

# Current Laparoscopic Management of Symptomatic Meckel's Diverticulum

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## ABSTRACT

Laparoscopic management is currently becoming an acceptable technique in the management of complicated Meckel's diverticulum. The study reviews the current techniques described in numerous series since over the past 10 years. Three laparoscopic techniques are described namely; LAMD (Laparoscopic-assisted Meckel's diverticulectomy—3 port technique with exteriorization of the diverticulum via the umbilical port and extracorporeal diverticulectomy), VATMD (Video-assisted Meckel's diverticulectomy—single umbilical port using operating laparoscope) and LMD (Laparoscopic Meckel's diverticulectomy—3 port technique with intracorporeal diverticulectomy). Small study sizes make in-depth statistical analysis impossible. Patient outcome with each technique however, seems similar, suggesting that the ultimate choice of procedure should be left to surgeon and institutional preference. The high incidence of heterotopic gastric mucosa (HGM) in complicated Meckel's diverticulum is confirmed and calculated to be an average of 78.2%.

**Keywords:** Meckel's diverticulum, Laparoscopic management, Complication.

## INTRODUCTION

Meckel's diverticulum is a rare congenital abnormality of the midgut widely accepted to occur in approximately 2% of the general population. The embryological and anatomic description of this anomaly was first published by Johann Friedrich Meckel in 1809 and as such it now carries his name. Meckel's diverticulum is a true diverticulum, containing all layers of the intestinal wall, and represents a failure of complete obliteration of the embryonic omphalomesenteric duct, and is usually present on the antimesenteric border of the distal ileum within approximately 100 cm of the ileocecal valve. It is also a common site for heterotopic mucosa, most frequently gastric although heterotopic, colonic and pancreatic tissues are not infrequently reported within the diverticulum.

The majority of cases are asymptomatic and may often be discovered incidentally. Even in symptomatic patients, preoperative diagnosis is often difficult. Clinically, there is as yet no consensus as to the precise management of asymptomatic diverticula, since the risk of postoperative complications may still be as high as 8%. Surgical excision, however, would still seem appropriate in those cases where patient profile and diverticulum morphology may increase the likelihood of complications later on in life.<sup>1</sup>

Morphological variations include:

- Short diverticulum with a wide base
- Long diverticulum with a narrow base
- Short diverticulum with adherent fibrous band to the umbilicus
- Patent vitellointestinal duct
- Periumbilical sinus.

Clinical presentation in symptomatic patients:

- Anemia/Lower GI bleeding
- Diverticulitis presenting as an acute abdomen

- Intestinal obstruction
- Nonspecific abdominal pain.

Intestinal obstruction may occur as a result of:

- Volvulus of the small bowel around the fibrous band of the diverticulum
- Luminal fibrosis and stenosis secondary to recurrent or chronic diverticulitis, or
- Intussusception.

Conventional surgical management has been laparotomy and any of:

- Simple diverticulectomy
- Diverticulectomy with wedge excision of adjacent ileum
- Segmental ileal resection and anastomosis.

There are two commonly performed laparoscopic procedures for Meckel's diverticulum. The 'conventional' procedure is a 3 port laparoscopy, identification of the diverticulum and either intracorporeal diverticulectomy using endoscopic linear stapler-cutting device or exteriorization of the diverticulum through the enlarged umbilical port site and subsequent extracorporeal excision of the diverticulum and repair of the enteric defect as appropriate. A more novel approach involves a single port technique using an operating laparoscope through the umbilicus—subsequent grasping and exteriorization of the diverticulum through the umbilical incision and diverticulectomy.

## AIM

Aim of this review is to determine whether laparoscopy offers a safe and feasible alternative to conventional surgery, particularly in the pediatric population.

## METHODS

A PubMed search was conducted using the keywords: Laparoscopy; Meckel's diverticulum; children; laparoscopic

management. Search revealed 20 articles, of which those published after the year 2000 were reviewed, and the search further expanded to include related citations. Articles describing laparoscopic management of Meckel's diverticulum were then selected for analysis. A description of the various procedures, as provided by the various authors is included. Attention is paid to key variables namely, mean operative time, intraoperative complications, duration of postoperative hospitalization and results tabulated to allow for easy comparison.

## RESULTS

The largest published series since 2000, was that by Sai Prasad et al.<sup>2</sup> This was a review of 36 patients (27 males and 9 females) who underwent laparoscopic-assisted transumbilical Meckel's diverticulectomy (LATUM) between October 2002 and April 2006.

