Patient Selection, Risks, and Long-Term Outcomes Associated with Colorectal Polyp Resection

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KEYWORDS

• Colonoscopy • Complications • Risk factors • Polypectomy • Perforation
• Postpolypectomy bleeding • Postpolypectomy syndrome

KEY POINTS

- Adverse events from endoscopic mucosal resection and polypectomy, although rare, include immediate and delayed bleeding, perforation, and postpolypectomy syndrome, which can compromise the success of the procedure if not recognized and managed appropriately in a timely manner.
- Intraprocedural bleeding can be managed effectively with a variety of endoscopic modalities depending on the type of lesion, completeness of resection, device availability, and operator preference, whereas delayed postpolypectomy bleeding can be managed conservatively in most cases.
- For perforations, mucosal clip placement is the primary endoscopic therapy, although newer devices, such as the over-the-scope clip and endoscopic suturing, have expanded the options.
- Perforation closures should be monitored carefully with a multidisciplinary approach, with prompt surgical intervention in the case of clinical deterioration.
- Colonoscopy and polypectomy are associated with a significant reduction in risk of colon cancer. However, recurrent polyps and interval cancer remain a concern and can usually be attributed to incomplete resection and missed lesions.

Video content accompanies this article at http://www.giendo.theclinics.com.

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INTRODUCTION

Colonoscopies are routinely used to screen for colorectal cancer (CRC), enabling the detection and resection of colorectal polyps and thereby reducing the incidence of and mortality from CRC.[1] However, colonoscopy alone or in association with polyp removal can cause a spectrum of complications, including bleeding, perforation, and postpolypectomy syndrome (PPS).[2] Although no technique for colonoscopic polyp removal is entirely devoid of adverse events, they are relatively rare and their risk is generally outweighed by the benefits. Here, we review the patient selection criteria; complications; including their risk factors and management; and long-term outcomes associated with colorectal polyp resection to improve the risk-benefit analysis by physicians and facilitate a comprehensive informed consent process for patients.

RISK ASSESSMENT FOR PATIENT SELECTION

The vast majority (>85%) of serious colonoscopy complications result from polypectomy.[3] However, gastrointestinal (GI) endoscopists will almost certainly have patients who experience some type of iatrogenic adverse event, which are virtually unavoidable complications of endoscopy. Therefore, the goal should be to minimize the associated risks. Although serious adverse events can result in substantial morbidity and mortality, even minor events strain the patient-physician relationship. The objective of this article is to provide the endoscopist with approaches to reduce the risk of iatrogenic complications and to manage those that will inevitably occur.

The endoscopist should always question whether the procedure is truly indicated, not only from their own perspective but also from that of the patient. The endoscopist should then prepare for the procedure according to the following:

1. Know the patient's history in addition to any underlying comorbidities and medications
2. Know the polyp-related factors, including size, location, history, and morphology
3. Understand the complications that may arise due to the polyp removal technique and the equipment involved

When antithrombotic therapy is required for a short period of time (ie, after venous thromboembolism or bare metal stent insertion), polypectomy should be delayed until such therapy is no longer indicated. Once this period has elapsed, the decision to proceed with the procedure should be made after discussing the associated risks and benefits with the patient and relevant medical professionals.[4] In addition, the ability to withstand complications in older patients is much reduced, and so perforation or bleeding postpolypectomy is more likely to result in a poor outcome.[5] Thus, polypectomy should be avoided for polyps less than 1 cm in patients aged 80 years or older because of the very low likelihood of progression to cancer within their life expectancy. Removal of polyps greater than 1 cm should only be considered after careful assessment of the patient's underlying comorbidities and overall functional status and after deliberation with the patient.[6]

The level of training and expertise of the practitioner greatly influence the risk involved in any procedure. Even the best-prepared endoscopists, however, should know their capabilities and their limitations. According to the American Society for Gastrointestinal Endoscopy (ASGE) Quality Committee, an endoscopist experienced in advanced polypectomy should be enlisted for the removal of suspected benign colorectal lesions that are considered more complex, for example, polypectomy of stalked polyps greater than 2 cm (level 3) and colonic endoscopic submucosal

resection (EMR) and endoscopic submucosal dissection (ESD) (level 4); level 2 competency, for example, removal of stalked polyps less than 2 cm, is recommended for independent basic practice.[7] The risk of adverse events increases with the complexity of the procedure. If the endoscopist does not feel confident in performing a procedure without incurring a serious adverse event, such as perforation or bleeding, an alternative clinically appropriate procedure should be considered or the patient should be referred to a more experienced endoscopist.[8]

The ASGE/American College of Gastroenterology Task Force on Quality in Endoscopy recommends that the postpolypectomy bleeding rate should be less than 1 of 100 procedures and the postcolonoscopy perforation rate for all examinations should be less than or equal to 1 of 500 colonoscopies; rates higher than these should initiate review by an endoscopy unit medical director or another expert to determine whether insertion or polypectomy practices are inappropriate.[9] Endoscopy units should strive for ongoing practice performance (quality) improvement. For example, endoscopists can present cases of adverse events at morbidity and mortality conferences and compare the rates in their unit with those reported across the country, such as with the GI Quality Improvement Consortium (GiQuIC), and/or enrolling in the ASGE Endoscopic Unit Recognition Program. By identifying trends associated with adverse events such as bleeding and perforation, the cause of a high adverse event rate can be more easily identified and addressed.

