Comparison of cold snare polypectomy and endoscopic mucosal resection for 3–10-mm colorectal polyps in end-stage renal disease patients

Chang Kyo Oh, Ho Soon Choi¹, Young-Seok Cho

Division of Gastroenterology, Department of Medicine, Seoul St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, ¹Division of Gastroenterology, Department of Internal Medicine, Hanyang University College of Medicine, Seoul, Korea

Abstract

Background: Patients with end-stage renal disease (ESRD) have a higher incidence of clinically relevant complications, such as bleeding and perforation after polyp resection, compared to patients without underlying diseases. Cold snare polypectomy (CSP) is increasingly used for the removal of small polyps and diminutive polyps due to its shorter procedure time and low risk of bleeding and perforation. However, there have been few studies on the effectiveness and safety of CSP in patients with ESRD. The aim of this study was to compare the efficacy and safety of CSP and endoscopic mucosal resection (EMR) in ESRD patients.

Methods: This study was a retrospective study. We performed propensity score-matched analysis in patients with ESRD who underwent endoscopic resection for 3–10-mm-sized colorectal polyps at Seoul St. Mary’s Hospital, from January 2014 to December 2019.

Results: After 1:1 ratio matching, 406 polyps were included: 203 polyps were resected with CSP and 203 polyps with EMR. There was no difference between the CSP group and EMR group in incomplete resection rate (4.43% vs. 1.97%, \(P = 0.16\)). There were no differences between the CSP and EMR group for immediate bleeding (5.42% vs. 7.88%, \(P = 0.32\)) and delayed bleeding (0% vs. 0.49%, \(P = 1.00\)). No perforation occurred in either group.

Conclusions: There were no differences between the CSP and EMR group in terms of efficacy and safety. CSP can be one of the standard methods for the removal of 3–10-mm-sized colorectal polyps in patients with ESRD.

Keywords: Colorectal polyp, Cold snare polypectomy, Endoscopic mucosal resection, End-stage renal disease

INTRODUCTION

Colorectal cancer (CRC) is a major cause of cancer-related mortality and morbidity worldwide.[1] Colonoscopy reduces the incidence of CRC as the endoscopic removal of precancerous polyps prevents the progression to CRC.[2,3]

Endoscopic mucosal resection (EMR) is commonly used for the removal of polyps with the use of snare and an electrosurgical unit for complete resection and hemostasis.[4,5] However, the use of an electrosurgical unit can cause adverse events such as post-polypectomy bleeding.
post-polypectomy perforation, and post-polypectomy coagulation syndrome. Horiuchi et al.\(^6\) reported that post-polypectomy bleeding is related to injury to vessels in the submucosal layer caused by an electrocautery effect. In that study, the rate of injured arteries in the submucosal layer was 39\% after EMR. The researchers speculated that this was a leading cause of post-polypectomy bleeding. Cold snare polypectomy (CSP) has grown in popularity worldwide because of its technical ease and low incidence of adverse events such as post-polypectomy bleeding, perforation, and post-polypectomy coagulation syndrome.\(^4,8,10\) Furthermore, CSP does not require an electrosurgical system and submucosal injector. As a result, CSP has a shorter procedure time and lower cost than EMR. Thus, several clinical guidelines recommend CSP for the removal of small- and diminutive-sized polyps.\(^6,8\) Major adverse events related to polypectomy are bleeding and perforation. Post-polypectomy bleeding and perforation occur in approximately 0.63\%–6.12\% and 0.01\%–0.63\% of cases, respectively.\(^6\) Owing to the aging of the population, a growing prevalence of CKD, and increased comorbidities, the prevalence of end-stage renal disease (ESRD) is increasing worldwide.\(^13\) The removal of colorectal polyps in ESRD patients is also expected to increase. ESRD patients have a high risk of post-polypectomy bleeding and perforation.\(^14,15\) Furthermore, ESRD patients usually have several comorbidities and receive multiple medications. Because of this, safe polypectomy is important in ESRD patients. Recently, several studies were conducted to compare CSP with EMR.\(^6,16–20\) However, no prior studies have compared CSP with EMR in ESRD patients. Therefore, the aim of our study was to compare the efficacy and safety of removal of small colorectal polyps (3–10 mm) by CSP and EMR in ESRD patients.

