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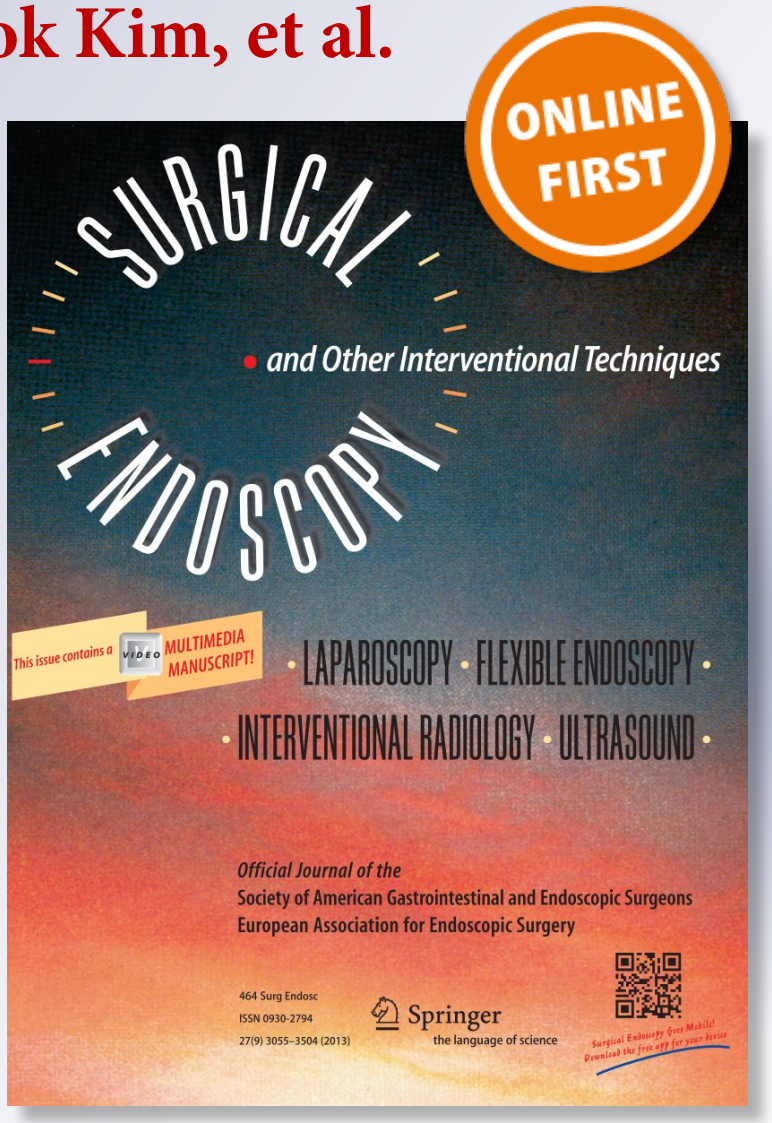

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NEW TECHNOLOGY

Endoscopic closure of iatrogenic colon perforation using dual-channel endoscope with an endoloop and clips: methods and feasibility data (with videos)

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Abstract

Background Colon perforation is the most serious complication associated with colonoscopic procedures. We performed a novel purse-string suture technique to close the iatrogenic colonic perforation using dual-channel endoscope with an endoloop and clips.

Methods Iatrogenic colon perforations developed during diagnostic colonoscopy referred to a tertiary hospital over 10 years were considered for this endoscopic closure. An endoloop was inserted through the left channel of the endoscope and placed around the defect. The first clip was placed at the proximal site of the defect through the other channel of the endoscope, and the endoloop was anchored on the mucosa around the defect. Then, subsequent clips were placed next to previous clips and the endoloop was fixed. After the defect was encircled by the endoloop and clips, the rim of the opening was approximated by fastening the endoloop with a purse-string technique.

Results A total of 8 patients were admitted to our hospital because of iatrogenic colon perforations during diagnostic colonoscopy. Of these, 2 underwent laparoscopic surgery and 6 underwent endoscopic closure by this novel purse-string suture technique. The estimated diameters of the perforations were 20 mm. All cases were successfully treated in the endoscopy unit without sedation or general anesthesia, and recovered without any complication or subsequent operation. Abdominal pain had nearly resolved within 3 days after the procedure in all patients, and only mild peritonitis was observed.

