

Laparoscopic Assisted Approach to  
Paediatric Meckel's Diverticulum in  
Laparoscopic EraAbdullah Yıldız<sup>1\*</sup>, Mirko Bertozzi<sup>2</sup>, Akgün Oral<sup>3</sup>, Melih Akın<sup>1</sup>, Ali Ahıskaloğlu<sup>4</sup>  
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## Abstract

**Materials and Methods:** The patients were treated either traditionally (open method, Group-1) or laparoscopically (Group-2). After obtaining informed consent, Group-2 patients were submitted to diagnostic laparoscopy under general anesthesia. Briefly, the patient was placed in the Trendelenburg position, after which a 5 mm umbilical port was made for the telescope, two 3 mm or 5 mm working ports were made in the left lower quadrant and a 3 mm or 5 mm port was made in the left suprapubic region using the open Hasson technique.

**Results:** No complications were observed during the procedures in both groups. Follow-up varied from 6 months to 8 years and no complications were observed except one patient who underwent laparoscopic assisted wedge resection for rectal bleeding and was hospitalized with a small bowel obstruction secondary to adhesions 2 weeks later. He was successfully managed with medical treatment.

**Discussion:** We included patients who initially were started laparoscopically and then were converted into an open approach. A comparison of these two groups showed some factors that can be used to predict failure of laparoscopy in a complicated case of MS.

**Conclusion:** In conclusion, laparoscopy can be an alternative to open approach for managing MD in children but the usefulness of laparoscopy is limited when the diagnosis is an intestinal obstruction due to MD.

## Introduction

Meckel's Diverticulum (MD) is a common malformation of the small intestine that occurs in 2-4% of the population with a lifetime complication rate of 4% [1,2]. Although it is usually found incidentally during abdominal surgery, it can produce complications such as inflammation, haemorrhage, intussusception, perforation or intestinal obstruction in children. Because of the low lifetime complication rate, some controversies have been raised regarding resection of incidentally found MD [3,4]. However, the widely accepted consensus is that resection should only be undertaken in symptomatic cases [5].

MD is traditionally resected with an open approach [6]. Because of its advantages, laparoscopic approaches for investigating and treating MD have also been gaining popularity [7]. This retrospective study was based on the outcome of 8-year experiences along with the technical details and clinical results of MD treated at three different institutions where laparoscopic repair is routinely or optionally done. We discuss the most appropriate surgical technique and determine which clinical conditions are appropriate for a laparoscopic-assisted approach to MD.

## Materials and Methods

A retrospective review was performed of case records of patients with MD from November 2007 to November 2015. The children were hospitalized for various reasons such as gastrointestinal bleeding and/or recurrent abdominal pain due to MD. The patients were treated either traditionally (open method, Group-1) or laparoscopically (Group-2). After obtaining informed consent, Group-2 patients were submitted to diagnostic laparoscopy under general anesthesia. Briefly, the patient was placed in the Trendelenburg position, after which a 5 mm umbilical port was made for the telescope, two 3 mm or 5 mm working ports were made in the left lower quadrant and a 3 mm or 5 mm port was made in the left suprapubic region using the open Hasson technique. A pneumoperitoneum of 8-10 mmHg pressure was established with carbon dioxide and insufflation of 0.5 L/min. Systematic inspection of the abdominal cavity and the small bowel were performed. MD was grasped and delivered via the umbilical port side. When identification of the MD was not possible under direct observation, the terminal ileum was grasped and the ileum was explored systematically before starting from the ileocaecal valve through proximally to the working ports. The

umbilical incision was extended to achieve a laparoscopic-assisted bowel resection. After the wedge resection, the resected diverticulum was carefully inspected and palpated to confirm complete removal of the Ectopic Gastric Mucosa (EGM). An anastomosis was made with a hand-sewn primary anastomosis, and the bowel was relocated to the abdomen. All of the specimens were sent to pathology for examination. At the end of the procedure, the trocars were removed, the trocar sides were infiltrated with local anaesthetic and the skin was approximated with interrupted sutures. The umbilical incision was closed with interrupted sutures, using 2-3/0 Vicryl to approximate the fascia. The open approach group (Group 1) was operated on by open abdominal exploration. No incidental appendectomy was performed concurrently with resecting of a symptomatic MD.