**METHODS**

**Patients**

This study was conducted in ESRD patients who underwent CSP or EMR for colorectal polyps at Seoul St. Mary’s Hospital, between January 2014 and December 2019. We retrospectively examined 961 colorectal polyps. We only included colorectal polyps that were 3–10 mm in size. ESRD was defined as patients on hemodialysis, patients on peritoneal dialysis, and CKD stage 5 patients scheduled for kidney transplantation or dialysis within 6 months (CKD 5). We excluded pedunculated polyps (Ip) and those less than 3 mm or larger than 10 mm in size. We performed propensity score matching to control and reduce selection bias in the CSP and EMR groups. This study was approved by the Institutional Review Board of the Seoul St. Mary’s Hospital (Approval number: KC20RIS10588).

**Procedures**

All patients underwent bowel preparation with a 4-L of polyethylene glycol (PEG) solution or a 2-L of PEG plus ascorbic acid solution. All procedures were performed by an expert (>1500 colonoscopies performed), endoscopists, and fellowship trainee endoscopists. A high-definition colonoscope (CF-H260AI, CF-H260AL, CF-HQ290I; Olympus, Tokyo, Japan) was used in all procedures. The endoscopic resection methods were selected according to the size, morphology, location of the colorectal polyp, and the endoscopist’s preference. In EMR, normal saline with or without a few drops of indigo carmine solution was used for submucosal injection. A 10- or 15-mm oval snare (Optimos®; Taewoong Medical, Gimpo, Korea; SnareMaster®; or Olympus, Tokyo, Japan) with forced coagulation or EndocutI of the electrosurgical unit (VIO300D; ErbeElektromedizin GmbH, Tübingen, Germany) was used for resection. CSP was performed by using a 10- or 15-mm oval snare (Optimos®; Taewoong Medical, Gimpo, Korea; SnareMaster®; or Olympus, Tokyo, Japan) without an electrosurgical unit and submucosal injection. The polyps were categorized based on the Paris classification.\(^21\) Protruded and superficial colorectal polyps were classified as type I and type II, respectively. The location of colorectal polyps was divided into the right-side colon (from cecum to the splenic flexure), left-side colon (from splenic flexure to the sigmoid colon), and the rectum. The size of each colorectal polyp was estimated by comparing the fully deployed snare of known size. Each resected specimen was reviewed by expert pathologists according to the routine procedure followed at our institution. Histological classification was conducted based on the World Health Organization classification. Adenomas, sessile serrated lesions (SSLs), and hyperplastic polyps (HPs) were classified as colorectal polyp histology. Incomplete resection was defined in cases in which histological lateral or basal positive margins were detected.

**Complications**

Immediate bleeding was defined as continuous bleeding over 30 s requiring any form of endoscopic hemostatic procedure (therapeutic clip or electrocoagulation). Delayed bleeding was defined as hematochezia occurring >12 h after colorectal polypectomy that required an endoscopic hemostatic procedure on a post-polypectomy ulcer. Post-polypectomy ulcers showing bleeding signs (spurting, oozing bleeding, exposed vessels, or adherent clots) at the time of endoscopic evaluation were considered as a culprit site of post-polypectomy bleeding. Perforation was defined as a
target sign in the colonic wall requiring immediate endoscopic intervention. All patients were routinely instructed to visit the outpatient department within 2 weeks to check for any signs or symptoms suggesting delayed adverse complications.

**Statistics**

The Chi-square test or Fisher’s exact test was used for analysis of categorical data. Continuous data were compared using the Mann–Whitney U test. Median values are reported with ranges. Bias was minimized by applying nearest neighbor propensity score matching with a caliper width of 0.02 based on the type of ESRD, presence of hypertension, presence of heart failure, use of anticoagulants, identification of the operator, size of the polyp, and morphology of the polyp. Multivariate analyses were performed using the risk factors that were identified as being significant by univariate analysis. If the standardized mean difference was lower than 0.1, the covariate was considered well-balanced. All statistical analyses were performed using SPSS software (SPSS 21.0 version, Chicago, IL, USA). \( P < 0.05 \) was considered statistically significant.

**RESULTS**

**Baseline characteristics of the subjects**

Initially, 961 colorectal polyps 3–10 mm in size were included in the study. However, 98 colorectal polyps were subsequently excluded because these colorectal polyps were larger than 10 mm in size (n = 73) or pedunculated (n = 25) [Figure 1]. Of the remaining 863 colorectal polyps, 458 (53.07%) were treated with CSP and 405 (46.93%) with EMR. The baseline characteristics of the subjects are presented in Table 1. After 1:1 ratio propensity score matching, 203 colorectal polyps were assigned to the CSP group and 203 to the EMR group. The median age was 58 (22–85) and 57 (33–86) in the CSP and EMR groups \( (P = 0.70) \), respectively. Males comprised 71.43% and 67.49% of the CSP and EMR groups \( (P = 0.39) \), respectively. There were no significant differences between the groups after propensity score matching.

