Appendiceal Diverticulosis: A Clinicopathological Analysis of 12 Cases

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Abstract

Purpose : Perforation occurs more often with appendiceal diverticulosis than with acute appendicitis; thus, confirming a diagnosis of appendiceal diverticulosis is critical. We compared the clinicopathological features of 12 appendiceal diverticulosis cases (3 confirmed preoperatively) and 321 acute appendicitis cases (excluding catarrhal) and investigated the pathological features specific to appendiceal diverticulosis.

Methods : Over a 7.5-year period, 12 of 392 patients with appendiceal disease were diagnosed with appendiceal diverticulosis (3 confirmed preoperatively). Findings from physical examination, abdominal ultrasonography and/or computed tomography, surgery, and histopathology were statistically analyzed. **Results :** Onset age was significantly later for appendiceal diverticulosis than for acute appendicitis ($p = 0.0176$) (average, 54.3 years). Perforation occurred more frequently with appendiceal diverticulosis ($p < 0.001$). There were no significant gender differences. Moreover, 11 patients had appendiceal diverticulitis. The average preoperative white blood cell count and C-reactive protein levels were 11929/ μ L and 7.15 mg/dL, respectively. Appendectomy (6 cases), partial cecal resection (4), and ileocecal resection (2) were performed. Pseudodiverticula were

confirmed histopathologically in all cases (mesenteric, 10; bilateral, 2). Six patients suffered perforations. The average number of diverticula was 2.5.

Conclusions : Excision is recommended when appendiceal diverticulosis is suspected or the presence of acute appendicitis is unclear.

Key words: acute appendicitis, appendiceal diverticulitis, pseudodiverticula

Introduction

Appendiceal diverticulosis is a relatively rare disease that is difficult to diagnose before surgery, and is most often diagnosed via postoperative pathological examination¹⁻¹³⁾. Appendiceal diverticulosis is reported to cause perforation more often than common acute appendicitis¹⁴⁾. Of 391 patients with appendiceal disease over a 7.5-year period, 12 were diagnosed with appendiceal diverticulosis in our hospital. We compared the clinicopathological features of patients with appendiceal diverticulosis and those with acute appendicitis (excluding catarrhal) and investigated the pathological features specific to appendiceal diverticulosis.

Methods

Over a 7.5-year period from January 2004 to June 2011, we identified 391 patients with appendiceal disease (diverticulosis, 12 cases; appendicitis, 368; mucinous cystadenoma, 8; carcinoid, 1; cancer, 2) for whom surgery was performed in our hospital. The clinicopathological features of the 12 patients with appendiceal diverticulosis and 321 patients

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Table 1 Details of appendiceal diverticulum cases

case	sex	age (y)	preoperation examination/diagnosis					operation	diverticulum			
			WBC (/μL)	CRP (mg/dL)	US	CT	diagnosis		location	number (n)	type	perforation
1	F	53	11,800	1.27	impossible	not done	acute appendicitis	appendectomy	mesenteric	2	pseudodi- verticulum	yes
2	M	24	7,750	0.75	impossible	not done	acute appendicitis	appendectomy	mesenteric	2	pseudodi- verticulum	yes
3	M	43	14,290	10.29	impossible	not done	acute appendicitis	cecum excision	mesenteric	4	pseudodi- verticulum	yes
4	M	66	17,290	2.96	impossible	not done	acute appendicitis	appendectomy	not mesenteric +mesenteric	2	pseudodi- verticulum	no
5	M	57	24,600	23.54	impossible	not done	acute appendicitis	appendectomy	mesenteric	3	pseudodi- verticulum	yes
6	M	71	8,840	0.2	impossible	not done	acute appendicitis	ileocecum excision	mesenteric	2	pseudodi- verticulum	no
7	M	64	8,570	11.71	possible	not done	appendiceal diverticulum	cecum excision	not mesenteric +mesenteric	5	pseudodi- verticulum	yes
8	F	66	15,490	22.75	possible	possible	appendiceal diverticulum	appendectomy	mesenteric	2	pseudodi- verticulum	yes
9	M	23	6,330	0.28	impossible	not done	acute appendicitis	ileocecum excision	mesenteric	1	pseudodi- verticulum	no
10	M	63	11,320	0.09	impossible	not done	acute appendicitis	cecum excision	mesenteric	2	pseudodi- verticulum	no
11	M	65	8,800	10.2	impossible	not done	acute appendicitis	cecum excision	mesenteric	2	pseudodi- verticulum	no
12	F	56	8,070	1.7	possible	possible	appendiceal diverticulum	appendectomy	mesenteric	3	pseudodi- verticulum	no