IBM SPSS20.0 (SPSS Inc. Chicago, IL, USA) software program was used to perform the statistical analysis. Descriptive statistics are expressed as medians ± standard deviations, mean or ranges. Categorical variables were analysed using the chi-square test. The distribution of the variables was evaluated for normality using the Kolmogorov-Smirnov and histogram tests. Normally distributed data composed of continuous variables were analyzed using the independent samples t-test. Otherwise, the Mann-Whitney U-test was used. A P value < 0.05 was considered statistically significant. No criteria were employed for patient selection, except the presence of MD. We routinely used local infiltration anesthesia when inserting a port site; therefore, analgesia was only applied when required in this group. We used 20 mg/kg acetaminophen on a regular basis during the postoperative period for patients who underwent open repairs. We did not use any measure of cosmetic assessment.

All of the patients underwent a clinical examination, routine laboratory tests, and abdominal ultrasound. Patients with intestinal bleeding were also subjected to lower gastrointestinal endoscopy and Meckel's scintigraphy, except in emergency situations. Patient demographics, clinical features, diagnostic tests performed, histopathology reports, conversion to laparotomy, hospital stay, and complications were analyzed. The retrospective design and the small number of patients were major limitations of this study but the results are useful for pediatric surgeons.

**Table 1:** Distribution of the cases.

Distribution of cases	Open group (Group1)	Laparoscopic group (Group2)	P
Total 68 cases	35 cases	33 cases	
<b>Age</b>			(p=0.001)
Range	5d-13y	8m-12 y	
Median	3.31±3.19 y	7.35±4.74 y	
<b>Sex</b>			(p=0.484)
Male	25	25	
Female	10	8	
<b>Hospital stay</b>			(p=0.001)
Range	3-22 d	3-9 d	
Median	8.65 ±3.52 d	5.93 ±1.93 d	
<b>Follow-up</b>			(p=0.792)
Range			
Median	59.75±35.65 m	57.40±32.82 m	

d: days; m: months; y: years

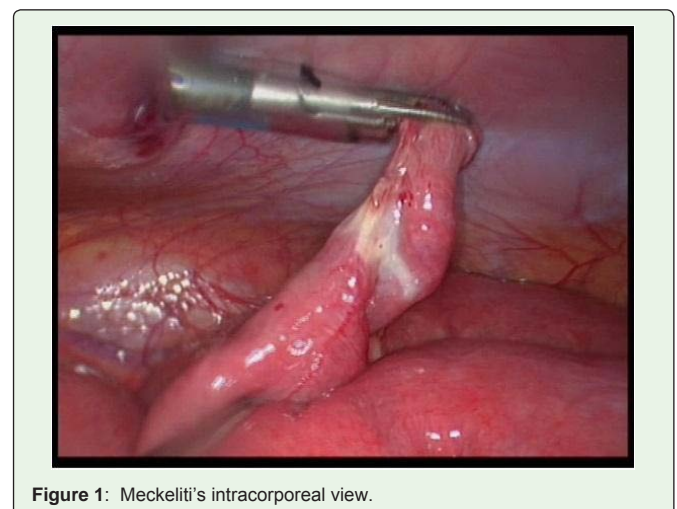
## Results

MD was identified in 68 cases (42 cases by first, 13 cases by second and 13 cases by the third institution) from November 2007 to November 2015. The male to female ratio was 50:18, so 64% of all of the cases were male.

Group 1 consisted of 35 cases (25 males and 10 females; age: 5 days to 13 years; mean age: 3.31 ± 3.19 years). MD was found incidentally in six cases in this group. Eight cases had a small bowel obstruction. Ten cases complained of an acute abdomen and two cases had an abdominal mass due to diverticulitis. Intussusception with MD acting as the lead point was found in five cases. Significant intestinal bleeding was the main factor for abdominal exploration in four cases. Table 1 summarizes the patient distribution (Table 1).