CONSENSUS-BASED DEFINITIONS

In 2010, the ASGE introduced standardized definitions for complications of endoscopy. An adverse event is defined as an event that prevents completion of the planned procedure and/or results in either admission to the hospital, a prolonged hospital stay, another procedure (needing sedation/anesthesia), or subsequent medical consultation. The complications can range from mild (requiring 3 or fewer nights' hospitalization) to severe (resulting in extended hospitalization, requiring surgical intervention, and resulting in permanent disability or even death).[10]

Bleeding is defined as a hemoglobin drop greater than 2 g/dL, although the requirement for blood transfusion has been proposed by others.[10,11] Perforation is determined by evidence of air or luminal contents outside the GI tract.[10]

ADVERSE EVENTS OF POLYPECTOMY

Although colonoscopy is generally considered safe, there are increased risks for several types of complications following polyp resection (**Box 1**), most of which are

Box 1
Complications of colonoscopy with polypectomy

- Hemorrhage
- Perforation
- Postpolypectomy syndrome
- Abdominal pain/discomfort
- Cardiopulmonary events/sedation related
- Rare: splenic hematoma or rupture, acute appendicitis, diverticulitis, incarcerated hernias, subcutaneous emphysema, intramural hematoma, ischemic colitis, chemical colitis, colonic explosion, infection, and death

largely self-limited or manageable with a conservative approach or endoscopy, although some can be life threatening and require surgery.[5] The complication rates reported by different studies are quite varied, likely as a result of different criteria, end points, and methods. In this section, we discuss some of the most common complications across all studies.

Hemorrhage

Hemorrhage is the most common adverse event of colonoscopy with polypectomy, with a reported average incidence rate of 9.8 of 1000 procedures for clinically significant bleeding compared with 2.4 of 1000 screening/surveillance colonoscopies.[12] Bleeding following endoscopic resection of polyps greater than or equal to 2 cm occurs in 6.5% of cases.[13] The rate of postcolonoscopy bleeding has declined from 6.4 of 1000 to 1.0 of 1000 colonoscopies from 2001 to 2015.[12] Most bleeding episodes are clinically trivial, whereas episodes requiring hospitalization, blood transfusion, repeat endoscopic intervention, or surgery are considered true complications.[10]

Risk factors

Several factors related to the polyp, the patient, and the resection technique can predict the risk of hemorrhage following polyp removal and are mentioned in **Box 2**.

Hemorrhage management

Bleeding can be immediate (intraprocedural bleeding or <24 hours) or delayed (postprocedural bleeding, generally occurring within 1–14 days, with presence of marked bloody stool after treatment or the requirement for hemostasis after treatment; caused by eschar slough, progressive tissue necrosis, and cautery-induced thermal spread).[11]

Immediate hemorrhage. Immediate polypectomy bleeding is generally not considered a true complication but can increase the complexity of the procedure by obscuring the visual field. Mild, transient oozing at the edge of an en bloc or piecemeal EMR generally does not require treatment, whereas ongoing active bleeding that interferes with completion of the procedure or oozing that persists by the end of the procedure requires immediate and aggressive endoscopic therapy, because intraprocedural bleeding is associated with clinically significant delayed bleeding after wide-field EMR.[27]

Delayed hemorrhage. Careful assessment of the patient and the severity of bleeding, based on clinical features such as hemodynamic instability, frequency of bloody bowel movements, comorbid conditions, patient age, resumption of antithrombotic agents, and so forth, is required for determining the best course of action in delayed postpolypectomy bleeding (**Fig. 1**).

More than half of all bleeding subsides spontaneously without any further intervention. Thus, in hemodynamically stable patients, expectant management is initially preferred and includes the following:

- Triage to the appropriate service (ward or intensive care unit) based on the severity of bleeding and patient comorbidities
- Fluid and blood transfusions as appropriate
- Withholding of anticoagulation and antiplatelet agents
- Correction of coagulopathy, if present
- If bleeding resolves spontaneously, the patients should be admitted to the hospital for observation and monitoring of hemoglobin, platelets, and coagulation profile for 24 hours before discharge.

Box 2
Risk factors for hemorrhage

Polyp-related factors

- Size greater than 1 cm[14–18]
- Location—right hemicolon,[18] cecum,[19] proximal to splenic flexure,[16] and rectum[20]
- Morphology—pedunculated with a thick stalk,[14] sessile,[21,22] and laterally spreading lesions[14]
- Histology—adenoma,[22] villous features,[23] and presence of adenocarcinoma[21,23]
- Multiple polyps (>4)[17]

Patient-related factor

- Age greater than 65 years[14]
- Male sex[17,20]
- Comorbidities—hypertension,[15] cardiac disease,[14,24] lung disease,[24] diabetes,[24] and renal disease[14]
- Medications—antiplatelet agents,[25] anticoagulants,[14,24,25] NSAIDs,[25] and steroids[25]

