Case Analysis

Laparoscopic Primary Repair of Iatrogenic Colon Perforation

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Purpose. Iatrogenic colon perforation is a rare but serious complication of colonoscopy. Surgical intervention is frequently performed using traditional exploratory laparotomy for repair or colectomy; however, the laparoscopic approach may be an alternative option. We report our experience with laparoscopic suture repair and evaluate its effects compared with open surgery.

Methods. We retrospectively analyzed data for eighteen patients who underwent surgical repair after colonoscopy-induced iatrogenic colon perforation between December 2003 and November 2008. Fourteen patients received traditional exploratory laparotomies with primary repair or colectomy. Four patients underwent diagnostic laparoscopy and direct laparoscopic suture repair. The estimated perforation duration, operative time, and length of hospitalization were compared.

Results. In the open surgery group, four patients underwent primary repair of the defect, one of whom added loop T-colostomy for fecal diversion. The others received colectomies, and fecal diversion with loop ileostomy was performed in two. In the laparoscopic group, four patients underwent laparoscopic primary intra-corporeal suture repair. Blood loss was statistically less significant during the laparoscopic approach and the operative times were not different. Although a higher wound infection rate along with more prolonged post-operative ileus and longer hospital stays were noted in the open method, the difference was not statistically significant due to the limited number of cases.

Conclusion. An initial laparoscopic approach for diagnosis of iatrogenic perforations followed by laparoscopic colorraphy of the colon seems safe and efficacious when compared to open surgery. It is reasonable to consider laparoscopic repair of iatrogenic colon perforation as an alternative option.

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W hether in the hands of a medical gastroenterologist or a colorectal surgeon, iatrogenic perforation of the colon is a rare but major complication[1-4] that introduces a risk of litigation against the endoscopists. Bleeding can almost always be treated non-operatively, but not the perforation itself. Although there are published reports that support conservative management in clinically stable individuals, surgical intervention is generally recommended to reduce morbidity and mortality.[5,6]

Compared to the traditional open method, there have been very few studies conducted that describe the application of the laparoscopic approach for repair of iatrogenic perforation of the colon.[7-13] In contrast,

the use of laparoscopic techniques in repair of emergent perforated peptic ulcers has been discussed at the level of evidence-based-medicine.[14] The use of laparoscopic techniques in colon surgery has been validated for both benign and malignant diseases of the colon. This suggests that the laparoscopic approach may be a promising option in select cases of iatrogenic perforation of the colon. In this report, we retrospectively review our data and discuss our experiences in this field.

Materials and Methods

We retrospectively analyzed our data from December 2003 to November 2008. During this period, eighteen patients, whose colonoscopies had been performed in our institution or other hospitals, underwent surgical repair after colonoscopy-induced iatrogenic colon perforation. Fourteen of these patients received traditional exploratory laparotomies with further treatment. Four patients underwent diagnostic laparoscopy and received direct laparoscopic suture repairs.

Between these two groups, the estimated time from colonoscopy to surgery, operative time, estimated blood loss, length of time until return of bowel function, and length of hospitalization were compared using the Mann-Whitney test. The complication rates were compared using Fisher's exact test. Probabilities less than 0.05 were considered significant. The SPSS® 13 program for Microsoft® Windows was used for statistical calculations.

Results

The fourteen patients who underwent open surgery were treated with a standard exploratory laparotomy, and the extent of the injury was assessed. Four patients underwent primary repair of the defect, and one of them had a loop T-colostomy added on for fecal diversion. The others received colectomies, and fecal diversion with loop ileostomy was performed in two of them.

The four patients in the laparoscopic group underwent diagnostic laparoscopy; and, once the area of injury was identified, primary intra-corporeal suture repair was possible in all four patients. The suture material was 3-0 Biosyn (Tyco Health Care, Norwalk, CT, U.S.A.) for the inner layer and 3-0 Sofsilk (Tyco Health Care, Norwalk, CT, U.S.A.) for the bowel outer serosa layer, interrupted.

The patients' characteristics are listed in Table 1. There were no statistically significant differences in age, sex, underlying disease, features of the perforation, pre- operative serum leukocytosis, and physical status as evaluated by the American Society of Anesthesiologists (ASA) score.