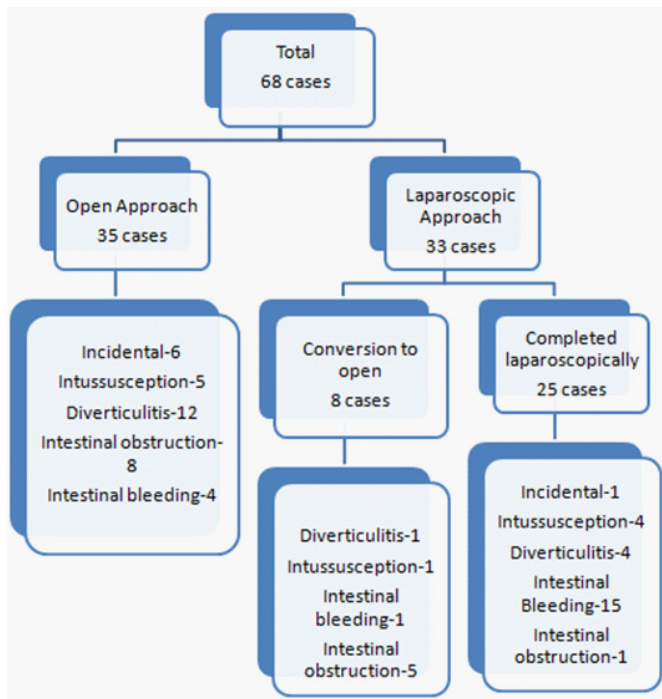
Thirty-three cases (25 males and 8 females; age: 8 months to 12 years; mean age: 7.35 ± 4.74 years) underwent the laparoscopic assisted approach (Group-2) Twenty-five cases were completed laparoscopically, but eight cases required conversion to an open approach. In five cases, the reason for conversion to an open approach was difficulty visualising the abdominal cavity because of a dilated intestinal loop due to intestinal adhesions causing by MD and in one case with intussusception caused by MD. Dense adhesions between the hernia sac and MD in a Littre's hernia were the reason for conversion to an open approach. One case of painless intestinal bleeding was converted into an open approach because of the suspicion of vessel injury. Wedge resection of MD was completed successfully with the open approach in this case (Table 2).

A total of 25 of 33 cases in Group 2 were completed laparoscopically. The patients underwent laparoscopic assisted Meckel's diverticulectomy with an extracorporeal hand-sewn anastomosis. One case with herpes simplex virus underwent laparoscopic exploration because of acute abdominal symptoms. The laparoscopic exploration in this case found the MD incidentally. MD was found as a lead point in four cases after reduction of intussusception, and all of these cases were treated successfully with laparoscopic assisted Meckel's diverticulectomy. One case with a small bowel obstruction, secondary to adhesions between MD and the umbilicus, was successfully managed laparoscopically. Adhesions were released initially and a laparoscopic assisted wedge resection



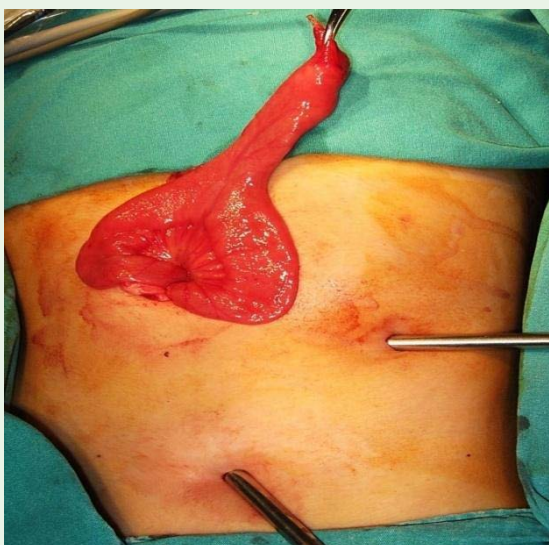
**Figure 1:** Meckel's intracorporeal view.

