Chapter 19
Endoscopic Mucosal Resection: Colon and Rectum

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Key Points

- Endoscopic mucosal resection of large non-pedunculated colorectal polyps is the safest, most effective, and most efficient method for treating most lesions.
- Lesion assessment is reliable in detecting areas of submucosal invasive cancer (especially in flat lesions) and guiding the best management strategy.
- Thermal ablation of the endoscopic mucosal resection margin reduces the risk of recurrence substantially.
- Clipping is now recommended for proximal lesions to prevent delayed bleeding after endoscopic mucosal resection.
- Recurrence can be reliably detected by optical diagnosis and effectively treated on surveillance.
- Previously attempted non-lifting lesions can still be salvaged and successfully treated using CAST or hot avulsion techniques.
- Cold endoscopic mucosal resection is now the preferred resection method for large sessile serrated lesions.

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Introduction

Most colorectal cancers arise from precancerous adenomatous and sessile serrated lesions of the colon [1, 2]. This process occurs through predicted, gradual, and well-described molecular pathways, the conventional adenoma-carcinoma pathway, and the more recently discovered serrated pathway [1–3]. This gradual process allows for effective endoscopic intervention and removal of these lesions prior to developing invasive cancer [4, 5]. Approximately 5% of these lesions are large (size >10 mm) and non-pedunculated, named laterally spreading lesions (LSLs). The risk of submucosal invasive cancer (SMIC) in such lesions is approximately 8% and can be managed effectively by endoscopists who undergo dedicated training in endoscopic imaging and endoscopic resection techniques [6–9]. Given the majority of LSLs are benign, recent society guidelines recommend management of such lesions by endoscopic resection, primarily endoscopic mucosal resection (EMR), and not surgery [10, 11]. The majority of the cases can be discharged on the same day.

EMR complications are often predicted and inevitable in centers with significant EMR volume that receive referrals for more complex lesions. Most of these complications can be precisely and effectively managed endoscopically if recognized swiftly. EMR complications can be categorized as:

– Intraprocedural (immediate) EMR complications
– Post-procedural (delayed) EMR complications

Bleeding (immediate or delayed) is the most common risk [6–17]. Immediate bleeding is rarely significant and is easily managed endoscopically. Clinically significant delayed bleeding requiring blood transfusion or intervention is also rare and almost never fatal.

Why Should These Lesions Be Managed Primarily by Endoscopic Mucosal Resection and Not Surgical Colectomy?

All extensively benign colorectal polyps should be primarily managed endoscopically and not surgery [10, 11]. In a large Australian multicenter prospective study of 1050 patients undergoing EMR for colonic LSLs (≥20 mm in size), the actual endoscopic mortality was 0% (0 patients). In comparison by modeling the predicted surgical mortality using validated surgical scoring systems (ACPGBI & CR-POSSUM) showed predicted surgical mortality of 3.3% (35 patients) [18]. The NNT to prevent 1 death was 30, indicating endoscopic management of these lesions can save lives. In a larger nationwide US study of 262,843 surgical colectomies for non-malignant colorectal polyps, mortality was approximately 1%, and postoperative adverse events were 25% [19].

Another advantage of endoscopic resection over surgical colectomy is significant cost savings. In a large multicenter study of 1353 patients with 1489 colonic LSLs managed by EMR, the predicted mean cost savings per patient managed by EMR compared with best surgical outcome was $7602 (95% CI $8458–$9220; $P < 0.001$) and reducing inpatient hospital stay per patient by 2.81 nights (95% CI 2.69–2.94; $P < 0.001$) [20]. When factoring in surgical complications, the cost and inpatient hospital stay is much greater.

Recent society guidelines endorsed the primary management of large colorectal LSLs by endoscopic removal and not surgery [10, 11].

Preparation for Endoscopic Mucosal Resection

What Are the Main Aims of Endoscopic Mucosal Resection of Benign Colorectal Neoplasia?

1. Safely, effectively, and completely resecting these lesions.
2. Minimize invasiveness and avoid harm to the patient.
3. Avoid lesion recurrence post-EMR.
4. Avoid unnecessary surgical-related morbidity and mortality.
5. Improving the efficiency of healthcare resources through avoiding unnecessary healthcare expenses and time expenditure.

What to Do When These Lesions Are Discovered During Routine Colonoscopy?

Large colonic lesions requiring EMR are different from standard polypectomy. Detailed informed consent for EMR is needed as it involves higher risks than standard polypectomy and mostly includes alternative options, including surgery [7, 8, 21]. In addition, referral to an internal or external EMR expert endoscopist in a tertiary setting, longer allocated procedure time, with the preparation of required ancillary EMR equipment is preferable.

Endoscopic Prerequisites for Performing Endoscopic Mucosal Resection

Carbon Dioxide Insufflation

Carbon dioxide (CO_2) insufflation has been shown to reduce pain scores after colonoscopy and polypectomy compared to air insufflation [22–27] due to the rapid absorption of CO_2

from the colonic lumen, causing less post-procedural luminal distension and reduced colonic wall tension. The use of CO_2 for insufflation during colonoscopy has also been confirmed to be safer and superior to air insufflation, causing less tension on large mucosal defects during wide-field colonoscopic resection of advanced colorectal neoplasia [28–30]. Bassan et al. prospectively studied 575 large colonic lesions (size ≥20 mm) resected with air or CO_2 [30]. EMR with CO_2 resulted in a 62% reduction (3.4% vs. 8.9%, $P = 0.01$) in post-EMR admission compared with air. Furthermore, there was an 82% reduction (1% vs. 5.7%, $P = 0.006$) in post-EMR admission due to pain when using CO_2 compared with air.

Microprocessor-Controlled Electrosurgical Generators

The use of modern microprocessor-controlled electrosurgical generators minimizes the risk for deep mural injury during tissue resection. For snare-based endoscopic resection (such as EMR), most experts recommend the use of *ENDO CUT Q mode, effect 3, cutting duration 1, cutting interval 6*, shown in Fig. 19.1 (ERBE VIO 300D, Tübingen Germany) [7, 8].

Submucosal Injectate

The constituents of the submucosal injectate include a submucosal lifting solution and a chromic dye with or without epinephrine. For the submucosal injectate, a colloidal solution (e.g., succinylated gelatin) is preferred over a crystalloid solution, as it provides a longer-lasting submucosal lifting cushion [31]. An inert chromic dye (e.g., indigo carmine 80 mg in 500 mL solution of methylene blue 20 mg in 500 mL solution) is helpful in recognizing submucosal fibrosis and easier delineation of the unstained muscularis propria [32]. Epinephrine (1:100,000) is commonly used, which may reduce intraprocedural bleeding (IPB) [8].

