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REVIEW ARTICLE

Management of colonoscopic perforation: a systematic review and treatment algorithm

Khalid N. Alsowaina[1,2] · Mooyad A. Ahmed[1,2] · Nawar A. Alkhamesi[1,2] · Ahmad I. Elnahas[1,2] · Jeffrey D. Hawel[1,2] · Nitin V. Khanna[3] · Christopher M. Schlachta[1,2]

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Abstract

Background The aim of this review is to evaluate and summarize the current strategies used in the management of colonoscopic perforations as well as propose a modern treatment algorithm.

Methods Articles published between January 2004 and January 2019 were screened. A total of 167 reports were identified in combined literature search, of which 61 articles were selected after exclusion of duplicate and unrelated articles. Only studies that reported on the management of endoscopic perforation in an adult population were retrieved for review. Case reports and case series of 8 patients or less were not considered. Ultimately, 19 articles were considered eligible for review.

Results A total of 744 cases of colonoscopic perforations were reported in 19 major articles. The cause of perforation was mentioned in 16 articles. Colonoscopic perforations were reported as a consequence of diagnostic colonoscopies in 222 cases and therapeutic colonoscopies in 248 cases. The site of perforation was mentioned in 486 cases. Sigmoid colon was the predominant site followed by the cecum. The management of colonoscopic perforations was reported in a total of 741 patients. Surgical intervention was employed in 75% of the patients, of these 15% were laparoscopic and 85% required laparotomy. The predominant surgical intervention was primary repair.

Conclusion Management strategies of colon perforations depend upon the etiology, size, severity, location, available expertise, and general health status. Usually, peritonitis, sepsis, or hemodynamic compromise requires immediate surgical management. Endoscopic techniques are under continuous evolution. Newer developments have offered high success rate with least amount of post-procedure complications. However, there is a need for further studies to compare the newer endoscopic techniques in terms of success rate, cost, complications, and the affected part of colon.

Keywords Management · Treatment · Colonoscopy · Colonoscopic perforation

Colonoscopy is a common procedure which is both diagnostic and therapeutic. It is an effective screening tool for colonic polyps, cancer, and precursor lesions. Colonoscopies are relatively safe, with only an 8 in 10,000 risk for serious complications—the most concerning of which is perforation of the colon [1–3]. Colonic perforations can also lead to severe bleeding, peritonitis, and sepsis. There is controversy surrounding the ideal management of colonoscopic perforations and there have been several advancements in the development of minimally invasive approaches. Such methods now include observation, endoscopic clipping, and laparoscopic repair before laparotomy [1–3]. The aim of this review is to systematically evaluate the recent literature, summarize the current strategies in place for the management of colonoscopic perforations, and propose a modern treatment algorithm.

This paper was presented at the 24th International Congress of the European Association for Endoscopic Surgery (EAES), in Amsterdam, The Netherlands June 16, 2016. This is original work that is not under consideration elsewhere. We thank you for your consideration and look forward to a favorable review.

✉ Khalid N. Alsowaina
khalid.alsowaina@gmail.com

Christopher M. Schlachta
Christopher.Schlachta@lhsc.on.ca

[1] Canadian Surgical Technologies & Advanced Robotics (CSTAR), 339 Windermere Road, P.O. Box 5339, London, ON N6A 5A5, Canada