**Outcomes**

There was no significant difference in the incomplete resection rate (4.43% vs. 1.97%, \( P = 0.16 \)) between the CSP and EMR groups. The characteristics of the incomplete resection cases are presented in Supplementary Table 1. The size of colorectal polyps was not significantly different between CSP and EMR groups \( (6 \text{ mm} [3–10 \text{ mm}] \text{ vs. } 6 \text{ mm} [3–10 \text{ mm}], P = 0.90) \). There was no significant difference in the location, morphology, and histology of colorectal polyps between the CSP group and the EMR group. Immediate bleeding was not significantly different between CSP and EMR groups (5.42% vs. 7.88%, \( P = 0.32 \)). The characteristics of the immediate bleeding cases are presented in Supplementary Table 2. One case of delayed bleeding occurred in the EMR group. There was no perforation case in either group [Table 2]. The characteristics of the delayed bleeding case are presented in Supplementary Table 3.

**Risk factors associated with incomplete resection**

The result of univariate analysis conducted to identify the risk factors associated with incomplete resection is presented in Table 3. Only the size of the polyp was significantly associated with incomplete resection \( (\text{OR}: 1.85; 95\% \text{ CI}: 1.30–2.64; P < 0.01) \). There were no other risk factors associated with incomplete resection.

**Risk factors associated with immediate bleeding**

The result of univariate and multivariate analysis conducted to identify the risk factors associated with immediate bleeding is presented in Table 4. In the univariate analysis, immediate bleeding was significantly associated with the size of polyp, superficial morphology, and use of antiplatelet medication. However, in the multivariate analysis, size of polyp \( (\text{OR}: 1.47; 95\% \text{ CI}: 1.11–1.95; P < 0.01) \) and superficial morphology \( (\text{OR}: 3.08; 95\% \text{ CI}: 1.23–7.69; P = 0.02) \) were significantly associated with immediate bleeding.
Table 1: Baseline characteristics before and after propensity score matching

| Before matching | P | SMD | After matching | P | SMD |
|-----------------|----|-----|---------------|----|-----|
|                | CSP (n=458) | EMR (n=405) | CSP (n=203) | EMR (n=203) |
| Age, years (range) | 58 (22-85) | 56 (29-86) | 58 (22-85) | 57 (33-86) |
| Sex, Male | 327 (71.40) | 286 (70.62) | 145 (71.43) | 137 (67.49) |
| Type of ESRD | | | 0.80 | 0.03 |
| HD | 306 (66.81) | 242 (59.75) | 143 (70.44) | 135 (66.50) |
| PD | 80 (17.47) | 77 (19.01) | 21 (10.34) | 32 (15.76) |
| CKD 5 | 72 (15.72) | 86 (21.23) | 39 (19.21) | 36 (17.73) |
| Comorbidity | | | | |
| Hypertension | 362 (79.04) | 345 (85.19) | 168 (82.76) | 171 (84.24) |
| Diabetes | 225 (49.13) | 197 (48.64) | 102 (50.25) | 95 (46.80) |
| Cardiovascular disease | 40 (8.73) | 26 (6.42) | 23 (11.33) | 15 (7.39) |
| Heart failure | 39 (8.52) | 18 (4.44) | 14 (6.90) | 12 (5.91) |
| Chronic liver disease | 9 (1.97) | 7 (1.73) | 2 (0.99) | 4 (1.97) |
| Cerebrovascular disease | 12 (2.62) | 9 (2.22) | 4 (1.97) | 3 (1.48) |
| Antipilet | 149 (32.53) | 124 (30.62) | 29 (14.29) | 23 (11.33) |
| Anticoagulant | 29 (6.33) | 9 (2.22) | 2 (0.99) | 1 (0.49) |
| Operator | | | 0.75 | 0.03 |
| Trainee | 347 (75.75) | 227 (56.05) | 139 (68.47) | 142 (69.95) |
| Expert | 11 (24.24) | 178 (43.95) | 64 (31.53) | 61 (30.05) |

Values are median or n (%). CSP, cold snare polypectomy; EMR, endoscopic mucosal resection; SMD, standardized mean difference.

