# Endoscopic mucosal resection: learning curve for large nonpolypoid colorectal neoplasia

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**Background and Aims:** Colorectal EMR for nonpolypoid neoplasia achieves better outcomes when performed by expert endoscopists. The time point at which the endoscopist achieves expert level remains to be defined. The objective of this study was to establish a learning curve of colorectal EMR for nonpolypoid neoplasia based on residual tissue on surveillance colonoscopy and adverse event rate.

**Methods:** Five hundred seventy-eight consecutive patients underwent EMR of colorectal neoplasia by 1 of 3 primary endoscopists between December 2004 and September 2013 in a tertiary academic center. Primary analyses focused on the largest lesion for patients with more than 1 lesion (median age, 69 years; median polyp size, 30 mm; 51% en bloc resection). Data on surveillance colonoscopy were available for 74%. Learning curves were calculated for each of the 3 main outcome measurements: the presence of residual neoplasia on surveillance colonoscopy, endoscopic assessment of incomplete EMR, and the occurrence of an immediate bleeding adverse event.

**Results:** Residual neoplasia on surveillance colonoscopy was present for 23.2% of patients, the rate of endoscopist-assessed incomplete EMR was 27.6%, and immediate bleeding adverse events occurred in 6.9% of patients. Although there was between-endoscopist variability, the overall rates of residual neoplasia and incomplete EMR decreased to below 20% to 25% after 100 EMRs; initial decreases in both rates were observed for earlier EMRs. Immediate bleeding adverse events occurred at a low frequency for each endoscopist across all EMRs. Perforation requiring surgical intervention occurred in 1 patient (0.2%).

**Conclusions:** This study demonstrated that an unexpectedly high number of 100 colorectal EMR procedures for large nonpolypoid colorectal neoplasia are required to achieve a plateau phase for crucial outcomes. (Gastrointest Endosc 2016;84:959-68.)

*(footnotes appear on last page of article)*

Endoscopic resection of large (≥20 mm) colorectal nonpolypoid neoplasia is commonly performed using the EMR technique. The reported data on short-term and long-term outcomes demonstrate substantial differences in the en bloc resection and residual neoplasia rates.[1-4] These differences can be partly explained by polyp sizes, polyp sites, and polyp histology. However, whether the EMR skill level of different endoscopists contributes to these differences is not known.

Despite the broad application of colorectal EMR for neoplasia, surprisingly few data exist on the procedure volume required per endoscopist to achieve satisfactory outcomes.[5,6] In the recent past, attention was drawn to endoscopic competency and quality measures in order to provide optimal patient care. In this context, learning curves can be established to define parameters when a sufficient procedure skill set is acquired to allow satisfactory procedure outcomes.[7-11]

Our primary goal was to define a learning curve for EMR of large colorectal nonpolypoid neoplasia, focusing on residual neoplasia at follow-up, endoscopist assessment of incomplete EMR, and immediate bleeding adverse events as quality-defining outcomes.

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## METHODS

### Patients

We included all patients who underwent EMR for sessile colorectal polyps, 20 mm or larger, from December 2004

to September 2013 at our academic endoscopy unit in this retrospective study. Institutional review board approval was obtained. All EMR procedures were performed by the advanced endoscopy group (M.R., M.B.W., and T.A.W.) at our institute since December 2004; all endoscopists were more than 5 years out of formal gastroenterology training. Before this date, none of the physicians had performed appreciable numbers of EMR procedures. This resulted in a sample of 578 colorectal EMRs in 578 patients; all EMRs were performed by the 3 endoscopists (endoscopist no. 1, n = 199; endoscopist no. 2, n = 223; endoscopist no. 3, n = 156).

A subset of patients (n = 66) had more than 1 lesion for a given colonoscopy with EMR, ie, these patients underwent 2 or more EMRs simultaneously. Our primary analysis focused on the largest lesion for the given colonoscopy. However, in a secondary analysis, we also evaluated the presence of each of the 3 primary endpoints (residual neoplasia at follow-up, immediate bleeding adverse events, and endoscopist assessment of incomplete EMR) for any lesions undergoing EMR.

