Laparoscopic Surgery in Luminal Gastrointestinal Emergencies—a Review of Current Status

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Abstract Laparoscopy has already established itself as the preferred surgical approach in a variety of elective surgical conditions. Along with its usual advantages of less tissue trauma and faster recovery, its diagnostic as well as therapeutic role is making it an attractive option in emergency surgery. In this paper, we have reviewed the current status of laparoscopic surgery in luminal gastrointestinal emergencies. Relevant papers were selected using Medline database from 2007 to the present. These were reviewed, and outcomes were stated under the headings of appendicitis, perforated peptic ulcer, colorectal emergencies and small bowel obstruction. The laparoscopic intervention was found to be of clear benefit in most of the patients with appendicitis. Its role, however, is not absolutely clear in managing perforated peptic ulcers. Laparoscopic lavage and drainage have been recommended in diverticular perforation with limited contamination. Small case series and studies have shown benefits of laparoscopic surgery in iatrogenic colonic perforations, colonic obstruction, emergency colectomy and small bowel obstruction. Laparoscopic surgery can be recommended in appendicitis and low-risk cases of perforated peptic ulcers. Its definitive role in other conditions needs more evidence. The surgeon's experience and careful patient selection are very important to improve the outcome.

Keywords Laparoscopy · Appendicitis · Perforation · Diverticulitis · Obstruction

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Introduction

Laparoscopic procedures have become increasingly popular due to proven quicker post-operative recovery, low rates of early and late post-operative complications, early mobilization and shorter hospital stay [1, 2]. Among elective surgeries, laparoscopic cholecystectomy and antireflux surgery have already replaced open surgeries as 'the gold standard', and the use of laparoscopy is now well accepted for elective colorectal surgery [3].

Although the first laparoscopic appendicectomy was undertaken in 1980 [4], it is only in the past couple of decades that laparoscopic surgery is establishing itself in abdominal emergencies. Due to the dual benefit of being diagnostic as well as therapeutic, it is deemed as an attractive alternative in emergency surgery [5]. The 2006 consensus statement from the European Association for Endoscopic Surgery (EAES) recommended laparoscopic approach in certain conditions (cholecystitis, appendicitis and perforated peptic ulcer), but found it of less and unclear benefit in others (acute diverticulitis and small bowel obstruction) [6].

In the current paper, we have reviewed the role of laparoscopic surgery in luminal gastrointestinal (GI) emergencies.

Methods

A literature search was carried out using Medline Database and the terms included were 'laparoscopy*' and 'appendicitis' or 'bowel obstruction', 'perforation' or 'colorectal'. The limits which were activated included humans, adults, controlled trials, randomized controlled trials, meta-analysis, review, systematic review, English language and the time frame of the last 5 years (2007 to the present).

The relevant papers were selected after screening the abstracts and through cross-reference. All the full text papers were reviewed, and the outcomes have been discussed under

the headings of appendicitis, perforated peptic ulcers, colorectal emergencies and small bowel obstruction. As the gall bladder is not the part of the luminal gastrointestinal tract and there is already sufficient level 1 evidence in support of laparoscopic cholecystectomy [6], it was excluded from the review.

Results

Appendicitis

Laparoscopic appendectomy (LA) is a safe and effective method for the treatment of uncomplicated appendicitis and may be used as an alternative to the standard open appendectomy (SAGES 2009) [7]. In 2012, grade A recommendation was made in EAES consensus statement [8] suggesting the use of diagnostic laparoscopy in suspected appendicitis and to proceed with laparoscopic appendectomy once the diagnosis was confirmed. In cases of complicated appendicitis, the laparoscopic approach may be preferred over open approach [7].

There was reported increase in incidence of intra-abdominal abscess after LA [Peto odds ratio 1.87 (95 % confidence interval (CI) 1.19–2.93)] in 2010 Cochrane review [9], but in a systematic review, Markides et al. reported this increase to be of no statistical significance [odds ratio (OR) 1.24 (95 % CI 0.84–1.84)] [10]. Intra-operative irrigation and suction continues to be a matter of debate. A retrospective study determined its inability in preventing abscess formation in complicated appendicitis [11]. Hussain et al., in their prospective study, suggested that it may be a contributory factor in abdominal contamination [12]. However, it has been suggested that laparoscopy is better for lavage due to better visualization [13], and the EAES consensus statement of 2012 favours it [8].