DISCUSSION

To the best of our knowledge, this was the first study to compare CSP and EMR in ESRD patients. In this study, we found no significant difference in incomplete resection rate between the CSP and EMR group in ESRD patients (4.43% vs. 1.97%; P = 0.16). Several studies in the general population reported that there was no significant difference in incomplete resection rate between the CSP and EMR group, respectively (0.47%–6.41% vs. 1.29%–7.41%). This is similar to the incomplete resection rate found in this study. As reported in previous studies, the size of polyp was associated with incomplete resection in this study also.

ESRD patients are at an increased risk of bleeding because of the following conditions: uremic platelet dysfunction, abnormal platelet-endothelium interaction, use of antiplatelet medication, use of anticoagulants, accumulation of medications in the blood leading to poor clearance, heparin use during dialysis, and hemodialysis itself.

A recent large national cohort study reported that the rates of post-polypectomy bleeding among patients with ESRD were much higher compared with those without ESRD (bleeding: 5.58% vs. 1.75%; P < 0.01). For this reason, safe colon polypectomy was more important in ESRD patients. In the general population, several studies reported that the immediate bleeding rate with CSP and EMR was 1.77%–6.61% and 0%–3.30%, respectively. In this study, we found more frequent immediate bleeding in ESRD patients than in the general population. We believe that the high risk of bleeding in ESRD patients and the use of antithrombotic agents affected

Table 2: Clinical outcomes of CSP and EMR before and after propensity score matching

| Before matching | P | SMD | After matching | P | SMD |
|-----------------|----|-----|---------------|----|-----|
|                | CSP (n=458) | EMR (n=405) | CSP (n=203) | EMR (n=203) |
| Incomplete resection | 13 (2.84) | 16 (3.95) | 9 (4.43) | 4 (1.97) |
| Size, mm (range) | 5 (3-10) | 6 (3-10) | 6 (3-10) | 6 (3-10) |
| Location | | | 0.90 | 0.02 |
| Rt. side | 259 (56.55) | 233 (57.53) | 108 (53.20) | 119 (58.62) |
| Lt. side | 180 (39.30) | 146 (36.05) | 87 (42.86) | 73 (35.96) |
| Rectum | 19 (4.15) | 26 (6.42) | 8 (3.94) | 11 (5.42) |
| Morphology | | | | |
| Superficial | 101 (22.05) | 73 (18.02) | 28 (13.79) | 23 (11.33) |
| Protruded | 357 (77.95) | 332 (81.98) | 175 (86.21) | 180 (88.67) |
| Histology | | | | |
| Adenoma | 329 (71.83) | 305 (75.31) | 147 (72.41) | 149 (73.40) |
| Hyperplastic polyp | 74 (16.16) | 48 (11.85) | 33 (16.26) | 26 (12.81) |
| Sessile serrated lesion | 55 (12.01) | 52 (12.84) | 23 (11.33) | 28 (13.79) |
| Immediate bleeding | 29 (6.33) | 38 (9.38) | 11 (5.42) | 16 (7.88) |
| Delayed bleeding | 3 (0.66) | 6 (1.48) | 0 | 1 (0.49) |
| Perforation | 0 | 0 | 0 | 0 |

Values are median or n (%). CSP, cold snare polypectomy; EMR, endoscopic mucosal resection; SMD, standardized mean difference.
these outcomes. Nevertheless, there was no significant difference in immediate bleeding between CSP and EMR groups (5.42% vs. 7.88%; \( P = 0.32 \)). In addition, immediate bleeding could be adequately controlled by endoscopic hemostatic procedures (therapeutic clipping and electrocautery), and there were no cases that required additional therapeutic treatments such as blood transfusions, hospital admission, or embolization. Kim et al.\(^{26}\) reported that old age (\( \geq 65 \) years), cardiovascular disease, chronic kidney disease, use of anticoagulant agents, poor bowel preparation, large polyps (\( \geq 1 \) cm), pedunculated polyps, laterally spreading tumors, polypectomy with cutting mode of the electrosurgical unit current, and the unwanted cutting of the polyp before current application were risk factors for immediate bleeding. In our study, the size of polyp and superficial morphology were associated with immediate bleeding.

