

Diverticulosis and Diverticulitis of the Vermiform Appendix *

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DIVERTICULA of the appendix, because of their uncommon occurrence are frequently looked upon as anatomic or surgical curiosities. A careful perusal of the literature reveals the infrequency with which these lesions have been observed, diagnosed and reported. It may be that the incidence is highest where the diverticula are especially sought and recorded. It is quite possible, therefore, that their incidence will increase as the condition becomes more widely known. The finding of these diverticula always attracts considerable attention first, because of their extraordinary diversity and mode of development and second, because of the frequent development of acute or chronic inflammation of the appendix incidental to their presence.

This paper is not a review in detail of the etiology, pathology and symptoms of diverticulosis and diverticulitis of the appendix, for this information is readily available in the literature. Our purpose is to discuss a few of the more salient factors which should be borne in mind when one is called on to treat this condition. An analysis of the literature on diverticulosis of the appendix has been presented in an admirable paper by Stout.¹⁰

The vast majority of diverticula of the appendix described in the literature were incidental findings observed during routine roentgenological examination of the gastro-intestinal tract, or were discovered accidentally during routine autopsy exami-

nation. In 1926, Spriggs and Marxer⁹ recorded the first case in which a roentgenologic diagnosis of appendiceal diverticula was made. The American literature contains only scattered clinical descriptions of this condition. Gilmore and Mahan² demonstrated roentgenologically the presence of diverticula in the appendix of a young man who presented symptoms of chronic, right lower abdominal pain, and tenderness. In recent years, due to improved radiologic technics, visualization of the appendix is more readily made. In a series of 3,932 roentgenologic examinations of the gastro-intestinal tract, Kadrinka and Sarasin⁷ discovered two cases of diverticulosis of the appendix. Feldman,¹ however, could not find a single instance of appendiceal diverticula among 20,000 patients subjected to x-ray studies of the intestine.

It is difficult to assess the percentage of diverticula of the appendix that undergo pathologic changes. It is becoming clear, however, from the increasing literature on this subject, that a fair percentage of such diverticula undergo inflammatory changes and produce symptoms of an acute or chronic nature. There can be no doubt that with the onset of complications these diverticula may place life in jeopardy. Further, diverticula of the appendix and the complications associated with them are of such a varied and unusual nature that they always remain an interesting subject.

Because of the apparent rarity of this condition it seemed worthwhile to report a group of ten consecutive patients with

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acute diverticulitis of the appendix who were operated upon during the period 1955 to 1960, all of whom recovered. There were two other cases with diverticulosis of the appendix that were discovered accidentally during routine autopsy examination. This number is the equivalent of the largest series yet presented and suggests that with better recognition of the disease it may not be as rare as heretofore thought. Some of the theories which have been advanced to explain the etiology and pathogenesis of diverticulosis and diverticulitis of the appendix, also will be described and discussed.

Table 1 summarizes the salient clinical and laboratory features of acute appendiceal diverticulitis. Of the ten surgical cases reported in this paper, six were men and four were women; the two cases found at autopsy both were men. The ages of the patients in this series ranged from 16 to 58, with an average of 32.6 years. All patients presented with acute abdominal pain, in some starting and staying on the

right side of the abdomen, in others commencing centrally or in the epigastrium and moving to the right, and, in a few, being generalized from its first appearance. In a few cases the pain appeared with dramatic suddenness and intensity so that within a few hours the patients were admitted to hospital. Most, however, had a longer history (12 to 96 hours), the first pain being comparatively slight but then getting progressively worse and finally becoming severe. Nausea was a prominent symptom in seven patients, and vomiting in three. Six patients complained of constipation and one had diarrhea.

Seven of the ten patients were well developed, slim, but well nourished; three were obese. Their temperatures ranged from 37.6° to 39.4° C. Seven patients showed exquisite right lower abdominal tenderness and release pain, while the three remaining showed a lesser degree of tenderness. In five of the patients there was found local rigidity of the abdominal wall; three had muscle spasm in the right lower

TABLE 1. Summary of Cases. Preoperative Diagnosis: Acute Appendicitis in All.