Conclusions Iatrogenic colon perforation can be treated with a purse-string suture technique using dual-channel endoscope with an endoloop and clips. This technique can be useful for relatively large colon perforations associated with diagnostic colonoscopy.

Keywords Colonoscopy · Perforation · Endoloop · Clip

Colonoscopy is often used to detect colorectal neoplasms or other diseases and remove colorectal polyps. Although colonoscopy is relatively safe, complications such as bleeding or perforation can occur. Colon perforation is the most serious complication associated with colonoscopic procedures. The incidence of iatrogenic colon perforation is 0.03–0.8% after diagnostic colonoscopy and 0.15–3% after therapeutic colonoscopy [1, 2]. Surgical treatment is required, especially when perforation occurs during diagnostic colonoscopy. However, endoscopic management has recently been suggested as a useful therapeutic option.

Hayashi was the first to introduce endoscopic clips [3]. Since Binmoeller et al. first used metallic clips to close a perforation after snare excision of a gastric leiomyoma [4], many different methods and clip devices have been

Ja Young Ryu and Byung Kwan Park have contributed equally to this work.

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introduced. Endoscopic clips have been used in treatment of bleeding ulcers, diverticular disease, and complications that develop during endoscopic procedures, such as post-polypectomy bleeding or colon perforation [5–7]. With advances in endoscopic techniques, the role of surgery for simple and uncomplicated colonic perforations has gradually decreased. However, most cases treated using endoclips were limited to small perforations, and large perforations remained difficult to treat [8].

This study presents 8 cases of iatrogenic colon perforation that developed during diagnostic colonoscopy. We performed a novel purse-string suture technique to close the perforations in 6 of the 8 patients using dual-channel endoscope with an endoloop and clips. We described the technique and reported the outcomes of treatment.

Patients and methods

Patients

A total of 8 patients were admitted to our hospital because of iatrogenic colon perforations that developed during diagnostic colonoscopy between 2006 and 2017. Of these, 2 underwent laparoscopic surgery and 6 underwent endoscopic closure using dual-channel endoscope with endoloops and clips. After endoscopic closure for the 6 patients, they were administered intravenous broad-spectrum antibiotics, fasted for several days, and were closely monitored for symptoms and signs of peritonitis. The study was approved by the institutional review board of the Chung-Ang University Hospital, Seoul, Korea.

Endoscopic procedures

Endoscopic closure for perforations was performed using dual-channel endoscope (Olympus GIF-2T240, Olympus Optical Co., Tokyo, Japan) with an endoloop (Olympus HX-20U-1, Tokyo, Japan) and metal clips (Olympus HX-610-090L and HX-610-135L, Tokyo, Japan) by the purse-string technique. Five of the patients had abdominal hyperinflation due to the perforation in the sigmoid colon, and an 18-G angiocatheter (Interocan® Certo, 18-G 4251342) was inserted just above the umbilicus to remove intraperitoneal air before performing endoscopic closure and remained in place until the procedure was completed. The angiocatheter was connected to an intravenous line and the other end of the line was submerged in water in a bottle to verify air drainage. Dual-channel endoscope was advanced to the injury site. First, an endoloop was inserted through the left channel of the endoscope and placed around the defect. Then, the first clip was placed at the proximal site of the defect through the other channel of the endoscope, and the endoloop was anchored on the mucosa around the defect. Then, subsequent clips were placed next to previous clips through the same endoscope channel and the endoloop was fixed. After the defect was enclosed with the endoloop and clips, the rim of the opening was approximated by fastening the endoloop with a purse-string technique. Then, the endoloop was released and the endoscope was withdrawn. The technique is shown in Fig. 1a for patient #3, in Fig. 1b for patient #4, in Video 1 for patient #1, and in Video 2 for patient #2. A simple schematic of the purse-string technique is shown in Fig. 2.