In the general population, several studies reported that delayed bleeding rate with EMR and CSP was 0.37%–1.91% and 0%, respectively.\(^{18,24,26}\) Horiuchi et al.\(^{7}\) also reported that delayed bleeding requiring an endoscopic hemostatic procedure occurred significantly less frequently in the CSP group than in the EMR group, despite continuation of anticoagulants. Delayed bleeding often led to endoscopic hemostatic procedures, hospitalization, blood transfusion, and/or embolization. Therefore, delayed bleeding is clinically significant. In addition, patients with ESRD are more likely to use antithrombotic agents (antiplatelet agents and anticoagulants) than those without underlying diseases, due to comorbidity and dialysis. Several studies have reported that patients who use antithrombotic agents have a higher incidence of bleeding after polypectomy than those who do not use antithrombotic agents.\(^{27,28}\) However, we had only one case of delayed bleeding in our study [Supplementary Table 3]. Future study is needed to confirm our delayed bleeding in CSP of ESRD patient findings.

Although there was no case of perforation in our study, ESRD patients have a higher risk of post-polypectomy perforation. A recent study reported that a higher rate of post-polypectomy perforation occurred in ESRD patients on hemodialysis compared with non-ESRD patients (0.45% vs. 0.02%; OR: 21.17; 95% CI: 5.05–88.73; \( P < 0.01 \)).\(^{18}\) Yang et al.\(^{14}\) reported that the rates of post-polypectomy perforation among ESRD patients were significantly higher compared with those among non-ESRD patients (0.28% vs. 0.04%; \( P < 0.01 \)). CSP does not require an electrosurgical unit. As a result, CSP has virtually no risk of perforation. In the general population, several studies reported that the perforation rate with EMR and CSP was less than 1% and 0%, respectively.\(^{29,30}\)

### Table 3: Risk factors associated with incomplete resection

| Variable          | Univariate OR (95% CI) | Univariate P | Multivariate OR (95% CI) | Multivariate P |
|-------------------|------------------------|--------------|--------------------------|----------------|
| Age               | 0.96 (0.91–1.02)       | 0.18         | Reference                | 0.17           |
| Method            | EMR: Reference         |              | Reference                |                |
| Type of ESRD      | EMR: Reference         |              | Reference                |                |
| CKD 5             | Reference              | 0.84         | 0.63                     | 0.34           |
| HD                | 1.17 (0.25–5.58)       | 0.90         | 1.93 (0.50–7.50)         | 0.63           |
| PD                | 0.82 (0.17–3.87)       | <0.01        | 1.47 (0.30–7.13)         | 0.63           |
| Polyp size        | 1.85 (1.30–2.64)       | <0.01        | 4.33 (0.81–23.13)        | 0.34           |
| Location          |                        |              |                          |                |
| Rt. side          | Reference              | 0.78         | Reference                | 0.60           |
| Lt. side          | 1.19 (0.36–3.96)       | 0.09         | Reference                |                |
| Rectum            | 4.33 (0.81–23.13)      | <0.01        | Reference                |                |
| Morphology        |                        |              |                          |                |
| Protruded         | Reference              | 0.57         | Reference                |                |
| Superficial       | 0.57 (0.07–4.49)       | <0.01        | Reference                |                |
| Histology         |                        |              |                          |                |
| Adenoma           | Reference              | 0.63         | Reference                | 0.54           |
| Hyperplastic polyp| 1.93 (0.50–7.50)       |             | 1.47 (0.30–7.13)         |                |
| Sessile serrated lesion | 1.47 (0.30–7.13)  |   |                        |                |
| Operator          |                        |              |                          |                |
| Trainee           | Reference              | 0.54         | Reference                |                |
| Expert            | 0.67 (0.18–2.46)       | <0.01        | Reference                |                |

\( \text{OR, odds ratio; CI, confidence interval; EMR, endoscopic mucosal resection; CSP, cold snare polypectomy; ESRD, end-stage renal disease; CKD, chronic kidney disease; HD, Hemodialysis; PD, peritoneal dialysis} \)

