Meckel's Diverticulum and Meckel's Diverticulum Disease *

A Study of 154 Cases

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MECKEL'S DIVERTICULUM, the most frequent malformation of the gastro-intestinal tract, remains virtually impossible to recognize clinically. Alleged to occur in one to three per cent of persons it is in most instances an incidental finding of operation or autopsy; it is generally a harmless anomaly, rarely a site of disease or a source of trouble.

When disease does occur, Meckel's diverticulum becomes at once the cause of dangerously obscure abdominal trouble. Confused most often with appendicitis, affections of the diverticulum are mistaken also for the common causes of intestinal ulceration, perforation, hemorrhage or obstruction. Even when Meckel's diverticulum disease is suspected, as in cases of obscure melena [1, 6, 7] or as a cause of intussusception,[17, 26] the precise diagnosis almost invariably eludes the most careful x-ray study.

Compared with appendicitis, disease of Meckel's diverticulum with its protean manifestations and clinical obscurity is more serious. The morbidity and mortality are greater. The need for prompt surgical intervention is more urgent.

This report is based on a study of 154 patients with Meckel's diverticula operated upon at the Johnston-Willis Hospital. A previous paper by Johns and Wilson [21] in 1946 reported 56 cases; 52 of these have been reanalyzed and included here.

Between the opening of the hospital in 1909 and December 31, 1937, 11 patients having Meckel's diverticula were operated upon. In eight of these the diverticula were present including intestinal obstruction, intussusception and hemorrhage. There was one postoperative death.[37]

The present study is an analysis of 143 patients with Meckel's diverticula operated upon between January 1, 1937 and July 1, 1958. During this twenty-one-and-a-half-year period there were 22 cases in which disease involving a Meckel's diverticulum was responsible for the patients' illness. In the remaining 121 cases, disease of the diverticulum was not found; therefore the diverticulum was presumably not causing the patients' illness.

This report illustrates the frequency of the well known complications of this anomaly. It also suggests a relationship between the presence of a Meckel's diverticulum found at appendectomy and an erroneous preoperative diagnosis of appendicitis. Finally it re-emphasizes the importance of a routine systematic search for a Meckel's diverticulum in patients undergoing various abdominal operations.

History

In 1809, Johann Friedric Meckel [30] published his classic paper, "Ueber die Divertikel am Darmkanal." As early as 1598, the small intestine diverticulum was recognized and considered due to increased tension in the intestine by Fabricius.[14] Lavater [31] in Paris described a diverticulum in 1671 and Littré [28] described a diverticulum in an inguinal hernia in 1700, a condition known today at Littré's hernia. In 1707, the Flemish anatomist, Frederick Ruysch,[34] published in Amsterdam a copper engraving

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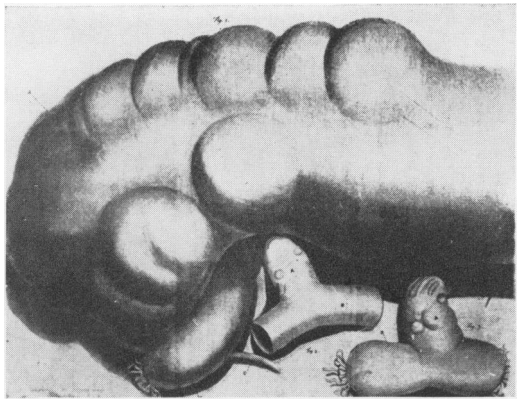

FIG. 1. Copy of the first illustration of a Meckel's diverticulum by Ruysch in 1698. Two diverticula are shown, presumably from two different individuals.

of such a diverticulum (Fig. 1). Obviously not the first to note the anomaly, Meckel clearly deserves the eponym since he introduced in detail the embryology of the diverticulum and predicted its important clinical implications. In this latter prediction, the dangers of Meckel's diverticulum disease were suspected long before clinical appreciation of inflammation of the appendix.

Subsequent writers have embellished Meckel's work with recognition of the various morbid states of the diverticulum, adding little to the clinical recognition of these

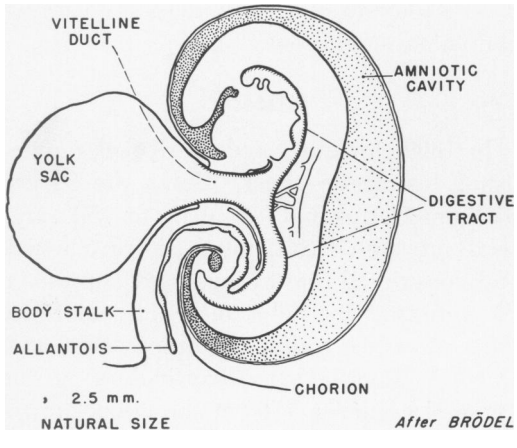

FIG. 2. Diagram (after Brodel) of a 3½-week embryo. As differentiation of the digestive tract progresses, narrowing of the neck of the yolk sac occurs and the vitelline duct is formed.

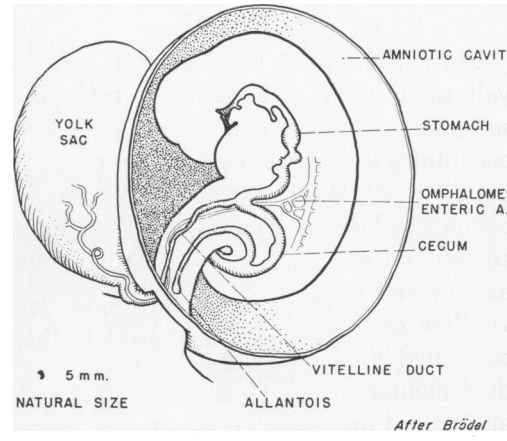

FIG. 3. Diagram (after Brodel) of a 4-week embryo. The vitelline duct has become long and narrow. At the fifth week the duct becomes obliterated and detached from the embryo. When the proximal end of the duct persists and fails to break loose from the embryo a Meckel's diverticulum is formed.

states. The first successful diverticulectomy was performed by Oderfeld [32] in 1892. The largest operative series on record is that of 149 cases at the Children's Hospital in Boston recorded by Gross [16] in 1953. In 128 of these patients complications of the diverticula were present.

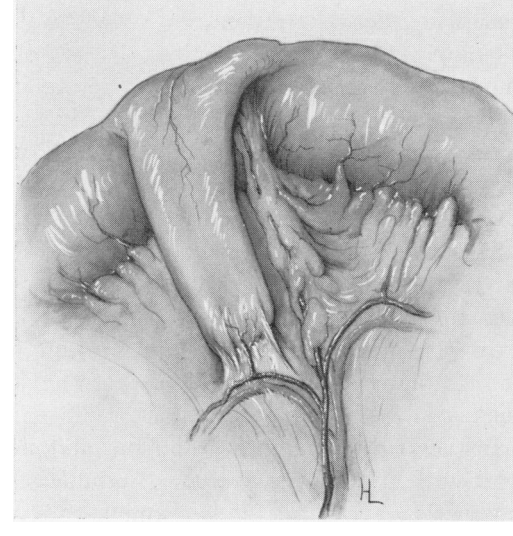

FIG. 4. Typical Meckel's diverticulum as illustrated at operation. The tip of the diverticulum is adherent to the mesentery as a result of previous inflammatory disease.