[2] Department of Surgery, Western University, London, ON, Canada

[3] Department of Medicine, Western University, London, ON, Canada

Methods

This systematic review was conducted based on the recommendations of the Preferred Reporting Items for Systematic reviews and Meta-analyses (PRISMA) statement (Fig. 1). Two authors searched the following scientific databases independently: Medline (via PUBMED), Embase, and Cochrane Central Register of clinical trials (via clinical trial.org). The authors resolved discrepancies of opinion by debate, and if they failed to reach a consensus, a third-author was consulted. To increase the sensitivity of identifying all relevant articles, the following medical subject headings (MeSH) terms were used in combination with the Boolean operators (AND) and (OR): colon/colonoscopy perforation, iatrogenic perforation, intestinal perforation, treatment, therapy, management, laparoscopy/laparoscopic surgery, open surgery/laparotomy, non-operative/conservative, endoclips, "over-the-scope clips," hemoclips, and clips. In addition, the reference lists of the reviewed papers and other relevant review articles were manually searched to identify any relevant articles not identified in the electronic search. Articles published between January 2004 and January 2019 in English language were retrieved and reviewed. A total of 167 reports were identified in combined literature search, of which 61 articles were selected after exclusion of duplicate and unrelated articles. To decide if articles met the eligibility criteria for inclusion, studies were screened based on the titles, abstracts, and full-text in the case of doubt. Only studies that reported on the management of colonoscopic perforation in an adult population were retrieved for review. Case reports and case series of 8 patients or less were not considered. Based on the aforementioned selection criteria, a total of 19 articles were deemed eligible for review. Data extracted from each trial include article-specific data (authors, years, and study period), participant characteristics (number of

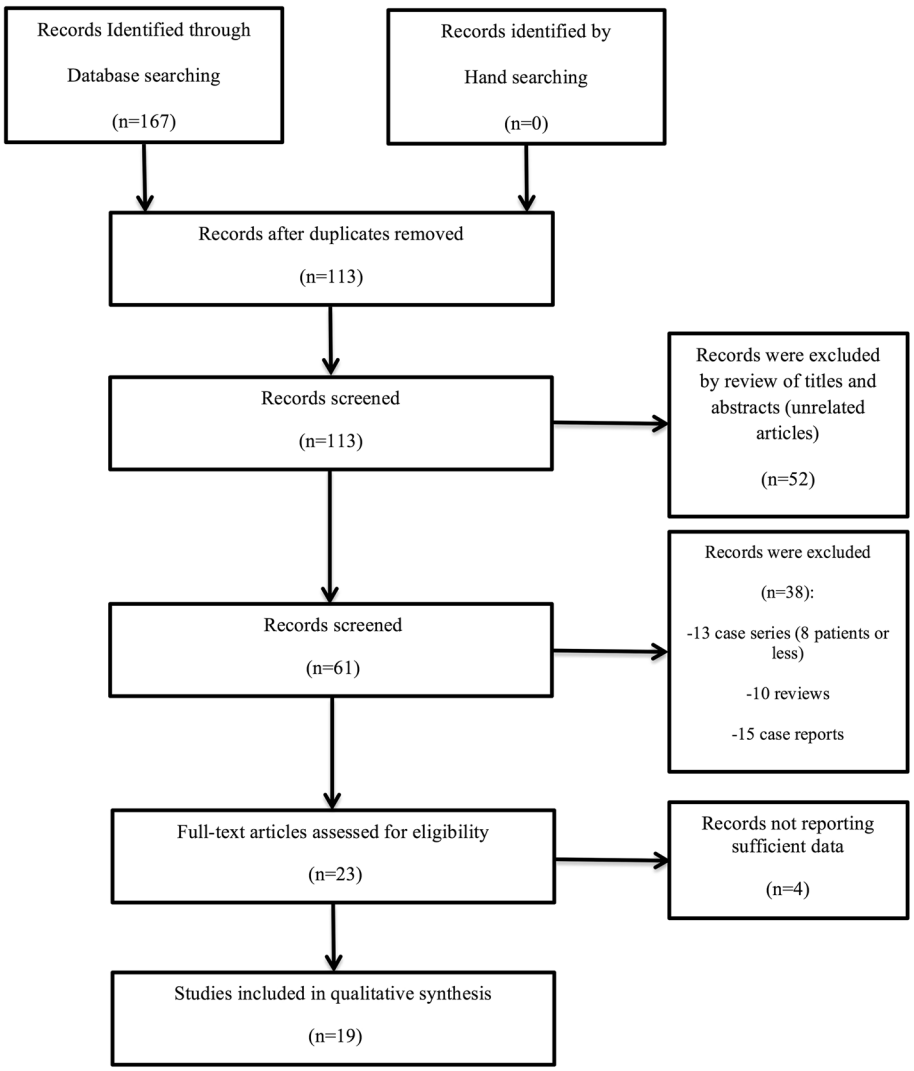

Fig. 1 Flowchart of the literature search and study selection process

colonoscopies, number of perforations, and time of recognition), and intervention (conservative, endoscopic clipping, and surgical). No Institutional Review Board (IRB) approval was required for this report.