with acute appendicitis (excluding catarrhal) were compared, and the pathological features specific to appendiceal diverticulosis were investigated. The diagnoses of 3 of the 12 patients were confirmed preoperatively by ultrasonography (3/12) and/or computed tomography (2/2). JMP version 8.0 (SAS Institute Inc., Cary, NC, USA) was used to perform statistical analysis, and χ^2 and Student's *t*-tests were used to assess significant differences. Results were considered to be significant for $p < 0.05$.

Results

Of the 12 patients with appendiceal diverticulosis, all except 1 (Case 6 in **Table 1**) exhibited appendiceal diverticulitis with severe inflammation surrounding the diverticula. Age of onset was significantly later for appendiceal diverticulosis (average, 54.3 years; range, 23–71 years) than for acute appendicitis (average, 39.7 years; range, 5–97 years; $p = 0.0176$).

There was a higher rate of perforation for appendiceal diverticulosis (6/12 cases) than for acute appendicitis (20/321 cases; $p < 0.001$). There were no significant gender differences associated with either appendiceal diverticulosis (9 men, 3 women) or acute

appendicitis (176 men, 145 women; $p = 0.2387$), but men represented a higher proportion of the cases studied in this dataset. A total of 3 patients were preoperatively diagnosed; all 3 (3/12, 25 %) were diagnosed by US, and 2 of the 3 were also diagnosed by CT (2/2, 100 %).

The average preoperative white blood cell count was 11,929/ μ L, and the average preoperative CRP levels were 7.15 mg/dL. The operative procedure was appendectomy in 6 cases, partial cecal resection in 4 cases, and ileocecal resection in 2 cases. Histopathological findings revealed pseudodiverticula in all patients, which arose on the mesenteric side in 10 patients and on both the mesenteric and non-mesenteric sides in 2 patients. The average number of diverticula was 2.5, and perforations were observed in 6 patients (**Table 1**).

Among the 12 patients with appendiceal diverticulosis, 3 were preoperatively diagnosed. Abdominal US findings revealed a hypoechoic area projecting outside the appendiceal wall (**Fig. 1a, a'**). Abdominal CT revealed a low-density area projecting outside the appendiceal wall (**Fig. 1b, b'**). Surgical findings during appendectomy revealed an enlarged

Fig. 1 a: Abdominal ultrasonography showing a diverticulum (arrow) in the appendix. Fig. 1a' shows a schema of Fig. 1a.

b: Abdominal computed tomography showing a diverticulum (arrow) in the appendix. Fig. 1b' shows a schema of Fig. 1b.

c: Resected sample (mucosal surface). The base of the appendix is on the right and shows thickening of the wall with a fecalith and 4 diverticula (arrow).
d: Histopathological findings. Hematoxylin and eosin staining under magnification. The base of the appendix is on the right. A diverticulum is indicated (arrowhead). The lumen of the appendix is greatly distended, allowing abscess and diverticulum formation with a fecalith. The figure displays an ambiguous appendix wall structure allowing access by lymphocytes, neutrophil infiltration, congestion, and bleeding affecting the entire wall and serosa.

appendix and diverticula observed from the root to the main body (**Fig. 1c**). Histopathological findings revealed an extremely enlarged appendix lumen

with an accumulation of intestinal calculi. Multiple pseudodiverticula were observed. The appendiceal wall structure was indistinct, with lymphocytes,

neutrophil infiltration, hyperemia, and hemorrhage observed across the appendiceal wall and serous membrane. Inflammation was considered to be due to cellulites (**Fig. 1d**).

Discussion

Appendiceal diverticulosis was first reported by Kelynnack et al. in 1893¹⁾, and a detailed investigation of this disease and its causes were reported by Stout in 1923²⁾. The frequency of this disease has been reported to be 0.004 %–2.1 % in surgical extraction surveys and 0.20 %–0.66 % in autopsy surveys, in which a majority of cases are incidentally discovered^{3,4)}. The number of cases reported is relatively high from countries outside Japan^{1–14)}, although Asano et al. reported 272 cases in Japan during 2004¹⁵⁾ and Kashiwagi et al. investigated 180 reported Japanese cases¹⁴⁾. According to these reports, the rate of perforation was 35.4 %, which was comparatively higher than the 27 % reported by Badr et al. in 2009¹³⁾. The most recent report documented that the perforation rate was higher in appendiceal diverticulitis than in acute appendicitis (33.3 % vs. 9.8 %; $p = 0.009$)¹⁶⁾.

