



## Multifaceted behavior of Meckel's diverticulum in children

Qingjiang Chen, Zhigang Gao, Lifeng Zhang, Yuebin Zhang, Tao Pan, Duote Cai, Qixing Xiong, Qiang Shu, Yunzhong Qian\*

Department of pediatric general surgery, Children's Hospital, Zhejiang University School of Medicine, No. 57 Zhugan Street, Xiacheng District, Hangzhou, P.R. China 310000

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### ABSTRACT

**Purpose/background:** Meckel's diverticulum (MD) is one of the most common congenital malformations of gastrointestinal tract in children. However, the nonspecific clinical manifestations of MD often cause a diagnostic as well as therapeutic challenge to pediatric surgeon. This study aimed to review our experience in managing this disease while evaluating the management strategies.

**Methods:** We retrospectively analyzed the clinical data of all patients diagnosed with MD admitted to our center between January 2010 and December 2015. Factors documented including demographic criteria, clinical manifestations, preoperative examinations, surgical methods, histopathological characteristics, postoperative complications, and outcomes.

**Results:** The patients included 210 males and 76 females, aged from 1 day to 15 years. In fifty three patients, the MD was an incidental finding at laparotomy or laparoscopy. The remaining 233 patients were symptomatic and presented with various clinical features. Ninety nine patients presented with episodes of bleeding per rectum or melena. Fifty six patients demonstrated symptoms of diverticulitis or perforated MD. Forty patients were diagnosed as intestinal obstruction, and 35 patients with intussusception requiring surgical reduction. Two cases of Littre hernia and one case of foreign body trapped in MD were also observed in this group. Six patients misdiagnosed as appendicitis at another institution were reoperated in our department. Among the 99 patients with bleeding per rectum, 78 underwent a Tc-99m scan that showed a positive tracer in 55 patients and negative in 23. All patients underwent resection of the diverticulum, except for 2 cases of postponed resection. Histology revealed ectopic gastric mucosa or ectopic pancreatic tissue in 154 patients; significant differences were observed between the symptomatic group and the accidentally found group. One patient died of peritonitis and sepsis postoperatively; one case of anastomotic leak and one case of adhesive intestinal obstruction were reoperated.

**Conclusion:** Meckel's diverticulum has various clinical presentations and it is difficult to make a precise diagnosis preoperatively. It is necessary to maintain a high suspicion of MD in the pediatric age group with symptoms of abdominal pain, gastrointestinal hemorrhage or intestinal obstruction. Heterotopic tissue is the main cause of complicated diverticulum, and it is safe and feasible to remove the incidentally found MD. Laparoscopy should become the first choice of methods in diagnosis and treatment of MD.

**Type of study:** Treatment study.

**Level of evidence:** Level IV.

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Meckel's diverticulum (MD) is one of the most common congenital gastrointestinal malformations in children, occurring in 2% to 4% of the population [1,2]. It develops as a result of incompletely obliterated vitelline duct or omphalomesenteric duct around the 5th to 7th weeks of gestation [3]. A wide spectrum of anomalies may result depending on the stage of arrest of this normal involution, including intestinal-umbilical fistulas, MD, omphalomesenteric cyst, mesodiverticular bands, umbilical sinus and umbilical polyp. MD is the most frequent entity of these potential anomalies. Microscopic histopathology reveals

the remnant of the omphalomesenteric duct contains heterotopic mucosa in 45%–80% of surgical specimens, mainly gastric mucosa, and sometimes pancreatic tissues or colonic mucosa [3–6]. The abnormal mucosa lines the greater part of the proximal end of the pouch and sometimes extends for a short distance into the nearby ileum. It is therefore vulnerable to bleeding, infection and obstruction.

The majorities of patients with MD are clinically silent and often identified incidentally by abdominal exploration [3,7]. However, still considerable MD accounts for diverse clinical processes, including painless rectal bleeding, acute abdominal pain and small bowel obstruction, occurs more commonly in children than adults [8]. Although rare, the complications of MD can cause extremely serious consequences such

\* Corresponding author. Tel.: +86 571 88873641; fax: +86 571 87033296.  
E-mail address: [qianyunzhong@zju.edu.cn](mailto:qianyunzhong@zju.edu.cn) (Y. Qian).

as mechanical obstruction, intestinal perforation and shock [9]. Thus prompt diagnosis and proper treatment are critical in warranting a better outcome of MD. Unfortunately, MD has varied clinical manifestations for different individuals, such as recurrent vague abdominal pain, abdominal distention, painless lower gastrointestinal bleeding, nausea and vomiting. These nonspecific presentations are usually confused with those of appendicitis, inflammatory bowel disease and other clinical scenarios. Traditional diagnostic methods, such as conventional abdominal radiography, abdominal ultrasonography, computed tomography (CT) or scintigraphy with Tc-99m pertechnetate often produce false-negative or false-positive result [3,5,10]. It is difficult to prospectively diagnose a Meckel's diverticulum, and it presents quite a diagnostic as well as a therapeutic challenge to the pediatrician and pediatric surgeon.

In order to provide more useful information to pediatricians for early diagnosis and treatment, this study investigated the clinical characteristics of MD with different manifestations in the pediatric population and shared our experience in managing this condition during recent six years.

**1. Methods**

A retrospective study of pediatric patients with a diagnosis of MD admitted to The Children's Hospital Zhejiang University School of Medicine between January 2010 and December 2015 was conducted. We recorded the data of demographic characteristics, clinical manifestations, associated anomalies, details of preoperative examination, surgical procedure performed, intraoperative and histological findings, short- and midterm complications, and final outcomes. The follow-up period ranged from 6 months to 5 years. Informed consent was obtained from each patient according to the research proposals approved by the local ethics committee of Zhejiang University.

