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Original Article

Features of colonic diverticulitis in children and adolescents: A multicenter study

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SUMMARY

Background: Colonic diverticulitis (CD), typically seen in the elderly of Western countries, is increasingly prevalent worldwide, yet data on CD in children and adolescents are scarce. This study explores the characteristics of CD in this younger demographic.

Methods: In a multicenter, retrospective review, 104 patients under 20 years diagnosed with CD at four Korean tertiary hospitals from June 2003 to December 2020 were analyzed. Abdominal CT scans were used for diagnosis, with the modified Hinchey classification assessing the severity of CD.

Results: CD was found in the cecum or ascending colon in 103 (99%) of cases. The mean patient age was 17.24 ± 2.4 years, with males constituting 59.6% of cases. Solitary lesions were noted in 93 (89.4%) of patients. Severity was classified as modified Hinchey stage 0 in 58.7%, stage Ia in 29.8%, and stage Ib in 11.5%, with no cases of stage II or higher. Misdiagnosis as acute appendicitis occurred in six instances. IV antibiotics were administered to 68.3%, and oral antibiotics were sufficient for 24%. Surgical treatment was necessary for two patients. A 7.8% recurrence rate was noted among first-time CD patients, yet all cases were amenable to conservative management.

Conclusion: While uncommon, CD in children and adolescents is a growing concern, with most cases presenting as solitary lesions in the cecum or ascending colon. The severity is typically less than that in adults, and conservative treatment is generally effective. These findings underscore the need for specific management guidelines for pediatric CD, advocating for non-surgical initial approaches.

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1. Introduction

Colonic diverticulitis (CD) is prevalent in industrialized Western countries, particularly among the elderly. In recent years, the prevalence of CD has risen globally, including in the East, likely due to the Westernization of lifestyles.[1] In Western countries, CD predominantly occurs in the left colon, with right-sided diverticulitis being rare, constituting about 1.5–5% of all cases.[2,3] However, in Asian patients, especially those from East Asia like Korea and Japan, approximately 70–76% of cases are found in the right colon. The average age of these patients is notably younger than the average age of patients with left-sided CD in the West, which stands at 63 years.[2,4,5]

What characterizes CD in children and adolescents? There are limited reports on CD within this age demographic. In 2021, Hatakeyama T. et al detailed the characteristics of 16 children and adolescents in Japan.[6] These patients were aged between 8 and 15 years, and all had solitary cecal diverticulitis. All were effectively treated with intravenous antibiotics, with 3 (18.8%) experiencing relapses but were again successfully treated with antibiotics. A recent case report of a 17-year-old male in the U.S. identified the lesion in the sigmoid colon, leading to a sigmoid colectomy.[7] Excluding this one patient, most recent case reports on CD in children and adolescents indicate that the lesions were predominantly right-sided diverticulitis. Four of these patients underwent surgery, one had a colonoscopic fecalith removal, and one improved post antibiotic treatment.[8–12] Among the four who had surgery for right-sided diverticulitis, three were initially misdiagnosed with acute appendicitis.

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CD is exceptionally rare in children and adolescents, and its characteristics within this age group remain elusive. This study aims to assess the clinical features and treatment outcomes of CD in children and adolescents.

2. Methods

This retrospective study analyzed patients under 20 years diagnosed with diverticulitis at four tertiary hospitals in Korea from June 2003 to December 2020. Given the varying definitions of adolescence based on cultural and legal norms, the study focused on patients below 20 years. The study examined factors such as gender, age, body mass index (BMI), alcohol and smoking history, symptoms (e.g., abdominal pain, nausea/vomiting, diarrhea, fever), duration of symptoms, laboratory findings (like white blood cell (WBC) count, neutrophil count, C-reactive protein (CRP) level), whether it was their first instance of CD, lesion location, treatment method, and recurrence.

All patients were diagnosed with CD using abdominal computed tomography (CT). Thirteen underwent colonoscopy. The CD stage classification in this study employed the modified Hinchey classification by Kaiser et al.[13] For this, abdominal CT images of patients from each hospital were reviewed by pediatric surgeons, with radiologists consulted when needed.

The treatment strategy across the four hospitals was to prescribe oral antibiotics for mild symptoms and only colonic wall thickening evident on abdominal CT. In more severe cases, like intense abdominal pain or pericolic soft tissue infiltration, patients were hospitalized and administered broad-spectrum intravenous (IV) antibiotics for 3–7 days. If symptoms subsided, they were discharged. However, surgery was the recourse for patients with recurring symptoms unresponsive to IV antibiotic treatment.