The procedure described in this series was a two or three port technique using first a 10 mm umbilical port for the laparoscope inserted by the Hassan technique and combined with two 5 mm operating ports inserted in the left iliac fossa and suprapubically. The second operating port being omitted for cases of bleeding MD.

After systematic laparoscopic examination of the intra-abdominal contents, Meckel's diverticular complications when present were managed laparoscopically, following which the freed MD was delivered through an extension of the linea alba, while maintaining the skin incision within the umbilical cicatrix, to allow extracorporeal diverticulectomy and hand-sewn intestinal anastomosis. The authors describe their procedure as LATUM. In this study, one patient with a torted MD underwent intracorporeal diverticulectomy after endoloop ligation of the base.

Clinical presentation of patients in this study population was as follows:

- Sixteen (44.4%) patients presented with lower gastrointestinal bleeding (14 with painless bleed and 2 with perforated peptic ulcer in the ileum adjacent to the MD).
- Six (16.7%) patients presented with intestinal obstruction (four due to a mesodiverticular band and one each due to intussusception and floppy giant cystic dilatation of MD causing intestinal compression)
- Four (11.1%) patients presented with features masquerading as appendicitis (one with Meckel's diverticulitis and perforation, one with perforated peptic ulcer adjacent to MD and two with a torted and gangrenous MD)
- Ten (27.8%) patients, incidental MD with a narrow, base were noted at laparoscopic exploration for suspected appendicitis.

All patients underwent successful LATUM along with appendicectomy.

LATUM along with appendicectomy was successfully performed in all patients.

Mean operative duration was  $125.9 \pm 48.4$  minutes, ranging from 72 to 266 minutes. No intraoperative complications were

reported, neither was there any need for conversion to open surgery in any of the procedures. The hospital stay ranged from 3 to 9 days (mean  $5.3 \pm 1.2$ ). There were three (8.3%) cases of postoperative adhesive intestinal obstruction; two underwent successful laparoscopic adhesiolysis and one necessitated conversion to suprapubic laparotomy to release the pelvic adhesions. Over the 16 months median follow-up period, no other complications were reported.

Ranitidine augmented 99mTc scintigraphy was performed in 14 out of the 16 patients presenting with lower GI bleeding and was suggestive of gastric heterotopia in 12 patients (85.7%). Histopathological analysis found 15 out of the 16 patients (93.7%) to have gastric with or without pancreatic heterotopia. Overall, this study found ectopic gastric, pancreatic or duodenal epithelium in 25 patients (69.4% of the study population). Five (50%) of the incidentally detected MD showed gastric heterotopia.

Shalaby et al<sup>3</sup> reviewed the clinical data of 33 children who were admitted with rectal bleeding and/or recurrent abdominal pain with no identifiable cause, over a period of 8 years, at their institution. This study group consisted of 23 male patients and 10 females with a mean age of 5.12 years (range, 3-12 years). In 21 cases, Meckel's diverticulum was an incidental finding on laparoscopic appendectomy and symptomatic in 12 cases. Preoperative workup for patients with rectal bleeding included upper gastrointestinal endoscopy; colonoscopy and technetium Tc 99m-labeled pertechnetate scan in the addition to the routine investigations performed for all other patients.

Pneumoperitoneum was created by open Hasson's technique using a 12 mm port to a pressure of 12 mm Hg. Through this port, a 10 mm telescope was used for initial visualization of the whole abdomen and two 3 mm accessory ports were inserted on both sides of the lateral borders of the rectus muscle below the level of the umbilicus. Following complete laparoscopic visualization of the abdomen, the ileocecal segment was identified and the terminal ileum was examined stepwise from ileocecal junction proximally using atraumatic graspers.

Laparoscopy was able to make a correct diagnosis in all 12 symptomatic patients. These included MD (n = 8), intussusception secondary to M (n = 1), duplication of distal ileum (n = 1) and no pathology was identified on detailed laparoscopic examination.

If a Meckel's diverticulum was identified, a 3.3 mm telescope was placed through the left accessory port leaving the umbilical port free for either application of an endostapler-cutter and specimen extraction (LMD-Laparoscopic Meckel's Diverticulectomy) or for exteriorization of the diverticulum to facilitate laparoscopy-assisted Meckel's diverticulectomy (LAMD).