Embryology

In the third week of embryonic life,[8] the yolk sac is about as large as the embryo itself and the entodermal roof of the yolk sac constitutes the dorsal lining of the primitive gut (Fig. 2). With growth the yolk sac becomes pinched off from the embryo and the constricted area between the two becomes narrow and elongated (Fig. 3). This is the vitelline or omphalomesenteric duct and is contained in the yolk stalk. Normally this duct elongates until it becomes completely obliterated and detached from the embryo during the fifth week.

When the proximal end of the vitelline duct persists, Meckel's diverticulum is produced. The crucial stage for the malformation is the end of the first month of intrauterine life. At this stage the embryo is still less than one centimeter in length.

Variations in the anomalous development at this stage determine the size and shape of the diverticulum and the extent of associated malformations. The diverticulum may be a short, stumpy outpouch of the ileum, or a long narrow structure resembling a reduplication of the bowel. It may be found at any point along the ileum within six feet of the ileocecal valve. The base of the diverticulum is invariably situated on the antimesenteric portion of the bowel. Its tip is usually unattached but it may be adherent to adjacent bowel or mesentery (Fig. 4), or, by fibrous remnants of the obliterated omphalomesenteric duct or vessels, to the undersurface of the umbilicus (Fig. 5). The diverticulum may be found together with umbilical hernia, umbilical sinus or cyst. Persistence of the entire intracoelomic length of the vitelline duct may leave an enteric fistula with discharge of ileal contents of the diverticulum onto the abdominal wall[24] (Fig. 6). Finally glandular tissues foreign to the small intestine[10, 19] may be found in the normal ileal mucosa and submucosa (Fig. 7) of Meckel's diverticulum. These include gastric (Fig. 8), duodenal (Fig. 9) and colonic mucosa and pancreas (Fig. 10).

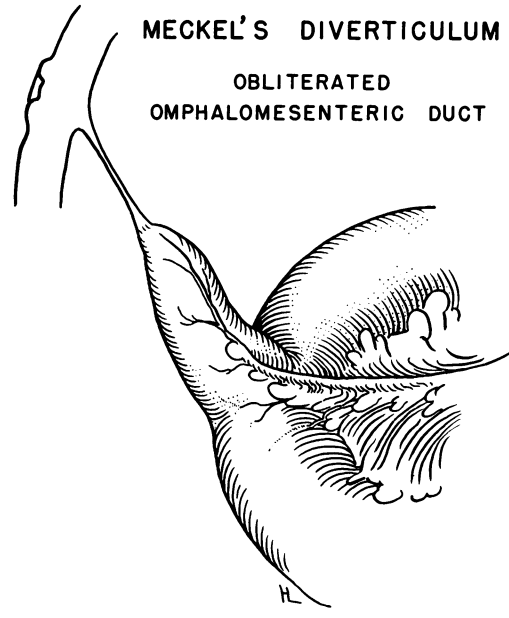

FIG. 5. The appearance of Meckel's diverticulum attached to the umbilicus by the obliterated omphalomesenteric duct.

Incidence

Meckel's diverticulum is the most frequent congenital anomaly of the digestive tract. The incidence is between 0.3 and 3.0 per cent. These percentages are derived

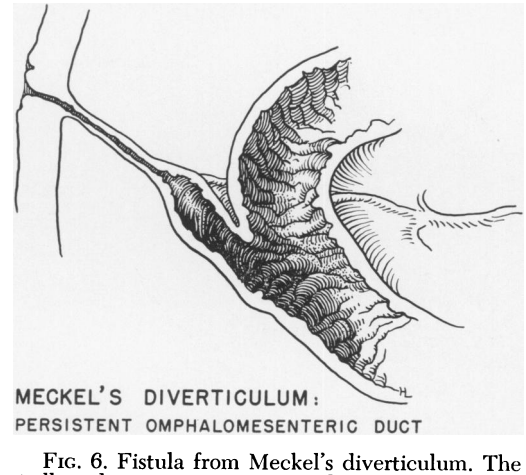

FIG. 6. Fistula from Meckel's diverticulum. The vitelline duct remains patent and the digestive tract is now open to the outside as it once was open to the yolk sac.

FIG. 7. Photomicrograph showing normal ileal lining of a Meckel's diverticulum.

from autopsy data published by Gant (0.3%),[15] Augier (1.6%),[2] Knox (0.6%),[25] Rich (0.7%),[33] Turner (0.8%),[38] Harkins (1.7%),[17] Cunningham (2.2%),[9] and Schaetz (2.3%).[35] According to Hennigar,[18] out of 8,000 autopsies at the Medical College of Virginia there were 38 cases of Meckel's diverticulum or an incidence of 0.5 per cent. The over-all estimated incidence calculated by combining the available data is 356 cases out of 44,163 autopsies or 0.8 per cent. These figures suggest that the true incidence of the anomaly is somewhat less than the 2.0 to 3.0 per cent generally stated. Unless the pathologist is looking for the anomaly as he runs the intestine, he may miss a small Meckel's diverticulum. This may account for some of the variability in published incidence figures.

As appreciated by Morgagni,[31] Meckel [12]

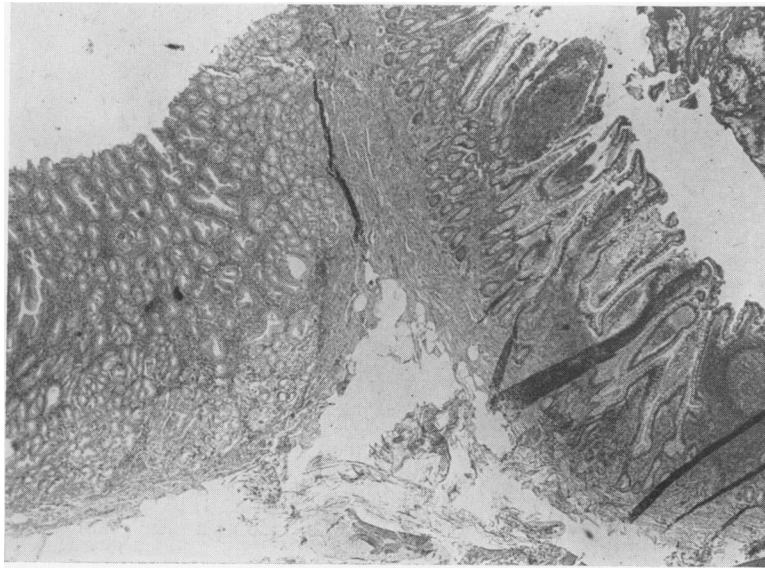

FIG. 8. Photomicrograph showing ectopic gastric mucosa in the wall of a Meckel's diverticulum.

