PRIMARY DIVERTICULA OF THE DUODENUM*

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PRIMARY DIVERTICULA OF the duodenum have been of interest to physicians and surgeons for little more than four decades. Some of the original controversy regarding the ability of these diverticula to cause symptoms and the advisability of surgical treatment continues today.

Case[3] first described the roentgenographic characteristics of duodenal diverticula. Key[6] is credited with the first operative removal of a duodenal diverticulum, which he accomplished in 1915. Possibly prophetic of much of the experience to come in the next three decades was the result in Key's case, as noted by Oehnell;[13] the patient's symptoms of enterocolitis were little altered by the operation for diverticulum.

Morton[11] was able to find only 49 cases recorded prior to 1940 in which duodenal diverticula were attacked surgically. Patterson and Bromberg[15] collected from the American literature reports on an additional 34 patients treated surgically prior to 1951. Cattell and Mudge[4] recently recorded 25 cases in which the condition was treated surgically.

MATERIAL

In this study we reviewed 30 cases of primary diverticulum of the duodenum in which surgical exploration was carried out at the Mayo Clinic in the period January, 1940, through December, 1952. During this period the diagnosis of duodenal diverticulum was recorded by the clinicians in 525 instances. In addition, 205 secondary diverticula associated with peptic ulcers in the first portion of the duodenum were noted during this time.

Before we present the observations made in this study it seems appropriate to distinguish between primary and secondary diverticula.

PRIMARY VERSUS SECONDARY DIVERTICULA

The simple classification of diverticula into primary and secondary types appeals to us. It avoids much of the confusion resultant from the conflicting use of the terms "true" and "false" (or pseudo) diverticula depending on whether one refers to their etiology or to the morphologic content of the wall of the sac.

Primary duodenal diverticula are typical thin-walled outpouchings that occur almost entirely on the concave side of the duodenal curve, with no musculature in the wall of the sac. Rokitansky's early concept of these diverticula as mucosal herniations is a useful one.

Secondary diverticula are those which result from traction or scarring of local inflammatory processes or ulceration, and the wall of these sacs usually consists of all the normal layers of the bowel.

The etiology of primary duodenal diverticula has been discussed at length in the literature. A constitutional predisposition to

a weakness of the *muscularis propria* at the site at which blood vessels or ducts enter the bowel wall would seem to explain best the increasing incidence of duodenal diverticula with aging, the association of duodenal diverticula with colonic and intestinal diverticula, and the absence of muscular elements in the wall of the sacs.

The incidence of primary diverticula in the duodenum is second only to diverticulosis of the colon. Necropsy studies have revealed diverticula in up to 14.5 per cent of careful duodenal dissections,[2] while roentgenographic surveys have disclosed an incidence of only 1 or 2 per cent.[4] The higher figure is probably closer to an accurate estimate for the adult population.[7]

GENERAL OBSERVATIONS

Duodenal diverticula occur more frequently in older persons. In our series the ages ranged from 34 to 78 years, the largest number of patients being between 55 and 65 years of age. There is no significant difference in the sex distribution of these lesions. Sixteen of our patients were women and 14 were men.

Diverticula are said to occur predominantly in the second or descending portion of the duodenum, near the ampulla of Vater. There were 39 duodenal diverticula in our 30 cases. Twenty-two diverticula (56.4 per cent) were in the second portion, 15 (38.5 per cent) in the third portion, and two in the fourth portion of the duodenum. These findings are somewhat different from the frequently quoted incidence of 65 to 85 per cent in the second portion,[5, 10, 17] and tend to agree more with Ackermann's findings[1] in a series of careful dissections of necropsy specimens; he reported a higher percentage in the third portion than had been recorded previously.

In our series, multiple duodenal diverticula occurred in eight cases (26.7 per cent). In four of these eight cases there was one diverticulum in the second and one in the third part of the duodenum. Two patients had two diverticula each in the second portion of the duodenum, one had two in the third portion, and one had three in the third portion. Other authors[4, 8, 11, 12, 17] have reported the presence of multiple diverticula in 10 to 35 per cent of their cases of duodenal diverticula. When two diverticula occur in the second part of the duodenum, usually one is located proximal and one distal to the ampulla of Vater. This paired perivaterian arrangement can be closely simulated when one diverticulum is in the second portion and one is in the third portion of the duodenum, owing to the somewhat variable relationship of the ampulla of Vater to the curve of the duodenum which marks the boundary between the second and third portions.