	Case No.									
	1	2	3	4	5	6	7	8	9	10
Age	16	25	18	48	25	58	29	34	42	31
Sex	F	M	M	F	F	M	M	M	F	M
Duration of symptoms (hrs.)	24	12	20	48	30	96	18	24	36	24
Pain at onset*	Mid-abd.	Epi.**	Epi.**		Mid-abd.	Diff.†	Diff.†		Diff.†	Diff.†
Tenderness	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Vomiting	Yes	No	No	Yes	No	Yes	No	No	No	No
Nausea	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No
Rigidity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constipation	Yes	Yes	No	Yes	Yes	Diarr.	Yes	Yes	No	Yes
Temperature (C.)	37.9	38.3	37.6	38.2	39.4	38.3	37.7	38.8	38.5	37.7
Distention	No	No	No	No	Yes	No	No	No	No	No
WBC	16M	10M	20M	10.5M	28M	22M	13M	24M	18M	21M

* All 10 had pain in right lower quadrant.

** Epigastrium.

† Diffuse.

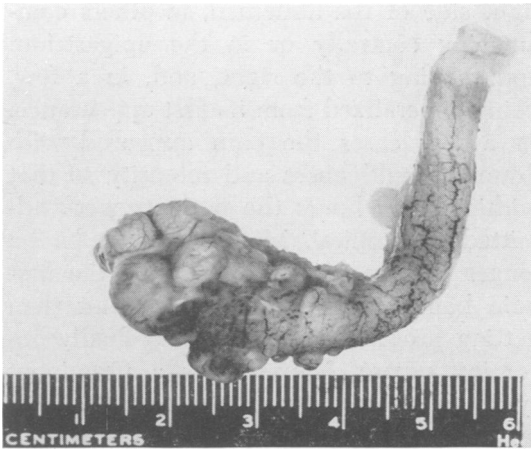


FIG. 1. Photographic appearance of appendix with diverticulosis removed from a man following an acute attack of appendicitis. Note the multiple diverticula along the mesenteric and antimesenteric borders of the appendix.

quadrant, and two others had diffuse muscle spasticity throughout the abdomen, associated with distention.

The white blood cell count was slightly raised in three patients with an average of 10,000. In the others it was considerably elevated and ranged between 16,000 and 28,000 per cubic millimeter. The differential count showed 74 to 92 per cent polymorphonuclear leucocytes and the remainder were lymphocytes and monocytes.

The preoperative diagnosis in all ten patients was acute appendicitis. At operation, three patients showed purulent fluid in the peritoneal cavity associated with perforation of the appendix; four had clear serous fluid. There was a striking appearance of the appendix when viewed at the operating table. In four patients multiple small diverticula of variable size were seen scattered along the mesenteric and antimesenteric border of the appendix. They averaged in size from 2.0 to 5.0 mm. in diameter, and from two to six in number. The diverticula imparted to the appendix a characteristic beaded-like appearance, which was quite unique (Fig. 1).

On section, the mouths of the diverticula varied in size from a mere slit to several

millimeters in diameter. The lumen of the diverticula was frequently of the same diameter as the appendix. In one instance a small fish bone, and in another, a melon seed, were found lodged within the diverticulum (Fig. 2).

Microscopically, the mucosa of the diverticula showed an elaborate duplication of the adjoining appendix. The diverticula were covered exclusively by mucosa, submucosa and muscularis mucosa, outside of which was adherent fatty tissue; the longitudinal and circular muscle fibers were completely absent. All coats of the diverticula, including those of the adjoining appendiceal wall were densely infiltrated with inflammatory cells, for the most part polymorphonuclear leucocytes, yielding a picture characteristic of acute inflammation (Fig. 3).

In four patients there was no evidence of appendiceal diverticulosis that one could discern with the naked eye. The proximal portion of the appendix was of normal size and appearance, but beyond this it plunged into a swollen mass which was acutely inflamed and covered mostly with a fibrinous exudate. The diameter of this mass was several times the size of the normal appendix. As will be shown later, the finding of such an inflammatory mass



FIG. 2. Photograph of a cross section of the appendix and adjoining diverticulum. The lumen of the diverticulum (arrow) is of about the same caliber as the appendix.