Results

Our literature review revealed a total of 744 cases of colonoscopic perforations reported in 19 major articles (18 retrospective and one prospective), each with 9 or more patients. The cause of perforation was mentioned in 16 articles with a total number of 470 patients. Colonoscopic perforations were reported as a consequence of diagnostic colonoscopies in 222 (47.23%) cases and therapeutic colonoscopies in 248 (52.77%) cases (Table 1). The site of perforation was mentioned in 486 cases from 15 studies; sigmoid colon was the predominant site (310 cases, 63.8%), followed by cecum (49 cases, 10%), transverse colon (44 cases, 9%), rectum (34 cases, 7%), ascending colon (27 cases, 5.6%), descending colon (21 cases, 4.4%), and hepatic flexure (1 case, 0.2%) (Table 2).

Table 3 presents the management of colonoscopic perforations reported on a total of 744 patients. The management of three patients was not reported because they either refused surgical intervention or were lost to follow-up. Conservative management was employed in 71 cases (9.1%), endoscopic clipping in 114 cases (15.4%), and surgical intervention in 556 patients (75%). The laparoscopic approach was performed in 83 patients (15%), while a laparotomy was performed in 477 patients (85%). The predominant surgical intervention was primary repair of the perforation (200 cases, 43.8%), followed by resection and anastomosis (141 cases, 30.8%) and diversion (116 cases, 25.4%) (Table 4).

Discussion

Incidence and risk factors

Colonoscopic perforation occurs in 0.03% to 0.07% of patients undergoing diagnostic colonoscopy [4–13]. Perforation is more frequent (0.1% to 0.15%) after therapeutic intervention such as polypectomy, endoscopic submucosal dissection (ESD), and endoscopic mucosal resection (EMR)

Table 1 Study characteristics of the included trials

Author	Study period	No. of colonoscopies	No. of colonoscopic perforations	Diagnostic	Therapeutic	Recognition		
						Immediate	Early	Late
Adam (2007)	1987–2004	NR	11	7	4	NR	NR	NR
Corey (2008)	1980–2006	258,248	180	NR	NR	42	98	40
Jovanoic (2010)	2002–2008	8601	12	5	7	NR	NR	NR
Lohsiriwat (2008)	1999–2007	17,357	15	12	3	14	0	1
Back (2016)	2005–2014	NR	109	39	70	25	NR	NR
Bleier (2008)	2001–2005	NR	18	NR	NR	NR	NR	NR
Teoh (2009)	1989–2005	37,971	43	27	16	13	21	9
Yang (2009)	2001–2008	118,115	38	13	25	19	16	3
Swan (2011)	2006–2009	445[a]	10	NA	10	10	0	0
Iqbal (2005)	1994–2000	NR	72	NR	NR	NR	NR	NR
Copp (2004)	1997–2003	43,609	14	7	7	4	NR	NR
Samalavicius (2013)	2007–2011	56,882	40	28	12	22	13	5
Zhang (2013)	2005–2011	105,261	17	17	0	13	4	0
Comibra (2011)	1989–2008	NR	43	28	11	NR	NR	NR
Nicolas (2010)	1997–2008	14,173	20	11	9	12	5	3
Miranda (2010)	2002–2009	NR	9	7	2	5	4	0
Taku (2016)	NR	15160[a]	23	NA	23	16	7	0
Park (2016)	2003–2014	31,708	40	18	22	19	11	10
Magdeburg (2007)	2004–2006	7589	30	3	27	NR	NR	NR
Total		715,119	744 (0.10%)	222 (47.23%)	248 (52.77%)	214 (46.1%)	179 (38.6)	71 (15.3)