Diverticula elsewhere in the small intestine and also in the colon are associated with diverticula in the duodenum. Five of our patients had multiple (more than two) diverticula of the small intestine, mostly in the jejunum, while one patient had a single jejunal diverticulum and another had two jejunal diverticula. Thus, seven of our 30 patients (23.3 per cent) had additional diverticula of the small intestine. This rate would undoubtedly have been even higher had complete roentgenologic studies of the small bowel been made in all our earlier cases.

Twenty of the 30 patients had barium-enema studies of the colon, and nine of these were found to have diverticulosis of the colon (45 per cent). This is certainly a significant increase over the 10 per cent incidence of diverticulosis of the colon reported in routine roentgen surveys. Four patients had diverticula in both the small intestine and the colon and have been included in both groups above. Such cases present problems in therapy that are somewhat different from those of diverticula localized to the duodenum. Their occurrence must be noted, however, as an aid to understanding the pathogenesis of duodenal diverticula and to point out the need for complete gastro-

intestinal roentgenographic studies when symptomatic duodenal diverticula are suspected. It is of interest that both of the patients who had single duodenal diverticula in the fourth part of the duodenum had diverticula also in the jejunum. Diverticula of the fourth portion of the duodenum may be related more closely to diverticulosis of other portions of the small intestine than to isolated diverticula in the second and third parts of the duodenum.

Other pathologic entities often related to duodenal diverticula include hiatal hernia, cholecystitis and peptic ulcer. Their association cannot be evaluated from a series of surgical cases, as the associated disease may play a part in the decision to operate and thereby weight the series unfairly.

Complications. The possible pathologic changes that may occur within the sac or as a direct result of the presence of a primary duodenal diverticulum may be outlined as follows:

A. Inflammation
  1. Diverticulitis and peridiverticulitis
  2. Perforation
     a. Abscess formation
     b. Fistula formation (internal or external)
B. Obstruction
  1. Common bile duct
  2. Pancreatic duct
  3. Duodenum
C. Hemorrhage
  1. Ectopic gastric tissue with ulceration
D. Tumors arising in a diverticulum.

Examples of each of these complications have been recorded in the literature, but are relatively uncommon.

In 25 of our cases in which one or more diverticula were excised or examined carefully *in situ* we found no examples of definite intrinsic diverticulitis. Peridiverticulitis of moderate degree was not uncommon, with adherence of the sac to surrounding structures and increase in number and size of blood vessels in close proximity to the diverticula. Perforation of the sac had not occurred in any of our cases and hence neither abscess nor fistula formation was observed.

We believe that obstruction of the common bile duct and obstruction of the main pancreatic duct are important, albeit rare, complications resulting from the presence of diverticula in the second portion of the duodenum. In one of our patients there were stones in the common bile duct, but the diverticulum did not appear to be obstructing the ampulla or the common duct. A small number of cases have been reported in which jaundice was present, and in which there was no demonstrable cause other than a perivaterian diverticulum. A rare finding is that the common bile duct, the pancreatic duct, or both drain into a diverticulum of the second portion.[16]

Ogilvie[14] described four cases of pancreatic necrosis associated with the presence of perivaterian diverticula. His findings leave little doubt that such diverticula can, in rare instances, interfere with pancreatic drainage and lead to acute pancreatitis. One of our patients with two large diverticula in the second part of the duodenum underwent partial gastric resection for gastric ulcer and died two and a half years later of pancreatitis. Evaluation of the role of the bypassed diverticula in this process is difficult in view of the gastrectomy performed.

Partial obstruction of the duodenum was noted in only two of our cases. In both instances barium passed through the duodenum satisfactorily, demonstrating moderate dilatation proximal to large diverticula in the second portion in one instance and in the third portion in the other.

In none of our cases was ectopic glandular tissue or tumors found within the diverticula.

SYMPTOMS

Primary diverticula of the duodenum cause no typical symptom or symptom complex. Nevertheless, the physician is obliged

to determine, in evaluating the condition of a patient found to harbor a duodenal diverticulum, whether the presenting symptoms are attributable to the diverticulum or to some other cause. The most common picture is that of abdominal distress that is located in the epigastrium, right upper quadrant or periumbilical region, that usually is made worse or brought on by eating a large meal, and that is relieved by vomiting or belching. Antacids may give partial relief to some of these patients, but adequate doses of antispasmodics are usually more helpful. The distress may be described as pain but more often as fullness, heaviness or tightness. It may be referred into the back. Lying supine with the knees drawn upward has been noted to relieve the discomfort by some patients who have later been relieved of their symptoms by removal of the diverticula. Borborygmus has been noted in a few cases. Nausea is a common symptom, while spontaneous vomiting is surprisingly less common. Loss of weight can be a helpful finding in the absence of other pathologic basis. Diarrhea is an uncommon symptom but has been associated with large duodenal diverticula in a few cases.