Laparoscopic appendectomy has been found to be feasible and potentially safe in the elderly (>65 years) with no increase in morbidity [14]. The overall complication rates were significantly lower in LA group as compared to open appendectomy (OA) group (36.27 % (LA) vs. 46.92 % (OA) $p < 0.01$) [14]. In pregnant patients undergoing LA, there is conflicting evidence with regard to increased foetal loss and preterm labour. Systematic review by Walsh et al. (2008) found significantly high foetal loss (6 %) but lower preterm delivery rate [15]. Systematic review and meta-analysis by Wilasrusmee et al. (2012) concluded the foetal loss was significantly more in LA group [pooled relative risk 1.91 (95 % CI (1.31–2.77)] [16]. It also suggested increased preterm labour [pooled relative risk 1.44 95 % CI (0.68 to 3.06)], but this was not statistically significant. A retrospective study by Lemieux et al. (2009) reported no foetal loss or preterm delivery in 45 consecutive patients undergoing LA [17].

Laparoscopy has been found to be safe in any trimester [18], but LA was associated with longer operating time and higher conversion rates in the third trimester [17].

If a normal appendix is found on laparoscopy, current recommendation is to remove it in the absence of any other pathology, but merits should be weighed against minor increase in complication rates [7]. Cases favouring the removal of normal appendix would include those with high clinical suspicion, radiology revealing a faecolith or faecal impaction in the appendix and surgical units where the rate of abscesses is minimal [8]. The presence of ‘endoappendicitis’ (normal looking serosa but inflammation of inner layers on histology) also justifies this approach [19].

Three-port appendectomy is still the gold standard surgical technique [8], although position of the ports may vary depending upon the surgeon’s choice and cosmesis (two suprapubic ports). Single-port appendectomy requires more prospective evidence to be widely accepted. In cases where needlescopic appendectomy (using 3-mm ports) is carried out, finer instruments may improve cosmesis but are associated with higher conversion rates and increase in operating time [20].

The appendix stump can be dealt with by an endoloop, stapler or clips (titanium or Hem-o-lok). Hue et al. suggested to use Hem-o-lok clips for mildly inflamed appendix base less than 10 mm, endoloops for moderately inflamed appendix base more than 10 mm and staples for severely inflamed appendix more than 10 mm to prevent necrosis of base and subsequent abscess formation [21].

In conclusion, laparoscopic appendectomy has established itself in majority of the adult population and for both uncomplicated and complicated appendicitis. Its role and safety, however, need more evidence in pregnant patients. Further research is needed regarding reduction of intra-abdominal abscess, single-port appendectomy and ideal method of dealing with appendix base.

Perforated Peptic Ulcer

The incidence of peptic ulcer disease (PUD) has been decreasing due to antiulcer drugs and *Helicobacter* eradication therapies. Despite the number of patients with complicated PUD that remains constant, it is still the most common indication for emergency gastric surgery [22]. Use of laparoscopy in the management of perforated peptic ulcer (PPU) was reported in the early 1990s for the first time [23].

There are numerous advantages to be offered by laparoscopic surgery in PPU, e.g. diagnostic, reduced pain and hospital stay and overall reduced complications (wound infections and incisional hernia) [1, 24].

A careful selection of patients is of utmost importance in performing laparoscopic repair of PPU. Boey’s score is a useful predictor in selection of laparoscopic repair. This risk

stratification score is based on blood pressure less than 90 mmHg, severe comorbidities and duration of symptoms more than 24 h with a value of 1 assigned to each factor. Patients with high score have an increased morbidity (11 % for score 0 and 77 % for score 3) and mortality (1 % for score 0 and 38 % for score 3) [25, 26]. The low scoring patients are the ideal candidates for laparoscopic repair [27]. Age more than 70 years was once considered a risk factor [26], but Wang et al. found laparoscopic repair to be safe and effective in the elderly [28].

There is an associated increase in operative time for laparoscopic repair [29], mostly due to difficult suturing, less experience [30] and time consumed by irrigation [22]. The increase in operative time is considered to be a risk factor for increased post-operative complications [24]. There is a constant effort to simplify the suturing technique, and this has evolved from the traditional omental plug or omentoplasty to simple suturing [27], clips [31] or suture less technique with sealants [32]. It remains to be seen whether this effort to reduce operating time is associated with increased risk of complications, i.e. suture line leakage [8]. It is best to judge the repair method by the properties of ulcer edge and size [26]. Easily opposable and viable edges can be repaired with suture repair with omental reinforcement, whereas infiltrated, friable and non-mobile edges should be repaired with sutured omental patch. Wadaani in his prospective case series of 45 patients (2013) has used the irrigation selectively in cases with visible food remnants in peritoneal cavity, and this has been postulated as an independent factor in reducing the operative time [33]. Due to improving surgical skills, technology and better teamwork, a progressive reduction in operative times [94 min (Lau et al. 1996), 75 min (Bertleff et al. 2009) and 42 min (Wadaani 2013)] has been achieved in the past years [8].