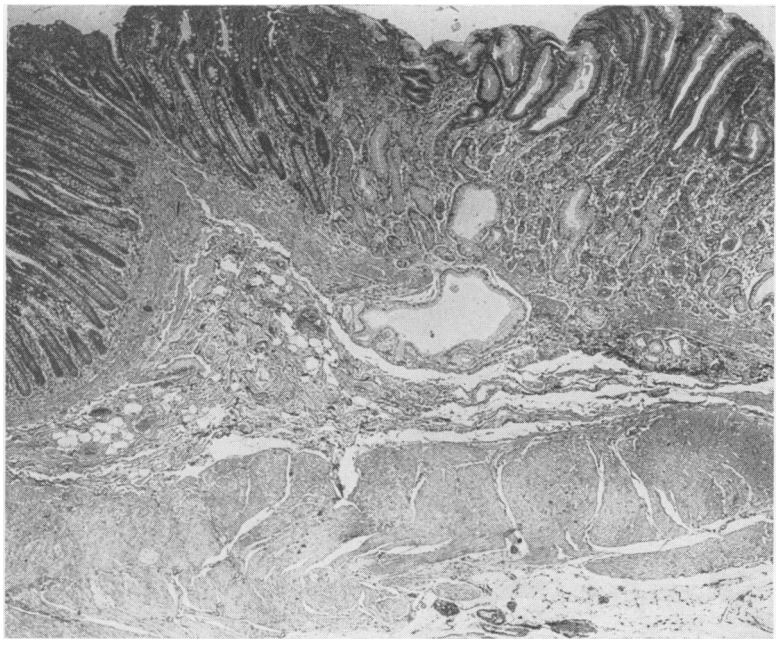

FIG. 9. Photomicrograph showing Meckel's diverticulum with duodenal mucus glands (Brunner's glands) in submucosa.

and subsequent observers, the diverticulum is a normal occurrence in bird species, including the goose, water hen, swan and snipe. It has also been observed in some mammals, such as the sheep.

Review of Cases

There were 71 males and 72 females in the series of 143 patients. Thirty-nine patients were children 12 years old or under. The mean age was 24.8 years with a mean

FIG. 10. Photomicrograph showing pancreatic tissue (lower right corner) in the wall of a Meckel's diverticulum.

TABLE 1. *Preoperative Diagnoses in Cases in Which Meckel's Diverticulum was Found at Operation*

Preoperative Diagnosis	Number of Cases	Meckel's Diverticulum Diseased	Meckel's Diverticulum not Diseased
Appendicitis	100	11	89
Gynecologic disease requiring pelvic laparotomy	24	0	24
Hernia	5	1	4
Intestinal obstruction	4	4	0
Hemorrhage	3	1	2
Intussusception	2	2	0
Hypersplenism	1	0	1
Mesenteric adenitis	1	0	1
Abdominal pain	1	1	0
Meckel's diverticulitis	1	1	0
Draining umbilicus	1	1	0
Totals	143	22	121

of 20 years in patients with Meckel's diverticulum disease and 25 years in the patients having a diverticulum found incidentally.

The anomaly is alleged to occur more often in males than in females with a ratio of about 2 to 1. In this series this usual sex distribution is distorted by the number of female patients found to have a Meckel's diverticulum at the time of pelvic laparotomy. Thus of 121 patients having the anomaly as an incidental finding, 66 were females and 55 were males. In contrast, of those patients with disease of the diverticulum, 16 were males and six were females.

Table 1 summarizes the 143 cases of Meckel's diverticulum in this series in terms of preoperative diagnosis and the presence or absence of disease of the diverticulum.

Meckel's Diverticulum as an Incidental Finding of Operation

In 121 patients Meckel's diverticulum was found as a result of a deliberate search during operation for suspected intra-abdominal disease. In these patients the diverticulum was not diseased and presumably asymptomatic. In 89 of these patients, a diverticulum was found at operation for suspected appendicitis; these are discussed subsequently.

Of the 32 patients in whom a diverticulum was discovered at operation for indications other than appendicitis, 24 were women with gynecologic disease, four were patients undergoing herniorrhaphy, and the remaining four were patients explored for hypersplenism, obscure hemorrhage, abdominal pain and intestinal obstruction.

Case 1. S. T., ℵ38–631. A 48-year-old woman was admitted on February 10, 1946, because of profuse metrorrhagia. Examination revealed large myomata uteri and bilateral adnexal masses. At laparotomy a large fibroid uterus and bilateral ovarian cysts were removed. An appendectomy was performed and a 6-cm. Meckel's diverticulum was found and removed. The patient made an uneventful convalescence and left the hospital on the 14th postoperative day. There had been no history of gastrointestinal complaints and no symptoms referable to Meckel's diverticulum.

Under such circumstances, the search for and removal of an incidentally discovered diverticulum is not only advisable but is even more important than removal of a normal appendix.

The large number of nondiseased diverticula in this surgical series, i.e., 121 or 85 per cent of the total 142 cases, is in contrast to the report of other series of comparable size. For example, in the report of Baker and Marshall [3] from the Lahey Clinic, there were 93 cases; 73 or 79 per cent were incidental finding of operation or autopsy. In Balfour's [4] report, in 1911, of 15 cases, ten (67%) were incidental findings. Kiesewetter [23] reported 84 cases; in 34 or 40 per cent the diverticulum was an incidental finding. In Gross' series [16] of 149 cases, only 26 or 18 per cent were discovered incidentally in operations for other diseases. And finally, Davidson and Hirsch [11] report 23 cases in which 20 required emergency operation for Meckel's diverticulum complications and only three were incidental findings.

Part of the explanation for this large number of incidentally discovered diver-

ticula is found in the 24 patients with gynecologic disorders. It would appear that at this hospital gynecologic surgery is done mainly by general surgeons who have an interest in the anomaly and search for it more frequently than do many gynecologists. Furthermore this series reflects a broader sampling of age groups—only 39 or 27 per cent of the patients being children under 12—than is found in the reports from children's hospitals. Also appendectomy may be a relatively more frequent operation at this hospital as compared with the larger referral centers.

Obviously a certain discretion is necessary in applying the routine search for Meckel's diverticulum. Assuming the patient's condition is favorable, the terminal ileum should be examined in all cases of suspected appendicitis in which a normal appendix is found, in uncomplicated gynecologic operations, in cases of appendicitis without perforation, abscess or peritonitis, and in certain uncomplicated operations for upper abdominal disease, ventral hernia, or trauma in which the additional short time necessary for the exploration will not be hazardous.

There was one operative death in this series of cases in which Meckel's diverticulum was discovered at operation for other disease. This patient was a 51-year-old man explored for gastro-intestinal hemorrhage. Preoperative x-rays were suggestive of a Meckel's diverticulum. The patient was known to have aortic stenosis. At operation the source of bleeding was not disclosed; there were adhesions between the diverticulum and adjacent mesentery but at pathologic examination the diverticulum was found to be normal. The patient developed cardiac arrest during closure of the abdomen and died. At autopsy a moderate degree of aortic stenosis was found and the site of intestinal bleeding was not found.

The operative findings as well as the clinical and pathologic picture of obscure hemorrhage in this patient are highly suggestive that the diverticulum was the cause of the disease. However, the lack of a positive pathologic diagnosis places it in the group in which the anomaly is an incidental finding.

