Review Article

Meckel's Diverticulum—Revisited

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ABSTRACT

Meckel's diverticulum is a true intestinal diverticulum that results from the failure of the vitelline duct to obliterate during the fifth week of fetal development. In about 50% cases, it contains ectopic or heterotopic tissue which can be the cause of complications. A systematic review of literature was undertaken to study the history, incidence, embryoanatomy, clinical presentation, complication and management of Meckel's diverticulum. Although Meckel's diverticulum is the most common congenital abnormality of the gastrointestinal tract, it is often difficult to diagnose. It may remain asymptomatic or it may mimic disorders such as Crohn's disease, appendicitis and peptic ulcer disease.

Key Words: Diverticulitis, perforation hemorrhage, laparotomy

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Meckel's diverticulum is the most frequently encountered diverticulum of the small intestine, which was first described by Fabricus Heldanus in 1650,[1] subsequently reported by Levator in 1671[2] and then Ruysch in 1730.[3] However, it was described in detail by Hohann Friedrick Meckel in 1808 and bears his name.

EMBRYOANATOMY

The embryologic origin and usual location of Meckel's diverticulum are explained by the development of the midgut. During the first few weeks of fetal life, the primitive yolk sac divides into two portions, the larger forming primitive gut while the smaller continuing as a yolk sac near the placenta. The two portions remain connected by a tube contained within the umbilical cord and this tube is called as omphalomesenteric or vitelline duct. Ordinarily, it becomes obliterated by the seventh week. Persistence of the duct may lead to following anomalies:

1. Meckel's diverticulum: Due to failure of closure of the intestinal end of the duct.
2. Fistula: When the entire duct remains patent, it forms a fistula between umbilicus and the ileum. Kittle *et al.* reported prolapse of the ileum from the umbilical fistula in 20% of cases.[4]
3. Umbilical sinus: when the umbilical side of the duct is not obliterated. Epithelial lining of this patent sinus may be everted to form an adenoma or raspberry tumor or enteroteratoma.
4. Fibrous cord: Between umbilicus and the ileum representing the obliterated duct and its vessels.
5. Enterocystoma: When both ends become obliterated but the central portion remains patent giving rise to an intra-abdominal cyst.
6. Mesodiverticular band.
7. Contraction of the band and pulling of Meckel's diverticulum into a congenital umbilical hernia.

Meckel's diverticulum is a congenital diverticulum possessing all three coats of the intestinal wall. Having its own blood supply, it is vulnerable to infection and obstruction. Ectopic gastric or pancreatic mucosa is found in 50% of patients with Meckel's diverticulum. Rarely a colonic or hepatobiliary tissue is found.[5] Gastrointestinal bleeding may develop due to ulceration within the gastric mucosa or ulceration in the adjacent ileal mucosa. Thus, if simple diverticulectomy is done in these patients, bleeding will recur in postoperative period; hence, segmental resection is recommended in these patients.[5]

INCIDENCE

In autopsy studies, the incidence of Meckel's diverticulum is 0.3% but may be placed as high as 2% when surgical cases are reviewed.[6] Males have been found to be more prone to develop complications, although Meckel's diverticulum occurs equally in both sexes.

Meckel's diverticulum occurs in the terminal ileum 45-90 cm proximal to the ileocecal valve on its antimesenteric border. Reported size varies from 1-56 cm in length and from 1-50 cm in diameter. Rutherford and Akers studied

147 surgical specimens and found heterotopic tissue in 57%.[6,7] A 6% incidence of heterotopic tissue was found in autopsy- specimens of asymptomatic diverticulum. Types of ectopic tissue found were gastric, pancreatic, colonic, jejunal and duodenal. Some other pathological conditions, which have been found to be associated with Meckel's diverticulum are intestinal obstruction due to band, volvulus, intussusception, regional enteritis, herniation, calcification and enterolith formation, diverticulitis, tuberculosis, foreign bodies, parasites, fistula and tumors such as angioma, lipoma, leiomyoma, neurofibroma, fibroma, carcinoid, adenocarcinoma and sarcoma. Other associated malformations have been reported such as exomphalos, anorectal malformations, CNS malformations, esophageal atresia, cardiovascular malformations and angiodysplasia.

CLINICAL FEATURES

Charles W. Mayo is credited with having stated that "Meckel's diverticulum is frequently suspected, often looked for, and seldom found". Clinical manifestations have been found more common in pediatric age group although it can produce symptoms at all ages. Meckel[7,8] reported an incidence of about 25%, while Michas and his colleagues reported an incidence of 25% to 33%.[9]

It presents only when some complication arises. In order of frequency, the complications are:

Hemorrhage

It occurs due to peptic ulceration and is the most common cause for painless major lower gastrointestinal bleeding in children aged less than 2 years.[10] This complication has been reported in about 50% of patients with symptoms associated with the diverticulum. Blood is usually maroon in color.