Technique-/device-related factors

- Hot-snare polypectomy in patients on warfarin[26]
- EMR,[27] ESD[19,25]—intraprocedural bleeding is associated with clinically significant delayed bleeding
- Pure cutting current—immediate bleeding[14]
- Electrosurgical current not controlled by a microprocessor[27]
- Blended current[a]—immediate bleeding[28]
- Suboptimal bowel preparation[14]
- Endoscopist less than 10 years since graduation,[17] less than 300 procedures performed[8,18]
- Procedure performed at ambulatory surgery centers[8]

NSAID, nonsteroidal anti-inflammatory drug

[a] A recent randomized controlled trial comparing blended and forced coagulation current for EMR found no significant difference in the occurrence of delayed bleeding.[28]

- If initial resuscitation measures fail, urgent intervention to achieve hemostasis should be attempted initially with colonoscopy, resorting to angiography for angioembolization or surgery if unsuccessful. Risk factors for ongoing bleeding or recurrence of bleeding requiring intervention include:
  - hematochezia hourly or every few minutes
  - hemodynamic instability
  - low hemoglobin on admission (<12 g/dL)
  - transfusion requirement
  - American Society of Anesthesiologists class II or higher

Endoscopic hemostasis techniques and devices It is important to visualize the field and identify the bleeding source. The transparent cap on the endoscope can be used to localize the bleeding vessel, and water pump irrigation can be used to identify the pinpoint source of bleeding (Fig. 2).

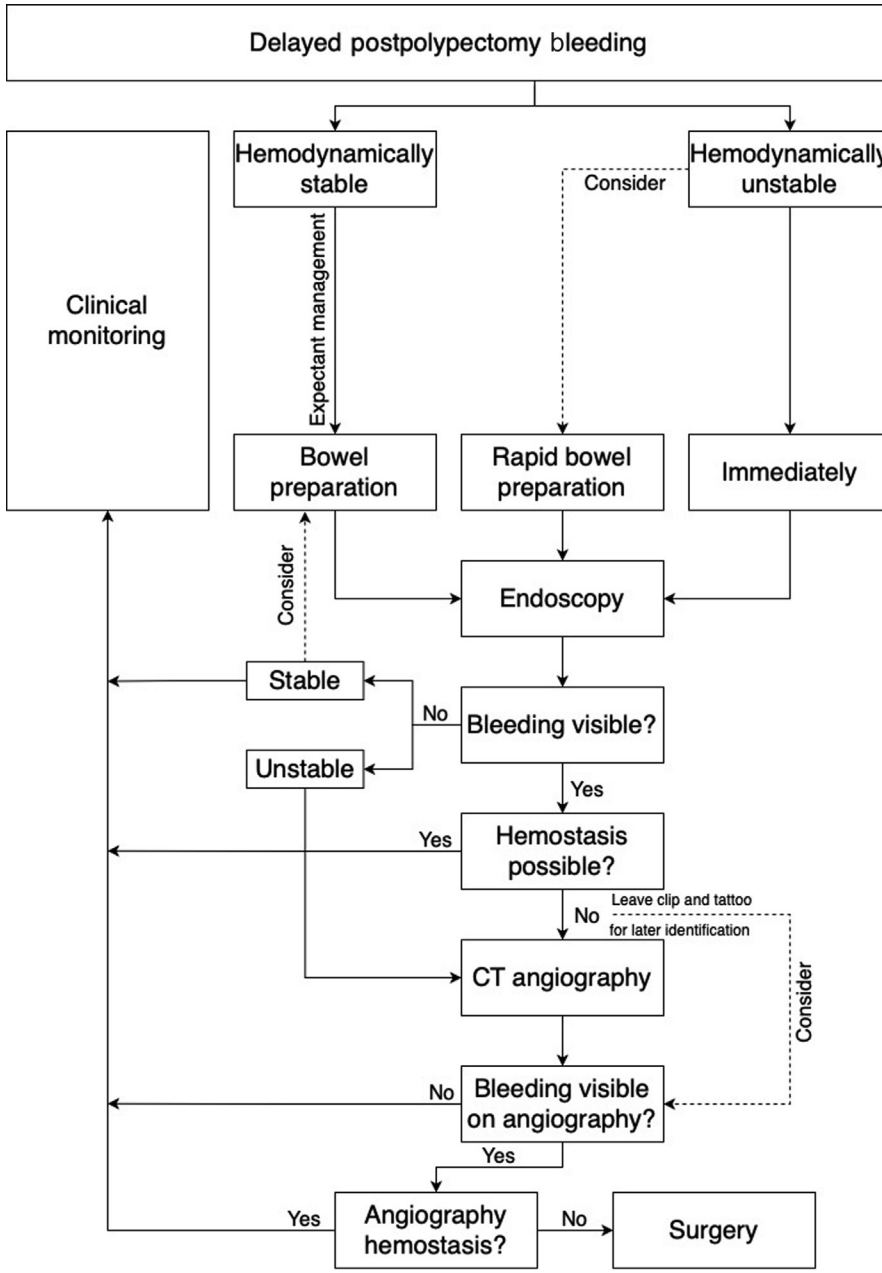

Fig. 1. Suggested management algorithm for delayed postpolypectomy bleeding. CT, computed tomography. (*Modified from* Werner DJ, Manner H, Nguyen-Tat M, et al. Endoscopic and angiographic management of lower gastrointestinal bleeding: review of the published literature. United European Gastroenterol J. 2018;6(3):337–42.)