At this point it seems appropriate to describe, for illustrative purposes, the symptoms in two cases in which surgical treatment gave unequivocal relief.

Case 1. A 34-year-old housewife presented a history of postcibal, crampy, upper abdominal pain of 3 months' duration. The discomfort was brought on only by eating, was associated with pronounced nausea, and was relieved by vomiting. If vomiting did not occur or was not induced, the pain would spread downward into the periumbilical and infra-umbilical region and diarrhea would be noted shortly thereafter. The patient had lost 30 pounds. The history was otherwise noncontributory and the physical examination gave essentially negative results. Thorough diagnostic investigation did not disclose any other abnormality and it was thought that her symptoms were due to a large diverticulum in the second portion of the duodenum. At operation the diverticulum was found to arise from the mesial border and to extend laterally, posterior to the duodenum. The sac was excised and the defect closed after placing a probe in the common bile duct. Follow-up examination 3½ years later revealed that she had obtained complete relief of symptoms and had gained weight.

Case 2. A 52-year-old man presented a history of episodic infra-umbilical pain, usually postcibal in onset but occasionally starting during a meal. The discomfort was described as a sensation of something being locked up inside that should be relieved by having a bowel movement but was not. He could obtain partial relief of his discomfort by lying supine with his knees drawn up. Nausea and borborygmus were associated with the attacks, but vomiting was rare. Abdominal tenderness sometimes lasted for 2 to 4 hours after an attack. He had lost 10 pounds. The history was otherwise essentially negative as was his physical examination. Diagnostic studies revealed 2 duodenal diverticula and no other demonstrable source of his symptoms. At the time of surgical exploration, 2 large diverticula were found to arise from the superior border of the third portion of the duodenum. These were inverted into the lumen of the bowel owing to the profusion of small vessels about the necks of the sacs and the proximity to the superior mesenteric vessels. The patient was feeling well and relieved of all his symptoms at last report.

These two cases present, in our experience, the more common clinical features of symptomatic duodenal diverticula. The mechanism by which such symptoms are caused is difficult to understand. Obstructive features may be attributable to duodenal dysfunction rather than to organic obstruction which is rarely of a severe degree in the few cases in which it has been noted. The diarrhea occasionally noted may be due to gastro-intestinal hypermotility related to duodenal dysfunction.

Bleeding from diverticula of the duodenum is probably extremely uncommon. Many of the cases of upper gastro-intestinal bleeding attributed to diverticula cannot be accepted as proved, for ulcerations, with or without ectopic-tissue rests, have been rarely demonstrated. In four of our cases there was a history of melena and secondary anemia. No ulcerative or bleeding lesions were found in any of the diverticula, although a clot was present in a diverticulum

of the one patient who obtained clear-cut relief from operation. Another of the four patients was thought to be relieved of the source of gastro-intestinal bleeding, but had a recurrence of bleeding two years later. Exploration revealed a gastric ulceration which had not been demonstrable at the first operation. One should be extremely hesitant in attributing upper gastro-intestinal bleeding to diverticula of the duodenum even if other more common sources cannot be proved definitely to be present.

INDICATIONS FOR OPERATION

More recent reports[4, 10] concerning duodenal diverticula have rightfully stressed the very limited indications for surgical intervention. Cattell and Mudge[4] have estimated that less than 5 per cent of duodenal diverticula discovered should require operation. In our series, of the 525 patients on whose records the clinician* mentioned the presence of duodenal diverticula, only 30 underwent exploration of the upper part of the abdomen. Only eight of the explorations were performed with the duodenal diverticula as the primary indication for operation (1.5 per cent of 525 cases). Adding to this group the two cases of exploration for upper gastro-intestinal bleeding of unknown source, in which duodenal diverticula were known to exist, the incidence of exploration for diverticula was 2 per cent or less. In 16 cases, other indications for operation were present, such as duodenal ulcer or disease of the biliary tract, and these were the conditions for which operation was primarily undertaken. Duodenal diverticula were entirely incidental in three additional patients operated on for other upper abdominal conditions. The remaining patient was operated on for cholecystoduodenal fistula and is of interest in that one other such case has been recorded.[17] A large diverticulum arising in

the second portion of the duodenum curved laterally and cephalad posterior to the duodenum and was mistaken for a cholecystoduodenal fistula on the roentgenograms.

