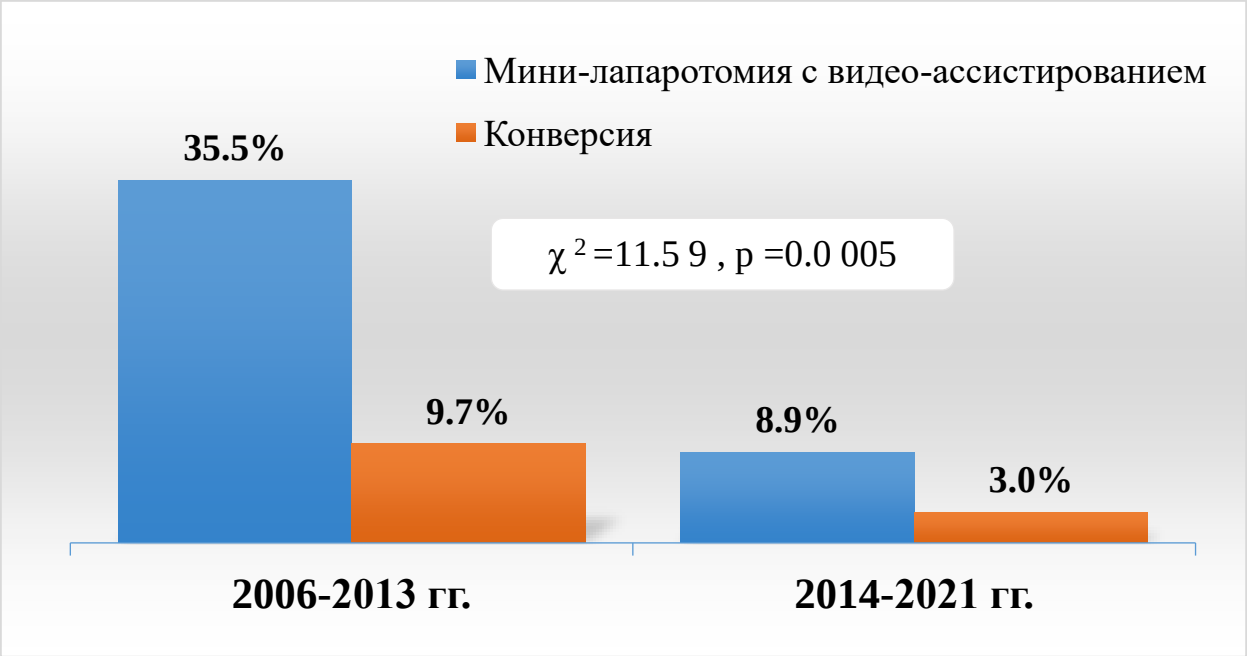

Fig. 5. Conversion rates for laparoscopic diverticulectomy at different study periods

From Fig. 6 it is evident that the reasons for conversion in 5 cases and transition to mini-laparotomy access in 17 cases were the presence of pronounced inflammatory and ischemic disorders in the diverticulum itself, as well as the intestine (9.1%), a wide base of the diverticulum (45.5%) and giant dimensions of about 200 cm (13.6%), destruction involving the wall of the ileum (22.7%) and concomitant acute gangrenous appendicitis with local peritonitis (9.1%). The results of the treatment of DM using the minimally invasive technique (laparoscopy) were analyzed by comparison with the group of open surgeries. The criteria were intra- and postoperative parameters, such as the duration of surgical intervention, the frequency of intraoperative complications, the length of the patient's stay in the hospital and the frequency of postoperative complications. The group of traditional operations (n = 76) was selected by statistical comparison with the group of laparoscopy (n = 98). Open operations were also performed for different variants of changes in the DM. Among them, 39.4% of cases were catarrhal diverticulum, 43.4% of patients had gangrenous changes in the diverticulum, 9.2% had phlegmonous forms, and 7.9% (6 of 76) had gangrenous-perforative changes in Meckel's diverticulum (Table 5). No intraoperative complications were observed in patients from the laparoscopy group and the laparotomy group for DM. The duration of laparoscopy was significantly shorter than that of open surgery through laparotomy - 38.4 ± 7.2 (from 45 to 60 min) versus 62.6 ± 8.4 minutes (from 57 to 74 min). The average volumes of intraoperative blood loss were 140 ± 8.2 and 12 ± 1.2 ml in the laparotomy and laparoscopy groups, respectively.