FIGURE 19.1 Example of commonly used electrosurgical generator EMR settings (ERBE VIO 300D, Tübingen Germany). For resection, *ENDO CUT Q mode, effect 3, cutting duration 1, cutting interval 6* (red box), and for snare-tip-soft-coagulation for controlling intraprocedural bleeding or thermal ablation of the post-EMR margin *SOFT COAG mode 80 W, effect 4* (green box)

Snares

Several snares with different characteristics, shapes, and width are available. In general, we do not recommend using a snare diameter size larger than 20 mm, as this increases the risk of muscularis propria entrapment and the risk of deep mural injury or perforation. Stiff, braided snares facilitate better tissue acquisition and are less likely to slip during snare closure. Examples of commonly used EMR snares are shown in Fig. 19.2.

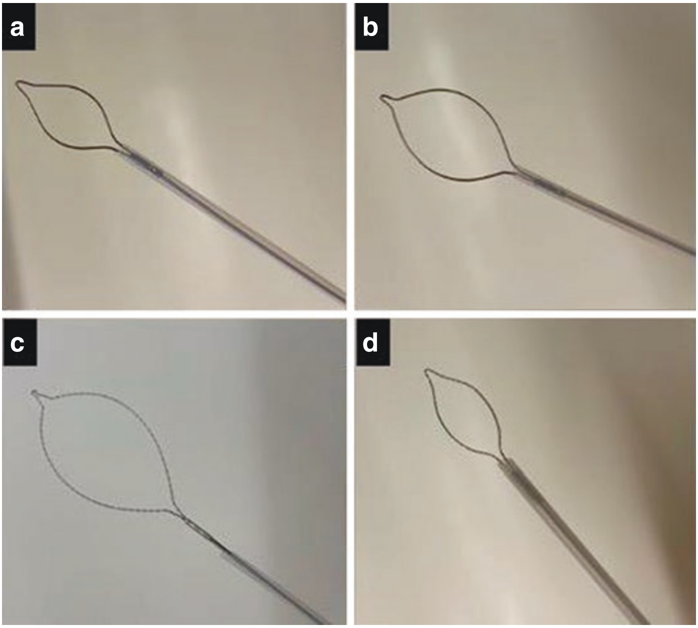

FIGURE 19.2 Examples of commonly used snares, (**a**) 10 mm Captivator II (Boston Scientific, USA); (**b**) 15 mm Captivator II (Boston Scientific, USA); (**c**) 20 mm SnareMaster (Olympus America); (**d**) 10 mm Captivator COLD (Boston Scientific, USA)

Lesion Assessment

Overview and Focal Lesion Assessment

Overview and focal lesion assessment for excluding visible areas of submucosal invasive cancer (SMIC) estimate the risk for covert SMIC, and the suitability of endoscopic resection is pivotal prior to attempting piecemeal or en bloc EMR. Also, whether the lesion is adenomatous or serrated will guide whether electrocautery use is needed. For large sessile serrated lesions, cold EMR is increasingly becoming the preferred method for endoscopic removal because of the attractive safety and efficacy profile for this technique over conventional EMR [33–36].

Focal interrogation of the lesion is performed using dye chromoendoscopy to assess for the surface pattern (Kudo classification, Table 19.1) [32, 37]. More common these days is the use of electronic chromoendoscopy (e.g., narrow-band imaging) to assess the vascular and surface patterns. The simple and validated Narrow-Band Imaging International Colorectal Endoscopic (NICE) classification (Fig. 19.3 and

Table 19.1 Polyp histology and corresponding imaging classifications

Histology	Surface pattern	Vascular pattern
Sessile serrated polyp	Kudo II	NICE type 1/JNET type 1
Tubular adenoma	Kudo III	NICE type 2/JNET type 2A or 2B
Villous adenoma	Kudo IV	NICE type 2/JNET type 2A or 2B
Submucosal invasive cancer	Kudo type V	NICE type 3/JNET type 3

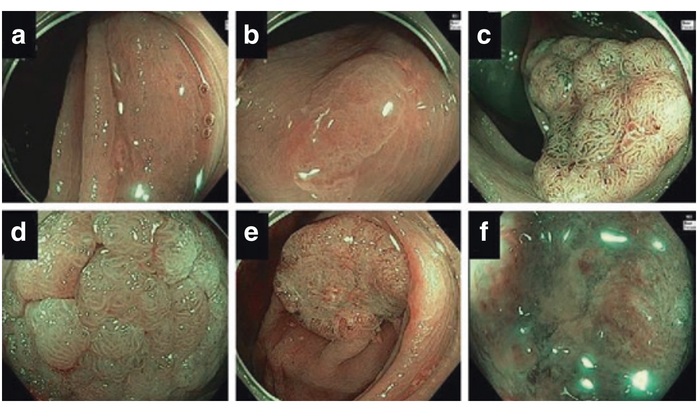

Figure 19.3 NICE classification, (**a**, **b**) Type 1, sessile serrated lesion; (**c**, **d**) Type 2, adenomatous lesion; (**e**, **f**) Type 3, submucosal invasive cancer

Table 19.1) or the Japan Narrow-Band Imaging Expert Team (JNET) classification is the most commonly used [32, 38–42]. Optical magnification increases the confidence in focal interrogation of the lesion and stratifies endoscopic resectability (non-cancerous lesions) or the need for surgery for lesions with SMIC (cancerous).

Risk Stratification of Covert Submucosal Invasive Cancer

An overview assessment of the lesion should be described using the Paris classification (morphology) and surface granularity (topography) to stratify the risk for SMIC [9, 43–45]. Location of the lesion is also important as the risk for SMIC is increased in distal lesions (especially in the rectum) compared to proximal lesions [44]. In general, bulky lesion (Paris Is), presence of a nodule (Paris IIa + Is), non-granularity, and distal location increase the cumulative risk for SMIC [44]. In a prospective multicenter EMR study of 1712 LSLs (≥20 mm in size), the risk of covert SMIC is summarized in Table 19.2 [44].

Endoscopic Mucosal Resection Technique

Lesion Access and Positioning

Lesion access needs to be optimized for maximizing technical success. Some techniques include:

- Reducing all colonoscopic loops for optimizing scope tip control and precision.
- The lesion is ideally positioned at the 6 o'clock position along the scope working channel.
- The use of distal transparent cap improves technical access in difficult locations (e.g., behind folds, ileocecal valve, anorectal junction).

Table 19.2 Risk of covert SMIC stratified by Paris morphology, granularity, and location [44]

Morphology granularity	Proximal SMIC risk (%)	Distal SMIC risk (%)	Overall SMIC risk (%)
Paris IIa Granular	0.7	1.2	0.8
Paris IIa + Is Granular	4.2	10.1	7.1
Paris Is Granular	2.3	5.7	3.7
Paris IIa Non-granular	3.8	6.4	4.2
Paris IIa + Is Non-granular	12.7	15.9	14.1
Paris Is Non-granular	12.3	21.4	15.3

- The use of distal attachment allows for swift temporary control of intraprocedural bleeding by tamponading the bleeding point while exchanging devices.
- The patient's position change may be necessary to shift the pooling luminal fluid and resected specimens away from the EMR working field to minimize extraluminal fluid spillage and procedural interference [9].
- Retroflection position can optimize access, especially in the proximal colon and rectum.