Intestinal obstruction

This is another common complication seen in young children.[10] It can occur due to a number of reasons. Common causes include volvulus of the small gut around a diverticulum that is attached to the anterior abdominal wall, intussusception or incarceration of the diverticulum in a hernia (Littre's Hernia) and enterolith formation in diverticulum. Single or multiple enteroliths may develop within the lumen of the diverticulum in as many as 10% patients. Most enteroliths show peripheral calcification.[5] Other reasons include internal herniation by a band attached to another viscus, herniation of small gut beneath a mesodiverticular band or volvulus, direct ileal compression by mesodiverticular band, formation of a knot in a long diverticulum involving another viscus and rarely an axial volvulus of the diverticulum causing infarction.

Meckelian diverticulitis

It accounts for 10%-20% of complication and is more common in older patients.[10] It usually presents as acute appendicitis except for the location of the pain and may or may not be associated with enteroliths, fecoliths or foreign bodies within the diverticulum. Failure to establish the diagnosis may lead to perforation, peritonitis and death. Tuberculosis and Crohn's disease in the diverticulum have been seen.

Tumors

Recent article about a Meckel's diverticulum has reported an unusual occurrence of a neoplasm in the diverticulum. The common benign neoplasm include lipoma, leiomyoma, neurofibroma and angioma, while as malignant tumors include leiomyosarcoma and carcinoid,[11] which represent about 80% of such lesions while adenocarcinoma and metastatic lesions constitute the remainder.

Chronic peptic ulceration

The diverticulum being part of the midgut, the pain, though related to meals, is felt around the umbilicus.

MANAGEMENT

Diagnosis

Meckel's diverticulum is the most common congenital anomaly of the gastrointestinal tract and occurs in 2-3% of the population. 60% of patients come to medical attention before the age of ten years with the remainder of cases presenting in adolescence and adulthood.[12] The diagnosis of symptomatic Meckel's diverticulum is difficult in male, especially in adult. The diagnosis must be considered in any patient with unexplained abdominal complaints nausea and vomiting or intestinal bleeding. Meckel's diverticulum can mimic a variety of more common ailments such as peptic ulcer disease, gastroenteritis, biliary colic and colonic diverticulitis. Appendicitis is the most common preoperative diagnosis in cases of complicated Meckel's diverticulum.

The average mortality from Meckel's diverticulum as reported in several surgical series is around 6%, with a large proportion of deaths occurring in elderly people. Similar to many other less common intra-abdominal conditions, death frequently occurs because of delay in diagnosis and treatment. Hence, various techniques in diagnosis have been evaluated.

Radiography

In case of a symptomatic Meckel's diverticulum, failure to visualize the diverticulum by radiography after a barium meal is common due to blockage of the entrance of diverticulum by edema. Dalinka and Wunder (1973)[13] found radiological abnormalities in only 10-17 patients and in only 3 patients

was the diverticulum demonstrated radiologically. Hence, contrast studies rarely outline the primary defect. However, a small bowel enema carried out by an infusion of dilute barium through a nasogastric tube guided into the duodenum will demonstrate diverticulum in 0.7% cases. The injection of contrast material into an umbilical fistula differentiates a patent vitelline duct communicating with ileum from patient urachus communicating with urinary bladder.[12] Plain radiograph may demonstrate appearance typical of an intestinal obstruction.[14] If the diverticulum is distended, a gas-filled viscus seen in the right iliac fossa or mid abdomen may provide a clue to diagnosis.[14] When perforation is a complication, plain abdominal and upright chest radiograph may reveal features of pneumoperitoneum. Typically, the diverticulum is depicted as a contrast-filled outpouching, 0.5-20 cm long, that is located on the antimesenteric border of the ileum and has junctional fold pattern. The characteristic junctional fold appearances are triradiate fold pattern in which the loops are collapsed and a mucosal triangular plateau, in which loops are distended.[14] An inverted Meckel's diverticulum without intussusceptions, which occurs in 20% of patients appears as an elongated smoothly marginated club-like intraluminal mass parallel to the long axis of the ileum.[14]

Arteriography

Mackey in 1975[15] demonstrated diagnosis of bleeding Meckel's diverticulum by superior mesenteric arteriography and devised that the technique is based on demonstration of abnormal superior mesenteric arterial branches or extravasation of contrast material.