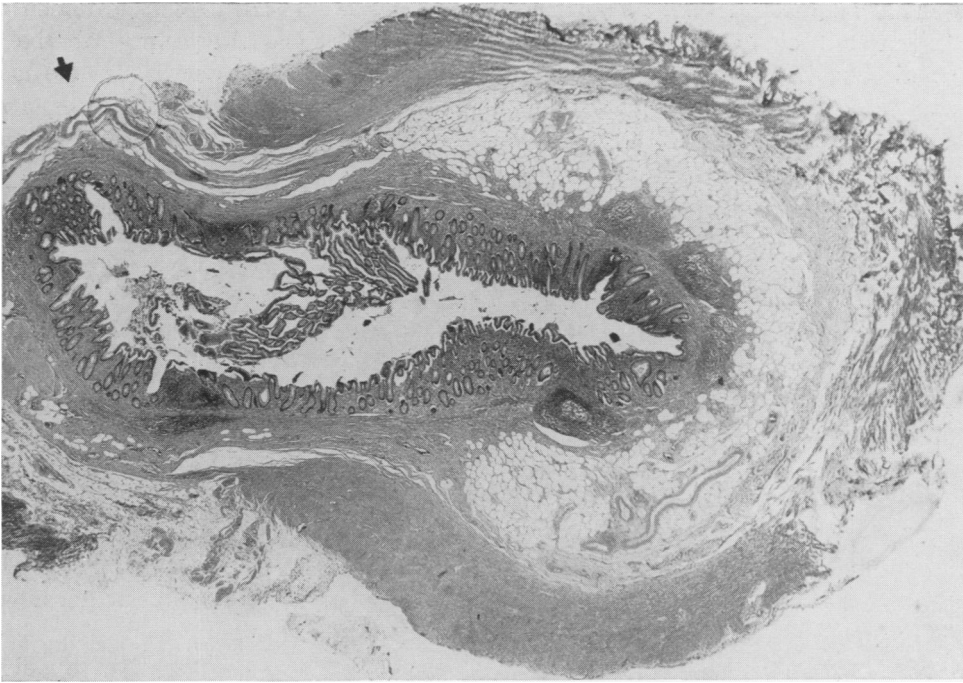


FIG. 3. Photomicrograph of a cross section of the appendix and diverticulum. Note the very thickened muscle coat of the appendix and the complete absence of muscle fibres in the diverticulum (arrow). The wall of the diverticulum is made up exclusively of mucosa, submucosa, and adherent fat.

justifies a high suspicion of the presence of diverticula which can be hidden from view by surrounding inflammation.

Microscopic sections of the inflammatory mass showed a double lumen pattern, with one segment bearing a distinct appendiceal mucosa, submucosa and muscularis, while the other segment, apparently a diverticulum of the appendix, had only a mucosa and submucosa, the muscle bundles being completely absent. Both the diverticulum and adjacent appendix showed a marked degree of acute inflammation, with an exudate composed largely of polymorphonuclear leucocytes (Fig. 4).

In the remaining two patients both the appendix and its diverticula were hidden from view by a large mass of inflammatory tissue which involved the entire appendix and adjoining cecum. It was difficult to tell at operation whether the mass was inflammatory or neoplastic; consequently a

right hemi-colectomy was done. Microscopically appendiceal diverticula were found associated with an inflammatory process which involved the appendix and its diverticula, and the cecum.

Evaluation

Acute inflammation of the appendix always has been an intriguing part of the surgeon's practice. It is well documented that the majority of patients with acute appendicitis follow a definite pattern of symptoms. However, diverticulitis of the appendix forms a subject of considerable interest because of the wide range of pathological processes, some poorly understood, which give rise to this condition. In our institution, an increased interest in this specific disease has also contributed to the increasing incidence of diagnosis, both surgically and pathologically. Generally, surgical text books do not separate