Submucosal Injection Technique

- We prefer using a 23 G, 3 mm long injection needle.
- Ensure that the needle catheter is fully primed with the submucosal injectate solution and no air bubbles to avoid injecting air into the submucosa.

- Position the needle tip tangentially against the lesion (we usually touch the mucosa with the needle tip).
- Ask the assistant to start the injection, then push the needle catheter to stab the mucosa, and you should instantly find the submucosal plane.
- Lift the lesion away using the scope knobs and by pulling back the needle catheter into the colonoscope working channel using the "dynamic submucosal injection" technique [46, 47].

Resection Technique

Well-planned and meticulous high-quality resection technique with continuous attention to snare tissue acquisition, snare slippage during the closure, EMR defect for deep mural injury, and residual neoplasia is critical for safe and effective EMR (Figs. 19.4, 19.5, and 19.6 and Box 19.1)

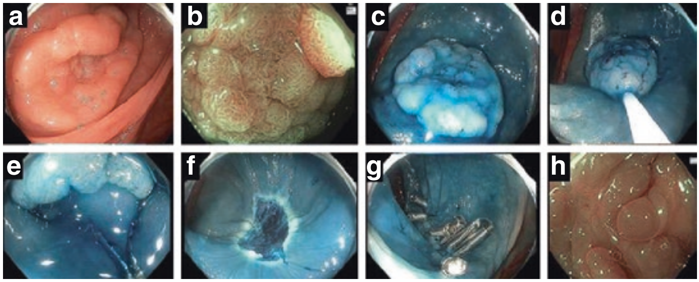

Figure 19.4 En bloc EMR of a 25 mm Paris IIa granular adenomatous lesion, (**a**) Lesion overview using high-definition white light; (**b**) NICE classification Type 2, adenomatous lesion; (**c**) submucosal injection using chromosaline (methylene blue with epinephrine 1:100,000); (**d**, **e**) en bloc snare placement including 2 mm of normal mucosa; (**f**) exposed submucosa following resection without evidence of DMI or residual neoplasia, thermal ablation to the margin applied; (**g**) clips applied to prevent delayed bleeding; (**h**) clip artifact within post-EMR scar with normal mucosa

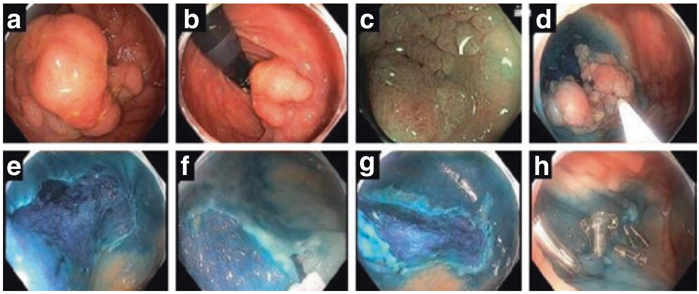

FIGURE 19.5 Piecemeal EMR of a 50 mm hepatic flexure Paris Is + IIa mixed-granularity adenomatous lesion. (**a**) Lesion overview on forward-view using high-definition white light; (**b**) lesion overview on retroflection view; (**c**) NICE classification Type 2, adenomatous lesion; (**d**) snare placement including 3 mm of normal mucosa; (**e**) exposed submucosa following resection without evidence of DMI or residual neoplasia; (**f**, **g**) thermal ablation to the margin applied; (**h**) clips applied to prevent delayed bleeding

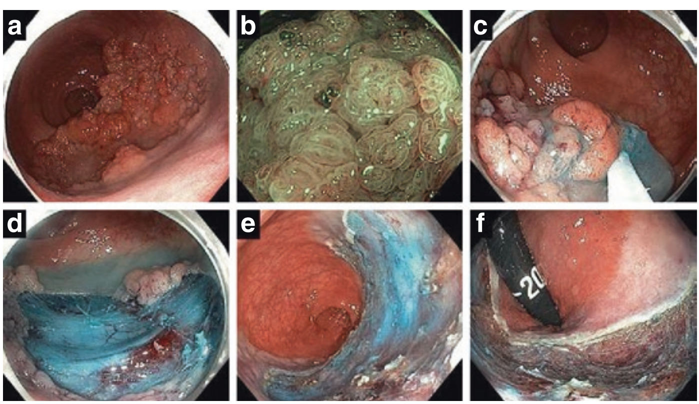

FIGURE 19.6 Piecemeal EMR of a 70 mm half-circumferential rectal Paris IIa granular adenomatous lesion. (**a**) Lesion overview on forward-view using high-definition white light; (**b**) NICE classification Type 2, adenomatous lesion; (**c**) dynamic submucosal injection; (**d**) EMR in progress with exposed submucosa with visible uninjured muscularis propria—DMI type I; (**e**) EMR completed without evidence of DMI; (**f**) retroflexion-view after thermal ablation to the margin

- Start resecting at the most technically difficult area first.
- Then place opened snare on the target neoplasia and included a 3 mm margin of normal mucosa.
- During snare closure, ensure that tissue margins within the snare are continuously maintained. This is better achieved by controlled-speed snare closure by the assistant, while the endoscopist is simultaneously advancing the snare catheter to guard against snare slippage and compromising tissue margins.
- The snare should be closed to maximum snare-handle resistance (usually up to 1–2 cm from complete snare handle closure).
- Check mobility: when swiftly moving the snare catheter, the entrapped tissue should move on the screen relatively independent of the colonic wall. If independent movement is lost, this could indicate entrapped muscularis propria and can risk DMI. This can be managed by partially opening the snare-handle to halfway to the point where snare-handle resistance is almost lost. Check mobility again and when independent mobility is achieved, reclose the snare handle to resistance.
- Transect the ensnared tissue rapidly using fractionated current. We use *ENDO CUT Q mode, effect 3, cutting duration 1, cutting interval 6*, shown in Fig. 19.1 (ERBE VIO 300D, Tübingen Germany). Usually, 1–3 pulses of a microprocessor-controlled electrosurgical generator are needed. If the snare stalls and does not transect after three pulses, this could be caused by entrapped muscularis propria, submucosal fibrosis, or submucosal invasive cancer.
- Examine the submucosal defect and utilize the water-foot pump to irrigate the defect and expand the submucosa for detecting residual neoplasia or DMI.
- Work systematically from one point and continue until the lesion is completely removed.

Box 19.1 Summary of Endoscopic Mucosal Resection Steps for Non-pedunculated Colorectal Laterally Spreading Lesions

- Optimize access and patient position.
- Place lesion at the 6 o'clock position.
- Careful lesion assessment in overview and focal mode to exclude areas of SMIC prior to EMR.
- Dynamic submucosal injection (preferably using colloidal solution when possible) to improve lesion access and prevent DMI.
- Use stiff, braided snares, and avoid using snare size >20 mm.
- The place opened snare on the target neoplasia and included a 3 mm margin of normal mucosa.
- Controlled-speed snares closure while observing margins of snare tissue acquisition.
- Transect the ensnared tissue rapidly using fractionated current (usually 1–3 pulses of a microprocessor-controlled electrosurgical generator).
- Examine the submucosal defect and utilize the water-foot pump to irrigate the defect and expand the submucosa for detecting residual neoplasia or DMI.
- Work systematically from one point and continue until the lesion is completely removed.
- Treat intraprocedural bleeding using STSC with or without coagulation forceps.
- Examine defect and remove any islands of residual neoplasia at defect or at margins.
- Examine defects for areas of DMI and use TSC for the unstained area.
- Apply clips to areas of DMI type II–V and consider antibiotics with overnight admission for treated DMI type IV–V.
- Apply thermal ablation to the post-EMR defect after removing all visible neoplasia.