Successful completion of laparoscopic surgery is denoted by conversion rate, and these have been reported to be 12.4 % [22]. Some studies have even reported no conversions in their series [34]. Various factors resulting in conversion that have been identified include failure to localize the ulcer, perforation associated with bleeding, large ulcer (>10 mm), increasing Boey's score and failure to tolerate pneumoperitoneum [26].

A higher suture leak rate (OR, 1.49; 95 % CI, 0.53–4.24; $p=0.45$) and subsequently re-operation rate (3.7 % for laparoscopic repair vs. 1.9 % for open repair) was reported in Lau's meta-analysis [1], but these were not statistically significant. Another comparison found the leak rate to be higher in laparoscopic group, but it was attributed to the learning curve rather than laparoscopy itself [30]. Other factors found contributing to high leakage rates were suture less repair or in groups where pedicled omentoplasty was not used routinely [22].

The role of routine laparoscopic surgery in cases of PPU is still inconclusive. Interestingly, the EAES guidelines which recommended laparoscopic approach for perforated peptic

ulcer in 2006 has been modified in 2012 and states 'Laparoscopy is a useful diagnostic tool when preoperative findings are not conclusive, especially if a laparoscopic treatment is likely; Laparoscopy is a possible alternative to open surgery in the treatment of perforated peptic ulcer'.

Cochrane database review in 2013 suggests the role of laparoscopic repair as equivocal and the need for more randomized controlled studies [35]. World Society of Emergency Surgery (2013 guidelines) has suggested that 'Laparoscopic repair of perforated peptic ulcers can be a safe and effective procedure for experienced surgeons' [36]. Other studies have suggested laparoscopic repair as a better approach in low risk patients [22, 27] and in experienced hands [33].

In conclusion, more studies will be required to assess the safety and efficiency of laparoscopy in the management of PPU. Laparoscopic repair of PPU can be performed in patients with relatively low risk and by experienced surgeons.

Colorectal Emergencies

Laparoscopic surgery has gradually been accepted as a feasible and safe technique in elective colorectal surgeries for benign and malignant lesions [37]. The role of laparoscopy in colonic emergencies is less well-documented in the literature, and limited data is available regarding the same [38]. Various common colonic emergencies include perforation (iatrogenic or diverticular), obstruction, volvulus and colitis. The well-known benefits of laparoscopic surgery, i.e. reduced pain, faster recovery, reduced hospital stay and reduced short-term complications, could also extend to emergency colorectal surgery too without increased complications and re-operation rate.

The role of laparoscopy in colonic perforation caused by colonoscopy has been reported mainly as case reports or case series involving less than 20 patients [39–42]. These studies have confirmed the excellent results of laparoscopic surgery regarding reduced morbidity, mortality and hospital stay (Table 1). The patients in whom there is doubt about integrity of laparoscopic repair or the perforation is not localized should be converted to an open procedures [39].

In the western world, acute diverticulitis is a common colonic emergency. Complications of acute diverticulitis are classified according to modified Hinchey classification (Table 2).

Until recently, colonic resection was considered the gold standard for complicated sigmoid diverticulitis, and laparoscopic lavage was suggested only in selective patients [6]. Laparoscopic lavage was originally described by O'Sullivan et al. in 1996 [45], and since then, many studies have supported its role in management of perforated diverticular disease [46]. In majority of Hinchey I and IIa, percutaneous drainage is usually sufficient to control the sepsis [47], and surgical treatment is required in cases classified as Hinchey IIb and above. Laparoscopic lavage with abundant fluid and drainage