The choice of whether LAMD or LMD was based on the appearance of the MD.

LAMD was performed for bleeding and for those patients with short incidental MDs, with height-to-width ratio (HD ratio) less than 1.6, so as to ensure complete removal of ectopic mucosa that may line the proximal end of MD and adjacent ileal mucosa. The intestinal segment bearing MD was delivered through the umbilical port site to the abdominal surface. Small bowel resection and anastomosis were then accomplished extracorporeally either by manual suturing or by an endostapler-cutting device.

LMD was performed for long MDs, either symptomatic or incidental with HD ratio greater than 1.6. The tip of the MD was held and pulled toward the anterior abdominal wall and an endoliner-stapler-cutter device was applied obliquely to its base to remove all the diverticular tissue without threatening the ileal lumen.

In those cases where no lesions were found on diagnostic laparoscopy, laparoscopic appendectomy (LA) alone was carried out.

In all, LMD and LAMD were done for 18 and 12 MDs, respectively.

The mean operative time was as follows:

- 45 minutes for LA and LMD was 45 minutes
- 55 minutes for LA and LAMD was 55 minutes
- The mean operative time for LA and laparoscopic release of intussusception was 30 and 35 minutes respectively.

Long MD with HD ratio greater than 1.6 was found in 18 cases. Short MD with HD ratio less than 1.6 was found in 12 cases. The histopathologic studies confirmed heterotopic gastric mucosa (HGM) in 13 cases (43.3%). HGM was present in the distal end of six long cases and in seven short MDs; it was found in the proximal end.

No intraoperative or postoperative complications occurred.

Mean hospital stay in this study group was  $1.66 \pm 0.8$  days (range, 1-5 days). No postoperative complications were reported. All patients were reported to be asymptomatic after 1 year of follow-up.

Clark et al<sup>4</sup> conducted a retrospective chart review of patients who underwent laparoscopic excision of MD from 2000 to 2005 at their center. Nine patients were identified. They describe a 3 port, laparoscopy-assisted procedure (LAP) and a single port video-assisted transumbilical procedure (VAT).

### VAT Technique

A 10 mm trocar is placed through a vertical, transumbilical incision and a pneumoperitoneum is established. A 10 mm, zero degree, operative laparoscope with a 400 mm atraumatic grasper is used to run the bowel and to locate the MD. The MD is pulled through the umbilical incision and resected extracorporeally. The umbilical incision is slightly enlarged to accommodate the bowel.

### LAP Technique

A 10 mm trocar is placed through a vertical, transumbilical incision and a pneumoperitoneum is established. Two working 5 mm

trocars are inserted in the lower quadrants. The MD is pulled through the umbilical incision and resected extracorporeally. The umbilical incision is slightly enlarged to accommodate the bowel.

Four patients underwent the three-trocar technique (LAP, n = 4). The remaining five underwent the video-assisted transumbilical single-trocar technique (VAT, n = 5) procedure. In this study, the choice of the technique of resection was left to the discretion of the surgeon. Indications for surgery included gastrointestinal bleeding (VAT, n = 3; LAP, n = 2), malrotation (LAP, n = 2), intussusception (VAT, n = 1) and abdominal pain (VAT, n = 1). All patients were male, and age ranged from 7 months to 17 years for the VAT group and 8 months to 15 years for the LAP group.

The average length of surgery for the LAP vs VAT was 128 minutes (94-170 minutes) and 81.4 minutes (42-96 minutes) respectively. Of the five patients undergoing LAP, two Ladd's procedures and three appendectomies were included during the same anesthesia. Only a single appendectomy procedure was performed during a VAT. The average time until full feeds with the LAP and VAT was 4.3 days (2-8 days) and 2.0 days (1-3 days) respectively. The overall length of stay with LAP vs VAT was 4.3 days (2-8 days) and 3.7 days (2-5 days). Only one case using the LAP method required conversion to an open laparotomy because of unclear anatomy. The only complication reported was a single patient who developed postoperatively ileus in the LAP group.

Chan et al<sup>5</sup> report their 10-year experience with laparoscopic management of complicated Meckel's diverticulum cases presenting in childhood from 1998 to 2007. Their study group contained 20 children (17 males and 3 females), with a mean age of 5 years, ranging from 7 months to 13 years.