The statement has been made repeatedly that most duodenal diverticula do not cause symptoms. This would seem to render the problem of their evaluation easy. Unfortunately, many of the patients found to harbor primary diverticula of the duodenum do have symptoms. They are a selected group of patients at this point, for they have usually presented some upper abdominal complaints which have prompted the roentgenologic examination necessary to demonstrate the presence of diverticula.

We have not found the oft-described roentgenologic features of diverticula, such as delayed emptying of the sac, the size of the neck of the sac, the mobility of the diverticula or changes in the mucosal pattern or motility of the duodenum, to be of much help in establishing which diverticula are causing symptoms. Somewhat more significant have been observations pertaining to such factors as the size of the diverticula, their location in relation to the ampulla of Vater, definite and persistent tenderness to palpation in the region of the diverticula, and the presence of any proximal dilatation of the duodenum.

The evaluation of the patient suspected of having a symptomatic duodenal diverticulum should be thorough, and should include roentgenologic studies of the stomach and duodenum, small intestine and colon, and the gallbladder. While most authors have stressed the advisability of ruling out the presence of organic disease elsewhere in the abdomen, few have adequately stressed the importance of functional complaints in the differential diagnosis of duodenal diverticula. The diagnosis of the rare diverticulum which is actually causing abdominal symptoms cannot be made by the exclusion of organic disease alone. Functional complaints such as the irritable-bowel syndrome or aerophagia may present many features

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* Many incidental diverticula of the duodenum noted on routine roentgenographic studies were not entered as diagnoses on the clinical records.

attributable to duodenal diverticula. One must make a determined effort to establish positive diagnoses of such functional disorders in the patient found to have duodenal diverticula. Poor results following surgical treatment are probably more often due to failure to recognize these functional complaints than to failure to discover lesions of the stomach, small intestine or gallbladder.

There remains a small number of patients known to have duodenal diverticula who will require surgical exploration. Most of these operations will be carried out for other indications such as disease of the biliary tract or peptic ulcer and their complications. A few will be in the nature of diagnostic explorations for such problems as unexplained upper gastro-intestinal bleeding, or in search of the cause of disabling symptoms. Finally, a rare patient with definite clinical features of a symptomatic duodenal diverticulum may require operation, but only if the symptoms are disabling and have failed to respond to more conservative medical measures. Diverticula known to be present in the duodenum or noted at operation when an unrelated procedure is being carried out are best left alone unless obviously associated with complications, or of large size and easily accessible.

OPERATIVE TECHNICS

There has been much discussion about the relative merit of complete excision of duodenal diverticula as compared with inversion of the sac or sidetracking procedures.[4, 10, 11] Diverticulectomy with careful closure of the neck of the sac has been the preferred procedure at the Mayo Clinic. The technic of MacLean[9] can be of help in avoiding injury to adherent structures. The technic of air insufflation of the duodenum advocated by Mahorner[10] is also useful. Choledochotomy and insertion of a probe through the ampulla of Vater should be carried out whenever any doubt exists concerning the exact relationship of the sac to these structures. Review of our cases suggests a need for more frequent use of the latter maneuver.

The methods of approach and exposure of diverticula in the different portions of the duodenum have been described by many authors, and have varied in our cases with the location of the sac and the preference of the surgeon.

Operative treatment of the duodenal diverticula was carried out in 20 of our 30 cases. Diverticulectomy was performed for one or more diverticula in 17 of these cases. Inversion of two diverticula in the third portion of the duodenum was done in one case, as noted previously. In another case, the neck of a diverticulum which was very adherent to the pancreas was obliterated from within the lumen of the bowel through a duodenal incision. Posterior gastroenterostomy was performed in the remaining case wherein one very wide-mouthed diverticulum was located immediately adjacent to the ampulla of Vater, and a second diverticulum was present in the third portion.

No complications occurred in the cases in which inversion of the sac or obliteration of the neck of the sac was carried out. Inversion of a sac, however, requires as much dissection and freeing up as is necessary for excision of such a sac. The polypoid intraluminal remnant of an inverted sac may occasionally cause partial obstruction of the duodenum or bleeding. Obliteration of the neck of a diverticulum without removal of the sac would seem to be indicated only rarely.

