

Meckel's diverticulum in pediatric patients: A retrospective analysis

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Meckel's diverticulum (MD) is the most common congenital anomaly of the gastrointestinal tract, resulting from incomplete obliteration of the omphalomesenteric duct during embryonic development.^[1] Although its prevalence is approximately 2% in the general population, only a minority of individuals develop symptoms, with a consistent male predominance reported in pediatric series.^[2,3]

In children, symptomatic MD most commonly presents with an acute abdomen or lower gastrointestinal bleeding. Acute abdominal presentations may arise from diverticulitis, intussusception, volvulus, or fibrous bands leading to intestinal obstruction, whereas bleeding is typically attributed to mucosal ulceration caused by ectopic gastric tissue.^[2,4-6] These heterogeneous and sometimes overlapping clinical presentations may complicate preoperative diagnosis and influence management strategies.

Several imaging modalities, including ultrasonography, plain radiography, computed

Abstract

Objectives: This study aims to characterize the clinical, diagnostic, operative, and pathological features of symptomatic Meckel's diverticulum (MD) in a pediatric population.

Patients and methods: This retrospective, single-center study included 71 pediatric patients who underwent surgery for symptomatic MD between January 2013 and January 2025. Patients were categorized according to presentation as gastrointestinal bleeding or non-bleeding. Demographic, clinical, laboratory, imaging, operative, and histopathological data were analyzed. Comparisons between groups were performed using appropriate statistical tests, with $p < 0.05$ considered significant.

Results: Seventy-one pediatric patients (56 males, 15 females; mean age: 8.47 ± 5.24 years; range, 0 to 18 years) met the inclusion criteria. Abdominal pain was the most common symptom, followed by gastrointestinal bleeding. Patients presenting with bleeding were younger and had significantly lower hemoglobin levels compared to those without bleeding ($p < 0.05$). Low hemoglobin levels were predominantly observed in the bleeding group. Ultrasonography frequently demonstrated findings such as intussusception or ileus, and technetium-99m pertechnetate scintigraphy showed a high positivity rate in evaluated patients. All patients underwent surgical treatment. Open surgery was the most common approach, although minimally invasive techniques were also used. The distribution of surgical approaches differed between groups but did not reach statistical significance. Segmental resection was the most frequently performed procedure. Ectopic mucosa was identified in both groups without a significant difference. No major postoperative complications or MD-related readmissions were observed during follow-up.

Conclusion: Symptomatic MD in children presents with a broad clinical spectrum. Gastrointestinal bleeding is associated with younger age and significant anemia. Although imaging modalities are helpful, definitive diagnosis and treatment rely on surgical intervention. Early recognition and timely management are associated with favorable outcomes.

Keywords: Acute abdomen, ectopic gastric mucosa, gastrointestinal bleeding, Meckel's diverticulum, pediatric surgery.

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tomography, and technetium-99m pertechnetate scintigraphy, are used in the diagnostic evaluation of MD. Ultrasonography is generally the first-line modality in pediatric patients, while technetium-99m scintigraphy is primarily used in cases of suspected gastrointestinal bleeding associated with ectopic gastric mucosa.^[1,6,7] However, variable sensitivity in certain clinical conditions, such as anemia, active bleeding, or atypical anatomical features, may limit diagnostic accuracy, and definitive diagnosis is frequently established intraoperatively.

Although MD has been extensively reported in the pediatric population, many studies include both symptomatic and incidentally detected cases,^[5,6] which may obscure the clinical characteristics of symptomatic disease. Furthermore, data evaluating the relationship between clinical presentation, laboratory findings, operative strategies, and histopathological features remain limited.^[8,9]

Therefore, the aim of this single-center retrospective study is to analyze children with symptomatic MD by focusing exclusively on clinically manifest cases. Patients were categorized according to their primary presentation as gastrointestinal bleeding or non-bleeding manifestations. The study evaluates clinical features, laboratory findings, imaging modalities, surgical management, and histopathological characteristics to provide a structured characterization of symptomatic MD and to contribute clinically relevant data to pediatric surgical practice.

PATIENTS AND METHODS

This retrospective, single-center study was conducted at Ümraniye Training and Research Hospital, Department of Pediatric Surgery. Medical records of pediatric patients aged 0-18 years who underwent surgical treatment for symptomatic MD between January 2013 and January 2025 were retrospectively reviewed. The study protocol was approved by the Ümraniye Training and Research Hospital Scientific Research Ethics Committee (Date 07.08.2025, No.: 218). Patients were included if their clinical presentation was attributable to MD and classified as either gastrointestinal bleeding or non-bleeding presentations, including acute abdomen, intestinal obstruction, intussusception, and peritonitis. Patients in whom MD was incidentally detected during surgery for unrelated

conditions, as well as those with incomplete clinical, operative, or pathological data, were excluded. The requirement for informed consent was waived due to the retrospective nature of the study and the use of anonymized medical records. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Diagnostic evaluation and data collection

Ultrasonography was used as the first-line imaging modality in most patients. Additional imaging, including abdominal radiography or computed tomography, was performed selectively when ultrasonographic findings were inconclusive. Technetium-99m pertechnetate scintigraphy was performed in patients with suspected gastrointestinal bleeding or unclear diagnosis after initial evaluation.