- Consider clipping post-EMR defects in the proximal colon to prevent delayed bleeding.
- Post-EMR scar surveillance in 6 months and 18 months.
- Use image-enhanced endoscopy (e.g., NBI) to detect neoplasia recurrence.
- Re-resect all non-fibrotic residual neoplasia using cold snare polypectomy. Then remove fibrotic residual neoplasia using salvage avulsion techniques (CAST or hot avulsion).
- Examine treated areas for DMI and consider clipping if needed.

Complications and Optimizing Outcomes

Intraprocedural (immediate) or post-procedural (delayed) EMR complications are often predicted and inevitable in centers with significant EMR volume. Most of these complications can be effectively and safely managed endoscopically if they are recognized swiftly. Bleeding (immediate or delayed) is the most common risk. Immediate bleeding is rarely significant and is easily managed endoscopically.

Intraprocedural Bleeding

Intraprocedural bleeding (IPB) frequency is usually one in ten EMR cases. This can be swiftly and effectively controlled by snare-tip-soft-coagulation (STSC) in >90% cases, Fig. 19.7. If STSC fails to achieve hemostasis, Coagulation forceps using the same electrocautery settings as STSC is almost always successful. The technique for using both is described below:

- Use a fixed low-voltage output (190 V maximum) microprocessor-controlled electrosurgical generator (e.g. *SOFT COAG mode, 80 W effect 4, ERBE VIO300D, Tübingen Germany*) (Fig. 19.1).

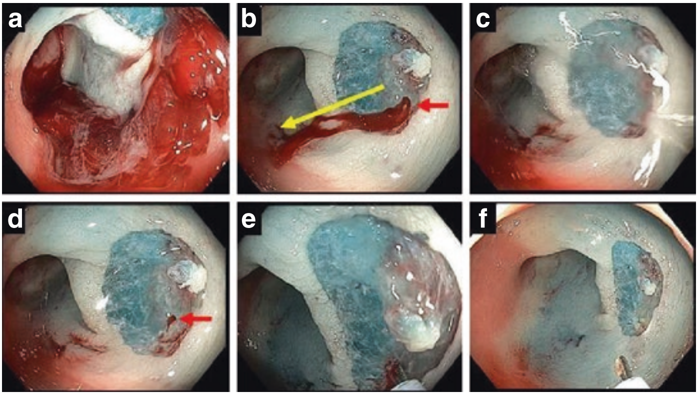

FIGURE 19.7 Intraprocedural bleeding controlled by STSC, (**a**) intraprocedural bleeding with fresh clot concealing bleeding point; (**b**) clots suctioned and active oozing from the bleeding point (red arrow) toward the gravitational side were luminal fluid pools (yellow arrow); (**c**) irrigating EMR defect to confirm bleeding point; (**d**) bleeding point confirmed (red arrow); (**e**) STSC applied to bleeding point; (**f**) hemostasis achieved

– Use the water-jet function and gravity direction to your advantage to detect the bleeding point.
– STSC: With the tip of the snare protruding 1–2 mm, apply pressure to the bleeding point. Often you will notice a tamponade effect with partial or complete hemostasis confirming that you are tamponading the culprit bleeding point. Apply brief 2–3 s duration of energy application to the bleeding point as needed until bleeding stops.
– Coagulation forceps: If STSC fails after three attempts, then use a coagulation forceps. Using the same setting, grasp the bleeding point, and then lift the vessel 3 mm into the lumen to limit injury to the muscularis propria, before applying brief 2–3 s duration of energy application to the bleeding point prior to releasing the vessel to confirm hemostasis.
– If thermal hemostasis fails although is rare, then clipping can be used in difficult cases.

Delayed Bleeding

Delayed bleeding post-EMR requiring hospitalization, blood transfusion, or intervention is termed *Clinically significant post-EMR bleeding (CSPEB)* [15, 17]. In a large prospective multicenter study of 1172 patients with colorectal polyps ≥20 mm in size (mean size, 35.5 mm), CSPEB occurred in 6.2% of patients [17]. More than two-thirds of patients with CSPEB presented within 48 h. Predictive risk factors for CSPEB were:

– Intraprocedural bleeding (IPB).
– Proximal colon location.
– Using a non-microprocessor-controlled electrosurgical unit.

More than half of CSPEB resolve spontaneously without intervention [15]. Predictive factors for requiring intervention for hemostasis are:

– Severe hematochezia.
– American Society of Anesthesiologists grades 2 or higher.
– Blood transfusion.

CSPEB remains a challenge with suboptimal prophylactic measures. In a randomized controlled trial of 347 receiving prophylactic thermal ablation of visible vessels within the EMR defect did not result in a significant reduction of CSPEB compared with no additional therapy [16]. A single-center retrospective case–control study of 524 EMR defects showed prophylactic clipping to reduce delayed bleeding from 9.7% to 1.8% [48]. However, there is a lack of prospective data and economical modeling studies have shown prophylactic clipping not to be cost-effective even for high-risk EMR defects [13, 49]. More recently, a novel synthetic hemostatic agent appears to mitigate against delayed bleeding but more studies are needed [50].

Deep Mural Injury and Perforation

Perforation is the most serious complication of EMR. Significant deep mural injury (DMI) and perforation occur in up to 3% of EMR cases [51–53]. Risk factors are en bloc resection for LSLs ≥25 mm in size, transverse colon location, and presence of high-grade dysplasia or covert submucosal invasive cancer.

An important endoscopic sign for the colonoscopist to be aware of during EMR is the *Target sign* [54]. This appears as a white-cautery ring within the EMR defect or the resected specimen and indicates an excision to the muscularis propria. The *target sign* is easily recognized and a reliable marker of MP injury and should be treated by mechanical closure using clips to avoid delayed perforation. White or unstained areas within the EMR defect interfere with endoscopic interpretation of the EMR defect resection depth. Unstained areas can be caused by submucosal fibrosis (SMF) or MP injury [7]. Topical submucosal chromoendoscopy (TSC) is a simple and helpful technique to identify the resection plane and recognize MP injury [55]. This is performed by injecting the EMR defect using the same injectate and the injection catheter without the needle (Fig. 19.8).