Similar to colonic diverticula, appendiceal diverticula are classified as true diverticula (congenital) and pseudodiverticula (acquired). True diverticula have mucous membranes, submucosa, individual muscle layers, and serous membranes. They are extremely rare, and Collins reported appendiceal diverticula in only 691 cases out of 50,000 resected specimens and autopsy samples (1.37 %), out of which only 7 cases (0.014 %) had true diverticula¹⁷⁾.

Pseudodiverticula lack individual muscle layers in the diverticular wall. This type comprises a majority of appendiceal diverticulosis cases¹⁸⁾. Makuuchi et al.¹⁹⁾ and Nakayama et al.²⁰⁾ reported cases of multiple diverticula in which true diverticula and pseudodiverticula coexisted. All cases detected in the present study were of the pseudodiverticula type.

Badr et al.¹³⁾ described the developmental mechanisms of appendiceal pseudodiverticula, which are divided into inflammatory and noninflammatory causes. The inflammatory cause involves a narrowing of the lumen due to inflammation or infection before onset, leading to atrophy of the lymphatic tissue. This results in embrittlement and thinning of the remaining wall, which causes diverticula formation^{5, 21, 22)}.

The noninflammatory causes involve subsequent development of elevated luminal pressure due to a range of factors²²⁾. Obstruction following chronic inflammation, stenosis, intestinal calculi, or tumors cause muscular contractions and elevated luminal pressure, whereas a combination of luminal obstruction and active muscular contractions is considered to be a driving force in the creation of diverticula^{6,7)}.

The three cases that were preoperatively diagnosed presented in this study (case 7, 8, 12) were of the pseudodiverticula type, and were diagnosed with diverticulitis associated with inflammatory invasion of the surrounding tissues. Moreover, cases 7 and 8 involved perforation; in addition, case 12 involved intestinal calculi inside the diverticula, which was considered to have led to diverticulitis because of the formation of pseudodiverticula after obstruction by the calculi, as described previously (**Fig. 1c**).

Of the 3 patients in which preoperative diagnosis was possible, all 3 were diagnosed by US and 2 were diagnosed by CT as well. In these 2 patients, CT revealed a circular structure exhibiting low density protruding out of appendiceal wall.

In all the 3 patients, US revealed a hypoechoic circular structure protruding out of the appendiceal wall along with narrowing of the lumen of the appendix. Diverticula are reportedly visible as hypoechoic areas on US^{16, 23–25)}. US findings from this hospital were characterized by a more pronounced narrowing of the lumen compared with the acute appendicitis findings, which may be because inflammation occurs principally in the mucous membrane during acute appendicitis and involves enlargement of the lumen of the appendix, whereas the lumen narrows as a result of inflammation around the diverticula during diverticulitis. Lee et al. reported that diagnosis on the basis of CT is possible because appendiceal diverticula are visible as round cystic protrusions that produce a contrast effect, facilitating differentiation from acute appendicitis²⁶⁾.

The primary limitation of our study was the small number of cases.

In addition, there is a lack of consensus on the definitive CT and US findings that is necessary for diagnosis of diverticulosis.

Several reports have stated that appendectomy should be selected for symptomatic appendiceal diverticulitis³⁾, whereas laparoscopic appendectomy is both safe and sufficient as a treatment for simple

appendiceal diverticulosis^{2,5)}. However, consensus is still lacking in Japan. There have been reports of deaths in appendiceal diverticulosis cases, and the perforation rate is high, even when catarrhal appendicitis is suspected. Therefore, there is a need for proactive surgery when diverticula are observed during preoperative examination.

In summary, CT and US were useful for the diagnosis of appendiceal diverticulosis. It is necessary to proceed with excision when appendiceal diverticulosis is suspected before surgery. Histopathological investigation of the entire appendix is necessary for confirmation in patients diagnosed with appendicitis or ileocectitis, and excision is recommended when the presence of acute appendicitis is unclear.

Conflict of Interest Statement

The authors present no potential conflicts of interest.

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