Categorical variables were verified using the chi-square test or Fisher's exact test. The Mann–Whitney U test or Kruskal–Wallis test was performed to analyze continuous variables. The statistical significance was set at $p < 0.05$. Statistical analysis was conducted using SPSS software version 20 (SPSS Inc., Chicago, IL, USA).

This study received approval from the Institutional Review Board at Korea University Ansan Hospital (IRB File No.2023AS0334).

3. Results

104 patients were diagnosed with CD based on abdominal CT scans. Of these, 62 (59.6%) were male. The average age was 17.24 ± 2.4 years, with the youngest being a 7.6-year-old male. Twelve patients (11.5%) were below 14 years, and 51 (49%) were aged 18 or 19. The mean BMI was $22.8 \pm 4.4\ kg/m^2$. Males had a slightly higher average BMI of $23.43 \pm 4.86\ kg/m^2$ compared to females at $21.89 \pm 3.49\ kg/m^2$, but this difference wasn't statistically significant ($p = 0.063$). The average duration of symptoms was 44.01 ± 47.89 h. All patients reported abdominal pain, with 89 (85.6%) indicating right lower quadrant tenderness. Fever was present in 28 (26.9%) patients at the time of diagnosis. The number of first-time CD patients has been on a consistent rise over the past 18 years, though not linearly (Fig. 1). Excluding two patients, 102 (98.1%) were diagnosed with CD for the first time. The two exceptions had their fourth and second recurrences of CD, respectively. The average follow-up duration was 34.01 ± 41.52 months (Table 1).

CD was identified in the cecum or ascending colon in 103 (99%) patients, and in the sigmoid colon in one patient. CD was a solitary lesion in 93 (89.4%) patients. Based on the modified Hinchey classification, stage 0, characterized by mild clinical diverticulitis symptoms and CT findings of diverticuli ± colonic wall thickening, was the most prevalent, with 59 (58.7%) patients. Stage Ia, marked by colonic wall thickening + pericolic soft tissue changes, was present in 33 (29.8%) patients. Stage Ib, characterized by a pericolic abscess smaller than 4 cm, was found in 12 (11.5%) patients (Fig. 2). No patients with stage II or higher CD were identified in this study. Six patients (5.8%) were misdiagnosed as having acute appendicitis and underwent laparoscopic appendectomy. Seventy-one patients (68.3%) were hospitalized and received IV antibiotic treatment for an average of 4.39 ± 1.49 days, while 25 (24%) improved after oral antibiotic treatment (averaging 6.45 ± 1.8 days). Two patients had surgery due to deteriorating symptoms despite IV antibiotic treatment. The first, a 19.62-year-old male, had his fourth recurrence of sigmoid colon multiple diverticulitis and was diagnosed with stage Ia. The second, a 17.96-year-old male, had his second recurrence of multiple diverticulitis in the ascending colon and was also diagnosed with stage Ia (Fig. 3). Both patients were administered IV antibiotics for three days, but with worsening symptoms, they underwent anterior resection and right hemicolectomy, respectively. Among the first-time CD patients, 8 (7.8%) had a recurrence during the follow-up period. However, all these patients responded positively to conservative treatment (Table 2).

Comparisons between the modified Hinchey classification stages showed that stage Ib was associated with a higher proportion of males than the other stages (54.2% in stage 0 vs 57.6% in stage Ia vs 91.7% stage Ib, $p = 0.046$), higher CRP levels (2.89 ± 2.57 in stage 0 vs 3.02 ± 3.43 in stage Ia vs 5.44 ± 3.19 stage Ib, $p = 0.032$), and a higher rate of hospitalization for IV antibiotic therapy (64% in stage 0 vs 63.6% in stage Ia vs 100% stage Ib, $p = 0.028$). However, there were no significant differences in BMI, alcohol, smoking, multiple lesions, or recurrence between the stages (Table 3).

4. Discussion

A colonic diverticulum is a pseudodiverticulum that forms when the mucosa and submucosa herniate through a weakened muscle layer, creating a small, bulging pouch. Diverticulosis refers to the condition of having multiple diverticula. Diverticulosis is more common in older adults, with about 30% of individuals in their 50s found to have it during colonoscopies, and this number rises to 70% for those over 80.[14] Approximately 4–15% of patients with colonic diverticulosis develop inflammation or infection, termed CD.[2] While most cases of colonic diverticulosis are asymptomatic, CD can manifest symptoms like abdominal pain, fever, nausea, anorexia, constipation, and diarrhea.[15]