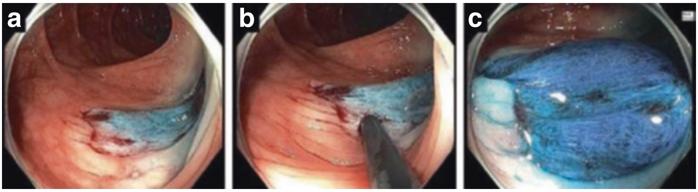

Figure 19.8 Topical submucosal chromoendoscopy, (**a**) Unstained area rendering the defect uninterpretable for excluding DMI; (**b**) topical submucosal chromoendoscopy applied to the unstained area; (**c**) blue dye submucosal uptake confirming no DMI and no need for clipping

DMI during EMR can be classified using the *Sydney Classification of DMI* Table 19.3, Fig. 19.9 [53]. Burgess et al. retrospectively studied images and histologic specimens of consecutive 911 LSLs ≥20 mm in size (mean size 37 mm) that underwent EMR. Deep mural injury occurred in 83 patients (10.3%) with significant DMI (type III–V) occurring in 24 patients (3%). All DMI cases were successfully clipped and 85.5% of patients were discharged on the same day. DMI type III–V was associated with transverse colon location, en bloc resection, presence of high-grade dysplasia, or covert submucosal invasive cancer.

Table 19.3 Sydney classification of deep mural injury [7, 53]

DMI type	Definition	Recommendation
0	Normal defect with blue submucosa and non-visible muscularis propria	No endoscopic intervention needed
I	Visible but uninjured muscularis propria	No endoscopic intervention needed
II	Focal loss of the blue submucosal plane causing uninterpretable muscularis propria to exclude injury	Clipping and may be discharged if asymptomatic
III	Injured muscularis propria with defect or specimen target sign	Clipping and may be discharged if asymptomatic
IV	Hole within a white-cautery ring, without observed contamination	Clipping, antibiotics, and admission for overnight monitoring
V	Hole within a white cautery ring, with observed contamination	Clipping, antibiotics, and admission for overnight monitoring

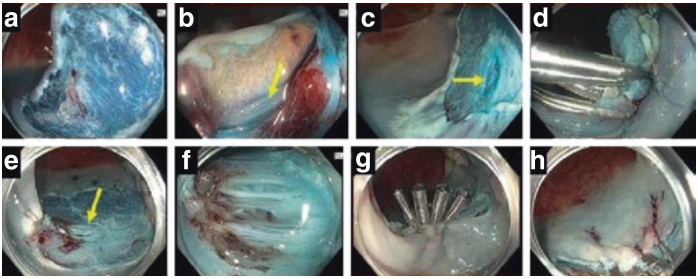

Figure 19.9 Examples of Sydney Classification of DMI, (**a**) normal post-EMR defect with homogenous blue submucosa without visible muscularis—DMI type 0; (**b**) visible uninjured muscularis propria during cold EMR—DMI type I, patient was stable and discharged same day; (**c**) defect target sign during EMR—DMI type III; (**d**) treated using clips, patient was stable and discharged on the same day; (**e**, **f**) defect target sign during EMR (DMI type III); (**g**) treated using clips; (**h**) clips deflected to ensure effective closure of the DMI, patient was stable and discharged on the same day

Adenoma Recurrence

The most frequent criticism of colonic EMR is adenoma recurrence. At the first surveillance colonoscopy, adenoma recurrence is proportionally high ranging from 15% to 30% [56–58]. However, this is often diminutive in size and can still be managed endoscopically. Thermal ablation of the post-EMR margin has been shown to significantly reduce adenoma recurrence on surveillance [59]. An Australian prospective multicenter randomized trial examined 416 large LSLs (size ≥20 mm) undergoing colorectal EMR. Post-EMR defects were randomized to thermal ablation of the post-EMR margin using STSC or receiving no additional treatment. Thermal ablation of the post-EMR margin resulted in a fourfold reduction in adenoma recurrence at first surveillance (21.9% vs. 4.7%, $p < 0.001$) [59].

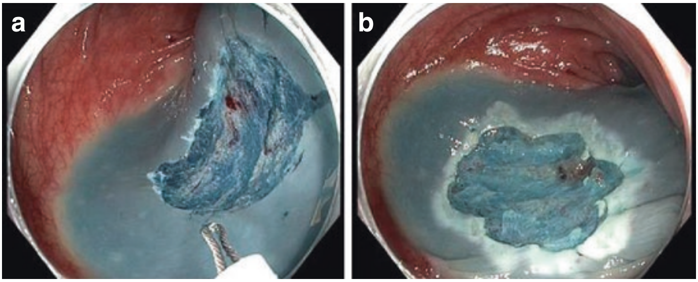

FIGURE 19.10 (**a**) Thermal ablation of post-EMR defect using STSC; (**b**) completed

Thermal Ablation of the Post-EMR Margin Technique

– All visible residual adenoma needs to be resected prior to applying thermal ablation.
– Use a fixed low-voltage output (190 V maximum) microprocessor-controlled electrosurgical generator (e.g., SOFT COAG mode, 80 W effect 4, ERBE VIO300D, Tübingen Germany) (Fig. 19.10).
– With the tip of the snare protruding 1–2 mm, confluent energy application to the post-EMR defect is applied, aiming for a 3 mm rim of ablated margin.

Special Locations and Salvaging Techniques

Anorectal Junction Lesions

Lesions involving the anorectal junction (ARJ) can still be effectively managed by EMR, Fig. 19.11 [7, 8, 60]. In an Australian prospective study, 24 large adenomatous LSLs (size ≥20 mm) involving the ARJ were successfully removed using EMR. Adenoma recurrence at first surveillance colonoscopy was 22% and all cases were managed endoscopically without recurrence at second surveillance [60].

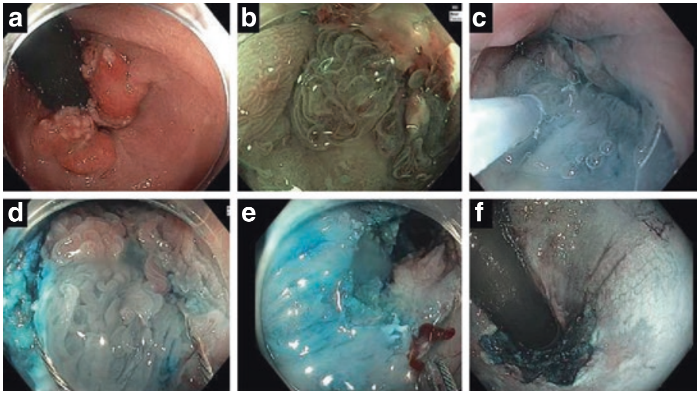

FIGURE 19.11 Piecemeal EMR of a 50 mm, semi-circumferential anorectal Paris IIa + Is symptomatic inflammatory polyp causing severe anemia, (**a**) lesion overview on retroflexion-view using high-definition white light; (**b**) focal lesion assessment using NBI; (**c**) dynamic submucosal injection starting at the anal side to improve access by pushing the lesion into the rectum; (**d**) snare placement including normal anal mucosa; (**e**) STSC applied to bleeding point; (**f**) EMR completed

Additional EMR steps recommended for ARJ lesions include:

- Use of long-acting anesthetic in the submucosal injectate (e.g., Ropivacaine 0.5%, up to 40 mg). This is injected at the ARJ and provided anesthesia for 4 h and analgesia for 12 h.
- Empirical single dose of broad-spectrum IV antibiotic (e.g., Cefazolin 2 g) can be given intraprocedurally to guard against bacteremia for distal rectal lesions (within 10 cm from the dentate line) and size >30 mm in diameter. This is because the inferior hemorrhoidal veins drain systematically bypassing the portal lymphovenous drainage system and may result in clinical bacteremia (fever and rigors).
- Use of distal attachment to optimize access and lesion positioning.