Littré's Hernia

In five cases a Meckel's diverticulum was found in a hernia sac (Fig. 11). In one, an inguinal hernia, there was strangulation of the diverticulum and adjacent bowel; in the remaining four the diverticulum was normal. The diverticulum was found in inguinal hernia in two cases, femoral hernia in two cases and umbilical hernia in one case. The presence of a Meckel's diverticulum in any kind of hernia sac is usually classified as a Littré's hernia; however Iason [20] includes in the Littré's hernia group the type of hernia usually called Richter's in which only a portion of the circumference of the small intestine finds its way into a hernia sac.

Sneierson's [36] review in 1957 indicating a total of 259 cases in the literature and the findings of Littré's hernia in 3 per cent in the present series confirm the relative frequency of this condition.

Meckel's Diverticulum, Appendectomy and Appendicitis

The most frequent indication for operation leading to the discovery of Meckel's diverticulum is a preoperative diagnosis of appendicitis, there being 100 such cases or 70 per cent of this series. Table 2 indicates the operative findings on these 100 patients. In 11 patients complications of the diverticulum were present, the appendix being normal in nine and chronically inflamed in two. In 89 patients the diverticulum was not diseased; of these 89, the appendix was normal in 55, or 62 per cent, acutely inflamed in 23 or 26 per cent, and a diagnosis of chronic appendicitis was made by the pathologist in 11 or 12 per cent.

The diagnosis of appendicitis proves correct approximately three times out of four

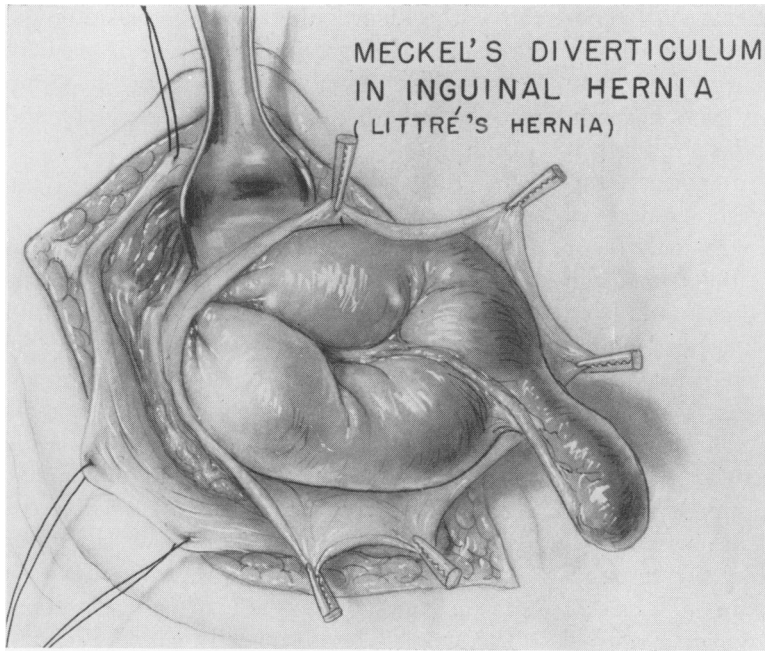

FIG. 11. Littré's hernia.

at this hospital. Thus in 434 consecutive cases diagnosed as appendicitis during the two years 1956 and 1957, there were 318 cases (73%) in which inflammation of the appendix was found and 116 cases (27%) in which the appendix was normal.

Thus when a preoperative diagnosis of appendicitis is made, appendicitis is found half as often (36%) in the presence of a Meckel's diverticulum as in cases of appendectomy for appendicitis not revealing a diverticulum (73%).

This comparison together with the fact that neither the appendix nor the diverticulum were diseased in 55 per cent of patients operated upon for suspected appendicitis suggests that Meckel's diverticulum may cause symptoms even when morphologic evidence of disease is not found in the diverticulum removed.

TABLE 2

Pathologic Diagnosis of Appendix	Number of Cases	Meckel's Diverticulum Diseased	Meckel's Diverticulum not Diseased
Appendix normal	64	9	55
Appendix acutely inflamed	23	0	23
Appendix chronically inflamed	13	2	11
Totals	100	11	89

One hundred cases operated upon with a preoperative diagnosis of acute appendicitis in which Meckel's diverticulum was found.

When appendectomy is performed for suspected appendicitis, the finding of an inflamed appendix is less frequent in the presence of Meckel's diverticulum than in its absence.

Case 2. C. T., #43-6079. An 8-year-old boy was admitted on August 15, 1951, complaining of abdominal pain, nausea and vomiting of 24 hours' duration. For eight months previously he had suffered recurrent attacks of similar abdominal pain, often associated with nausea and vomiting but with no other symptoms. Examination revealed a temperature of 99 degrees, moderate tenderness in the right lower quadrant and a normal hemogram and urinalysis. A diagnosis of appendicitis was made; at operation a normal appendix was found and removed. Examination of the terminal ileum revealed a Meckel's diverticulum four centimeters long, which was excised. Gross and microscopic examination of the appendix and diverticulum showed neither organ to be diseased. The patient made an uneventful recovery and left the hospital on the seventh postoperative day. When examined

TABLE 3. *Twenty-two Cases of Meckel's Diverticulum Disease Together with Preoperative Diagnosis. In One Instance Only Was the Correct Preoperative Diagnosis Made*

Patient	Sex	Age	Preoperative Diagnosis	Operative Findings of Meckel's Diverticulum
A. T.	M	3		Intestinal obstruction
R. A.	M	9		Intestinal obstruction
C. M.	M	11		Diverticulitis
C. G.	M	12		Diverticulitis with gangrene and perforation
R. C.	F	15		Ulceration and hemorrhage
C. C.	M	18	Appendicitis	Diverticulitis
B. G.	M	20		Diverticulitis
H. D.	M	23		Diverticulitis with obstruction
C. G.	M	49		Intestinal obstruction
E. W.	M	53		Diverticulitis
E. S.	F	54		Intestinal obstruction
J. B.	F	6		Intestinal obstruction
M. K.	M	11	Intestinal obstruction	Intussusception
R. H.	F	36		Intestinal obstruction
A. W.	F	58		Intestinal obstruction (Meckel's in femoral hernia)
J. M.	M	6 mo.	Intussusception	Intussusception
W. N.	M	1	Intussusception	Intussusception
P. B.	F	16	Hemorrhage	Ulceration with hemorrhage
G. M.	M	11	Abdominal pain	Diverticulitis with ulceration
S. S.	M	13	Meckel's diverticulitis	Diverticulitis
F. W.	M	18	Draining umbilicus	Persistent omphalomesenteric fistula
C. J.	M	22	Hernia	Strangulated hernia with gangrene

two years later he had had no subsequent episodes of abdominal pain and was entirely well.

