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Evolving Management of Colonoscopic Perforations

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Abstract
Background Perforations of the large bowel during diagnostic or therapeutic colonoscopy are a rare but significant complication. Their treatment has evolved over the last decade, but there are still no specific guidelines for their optimal management.
Materials and Methods Retrospective review of 105,786 consecutive colonoscopies performed in a 21-year period allowed assessment of the medical records in all patients treated at our institution for colonoscopic perforation.
Results Thirty-five patients suffered perforation (perforation rate 0.033%) during colonoscopy from January 1986 to October 2007 (14 men, 21 women; mean age 69.4 years). Twenty-four of the perforations occurred during diagnostic colonoscopy, whereas 11 during therapeutic colonoscopy. Twenty-three (66%) of the patients underwent operative treatment and 12 (34%) were managed nonoperatively. The average length of stay was 15.2 days, and there was one death (2.9% 30-day mortality rate) among the patients.
Conclusions Perforations from diagnostic colonoscopy usually are large enough to warrant surgical management, whereas perforations from therapeutic colonoscopy usually are small, leading to successful nonoperative treatment. Over the last decade, the surgical treatment of colonoscopic perforations has evolved, as there has been a trend that favors primary repair versus bowel resection with successful outcome. Careful observation and clinical care adherent to strict guidelines for patients treated nonoperatively is appropriate in order to minimize morbidity and mortality and identify early those who may benefit from operation. Each treatment, however, has to be individualized according to the patients' comorbidities and clinical status, as well as the specific conditions during the colonoscopy that lead to the perforation.

Keywords Colonoscopy · Colon perforation · Operative management · Nonoperative management

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Introduction

Since the introduction of flexible fiber-optic colonoscopy in 1969 at the Department of Surgery at Beth Israel Medical Center in New York City by Drs. Wolff and Shinya,[1] there have been numerous reports on the safety, cost-effectiveness, and low morbidity and mortality rates of diagnostic and therapeutic colonoscopy.[2] Perforation is a significant and well-recognized, although rare, complication of fiber-optic colonoscopy. Its frequency is estimated to be between 0.01% and 0.6% in the various published series.[3–6]

However, the management of colonoscopic perforations remains controversial, since there are no specific guidelines, and has evolved during the last decade. Most authors emphasize the need for operative treatment of these patients, but, more recently, there have been reports of suc-

Table 1 Indications for Colonoscopy by Colonoscopy Type

Diagnostic	Therapeutic
Tumor	Polypectomy
Low GI bleeding	Laser application
Change in bowel habits	Colonic decompression, e.g., volvulus
Inflammatory bowel disease	Coagulation for bleeding
Abdominal pain	A–V malformation
Anemia	
Obstruction	
Diverticulosis	
Routine examination (screening)	

cessful nonoperative management in selected patients.[7–10] The purpose of this study is to determine the incidence of perforation after colonoscopy of our institution, the clinical presentation and diagnosis workup of these patients, the evolving optimal management, and, finally, the impact of the mechanism of injury in the selection of the ideal treatment modality.

Materials and Methods

After approval by the Institutional Review Board of our hospital, a retrospective review was carried out of colonoscopic perforations of the large bowel during a 21-year period, in an attempt to identify their incidence, optimal management, and clinical outcome. The electronic database of the endoscopic suite of our medical center was analyzed to identify the patients that had "perforation" or "abdominal pain" as an acute or late complication after or during the colonoscopy. Medical records of the patients that suffered a colonoscopic perforation were reviewed for the following data: patient demographics, past medical and surgical history, type and indication for colonoscopy, clinical presentation after the suspected perforation, diagnostic laboratory and radiological studies, time between colonoscopy and diagnosis and treatment, type of management, intraoperative findings, final pathology, length of hospital stay, clinical course, and final outcome. The general indications for colonoscopy are given in Table 1, based on the type of colonoscopy either as diagnostic or therapeutic.

Results

Demographics and Endoscopy

From January 1986 to October 2007, 105,786 colonoscopies were performed in the endoscopy suite of our institution that resulted in 35 perforations, meaning a perforation rate of 0.033%. The study group consisted of 14 (40%) men and 21 (60%) women, with a mean age of 69.4 years (range 43–88 years). All colonoscopies were performed or supervised by either attending gastroenterologists or attending general surgeons. Mild analgesia and anesthesia, administered by attending anesthesiologists in most of the cases, were used for all the patients in order to achieve their comfort.