Results

Endoscopic treatment using dual-channel endoscope with an endoloop and clips

Six patients (2 men, 4 women; mean age 70 years; range 66–76 years) underwent endoscopic closure for iatrogenic colon perforations. All 6 patients were treated in the endoscopy unit without sedation or general anesthesia. The bowel cleansing quality was good and endoscopic closure was performed within 4 h after iatrogenic perforation in all patients. The perforation sites were in the sigmoid colon in 5 patients and the rectum in 1. The estimated diameters of the perforations were 20 mm, and the procedure time was less than 40 min in all patients. Detailed information about the patients is shown in Table 1. Abdominal-pelvic CT was performed in all patients after perforation, and pneumoperitoneum and/or pneumoretroperitoneum were documented. Endoscopic closure was successful in all cases and they were recovered without any complication or subsequent operation. Abdominal pain had nearly resolved within 3 days after the procedure in all patients, and only mild peritonitis was observed. Four of the patients underwent follow-up abdominal-pelvic CT several days later, with no or mild peritonitis apparent. Initial and follow-up abdominal-pelvic CT findings are shown in Table 2. All patients sipped water in 24 h, and a diet was started 2 or 3 days later in 5 patients. One patient fasted for 4 days because of a pneumothorax concurrent with colon perforation. A chest tube was inserted after the endoscopic procedure and was removed 1 week later without sequelae. All patients were safely discharged from the hospital within 2 weeks, except one with pneumothorax who was discharged after 17 hospital days.

Cases underwent laparoscopic surgery

One of 2 patients who underwent laparoscopic surgery was an early case. This was a 50-year-old woman whose perforation site was the sigmoid colon. This was at a time when the current endoscopic method could not be applied and