## EMR information

EMR materials and technique varied depending on the lesion and the preference of the operators. Colorectal lesions were removed by submucosal injection of a large volume of normal saline solution (normal saline solution; indigo carmine, 0.04%; Taylor Pharmaceuticals, Decatur, Ill; with or without 1:10,000 epinephrine) or a solution of hydroxypropyl methylcellulose (hydroxypropyl methylcellulose, normal saline solution, indigo carmine, 1:10,000 epinephrine). Lesions were marked with tattoo (Spot; GI Supply, Camp Hill, Pa), at the discretion of the endoscopist, to facilitate site recognition at follow-up. Piecemeal or en bloc resection depended on lesion size and morphology. At the initial endoscopy, supplemental methods were used at the endoscopist's discretion to achieve maximal macroscopic polyp resection, which included argon plasma coagulation (APC), EMR-cap, ablation-cautery, snare, forceps avulsion, and endoloop. APC was used to treat residual macroscopic neoplasia but not for prophylactic measures. An endoloop was used to facilitate wound closure after snare resection of particularly large neoplasia.

All patients were scheduled for surveillance colonoscopy at 3 to 6 months. In light of limited compliance with this timeframe, all first surveillance colonoscopies were included in our evaluation and were performed within 24 months after the initial EMR. All follow-up colonoscopies were performed by the advanced endoscopy group.

## Data collection and outcomes

A retrospective chart review was performed to extract the following data: baseline characteristics (age, gender, race, prior EMR or snare resection attempt [prior therapy], American Society of Anesthesiologists [ASA] class), EMR information (endoscopist, colon site, polyp size, Paris classification, Kudo classification, Sano classification, injection type, lift sign, cap-assisted EMR, EMR-snare methods, prophylactic APC, prophylactic clips, specimen [en bloc vs piecemeal]), optical methods (narrow-band imaging [NBI]), supplemental methods to remove residual neoplasia after EMR (ablation-APC, EMR-snare, Grasper assist [snare resection and simultaneous grasper assist with a dual-channel endoscope], snare, EMR-cap, ablation-cautery, endoloops), and outcomes (endoscopist assessment of complete resection with EMR, endoscopist assessment of complete resection with EMR using NBI, neoplasia histology according to pathology report, immediate adverse events, residual neoplasia at follow-up). Residual neoplasia at follow-up was defined as the presence of macroscopically visible neoplastic tissue at the polypectomy scar, which was confirmed histologically in each case. Other quality measures such as procedure times, which included the withdrawal time, bowel preparation quality, and pain score assessments were not available for data analysis. Description of neoplasia, including size and other classifications, was based on real-time endoscopist assessment without the use of additional tools (eg, for exact measurement of neoplasia size). There was a substantial amount of missing data for ASA class (n = 78), Paris classification (n = 380), Kudo classification (n = 367), and Sano classification (n = 446). The 3 primary outcome measures were residual macroscopic neoplasia at follow-up, endoscopist assessment of incomplete EMR, and immediate bleeding adverse events, defined as unexpected hemorrhage during EMR requiring additional treatment for hemostasis (epinephrine, clip, APC, cautery, endoloop). EMR specimens of 19 patients revealed T1 adenocarcinoma, of which 9 were referred to surgery; the remaining patients (5 T1m and 5 T1sm) were assigned to surveillance colonoscopy according to the patient's preference.

## Statistical analysis

Continuous variables were summarized using the sample median and range. Categoric variables were summarized using the number and percentage. In order to address potential confounding in learning curve evaluation separately for each endoscopist and in the overall group, we examined changes in prior therapy, piecemeal specimen, and polyp size as the endoscopists' EMR experience increased using logistic regression models (prior therapy and specimen) and linear regression models (polyp size). Odds ratios (ORs) and 95% confidence intervals were estimated, and this analysis was performed separately for each endoscopist as well as overall. Linear and logistic regression models involving the overall group were adjusted for endoscopist. Polyp size was considered on the logarithm scale in all analyses due to its skewed distribution.