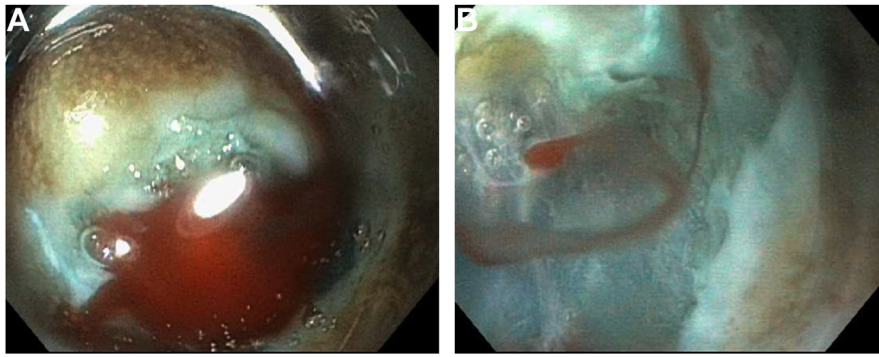

Fig. 2. (*A*) Brisk bleeding during ESD. (*B*) Pinpoint bleeding localized using the transparent cap and water flush.

After localizing the source, 1 of 4 hemostasis techniques, that is, injectable solutions, thermal devices, mechanical devices, or topical agents (**Box 3**), alone or in combination, can be used to control the bleeding, as discussed in the following sections.

Injectable solutions for hemostasis Injection of a 1:10,000 epinephrine-saline solution into the site of active bleeding will help achieve temporary hemostasis by vasoconstriction and the tamponade effect. However, epinephrine provides only temporary hemostasis and should be followed by more definitive therapy.

Thermal hemostatic devices Thermal devices can be contact (heater probe, gold probe, snare tip, and hemostatic forceps) or noncontact (argon plasma coagulation) and result in hemostasis by generating heat and causing edema, coagulation, and vessel constriction (Video 1). These, however, can extend the depth of tissue injury and should be used with caution. The electrocoagulation setting and argon plasma coagulation, where electrons flow through ionized argon gas, result in tissue desiccation, which creates resistance to further current flow, thus limiting injury.

An actively bleeding vessel within an EMR defect is best treated with grasping coagulation forceps (eg, Coagrasper, Olympus America (Center Valley, PA, USA) or with clip placement, with or without prior epinephrine injection. The Coagrasper device is a monopolar coagulation forceps designed for dual mechanical and thermal hemostasis. Although it is used primarily during ESD for coagulation of submucosal vessels, it can be used to grasp and seal bleeding vessels atop the resected stalk or polypectomy base, provided the grasped tissue can be tented.

Mechanical hemostatic devices Mechanical devices include endoscopic clips, which can be placed directly on the bleeding point or on the residual polypectomy stalk, and detachable loops, which are placed more easily over protuberant lesions such as a bleeding polypectomy stalk. The most popular method for endoscopic hemostasis is the application of through-the-scope clips (TTSCs). Mechanical hemostatic devices are preferred over thermal devices when technically feasible, because they do not extend the depth of tissue injury, which occurs with the use of thermal devices.

Topical hemostatic agents Three different topical hemostatic agents are commercially available, but only Hemospray (also known as TC-325; Cook Medical, Winston-Salem, NC, USA) is currently cleared by the US Food and Drug Administration for use in the United States. Hemospray is a hemostatic powder thought to cause hemostasis by sealing injured blood vessels and activating platelets and the intrinsic coagulation pathway.

Box 3
Hemostatic therapies/devices

Injection

- Dilute epinephrine (1:10,000 solution)
- Pilodocanol
- Fibrin glue
- Histoacryl
- EUS-guided angiotherapy

Thermal (contact)

- Heater probe
- Bipolar electrocoagulation—gold probe, silver probe, BICAP
- Monopolar electrocautery—snare tip cautery, hemostatic forceps
- Coagulation grasper
- Radiofrequency ablation
- Cryotherapy

Thermal (noncontact)

- Argon plasma coagulation
- Laser photocoagulation

Mechanical

- Grasp bleeding stalk with snare device and constrict
- Band ligation
- Detachable loop
- TTSC or endoclip
- OTSC, Padlock clip (STERIS Corp., Mentor, Ohio, USA)
- Endoscopic suturing device (OverStitch, Apollo Endosurgery, Austin, TX, USA)
- Flexible linear stapler

Topical

- Hemospray
- Ankaferd Blood Stopper (ABS) (Ankaferd Health Products Ltd, Istanbul, Turkey)
- EndoClot (EndoClot Plus, Inc, Santa Clara, CA, USA)
- Pure-Stat (3D Matrix Europe SAS, Caluire-et-Cuire, France)
- Oxidized cellulose

BICAP, bipolar circumactive probe; EUS, endoscopic ultrasonography; OTSC, over-the-scope clip.

Modified from Thirumurthi S, Raju GS. Management of polypectomy complications. Gastrointest Endosc Clin N Am 2015 Apr;25(2):335-57; with permission.

