How to Perform High-Quality Endoscopic Mucosal Resection During Colonoscopy

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Colonoscopy with polypectomy reduces mortality from colorectal cancer.\textsuperscript{1,2} A small fraction of polyps are >2 cm and termed lateral spreading lesions (LSLs) of the colon.\textsuperscript{3} These polyps require advanced resection techniques such as endoscopic mucosal resection (EMR) for safe and effective removal.

However, colonic EMR is not routinely part of the general endoscopic curriculum available to gastroenterologists upon completion of their training. It requires dedicated training in advanced endoscopic resection techniques, the acquisition of clinical and interpretive skills, and the knowledge and ability to manage complications.\textsuperscript{4}

Performing high-quality, safe, and effective colonic EMR requires a team effort both inside and outside the endoscopy suite. To achieve this, colonic EMR for advanced lesions should be performed preferably in tertiary referral centers. This provides a large case volume for training fellows and the opportunity for a multidisciplinary team structure including surgical, radiologic, and anesthetic support. This multifaceted and comprehensive approach provides the necessary context for advanced endoscopic tissue resection procedures.

Over the last decade, a steady accumulation of scientific evidence has elucidated the technical aspects of colonic EMR,\textsuperscript{5} including safety and efficacy,\textsuperscript{6,7} long-term outcomes,\textsuperscript{8,9} and the clinical and economic benefits compared with surgery.\textsuperscript{10} An intimate knowledge of the evidence base is critical to achieve technical competence. Herein we review the step-by-step evidence-based methodology for performing best practice colonic EMR.

Preprocedural Assessment and Care: “This Is Not Your Standard Open-Access Procedure”

Community gastroenterologists who discover large LSLs during routine colonoscopy usually refer patients for colonic EMR. It is important to emphasize to the patient the differences between standard polypectomy and EMR, and to ensure the patient is fully consented to the procedure and its alternatives. The patient’s medical history including medication list need to be reviewed thoroughly and the patient’s comorbidities constantly factored into the therapeutic process.

Be prepared and organized. Preferably, a dedicated list should be scheduled for such procedures. All the required equipment should be readily available in the endoscopy suite and both physician and nurse need to be familiar with their use (Table 1).

Before commencing resection, take time to meticulously inspect the lesion with high-definition white light and chromoendoscopy or “virtual chromoendoscopy” (we use narrow band imaging). A thorough assessment can identify lesions with possible submucosal invasion. This is of great importance, because it may result in a different endoscopic approach or referral for surgical treatment.

Lesion Assessment: “Not Every Lesion That Can Be Removed Should Be”

The Paris classification of superficial neoplasia should be used for morphologic classification\textsuperscript{14,15} in combination with surface topography (granular or nongranular). The Paris classification and surface topography are helpful in stratifying the risk of submucosal invasion.\textsuperscript{6,16,17} Focal interrogation uses narrow band imaging to assess the surface pit pattern according to the Kudo classification\textsuperscript{18} and the vascular patterns according to the Sano classification or more recently the Narrow-Band Imaging International Colorectal Endoscopic (NICE) criteria.\textsuperscript{19,20} In expert hands, focal interrogation is accurate in identifying histologic subtypes and predicting submucosal invasive cancer.\textsuperscript{21-23} Tubular adenomas typically have large or elongated pits (Kudo type III) and an organized brown capillary network surrounding the pits (Sano type 2/NICE type 2). Villous adenomas have more complex branching gyrus like pits (Kudo type IV). Submucosal invasive cancer is suspected when irregularly mixed types or nonstructural or absent pits are present (Kudo type V), or when irregular complex branching...
Capillaries or avascular areas are seen (Sano type 3/NICE type 3). Often, a clear demarcation line can be discerned between the background regular pattern of the noninvasive adenoma and the irregular area of the suspected invasive component.

Resection Technique: “Make a Plan and Be Prepared”

EMR is a multistep process (Figure 1).

- Optimize your access and secure a good endoscopic position with a shortened, straight, and relaxed endoscope. Position the lesion at 6 o’clock in the endoscopic field. Position the patient in a way that any fluid or resected specimens accumulate away from the lesion. This ensures a clean, unobscured working field and enables optimal views and swift therapy in the event of a complication.