Table 1. Patient characteristics

	Laparoscopic approach	Open method
Patients (number)	4	14
Age(y) mean (range)	69.3 (55-76)	64.5 (55-76)
Sex(female: male)	2:2	7:7
Underlying disease		
Abdominal surgery Hx	0	1
Cancer Hx	0	1
Diabetes	0	2
Liver cirrhosis	1	1
Hypertension	3	4
Ischemic heart disease	1	2
Cerebral vascular disease	0	1
Pulmonary TB/asthma	1	1
Perforation		
Probable mechanism	2 mechanical 2 polypectomy	1 coagulation 5 mechanical 8 polypectomy
Perforation site	1 Ascending colon 2 Sigmoid 1 RS junction	2 Cecum 1 Ascending colon 1 Hepatic flexure colon 1 Transverse colon 1 Descending colon 3 DS junction 3 Sigmoid 1 RS junction
Size (cm)	0.5-1.5	0.5-10
Duration, perforation to OP (hrs) mean (range)	15.3 (6.5-32)	25.4 (1.3-74)
[c] Serum Leukocytes (/mm^3)	9500 (3600-15000)	12000 (5800-28700)
Neutrophils (%)	72 (69-88)	80 (56-97)
ASA score	3-4	1-4

ASA: American Society of Anesthesiologists physical status
Non factors are statistic significant.

The details and results of the surgeries are listed in Table 2. There was no statistically significant difference in surgical time, but laparoscopy did cause significantly less blood loss. With respect to complications, there were six wound infections in the open group, and none in the laparoscopic group, although this difference did not reach statistical significance. Leakage, intra-abdominal abscess, and post-operative prolonged ileus also occurred in the open group and not in the laparoscopic group, although these differences were not significant.

The time required for the return of bowel function to flatus was not different between the two groups. The hospital stay appeared shorter in the laparoscopic group, but this difference did not reach statistical significance. There was one mortality case in the open group. A 57-year-old (y/o) man recovered rapidly from the iatrogenic colon perforation, but he expired 25 days later from hepatic failure with underlying Child class C cirrhosis.

Insight discussion of the different conditions was

listed below.

First, we observed those who accepted surgical intervention less than 24 hours to colonic perforation. Four are in the laparoscopic group, and eight in the open group. The patient characteristic (age, sex, underlying disease), pre-operative sepsis condition (serum leukocytosis, ASA score), operative status (intra-abdominal contamination status, operation time), post-operative complications, and results (hospital stay, mortality, return bowel movement) were not statistically significant (data not show). Furthermore, blood loss was significant ($P = 0.046$). Also there were no leakage cases when early surgical intervention was less than 24 hours.

Second, we removed three cases who suffered from toxic sepsis signs before surgery, including respiratory failure, ASA score 4. Two were in the open group, and one in the laparoscopic group. The remaining fifteen patients did not revealed significant differences from patient characteristics, preoperative sepsis condition (pre-operative serum leukocyte (mean, /mm^3): 10400 vs 10675, $P = 0.885$), intra-abdominal contamination status (Hinchey 2/3/4 in lapascopy vs open = 2/2/0 vs 6/2/0), results and surgical complication (other data not show). Reviewing the medical charts revealed there was one leakage case in the open group. A 58 y/o female developed a case of sigmoid colon perforation after polypectomy. This patient also suffered from pre-existing congestive heart disease. The localized pelvic abscess (Hinchey class III) was noticed during the operation, and she was treated for partial colectomy with protective ileostomy. The fecal diversion with proper drainage finally prevented the surgical mortality.

Third, we limited the intra-abdominal status according to Hinchey classification II/III cases. There were sixteen cases after removing two cases in open group. There were no differences among all the factors between laparoscopy and open groups.

Fourth, we compared the simple closure technique cases only. There were four in each group. No results or complications appeared to be significantly different. The mean hospital stay was 9.5 days (range 6-17 days) in the laparoscopic group, and 17.25 days (range 8-29 days) in the open group ($P = 0.11$).