**Table 2:** Comparing of the groups.



was performed. Laparoscopic assisted wedge resection was completed successfully in all of the 15 cases with complaint of rectal bleeding and 4 cases with an acute abdomen due to diverticulitis (Figures 1 & 2).

A total of 16 of 18 patients with intestinal bleeding, containing both groups, underwent a technetium-99m pertechnetate scan. The scan was not obtained in one case because it was an emergency condition. Of these, eight cases (50%) had positive technetium-99m pertechnetate scans. Lower gastrointestinal endoscopy did not lead to detection of the source of hemorrhage in the bleeding patients. Four patients required preoperative blood transfusions (Figures 3 & 4).



**Figure 2:** Meckel's diverticulum at the outside of the abdomen.

**Table 3:** laparoscopically completed.

Distribution of laparoscopic cases	Laparoscopically completed	Conversion to open	P
Total 33 cases	25 cases	8 cases	
Intestinal bleeding	15 cases	1 case	(p=0.025)
Intestinal obstruction	1 case	5 cases	(p=0.014)
Meckelitis	4 cases	1 case	(p=0.025)
Intussusception	4 cases	1 case	(p=0.025)
Incidental	1 case		

The two groups were not similar in age, and patients in Group-2 were older than those in Group-1 (p = 0.001). No difference in the sex distribution was observed between the two groups (p = 0.484). Median hospital stay was 8.65 ± 3.52 days in Group-1 and 5.93 ± 1.93 days in Group-2 (range: 3-22 days; p = 0.001). The median follow-up in Group-1 was 59.75 ± 35.65 months and was 57.40 ± 32.82 months in Group-2 (p = 0.792). The laparoscopy subgroups (laparoscopically completed and conversion groups) were compared to find suitable conditions for laparoscopy and the open approach. In terms of intestinal bleeding, laparoscopy (laparoscopically completed vs open approach, 15 cases vs 1 case) was significantly more suitable than the open approach (p < 0.001). Laparoscopy (laparoscopically completed vs open approach, four cases vs one case) was also better than the open approach in cases with diverticulitis (p = 0.025). The same outcomes occurred in cases with intussusception due to MD (laparoscopically completed vs open approach, one case vs four cases). A high conversion to open approach ratio was found in cases with an intestinal obstruction due to MD (laparoscopically completed vs conversion to open approach, one case vs five cases) (p = 0.014) (Table 3). The pathological analysis of the resected specimens confirmed that none of the incidentally found MD contained EGM. In contrast, all of the cases with intestinal bleeding had EGM. The laparoscopic group contained 18 gastric mucosae in 33 cases, whereas only 6 cases had gastric mucosa in the open group of 35 cases (p = 0.001).

No complications were observed during the procedures in both groups. Follow-up varied from 6 months to 8 years, and no



**Figure 3:** Resection completed.





Figure 4: Post operative view.

complications were observed except one patient who underwent laparoscopic assisted wedge resection for rectal bleeding and was hospitalized with a small bowel obstruction secondary to adhesions 2 weeks later. He was successfully managed with medical treatment.

## Discussion

MD is one of the most common congenital malformations of the intestinal tract. Most of the time it is asymptomatic and is found incidentally during abdominal exploration [8]. In our series, only 10 cases (14%) of MD were found incidentally. None of the clinical findings in complex MD are pathognomonic or easily diagnosed as is the case with appendicitis. Therefore, the correct diagnosis is usually not established preoperatively, even in complicated MD [9]. The availability of modern imaging techniques, such as Ultrasonography (USG) or computed tomography, usually has little value because distinguishing between MD and intestinal loops is difficult, and it is very difficult to detect MD in cases of intestinal obstruction or intussusception [10]. An abdomen inflicted with peritonitis can easily be misdiagnosed as perforated appendicitis [10]. In our study, USG was not effective for detecting MD.