- Formulate a resection strategy; ideally, commence in the least accessible area.

- An uncomplicated inject and resect piecemeal EMR is then typically composed of 3 steps which are performed repetitively: injection, 1–3 snare excisions, and then inspection of the mucosal defect (Figure 2).

- A good injection should be dynamic and elevate the tissue into the lumen and toward the colonoscope.

- For piecemeal EMR, start at 1 edge of the lesion and try to include a 2- to 3-mm margin of normal mucosa. Use the edge of the advancing mucosal defect as a convenient step for the next snare placement to reduce the risk of adenoma islands.

- En bloc snare excision is appropriate for lesions up to 20–25 mm and is associated with lower rates of recurrence compared with piecemeal resection.24 Larger LSLs require piecemeal EMR for complete removal.5,25

- Thermal ablative techniques (argon plasma coagulation) to treat visible residual adenoma should be avoided as this is associated with high rates of recurrence.26,27 Complete snare excision should be the goal.

- After each resection, the mucosal defect should be cleaned with the colonoscope fluid jet (these authors use saline because it is isotonic) to ensure no adenoma islands remain and to exclude deep mural injury; it also provides some tissue elevation.

- Some LSLs are found in unique locations. In such cases, small adjustments to the standard technique may be necessary (Table 2).

**Dealing With Complications: “Anticipate, Prevent, and Treat With Confidence”**

Complications during or after EMR are inevitable with any significant procedural volume and to some extent predictable; however, they are managed readily and safely if recognized early. Delayed recognition may lead to serious sequelae. As such, endoscopists performing colonic EMR need to be familiar with their presentations and management. Bleeding is the most common complication and can be categorized as intraprocedural bleeding (IPB) or delayed bleeding.

- IPB occurs in up to 11% during EMR, is rarely serious and readily amenable to endoscopic hemostasis.22

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**Table 1. Recommended Endoscopic Equipment for Colonic EMR**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Recommendations/Evidence</th>
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<tbody>
<tr>
<td>Microprocessor-controlled electrosurgical generators</td>
<td>Minimizes potential for deep tissue injury during resection</td>
</tr>
<tr>
<td></td>
<td>Snare excision - Endocut Q effect 3 (ERBE VIO, Tübingen Germany)</td>
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<tr>
<td></td>
<td>Coagulation of bleeding – Soft coagulation 80-W effect 4 (ERBE VIO)</td>
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<tr>
<td>Insufflation</td>
<td>CO₂ significantly reduces post procedural admissions for pain during colonic EMR</td>
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<tr>
<td>Colloid solution for submucosal injection</td>
<td>Succinylated gelatin (Gelofusine; Braun, Melsungen, Germany) was superior to normal saline in a randomized trial requiring significantly fewer injections, fewer resections, and an overall reduced EMR time</td>
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<tr>
<td></td>
<td>Alternatives: Normal saline, hydroxyethyl starch</td>
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<tr>
<td>Inert dye</td>
<td>80 mg indigo carmine or 20 mg methylene blue in 500 mL solution</td>
</tr>
<tr>
<td>Adrenaline</td>
<td>1:100,000</td>
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<tr>
<td></td>
<td>May be effective in decreasing delayed bleeding</td>
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<tr>
<td>Snares</td>
<td>Stiff 20- or 15-mm snares with a braided wire are preferred for en bloc and piecemeal EMR, respectively. Small thin wire (0.3-mm monofilament) snares may enable better tissue capture in poorly lifting lesions (ie, previously attempted lesions, recurrence after EMR, periananeous lesions)</td>
</tr>
<tr>
<td>Coagulation of IPB</td>
<td>Management of IPB can be achieved quickly, safely and effectively with STSC</td>
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<td></td>
<td>Coagulating forceps are used for more severe bleeding or if STSC fails after 2-3 attempts</td>
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<tr>
<td></td>
<td>Clips are used less often as they tend to get in the way, and may not adequately compress small bleeding vessels</td>
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EMR, endoscopic mucosal resection; IPB, intraprocedural bleeding; STSC, snare tip soft coagulation.