### Table 4: Risk factors associated with immediate bleeding

| Variable          | Univariate OR (95% CI) | Univariate P | Multivariate OR (95% CI) | Multivariate P |
|-------------------|------------------------|--------------|--------------------------|----------------|
| Age               | 0.97 (0.93–1.01)       | 0.08         | Reference                | 0.32           |
| Method            | EMR: Reference         |              | Reference                |                |
| Type of ESRD      | EMR: Reference         |              | Reference                |                |
| CKD 5             | Reference              | 0.57         | 1.38 (0.46–4.16)         | 0.94           |
| HD                | 1.07 (0.23–4.97)       | <0.01        | 1.48 (1.10–1.95)         |                |
| PD                | 1.47 (1.11–1.95)       |              |                         |                |
| Polyp size        |                        |              |                          |                |
| Location          |                        |              |                          |                |
| Rt. side          | Reference              | 0.41         | Reference                |                |
| Lt. side          | 0.69 (0.29–1.66)       | 0.18         | Reference                |                |
| Rectum            | 2.47 (0.65–9.38)       |              | Reference                |                |
| Morphology        |                        |              |                          |                |
| Protruded         | Reference              | <0.01        | Reference                | 0.02           |
| Superficial       | 3.29 (1.36–7.97)       | <0.01        | Reference                | 3.08 (1.23–7.69) |
| Histology         |                        |              |                          |                |
| Adenoma           | Reference              | 0.71         | Reference                |                |
| Hyperplastic polyp| 1.21 (0.44–3.56)       | 0.20         | Reference                |                |
| Sessile serrated lesion | 0.26 (0.04–1.2)  |   |                        |                |
| Use of antiplatelet|                        |              |                          |                |
| No                | Reference              | 0.04         | Reference                | 0.06           |
| Yes               | 2.60 (1.04–6.49)       |              | Reference                | 2.48 (0.96–6.38) |
| Use of anticoagulant|                       |              |                          |                |
| No                | Reference              | 0.11         | Reference                |                |
| Yes               | 7.25 (0.64–82.61)      |              | Reference                |                |
| Operator          |                        |              |                          |                |
| Trainee           | Reference              | 0.57         | Reference                |                |
| Expert            | 0.77 (0.32–1.88)       | <0.01        | Reference                |                |

\( \text{OR, odds ratio; CI, confidence interval; EMR, endoscopic mucosal resection; CSP, cold snare polypectomy; ESRD, end-stage renal disease; CKD, chronic kidney disease; HD, Hemodialysis; PD, peritoneal dialysis} \)
This study has some limitations. First, it is limited by its retrospective design and by allowing the decision to perform CSP or EMR to be at the operator’s discretion. However, we minimized selection bias and confounding factors by using a propensity score-matched analysis. Second, follow-up data were not collected; the relationship between incomplete resection and local recurrence has therefore not been evaluated. Further studies are needed to determine whether incomplete resection results in local recurrence more frequently after CSP and EMR. Third, procedure times were not evaluated. However, several studies reported that shorter procedure time is an advantage of CSP. CSP does not require electrosurgical unit preparation, submucosal injection, and electrocautery. As a result, the procedure time can be significantly shortened clinically.[7,24] Despite these limitations, our study has several strengths. This is the first study to compare CSP with EMR in ESRD patients. We demonstrated that CSP was useful in ESRD patients. In addition, this study has the advantage of being conducted to include experts and trainees. CSP is technically easy and has a low risk of complications and short procedure time. Trainees can conduct CSP safely in ESRD patients.