DISCUSSION. Children generally tolerated surgical interventions for Meckel's diverticulum well. At the same time, the early postoperative period in traditional open surgeries was characterized by the development of complications in 10.6% (8) of cases. Formation of an infiltrate in the abdominal cavity was detected in 4 (5.3%) patients, which required additional conservative treatment measures and a longer hospitalization. Wound infection and suppuration of the postoperative wound were noted in 2 (2.6%) patients, which required a repeated course of antibiotic therapy, with the addition of physiotherapy and local therapy for a week. In the postoperative period, acute adhesive intestinal obstruction developed in 2 (2.0%) patients after laparotomy, of which in 1 case this complication was stopped by conservative measures, and in the other case it was necessary to perform a repeated surgical intervention - to separate the adhesions laparoscopically. As a result, repeated interventions in the laparotomy group were required in 1 case, which was not observed in the laparoscopy group. But it is also necessary to note the fact of a more pronounced pain syndrome after laparotomy, while after laparoscopy the pain was easily relieved by non-narcotic drugs. The average duration of persistent pain was 1.8±0.2 days with laparoscopy and 5.2±0.8 days after laparotomy ($p<0.05$).

Table 5.
Comparative characteristics of the study groups

Parameter	Laparotomy for DM (n =76)	Laparoscopy in DM (n = 98)	*p*

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	n	%	n	%	
Sexual characteristic					
Boys	46	60.5%	63	64.3%	>0.05
Girls	30	39.5%	35	35.7%)	
The severity of the condition					
Satisfactory	30	39.4%	20	35.3%	>0.05
Average	28	36.8%	32	39.7%	
Heavy	18	23.8%	46	25.0%	
Symptoms of Meckel's diverticulum					
Acute abdomen	47	61.84%	60	61.22%	>0.05
Housing and communal services	21	27.63%	26	26.53%	
OKN	8	10.53%	12	12.25%	
Length DM, cm					
2-8 cm	70	92.1%	64	95.9%	>0.05
More than 10 cm	6	7.9%	4	4.1%	
Form DM					
Cone shape	42	55.3%	54	55.1%	>0.05
Cylindrical shape	30	39.4%	38	38.8%	
Pear shape	4	5.3%	6	6.1%	
Base DM, cm					
Up to 2 cm	34	44.7%	46	46.9%	>0.05
More than 2 cm	42	55.3%	52	53.1%	
Distance of DM from ileocecal angle, cm					
Less than 20 cm	2	2.6%	3	3.1%	>0.05
20-100 cm	72	94.8%	93	94.9%	
More than 100 cm	2	2.6%	2	2.0%	
Localization of DM					
Against the mesenteric edge	37	48.7%	51	52.1%	>0.05
Lateral surface	33	43.4%	41	41.8%	
The mesenteric margin of the intestine	6	7.9%	6	6.1%	
Pathological changes in the DM					
Catarrhal changes	30	39.4%	40	40.8%	>0.05
Phlegmonous changes	7	9.2%	18	18.4%	
Gangrenous	33	43.4%	35	35.7%	
Gangrenous -perforative	6	7.9%	5	5.1%	

In the laparoscopy group, children had earlier normalization of body temperature, both with complicated and uncomplicated Meckel's diverticulum.