NR not reported, *NA* not applicable

[a]Reported only on therapeutic colonoscopies

Table 2 Site of colonoscopic perforations

Author	No.	Cecum	Ascending	Hepatic flexure	Transverse	Splenic flexure	Descending	Sigmoid	Rectum
Adam (2007)	11[a]	1	0	0	3	0	0	6	0
Corey (2008)	180[b]	40	15	0	15	0	8	87	0
Jovanoic (2010)	12	1	0	0	1	0	1	7	2
Lohsiriwat (2008)	15	0	1	0	2	0	0	12	0
Back (2016)	109[c]	NR	NR	NR	NR	NR	NR	49	10
Bleier (2008)	18	NR	NR	NR	NR	NR	NR	NR	NR
Teoh (2009)	43[d]	0	1	1	7	0	0	29	1
Yang (2009)	38	0	4	0	6	0	3	14	11
Swan (2011)	10	0	0	0	4	0	2	4	0
Iqbal (2005)	72	NR	NR	NR	NR	NR	NR	NR	NR
Copp (2004)	14	4	2	0	0	0	1	7	0
Samalavicius (2013)	40	3	2	0	4	0	2	29	0
Zhang (2013)	17	0	2	0	1	0	3	11	0
Comibra (2011)	43[c]	NR	NR	NR	NR	NR	NR	26	NR
Nicolas (2010)	20	NR	NR	NR	NR	NR	NR	NR	NR
Miranda (2010)	9	0	0	0	1	0	1	7	0
Taku (2016)	23[e]	NR	NR	NR	NR	NR	NR	NR	4
Park (2016)	40[c]	NR	NR	NR	NR	NR	NR	22	6
Magdeburg (2007)	30	NR	NR	NR	NR	NR	NR	NR	NR
Total	744	49 (10%)	27 (5.6%)	1 (0.2%)	44 (9%)	0	21 (4.4%)	310 (63.8%)	34 (7%)

[a]One perforation not found

[b]165 perforations detected (intraoperatively)

[c]Other sites are not specified

[d]One patient treated conservatively and three patients refused surgery

[e]Right side = 9 and left side = 10 colonoscopic perforations

[14–18]. Risk factors can be divided into patient factors (advanced age, female sex, small body mass index, medical comorbidities, or low albumin), disease-related factors (Crohn's disease, diverticular disease, or bowel obstruction), and procedure-related factors (biopsy or polypectomy) [4, 9, 13, 15, 19–23]. The predominant site of perforation is the rectosigmoid colon (53%) and the cecum (24%), followed by the ascending and transverse colon (9%) and the descending colon (5%) [4, 12] (Fig. 2).

Mechanism

Several mechanisms are involved in the incidence of colonoscopic perforation. The majority of such perforations develop as a result of blunt injury due to direct trauma with the endoscope, retroflexion injury, or application of torque. As such, the resultant perforation is located mostly in the rectosigmoid colon with a mean diameter of 2 cm [4, 24]. Smaller perforations (with a mean diameter of 1.4 cm) may take place in the right colon and cecum due to unintentional resection during polypectomy (ESD, EMR, snare resection, or electrocoagulation biopsy) [4, 24].

Diagnosis

Many studies have emphasized that prompt diagnosis is one of the most important prognostic factors after colonoscopic perforation. The severity of peritoneal contamination and further treatment depend on the size of perforation as well as the duration of contamination [12].

In general, perforations caused by diagnostic colonoscopy are often larger and noticed earlier than those caused by therapeutic colonoscopy [17, 25, 26]. Almost 30% of colonoscopic perforations are diagnosed at the time of colonoscopy. The remaining perforations usually present within 24–48 h after the procedure; however, some cases can present as late as 14 days [6, 11, 13].

Diagnosis at time of colonoscopy

Diagnosis can be confirmed by direct visualization of mesenteric vessels, fat, bowel loops, or other viscera through a tear in colon or rectum [27–29]. Sudden onset of pain, tension pneumoperitoneum, and difficulty in maintaining colonic insufflation may be a good indicator of immediate perforation [30, 31]. Thus, periodic assessment of the