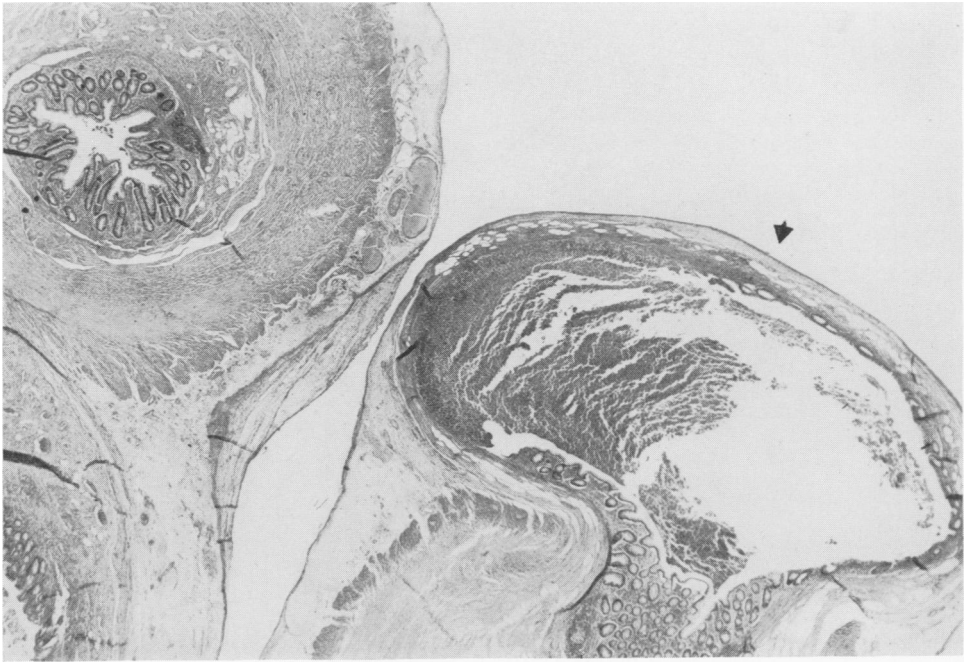


FIG. 4. Photomicrograph showing the double lumen pattern, with one segment bearing a distinct appendiceal mucosa, submucosa and muscularis, and the other segment, the diverticulum (arrow), consisting of mucosa and submucosa alone.

diverticulitis of the appendix as a clinical entity, although mention is sometimes made of diverticulitis being one of the rarer forms of appendicitis. Diverticulitis of the appendix is now recognized as a cause of appendicitis and acute abdominal pain. The clinical picture and operative and pathologic findings are quite definite; there seems to be sufficient justification for regarding it as a clinical and pathological entity.

Not all cases of diverticulitis pursue an acute course. A more chronic course has also been known to occur where neighboring viscera become involved in the inflammatory process, and often produce a mass which is difficult to distinguish, even at operation, from carcinoma. Inability to exclude carcinoma was the reason for two radical resections of right colon in our series.

In some of the cases the anatomic changes observed at operation or at autopsy were indicative of diverticulosis or diverticulitis of the appendix, and a correct diagnosis could be made grossly with-

out reservation. In the majority of cases, however, the inflammatory process was so extensive that a correct diagnosis was possible only after microscopic examination of the resected specimen. It is in the latter group of cases that the diagnosis will be missed unless the surgeon or pathologist are fully alerted to the condition.

While it is agreed that many people with appendiceal diverticula live healthy, normal lives, there can be no doubt that with the onset of complications, life is in jeopardy. Diverticula of the appendix, because of their peculiar anatomic structure, are very much susceptible to inflammatory changes. The inflammatory process may be acute or chronic, traumatic from the presence of a foreign body, or even parasitic in origin. When an inflammatory reaction sets in a diverticulum it frequently involves the adjoining appendix and forms a mass which may hide the diverticulum from view. The appendix usually assumes here a bulbous appearance which is fairly characteristic

and often diagnostic of the condition. If this were a constant finding in every case, the diagnosis would then become routine.

The etiologic factors responsible for the development of appendiceal diverticulitis are probably the same as those which cause acute appendicitis. It may be that in certain conditions the presence of a foreign body within a diverticulum sets up an inflammatory reaction, with edema and congestion of the diverticular wall. Two patients reported in this series had a foreign body lodged in the diverticulum; these could have very well initiated the inflammatory process in these two cases. However, since the exact role of these substances in the production of the inflammatory changes was uncertain, and there were no major differences in the inflammatory patterns in these patients as compared with the others under study, the part they played in this picture remains questionable.

Practically all appendiceal diverticula are of the acquired or false type and their wall is made up almost exclusively of mucosa, submucosa, and muscularis mucosae, with complete absence of the circular and longitudinal muscle bundles. Because of their thinned out wall diverticula are prone to perforate early in the presence of acute inflammation. Perforation may occur into the free peritoneal cavity with a resulting general purulent peritonitis, or with the formation of a localized abscess walled off by omentum. In the more chronic forms a mass may form about the appendix and cecum which may be indistinguishable from carcinoma.