Table 2. Comparison of operations, complications, and results

	Laparoscopic approach (n = 4)	Open method (n = 14)
OP method	laparoscopic primary repair	4 repair/ 10 colectomy 2 ileostomy/ 1 T-colostomy
Intra-abdominal status (as Hinchey classifica-tion, case number as 1/2/3/4 grade)	0/2/2/0	0/7/5/2
OP time (min) mean (range)	122.5 (90-140)	138.6 (60-245)
Blood loss (mL) mean (range)	7.5 (5-10)	77.5 (5-400)*
Complications		
Wound infection	0	6
Bleeding	1	0
Intra-abdominal abscess	0	2
Leakage	0	1
Prolonged ileus	0	2
Results		
Hospital stay (days)	9.5 (6-17)	17.8 (6-33)
Bowel movement (post OP days)	3 (2-4)	2.7 (1-5)
Mortality	-	1[a]

[a] Patient recovered from perforation, but died later from liver cirrhosis with hepatic failure

* Significant when P-value < 0.05 (Mann-Whitney Test)

Discussion

The emergence of laparoscopy in the late 1980s marked a milestone in surgery. Its advantages included diminished pain, fewer surgical wound complications, reduced hospital stay, and lower global costs for treatment of uncomplicated cases of gallbladder disease and other intra-abdominal organs. Most of the early laparoscopic approaches were confined to elective surgery. However, with gains in technology and experience, the laparoscopic approach for acute intra-abdominal pathologies has been applied more widely. For the treatment of gastro-intestinal perforations, the first success was reported by Mouret et al in 1989 who performed laparoscopic repair of a perforated peptic ulcer using fibrin glue and an omental patch.[15] Since then on, laparoscopic repair of perforated peptic ulcers has gained acceptance by many surgeons; and several publications have discussed the management strategies, early results, benefits, and risk factors.[16] The European Association for Endoscopic Surgery (EAES) announced an evidence-based guideline statement on laparoscopy for abdominal emergencies in 2005,[14] and laparoscopic approaches to repair of iatrogenic perforation of colon have been attempted since 1997.[7-13,17-23]

In contrast, the advantages of colonoscopy are well known, and both patients and endoscopists have confidence in the benefits of this minimally invasive technique. However, although rare, iatrogenic perforation represents a nightmare scenario for both the patients and the endoscopists. The average incidence of perforation is 0.1% to 0.8% during diagnostic colonoscopy and 0.15% to 3% during therapeutic colonoscopy,[1,4] and mortality rates range from 0% to 0.65%.[2,9] As training, experience, and device design improved, the colonoscopy examination time shortened; and the rates of pneumatic pressure blow-out of the bowel wall decreased. Unfortunately, the potential for mechanical perforation during diagnostic colonoscopy or thermal perforation during therapeutic colonoscopy is still of concern. Mechanical perforations mostly occur because of excessive stretching by the shaft of the colonoscope, which happens primarily when the endoscopists tries to untie the loop.[24] In our experience, the loop formation during colonoscopy manipulation was usually concurrent with tension. When the endoscopists felt "tension sudden release" during untying the loop, there might be something out of the ordinary. Clinical physicians should be aware. Another frequent cause of perforation is thermal injury occurring during hot biopsy or polypectomy. This accident causes a smaller injury with less contamination than a tear resulting from diagnostic colonoscopy.[3]

Perforation is of particular surgical interest because the treatment decision is usually at the discretion of the surgeon. Successful conservative treatment has been reported,[2,25] and advised that the outcome of conservative treatment depends on two factors: 1. whether the patient has undergone a bowel preparation before colonoscopy; 2. whether the omentum provides peritoneal macrophages and adheres firmly to the inflamed area.[4] In the meanwhile, the timing of surgery is still controversial. Some authors recommend conservative treatment for patients with mild or localized symptoms and signs diagnosed within 4-8 h of injury.[2] Other authors argue that perforations during diagnostic colonoscopy are generally large and should be surgically repaired.[3] Still others recommend a selective approach depending upon repeated reassessment of the patient according to guidelines similar to those for diverticulitis or acute abdomen.[4] We agreed with the opinion of Putcha et al.[4] The well bowel prepare and polypectomy cases may have more chances of small perforation with self healing and less intra-abdominal contamination. It is reasonable and acceptable in clinical practice which we also had few experiences in our institute. For instance, one patient was a 40 y/o male admitted the next day after colonoscopic polypectomy over sigmoid colon in December, 2007. The abdominal CT reported "perforation of colon wall with minimal stranding and air bubbles in mesocolon". The conservative treatment with empiric antibiotics (ampicillin/sulbactam and metronidazole) subdued the symptoms, and the patient was discharged successfully four days later. The other similar cases were lacking in visual image evidence and were not discussed here. However, in this study, two of the mechanical perforations and three of the thermal perforations had failed in conservative treatment. Surgical intervention was arranged due to persisting high

fevers or worsening abdominal pain during one day. Though we agreed to conservation treatment at first, the early surgical intervention should be arranged if the sepsis condition worsens during these 24 hours observation time.