Our series was slightly different than the classic series in which the “rule of twos” applies, meaning that boys are affected more than twice that of girls. Children older than 2 years of age have the highest incidence of complicated MD [11]. Despite the classic view, Rho et al. reported an age range of incidence of 7 days to 19 years [12]. The authors postulated that the wide age range was because MD can be clinically silent for a long time [12]. The age distribution of our cases showed the same trend. The vast majority of our cases were > 2 years and only 24 of 69 cases were < 2 years. Intestinal bleeding was found in only two cases < 2 years. Therefore, complicated MD can be seen at any pediatric age. A high index of suspicion is necessary for the diagnosis and treatment of MD. However, the second part of the rule on male predominance was strongly supported with our data. In our series, the male: female ratio was approximately 4:1.

The incidence of heterotopic gastric mucosa in cases with MD is 15-50% [13]. Shalaby et al. reported that the incidence of EGM in symptomatic patients is 61-80% and in only 13-30% of incidental cases [13]. In our series, EGM was found in 34% of all of the cases. The range of EGM decreased to 15% in incidental and intussusception cases and

increased to 100% in the intestinal bleeding group. Therefore, it is clear that heterotopic mucosa in symptomatic patients was reported at a much higher rate than in patients with asymptomatic MD [13]. The open group had no intestinal bleeding because the nature of intestinal bleeding raises a suspicion of complicated MD. All of the cases with intestinal bleeding had been investigated in the gastroenterology department where all of the patients underwent endoscopic exploration. These cases were operated on laparoscopically because of massive bleeding and no time was left for endoscopic investigations. In general, upper and lower gastrointestinal endoscopy play no role, as they cannot reach the ileum where MD exists [8,14].

Radionuclide scans ( $^{99m}\text{Tc}$ -pertechnetate) can be used to diagnose MD when uptake occurs in the EGM or the site of gastrointestinal bleeding can be identified [15-17]. The accuracy of this test is 25-92% [18] and it is the best non-invasive method for a preoperative diagnosis of MD [12]. Menezes et al. showed that the sensitivity of this scan as a diagnostic tool in patients with gastrointestinal bleeding and MD is 66.6%, with a false-negative rate of 33.3% [18]. In our series, a 60% positive scan result rate was detected in cases with intestinal bleeding, despite the fact that the pathological analysis of the resected specimen revealed EGM in all of these cases. It is postulated that a false-negative diagnosis may be due to insufficient gastric mucosa to capture Tc99, and cases with a “wash out” phenomenon may be due to fast intestinal transit [12]. Rho et al. recommended performing this scan in patients with lower GI bleeding, abdominal distension, and/or pain and severe anemia [12]. Because radionuclide scans have high false-negative rates, we postulated that laparoscopy would be beneficial for diagnosis and treatment, particularly in patients in whom the clinical findings are suspicious [12]. Some authors still suggest a diagnostic algorithm, such as radionuclide scans and endoscopic evaluations, for massive and painless lower gastrointestinal bleeding in children [14]. Although gastrointestinal endoscopy cannot diagnose MD, it is an essential tool for identifying other possible sources of bleeding [14]. In addition, some reports have claimed that a laparoscopic approach is a better first-line procedure for cases of complications due to MD and painless large intestinal bleeding [14,19].

The recent development of minimally invasive surgery has changed the surgical approach to many pediatric diseases. It is easy to mobilize the bowel, observe the abdominal cavity and minimize the incision size [8]. A progressive shift in favor of laparoscopy has been made [20]. Laparoscopic exploration and management of MD is one of them [20]. Diagnostic laparoscopy is also very useful for patients who present with nonspecific preoperative diagnoses. In our series, laparoscopy was successfully used in cases with intussusception due to MD, as a diagnostic and therapeutic tool. In our experience, MD can be found easily with a laparoscopic approach. Some situations, such as ileus due to dilation in the proximal intestine, reduce the capacity of the abdominal cavity and limit the visual examination. In these cases, we have observed very high conversion from a laparoscopic to an open approach. In cases with intestinal bleeding, intestinal dilation was very rarely observed and was less obvious; therefore, all of the procedures were completed laparoscopically. Only one case of conversion was observed in these cases due to possible vascular injury.