In patients presenting with acute gastrointestinal tract bleeding from a Meckel's diverticulum, superior mesenteric angiograms may demonstrate not only the site of bleeding by focal contrast agent extravasation but also the cause of bleeding. Demonstration of the vitelline artery, which is an anomalous end branch of the superior mesenteric artery, is pathognomonic. The vitelline artery originates as an ileal branch of the superior mesenteric artery; this vessel is nonbranching and directed toward the right lower quadrant of the abdomen. This artery supplies the diverticulum via a network of tortuous and irregular small vessels likened weave pattern. Super-selective technique and the use of epinephrine are recommended to cause selective constriction of the normal splanchnic circulation for optimal depiction of the site of the lesion.[14] Angiography has an accuracy of 59%.[14]

False positive/negative

Bleeding at a rate of 2-3 mL/min is required in adults for angiographic detection; higher rates of hemorrhage may be required in children for angiographic detection. Rarely, a Meckel's diverticulum is supplied by branches arising from the ileocolic artery, which makes it more difficult to differentiate the causes of bleeding related to the cecum and ascending colon.[14]

Scintigraphy

The muciod cells of the gastric mucosa secrete chloride into the intestinal lumen. Tc-99m pertechnetate behaves in a manner that is analogous to chloride ions. The mucoid surface cells on gastric mucosa actively accumulate and secrete pertechnetate into the intestine. This is the basis for detecting ectopic gastric mucosa.[14]

In 1967, Harden *et al* demonstrated that technetium 99m was concentrated in the gastric mucosa.[6] In 1970, Jewett *et al* identified uptake by Meckel's diverticulum on abdominal scans after the injection of sodium pertechnetate Tc-99m.[9] It involves injection of 30-100 mCi Tc-99m pertechnetate intravenously and scanning the patient. The isotope is selectively taken up by gastric, salivary and thyroid tissue and excreted in urine and feces.[6-9] Uptake of isotope by the peptic mucosa may be enhanced by pentagastrin 0.6 μg/kg given subcutaneously; however, it may also increase the washing away of isotope by stimulating peristalsis. Cimetidine improves diagnostic accuracy by inhibiting the intraluminal release of technetium and glycogen does so as an antiperistaltic.[15,16] The combination of pentagastrin and glycogen can be used to increase the uptake of isotope and cease peristalsis simultaneously.[17,18]

There were however reports of both false-positive and false-negative scans possibly because of technical difficulties and overlap of the bladder over the area of the diverticulum.[19,20] Other reports have indicated that the radionuclide may be taken up by intussusceptions, hemangiomas and small bowel duplication, and that laxatives and recent barium studies distort the finding.[21] Scintigraphy has an accuracy of 83%-88%, a sensitivity of more than 85% and a specificity of more than 95%. Sensitivity decreases after adolescence.[5,22] Refinement in imaging technique have improved the accuracy of imaging to nearly 100%.[23] Keeping in view the safety and noninvasiveness of the procedure, it can be used in children with unexplained gastrointestinal bleeding, hence identifying the source of hematochezia or melena.[24]

False positive/negative

False-positive results have been reported for a variety of reasons, including faulty technique, uptake at other sites of ectopic gastric mucosa (eg, in a gastrogenic cyst) and some enteric duplications. Occasionally, false-positive results are observed in a normal small bowel.[5,19,20]

Vascular anomalies (such as aneurysms, arteriovenous malformations, hemangiomas and hypervascular tumors) are a further source of false-positive findings because Tc

pertechnetate is excreted by the kidneys, horseshoe kidneys, caliceal diverticulum and urinary tract obstruction resulting from a variety of causes. False-positive scans also may occur with a variety of bowel ulcerations, inflammations and obstructions, including those due to duodenal ulcers, ulcerative colitis, Crohn's disease, appendicitis, laxative abuse, intestinal obstruction, intussusception and volvulus. These false-positive results are thought to be due to hyperemia caused by these condition.[5,19,20]

Careful attention to the timing of appearance of abnormal accumulations of pertechnetate can aid in distinguishing the false-positive causes from those due to ectopic gastric mucosa. The accumulations of pertechnetate due to hyperemia appear early in the study and tend to fade over time. The accumulations in ectopic gastric mucosa appear at, or nearly simultaneous with, the stomach and increase in intensity in parallel with the stomach. Lateral and oblique views are often helpful in differentiating the anterior location of a diverticulum from the posterior location of urinary activity.[5,19,20]

False-negative scans may occur if the gastric mucosa mass within the diverticulum is insufficient or if interluminal scintigraphic activity is diluted as a result of brisk hemorrhage or bowel hypersecretion. The quality of images is poor in patients who have received perchlorate or atropine.[5-14]