Table 3 Reported management of colonoscopic perforations of the included trials

Author	No.	Management		
		Conservative	Endoscopic clipping	Surgical
Adam (2007)	11	0	0	11
Corey (2008)	180	15	0	165
Jovanoic (2010)	12	1	5	6
Lohsiriwat (2008)	15	0	0	15
Back (2016)	109	24	31	54
Bleier (2008)	18	0	0	18
Teoh (2009)	43	1	0	39[a]
Yang (2009)	38	7	22	9
Swan (2011)	10	0	10	0
Iqbal (2005)	72	10	0	62
Copp (2004)	14	0	1	13
Samalavicius (2013)	40	0	0	40
Zhang (2013)	17	0	0	17
Comibra (2011)	43	1	0	42
Nicolas (2010)	20	0	0	20
Miranda (2010)	9	0	0	9
Taku (2016)	23	8	9	6
Park (2016)	40	4	11	25
Magdeburg (2007)	30	0	25	5
Total	744	71 (9.6%)	114 (15.4%)	556 (75%)

[a]Three patients refused surgical intervention

abdomen during colonoscopy is important. With therapeutic intervention, routine submucosal injection of methylene blue or indigo carmine dye is helpful in determining the plane of resection and gives a clue if perforation occurs. A completely blue resection base indicates intact submucosa, while white base indicates deeper resection into the muscularis propria or fibrosis at the base of the polyp. A white center with a surrounding blue area known as the "target sign" may indicate a perforation (Fig. 3). Shiny serosa seen through the defect is a sign of a more subtle perforation [32].

Diagnosis after completion of colonoscopy

Delayed perforations secondary to therapeutic maneuvers are usually a result of thermal injury of the submucosa and can progress to full thickness over time. These small perforations are less likely to cause immediate peritoneal irritation and are usually associated with delayed diagnosis [15, 25, 26]. Clinical signs and symptoms are extremely variable. Most commonly, persistent abdominal pain that might be accompanied by peritoneal signs such as muscle guarding, tenderness, and rebound tenderness, and or/abdominal distention may be useful for making a diagnosis of perforation. Tachycardia, tachypnea, and fever should increase the suspicion of colonic perforation. Extra-colonic air may also dissect through the retroperitoneal tissue planes and present as subcutaneous emphysema in the scrotum, abdominal or chest wall, and the neck [30].

The diagnosis of perforation may require plain chest and abdomen radiographic studies and/or abdominal computed tomography (CT) scanning for definite identification. An abdominal radiograph demonstrating free intraperitoneal air is a very good indicator of perforation. If the plain radiograph does not indicate pneumoperitoneum but a high degree of suspicion exists, a CT scan may demonstrate retroperitoneal air [33].

Management

Historically, colonoscopic perforations have most commonly been treated by laparotomy or laparoscopy. With advancements in technology over the last decade, less invasive techniques have been developed and are currently in place, including the use of flexible endoscopy with clips or loops to handle the perforations [34] (Fig. 4). In highly selected patients (e.g., subdiaphragmatic free air without signs of peritoneal irritation), conservative management with antibiotics, bowel rest, and serial abdominal examination has been reported in many small series [25, 35–37]. Conservative management of select colonoscopic perforations is associated with shorter hospital stay and low mortality [35].

Management of colonic perforations depends on the etiology, severity, affected colonic location, and general health status of the individual case [38]. Patients without peritonitis or sepsis may be treated with broad-spectrum antibiotics and serial abdominal examinations every 3–6 h. Evidence of peritonitis, sepsis, or hemodynamic instability will require surgical intervention such as primary repair, resection and anastomosis, or alternatively, external fecal diversion [19].

Mortality and morbidity are higher among those who undergo surgical treatment for colonoscopic perforations, especially if complications develop. In addition, surgery requires anesthesia which may increase the cost and risk [39, 40]. In different studies, overall operative morbidity was reported to be 21–44% with a mortality rate of 7–25% [12, 19, 36, 41–44]. Adverse outcomes are associated with poor bowel preparation, delays in treatment or surgery, corticosteroid use, and advanced age [45–49]. Careful selection of candidate patients for surgical intervention and prompt response is crucial to minimize risk. It is also important to plan and prepare for cases where a perforation is high risk, such as those with a large sessile lesion, unremitting colitis, or an obstructing lesion [4].