capillaries or avascular areas are seen (Sano type 3/NICE type 3). Often, a clear demarcation line can be discerned between the background regular pattern of the noninvasive adenoma and the irregular area of the suspected invasive component.
Factors for IPB include larger lesions, Paris 0-IIa + Is morphology, villous or tubulovillous histology, and procedures performed at lower volume centers. IPB can be treated safely and effectively with snare tip soft coagulation. In this technique, active bleeding points are treated using a light touch with 1–2 mm of exposed snare tip in a specific electrosurgical unit mode (Soft Coagulation 80W, Effect 4, ERBE VIO, Tübingen Germany). Coagulation forceps can be used in more severe cases, for example, pulsatile bleeding or when snare tip soft coagulation fails.

- Delayed bleeding occurring after the procedure and requiring presentation to the emergency department, hospitalization, or medical intervention is termed clinically significant postendoscopic resection bleeding. Clinically significant postendoscopic resection bleeding occurs in up to 7% of patients after colonic EMR.

**Injection technique**
- Advance the needle tip tangentially to the mucosal surface.
- Ask your assistant to inject while simultaneously "stabbing" the mucosa with the needle tip.
- The correct plane is confirmed by an immediate elevation of the mucosa.
- Use a "dynamic" injection technique - pull back slightly on the injection catheter and slowly deflect the tip of the colonoscope (using the up-down wheel) to lift the target tissue into the lumen and optimize access.
- Avoid excessive injection. This can obscure your field and create excessive tension within the cushion which makes snare capture difficult.

**Piecemeal snaring technique**
- Open the snare fully over the lesion.
- Angle down firmly with the up-down wheel onto the fluid cushion while aspirating luminal gas.
- Close the snare, while maintaining the snare base at the lesion edge; Close the snare tightly to exclude MP from the captured tissue.
- To ensure optimal and safe tissue capture, re-insufflate the lumen and take the snare from your assistant for the final transection phase.
- You can use 3 criteria to confirm safe tissue capture:
  1. Free mobility of the captured tissue relative to the underlying colonic wall.
  2. Closure of the snare handle to within 1 cm between the thumb and the fingers with a sense that the captured tissue is compressible (not hard).
  3. A fast transection speed (one to 3 short taps of the pedal are usually sufficient).

**Problems**
- Lack of free movement, difficulty in complete snare closure or a long transection phase raises concerns of either MP entrapment or deeper neoplastic invasion.
- Sub-mucosal fibrosis resulting from excessive biopsies, previous resection attempts or inherent biology of the lesion (flat non-granular lesions) may hinder adequate snare excursion and require use of ancillary techniques.

**Figure 1.** Sequential steps in colonic endoscopic mucosal resection of a large lateral spreading lesion.
Proximal colon location is the most consistent risk factor across all studies (odds ratio [OR], 2.3–4.86), with aspirin use (OR, 3.16–6.3), lesion size (OR, 1.91–2.5), age (OR, 2.36), and comorbidities (OR, 1.9) being significant in most. Recently, 2 predictive clinical risk scores were introduced. These stratify patients into low (0.6%–1.7%), medium (5.5%–7.1%), and high (17.5%–40%) risk of delayed bleeding based on weights assigned to independent predictors found in multivariate logistic regression.