Box 4
Prevention of postpolypectomy bleeding

- Consider patient- and condition-related risk factors
- Ensure the lumen is adequately visible
  - Avoid blind dissection
  - Ensure that the correct layer is selected for dissection and verify the orientation in a tubular structure
  - Apply liberal water irrigation
  - Reschedule the procedure if bowel preparation was poor
- Patients on antithrombotics with a colorectal lesion greater than or equal to 2 cm should be individually assessed, with the risks of interrupting anticoagulation balanced against those of significant bleeding
- Use proper polypectomy technique
  - Avoid hot biopsy forceps
  - Treat intraprocedural bleeding during EMR/ESD, especially in the cecum, using endoscopic coagulation (eg, coagulation forceps or snare-tip soft coagulation) or mechanical therapy (eg, clip), with or without dilute epinephrine injection to prevent delayed bleeding
  - Use forced coagulation on thick vessels with the tip or shaft of the ESD knife to prevent bleeding
  - Consider prophylactic mechanical ligation of the stalk with a detachable loop or clips on pedunculated lesions with a head greater than or equal to 2 cm or with stalk thickness greater than or equal to 0.5 cm to reduce immediate and delayed bleeding.
  - Know when to refer to tertiary center for EMR (and do not attempt resection, biopsy the center of the polyp, or tattoo the polyp directly)

Prevention

The techniques for preventing postpolypectomy bleeding are summarized in **Box 4**.

Perforation

Immediate perforation occurs when the muscularis propria is grasped by a snare, whereas delayed perforation results from a deep cut or tissue necrosis from cautery.[29] According to a systematic review, the perforation rate is 0.8 of 1000 polypectomy procedures compared with 0.3 of 1000 colonoscopies for the screening/surveillance setting. However, the rate can be up to 5% following therapeutic procedures, such as ESD.[29,30] Perforations occurring during resection (eg, EMR and ESD) tend to be smaller (0.5 cm vs up to 2 cm for diagnostic colonoscopy)[31] and typically do not require laparotomy.[32,33]

Risk factors

Several factors related to the polyp, patient, and resection technique can predict the risk of perforation following polyp removal and are mentioned in **Box 5**.

Management of postpolypectomy perforation

When perforation is suspected, it can be helpful to devise a strategy (**Fig. 3**): preventing leakage of the intestinal contents by positioning the patient so that the defect is in a nondependent location and ensuring appropriate use of suction. Endoscopists should be comfortable with the various closure techniques.

Assessment of depth of resection for early recognition of perforation. Roughly one-third of perforations are detected during the colonoscopy,[34] apparent as a mucosal rent, shiny-appearing serosa, epiploic fat, or free intraperitoneal space. Submucosal

Box 5
Risk factors for perforation

Polyp-related factors

- Size greater than 2 cm[25]
- Location—cecum[34,35] and ascending colon[34]
- Morphology—nonpedunculated,[35] nonpolypoid,[36] and laterally spreading[36]
- Deeper layer involvement—Vienna classification 4 (noninvasive high-grade dysplasia) and 5 (invasive neoplasia)[37]
- Prior attempted polypectomy leading to submucosal fibrosis[38,39]

Patient-related factors

- Age greater than 75 years[40–42]
- Comorbidities—renal disease,[25] severe diverticulosis,[42] active severe colitis,[42] and adhesions from prior surgery[42]
- Male sex[25,40]
- Medications—warfarin, NSAIDS, and steroids[25,42]
- Prior radiation therapy[42]

Technique/device-related factors

- Mechanical injury
  - Tip of colonoscope—diverticula and tight/angulated turns (eg, in a redundant sigmoid or fixed by adhesions)[34]
  - Shaft of colonoscope—excessive looping or during retroflexion (eg, in a small rectum due to severe proctitis or pelvic radiation therapy)[34]
- Thermal injury—argon plasma coagulation and electrocautery[34]
- Barotrauma—air insufflation[34]
- Snare polypectomy—greater than 1 cm in right colon, greater than 2 cm in the left colon, or multiple polyps[34]
- ESR and ESD[25]
- Inadequate bowel preparation[42]
- No submucosal injection before snaring and electrocautery[34,36]
- Low-volume endoscopist, less than 300 procedures performed[8,30,40]
- Procedure performed at ambulatory surgery centers[8]
- Procedure performed by non-GI endoscopists (surgeons, family physicians, etc.)[43]

injection of a blue dye (eg, methylene blue or indigo carmine) can reveal the "target sign" of a probable perforation at the base of the resection site, that is, a white center (muscularis propria) surrounded by pinkish or bluish dye-stained submucosa. The underside of the resected specimen will appear as a reverse image. It is essential to detect these signs of perforation during the procedure rather than after clinical signs develop or radiography indicates the appearance of free air; this is particularly crucial during polypectomy, during which perforations can be treated endoscopically.

Endoscopic closure versus operative repair. The decision to manage the perforation conservatively with endoscopic closure or intervene operatively is influenced by many factors, summarized in **Box 6**.