– Start the submucosal injection at the distal part of the involved area of the ARJ to push the lesion into the rectum.
– Use small diameter size snares (10 mm) when resecting over the ARJ.
– Retroflexion position and switching to a pediatric colonoscope or gastroscope can improve access and technical success.
– Post-EMR oral analgesia (e.g., Paracetamol 1 g every 6 h) can be used for another 24 h, then as needed over the next 72 h.
– Laxatives to maintain soft stool for 2 weeks.

Ileocecal Valve Lesions

Lesions involving the ileocecal valve (ICV) are challenging with a fourfold increased risk for recurrence, Fig. 19.12 [61, 62]. In a prospective Australian study of 44 large adenoma-

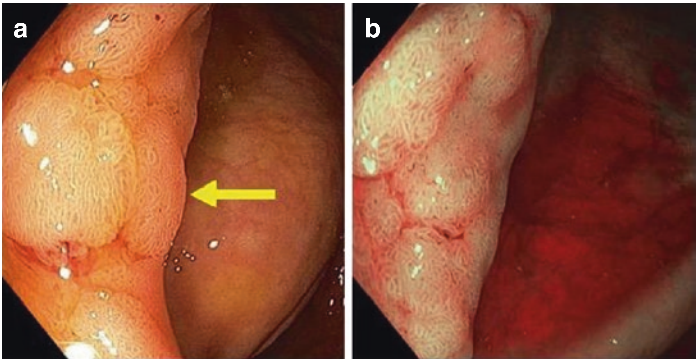

Figure 19.12 (**a**) Cecal adenomatous laterally spreading lesion extending into the ileocecal valve, overview using high-definition white light; (**b**) NICE classification Type 2, adenomatous lesion

tous LSLs (size ≥20 mm) involving the ICV, EMR technical success was 94%. Predictive factors for EMR technical failure were adenomatous infiltration to the ileum and involvement of both ICV lips [62].

Additional EMR steps recommended for ICV lesions include:

- Use of distal attachment to optimize access and lesion positioning.
- Start the submucosal injection at the proximal part of the involved area of the ileum and avoid over injecting.
- Retroflexion position can improve access and technical success.

Circumferential Lesions

Colorectal circumferential or semi-circumferential LSLs are very rare (approximately 1%) and can still be managed effectively by EMR, Fig. 19.13 [7, 63]. In an Australian prospective

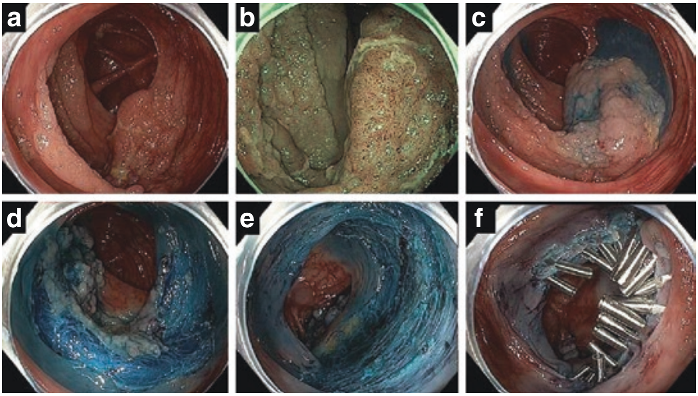

Figure 19.13 Piecemeal EMR of a 90 mm, semi-circumferential, Paris IIa, mixed-granularity, proximal ascending colon, adenomatous lesion. (**a**) Lesion overview using high-definition white light; (**b**) NICE classification Type 2, adenomatous lesion; (**c**) submucosal injection; (**d**) progressive EMR; (**e**) resection completed; (**f**) clipping after thermal ablation of margins

study of 979 patients with LSLs (≥20 mm in size), 12 patients had circumferential or semi-circumferential lesions [63]. All lesions were Paris IIa + Is, median length 95 mm (range 60–160 mm), and more than half were found in the rectum. EMR was successfully completed in all cases without major complications. Up to half of the cases can develop post-EMR luminal stricture.

Additional steps recommended for mitigating stricture formation in circumferential and semi-circumferential lesions include [7, 63]:

- Preserving a rim of normal mucosa during EMR if possible.
- Post-EMR corticosteroid enemas for rectosigmoid lesions (e.g., prednisolone sodium phosphate 20 mg twice daily for 8 weeks).
- Elective gradual colonic multidiameter balloon dilation (10–12 mm and up to 15 mm) starting at 2 weeks post-EMR and repeat dilation is guided by symptoms and ceased after maintaining 15 mm diameter.

Non-lifting Lesions

Some areas of neoplasia can be flat and resistant to snare capture despite good technique. If encountered during EMR, this is often caused by iatrogenic submucosal fibrosis (caused by previous attempts from biopsy or incomplete resection) or naïve submucosal fibrosis (associated with flat non-granular lesions) which manifest endoscopically when there is partial or complete non-lifting after submucosal injection Fig. 19.14. Such challenging lesions can still be safely and effectively salvaged endoscopically and avoid surgery. Salvage endoscopic techniques include

- Cold-forceps avulsion with adjuvant STSC (CAST) technique, Fig. 19.15 [7, 64]:
  - Isolate the fibrotic non-lifting area by snare excision of surrounding neoplastic and/or normal mucosa.

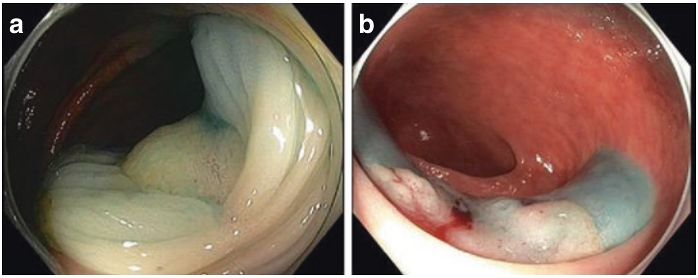

FIGURE 19.14 Adenomatous non-lifting lesions. (**a**) Iatrogenic central submucosal fibrosis from previous incomplete resection attempt; (**b**) iatrogenic central submucosal fibrosis from previous biopsy