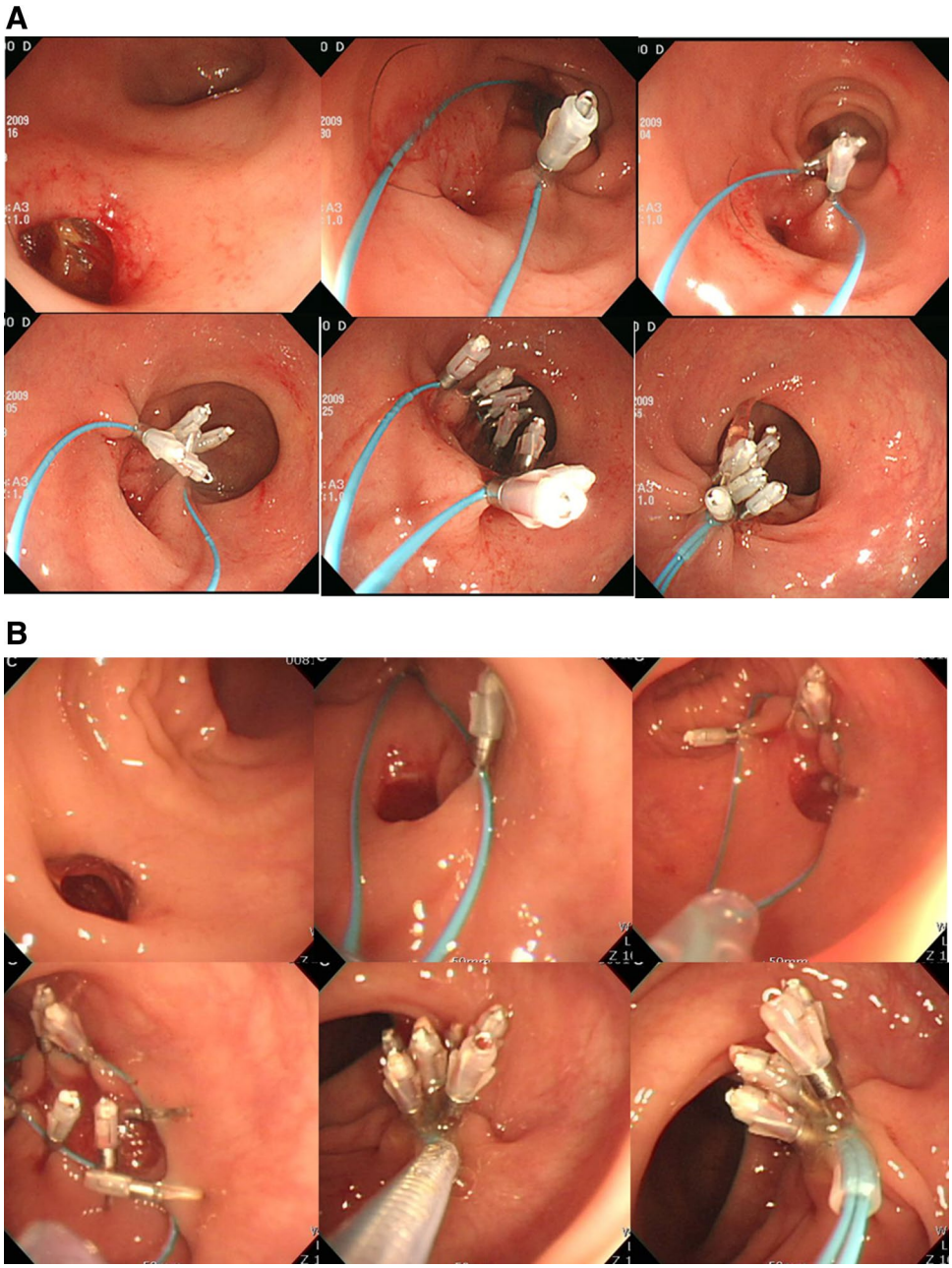

Fig. 1 Purse-string technique using dual-channel endoscope with an endoloop and clips in case #3 (**A**) and #4 (**B**). Iatrogenic colon perforation developed during diagnostic colonoscopy, and about 20 mm-mucosal defect was noted in the sigmoid colon. Endoscopic sealing with the purse-string technique was performed using an endoloop and clips to close the perforation

only endoscopic clipping was performed. However, the abdominal pain and tenderness did not improve after endoscopic clipping, and laparoscopic repair was performed 2 days later. The operative findings showed a 5-mm residual defect in the colonic wall. Another operative case was a 65-year-old woman with schizophrenia and severe chronic constipation. Prior to colonoscopy, 1.5 times the usual dosage of bowel cleansing solution was administered, but the bowel preparation was still insufficient. As the patient could not take any more cleansing solution, colonoscopy was performed with insufflation of excessive air. After insertion to the cecum, the colonoscope was retrieved and the examination was completed, but the patient had persistent abdominal pain and distension for 1 h. Simple chest and abdominal X-ray showed intraperitoneal free air. It was thought that fecal material had already leaked significantly into the abdominal cavity. Therefore, laparoscopic surgery was immediately performed without attempting endoscopic closure, and operative findings indicated fecal contamination, a wall defect, and severe adhesions in the sigmoid colon. Both of the above patients recovered well and were discharged after laparoscopic surgery.

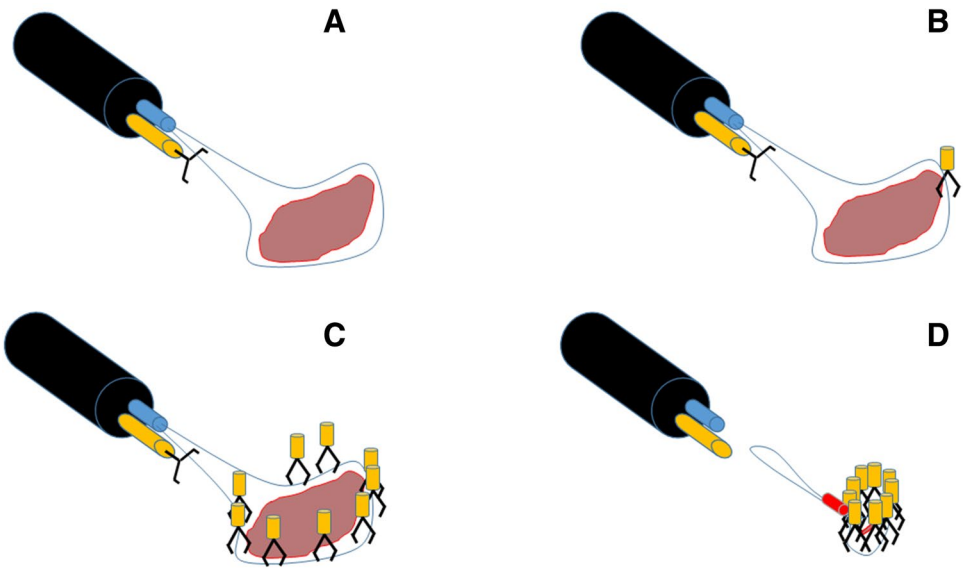

Fig. 2 Simple schematic of purse-string technique. First, an endoloop is placed at the perforation site. Then, the first clip is placed at the proximal site of the defect and anchors the endoloop on the mucosa around the perforated lesion. Next, subsequent clips fix the endoloop beside previous clips. After the defect is encircled by the endoloop and clips, the rim of the opening is approximated by fastening the endoloop with a purse-string technique