In addition, it is important to state that educating the patient is very essential. Straightforward counseling with the patient and family about perforation symptoms and signs should be done routinely. We experienced difficulties with a 68 y/o male who constantly disregarded our patient/care instructions. The patient did not report his persistent abdominal pain for three days.

If the decision is made to perform surgical intervention, the criteria for selection of patients who will derive optimal benefit from laparoscopic treatment are still unknown. Therefore, we have reviewed the literature on laparoscopic treatment of perforated peptic ulcers, for which both retrospective and prospective studies report similar findings. Other than the Boey score,[26] seven factors have been emphasized, including shock on admission; delayed presentation of more than 24 hours; underlying severe medical illness; age greater than 70 years; ASA scores of III to IV; Acute Physiology, Age, and Chronic Health Evaluation (APACHE II) score equal to 5;[7] and the surgeon's expertise in laparoscopic surgery. There were two ASA III patients in our laparoscopic series. One was a 55 y/o male showed signs of respiratory failure, needed Endo intubation before surgery, and recovered without complications. The other, a 71 y/o male, had an ischemic heart disease history. Though early operation was archived (6.5 hours from colonic perforation to surgery), port-site bleeding and long term bowel function returned to prolong his hospitalization. He was discharged after 17 days without other morbidity. Hence, we did not agree with ASA score as it indicated and adopted other index.

The perforation site should be easily identified by laparoscopy because the diagnosis of mechanical or thermal injury perforation is clear before surgery. Owing to the limited number of cases reported, a uniform surgical method is still not standardized, although Wullstein et al. attempted to introduce a surgical decision method.[9] The majority of the studies in literature report used sutures, linear stapling, or segmental re-section (Table 3). Because thermal perforations induced during polypectomy are usually small in caliber, they are readily approached via simple colorraphy if addressed early. In opposite, perforations induced by undue pressure exerted by the endoscopists or from traction on adhesions can cause larger tears. These often require more extensive repairs, but are also amenable to laparoscopic approach.[11,13] Unlike in the repair of a perforated peptic ulcer, repair of a colon perforation using omentopexy alone are never advocated.

Irrigation of the peritoneal cavity is one of the most important parts of the surgery. In addition, the peritoneal cavity is usually drained. Fecal diversion does not appear in the literature, nor did in our study. Such a bias may be due to the selection of cases.

Due to the small number of cases reported, the benefits of laparoscopic surgery for repair of colon perforations could not be demonstrated as clearly as was done for laparoscopic repair of perforated peptic ulcers. Regardless, the five patients who received laparoscopic treatment experienced a return of their bowel movements on the second or third day, according to the report by Wullstein et al.[9] Another clinical trial done by Bieier et al. confirmed a shorter length of hospital stay (5.1 days for laparoscopic treatment versus 9.2 days for open surgery), a minimal incision length, and slightly longer operation time (104 minutes versus 98 minutes).[13]

In our study, advantages of the laparoscopic approach are not proved, except less blood loss. Unlike Bieier et al.,[13] we observed that the operative time was not different between two groups. Furthermore, our findings were not in accord with those of Wullstein et al.[9] concerning the more rapid return of bowel function, because the return of bowel function is strongly associated with intra-abdominal infection status. Though our data failed to prove the intra-abdominal fecal contamination as a single index for surgical morbidity or mortality, we did notice an interesting phenomenon– none of the sixteen patients, early enrolled into operations, suffered from leakage. Also, our research may be bias due to the limited cases studied, in fact there are not enough studies or publications to prove otherwise. No doubt, further studies need to be done.