In conclusion, we demonstrated the efficacy and safety of CSP in ESRD patients. CSP is a viable treatment method for removal of 3–10 mm-sized colorectal polyps in ESRD patients based on the results of this study. In the future, multicenter randomized controlled trials are needed to confirm our results.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES
1. Sun H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jamal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2021;71:209-249.
2. Winawer SJ, Zauber AG, Ho MN, O’Brien MJ, Gottlieb LS, Sternberg SS, et al. Prevention of colorectal cancer by colonoscopy polypectomy. N Engl J Med 1993;329:1977-81.
3. Kahi CJ, Imperiale TF, Julian BE, Rex DK. Effect of screening colonoscopy on colorectal cancer incidence and mortality. Clin Gastroenterol Hepatol 2009;7:770-5.
4. Ferlitsch M, Moss A, Hassan C, Bhandari P, Dumonceau JM, Pasparitis G, et al. Colorectal polypectomy and endoscopic mucosal resection (EMR): European Society of Gastrointestinal Endoscopy (ESGE) clinical guideline. Endoscopy 2017;49:270-97.
5. Kawamura T, Takeuchi Y, Asai S, Yokota I, Akamine E, Kato M, et al. A comparison of the resection rate for cold and hot snare polypectomy for 4–9 mm colorectal polyps: A multicentre randomised controlled trial (CRESCENT study). Gut 2018;67:1950-7.
6. Papastergiou V, Paraskeva KD, Fragnaci M, Dimas I, Vardas E, Theodoropoulou A, et al. Cold versus hot endoscopic mucosal resection for nonpedunculated colorectal polyps sized 6–10 mm: A randomized trial. Endoscopy 2018;50:403-11.
7. Horiiuchi A, Nakayama Y, Kajiyama M, Tanaka N, Sano K, Graham DY. Removal of small colorectal polyps in anticoagulated patients: A prospective randomized comparison of cold snare and conventional polypectomy. Gastrointest Endosc 2014;79:417-23.
8. Kaltenbach T, Anderson JC, Burke CA, Dominitz JA, Gupta S, Lieberman D, et al. Endoscopic removal of colorectal lesions—recommendations by the US Multi-Society Task Force on Colorectal Cancer. Gastroenterology 2020;158:1095-129.
9. Singh H, Penfold RB, DeCoster C, Kaita I, Proulx C, Taylor G, et al. Colonoscopy and its complications across a Canadian regional health authority. Gastrointest Endosc 2009;69:665-71.
10. Ko C, Dominitz J. Adverse events of colonoscopy: Magnitude and management. Gastrointest Endosc Clin N Am 2010;20:659-71.
11. Arora G, Mannalithara A, Singh G, Gerson LB, Triadafilopoulos G. Risk of perforation from a colonoscopy in adults: A large population-based study. Gastrointest Endosc 2009;69:654-64.
12. Rosen L, Bulh DS, Reed JF 3rd, Nastasea SA. Hemorrhage following colonoscopic polypectomy. Dis Colon Rectum 1993;36:1126-31.
13. Williams ME, Sandeen J, Catic A. Aging and ESRD demographics: Consequences for the practice of dialysis. In Seminars in Dialysis. Wiley Online Library, 2012.
14. Yang SC, Wu CK, Tai WC, Liang CM, Li YC, Yeh WS, et al. Incidence and risk factors of colonoscopic post-polypectomy bleeding and perforation in patients with end-stage renal disease. J Gastroenterol Hepatol 2020;35:1704-11.
15. Imai N, Takeda K, Kuzuya T, Utsumonimi S, Takahashi H, Kasuga H, et al. High incidence of colonic perforation during colonoscopy in hemodialysis patients with end-stage renal disease. Clin Gastroenterol Hepatol 2010;8:55-9.
16. Fujiiya M, Sato H, Ueno N, Sakatani A, Tanaka K, Dokiishi T, et al. Efficacy and adverse events of cold vs hot polypectomy: A meta-analysis. World J Gastroenterol 2016;22:5436-44.
17. Ichise Y, Horiiuchi A, Nakayama Y, Tanaka N. Prospective randomized comparison of cold snare polypectomy and conventional polypectomy for small colorectal polyps. Digestion 2011;84:78-81.
18. Jegadeesan R, Aziz M, Desai M, Sundararajan T, Gorrepati VS, Chandrasekar VT, et al. Hot snare vs. cold snare polypectomy for endoscopic removal of 4–10 mm colorectal polyps during colonoscopy: A systematic review and meta-analysis of randomized controlled studies. Endosc Int Open 2019;7:E708-16.
19. Pasparitis G, Tribonias G, Konstantinidis K, Theodoropoulou A, Vardas E, Vouloukis E, et al. A prospective randomized comparison of cold vs hot snare polypectomy in the occurrence of postpolypectomy bleeding in small colonic polyps. Colorectal Dis 2011;13:345-8.
20. Qu J, Jian H, Li L, Zhang Y, Feng B, Li Z, et al. Effectiveness and safety of cold versus hot snare polypectomy: A meta-analysis. J Gastroenterol Hepatol 2019;34:49-58.
21. The Paris endoscopic classification of superficial neoplastic lesions: Esophagus, stomach, and colon: November 30 to December 1, 2002. Gastrointest Endosc 2003;58:S3-43.
22. Akizawa T, Koshikawa S, Ota K, Kazama M, Mimura N, Hirasawa Y. Nafamostat mesilate: A regional anticoagulant for hemodialysis in patients at high risk for bleeding. Nephron 1993;64:376-81.
23. Kaw D, Malhotra D. Hematology: Issues in the dialysis patient: Platelet dysfunction and end-stage renal disease. In Seminars in Dialysis. Wiley Online Library, 2012.
24. Repici A, Hassan C, Vitetta E, Ferrara E, Manes G, Gullotti G, et al. Safety of cold polypectomy for<10 mm polyps at colonoscopy: A prospective multicenter study. Endoscopy 2012;44:27-31.
25. Kim HS, Kim TI, Kim WH, Kim YH, Kim HJ, Yang SK, et al.
Risk factors for immediate postpolypectomy bleeding of the colon: A multicenter study. Am J Gastroenterol 2006;101:1333-41.