Laparoscopic treatment of MD was originally introduced by Attwood in 1992 [21]. In some reports, laparoscopy is equivalent

to the open approach in safety, length of hospital stay and cost [22]. Another survey on trends in surgical management of MD in the United States demonstrated that the laparoscopic approach has been underused and that it may improve results and cost [22]. In our series, we were unable to compare the laparoscopic approach with the open approach to determine superiority. Length of stay seemed shorter in the laparoscopic group, but this may be an elusive condition because the two groups did not have similar clinical situations. Laparoscopy was a viable option, even for bowel necrosis [1]. Although open conversion in our series was very high in cases with ileus, we believe that the laparoscopic experience of the surgeon will increase in time and it may be possible that the laparoscopic approach will be accepted, even in these cases.

Most of the published literature is based on single-institution experiences on laparoscopic or open approaches [5]. Attwood described that laparoscopic treatment of MD originally used a staple transversally at the base of diverticulum extracorporeally [21]. However, our series focused on treating MD to determine whether an open or laparoscopic approach was most suitable. A laparoscopic Meckel diverticulectomy can be performed intracorporeally or extracorporeally [9,23]. The intracorporeal laparoscopic approach can be done using a loop if the base of the diverticulum is very narrow [21] (Figure 1). The resection and anastomosis can be done with an endo-stapler or the intestinal resection can be completed with intracorporeal sutures [9,24]. Intracorporeal loops increase the risk of leaving ectopic mucosal tissue if it is located at the base of the diverticulum; therefore, wedge or total resection of the adjacent bowel is the treatment of choice [23]. The other intracorporeal technique, intracorporeal anastomosis, is a difficult task even in the hands of skilled laparoscopic surgeons [18,23]. Using an endostapler device is an expensive choice. An extracorporeally performed anastomosis is not different from that applied in the open approach. Moreover, extracorporeal repair can be easily applied by anyone accustomed to open repair; therefore, the learning curve is typically much shorter [18,23]. It is also less expensive because extracorporeal resection and anastomosis require no expensive tools, such as stapler devices [18,23]. In addition, the extracorporeal approach has a big advantage that any intraluminal mass can be identified with only palpation of the bowel, allowing a proper diagnosis if no diverticulum is found [18]. In all of the patients, diagnosis and treatment were completed without complications. We believe that laparoscopy is a valuable tool not only in the diagnosis but also for the treatment of MD.

Some authors have reported that ectopic mucosa can be found in the distal area in a long diverticulum with a height-diameter ratio > 1.6 and that a simple transverse resection with a stapling device can be appropriated [25]. This approach should not be done in the longitudinal axis of the ileum to leave a wide lumen [25] (Figure 2). Even in these cases, a frozen section of the resected specimen is required to ensure that the specimen does not contain any ectopic mucosa [25]. In our series, all of the cases underwent wedge or complete resection of the MD with some sleeve of the ileum to avoid unnecessary frozen sectioning and to remove the ectopic epithelium completely with minimal risk. We postulated that the wide resection prevented any rebleeding in our series. One of the important points of this technique is to create an adequate fascial opening rather than skin opening around the umbilicus [18,23,24]. This opening allows easy exteriorisation of the intestine for diagnosis and treatment, and

also prevents the difficult replacement of intestine into the abdominal cavity and serious bleeding due to congestion and oedema of the intestine [18,23,24]. Adhesive intestinal obstructions after resecting the MD are seen in 5-10% of the patients [18]. In our series, only one case had adhesive intestinal obstructions and was treated medically.

The major limitation of our study is that it was a retrospective chart review (Figures 3 and 4). We included patients who initially were started laparoscopically and then were converted into an open approach. A comparison of these two groups showed some factors that can be used to predict failure of laparoscopy in a complicated case of MS. Therefore, we postulate that the transumbilical laparoscopic-treatment of MD is generally better than the conventional approach; however, a prospective, multi-institutional structural study is needed for confirmation.

## Conclusion

In conclusion, laparoscopy can be an alternative to open approach for managing MD in children but the usefulness of laparoscopy is limited when the diagnosis is an intestinal obstruction due to MD.

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