Table 1 Laparoscopy in Iatrogenic perforation by colonoscopy

Study	Attempted laparoscopy	Laparoscopic surgery	Morbidity (%)	Mortality (%)	Hospital stay (days)	Conversion rate (%)
Hansen et al. [39]	11	7	28.4	0	7.6	27
Bleier et al. [40]	11	11	18.1	0	5.1	0
Rotholtz et al. [41]	14	14	21	0	4.2	0
Coimbra et al. [42]	19	16	12.5	0	10	16

of cavity is done to convert generalized purulent peritonitis to localized diverticulitis, which can then be treated safely with antibiotics [8]. Systematic review by Toorenvliet et al. in 2010 concluded that laparoscopic lavage could control the infection and sepsis in more than 95 % patients and was associated with decreased morbidity and mortality with benefit of avoiding a stoma [48]. Another multicentric retrospective study (38 patients) by Swank et al. in 2013 reported a success rate of 86 % in controlling sepsis [49]. It emphasized on patient selection and stated that the presence of overt perforation with faecal peritonitis is an absolute contraindication to laparoscopic management. It also suggested that multiple comorbidities, high C-reactive protein concentration and higher Mannheim Peritonitis Index may predict the failure of lavage. Lavage may not be sufficient to for Hinchey IV faecal peritonitis, and colonic resection is recommended for these patients [48]. The colonic resection may be performed laparoscopically [50] or open depending upon the surgical expertise, but the evidence is not sufficient to make some recommendation [8].

The EAES recommendations in 2012 deemed laparoscopic lavage and drainage as the standard of care in Hinchey I and II and selected cases of Hinchey III. Colonic resection was recommended for majority of Hinchey III and all the Hinchey IV patients.

The literature is sparse regarding laparoscopic management of large bowel obstruction (LBO). A retrospective study by Ng et al. comparing laparoscopy-assisted right hemicolectomy with open surgery for right-sided LBO suggested increased operative time but less blood loss (20 ml for laparoscopic vs. 100 ml for open) and faster recovery [51]. Gash et al. suggested that laparoscopic management of LBO is a feasible and safe approach with less tissue trauma, faster recovery and reduced complications [52] (Table 3).

Emergency colectomy may be required for other colonic conditions, e.g. lower gastrointestinal bleed, toxic colitis and colonic ischaemia [38, 53]. Though majority are performed with a laparotomy, the laparoscopic approach has been described by a few authors [51, 53]. Total laparoscopic surgery is performed by fewer [53] as others used predominantly laparoscopic-assisted or hand-assisted techniques [38]. Majority of the limited available evidence favours laparoscopic surgery due to faster recovery and low complication rates [38, 53, 54]. One Danish study did not find laparoscopic subtotal colectomy a feasible option due to high complication rate and high conversion (48 %) [55]. This may have been due to the limited laparoscopic experience of the surgeons as others have reported the conversion rates varying from 5 to 17.4 % [38, 56]. Major reasons for conversions were found to be adhesions, difficult dissection [38], extremely distended bowel and doubtful bowel viability [54]. Koh et al. clearly demonstrated lower conversion rates [3/11 (first half of study period) vs. 1/12 (second half of study period)] and less operative time (158 vs. 180 min) as the experience of the surgeons increased, thus emphasizing on learning curve [38]. The laparoscopic approach has been found to be safe and feasible in cases of severe colitis [57] or complicated inflammatory bowel disease [58]. However, there were some suggested relative contraindications, i.e. increased body index mass [58] and moribund patients [54].

In conclusion, laparoscopic surgery can be performed successfully in cases of iatrogenic perforation, and the case series show good outcome. It is unlikely that we will have randomized studies for the above as the incidence is low. In patients with large bowel obstruction, the current evidence is limited to make any recommendation, and further studies will be required to establish the criteria where it is likely to be

Table 2 Hinchey classification and modified Hinchey classification

Hinchey Classification [43]		Modified Hinchey Classification [44]	
I	Pericolic abscess or phlegmon	I	Pericolic abscess
II	Pelvic, intraabdominal or retroperitoneal abscess	IIA	Distant abscess amenable to percutaneous drainage
		IIB	Complex abscess associated with fistula
III	Generalized purulent peritonitis	III	Generalized purulent peritonitis
IV	Generalized faecal peritonitis	IV	Faecal peritonitis

Table 3 Laparoscopy in large bowel obstruction

Study	Attempted laparoscopy	Laparoscopic surgery	Morbidity (%)	Mortality (%)	Hospital stay (days)	Conversion rate (%)
Ng et al. [51]	14	14	28.6	7.1	7	0
Gash et al. [52]	24	22	25	4	5.9	8

beneficial. The limiting factors are visualization and experience in emergency. The authors feel that with growing experience, there will be a role of laparoscopic resection in selected cases. Promising results have been shown by using laparoscopic lavage and drainage in cases of perforated diverticulitis (up to Hinchey II and selected cases of Hinchey III). In cases of Hinchey III and Hinchey IV, colonic resection is advised which can be performed laparoscopically depending upon the surgeon's experience and patient's general condition. Based on the current evidence, it can be suggested that minimally invasive colectomy is a safe and effective procedure in selected colonic emergencies and likely to be performed more frequently in the future as the experience of laparoscopic surgeons increases. Further research in the form of well-conducted prospective randomized controlled trials is needed to support its role.