Of the 105,786 colonoscopies performed in the 21-year period, 68,082 (64%) were diagnostic and 37,704 (36%) were therapeutic. Twenty-four out of the 35 perforations (69%) occurred during diagnostic colonoscopy (0.035% perforation rate), whereas 11 perforations (31%) occurred during therapeutic colonoscopy (0.029% perforation rate). The average age of patients with perforation from diagnostic procedures was 72.6 versus 65.9 years in the therapeutic procedure group. The indications for diagnostic and therapeutic colonoscopy of the 35 patients that suffered perforation are described in Tables 2 and 3.

Presentation and Diagnosis

After colonoscopy, 33 (94%) patients developed abdominal pain, which was the most consistent symptom. The most frequent occurring sign was tachycardia (19 patients or 54%), followed by guarding and rebound tenderness, abdominal distention, leukocytosis, fever, hypotension, whereas only two (6%) patients remained asymptomatic (Table 4).

Seven patients (20%) were diagnosed at the time of colonoscopy, whereas the majority of patients were diagnosed within 12 h (25 patients or 71%). Two patients (6%) were diagnosed after 12 h but before 24 h, and one patient (3%) had delayed diagnosis after 24 h (Table 5). All seven patients in whom the perforation was seen during the colonoscopic procedure were immediately taken to the operating room without any radiologic studies. For the rest of the patients in whom the perforation was not directly seen during the endoscopy but was suspected based on the signs and symptoms, either an upright chest or abdominal radiograph was obtained looking for free intraperitoneal air. In addition to plain films, stable patients with no peritoneal

Table 2 Indication and Number of Perforations for Diagnostic Colonoscopies

Indication for colonoscopy	Number of perforations (%)
Routine examination (surveillance)	10 (42)
Low GI bleeding	8 (34)
Change in bowel habits	2 (8)
Inflammatory bowel disease	2 (8)
Abdominal pain	1 (4)
Tumor	1 (4)
Total	24 (100)

Table 3 Indication and Number of Perforations for Therapeutic Colonoscopies

Indication for colonoscopy	Number of perforations (%)
Polypectomy	9 (82)
A–V malformation	2 (8)
Total	11 (100)

signs on physical examination would also undergo either a gastrografin enema or computed tomography (CT) of the abdomen and pelvis with rectal water-soluble contrast in order to try to identify the exact location and extent of the perforation or other pathology, like formation of abscess or intra-abdominal fluid.

Regarding the site of the perforation, the majority (18 out of 35 or 51%) were found at the sigmoid and rectosigmoid, followed by the descending and transverse colon (four out of 35 or 11%), the cecum (three out of 35 or 9%), and the ascending colon (two out of 35 or 6%), whereas in two cases no perforation was found during the operation and in one case the site was unknown (Fig. 1). The location of the perforation did not vary with therapeutic versus diagnostic colonoscopies, with the sigmoid–rectosigmoid region being the predominant site for both types of colonoscopy.

Treatment

Twenty-three or 66% of the 35 patients that suffered perforation underwent operative treatment (21 after diagnostic colonoscopy vs. one after therapeutic colonoscopy), whereas 12 or 34% of the patients were managed nonoperatively (three after diagnostic colonoscopy vs. ten after therapeutic colonoscopy). In total, 88% (21 out of 24) of the patients that suffered perforation after diagnostic colonoscopy underwent exploratory laparotomy and the 12% (three out of 24) were managed nonoperatively. On the other hand, 9% (one out of 11) of the patients that suffered perforation after therapeutic colonoscopy underwent exploratory laparotomy and the 91% (ten out of 11) were managed nonoperatively. Table 6 shows the patients who received Hartmann's procedure or other kind of bowel resection versus those who underwent primary repair of the bowel wall defect with or without protective ostomy.

Nonoperative treatment consisted of placing the patients in a monitored bed, keeping them nil per os for bowel rest, with a nasogastric tube for drainage of gastric contents, and on broad-spectrum intravenous antibiotics for coverage against the colonic flora. Serial abdominal exams were performed in order to monitor for development of peritoneal signs. This was the case with one patient who initially was treated nonoperatively but 8 h later developed signs of peritoneal irritation and therefore was taken for operation. If during the course of conservative management the patient's condition changed to the worse, either a CT scan or a gastrografin enema would be obtained to evaluate possible further intra-abdominal pathology and guide further treatment.