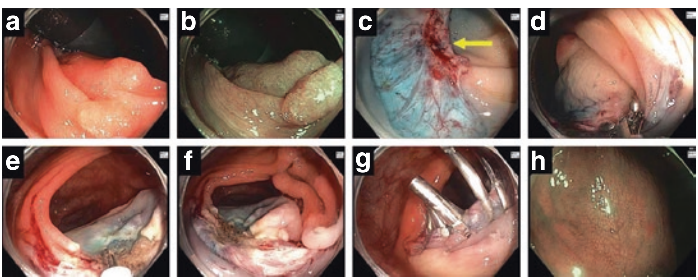

FIGURE 19.15 Previously attempted incompletely resected distal ascending colon lesion. (**a**) Lesion overview on retroflexion using high-definition white light; (**b**) NICE classification Type 2, adenomatous lesion; (**c**) fibrotic non-lifting area isolated; (**d**) cold-forceps avulsion of all visible fibrotic neoplasia prior to STSC; (**e**) adjunctive STSC of the avulsed fibrotic area; (**f**) EMR defect after CAST showing DMI type II; (**g**) targeted prophylactic clipping to the area of DMI type II; (**h**) EMR scar at 6-month surveillance showing normal bland EMR scar without adenoma recurrence

- Use cold biopsy forceps to grasp the fibrotic tissue.
- Repeat the steps until all visible fibrotic neoplastic tissue is removed.
- Minor ooze is usually encountered which is often transient.

- STSC electrosurgical generator settings (*SOFT COAG mode, 80 W effect 4, ERBE VIO300D, Tübingen Germany*).
- After removing all visible neoplasia, adjunctive STSC is applied to the avulsed fibrotic area for destroying microscopic residual and to control any persistent ooze.
- Examine the EMR defect for features of DMI using the Sydney classification of DMI and manage accordingly.

• Hot avulsion technique, Figs. 19.16 and 19.17 [7, 65]:

- Isolate the fibrotic non-lifting area by snare excision of surrounding neoplastic and/or normal mucosa.
- Use hot biopsy forceps to grasp the fibrotic tissue.

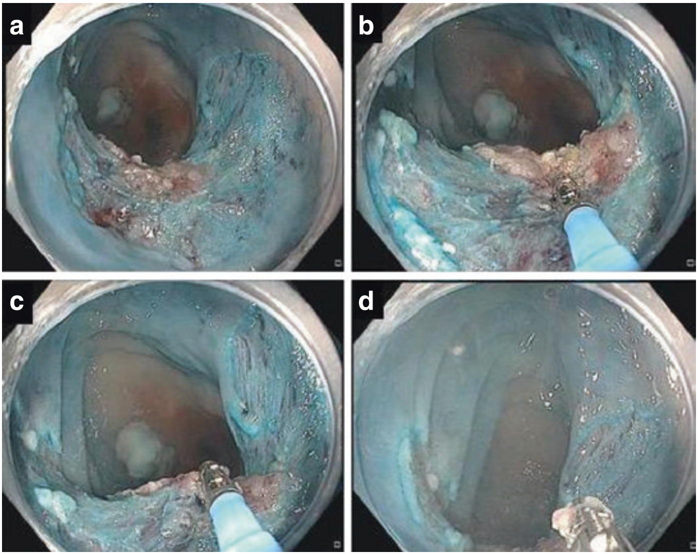

FIGURE 19.16 A 50 mm, distal ascending colon, half-circumferential, Paris IIa, granular adenomatous lesion with central submucosal fibrosis from previous resection attempt. Hot avulsion steps, (**a**) fibrotic non-lifting area isolated; (**b**) hot biopsy forceps used to grasp fibrotic residual; (**c**) grasped fibrotic tissue is tented and lifted away from the colonic wall to limit deep thermal injury prior to applying electrocautery; (**d**) electrocautery applied while pulling the tissue off

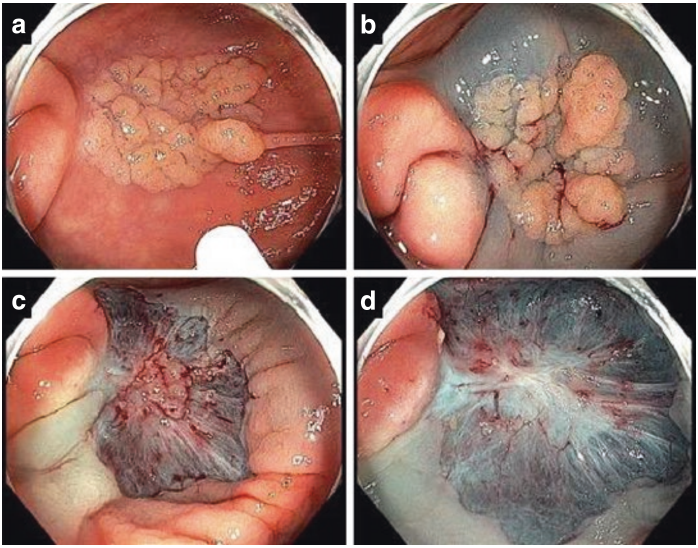

Figure 19.17 A 35 mm, cecal, Paris IIa, granular adenomatous lesion with central submucosal fibrosis from previous biopsy. (**a**) Lesion overview using high-definition white light; (**b**) non-lifting sign; (**c**) fibrotic non-lifting area isolated; (**d**) EMR defect after avulsion

- Tent and lift the fibrotic tissue away from the colonic wall to limit deep thermal injury prior to applying electrocautery.
- Electrosurgical generator settings (*ENDO CUT I mode, effect 3, cutting duration 1, cutting interval 3, or effect 1, cutting duration 4, cutting interval 1, ERBE VIO 300D, Tübingen Germany*).
- Electrocautery applied while pulling the fibrotic tissue off.
- Repeat the steps until all visible neoplastic tissue is removed.
- Examine the EMR defect for features of DMI using the Sydney classification of DMI and manage accordingly.

Surveillance and Post-EMR Scar Assessment

Typically, the first surveillance colonoscopy (SC1) is performed in 4–6 months post-EMR and the second surveillance colonoscopy (SC2) is performed after 12 months from SC1, if there was no recurrence. Recurrence at SC1 is commonly diminutive in size (1–5 mm) and easily manageable [58]. Post-EMR clipping can result in clip artifact on surveillance in 32–47% of cases [66, 67]. However, optical imaging using near-focus narrow-band imaging (NBI) can be used with high accuracy and sensitivity for detecting residual adenoma within post-EMR scars, Fig. 19.18 [68, 69].