Table 6.
Comparative characteristics of the intra- and postoperative period

Complication	Laparotomy group, n = 76		Laparoscopy group, n = 98		χ^2	R
Operation duration, min	62.6±8.4		3 8.4±7.2		-	< 0.05
Volume of blood loss, ml	140±8.2		12±1.2		-	< 0.01
Infiltrate in the abdominal cavity, n, %	4	5.3%	0	0.0%	5.279	0.022
Wound infection, n, %	2	2.6%	0	0.0%	2 .6	0. 107
Postoperative OSCN	2	2.6%	0	0.0%	2 .6	0. 107
Repeated interventions, n, %	1	1.3%	0	0.0%	1.1	0.513
Pain relief, 24 hours	5.2±0.8		1.8±0.2		-	< 0.05

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Normalization of body temperature, 24 hours	2.8±0.4		1.4 ± 0.2		-	< 0.05
Restoration of stool, 24 hours	2.8±0.2		1.9±0.2		-	< 0.05
Activation of patients, days	2.7±0.4		1.4±0.2		-	< 0.05
Duration of hospitalization, days	8.2±1.1		4.4±0.8		-	< 0.05
Died, n, %	0	0.0%	0	0.0%	-	-

After traditional operations for Meckel's diverticulum, a longer recovery of stool (2.4 days) was recorded than after laparoscopic interventions (1.2 days) due to a significant reduction in the severity of intestinal paresis.

Patients were activated 1.4±0.2 days after laparoscopy and 2.7±0.4 days after laparotomy.

There were no fatalities in either group.

The duration of hospitalization was also reduced with a significant statistical difference ($p<0.05$) when using the laparoscopic technique, averaging 4.4±0.8 days, while in the laparotomy group, this indicator had a value of 8.2±1.1 days.