One manageable way to reduce morbidity is to reduce surgical delay time. Delays in surgical treatment can lead

Table 4 Reported surgical management

Author	No.	Open	Laparoscopic	Primary repair	Resection and anastomosis	Diversion
Adam (2007)	11	0	11	NR	NR	NR
Corey (2008)	165	165	0	48	55	62
Jovanoic (2010)	6	6	0	NR	NR	NR
Lohsiriwat (2008)	15	15	0	4	4	7
Back (2016)	54	54	0	29	23	2
Bleier (2008)	18	7	11	18	0	0
Teoh (2009)	39	39	0	11	13	15
Yang (2009)	9	9	0	NR	NR	NR
Swan (2011)	0	0	0	0	0	0
Iqbal (2005)	62	62	0	NR	NR	NR
Copp (2004)	13	13	0	3	8	2
Samalavicius (2013)	40	39	1	25	4	10
Zhang (2013)	17	0	17	17	0	0
Comibra (2011)	42[a]	26	19	21	10	8
Nicolas (2010)	20	6	14	0	15	5
Miranda (2010)	9	0	9	6	1	2
Taku (2016)	6	6	0	NR	NR	NR
Park (2016)	25	25	0	16	7	2
Magdeburg (2007)	5[b]	5	1	2	2	1
Total	556	47 (85%)	83 (15%)	200 (43.8%)	142 (30.8%)	116 (25.4%)

[a]Three patients were converted from Laparoscopic to laparotomy

[b]One patient underwent diagnostic Laparoscopic exploration then open resection

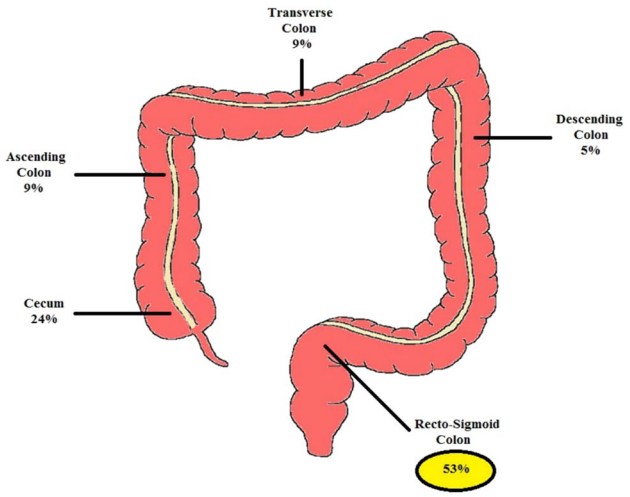

Fig. 2 Incidence of colonoscopic perforation in each part of colon

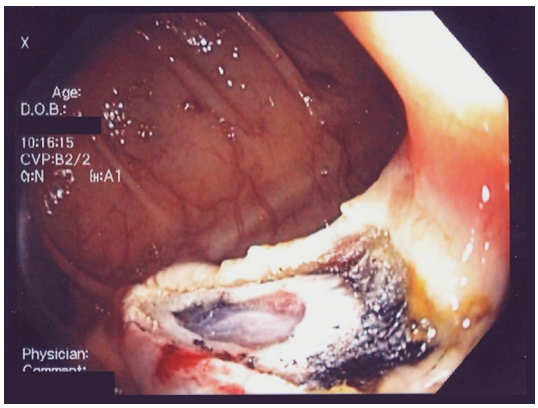

Fig. 3 Target sign

to peritonitis and inflammation, potentially requiring more invasive surgery. Late interventions in this population have been associated with poorer prognosis and mortality [1, 19, 36].

The use of minimally invasive surgery for the management of colonoscopic perforations has been increasingly adopted, and has shown to significantly lower morbidity compared to open surgery. The decision to approach cases laparoscopically depends on several factors, including surgeon experience and training, access to the area of perforation, and ability to secure the repair [1, 19, 50–55]. Compared to open surgery, laparoscopic management of colonoscopic perforations is associated with significantly smaller incision, shorter hospital stay, and lesser perioperative morbidity and complications [35, 56].