The author of this study observed an increasing incidence of CD in children and adolescent patients presenting with abdominal pain to emergency rooms or outpatient clinics. In adults, the incidence of acute diverticulitis in those aged 40–49 surged by 132% from 1980 to 2007.[16] In 2022, Grag A. Turner et al suggested that the rise in acute diverticulitis in young adults could be attributed to factors like low fiber intake, decreased physical activity, smoking, and enhanced diagnostic procedures.[17]

Obesity is recognized as a risk factor for acute and complicated diverticulitis.[18,19] However, in this study, only 8.7% of patients had a BMI of 30 or higher, and just 22.1% had a BMI of 25 or higher, which defines obesity in Asian individuals. No correlation was found between BMI and severity based on the Hinchey classification. Thus, it's inferred that there's no link between obesity and acute diverticulitis in the children and adolescent patients of this study. Smoking is also a potential cause of diverticulitis.[20] However, the recent decline in smoking rates in the U.S., Europe, and other countries doesn't align with the increasing incidence of acute diverticulitis in young adults.[17] This trend is mirrored in Korea, where the adult smoking rate dropped from 66.3% in 1998 to 34% in 2020,[21] and the adolescent smoking rate decreased from 17.2% for

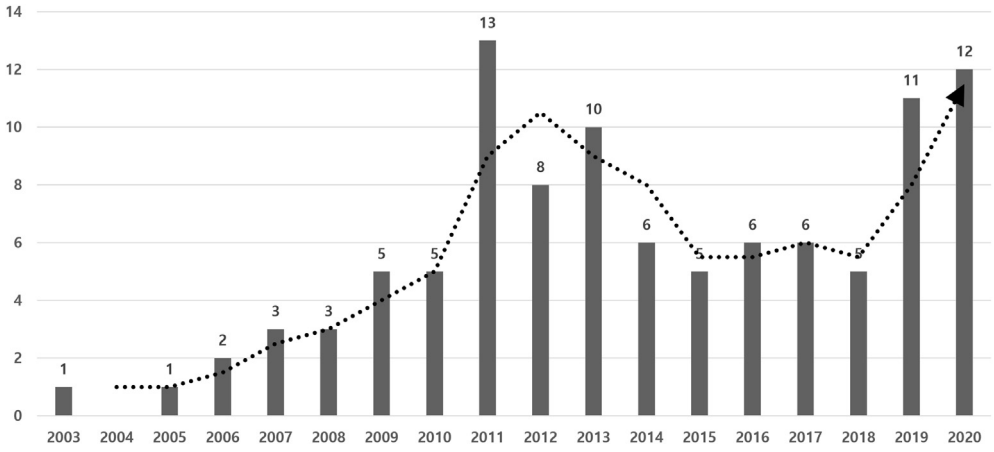


Fig. 1. Annual number of first-time colonic diverticulitis.

Table 1
Demographics and symptoms of the patients.

Findings	Total (n = 104)
Male	62 (59.6%)
Age (years)	17.24 ± 2.4
<14	12 (11.5%)
14 ≦ age <18	41 (39.5%)
≧ 18	51 (49%)
Body mass index (kg/m^2)	22.8 ± 4.4
≧ 23	38 (36.5%)
≧ 25	23 (22.1%)
≧ 30	9 (8.7%)
Alcohol	15 (14.4%)
Smoking	9 (8.7%)
Duration of symptoms (hours)	44.01 ± 47.89
Symptoms	
Abdominal pain	104 (100%)
RLQ tenderness	89 (85.6%)
Epigastric tenderness	7 (6.7%)
Periumbilical/LLQ/RUQ	6 (5.8%)
Nausea/vomiting	4 (3.8%)
Diarrhea	8 (7.7%)
Fever	28 (26.9%)
First-time diverticulitis	102 (98.1%)
Duration of follow-up (months)	34.01 ± 41.52

[a]RLQ; right lower quadrant, LLQ; left lower quadrant, RUQ; right upper quadrant.

boys and 6.5% for girls in 2011 to 6% and 2.9%, respectively, in 2021.[22] This is thought to be similar to the overall adolescent smoking rate, given the period of the study, and it is not thought that the patient group had a particularly high smoking rate. Given the study's timeframe, it's believed that the overall adolescent smoking rate is similar, indicating that the patient group didn't have an unusually high smoking rate. The most plausible reason for the rising incidence of acute diverticulitis in young adults, children, and adolescents is the enhanced diagnostic workup. Abdominal CT is the most accurate tool for diagnosing CD. Historically, CT scans were avoided in young adults, especially pediatric patients, due to concerns about ionizing radiation exposure. However, with the advent and utilization of radiation dose-reduced CT, CT scans have become more prevalent in young adults,[23] extending to children and adolescents as well.[24,25]

CD is no longer exclusive to elderly patients in the West. Several studies indicate that its prevalence is on the rise in Europe, South America, and East Asia.[26] This could be attributed to the global adoption of Western lifestyles and the increased detection due to advancements in diagnostic techniques like abdominal CT.