Discussion

Novel endoscopic techniques for diagnosis and treatment of gastrointestinal lesions have been developed, including esophagogastroduodenoscopy, colonoscopy, endoscopic submucosal dissection, peroral endoscopic myotomy, and natural orifice transluminal endoscopic surgery. However, diagnostic and therapeutic endoscopy can cause complications. Among these, iatrogenic colon perforation is a serious condition that demands immediate management. Perforation mechanisms vary and include direct mechanical penetration, pneumatic pressure, and colon pathology [9–11]. The most common site of colonic perforation is the sigmoid. The sigmoid colon is susceptible to perforations due to diverticula and angulation. When physical injury or over-insufflation occur, the sigmoid colon is likely to tear. Many risk factors have been suggested, including age, female sex, and comorbid diverticular disease, diabetes, chronic lung disease, and chronic renal disease [10, 12, 13].

Iatrogenic colon perforation can be managed with surgical or medical techniques. In the past, open or laparoscopic intervention was the treatment of choice. The European Society of Gastrointestinal Endoscopy advised that surgical management should be based on perforation size, perforation type, and endoscopic expertise [14]. Surgical management is essential in patients with severe peritonitis, fecal contamination, and gastrointestinal malignancies. Several reports recommended surgical management for perforation caused by diagnostic colonoscopy, with medical management for perforation caused by therapeutic colonoscopy [15]. This is because perforations associated with diagnostic colonoscopy are usually larger than those associated with therapeutic colonoscopy [9, 15]. Laparoscopic surgery has the advantage of proper intraperitoneal assessment and cleaning of any residual contamination. However, surgical treatment may be associated with higher morbidity, such as postoperative bowel adhesions, and can increase the cost and risk with the need for general anesthesia.

Recent advances in endoscopic technology have enabled treatment of colon perforations with endoscopy. A patient with no peritonitis signs and a small perforation can be managed with endoscopic closure, broad-spectrum antibiotics, and bowel rest. In a study comparing efficacy of techniques, the success rate of endoscopic closure was 81.3% (13 of 16 patients with diagnostic endoscopy-related perforations), similar to that of surgery in the study [1]. There was no statistical difference in fasting status, intravenous antibiotic usage, and hospitalization period between the endoscopic and surgical treatment groups; however, surgical treatment was associated with higher morbidity and mortality rates. In other studies, the success rate of medical treatment ranged from 60 to 100% for small perforations caused by therapeutic colonoscopy [15, 16]. In the current report, we successfully performed endoscopic treatment without general anesthesia or sedation in all 6 patients. Our patients were hospitalized somewhat longer than in other reports, but the main reason for the longer stay was their desire to recover more prior to discharge, as they were hospitalized for procedure-related complications. In fact, they were capable of leaving the hospital a few days earlier.

Transanal endoscopic microsurgery (TEM) is a safe, effective, and minimally invasive technique for the treatment of rectal neoplasms [17], and can be used for iatrogenic rectal perforation. However, TEM also requires general anesthesia and may cause anal sphincter impairment [18–20]. TEM seems to be more invasive than endoscopic treatment and may be better for relatively large perforations that cannot be managed endoscopically. Further investigation would be

needed to determine the role of TEM in primary closure of iatrogenic rectal perforations.

Several endoscopic methods have been used to manage relatively large colon perforations. Among these, the over-the-scope clip (OTSC) technique has lasting efficacy because it fixes more tissue, including the entire visceral wall. Because OTSCs can approximate large mucosal defects, this method has been used for gastrointestinal bleeding, perforation, anastomosis site leaks, and fistulas [21, 22]. Surgery was avoided in 4 of 7 patients with perforations or anastomosis site leaks with use of the OTSC procedure [22]. Another method of closing colon perforations used endoloops and clips. This was used for a large (> 3 cm), oval-shaped rectal perforation that developed during colonoscopy [23], with a slightly different purse-string technique. The endoloop was placed on the perforation site and 2 clips fixed the endoloop on the opposite margin of the defect. The endoloop was then fastened to approximate the defect margin. Finally, additional clips grasped the mucosa with endoloop. In animal studies, a technique similar to our purse-string method (King's closure) provided a reliable, long-term seal of a gastrointestinal perforation without causing stenosis or a fistula [24, 25]. The efficacy was comparable to that using the OTSC method. Band ligation has also been used to close iatrogenic colon perforations after failure of endoscopic clipping. A perforated lesion was sucked into the cap and an elastic band was fastened at the base using a ligator [26].