This patient exemplifies 55 patients, or over one-third of this entire series, in whom operation was performed for a diagnosis of appendicitis but revealed a normal appendix and a normal diverticulum. Patients in this group appear to fit into a characteristic clinical pattern with vague abdominal complaints extending over a period of months or years. Symptoms are nearly always relieved by removal of the appendix and the diverticulum. It is impossible to know which if either of the two structures is responsible for the symptoms. Since there are no known cases of operation for suspected appendicitis in which a normal diverticulum is removed and a normal appendix left in, it is not known how frequently a normal Meckel's diverticulum in the absence of the appendix can cause symptoms. However, it seems possible that this group of cases may constitute a clinical entity. More careful histologic study of the diverticula in these cases, as for example by serial histologic sections, might reveal evidence of previous disease.

Meckel's Diverticulum Disease

Twenty-two cases having complications of Meckel's diverticulum, comprising 15 per cent of this series, are summarized according to preoperative diagnoses and operative findings in Tables 3 and 4.

Appendicitis was the most frequent preoperative diagnosis of patients found to have complications of Meckel's diverticulum. Of 11 patients with a preoperative diagnosis of appendicitis six were found to have Meckel's diverticulitis; four had intestinal obstruction and one had ulceration with hemorrhage.

Diverticulitis (Fig. 12, 13) and intestinal obstruction (Fig. 14, 15) were the commonest complications of Meckel's diverticulum in this series occurring in eight and seven cases respectively. There were three cases of intussusception in which the inverted Meckel's diverticulum was the leading point of the intussusceptum (Fig. 16).

TABLE 4. *Complications of Meckel's Diverticulum in 22 Cases*

Complication	Number of Cases	Mean Age in Years
Diverticulitis	8	20
Intestinal obstruction	7	31
Intussusception	3	5
Ulceration and hemorrhage	2	13
Omphalomesenteric fistula	1	18
Strangulation and gangrene	1	22
	22	18

Peptic ulceration and hemorrhage occurred in two cases. The following cases illustrate the seriousness of these complications.

Case 3. G. M., ℵ50–3107. An 11-year-old boy was admitted on May 7, 1958 because of abdominal pain, nausea, vomiting and diarrhea of 4 days duration. He had been admitted three days previously with abdominal pain and was discharged improved in 24 hours. On examination, the temperature was 99.8° and there was tenderness in both lower quadrants of the abdomen, more marked on the left. At operation a normal appendix was found and removed and a large Meckel's diverticulum densely adherent to the cecum and mesentery was exposed. The diverticulum was resected together with a 40-centimeter segment of adjacent ileum. Pathologic examination revealed ulceration of the diverticulum with inflammation of the wall. After a satisfactory convalescence the patient was discharged May 17, 1958. He has been well since.

Case 4. J. B., ℵ41–6699. A 6-year-old girl was admitted on September 28, 1949 with the chief complaint of generalized severe abdominal pain and vomiting of 17 hours' duration. Examination revealed a pale, fretful child in acute distress without marked tenderness or distention but with crampy abdominal pain. The patient was observed for 48 hours and appeared to have clinical signs of intestinal obstruction. At operation, small bowel obstruction was found caused by an adhesive band between the tip of a Meckel's diverticulum and the mesentery. The diverticulum was removed and an appendectomy was done. The patient had an uneventful recovery.

Case 5. M. K., ℵ50–4504. A 6-year-old male was admitted to the hospital on June 30, 1958 complaining of severe cramping midabdominal pain with nausea and vomiting of six hours duration. A similar less violent attack had occurred six months previously and subsided spontaneously. Examination revealed an acutely ill dehydrated boy with diffuse abdominal tenderness and an exquisitely tender six by eight cm. mass between the symphysis and the umbilicus. There was no blood in the rectum and no history of bleeding. A diagnosis of intestinal obstruction was made.

At operation an ileo-ileal intussusception was present involving approximately 30 centimeters of bowel ending 10 centimeters proximal to the ileocecal valve. The intussusception was reduced and inverted Meckel's diverticulum was found to be the leading point of the intussusceptum. Subsequent examination revealed an infarcted Meckel's diverticulum with gastric mucosa at the tip. The patient recovered and left the hospital on the sixth day following operation.

Case 6. P. B., ℵ46–8008. A 16-year-old girl was admitted to the hospital on November 16, 1954 because of massive melena and anemia. After repeated transfusions and unsuccessful attempts to find the source of bleeding by gastro-intestinal x-rays and barium enema, exploratory laparotomy was performed revealing a large Meckel's diverticulum with adhesions between the diverticulum and loops of bowel. The diverticulum was removed. The patient's postoperative course was complicated by intestinal obstruction requiring re-operation two weeks later. She was discharged on the 27th postoperative day. She was last seen in May 1958, having been completely well for three and one-half years. Examination of the diverticulum revealed an area of gastric mucosa. Adjacent to this was a peptic ulcer with fresh hemorrhage (Fig. 17, 18).

In the group of patients with Meckel's diverticulum disease there was one postoperative death. This patient was a 54-year-old woman operated upon with a preoperative diagnosis of appendicitis. At operation intestinal obstruction caused by a Meckel's diverticulum was found. Death occurred suddenly on the third postoperative day after an apparently satisfactory recovery. Autopsy was not performed. The cause of death was presumed to be a pulmonary embolus.

Technic

The preferred method of diverticulectomy for an uncomplicated Meckel's diverticulum is illustrated in Figures 19 and 20. A number of patients operated upon in the early years of this study were treated by inversion of the diverticulum into the lumen of the ileum through a purse-string suture.

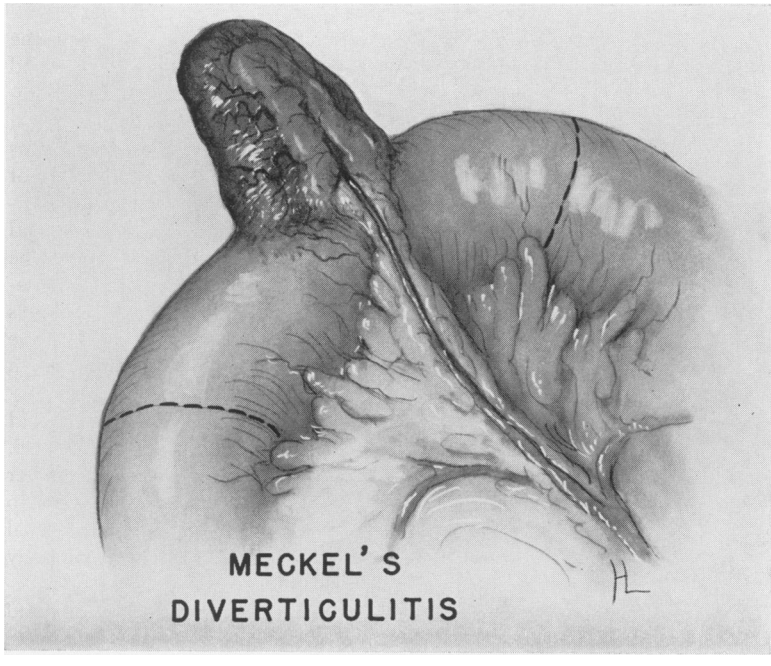

FIG. 12. Acute Meckel's diverticulitis. The inflammatory process has extended into the wall of the adjacent ileum making a simple diverticulectomy impossible. In such cases a formal intestinal resection is necessary with the boundaries of removal shown above.