Injury of the common bile duct occurred in one case during excision of a perivaterian diverticulum, and transplantation of the duct was necessary. The common bile duct was similarly transplanted in another case in which closure of the stump of a diverticulum seemed to compromise the intramural portion of the duct.

Injury to the pancreas must be minimized in exposing diverticula which are partially or completely embedded in the substance of the gland. Acute pancreatitis is a serious complication associated with operative trauma to the gland. If a diverticulum that is

within the substance of the pancreas must be attacked surgically, a sidetracking procedure may be the operation of choice. Subtotal gastric resection would be preferable to gastroenterostomy in such instances in order to obtain complete diversion of gastric contents from the duodenum.

RESULTS OF SURGICAL TREATMENT

The mortality associated with the operative treatment of duodenal diverticula is not insignificant.[4, 11, 15] Two of the 20 patients discussed above died postoperatively. Both deaths were due to complications attributable to the excision of the duodenal diverticula, although in one of the cases cholecystectomy also had been carried out. The latter case was the instance, described above, in which the common bile duct was injured in excising the diverticulum, and the duct was transplanted. Postoperatively, signs of renal shutdown developed and the patient died rather suddenly on the seventh postoperative day. Necropsy revealed acute hemorrhagic pancreatitis.

The second death in this series was that of the other patient whose common bile duct was transplanted when closure of the neck of a large diverticulum appeared to compromise the ampulla of Vater. A duodenal fistula developed four days after operation and peritonitis followed (this occurred in 1943). Necropsy confirmed the diagnosis of fistula and resulting peritonitis, but also confirmed the presence of a contributory factor in this death, namely a retroperitoneal and mediastinal lymphoblastoma which had been subjected to biopsy at the time of operation.

In one case a subhepatic abscess developed from a duodenal fistula (demonstrated by roentgenograms) following diverticulectomy, but the patient recovered completely. There was no other significant morbidity.

These two complications, namely (1) injury of the ampulla of Vater with interference with the drainage of bile or pancreatic secretions, and (2) duodenal fistula, are the factors which have caused the relatively high mortality and morbidity in our series as well as in others. Most of our patients were operated upon before development of the wide-spectrum antibiotics; hence, the mortality rate would doubtless be lower for more recent years.

Of the ten patients who had no operative procedures other than for their duodenal diverticula, data were satisfactory for evaluation of the clinical result in only seven. One patient was lost to follow-up and two died; one noted previously as a postoperative death and one who died of recurrence of an unrelated lesion.

The results in the remaining seven cases must be divided into two groups. Two of the patients mentioned previously who underwent exploration for upper gastro-intestinal hemorrhage comprised a special problem. One of these patients had no further bleeding following obliteration of the diverticulum. The other patient had recurrent bleeding from a lesion later demonstrated in the stomach, as noted above. Again, let us state that it is doubtful that duodenal diverticula are often the source of upper gastro-intestinal bleeding even in those cases in which no other lesion is demonstrable.

The results in the other five cases were as follows: Two patients experienced complete relief of their symptoms; these are the patients whose case records have been presented in some detail. The results in the other three patients must be classified as unsatisfactory; they continued to have the symptoms complained of prior to operation; the procedures carried out included diverticulectomy in two instances and posterior gastroenterostomy in the third.

Previous authors[11, 15] have recorded up to 80 per cent incidence of relief of symptoms following operative treatment of duodenal diverticula. Cattell and Mudge found that an excellent result had been obtained in only nine of 17 cases. We feel that definite benefit from operation can be expected in little more than 50 per cent of the most carefully selected patients, and that the literature

would show this were it not for the natural tendency to report only cases in which satisfactory results are obtained.

SUMMARY AND CONCLUSIONS

Primary diverticula of the duodenum are associated with diverticula of the colon and the other parts of the small intestine. They are rarely the cause of symptoms, but the evaluation of symptoms complained of by patients found to harbor duodenal diverticula can be extremely difficult.

Operative intervention is indicated in less than 1 to 2 per cent of the cases of duodenal diverticula noted on roentgenograms. Excision of the sac with careful closure of the duodenum is the operation of choice in most cases. Injury to the common bile duct or the pancreas must be avoided.

The results of operative treatment of primary diverticula of the duodenum have been disappointing in our series. Less than half of our patients on whom data were adequate for final evaluation can be said to have obtained an excellent result.

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