Varying ideas have been propounded from time to time to account for the development of diverticulosis of the appendix, but the underlying agent or agents still remain not fully determined. The peculiar and almost constant localization of the lesion at the mesenteric or anti-mesenteric border of the appendix has been given special etiologic significance, and it has been often correlated with an

assumed defect in the muscular coat created by the passage of the blood vessels as they reach the mucosa and submucosa. According to Graser,³ chronic distention of the blood vessels as they pass through the muscular coats, tend to separate the muscle bundles and thus increase the diameter of the defect. This theory lacks support since no dilated vessels were ever seen in cases of appendiceal diverticulosis.

Klebs⁸ explains that in obese people collections of fat about the blood vessels as they pass through the wall of the appendix tend to force the muscle bundles apart, with consequent increase in the diameter of the defect; this in turn leads to a potential weakness and the formation of a diverticulum. This theory has not received universal acceptance since most patients with appendiceal diverticulosis are not obese. Seven of the surgical cases and two of the autopsy cases in our series were thin individuals.

There remains the theory propounded by Stout who maintains that there must be a weak point in the wall of the appendix which is probably due to an especially broad vascular defect in the mesenteric and anti-mesenteric border filled with connective tissue, a condition found in most appendices with diverticula; or to a scar in the muscularis, the result of a suppurative process; or to perforation during an acute attack, with protrusion of the mucosa and subsequent subsidence of infection followed by regeneration of mucosa within the former extramuscular cavity.

Most investigators believe that there exists a force which tends to drive the mucosa and submucosa through the muscularis. Such force may be produced by increased hydrostatic tension within the lumen of the intestine. This theory has received strong support by some of the experimental work done in this connection. Thus, Heschl,⁸ Hansemann,⁵ and Grassberger⁴ distended segments of large bowel with water and noted a bulging along the

mesenteric borders, which disappeared when the tension was released. They asserted that these occurred at the defects in the mesenteric border through which the vessels pass.

In a series of experiments conducted by Stout in dogs and subsequently repeated by two of the authors (J.R. and P.R.) in rabbits, it was demonstrated that an appendiceal diverticulum may develop both as a result of intraluminal distention and muscular contraction. Increased muscular contraction causes the mucosa to protrude, while greatly increased intraluminal distention tends to cause muscle fatigue and lead to diminution and, eventually, cause the disappearance of the diverticulum. In support of this theory was the observation that the muscularis in appendices with diverticula was considerably thicker than in the average appendix removed at operation. Stout attributed the thickening of the muscle coat to increased function, allowing more powerful contraction and greater intraluminal tension.

In summary, it may be said that defects may occur in the muscularis of the appendix either as a result of the passage of blood vessels, or as a result of inflammatory changes which destroy the muscle coat and replace it with scar tissue. This is further aided by strong contraction of the muscle bundles of the appendix with a resultant increase in intraluminal tension.

Summary

The clinical history of ten patients was carefully analyzed in the hope of obtaining certain clues which could be of value in diagnosis of appendiceal diverticulitis. All patients had histories which could be considered typical of acute appendicitis.

Acute diverticulitis of the appendix is not particularly uncommon, yet so rare that few individual surgeons have the opportunity of becoming familiar with it through personal experience.

Diverticula of the appendix are being

discovered with increasing frequency. Our records offer convincing evidence that the frequency depends to a considerable degree on awareness of its possible presence.

Basically, diverticula are evaginations of the mucosa and submucosa through an enlarged defect in the muscular coat. Histologically, they may be classified as false or acquired and are distinguishable by the structure of their wall which is made up exclusively of mucosa and submucosa, with complete absence of the circular and longitudinal muscle fibres.

A study of these cases has offered convincing evidence that diverticulitis of the appendix is a distinct entity and should be so considered. Its histological structure is sufficiently characteristic to set it apart from other forms of appendicitis.

The several theories concerning the formation of appendiceal diverticula were discussed generally. Defects in the musculature associated with increased intraluminal tension, are perhaps the most important factors in the development of these diverticula.

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