This technic, quick and simple, carries the hazard of producing intussusception and intestinal obstruction: excision is preferable in all cases.

In some instances of diverticulitis the inflammatory process extends to the base of the diverticulum and the adjacent ileum. In these, a formal intestinal resection (Fig. 12) is necessary. Intestinal resection may also be indicated when strangulation of the

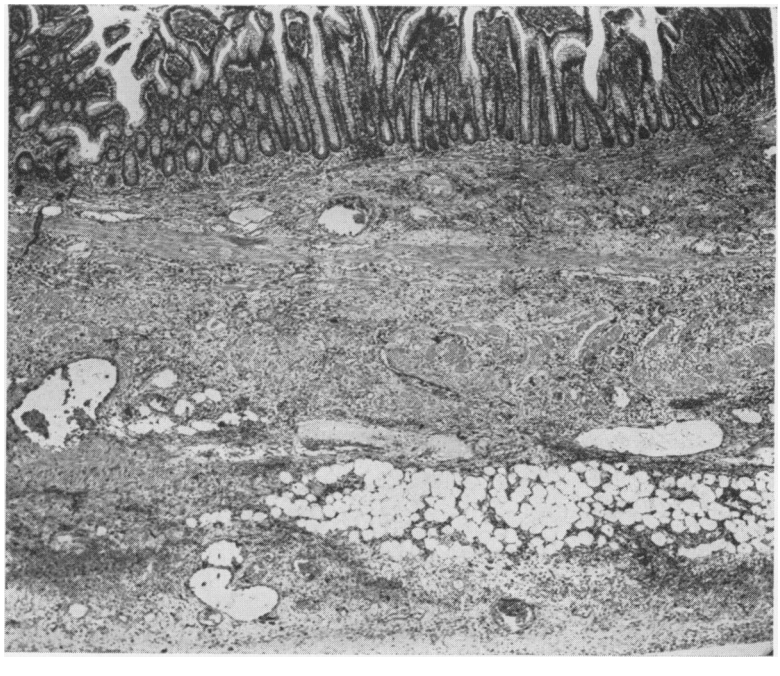

FIG. 13. Photomicrograph showing changes of acute Meckel's diverticulitis. The wall is thickened and edematous; there is a diffuse infiltration of all layers with leucocytes.

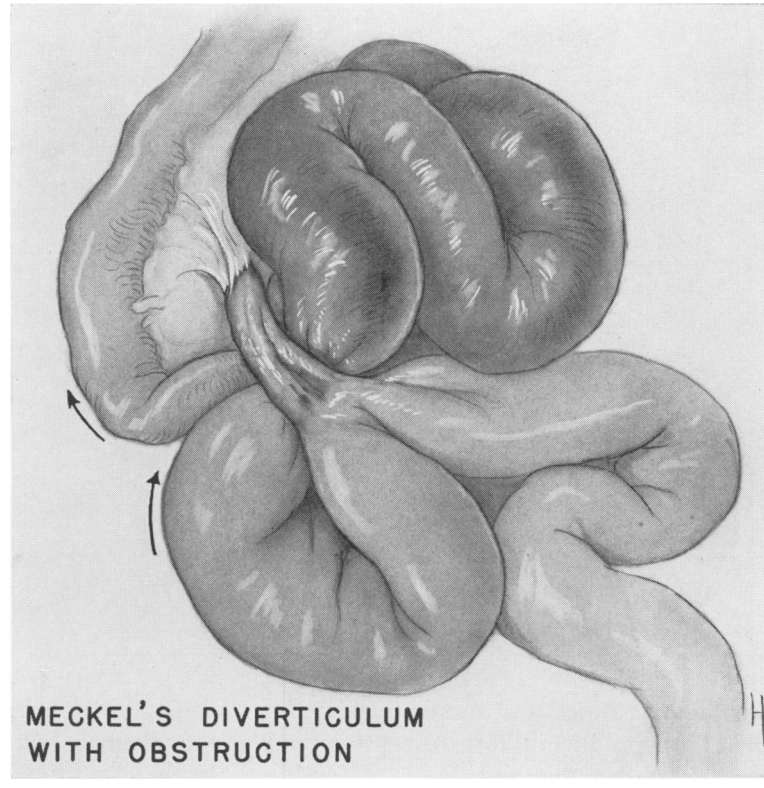

FIG. 14. Illustration demonstrating how a Meckel's diverticulum with its tip adherent to adjacent mesentery may cause intestinal obstruction.

bowel has occurred as a result of intestinal obstruction with volvulus or intussusception.

Discussion

Despite the alleged similarity between the appendix and a Meckel's diverticulum,

FIG. 15. Photomicrograph of the wall of a Meckel's diverticulum showing congestion of the submucosa due to intestinal obstruction. The wall is thickened and edematous and there is marked vascular congestion.

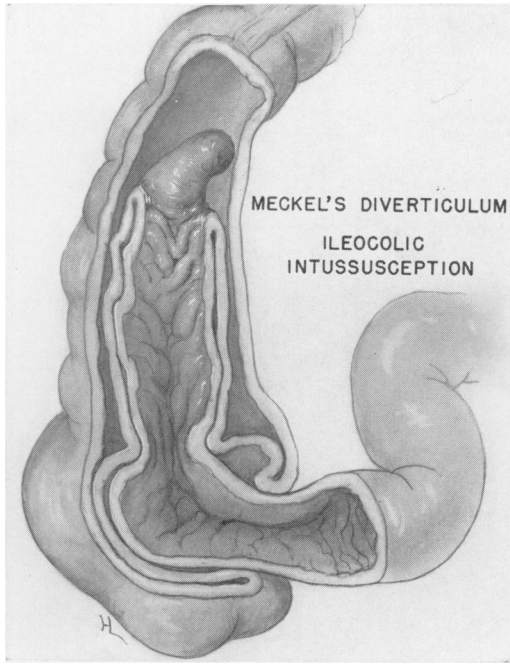

FIG. 16. The diverticulum has become inverted and the leading point of an ileo colic intussusception. There were two such cases in this series.

disease of the diverticulum cannot invariably be compared with disease of the appendix. The greater frequency of intestinal obstruction, the occurrence of intussusception, peptic ulceration and hemorrhage and the tendency of the diverticulum to find its way into a hernia sac are complications which distinguish this anomaly from disease of the appendix. Inflammation alone in Meckel's diverticulum is more serious than in the appendix. Since the diverticulum is situated on the anti-mesenteric border of the free-lying ileum, open perforation and fulminating peritonitis are more likely than in appendicitis. In the latter the cecum, parieties and other surrounding tissues in the iliac fossa tend to contain the inflammatory process.

The studies of 100 patients with Meckel's diverticulum found at operation for appendicitis require special comment. Similar studies have not been found in the literature. First of all, this is a large group, 70 per cent of the total of 143 cases of Meckel's diverticulum. Second, when a diverticulum was present, the appendix was normal in a much higher proportion (64%) of cases than usual, i.e., than when an appendectomy for appendicitis is performed and a Meckel's diverticulum is not found. Third, in most instances, although follow up data is incomplete, symptoms of recurrent abdominal pain with nausea and vomiting are relieved by removal of the appendix and the diverticulum even when both structures are normal (55%).