Table 4 Clinical Presentation and Frequency

Symptoms and signs	Number of patients (%)
Abdominal pain	33 (94)
Tachycardia	19 (54)
Guarding and/or rebound tenderness	14 (40)
Abdominal distention	12 (34)
Leukocytosis	7 (20)
Perforation seen during colonoscopy	7 (20)
Fever (>38°C)	5 (14)
Hypotension	2 (6)
Asymptomatic	2 (6)

Table 5 Time Interval Between Perforation and Diagnosis

Time between perforation and diagnosis	Number of patients (%)
During colonoscopy	7 (20)
<12 h	25 (71)
12–24 h	2 (6)
>24 h	1 (3)
Total	35 (100)

Length of Stay and Final Clinical Outcome

The average length of hospitalization for all patients was 15.2 days (range 3–42 days). The patients that suffered a

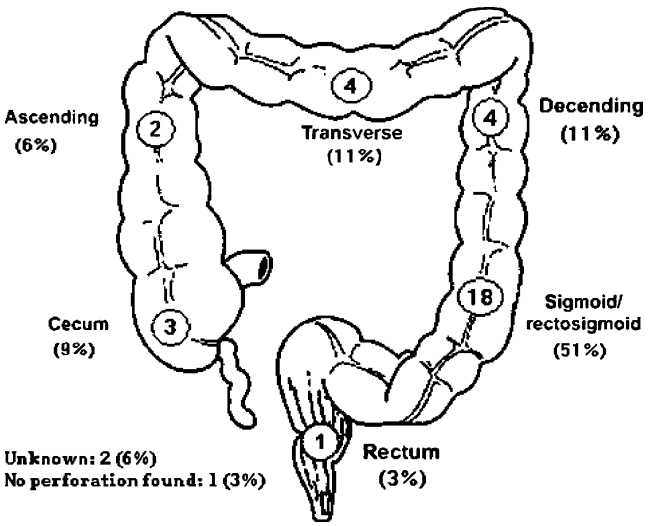

Figure 1 Site of perforation for all 35 cases.

Table 6 Type of Operative Treatment

Type of operation	Number of cases (%)
Hartmann's or other resection	15 (68)
Primary repair with or without protective ostomy	7 (32)
Total	22 (100)

perforation during diagnostic colonoscopy had an average length of stay of 17.1 days (range 4–42 days; 19.4 days in the operative group vs. 5.3 days in the nonoperative group), whereas the patients that suffered a perforation during therapeutic colonoscopy had an average length of stay of 6.1 days (range 3–12 days; 5 days in the operative group vs. 6.3 days in the nonoperative group; Table 7).

We had only one fatal outcome (one out of 35 patients, or 2.9% 30-day mortality; Table 8), which occurred in an 81-year-old male patient that underwent diagnostic colonoscopy for evaluation of low gastrointestinal bleeding. The patient had multiple comorbid conditions including severe coronary artery disease, aortic stenosis, and diabetes mellitus and expired in the surgical intensive care unit 2 days postoperatively due to extensive myocardial infarction.

Discussion

With technological advancements, colonoscopy has enjoyed a large number of broad diagnostic and therapeutic applications since its introduction at the Beth Israel Medical Center by Wolff and Shinya in June of 1969.[1] A main reason for the lack of guidelines for management of colonoscopic perforations is the presence of a large number of variables that need to be considered in order to make such guidelines practicable. Bowel preparation, diagnostic versus therapeutic colonoscopy, interventions performed, underlying disease process, clinical patient history, clinical status after the perforation, radiologic studies and laboratory data, and timing of recognition of the perforation are some of the variables that have to be taken into account when selecting the optimal treatment modality. The incidence of perforation in the high-volume centers is estimated between 0.01%

Table 7 Average Length of Stay Divided by Type of Colonoscopy

Type of treatment	Diagnostic colonoscopies, days	Therapeutic colonoscopies, days
Operative	19.4 (11–42)	5
Nonoperative	5.3 (4–7)	6.3 (3–12)
Average	17.1 (4–42)	6.1 (3–12)