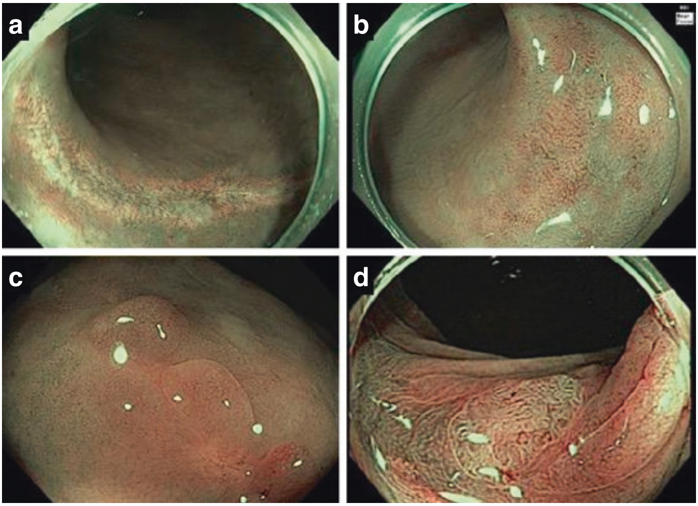

Figure 19.18 Post-EMR scar surveillance (**a**, **b**) normal flat bland post-EMR scar with normal mucosa and regenerative changes without recurrence, (**c**) clip artifact within post-EMR scar with normal mucosa, (**d**) diminutive residual adenoma within post-EMR scar

Post-procedural Care

Close post-procedural monitoring is needed to monitor for complications [7, 8]. Uncomplicated cases are closely monitored in the recovery area and discharged after 2 h.

Diet

We recommend keeping the patient NPO for 1-h post-EMR and can start a clear liquid diet after that in recovery and if no pain can be discharged home after 2 h and often resume regular diet next day.

Pain

Extramural injection of the dye can sometimes cause post-procedural pain. Often the pain can be quite severe with tender palpation and minimal guarding but the abdomen is often soft. This seems to be more common when epinephrine is used in the submucosal injectate. These situations need to be monitored in the recovery area often for a couple of hours as the pain improves significantly or resolves. The following steps are recommended:

1. Check vitals (often the blood pressure and oxygen saturation will be normal with transient mild tachycardia due to pain and distress).
2. Reassure the patient especially when the risk of deep mural injury or perforation is confidently excluded peri-procedurally (e.g., in cold EMR or if the EMR defect was closed effectively with clips in the case of conventional EMR).
3. Give simple analgesia (e.g., Paracetamol 1000 mg IV for analgesia).
4. Get a bladder scan to exclude urinary retention that can occur rarely with prolonged anesthesia.

5. If the pain does not improve after 1-h post recovery or the development of complications signs, then an urgent CT scan of the abdomen is recommended to exclude colonic perforation and free air under the diaphragm. Some patients will require admission overnight even if the CT was normal for supportive treatment and rarely for endoscopic or surgical management of complications.

Cold Endoscopic Mucosal Resection

Over the last few years, cold resection techniques including piecemeal cold endoscopic mucosal resection (CEMR) have revolutionized the management of colorectal neoplasia due to the safety and efficacy profile of this technique compared to conventional EMR and hot resection techniques [10, 11, 33]. For example, for large sessile serrated lesions, piecemeal CEMR is now becoming the standard of care [33–36]. Cold resection techniques eliminate electrocautery-related delayed complications. These include:

– Delayed bleeding
– Deep mural injury (immediate and delayed)
– Perforation (immediate and delayed)

It is still unclear how far can CEMR go in replacing conventional EMR as there are still unresolved questions (Box 19.2) [33]. The CEMR technique is described below, Fig. 19.19 [33].

Cold Endoscopic Mucosal Resection Technique

– Principles of lesion access, positioning, and submucosal injection techniques are the same as conventional EMR. Note that the volume of submucosal injection needed with CEMR is often less as the aim is to delineate the lesion's borders rather than guard against DMI Fig. 19.19.

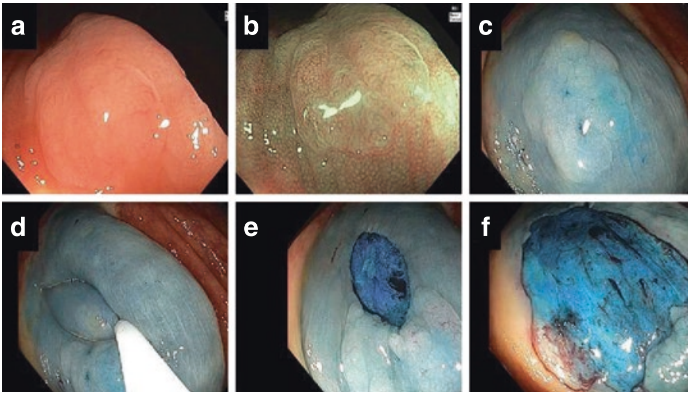

Figure 19.19 CEMR of a 20 mm Paris IIa sessile serrated lesion. (**a**) Lesion overview using high-definition white light, (**b**) NICE classification Type 1, sessile serrated lesion, (**c**) submucosal injection using chromosaline (methylene blue with epinephrine 1:100,000), (**d**) 10 mm dedicated cold snare placement including 5 mm of normal mucosa, (**e**) exposed submucosa following resection, (**f**) CEMR completed without evidence of DMI

- Use dedicated cold snares Fig. 19.2.
- Start resecting at the most technically difficult area first.
- The place opened snare on the target neoplasia and included 5 mm margin of normal mucosa.
- Limit the diameter of snare tissue acquisition to 10 mm or less to prevent snare stalling.
- During snare closure, ensure that tissue margins within the snare are continuously maintained. This is better achieved by controlled-speed snare closure by the assistant, while you simultaneously advance the snare catheter to guard against snare slippage and compromising tissue margins.
- Snare-handle should be closed to the end until transection occurs.
- Suctioning resected fragments as you go is possible and efficient, especially when using a scope with a working channel size of 3.7 mm or more.

- If snare stalls, do not use electrocautery as this risks DMI or perforation. Instead, partially open the snare-handle to a third or halfway and lift the entrapped tissue away from the colonic wall to facilitate slippage of the muscularis propria, and then slowly reclose the snare to transect the tissue.
- Examine the submucosal defect and utilize the water-foot pump to irrigate the defect and expand the submucosa for detecting residual neoplasia or DMI.
- Work systematically from one point and continue until lesion is completely removed.
- Persistent IPB is very rare, especially when using epinephrine, and prophylactic clipping to prevent delayed bleeding is not required unless the patient is on antithrombotics [70].

Box 19.2 Unanswered Research Questions for COLD Endoscopic Mucosal Resection

- What lesions are suitable for CEMR?
- Is thermal ablation of the margin needed for CEMR.
- Is epinephrine needed, especially in CEMR, to improve intraprocedural visualization by reducing intraprocedural bleeding and results in reducing residual neoplasia on surveillance?
- Can CEMR be safely and effectively performed without cessation of antithrombotic agents?

Summary

The last decade has seen a plethora of high-quality evidence of endoscopic techniques and tools revolutionizing the management of noninvasive colorectal neoplasia. In expert centers, the majority of these complex lesions are cured by EMR and avoid surgery in long-term follow-up. A unique advantage of endoscopic resection over surgery is the ability for treatment revision. However, significant surgical colectomies for noninvasive colorectal neoplasia are still performed despite societies' endorsement of primary endoscopic management. Scheduled surveillance after EMR is important. Thermal ablation of the EMR margin has further enhanced the efficacy of EMR and substantially reduced recurrence . Widespread adoption of EMR is still required to enhance outcomes further.

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