Data collected included demographic characteristics, presenting symptoms, hemoglobin levels, and laboratory parameters. Imaging findings, operative details (surgical approach, intraoperative findings), histopathological results (including the presence of ectopic mucosa), and postoperative outcomes were also recorded. Follow-up data were obtained from hospital records and supplemented by telephone interviews when necessary.

Outcome measures

The primary aim of the study was to characterize the clinical, laboratory, radiological, surgical, and histopathological features of symptomatic MD.

Patients were categorized according to presentation type (gastrointestinal bleeding *vs.* non-bleeding) to allow subgroup evaluation.

Statistical analysis

Statistical analyses were performed using Python software version 3.11, (Python Software Foundation, Wilmington, DE, USA) and standard scientific libraries. Continuous variables were assessed for normality using the Shapiro-Wilk test and are presented as mean $\pm$ standard deviation (SD) or median (interquartile range), as appropriate. Categorical variables are expressed as counts and percentages.

Comparisons between patients with and without gastrointestinal bleeding were performed using the independent samples t-test or the Mann-Whitney U test for continuous variables, and the chi-square

test or Fisher's exact test for categorical variables, as appropriate. A p -value < 0.05 was considered statistically significant.

Due to the retrospective design of the study, no formal sample size or power calculation was performed, and all eligible cases identified during the study period were included in the analysis.

RESULTS

A total of 71 pediatric patients (56 males, 15 females; mean age: 8.47 ± 5.24 years; range, 0 to 18 years) who underwent surgery for symptomatic MD were included in the study.

Abdominal pain was the most common presenting symptom, followed by gastrointestinal bleeding. Vomiting frequently accompanied abdominal pain, whereas isolated vomiting was rare, as shown in Table 1.

Patients presenting with gastrointestinal bleeding were significantly younger than those without

bleeding and had significantly lower hemoglobin levels. Low hemoglobin levels were predominantly observed in the bleeding group, as shown in Table 2.

Ectopic mucosa was identified in both bleeding and non-bleeding groups with comparable frequencies (Table 2).

Radiologic evaluation revealed variable findings, including intussusception, ileus, and nonspecific inflammatory changes on ultrasonography, as well as signs of bowel obstruction on abdominal radiography. Meckel scintigraphy was performed in selected patients with suspected bleeding (Table 1).

All patients underwent surgical treatment. Open surgery was the most common approach overall, while minimally invasive techniques were also utilized. The distribution of surgical approaches and procedures according to clinical presentation is summarized in Table 3.

Intraoperative findings included inflamed or thickened diverticula, fibrous bands, intussusception,

TABLE 1			
Demographic, clinical, and radiologic characteristics of pediatric patients with symptomatic Meckel's diverticulum (n = 71)			
Variables	n	%	Mean $\pm$ SD
Age (year)			8.47 ± 5.24
Sex			
Male	56	78.8	
Abdominal pain	49	69.0	
Gastrointestinal bleeding	19	26.8	
Abdominal pain + bleeding	8	11.3	
Vomiting	34	47.9	
Isolated vomiting	2	2.8	
SD, standard deviation.			

TABLE 2							
Comparison of demographic, laboratory, and pathological findings between patients with and without gastrointestinal bleeding							
	Bleeding (n = 19)			Non-bleeding (n = 52)			
Variables	n	%	Mean $\pm$ SD	n	%	Mean $\pm$ SD	p
Age (year)			6.8 ± 5.2			9.4 ± 5.1	0.048
Hemoglobin (g/dL)			9.21 ± 2.25			13.84 ± 1.67	< 0.001
Low hemoglobin (< 10 g/dL)	14	73.7		0	0.0		< 0.001
Ectopic mucosa	12	63.2		33	63.5		0.62
SD, standard deviation.							

TABLE 3					
Surgical techniques according to clinical presentation in pediatric patients with symptomatic Meckel's diverticulum					
	Bleeding (n = 19)		Non-bleeding (n = 52)		
Variables	n	%	n	%	<i>p</i>
Open surgery	10	52.6	40	76.9	0.08
Minimally invasive	9	47.4	12	23.1	
Laparoscopic	2	10.5	7	13.5	
Laparoscopic-assisted	7	36.8	5	9.6	
Resection and anastomosis	15	78.9	34	65.4	
Diverticulectomy	4	21.1	18	34.6	

and ulcerated mucosal surfaces. The diverticulum was most commonly located within 50-70 cm of the ileocecal valve. Representative intraoperative images are shown in Figures 1, 2, and 3.

Histopathological examination confirmed MD in all cases. Ectopic mucosa, predominantly

gastric, was identified in a substantial proportion of patients.

The mean follow-up duration was 5.9 ± 3.1 years. No major postoperative complications, MD-related readmissions, or long-term sequelae were observed.