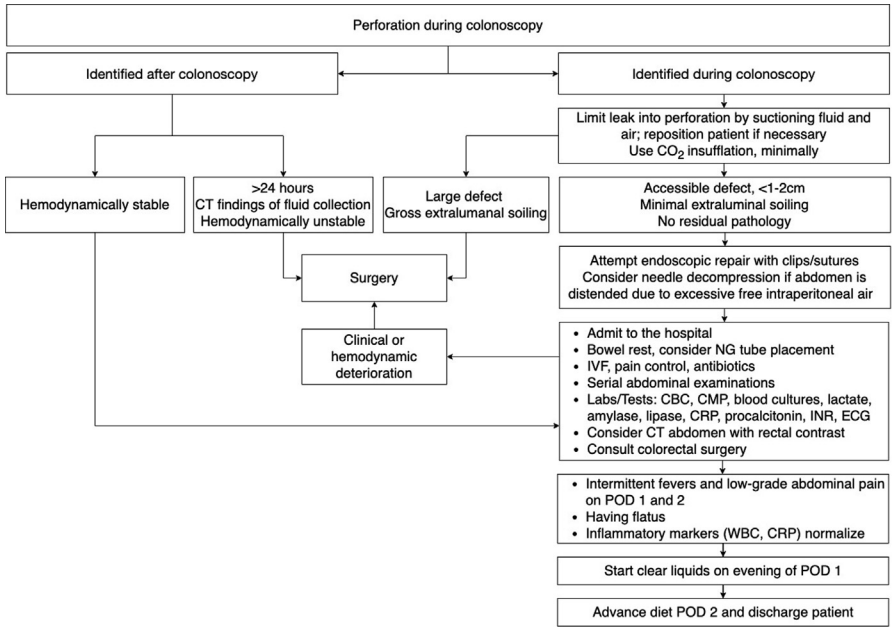

Fig. 3. Suggested management algorithm for colonic perforation during colonoscopy. *Abbreviations:* CT, computed tomography; CBC, complete blood cell count; CMP, comprehensive metabolic panel; CRP, C-reactive protein; ECG, electrocardiogram; INR, international normalized ratio; IVF, intravenous fluids; NG, nasogastric; POD, postoperative day; WBC, white blood cell count.

Endoscopic devices for perforation closure. When opting for endoscopic closure, the submucosa surrounding the perforation should be dissected to provide sufficient space for perforation closure. Endoscopic closure of perforation defects can be achieved with TTSCs (**Fig. 4**) (Video 2), over-the-scope clips (OTSCs), and endoscopic suturing devices (**Box 7**). The specific techniques of use are outside the scope of this review and are discussed more thoroughly by Raju.[44]

Postprocedural monitoring and management. Although the defect may appear to be sealed, the possibility of procedural failure due to incomplete clip closure, clip loss, or inaccurate/superficial stitch placement is not completely ruled out. Close monitoring in the period after endoluminal closure is crucial for early detection of failed clipping requiring surgical intervention. An evidence-based strategy for management of perforation after endoluminal closure is outlined in **Fig. 3** and summarized in **Box 8**.[47]

Prevention techniques

The techniques for preventing colonic perforation are discussed in depth by Rogart[42] and are summarized in **Box 9**.

Postpolypectomy Syndrome

PPS, also called postpolypectomy coagulation syndrome or transmural burn syndrome, occurs with localized serosal inflammation and peritonitis in up to 3% of patients undergoing hot snare polypectomy if there is full-thickness thermal injury of the bowel wall, without perforation.[48,49] PPS occurs most often after resection of large

Box 6
Indications for endoscopic and operative repair of perforation

Endoscopic repair

- Perforation defect less than 2 cm
- Adequate bowel preparation
- No extraluminal soiling
- No residual pathology
- Clinically stable patient
- Availability of devices
- Controlled access to the perforated site (the patient should be positioned so that the perforation is opposite the pooling of colonic contents, and CO_2 should be used for insufflation)
- Endoscopists' expertise

Operative repair

- Presence of a large perforation
- Inadequate bowel preparation
- Gross feculent peritoneal contamination
- Residual pathology (eg, incomplete EMR)
- Clinical deterioration on conservative management
- Failure to access and completely close the perforation
- Failed attempt at endoscopic closure

(>2 cm) sessile polyps, particularly in the thin-walled right colon, with prolonged application of electrosurgical current (coagulation mode). PPS has been associated with hypertension, large lesions, and nonpolypoid lesions.[48] Submucosal fluid cushions during EMR may reduce, but not eliminate, the risk of PPS.[50]

As a result of serosal irritation and localized peritonitis, patients can experience localized abdominal pain, fever, and leukocytosis, which mimic colonic perforation, within hours and up to 5 days postprocedure. Abdominal computed tomography is

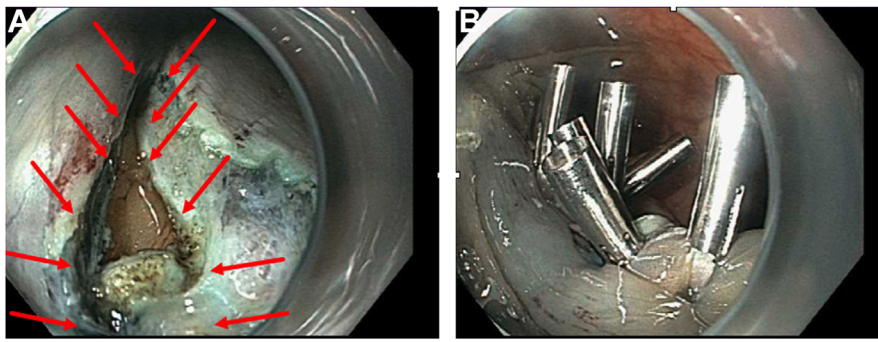

Fig. 4. (*A*) Perforation defect following EMR (red arrows). (*B*) TTSC closure of perforation in a zipper fashion.