This report presented a novel purse-string method using dual-channel endoscopy with an endoloop and clips to close iatrogenic colon perforations developed during diagnostic colonoscopy. This treatment method may also be applied in obstetrics and gynecology cases, such as placenta percreta, although hysteroscopy and gastrointestinal endoscopy techniques are somewhat different. However, in the case of placenta percreta, the optimal treatment is removal of the uterus, since conservative management can be associated with hemorrhage and infection, and residual placental tissue can lead to trophoblastic cancer [27]. Thus, endoscopic closure of the uterine wall in patients with placenta percreta is not currently performed. In the future, endoscopic treatment of placental adhesions with appropriate medical treatment may be used for uterine preservation.

In our cases, endoscopic treatment using a novel purse-string method was successfully performed without complications or subsequent surgery for a colonic perforation. For endoscopic treatment to be successful, it is important to close the perforation site completely to prevent the bowel contents from escaping the lumen, but it is very difficult to seal the defect perfectly with clips alone. Our method using an endoloop and clips can perfectly close large defects, without the need for special clips such as OTSC. However, this method can only be performed successfully in cases with a well-cleaned bowel, within a few hours after perforation

Table 1 Details of 6 patients who underwent endoscopic closure with an endoloop and clips for iatrogenic colon perforations during diagnostic colonoscopy

Patient	Sex	Age (year)	Indication	Location	Size (mm)	Procedure-time (min)	Hospital day	Antibiotics	Duration of antibiotics	Angiocatheter insertion	Subsequent operation
1	F	66	Screening	SC	20	26	17	Ceftriaxone + metronidazole	17	Yes	No
2	F	76	Screening	SC	20	36	10	Ciprofloxacin + metronidazole	10	Yes	No
3	M	69	Screening	R	20	15	11	Ceftriaxone + metronidazole	10	No	No
4	F	71	Screening	SC	20	17	7	Ciprofloxacin + metronidazole	7	Yes	No
5	M	67	Screening	SC	20	23	11	Ciprofloxacin + metronidazole	11	Yes	No
6	F	73	Screening	SC	20	38	10	Ciprofloxacin + metronidazole	10	Yes	No

SC sigmoid colon, *R* rectum

Table 2 Findings of initial and follow-up (3–7 days later) abdominal-pelvic computed tomography scans for the patients

Patient	Initial APCT scan	Follow-up APCT scan
1	Moderate amount of pneumoperitoneum, no definite bowel wall thickening	Much decreased peritoneal free air, no fluid collection, minimal peritoneal thickening
2	Large amount of free peritoneal air, no ascites or peritoneal thickening	Decreased peritoneal free air, no ascites or peritoneal thickening
3	Large amount of pneumoperitoneum, pneumoretroperitoneum, pneumomediastinum and soft tissue emphysema, no ascites or peritoneal thickening	Not done
4	Moderate amount of pneumoperitoneum, no definite bowel wall thickening	Not done
5	Large amount of pneumoperitoneum, no ascites or peritoneal thickening	Decreased peritoneal free air, scanty amount of ascites, mild peritoneal thickening, small loculated air collection with wall enhancement adjacent hemoclips in sigmoid colon (probable sealed-off air leakage in perforation site)
6	Pneumoretroperitoneum and extended to pelvic cavity, suspicious wall defect in proximal sigmoid colon with wall thickening, no significant combined peritonitis	Much improved pneumoperitoneum, mild bowel wall thickening at the sigmoid colon, small complicated ascites in the pelvic cavity with localized peritonitis

APCT abdominal-pelvic computed tomography

before serious fecal contamination occurs, and requires an expert endoscopist. This technique can be useful for relatively large iatrogenic colon perforations caused by diagnostic colonoscopy.

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Compliance with ethical standards

Disclosures Ja Young Ryu, Byung Kwan Park, Won-Seok Kim, Kisung Kim, Jae Young Lee, Young Kim, Jae Yong Park, Beom Jin Kim, Jeong Wook Kim, and Chang Hwan Choi have no conflicts of interest or financial ties to disclose.

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