Table 8 Final Clinical Outcome Divided by Type of Colonoscopy

	Type of treatment	Survived, *n* (%)	Died, *n* (%)	Total, *n* (%)
Diagnostic colonoscopies	Operative	20	1	21 (88)
	Nonoperative	3	0	3 (12)
	Total	23 (96)	1 (4)	24 (100)
Therapeutic colonoscopies	Operative	1	0	1 (82)
	Nonoperative	10	0	10 (8)
	Total	11 (100)	0 (0)	11 (100)

and 0.6% in the various reported case series.[3–6] The incidence of perforation from diagnostic colonoscopy ranges between 0.14% and 0.65%, while the same incidence from therapeutic colonoscopy ranges from 0.15% to 2.14%.[11,12] This wide variation in the incidence of perforation is best explained, most probably, by the expertise of the individual endoscopist and by how meticulously medical centers search for and report postcolonoscopy perforations.[2] Our overall perforation rate of 0.033% or one perforation per 3,030 colonoscopies is in accordance with the above range reported in the literature. The perforation rate in the current study regarding diagnostic and therapeutic colonoscopy was 0.035% and 0.029%, respectively, during a 21-year period with 105,786 consecutive procedures. However, it has to be mentioned that there may be patients with perforations who presented late in a different hospital and, thus, were missed in the follow-up and not included in the above rate calculations.

Various mechanisms may result in perforation of the large bowel during colonoscopy as illustrated in Fig. 2. Five main mechanisms have been identified. First, the perforation may result from direct mechanical penetration of the tip of the colonoscope in the bowel wall, especially when visualization is poor (Fig. 2a). Second, bowing of a loop of the scope may cause sufficient lateral pressure to perforate the colonic wall, making the perforation invisible from the tip of the instrument (Fig. 2b). Third, perforation may occur along a pathologic area of the colon, such as stricture, diverticulum, or tumor (Fig. 2c). Fourth, aggressive air insufflation may cause colon overdistention and rupture (Fig. 2d).[13] Fifth, perforation may occur during a snare polypectomy or with direct thermal injury to the bowel wall (Fig. 2e).

Because colonoscopic perforation is regarded as surgical emergency, most authors in the past believed that the appropriate treatment is operative, suggestive that possible failed conservative management will result in further intra-abdominal contamination and inflammation of the bowel wall, diminishing the chances for primary closure of the defect and increasing mortality.[2,14] However, the results of the present study show that management of such perforations should differ from traumatic injury of unprepped