Figure 1. Intraoperative appearance of a Meckel's diverticulum identified during surgery. The diverticulum appears non-inflamed without gross evidence of ectopic mucosa.



Figure 2. Intraoperative view of a Meckel's diverticulum with ectopic gastric mucosa in a patient presenting with gastrointestinal bleeding, demonstrating a thickened and nodular appearance.



Figure 3. Inflamed Meckel's diverticulum with histologically confirmed ectopic mucosa in a patient with gastrointestinal bleeding. The diverticulum appears edematous and hyperemic.

DISCUSSION

This 12-year single-center study characterizes the clinical spectrum of symptomatic MD in children and demonstrates the heterogeneity of its presentation. Although MD is present in approximately 2% of the general population, only a minority of patients become symptomatic, with a consistent male predominance, as also observed in our cohort.^[1,3,5]

In our series, the two principal clinical presentations were acute abdomen and lower gastrointestinal bleeding. Obstruction-related symptoms, including abdominal pain and vomiting, were frequently associated with intraoperative findings such as inflamed diverticula, fibrous bands, and intussusception, consistent with previous reports emphasizing the role of mechanical complications in symptomatic MD.^[2,4] These findings support the importance of including MD in the differential diagnosis of pediatric acute abdomen.

A key finding of the present study is that patients presenting with gastrointestinal bleeding were significantly younger and had significantly lower hemoglobin levels compared to those without bleeding. Furthermore, low hemoglobin levels were predominantly observed in the bleeding group. These findings highlight the clinical severity of bleeding presentations and are consistent with previous studies describing anemia as a common manifestation of MD-related hemorrhage.^[2,5,6]

Ectopic mucosa, predominantly gastric, was identified in a substantial proportion of patients; however, its frequency was comparable between bleeding and non-bleeding groups in our cohort. This contrasts with the traditionally emphasized association between ectopic gastric mucosa and bleeding.^[6,10,11]

While ectopic mucosa likely contributes to mucosal ulceration and hemorrhage, our findings suggest that it may not be the sole determinant of clinical presentation. Similar variability has been reported in previous pediatric series, indicating that additional factors, such as local inflammation or mechanical effects, may influence symptomatology.^[8]

Preoperative diagnosis of MD remains challenging due to overlapping clinical features with other pediatric conditions.^[3] In our practice, ultrasonography served as the primary imaging modality and was particularly useful in identifying associated conditions such as intussusception or ileus. Technetium-99m pertechnetate scintigraphy was used selectively, mainly in patients with suspected bleeding, and demonstrated a high positivity rate in evaluated cases. However, its diagnostic performance may be affected by clinical factors such as anemia or active bleeding, as previously reported.^[8]

Surgical intervention remains the definitive diagnostic and therapeutic approach for symptomatic MD. Both open and minimally invasive techniques were used in our cohort. Although minimally invasive approaches were more frequently applied in patients presenting with bleeding, this difference did not reach statistical significance. This finding suggests that surgical decision-making is likely influenced by intraoperative findings and clinical context rather than presentation type alone.^[4,5,9,12,13]

Consistent with the classic “rule of 2,” most diverticula in our series were located within 50-70 cm of the ileocecal valve. Surgical management was tailored to intraoperative findings, with diverticulectomy performed in selected cases and segmental resection preferred when inflammation or ulceration extended to adjacent bowel.^[8,14]

Long-term outcomes were favorable in our cohort. During follow-up, no major postoperative complications, MD-related readmissions, or long-term sequelae were observed, supporting the safety and effectiveness of surgical management in symptomatic MD.

By focusing exclusively on symptomatic cases, this study provides a clinically relevant characterization of pediatric MD while avoiding confounding factors associated with incidentally detected diverticula. Our findings emphasize that symptomatic MD should be considered in children presenting with an acute abdomen, unexplained anemia, or gastrointestinal bleeding.

This study has several limitations inherent to its retrospective, single-center design. Selection and information bias cannot be excluded, and variability in clinical assessment and imaging documentation over the 12-year period may have affected data consistency. Diagnostic imaging, particularly technetium-99m pertechnetate scintigraphy, was not performed uniformly across all patients. In addition, although follow-up data were available, standardized long-term functional outcomes were not systematically assessed. Despite these limitations, the inclusion of exclusively symptomatic cases, along with a relatively large cohort and extended follow-up, strengthens the clinical relevance of the findings.

In conclusion, symptomatic MD should be considered in children presenting with acute abdominal symptoms or lower gastrointestinal bleeding. The heterogeneous clinical presentation continues to complicate preoperative diagnosis, and although imaging modalities may provide supportive information, definitive diagnosis and treatment are most often established surgically with histopathological confirmation. In this study, gastrointestinal bleeding was associated with younger age and significantly lower hemoglobin levels, underscoring the clinical relevance

of laboratory findings in the evaluation of suspected cases. Surgical management provided excellent outcomes, with no major postoperative complications or MD-related readmissions observed during follow-up. A high index of clinical suspicion, combined with timely surgical intervention, remains essential for achieving favorable outcomes in children with symptomatic MD.

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Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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