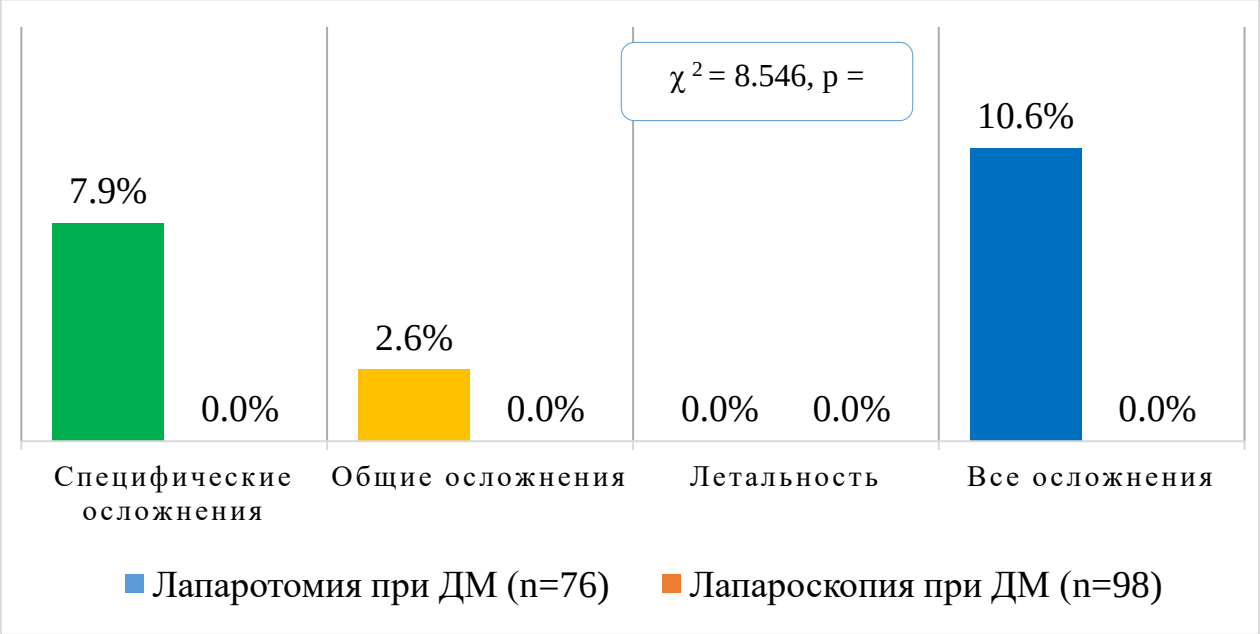

Fig. 6. Results of surgical treatment of Meckel's diverticulum

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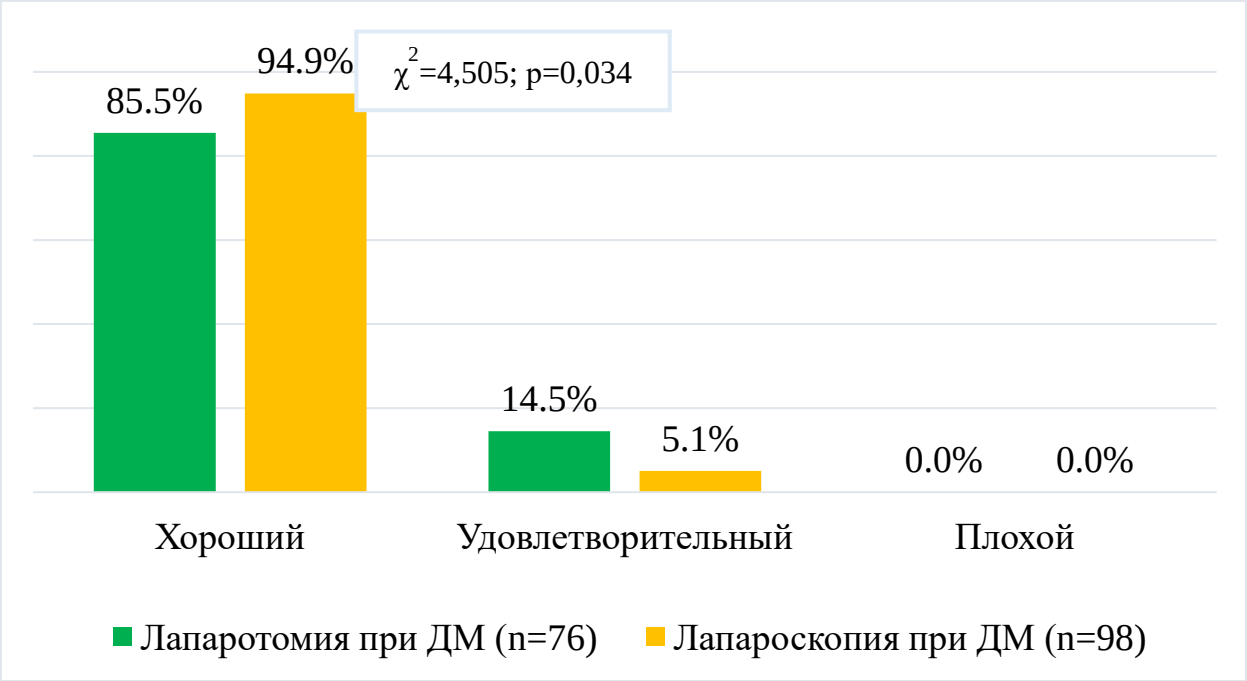

Fig. 7. Summary results of surgical interventions.

Analysis of the pooled results showed that the proportion of good results in the surgical treatment of Meckel's diverticulum in children was higher after laparoscopic operations, amounting to 94.9% (93 of 98) versus 85.5% (65 of 76) after open interventions (Fig. 8).

CONCLUSIONS: Thus, in terms of age, most children with diverticulum Meckel's diverticulum is made up of young children - 38.8%. In 582% of cases, acute appendicitis was suspected in children. The triad of symptoms - a symptom of acute abdomen, gastrointestinal bleeding, and acute intestinal obstruction were the basis for laparoscopic interventions. With increasing experience in video laparoscopic operations, the conversion rate was reduced from 9.7% to 3%. Optimization of the tactical aspects of minimally invasive surgery for Meckel's diverticulum in children made it possible to reduce the frequency of postoperative complications from 10.6% (8 of 76 laparotomies) to 0.0% with a statistically significant difference ($\chi^2 = 8.546$, $p = 0.004$), including the proportion of specific complications was reduced from 7.9% to 0.0%, general complications - from 2.6% to 0.0% (Fig. 8).

The author's contribution to the work is equal.

No conflict of interest is noted.

The article is an initiative, there are no sponsors.

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