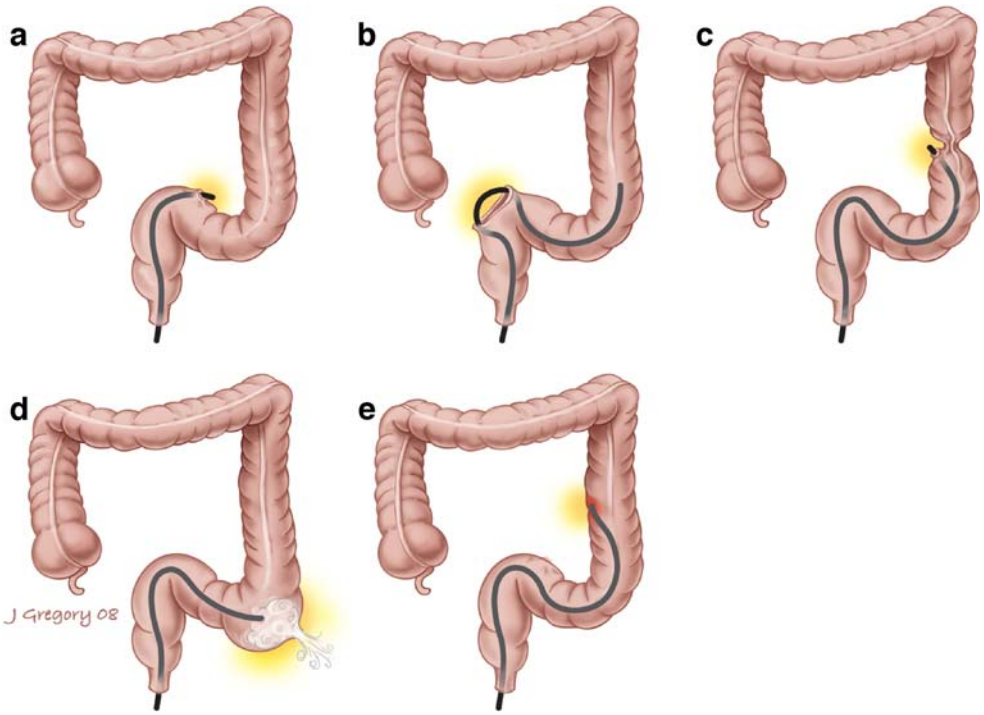

Figure 2 Mechanisms of perforation during colonoscopy. **a** Direct mechanical penetration of the tip of the colonoscope in the bowel wall. **b** Bowing of a loop of the scope may cause sufficient lateral pressure to perforate the colonic wall, making. **c** Perforation may occur along a pathologic area of the colon, such as stricture, diverticulum, or tumor. **d** Aggressive air insufflation may cause colon overdistention and rupture. **e** Perforation may occur during a snare polypectomy or with direct thermal injury to the bowel wall.

bowel, making the nonoperative approach in carefully selected patients a feasible approach with zero mortality. This is mainly first due to the fact that endoscopic perforations are routinely discovered early with prompt initiation of treatment and second due to the vigorous mechanical intestinal preparation before the colonoscopy which evacuates most of the fecal material and markedly decreases the intracolonic bacterial load.

As the current study shows, 88% of perforations during diagnostic colonoscopy required operative treatment. These perforations tend to be generally large enough in order not to seal by themselves. During the exploratory laparotomy, the abdominal cavity needs to be copiously irrigated and every attempt should be made to identify the exact site of the perforation, which in the majority of cases is the sigmoid colon. If there is no specific pathology and extensive wall inflammation at the site of the perforation, which is usually the case with patients that are diagnosed in the first 12 h after the colonoscopy, then a primary repair of the defect may be performed with or without creation of protective ostomy. If, however, the segment of the perforated bowel contains tumor, stricture, or a large injury with very inflamed wall, then colon resection should be the selected surgical option. Our data show that, over the last decade, surgeons at our institution have been favoring primary repair versus colon resection for the surgical treatment of colonoscopic perforations with excellent results (Fig. 3), a trend which has also been observed in trauma surgery.[15] We are also aware of successful methods of either laparoscopic or endoscopic repair in selected patients with colonoscopic perforations,[16] but none of our patients received such a treatment.

Ninety-one percent of the patients that suffered perforation during therapeutic colonoscopy were successfully treated nonoperatively. The main reason behind this is the fact that therapeutic endoscopic perforation is the result of an entirely different mechanism. During polypectomy, electrical current is applied to the base of the polyp. Prolonged application of this current may cause coagulation into the muscularis mucosa, resulting in a transmural burn and perforation. Also, if the pedicle of the polyp is long and the polyp touches the adjacent colonic wall, the transmitted current may cause the perforation in the wall opposite the

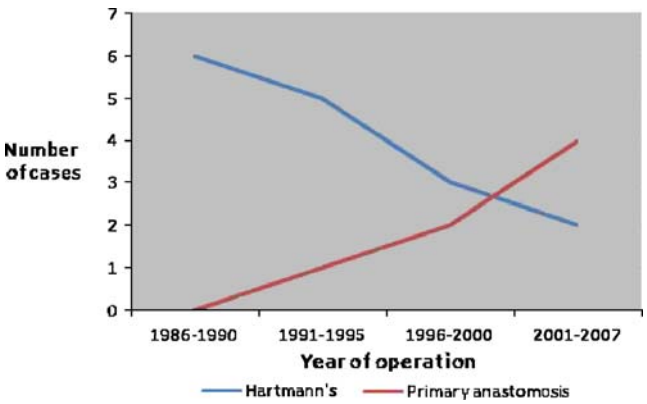

Figure 3 Change in surgical practice. Most colonoscopic perforations are treated with primary repair than with bowel resection over the last decade.

polyp.[2] In general, such perforations are quite small. The sudden opening in the distended colon will allow rapid egress of intracolonic air into the peritoneal cavity, resulting in pneumoperitoneum. Fortunately, these perforations seem to be rapidly sealed by the pericolonic fat or omentum leading to minimal contamination of the peritoneal cavity, warranting successful nonoperative management. The final outcome of such conservative management depends on careful clinical observation. However, clinical signs of peritonitis or deterioration of the patient should make the surgeon consider immediate operation since it indicates that the perforation has not sealed and there is ongoing contamination of the abdominal cavity with intracolonic material. Iqbal et al. agree that the presence of pneumoperitoneum alone is not an indication for operative management. In their study from the Mayo clinic, they reported on 72 patients with colonoscopic perforations, ten of which were treated nonoperatively, with low morbidity and length of stay. The authors also believe that timing of diagnosis is of great essence since patients diagnosed more than 24 h following colonoscopy have higher rate of fecal contamination.[17]

