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## Introduction and History

Meckel's diverticulum (MD) is one of the commonest diverticulum in human beings. It occurs in 2% of the population. As Charles Mayo described—"Meckel's diverticulum is frequently suspected, often looked for, and seldom found".

Heladnus first described it in 1598 [1]. Ruysch and Levater described the diverticulum much before Meckel's description [2]. However, Johann Friedrich Meckel described the diverticulum in detail in 1809 and is credited with the first detailed description [3].

In 1962, Harper et al. suggested that as <sup>99m</sup>Tc pertechnetate is concentrated by gastric mucosa, the MD containing the gastric mucosa should be identifiable scintigraphically using <sup>99m</sup>Tc pertechnetate [4]. However, most MD may be identified intra-operatively due to its varying presentation of intestinal obstruction caused by either band with volvulus or intussusception, umbilical discharge and diverticulitis.

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## Embryology

During the first few weeks of gestation, primitive yolk sac divides into primitive midgut and yolk sac. Omphalo-mesenteric duct or vitello-intestinal duct connects the two. This structure usually regresses between 5th and 7th week of intrauterine life. Failure of regression leads to various presentations of patent vitello-intestinal duct (VI duct). Persistence of the tube proximally causes MD.

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## Incidence

MD is usually described by rule of 2. Common dictum is that it is present in around 2% of the population. It is 2 in. long and found around 2 ft from the ileo-caecal (I/C) valve. It may contain two types of heterotopic mucosa—gastric or pancreatic.

However, these are more generalisations than fact. Incidence of symptomatic MD is thought to be around 4% in the first 3 years of life. Following that, the incidence decreases. Prevalence of MD during postnatal autopsies is 1.23% [5].

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## Associated Anomalies

MD is usually an isolated condition. However, patients with Hirschsprung's disease, Down syndrome, oesophageal atresia, duodenal atresia, malrotation and congenital cardiac abnormalities show increased incidence [6].

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## Gross and Microscopic Anatomy

MD arises on the anti-mesenteric border of the ileum. Its distance from I/C valve is variable and is thought to be anywhere from 30 to 120 cm. Hence, during surgery, it is advisable to inspect at least 150 cm of terminal ileum. It has its own blood supply from persistent vitelline artery which is a branch of superior mesenteric artery.

On histology, it usually resembles the ileum. As it is a true diverticulum, it contains all layers of a normal intestine, that is, mucosa, submucosa, muscularis propria and serosa. However, it may contain heterotopic mucosa—either gastric or pancreatic tissue. Incidence of gastric mucosa occurs in around 9% of the patients. Pancreatic mucosa is seen in 2.5% of patients [7]. Various studies have also showed presence of carcinoid, lipoma, leiomyoma or enterolith.

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## Variations of Patent VI Duct Anomalies

VI duct anomalies occur due to variation of persistence of VI duct remnant and its attachment to the umbilicus.

Various anomalies are

1. MD—persistent proximal part of the VI duct
2. Isolated fibrous band—persistent remnant of whole VI duct
3. Omphalo-mesenteric fistula—presents as stoma at the umbilicus [8] or prolapse through the umbilicus [9]
4. Enterocyst—persistent middle part of the fistula.
5. Meckel's diverticulum may also have attached fibrous band.

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## Clinical Features

Most MDs are asymptomatic throughout life. In symptomatic cases, presentation varies with age.

### Neonatal

In neonates, the presentation is usually due to persistent VI duct presenting as either a discharging sinus at the umbilicus [8] or a prolapsing VI duct remnant [10, 11]. Other presentations may be due to a band with associated volvulus causing partial or complete obstruction. Perforation is rare.

### Pediatric Age Group

In pediatric age group, presentation varies between gastrointestinal (GI) bleeding, Intestinal obstruction and inflammation.

### GI Bleeding

GI bleeding is the commonest presentation in children below 2 years of age. It is usually the major lower GI bleed, which is painless or associated with minimal pain. The bleeding is associated with gastric heterotopia in majority of cases [12]. Bleeding is due to peptic ulcer in the surrounding normal ileal tissue.

In cases where the gastric mucosa is absent, bleeding is usually attributable to other causes like intussusception or gastritis.

Management of major GI bleed should include—assessment of hemodynamic stability, differentiation between upper and lower GI bleeding and then to determine the diagnosis and site of the bleeding.