Historically, right-sided CD was believed to be congenital, solitary, and true diverticula. However, several studies have reported that it can be multiple or false diverticula, and others have suggested that right-sided CD, like its left-sided counterpart, can be acquired.[27,28] Although the pathogenesis of right or left-sided CD hasn't been fully understood, these two conditions might be more similar than previously believed. It's evident, however, that right-sided CD is uncommon in Western populations but prevalent in Asian populations, with reported incidences ranging from 39.5% to 85.3%.[28] Recent studies in Asia have compared adult right-sided CD with left-sided CD. A study from Singapore found the incidence of right-sided CD (49.5%) to be similar to that of left-sided CD, with right-sided CD patients being younger, having milder severity, and



Fig. 2. Modified Hinchey classification of abdominal CT findings (A) Stage 0: In an 18-year-old male, a calcified diverticulum (arrow) is seen with mesenteric fat infiltration adjacent to the diverticulum in the proximal ascending colon (B) Stage Ia: In a 13-year-old female, focal infiltration (arrow) is observed around the diverticulum of the proximal ascending colon, accompanied by segmental wall thickening along the ascending colon (C) Stage Ib: A 2.0 × 1.5 × 1.7 cm pericolic abscess (arrow) is associated with proximal ascending colon diverticulitis in a 14-year-old male.

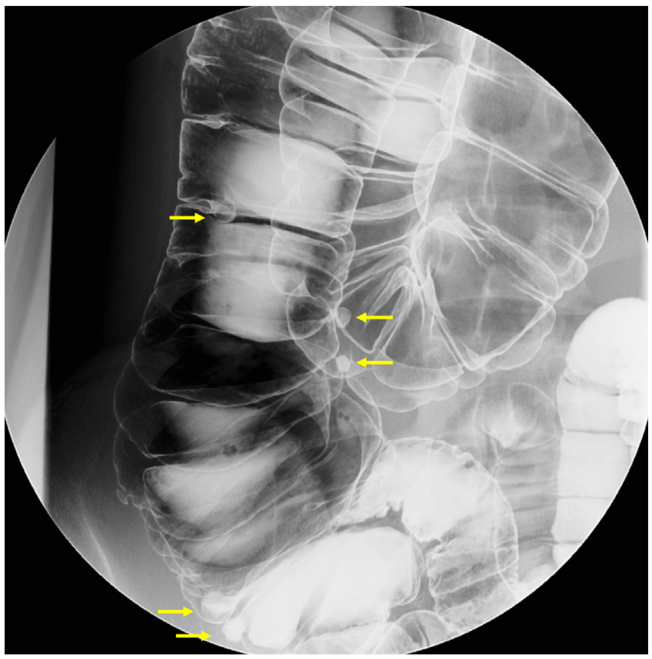


Fig. 3. Barium enema. Multiple diverticula (yellow arrow) were found in the cecum and ascending colon of a 17-year-old boy through a barium enema. The appendix is not visible due to a previous appendectomy.

Table 2
Clinical and treatment features of patients.

Findings	Total
Laboratory finding	
WBC (/μL)	12,070 ± 2962
Segmented neutrophil (%)	72.8 ± 8.3
>11,000/μL	65 (62.5%)
CRP (mg/dL)	3.26 ± 3.02
Location	
Cecum/Ascending colon	103 (99%)
Sigmoid colon	1
Solitary lesion	93 (89.4%)
Modified Hinchey classification	
0	59 (56.7%)
Ia	33 (31.7%)
Ib	12 (11.5%)
Treatment	
Appendectomy due to misdiagnosis	6 (5.8%)
Admission with IV antibiotics	71 (68.3%)
Discharge with oral antibiotics	25 (24%)
Operation for diverticulitis	2 (1.9%)
Recur	8 (7.8%)
Duration of recur (months)	33.07 ± 30.57

a lower recurrence rate.[29] In a study from Korea, the incidence of right-sided CD (92%) was much higher than that of left-sided CD, and right-sided CD patients were younger, had lower severity, and had a lower recurrence rate.[30] Other studies from Asia have reported similar results.[2]