Box 7
Closure devices

TTSC

- Readily available and easy to deploy for both the endoscopist and the assisting technician; most effective for perforation defects up to 2.5 cm in size, with noninflamed, nonfibrotic surrounding tissue, and treated within 24 hours
- Successfully approximate the mucosal and submucosal layers in a partial-thickness closure; restricted wingspan, low compression force, and potential for early detachment limits their usage with larger defects with gaping holes
- Avoid spillage of colon contents, because they can be deployed through the endoscope immediately after endoscopic recognition of perforation without leaving the operating field
- Successful in the closure of 90% of iatrogenic colon perforations[45]

OTSC

- Larger perforations (up to 3 cm), perforations with a fibrotic edge, and those not amenable to TTSC closure
- Grasp more tissue and apply a greater compressive force with the potential for single-layer, full-thickness closure
- Risks spillage of colon content, because the endoscope must be removed from the perforation site to load the device onto the end of the endoscope and then reinserted, followed by closure of the perforation; thus, the patient should be positioned so that the defect is in a nondependent location and the colon is fully decompressed before scope withdrawal to attach the OTSC
- Successful in the closure of 90% to 100% of iatrogenic colon perforations[45]

Over-the-scope suturing devices

- Prophylactic closure of very large (~4.25 cm to 5–8 cm) rectal EMR and ESD defects not amenable to standard clip closure for prevention of delayed perforation and bleeding; capable of deploying multiple interrupted or running stitches for accurate full-thickness closure[46]

optimal for distinguishing PPS from perforation, revealing localized colonic wall thickening and adjacent fat stranding without extraluminal air. PPS can be managed with bowel rest, intravenous fluids, antibiotics, and pain control or simply oral antibiotics and a day or two of a clear-liquid diet if symptoms are mild.

LONG-TERM OUTCOMES OF COLORECTAL POLYP RESECTION

Risk for Polyp Recurrence

Recurrence of adenomatous polyps following resection is common, occurring in 10.9%, 38.2%, and 52.6% of cases at 1, 3, and 5 years, respectively.[51] The primary cause of recurrence is incomplete polyp resection and, with an incomplete resection rate of 10.1% for all neoplastic polyps, is a risk factor for polyp progression to cancer.[52] Incomplete polyp resection may also lead to a buildup of scar tissue and fibrosis, making the subsequent resection more difficult. In addition, it increases incremental cost owing to the need for a follow-up resection. Factors related to incomplete polyp resection and recurrence are listed in **Box 10**. A submucosal lift can help delineate polyp margins and improve complete resection rates. The addition of a contrast dye agent to the submucosal injection solution can further help visualize the lesion and

Box 8
Postprocedural monitoring for perforations

- Perform serial abdominal examinations to monitor for tension pneumoperitoneum; if abdominal distension and respiratory distress are noted, perform percutaneous needle decompression with 18- or 20-gauge needle
- Maintain NPO status and consider nasogastric tube placement for decompression in the endoscopy room
- Start broad-spectrum intravenous antibiotics for aerobic and anaerobic coverage (eg, ciprofloxacin 400 mg every 12 hours + metronidazole 500 mg every 8 hours) and intravenous fluids
- Obtain blood work/tests, including complete blood cell count, comprehensive metabolic panel, lactate, amylase, lipase, C-reactive protein, and international normalized ratio, and an electrocardiogram
- Consult for colorectal surgery
- Coordinate admission to the hospital with medical and surgical team
- Consider ordering computed tomography of the abdomen and pelvis with rectal water-soluble contrast only; abdominal imaging may not be necessary if the patient is doing well clinically, because there is a tendency to treat the imaging findings and not the patient
  - No leak, continue conservative management
  - Leak present, surgery is required, especially if diagnosed after 24 hours
- Start oral intake with clear-liquid diet once pain and fever subside, appetite and bowel function return, and leukocytosis has resolved, which may be as early as postoperative day 1, followed by diet advancement and discharge on postoperative day 2

NPO, nil per os

Box 9
Prevention of postpolypectomy perforation

- Consider patient- and condition-related risk factors
- Ensure the lumen is adequately visible
  - Avoid pushing blindly
  - Use a smaller endoscope for severe diverticulosis or tight/sharp angulated colon
  - Apply liberal water irrigation
  - Reschedule the procedure if bowel preparation was poor
- Avoid excessive colonoscope looping, abdominal pressure, and position changes (keep lesion nondependent)
- Avoid retroflexion in small rectum
- Routinely decompress the colon; use CO_2 for insufflation
- Perform detailed inspection of the postresection mucosal defect to identify features for immediate or delayed perforation risk and perform endoscopic clip closure, accordingly
- Use proper polypectomy technique
  - Avoid hot biopsy forceps
  - Tent polyp away from wall when using snare cautery
  - Submucosal injection/lifting for larger sessile polyps
  - Consider piecemeal resection if polyp greater than 2 cm
  - Know when to refer to tertiary center for EMR (and do not attempt resection, biopsy the center of the polyp, or tattoo the polyp directly)

Modified from Rogart JN. Foregut and colonic perforations: practical measures to prevent and assess them. Gastrointest Endosc Clin N Am 2015;25(1):9–27; with permission.