Most bleeding episodes occur within the first 48 hours after resection and 60% settle with supportive care only. Endoscopic intervention is required for ongoing or recurrent bleeding or those with unresponsive shock, and is usually effective. Rarely, angiography or surgery are needed. Measures to reduce the risk of clinically significant postendoscopic resection bleeding, such as prophylactic coagulation of nonbleeding vessels in the post-EMR mucosal defect or prophylactic clip closure of the defect, have been neither consistently successful nor cost effective thus far. Rarely, angiography or surgery are needed. Measures to reduce the risk of clinically significant postendoscopic resection bleeding, such as prophylactic coagulation of nonbleeding vessels in the post-EMR mucosal defect or prophylactic clip closure of the defect, have been neither consistently successful nor cost effective thus far. Rarely, angiography or surgery are needed. Measures to reduce the risk of clinically significant postendoscopic resection bleeding, such as prophylactic coagulation of nonbleeding vessels in the post-EMR mucosal defect or prophylactic clip closure of the defect, have been neither consistently successful nor cost effective thus far. Rarely, angiography or surgery are needed. Measures to reduce the risk of clinically significant postendoscopic resection bleeding, such as prophylactic coagulation of nonbleeding vessels in the post-EMR mucosal defect or prophylactic clip closure of the defect, have been neither consistently successful nor cost effective thus far. Rarely, angiography or surgery are needed. Measures to reduce the risk of clinically significant postendoscopic resection bleeding, such as prophylactic coagulation of nonbleeding vessels in the post-EMR mucosal defect or prophylactic clip closure of the defect, have been neither consistently successful nor cost effective thus far.

- Perforation occurs in 1%–2% of colonic EMR and is readily managed by endoscopic clip closure when recognized intraoperatively. It is important to be able to differentiate in real time true muscularis propria (MP) injury from an uncomplicated post-EMR mucosal defect, which can include visible uninjured MP, submucosal fibrosis, submucosal fat, and vessels. True MP injury is manifested by nonstaining, often surface disrupted areas within the relatively homogeneous “blue mat” of the post-EMR defect or by the appearance of the blue target sign. Recently, a classification system for deep mural injury during colonic EMR was introduced. Risk factors for deep mural injury were transverse colon location (OR, 3.55), en bloc excision (OR, 3.84), and the presence of high-grade dysplasia or invasive cancer (OR, 2.97). Topical submucosal chromoendoscopy can be used to improve detection of MP injury. With this technique, dye is flushed on the mucosal defect surface. Poorly staining areas suspicious for deep injury are recognized and treated by clip closure. Full-thickness perforation always warrants immediate treatment, which can usually be readily achieved with clip closure. This technique has revolutionized the safety of advanced colonic endoscopic tissue resection and greatly expanded the horizons of the possible.

- Recurrence after colonic EMR ranges from 10% to 30% and is considered the greatest drawback of EMR, particularly piecemeal EMR. Long-term data from the ACE (Australian Colonic Endoscopic Resection) study demonstrates that recurrences are usually small, unifocal, and easily treated during surveillance endoscopy. If the initial EMR was successful, then >95% of patients are free of adenoma during long-term follow-up. However, to ensure such results, a meticulous technique at the initial EMR and a structured surveillance regimen, with colonoscopy and scar examination at intervals of 6 and then 12 months is necessary. Risk factors for recurrence include lesion size >40 mm, piecemeal resection, and the presence of high-grade dysplasia.

**Postprocedural Care: “An Ongoing Responsibility”**

Patients undergoing colonic EMR require close monitoring after the procedure. Patient discomfort and the development of clinical signs of complications should be recognized early and treated expeditiously. Our protocol for uncomplicated cases include 2–3 hours of monitoring in the endoscopy unit and then discharge on a clear fluid diet for an additional 12 hours overnight.

First surveillance colonoscopy is performed 5–6 months after the index procedure to assess the scar area for any residual/recurrent tissue. The scar is interrogated carefully using both high-definition white light and narrow band imaging, and biopsies are obtained from any suspicious areas within the scar. We now know that, in expert hands, endoscopic diagnosis of recurrence is feasible and accurate, and routine biopsies from a normal appearing scar are probably not necessary or at least can be better targeted. One should be able to differentiate a normal appearing scar from a scar with granularity tissue, or clip artifact or a true adenomatous recurrence within the scar. Residual/recurrent tissue can be treated with hot snare resection or cold avulsion followed by thermal ablation, however there is no comparative data on the optimal method. Second surveillance is performed after an additional 12 months. Then, the patient can

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**Table 2: EMR in Unique Situations: Site-Specific Characteristics and Adjustments to the Standard EMR Technique**