The explanation is entirely conjectural as to how a diverticulum may produce symptoms in the absence of frank disease. It seems possible, however, that two derangements, one mechanical and one secretory, may be implicated.

In regard to possible mechanical derangements, it is apparent that a Meckel's diverticulum is a true diverticulum with smooth muscle in its wall. It therefore shares in accepting the stimuli to peristaltic movement and must interfere to some extent with the

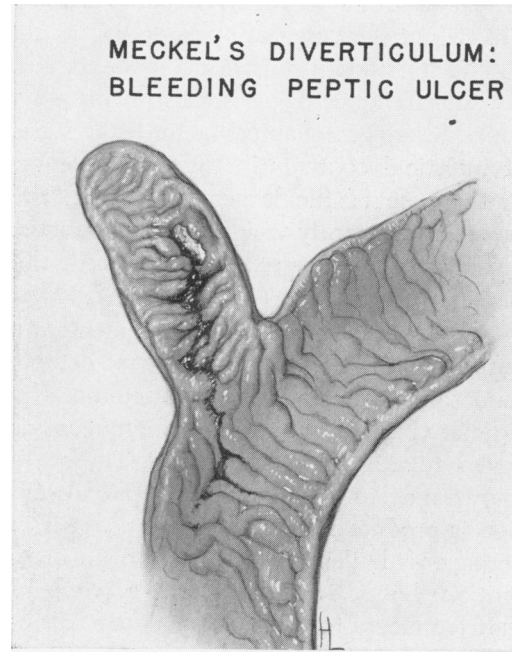

FIG. 17. An illustration of a Meckel's diverticulum with peptic ulceration and hemorrhage. Gastric mucosa may be found adjacent to the ulcer.

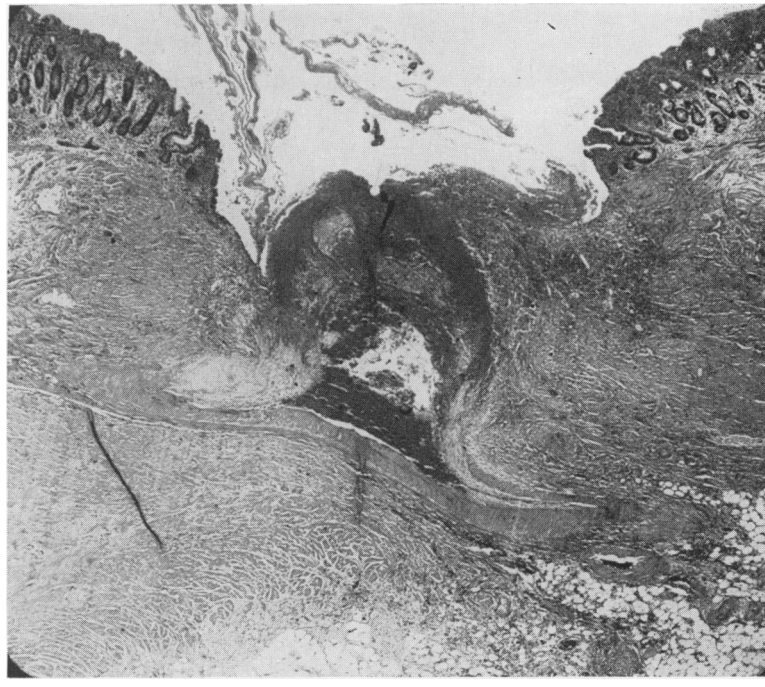

FIG. 18. A photomicrograph of a peptic ulcer in a Meckel's diverticulum. Hemorrhage is seen in the base of the ulcer coming from an erosion of a branch of the omphalomesenteric artery.

propagation of normal peristaltic waves. This is not the case with pseudodiverticula having no smooth muscle components and not interfering with peristalsis in this way. An additional mechanical factor is the stasis of intestinal contents in the diverticulum: in the case of the larger diverticula, the bowel is constantly weighted into the most dependent position which varies with the patient's posture.

The possible secretory derangements are based upon the frequent finding of ectopic mucosa in the wall of the diverticulum. The estimated incidence of gastric mucosa is seven to 25 per cent.[3, 22, 29, 39] The well-known mechanisms by which peptic ulceration is produced when gastric mucosa is in contact with ileum [5, 13, 27] require no elaboration, but it is striking that a patch of gastric mucosa as small as one square centimeter can produce peptic ulceration and severe hemorrhage. It, therefore, seems possible that many patients with gastric epithelium in a Meckel's diverticulum have repeated superficial ulcerations which may be responsible for recurring symptoms of abdominal pain.

Summary

1. A series of 154 cases of Meckel's diverticulum found at operation is presented: 143 cases observed in the past twenty-one and a half years are analyzed in detail.

2. Death occurred in three of the 154 cases, a mortality rate of 2 per cent.

3. Complications of the diverticulum were found in 22 of 143 cases but in the great majority (85%) the diverticulum was not considered diseased, being found at operation for various intra-abdominal conditions.

4. The most frequent operation leading to the discovery of a Meckel's diverticulum is appendectomy for suspected appendicitis, this preoperative diagnosis being made in 100 cases (70%) in this series.

5. The data suggest that in many instances an apparently normal diverticulum may be responsible for symptoms.

6. The importance of the routine systematic search for Meckel's diverticulum is emphasized.

Acknowledgment

We thank Dr. Donald S. Daniel and Dr. William A. Johns whose patients are included in this series.

References

1. Abt, I. A. and A. A. Strauss: Meckel's Diverticulum as a Cause of Intestinal Hemorrhage. J. A. M. A., **87**:991, 1926.
2. Augier, L.: Contribution à l'Étude du Diverticule de l'Ileon ou Diverticule de Meckel. These. Paris, 1888.
3. Baker, L., Jr. and F. Marshall: Meckel's Diverticulum: A Report of Ninety-three Cases. Am. Surgeon, **21**:1173, 1955.
4. Balfour, D. C.: Meckel's Diverticulum: A Report of Fifteen Cases. J. Minnesota Med. Assoc., **31**:110, 1911.
5. Berman, E. J., A. Schneider and W. J. Potts: Importance of Gastric Mucosa in Meckel's Diverticulum. J. A. M. A., **156**:6, 1954.
6. Chesterman, J. T.: Hemorrhage per Rectum as an Indication of Disease in a Meckel's Diverticulum. Brit. J. Surg., **23**:267, 1935.
7. Clark, D. F.: Hemorrhagic Meckel's Diverticulum. Am. J. Surg., **22**:308, 1933.
8. Cullen, Thomas S.: Embryology, Anatomy and Diseases of the Umbilicus. Philadelphia, W. B. Saunders Co., 1916.
9. Cunningham, D. J.: Textbook of Anatomy, Ed. 5. William Wood & Co., 1923.
10. Curd, H.: A Histologic Study of Meckel's Diverticulum. Arch. Surg., **32**:506, 1936.
11. Davidson, L. and S. Hirsch: Meckel's Diverticulum. Clinical and Necropsy Cases. Am. J. Surg., **88**:602, 1954.
12. Doane, A.: Manual of General, Descriptive and Pathological Anatomy, by J. F. Meckel. Philadelphia, Cary & Lea, 1832.