All data were processed using descriptive statistical procedures for calculating means, standard deviations, frequencies, and percentages. Statistical analysis was completed using the Statistical Program for Social Sciences (SPSS, version 19.0, Chicago, IL) to perform analysis of variance (ANOVA) or the chi-square tests;  $P < 0.05$  was considered to be statistically significant.

**2. Results**

Between January 2010 and December 2015, a total of 286 children (210 boys and 76 girls) were diagnosed with Meckel's diverticulum in our department. The patients' age range from 1 day to 15 years (median 2.75 years), with 75 cases less than 1 year, 71 cases aged between 1 and 3 years, and 140 cases aged 3 to 15 years (Table 1).

Among the entire cohort, 53 cases (18.53%) of MD were an incidental finding during abdominal exploration (Table 2), mainly occurring in the first year of life (62.26%). The remaining 233 patients were symptomatic and presented with various clinical features (Table 3). Ninety nine patients presented with episodes of bleeding per rectum or melena, without abdominal pain in most cases, and their hemoglobin level was dramatically decreased (means,  $77.16 \pm 15.96$  g/L vs  $127.13 \pm 27.71$  g/L) and was significantly different from other groups ( $F = 264.27, P < 0.001$ ). Fifty six patients with abdominal pain and

**Table 2**  
Associated disease of MD during abdominal exploration.

Associated disease	< 1 year (n = 33)	1–3 years (n = 6)	3–15 years (n = 14)
<b>Alimentary tract duplication</b>	1	1	
<b>Annular pancreas</b>	3		
<b>Anorectal malformation</b>	3	1	
<b>Appendicitis</b>		1	11
<b>Choledochocyst</b>	1	2	
<b>Colitis gravis</b>	1		
<b>Colonic perforation</b>	1		
<b>Foreign body ingestion</b>	1		
<b>Gastric perforation</b>	1		
<b>Hirschsprung's disease</b>	4		1
<b>Inguinal hernia</b>	1		
<b>Intestinal atresia</b>	6		
<b>Malrotation</b>	2		
<b>Meconium peritonitis</b>	1		
<b>Mesenteric cyst</b>		1	2
<b>Mesenteric hiatal hernia</b>	1		
<b>Necrotizing enterocolitis</b>	1		
<b>Omphalocele</b>	5		

fever, with/without nausea and vomiting, were suspected to have appendicitis or peritonitis preoperatively, while were identified to have diverticulitis or perforated MD at laparoscopy or laparotomy. Forty patients presented with bilious vomiting, stomach ache and abdominal distention, and abdominal radiography showed signs of intestinal obstruction. During operation, Meckel's band (by direct compression, induction of volvulus or internal hernia) or diverticulitis associated with intestinal adhesive was found to be the cause of the obstruction. Intussusception were revealed by ultrasound in 35 patients who required open reduction, and MD was confirmed as the lead point during operation, with 71.43% (25/35) cases of small-bowel intussusception with or without colonic involvement and that relapsed at a mean of  $1.57 \pm 0.33$  times. Two cases of Littre hernia and one case of foreign body incarcerated in MD were also observed. Six patients who still had symptoms of peritonitis, intestinal obstruction or hematochezia after procedure of appendectomy at another institution were confirmed with MD in our department. Complicated MD was found in 43 patients, including 11 cases of volvulus and intestinal necrosis, 17 cases of diverticulum perforation and peritonitis, and 15 cases of severe anemia (hemoglobin  $< 60$  g/L), accounting for 18.45% (43/233) of the symptomatic patients.

Various imaging studies, including Meckel's scan, gastroscopy, colonoscopy, abdominal radiography, ultrasonography or CT, and sometimes capsule endoscopy or intestinal magnetic resonance hydrography were performed to assist the diagnosis, depending on the clinical presentations of the patients. Among 99 cases of intestinal bleeding, 78 cases underwent a Tc-99m scan and 55 cases showed a positive result (Fig. 1A). No significant differences of hemoglobin level were observed between Meckel's scan positive patients and negative patients ( $F = 1.138, P = 0.363$ ). Three cases of Meckel's diverticulum were identified under capsule endoscope. Other results reported included intestinal obstruction in 48 cases, intussusception in 36 cases, appendicitis in 16 cases, thickening of intestinal wall and ascites accumulation in 12 cases, pneumoperitoneum in 6 cases, strip echogenic structure of right low quadrant in 6 cases, inguinal hernia incarceration in 2 cases and foreign body ingestion in 1 case. The preoperative diagnostic rate of MD was only 24.89% (58/233).

All patients with MD underwent diverticulectomy or partial ileal resection under laparoscopy or laparotomy, besides one case of necrotizing enterocolitis and one case of colon perforation owing to colonoscopy. Enterostomy was performed in the two patients and the diverticulum was left in situ during initial operation, and a postponed diverticulectomy was performed during enterostomy closure. Surgical approaches were selected according to the clinical presentations. For all cases of bleeding MD and a portion of diverticulitis cases or incidentally found cases, a total of 135 cases of laparoscopic-assisted

**Table 1**  
Various clinical presentations distributed in different age groups.

	<1 year (75 cases)	1–3 years (71 cases)	>3 years (140 cases)
<b>Incidental finding</b>	33	6	14
<b>Gastrointestinal bleeding</b>	12	29	58
<b>Diverticulitis/perforation</b>	4	13	39
<b>Intestinal obstruction</b>	10	12	18
<b>Intussusception</b>	13	11	11
<b>Littre hernia</b>	2	0	0
<b>Foreign body incarceration</b>	1	0	0

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