Diagnostic laparoscopy was performed on all patients and proceeded successfully to laparoscopically-assisted transumbilical Meckel's diverticulectomy in 18 patients. Two patients required conversion to open surgery due to nature of the pathology. The mean operative time was 115 minutes with a range from 50 to 190 minutes. All the children had an uneventful recovery, except one, who experienced a postoperative wound infection. Ectopic gastric mucosa was found in 14 cases. Mean hospital stay reported was 6.9 days (range of 5-9 days).

Cobellis et al<sup>6</sup> describe their experience with nine patients with a median age of 6.1 years (range, 6 months to 13.6 years) who underwent single trocar transumbilical laparoscopic-assisted procedures for Meckel's diverticulum between January 2001 and December 2004. They used an intraumbilical Hassan 10 mm trocar inserted in an open fashion after which a 10 mm operative laparoscope was introduced. Using an atraumatic instrument, the terminal ileum was grasped exteriorized through the umbilicus allowing ileal exploration and treatment to be performed extracorporeally.

Meckel's diverticulum was identified in eight patients and ileal duplication in one patient. Resection/anastomosis was

performed in seven patients and excision of diverticulum performed in two. The mean operative time was 70 minutes (range, 40-100 minutes). There were no operative complications. The histology of the resected MDs showed ectopic gastric mucosa in all eight patients, associated with focal ulceration in two. The authors reported no operative complications. Median hospital stay was four days (range, 3-7 days). At a median follow-up of 24 months (range, 3-51 months), all patients were asymptomatic.

The series by Palanivelu et al<sup>7</sup> 2008 included 12 patients with symptomatic Meckel's diverticulum treated from 1994 to 2006. All the patients presented with features of either appendicitis or peritonitis, some with a vague abdominal mass. Clinical diagnosis of Meckel's diverticulum was made in only four patients. Diagnostic laparoscopy confirmed Meckel's diverticulitis in all patients. The open Hasson technique was used to establish pneumoperitoneum. A 10 mm trocar was inserted into the umbilicus followed by two working ports, a 5 mm suprapubic port and another 5 mm port in the right lower quadrant; both introduced under vision. A 10 mm (300) laparoscope was introduced into the 10 mm port for diagnostic laparoscopy. Laparoscopic stapler resection of the lesions was performed for all patients using an endostapler-cutter which was introduced into a 12 mm trocar, replacing the 10 mm umbilical trocar. Tangential excision was performed in 10 patients and wedge excision in two patients in whom the base of the diverticulum was thought to be inflamed. Routine appendectomy was performed for all patients.

No cases of staple line leaks were reported in this study. One patient had infection of the umbilical wound, which was treated with the appropriate antibiotics. One patient had postoperative pneumonitis, treated with intravenous antibiotics for 5 days. Histopathology of the diverticulum showed heterotopic gastric mucosa in 11 (73%) patients, pancreatic tissue in one (27%) patient, evidence of acute inflammation in nine patients and perforation in three patients. The day of discharge was in the range of the fourth to the seventh postoperative day. Eight patients were followed up for 24 months and four patients reported for follow-up after 45 months. All were found to be symptom free.

## DISCUSSION

Meckel's diverticulum, even today still presents as a diagnostic and therapeutic challenge. As already stated, the majority of people with Meckel's diverticulum are asymptomatic. Cullen et al<sup>8</sup> found the lifetime risk of complications in people with Meckel's diverticulum to be 6.4%. The potential for complications though may be greater in people who are less than 50 years of age; male; have diverticuli greater than 2 cm in length; and in diverticuli that contain heterotopic mucosa.<sup>1</sup>

Cullen et al<sup>8</sup> also showed that surgery for complicated Meckel's diverticulum is associated with significant operative mortality and morbidity, 2 and 12% respectively. Long-term

postoperative complications are likely to occur in approximately 7% of patients.<sup>8</sup> Significantly, this study also showed that even incidental diverticulectomies carried an operative surgical mortality and morbidity risk of 1 and 2% respectively as well as a risk of long-term complications in 2% of patients.

Complicated Meckel's diverticulum is thus by no means an innocuous diagnosis and highlights the need for both a reliable diagnostic and therapeutic tool to optimize management in these patients. Advances in minimal access surgery, we may now provide us with such a tool. The low incidence of symptomatic Meckel's diverticulum in the general population implies that high-powered randomized controlled trials comparing various modes of laparoscopic and even open surgical procedures are unlikely to occur. As such institutional experience becomes increasingly significant in determining optimal management of this condition.