In children suspected to have MD, after adequate fluid resuscitation, they should be started on H2 blockers like raniti-

dine or famotidine. Currently, proton pump inhibitors like omeprazole or lansoprazole are routinely used. Once bleeding is controlled, 99 m technetium-pertechnetate scan should be done to look for the diagnosis of MD. If diagnosed, they should be resected.

### Diverticulitis

Inflammation of the MD may be the presenting sign in 10–20% of children. Children are usually older. They are often mistaken as acute appendicitis. During surgery, inflamed MD is identified and should be excised.

### Obstruction

Obstruction is a common presentation in children as well as adults. Obstruction could be due to multiple reasons like volvulus around the MD with fibrous band, intussusception [13], enterolith or incarceration in Littre's hernia [14] or within umbilical hernia [15].

### Other Presentations

Other rare presentations can be due to development of bezoar in the diverticulum [16] or malignancy. The commonest tumour affecting the MD is carcinoid tumour [17, 18]. However, villous adenoma [19] or GI stromal tumour [20] has also been reported.

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## Investigations

As MD has very varied presentation, it is not always possible to diagnose it prior to surgery. The surgeon needs to have high index of suspicion.

However, the investigations, which might raise the possibility of MD, are as follows:

1. *Plain X-ray abdomen*: Plain X-ray may show evidence of intestinal obstruction. If enterolith is present, it may be visible. If MD has perforated, pneumoperitoneum may be visible.
2. *GI Contrast study*: It is unusual to identify MD by barium meal. However, it may be visible in 0.7% cases by small bowel enema.
3. *Fistulogram*: Patent VI duct may be identified by fistulogram from umbilical fistula.
4. *Angiography*: In adults and older children, bleeding MD may be identified by selective superior mesenteric artery angiography. If the patient is very unstable, it may be possible to temporarily occlude the bleeder by embolising the vessel. However, the patient should have laparotomy as soon as he is stabilised as embolisation may lead to gangrene and perforation of MD in a few hours' span.
5. *Scintigraphy*: Harden demonstrated that technetium-99m was concentrated in the gastric mucosa. Hence, it can

demonstrate the presence of heterotopic gastric mucosa in MD when present. The isotope is selectively taken into gastric, salivary and thyroid tissue. It is excreted in urine. Hence, sometimes, false-negative scans may be reported if the diverticulum is overlapped by urinary bladder. Sensitivity of the scan can be increased by using either pentagastrin or glycogen [21]. Scan has specificity of more than 95% and sensitivity of more than 85%.

## Surgical Technique

Resection of the diverticulum is the final aim. Whole diverticulum with heterotopic mucosa, if present, should be excised. After the excision, the bowel needs to be anastomosed without causing luminal obstruction. This can be achieved either by diverticulectomy alone if the base is narrow or by resection of the ileum containing the diverticulum with end-to-end anastomosis.

Decision about diverticulectomy or segmental resection is usually on individual surgeons. MD Resection Index (MDRI) has been proposed which calculates the index using the length and width of the diverticulum [22].

This procedure was routinely performed by laparotomy but, with changing practice, laparoscopy is playing an increasing role. During diagnostic laparoscopy performed whether for GI bleeding or acute appendicitis, routine examination of the terminal ileum should be carried out for at least 150 cm from the I/C valve to look for MD. Surgeon should start inspecting the ileum systemically from I/C valve. Two bowel graspers at anti-mesenteric border should grasp intestinal loops, and both sides should be examined. When MD is identified, it can either be excised in situ or the same can be delivered outside the abdominal cavity and the resection and anastomosis performed. The intestine can then be repositioned inside.

With advances in the minimal access techniques, now the same can be performed either using single-port technique [23] or natural orifice trans-luminal surgery (NOTES) [24].

## Outcome/Conclusion

Meckel's diverticulectomy has low morbidity and mortality. However, its first presentation may be at any age and is varied with obstruction, diverticulitis, haemorrhage or neoplasm [25]. Hence, the clinician needs to show high degree of suspicion and look out for this. It is seldom found easily, and early diagnosis and proper treatment is essential to manage its varied clinical symptoms. Surgical or laparoscopic techniques have developed over time, and today laparoscopy has found its increasing use in the management of MD.

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