Even in adults, there's no clear guideline for managing right-sided CD. In this study of children and adolescents with CD, barring one patient with sigmoid CD, all had right-sided CD, specifically in the cecum or ascending colon. No patients had transverse colon involvement. All patients had a modified Hinchey classification of stage Ib or lower, which was less severe than in adults. Most patients responded positively to IV or oral antibiotics. In this study, multiple diverticula were found in 11 patients (10.6%), with a significantly higher occurrence in males (16.1%) than in females (2.4%) ($p = 0.047$). However, these multiple diverticular lesions didn't show statistical significance for disease severity or recurrence. During the study period, 8 patients (7.8%) with first-time CD had a recurrence, with an average duration of 30.7 ± 33.1 months between episodes. Of these, 3 patients had up to 3 recurrences, but all were effectively treated with conservative therapy. In this study, the two patients who underwent surgical treatment were a 19.62-year-old male and a 17.96-year-old male, respectively. The first patient was enrolled in this study during his fourth recurrence of sigmoid colonic diverticulitis. For his first, second, and third episodes, he received medical treatment at different hospitals and experienced recurrences at 4-month intervals. The second patient had previously improved after receiving medical treatment for ascending colonic diverticulitis at another hospital 8 months prior. Both patients were administered IV antibiotics for 3 days, but their symptoms did not improve, and they continued to have a fever, leading to the decision for surgical intervention.

This study's strength lies in its report on a large number of children and adolescent CD patients. Additionally, the fact that all patients were diagnosed using abdominal CT is a notable strength. However, being a multicenter, retrospective study that collected data over a relatively extended period, there might be variations in treatment consensus across centers and different study periods. Additionally, due to its retrospective nature, potential contributing factors to CD, such as bowel habits including constipation, were not investigated. This represents a limitation of the study. There are no specific guidelines for children and adolescents with CD. Further research is needed to establish guidelines for the diagnosis, treatment, prognosis, and follow-up of CD in children and adolescents. Given the rarity of CD in this demographic, a prospective study involving more institutions is essential.

5. Conclusion

CD in children and adolescents is a rare disease, but it is a disease with a steadily increasing incidence. In almost all cases, it occurred in the cecum or ascending colon, and most lesions (89.4%) were solitary. Abdominal CT is helpful for diagnosis. The severity was lower than in adults, and most cases respond well to conservative treatment. Therefore, non-operative treatment should be the initial treatment for CD in children and adolescents. This study provides valuable insights into the presentation, treatment, and outcomes of CD in children and adolescents. However, given the variations in treatment across different centers and timeframes, there's a clear need for standardized guidelines tailored to children and adolescents with CD. Future collaborative, prospective studies involving multiple institutions will be crucial in establishing these guidelines and further understanding this evolving medical phenomenon.

Funding

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Table 3
Comparison according to modified Hinchey classification.

Findings	Stage 0 (n = 59)	Stage Ia (n = 33)	Stage Ib (n = 12)	p-value
Male	32 (54.2%)	19 (57.6%)	11 (91.7%)	0.046
Age at first attack (years)	16.96 ± 2.53	17.54 ± 2.32	17.82 ± 1.62	0.481
Body mass index (kg/m$^{2)}$	23.29 ± 4.43	22.38 ± 4.64	21.63 ± 3.55	0.269
Alcohol	9 (15.3%)	4 (12.1%)	2 (16.7%)	0.852
Smoking	7 (11.9%)	1 (3%)	1 (8.3%)	0.343
Symptoms				
Abdominal pain	59 (100%)	33 (100%)	12 (100%)	1.0
Nausea/vomiting	2 (3.4%)	2 (6.1%)	0	0.767
Diarrhea	6 (10.2%)	1 (3%)	1 (8.3%)	0.49
Fever	11 (18.6%)	12 (36.4%)	5 (41.7%)	0.081
WBC (/μL)	11,663 ± 3255	12,449 ± 2383	13,025 ± 2729	0.245
CRP (mg/dL)	2.89 ± 2.57	3.02 ± 3.43	5.44 ± 3.19	0.032
Solitary lesion	51 (86.4%)	30(90.9%)	12 (100%)	0.478
Treatment				
Misdiagnosed as appendicitis	3 (5.1%)	3 (9.1%)	0	0.587
Admission with IV antibiotics	38 (64.4%)	21 (63.6%)	12 (100%)	0.028
Discharge with oral antibiotics	18 (30.5%)	7 (21.2%)	0	0.06
Operation for diverticulitis	0	2 (6.1%)	0	0.185
Recur	4 (6.8%)	3 (9.1%)	1 (8.3%)	0.877
Duration of follow-up (months)	33.09 ± 41.78	34.84 ± 44.09	35.91 ± 35.57	0.832

Declaration of competing interest

None.

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