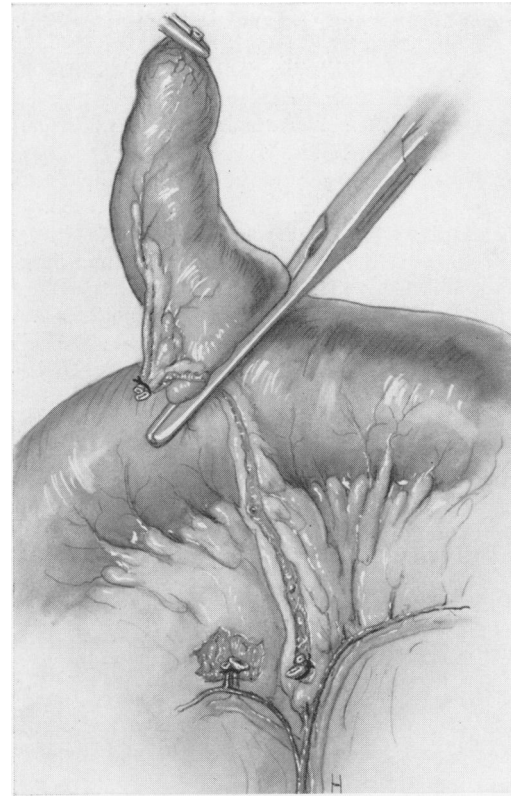

FIG. 19. Preferred technique of diverticulectomy for uncomplicated Meckel's diverticulum. The omphalomesenteric vessels are divided and an atraumatic clamp is placed obliquely at the base of the diverticulum.

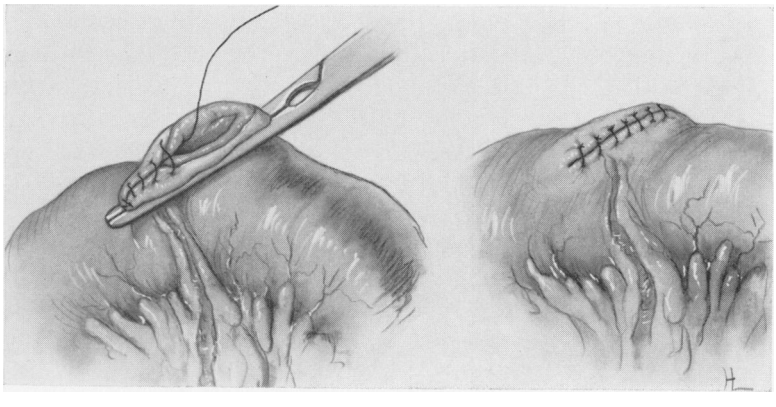

FIG. 20. The diverticulum is amputated distal to the clamp and closed by the open technic with two layers of sutures. Care is taken not to constrict the lumen of the ileum.

13. Dragstedt, L. R.: Ulcus Acidum of Meckel's Diverticulum. J. A. M. A., **101**:20, 1933.
14. Fabricius, Hildanus: Animadv. Var. Argum. Med. Helmst., edit. Jan., 1750.
15. Gant, S. G.: Diverticula, Diverticulitis, and Peri-diverticulitis. J. A. M. A., **77**:18, 1915.
16. Gross, R.: Surgery of Infancy and Childhood. Philadelphia, W. B. Saunders Co., 1953.
17. Harkins, N.: Intussusception Due to Invaginated Meckel's Diverticulum. Ann. Surg., **98**:1070, 1933.
18. Hennigar, E. H.: Personal Communication.
19. Hudson, H. W., Jr. and L. H. Koplik: Meckel's Diverticulum in Children. New England J. Med., **206**:827, 1932.
20. Iason, A. H.: Hernia, 717. Philadelphia, Blakiston Company, 1941.
21. Johns, F. S. and J. K. Wilson: Meckel's Diverticulum, Fifty-six Cases. Virginia Med. Monthly, **73**:17, 1946.
22. Johnston, L. B. and G. Renner: Peptic Ulcer in Meckel's Diverticulum. Surg., Gynec. & Obst., **59**:198, 1934.
23. Kiesewetter, B.: Meckel's Diverticulum in Children. Arch. of Surg., **75**:914, 1957.
24. King, T. W.: A Feculent Discharge at the Umbilius from Communication with the Diverticulum Ilei. Guy's Hospital Reports, Series 467, April, 1843.
25. Knox, cited by F. S. Mathews: Meckel's Diverticulum: A Report of Twelve Cases Including One Tumor. Am. Surg., **10**:720, 1925.
26. Küttner, H.: Ileus durch Intussusception eines Meckelschen Divertikel. Beitrage für klin. Chir., 21:289, 1898.
27. Lindau, A. and H. Wulff: The Peptic Genesis of Gastric and Duodenal Ulcer, Especially in the Light of Ulcers. Meckel's Diverticulum and Postoperative Ulcers in Jejunum. Surg., Gynec. & Obst., **53**:621, 1931.
28. Littré, A.: Memoires de l'Academie Royale des Sciences, **2**:300, 1700.
29. Matt, J. E. and P. J. Timpone: Peptic Ulcer of Meckel's Diverticulum. Am. J. Surg., **47**:612, 1940.
30. Meckel, J. F.: Ueber die Divertikel am Darmkanal. Arch. für die Physiol., **9**:421, 1809.
31. Morgagni, J. B.: The Seats and Causes of Diseases. Vol. II, ed. Wm. Cooke. Boston, Wells and Lilly, 1824.
32. Oderfeld, H.: Gazeta Lekarska, Nr. 37, Tom XI. Warsaw, 1891.
33. Rich, A. R., cited by R. T. Shackelford: Surgery of the Alimentary Tract. Vol. II, 1263. Philadelphia, W. B. Saunders Company, 1955.
34. Ruysch, Fredericus: Thesaurus Anatomicus, Vol. VII. Walters Amsteraedami, 1707.
35. Schaetz, G.: Beitrage zur Morphologie des Meckelschen Divertikels. Beitrage zur Path., **74**:115, 1925.
36. Sneierson, H. and R. Cunningham: Littré's Hernia. Am. J. Surg., **94**:676, 1957.
37. Stone, J. B., cited by D. F. Clark: Hemorrhagic Meckel's Diverticulum. Am. J. Surg., **22**:308, 1933.
38. Turner, cited by W. Doolin: Acute Abdominal Emergencies Due to the Presence of Meckel's Diverticulum. Irish J. Med. Sci., **43**:299, 1929.
39. Wagner, B., Jr., T. A. Shallow and S. A. Eger: Gastroenterological Aspects of Meckel's Diverticulum. Analytical Review of 100 Cases. Am. J. Gastroen., **23**:195, 1955.