Ultrasonography

When the Meckel's scan is nondiagnostic, or in patients with nonbleeding presentations, ultrasongraphy is perhaps the must useful noninvasive method of achieving diagnosis.[25] Sonographic findings of an inflamed Meckel's diverticulum may mimic findings for acute appendicitis or intestinal duplication.[25] In patients with rectal bleeding due to diverticulitis, the visualization of a tubular hyperechoic structure on sonography is suggestive of Meckel's diverticulum.[25] The inflamed Meckel's diverticulum may present as a cyst, but its mucosal layer is more irregular than that found in an intestinal duplication. Routine color Doppler sonography revealed anomalous vessels and signs of inflammation on the wall of the Meckel's diverticulum.[25]

Computed tomography

CT scan is rarely used as a primary imaging modality in patients in whom Meckel's diverticulum is suspected. Most of the diagnoses made by using CT scans are incidental. An inverted Meckel's diverticulum associated with an intussusception may be revealed as an intraluminal mass composed of a central area of fat attenuation representing the entrapped mesenteric fat of the inverted diverticulum surrounded by a thick collar of soft tissue attenuation. Other features that support Meckel's diverticulum on CT include soft tissue stranding, abnormal calcifications, bowel obstruction, free air, free peritoneal fluid, cystic mass and obvious lead point. However, intussusception from other causes may appear similar to intussusception associated with Meckel's diverticulum on CT scan. Significant experience has not yet been gained to suggest the degree of confidence with CT scan.[5,10,26,27]

Laparoscopy

Several reports have shown that laparoscopy is safe and efficient way of localizing the lesion for the purpose of the removal of the Meckel's diverticulum.[28-31] In fact, some contend that laparoscopy also has a place in the diagnosis of a complicated Meckel's diverticulum, given the difficulties presented by other imaging studies, since it allows a complete resection of the lesion during the same procedure.[29-31] The technique however is more invasive than traditional imaging studies, and therefore is not included as an initial step in the diagnosis. Laparoscope can be used to remove an incidentally discovered diverticulum. Laparoscope has been successfully used for diverticulectomy in infants with bleeding Meckel's diverticulum. Use of gastrointestinal stapling device has made this an acceptable tool in simple, uncomplicated diverticulectomy. In this technique, the mouth of the diverticulum is stapled before the diverticulum is removed to lower chances of contamination.[28-31]

TREATMENT

Silent/incidentally detected Meckel's diverticulum

The treatment of incidentally detected or asymptomatic Meckel's diverticulum at laparotomy remains controversial. The incidence of complications from prophylactic resection is approximately 1%. This is in comparison to the lifelong potential complication rate of 5%-6% in all individuals, with Meckel's diverticulum. Given the significant lifetime risk of developing complications from the Meckel's diverticulum and the low rate of postoperative complications following prophylactic removal, incidentally detected diverticulum should be resected in the absence of any complicating condition such as peritonitis, patient instability and presence of ascites.[18,30]

Complicated Meckel's diverticulum

An omphalomesenteric remnant with a narrow base may be treated by amputation and closure of the bowel defect. In cases where the anomaly has a wide mouth with ectopic tissue or where an inflammatory or ischemic process involves the adjacent ileum, intestinal resection with the diverticulum and anastomosis may be necessary.[27] Involvement of the Meckel's diverticulum by tumors would require wide intestinal resection along with the lymphatic pathways of the mesentery. Ileal resection is also advisable if the base of diverticulum is edematous, inflamed or perforated. Therefore, the need for simple diverticulectomy and

segmental resection is explained.[27]

APPENDICITIS AND MECKEL'S DIVERTICULUM

In usual surgical practice, owing to difficult preoperative diagnosis, patients are subjected to surgery for appendicitis and finding a normal appendix needs examination of 180 cm of terminal ileum for location of a diverticulum. Both pathologies being present, is very rare, and therefore little is to be gained by searching for a diverticulum where acute appendicitis is present and dealt with. However, some recommended that Meckel's diverticulum should be looked for in all cases of appendicitis and if found, it should be removed.[10] The guidelines for management can be summarized as follows[22]:

1. Operating definite acute appendicitis does not need any search for the diverticulum.
2. In children or young adults, a diverticulum if found during a nonacute operation, should be removed especially if it bears a narrow neck, provided the patient's general condition and nature of primary operation is appropriate.
3. An incidental nonadherent Meckel's diverticulum in a patient aged over 40 years should be left alone.
4. Operating for abdominal pain and finding a normal appendix needs removal of appendix as well as the diverticulum.
5. During a routine laparotomy, if a band is found attached to umbilicus at any age, it needs division of band between ligature and resection of diverticulum, if feasible.

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