Endoscopic treatment is a valuable less invasive method for the management of iatrogenic colonic perforation,

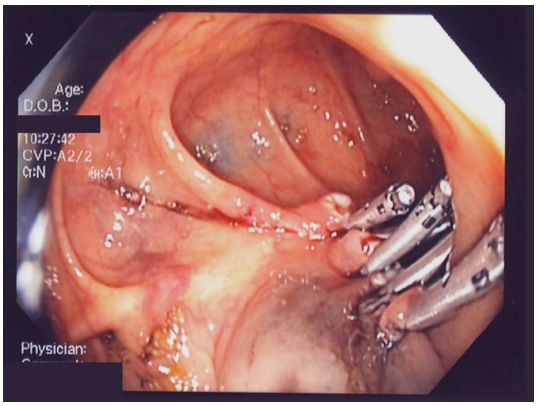

Fig. 4 Endoscopic clips

especially those which are recognized intra-procedurally or within four hours after the procedure [38]. Endoscopic closure can provide an adequate sealing and healing of the perforation and prevention of peritonitis while limiting peritoneal adhesions and avoiding invasive surgery [4, 26, 28, 57–68]. However, the decision to pursue endoscopic treatment depends on several factors such as size of perforation, endoscopist experience, and the availability of specialized instruments [38]. Although traditional clips can be used, their effect may be relatively superficial in the management of deep-layer perforations involving muscularis propria and serosa [35]. Alternatives to traditional clips include Over-The-Scope-Clip (OTSC) (OVESCO, Cary, North Carolina) for full-thickness closure. The OTSC device is mounted on the tip of the endoscope and passed to the area of treatment [35]. Once the tissue is trapped in the cap of the device, a 'bear claw' clip is deployed [69]. OTSC devices are currently recommended for larger perforations while rotating TriClips (COOK, Bloomington, Indiana) are used for smaller cases [34, 70]. The maximum size limit for lesions that can be successfully closed with OTSC usually ranges from 2 to 3 cm. Endoloops have been also utilized to close perforations by bringing the perforation edges together by applying clips and then placing the suction cap towards the lesion. Subsequently, an endoloop is released in the base of the injury following tissue suction [34, 69, 71]. Recently, a novel purse-string suture technique has been developed to close colonoscopic perforations. This technique uses dual-channel endoscope having endoloop and clips. It is useful to cover large colonic perforations with 100% success rate as it has been performed without complications [39].

Based on the findings of this literature review, immediate endoscopic closure is recommended for colonoscopic perforations smaller than 2 cm in order to avoid early complications [40]. It has been reported in the literature that immediate through-the-scope-clip (TTSC) and OTSC are highly effective with 92–100% success rate among those patients with iatrogenic perforations [67]. A study conducted by Yilmaz et al. recommended TTSC, OTSC, and surgery for gastrointestinal perforations of < 1 cm, 1–3 cm, and > 3 cm with sepsis, respectively [72]. Post-procedure monitoring is necessary to detect early complications, especially the presence of sepsis. The development of peritonitis should immediately result in surgical exploration to avoid further complications. Currently, OTSC as well as TriClips may be an effective alternative if deployed properly in select cases. Future trials are needed in order to compare the use of OTSC to other novel technologies used to treat colonoscopic perforations. A proposed algorithm for management of colonoscopic perforation is presented in Fig. 5.

In conclusion, colonoscopic perforations are rare but grave procedure-related complications. Management strategies of these colon perforations depend upon the etiology, size, severity, location, available expertise, and general health status. Usually, peritonitis, sepsis, or hemodynamic compromise requires immediate surgical management. Endoscopic closure is a valuable less invasive technique for the closure of some colonoscopic perforations. Endoscopic techniques are under continuous evolution. Newer developments like OTSC and purse-string suture have offered high success rate with least amount of post-procedure complications. However, there is a need for further studies to compare the newer endoscopic techniques in terms of success rate, cost, complications, and the affected part of colon.