Box 10
Risk factors for polyp recurrence

Polyp-related factors

- Size greater than or equal to 1 cm[54–56]
- Location—right hemicolon[55,56]
- Multiple polyps (>2)[55,56]
- Morphology—lesion occupying ≥75% of the luminal circumference[55]
- Histology—high-grade dysplasia, sessile serrated, villous, and tubulovillous features[54,55]

Patient-related factors

- Age greater than 60 years[55,56]
- Male sex[55]
- Obesity[55]
- Lifestyle—smoking,[56] alcohol use, low-fiber diet, red meat consumption[55]
- History of ulcerative colitis or inherited genetic predisposition for familial adenomatous polyposis[55]
- Low vitamin D and folate levels[55]
- Elevated serum homocysteine and ferritin levels[55]

Technique-/procedure-related factors.

- Cold biopsy forceps polypectomy[57]
- Piecemeal EMR and ESD resection[54,55]
- Suboptimal bowel preparation[55]
- Delayed postpolypectomy follow-up[55]
- Inexperienced endoscopist and/or endoscopy assistant[55]
- Missed diagnosis after the first colonoscopy[55]

distinguish normal tissue from polyp margins, especially in the case of sessile serrated adenomas/polyps. High-definition colonoscopes with imaging technologies such as chromoendoscopy, autofluorescence imaging, and confocal laser endomicroscopy have enabled endoscopists to make an in vivo optical diagnosis of colon polyp histology during colonoscopy. Additional tips and tricks to make the polypectomy process efficient and effective are discussed by Mahmood and colleagues.[53]

Risk for Colorectal Cancer

Despite the adverse events related to colonoscopy, the procedure can reduce the risk of CRC by ~70%.[1] Nevertheless, interval CRCs (ie, those that appear between serial colonoscopies) occur in 2.9% to 14% of cases and can arise from missed polyps (52%), incompletely resected polyps (19%), or de novo lesions (24%).[58,59] Risk factors for interval CRC are summarized in **Box 11**. The adenoma detection rate by endoscopists correlates inversely with interval CRC rates and death: each 1.0% increase in the adenoma detection rate is associated with a 3.0% decrease in the risk of cancer.[60] Although historically colonoscopy performance has been predicated on adenoma detection, it is detection combined with adequate resection that improves clinical

Box 11
Risk factors for interval colorectal cancer

Polyp-related factors

- Location—proximal colon[58,61]
- Prior polypectomy[61]
- Advanced adenomas[62]

Patient-related factors

- Age greater than 65 to 70 years[63]
- African American[64]
- Family history of CRC[58]
- Multiple comorbidities (≥3)[61,63]
- Previous diagnosis of diverticulosis[61,63]

Endoscopist-related factors

- Low adenoma detection rate[60]
- Performed few polypectomy procedures[61]
- High colonoscopy procedure volume[61]
- Specialty other than gastroenterology (eg, colorectal surgery, general surgery, internal medicine, or family practice)[61]

outcomes and consequences. Quality metrics should be implemented in all endoscopy centers and tracked over time to decrease the risk of interval cancer.[9]

SUMMARY

Endoscopic resection of polyps can result in complications, including those that are rare but devastating nonetheless. The risk for these can be minimized with appropriate recognition and consideration of the factors involved. Furthermore, adequate endoscopic training and cognizance of one's proficiency greatly influence the success of the procedure as well as the probability of complications. However, early recognition and assessment of complications that do occur provide the opportunity for prompt medical and/or surgical management, thereby promoting a successful outcome.

CLINICS CARE POINTS[65]

- Endoscopists should carefully assess all patient-, polyp-, and technique/device-related risk factors before attempting polypectomy to minimize complications.
- Endoscopic therapy is effective in managing most intraprocedural bleeding during EMR/ESD.
- Mechanical ligation of the stalk with a detachable loop or clips can be used for prophylaxis against immediate and delayed postpolypectomy bleeding on large pedunculated lesions.
- When removing nonpedunculated (≥2 cm) lesions, a contrast agent should be used, such as indigo carmine or methylene blue, in the submucosal injection solution to facilitate recognition of the submucosa from the mucosa and muscularis propria layers.
- Detailed inspection of the postresection mucosal defect should be performed to identify features for immediate or delayed perforation risk and perform endoscopic clip closure accordingly.

- Prophylactic closure of resection defects greater than or equal to 2 cm in size in the right colon should be used when feasible.
- CO_2 insufflation should be used instead of air during EMR to prevent barotrauma and perforation.
- Endoscopists should engage in a local (institution-, hospital-, or practice-based) quality assurance program, including measuring and reporting postpolypectomy adverse events.

DISCLOSURE

No conflicts of interest.

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SUPPLEMENTARY DATA

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