<table>
<thead>
<tr>
<th>Site</th>
<th>Adjustments to Standard Technique</th>
</tr>
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<tbody>
<tr>
<td>Anorectal junction</td>
<td>Region with unique sensory and lymphovascular anatomy. Use a local anesthetic (ropivacaine 0.5%) in the submucosal injectate and consider prophylactic antibiotics.</td>
</tr>
<tr>
<td>Appendiceal orifice</td>
<td>Often very fibrotic with poor lifting. Use small thin wire snares. If the lesion encompasses &gt;50% of the orifice or if the proximal margin within the appendix, EMR success may not feasible.</td>
</tr>
<tr>
<td>ICV involvement</td>
<td>Higher rates of recurrence after EMR (OR, 3.38). Difficult access often requires both anterograde and retrograde approaches and use of a cap.</td>
</tr>
<tr>
<td>Sessile serrated polyps</td>
<td>Comprise up to 15% of LSLs referred for EMR. Detection may be difficult and the presence of adherent mucus or debris may alert the endoscopist to their presence. Recognition of the true margins is critical to ensuring success and often these may only be fully discerned after submucosal injection. They can be removed with EMR with comparable or superior efficacy to adenomatous LSLs.</td>
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</table>
be followed according to the current postpolypectomy recommendations for colorectal cancer screening and prevention.49

Conclusions
Performing high-quality EMR in the colon has the following prerequisites.

- Training, experience, and support are required. A well-trained endoscopy team including trained nursing staff and at least 1 additional experienced endoscopist, is extremely valuable. High-volume centers should train fellows. The teaching and mentoring process is essential to the professional development of the fellow, but also contributes to that of the mentor.

- Owing to their complexity, these procedures are best performed in a tertiary level environment with multidisciplinary support.

- Quality measures are important and should be implemented. Continuous evaluation of performance and outcomes, including detailed photo documentation and video recording, is recommended. This type of ongoing reflection is crucial.

- Do not forget the follow-up. It is the endoscopist’s responsibility to ensure that patients return for surveillance. We recommend that at least the first surveillance colonoscopy be conducted with the physician who performed the index EMR, thus ensuring adequate assessment of the scar.

In the era of highly specialized medicine, these core principles of EMR practice should be the standard of care.

References


29. Tate DJ, Desomer L, Hourigan LF. Endoscopic mucosal resection of laterally spreading lesions around or involving the appendiceal orifice (PA LSLs): technique, risk factors for failure and outcomes of a tertiary referral cohort. Gastrointest Endosc 2016;83:AB144.


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Conflicts of interest
The authors disclose no conflicts.
1. When removing difficult lesions
   a. start resection with the most easily accessible part of the lesion
   b. Position the lesion at 6 o’clock in the endoscopic field
   c. Inject EMR solution to elevate the lesion away from the endoscopy
   d. En bloc resection is appropriate for lesions up to 25mm, but not larger lesions

2. When counseling patients for EMR, delayed bleeding risk requiring additional intervention should be quoted as occurring with a frequency of
   a. < 1%
   b. 1% to 2%
   c. Up to 7%
   d. 10% to 15%

3. Polyps areas with absent pits (as seen on NBI) are suggestive of invasive cancer and should be considered for surgical resection

4. If a patient is undergoing open-access routine screening colonoscopy and a 3cm flat polyp is identified, it should be removed using EMR during the procedure, additional consent is not needed

5. Lesions that involve the ileocecal valve are associated with high recurrence rates after EMR

6. 60% of delayed post EMR bleeding resolve with supportive measures alone

7. Recurrence after colonic EMR is 10% to 30%, repeat colonoscopy at 6 and 12 months is recommended for monitoring

8. Intraprocedural bleeding during EMR can often be managed with snare tip soft coagulation

9. Colloid solution is superior to normal saline for submucosal injection

10. CO₂ insufflation allows for a more complete EMR resection

11. APC is the best way to treat residual adenomatous tissue after EMR

12. Cecal lesions that encompass >50% of the appendiceal orifice should be referred to surgery

13. Full thickness perforation rarely responds to clip closure and often require surgery

14. During follow up colonoscopy after EMR, the scar area should be biopsied even if not lesions are seen