Small Bowel Obstruction

Small bowel obstruction (SBO) is one of the commonest causes of emergency surgical admissions. The most common aetiology is adhesions, while other causes include hernias, neoplasms, Crohn's disease, Meckel's diverticulum and gall stone ileus [59]. In the past, laparotomy had been the mainstay of treatment. First successful laparoscopic adhesiolysis was reported in 1991 [60], and since then, there has been constant effort to define the role of laparoscopic surgery in the management of SBO. Although there are potential benefits of laparoscopic surgery, i.e. less post-operative pain, quicker return of intestinal function, faster recovery, shorter hospital stay and fewer post-operative intra-abdominal adhesions [1,

61], there were apprehensions of its use in SBO due to the risk of abdominal entry, reduced operative field visualization due to dilated bowel loops, incomplete adhesiolysis and handling of friable gut [62].

Until present, no randomized controlled trial has been undertaken comparing laparoscopic and open adhesiolysis. However, many studies have tried to define the feasibility [63] and factors [64] affecting the possibility of successful laparoscopic approach to manage small bowel obstruction. A review of 2005 patients by O'Connor et al. found that the laparoscopic completion rate was 57 % (480/840) for studies between 1994 and 2001 which increased to 68 % (793/1,165) for studies published after 2001, suggesting better patient selection and improved instruments and skills [65]. Some recent studies have reported a higher success rate of around 75–90 % [66–68], but the number of patients were small (Table 4). Various factors which favour the success for laparoscopic approach are isolated bands [66, 69], early surgery [70], computed tomography findings of transition point above pelvis [67], midline incision above umbilicus [67] or non-median previous laparotomy [88] and experience of surgeon [88]. The distension of small bowel loop more than 4 cm which was an absolute contraindication previously [63, 68] is now considered a relative contraindication [64, 71]. Other relative contraindications are the number of previous laparotomies and adhesions [64]. It has been proposed that rather than contraindications, these should be considered as predictors of success, and exploratory laparoscopy may be attempted in these cases with low threshold for conversion [63]. The major factors resulting in conversion were dense adhesions [66, 72], bowel injury [72] and bowel ischaemia [71, 73].

Table 4 Laparoscopy in small bowel obstruction

Study	Number of patients	Successful laparoscopy (%)	Conversion (%)	Operating time (laparoscopy)	Operating time (open)	Morbidity (%)	Mortality (%)
Jhonson et al. [74]	63	60	40	96	—	—	0
O'Connor et al. [65]	2005	64	29	—	—	14.8	1.5
Simmons et al. [71]	26	36	64	32	—	—	0
Tierris et al. [68]	32	81	19	78	—	1	0
Qureshi et al. [66]	23	78	22	89	—	—	—
Grafen et al. [72]	93	71	26	74	113	0	3
Ghosheh et al. [73]	1,061	66.5	33.5	—	—	15.5	1.5
Khaikin et al. [61]	31	68	32	78	70	16	0
Lujan et al. [69]	61	67	33	59	—	6.6	0

The entry to the abdomen should be made via open technique away from the previous incision [63, 64]. Other means of entry like optical trocar and Veress needle have also been reported [64].

In conclusion, laparoscopic management of small bowel obstruction is a feasible alternative to open surgery with better short-term outcome. It should be attempted by experienced surgeon, and low threshold to conversion should always be maintained. The authors strongly recommend the use of open method to gain entry into the abdomen.

Conclusion

Laparoscopy is feasible and safe in selected luminal gastrointestinal emergencies. It has already been widely accepted in acute appendicitis and perforated peptic ulcer disease. Conditions like colorectal emergencies and small bowel obstruction need further studies and well-accepted defining factors for successful laparoscopic management.

What is of utmost importance is the surgeon's experience, local expertise and proper case selection leading to a successful operative outcome. A conversion should not be considered as a failure but a sound peri-operative judgment.

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