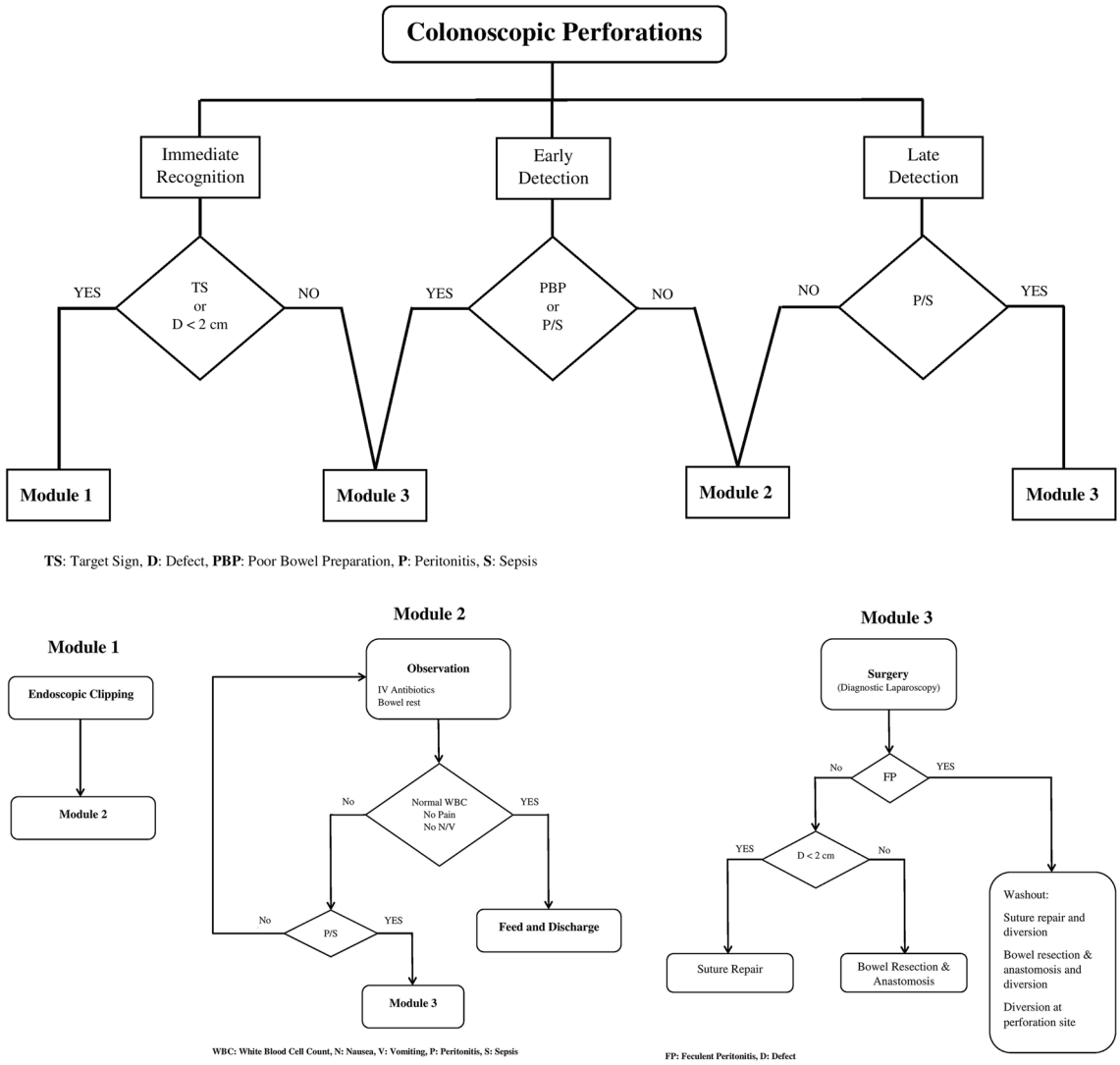

Fig. 5 Management algorithm of colonoscopic perforations

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Compliance with ethical standards

Disclosures Khalid N. Alsowaina, Mooyad A. Ahmed, Nawar A. Alkhamesi, Ahmad I. Elnahas, Jeffrey D. Hawel, Nitin V. Khanna, and Christopher M. Schlachta have no conflicts of interest or financial ties to disclose.

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