Table 3. Minimally invasive repairs of iatrogenic colon perforation: literature review

Investigator	n	Injury location	Procedure	Result/Complications
Regan MC[20] (1994)	1	Pelvic colon	Serosal pursestring suture	Unremarkable recovery
Goh PM[19] (1994)	1	Upper sigmoid	Tangential transverse resection with laparoscopic linear stapler	Unremarkable recovery
Hayashi K[17] (1996)	1	Middle sigmoid	Tangential transverse resection with laparoscopic linear stapler/drainage	Unremarkable recovery
Mehdi A[22] (1996)	1	Sigmoid	Primary suture repair	Septic shock POD 2, requiring vasopressors, then uneventful recovery
Miyahara M[23] (1996)	1	Transverse colon	Primary suture repair	Unremarkable recovery
Allam M[18] (1997)	1	Rectosigmoid	Laparoscopically assisted/end colostomy	Unremarkable recovery/colostomy closure 4 weeks later
Ibrahim IM[7] (1997)	1	Sigmoid	Primary suture repair	Unremarkable recovery
Velez MA[8] (1997)	1	Distal sigmoid	Primary suture repair	Unremarkable recovery
Wullstein C[9] (1999)	7	Deep rectum (1) Sigmoid (2) Splenic flexure (1) Transverse colon (1) Cecum (2)	Primary suture repair (1) Ileocecal resection (1) Tangential transverse resection with laparoscopic linear stapler (3)	Unremarkable recovery Conversion to open procedure (2)
Agresta F[10] (2000)	2	Rectum (1) Sigmoid (1)	Irrigation/drainage (1) Single suture repair (2)	Unremarkable recovery
Yamamoto A[11] (2001)	5	Sigmoid (4) Cecum (1)	Tangential transverse resection with laparoscopic linear stapler	3 patients unremarkable recovery 1 Prolonged recovery due to Parkinson's disease 1 Prolonged recovery due to dissecting aortic aneurysm
Busic Z[12] (2007)	1	Sigmoid	Primary suture repair	Unremarkable recovery
Hansen AJ[21] (2007)	7	Sigmoid (5) Transverse colon (1) Cecum (1)	Primary suture repair (5) Stapled repair (1) Primary repair, then converted (1)	Unremarkable recovery
Bleier JI[13] (2008)	7	Not described	Primary suture repair	Compared to 11 open methods, significantly shorter hospital stay, fewer complications, and shorter incision length
This study (2009)	4	Ascending colon (1) Sigmoid (2) RS junction (1)	Primary suture repair	1 Umbilical port-site bleeding Compared to open methods (14), significantly less blood loss

Abbreviations: RS: rectosigmoid, DS: descending colon-sigmoid, POD: post-operative day
(Arabic numerals): patient number.

Over the last decade, the surgical treatment of colonoscopic perforations has evolved toward primary repair rather than bowel resection.[27] However, each case must be considered individually taking into account the patients' co-morbidities and clinical status, as well as the specific conditions during the colonoscopy that lead to the perforation.

Conclusion

An early laparoscopic approach to the repair of iatrogenic colon perforation had some benefits and achieved similar outcomes compared to an open surgical method. In those cases where it is feasible and the surgical skills exist, a laparoscopic colon repair may probably be an alternative method.

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leagues whose work was not cited due to space limitations or our oversight.

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<u>病例分析</u>

以腹腔鏡直接修補醫源性結腸穿孔

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目的　大腸鏡檢查或治療的一個罕見但嚴重的問題是醫源性結腸穿孔。傳統上剖腹探查以直接修補或切除部份大腸是不可避免的。但若早期發現，有趨勢傾向直接以腹腔鏡手術修補。我們在此報告自己的經驗。

方法　回朔 2003 年 12 月至 2008 年 11 月，共有 18 個醫源性結腸穿孔在本院接受手術治療。其中 14 個接受剖腹探查後行部份大腸切除或直接修補；另 4 個接受診斷性腹腔鏡後直接以腹腔鏡手術修補。我們比較兩種手術之優劣。

結果　在開腹手術的 14 個病人中，有 4 個病人接受直接修補，其中 1 人合併橫結腸造廔口。另 10 人接受部份大腸切除，其中 2 人合併小腸造廔口。相對而這，4 個接受腹腔鏡手術者，都直接以腹腔鏡手術修補。手術時間在兩組並無差異，流血量明顯在腹腔鏡手術組較少。開腹手術組的術後傷口感染率，術後腸阻塞率較高，住院天數較長；但未達統計差異。

結論　與傳統開腹手術，結腸穿孔用腹腔鏡手術修補結果近似。腹腔鏡手術治療因大腸鏡造作結腸穿孔是可以考慮的。

關鍵詞　腹腔鏡手術治療、結腸穿孔、大腸鏡。