A management algorithm of colonoscopic perforations is suggested in Fig. 4, based on our experience. According to the illustration, if during the colonoscopy the scope is identified to have penetrated the bowel wall, the patient should be immediately taken to the operating room since the defect would be large enough (at least as wide as the diameter of the scope tip) to seal primarily. If, however, the perforation is suspected during or after the colonoscopy, based on the patient's symptoms, prompt physical exam will guide further actions. If the patient's vital signs are unstable or the physical exam reveals peritoneal signs, again, the best logical next step is operation. If the patient is stable with no signs of peritonitis, diagnostic radiologic workup should begin with an upright chest or abdominal film. Lack of free air in the X-ray warrants nonoperative treatment. The same conservative management should also be followed for the cases where the patient develops post-polypectomy syndrome, which can behave as frank perforation. On the other hand, presence of pneumoperitoneum should lead to further investigational studies, with either gastrografin enema or CT scan of the abdomen and pelvis with rectal water-soluble contrast. Studies that are negative for free fluid in the abdominal cavity, contrast extravasation, or clear perforation with extensive pericolonic inflammation warrant nonoperative management, whereas studies positive for the above findings should lead the surgeon towards operative treatment. Again, if during the course of conservative management the patient's clinical image worsens, consideration should be made for surgical treatment. The abovementioned algorithm, however, is only indicative and suggestive of the treatment that can be followed in a patient with colonoscopic perforation based on the clinical exam and radiologic findings. It has to be stated clearly that each case needs to be managed individually, taking into account the comorbidities of the patient and the exact interventions and mechanisms during the colonoscopy that lead to the perforation.

Conclusion

Perforation remains a serious complication of colonoscopy leading to significant morbidity if not diagnosed early. Perforations from diagnostic colonoscopy usually are large enough to warrant surgical management, whereas perforations from therapeutic colonoscopy usually are small,

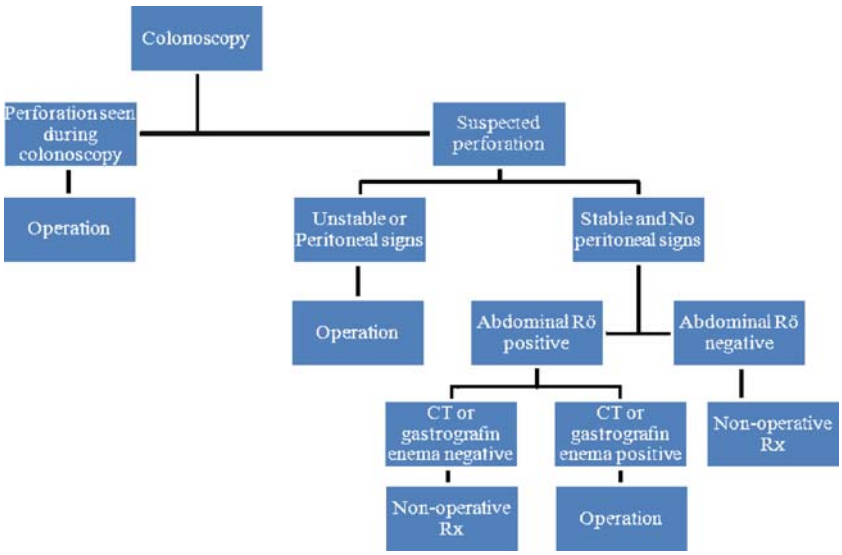

Figure 4 Suggested management algorithm for colonoscopic perforations.

leading to successful nonoperative treatment. Over the last decade, the surgical treatment of colonoscopic perforations has evolved, as there has been a trend that favors primary repair versus bowel resection with successful outcome. Careful observation and clinical care adherent to strict guidelines for patients treated nonoperatively is appropriate in order to minimize morbidity and mortality and identify early those who may benefit from operation.

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