As laparoscopic appendectomy and diagnostic laparoscopy increasingly gain popularity, it is more likely that the diagnosis of complicated Meckel's diverticulum will be made with the use of a laparoscope, particularly in patients presenting with an acute abdomen. At this point, the surgeon has three therapeutic options, namely proceed with LMD which implies intracorporeal diverticulectomy; LAMD; or if the pathology warrants conversion to open surgery. Conversion to open surgery is likely to be required in patients with gangrenous bowel, irreducible intussusception or alternate diagnosis.

Diverticulum morphology may also influence surgical management. Mukai et al<sup>9</sup> suggest that the external appearance of the diverticulum indicates the distribution of the HGM and as such would influence the choice of laparoscopic procedure. According to their results, long diverticula (more than 1.6 HD ratio) have HGM only in the distal area, while short diverticula (less than 1.6 HD ratio) have HGM in almost all areas. In long diverticula, simple transverse resection with a stapling device would be acceptable provided immediate frozen section analysis is present to ensure that the stump does not contain HGM. For short diverticula, wedge resection or ileal resection with end-to-end anastomosis after exteriorization would be more appropriate. Adequate resection of heterotopic mucosa is mandatory, not only because residual mucosa may result in persistence of symptoms following surgery, but also because of its possible neoplastic potential.<sup>10</sup>

The incidence of heterotopic mucosa in the analysis of the studies included in this review is calculated to be 78.2%. As such LAMD with exteriorization of the diverticulum, wedge resection and ileal repair would be the preferred procedure, given that it allows for tactile examination of the diverticulum, wedge excision, without significant differences in outcome and has the added cost-saving benefit of avoiding use of an endostapler-cutter device (Table 1).

A second distinct group of patients are those in whom the diagnosis of Meckel's diverticulum is suspected preoperatively. These patients are more likely to have presented with lower

**Table 1:** Comparison of outcomes

Study	N	LAMD	VATMD	LMD	RA	Mean operative time (min)		Mean hospital stay (days)		Postoperative complications	Ectopic gastric mucosa
						LAMD	VATMD	LMD	LAMD		
Sai Prasad et al, 2006	36	36	-	-	No	125.9 ± 48.4	-	5.3 ± 1.2	-	8.3%	93.7% (50% in incidental MD)
Shalaby et al 2005	33	18	-	12	Yes	55	-	1.66 ± 0.8 (for all patients)	-	0%	44%
Clark et al 2008	9	4	5	-	No	128	81.4	4.3	3.7	11%	n/r
Chan et al 2008	20	18	-	-	No	115	-	6.8	-	5.5%	92%
Cobellis et al 2007	9	-	9	-	No	-	70	-	4	0%	88.9%
Palanivelu et al 2008	12	-	-	12	Yes	-	-	-	-	16%	73%
Total	119	76	14	24		106	75.7	4.5	3.85	6.8%	78.3%
Average											

MD: Meckel's diverticulum; LAMD: Laparoscopically-assisted transumbilical Meckel's diverticulectomy (3 port technique); VATMD: Video-assisted transumbilical Meckel's diverticulectomy (single port technique); LMD: Laparoscopic Meckel's diverticulectomy (3 port intracorporeal diverticulectomy); RA: Routine appendicectomy

gastrointestinal bleeding with or without anemia and would have had endoscopic or radiological imaging of the GIT and possibly  $^{99}\text{Tc}$  pertechnetate scintigraphy (Meckel scan). The sensitivity of the Meckel scan, however, may only be in the region of 60 to 66%<sup>11,12</sup> and carries a relatively high false-negative rate.<sup>12</sup> In cases, where investigations and clinical suspicion favor the diagnosis of Meckel's diverticulum which seem most appropriate to proceed with the novel single-port video-assisted transumbilical procedure proposed by both Clark<sup>4</sup> and Cobellis.<sup>6</sup>

## CONCLUSION AND RECOMMENDATION

This study illustrates the fact that the laparoscopic era brings with it novel approaches to old pathologies. Large-scale trials comparing specific therapeutic strategies are unlikely to occur. From the available evidence, however, we can conclude that all current laparoscopic techniques in the management of Meckel's diverticulum are both safe and effective with no significant difference in outcome between them. In the appropriate clinical setting, I would however suggest that preference be given to either LAMD or VATMD rather than 'conventional' LMD using an intracorporeal stapler-cutter.

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