26. Yamashina T, Fukuhara M, Maruo T, Tanke G, Marui S, Sada R, et al. Cold snare polypectomy reduced delayed postpolypectomy bleeding compared with conventional hot polypectomy: A propensity score-matching analysis. Endosc Int Open 2017;5:E587-94.

27. Hui AJ, Wong RM, Ching JY, Hung LC, Chung SC, Sung JJ. Risk of colonoscopic polypectomy bleeding with anticoagulants and antiplatelet agents: Analysis of 1657 cases. Gastrointest Endosc 2004;59:44-8.

28. Shalman D, Gerson L. Systematic review with meta-analysis: The risk of gastrointestinal haemorrhage post-polypectomy in patients receiving anti-platelet, anti-coagulant and/or thienopyridine medications. Aliment Pharmacol Ther 2015;42:949-56.

29. Luigiano C, Consolo P, Scaffidi M, Strangio G, Giacobbe G, Alibrandi A, et al. Endoscopic mucosal resection for large and giant sessile and flat colorectal polyps: A single-center experience with long-term follow-up. Endoscopy 2009;41:829-35.

30. Doniec JM, Löhnert MS, Schniewind B, Bokelmann F, Kremer B, Grimm H. Endoscopic removal of large colorectal polyps. Dis Colon Rectum 2003;46:340-8.
### Supplementary Table 1: Characteristics of incomplete resection cases

| Case no. | Method | Age (yrs) | Sex | Type of ESRD | Size (mm) | Location | Morphology | Histology | Operator |
|----------|--------|-----------|-----|--------------|-----------|----------|------------|-----------|----------|
| 1        | CSP    | 59        | F   | PD           | 9         | Lt. side | Superficial | Adenoma   | expert   |
| 2        | CSP    | 52        | M   | CKD 5        | 7         | Rt. side | Protruded   | Adenoma   | Trainee  |
| 3        | CSP    | 62        | M   | PD           | 6         | Lt. side | Protruded   | SSL       | Trainee  |
| 4        | CSP    | 47        | M   | CKD 5        | 8         | Rt. side | Protruded   | Adenoma   | Trainee  |
| 5        | CSP    | 43        | M   | HD           | 6         | Rt. side | Protruded   | HP        | Trainee  |
| 6        | CSP    | 59        | M   | HD           | 10        | Lt. side | Protruded   | Adenoma   | Trainee  |
| 7        | CSP    | 55        | F   | HD           | 6         | Rectum   | Protruded   | Adenoma   | Trainee  |
| 8        | CSP    | 58        | M   | HD           | 7         | Rt. side | Protruded   | HP        | Expert   |
| 9        | CSP    | 62        | M   | CKD 5        | 8         | Lt. side | Protruded   | HP        | Trainee  |
| 10       | EMR    | 52        | M   | HD           | 6         | Rt. side | Protruded   | SSL       | Trainee  |
| 11       | EMR    | 55        | F   | CKD 5        | 6         | Lt. side | Protruded   | Adenoma   | Trainee  |
| 12       | EMR    | 56        | M   | HD           | 6         | Lt. side | Protruded   | Adenoma   | Expert   |
| 13       | EMR    | 37        | M   | HD           | 5         | Rectum   | Protruded   | Adenoma   | Trainee  |

ESRD, end-stage renal disease; CSP, cold snare polypectomy; PD, peritoneal dialysis; CKD, chronic kidney disease; SSL, sessile serrated lesion; HD, hemodialysis; HP, hyperplastic polyp; EMR, endoscopic mucosal resection

### Supplementary Table 2: Characteristics of immediate bleeding cases

| Case no. | Method | Age (yrs) | Sex | Use of Anti platelet | Use of Anti coagulant | Type of ESRD | Size (mm) | Location | Morphology | Histology | Operator |
|----------|--------|-----------|-----|----------------------|-----------------------|--------------|-----------|----------|------------|-----------|----------|
| 1        | CSP    | 59        | F   | Yes                  | No                    | PD           | 9         | Lt. side | Superficial | Adenoma   | expert   |
| 2        | CSP    | 52        | M   | No                   | No                    | PD           | 10        | Rt. side | Protruded   | Adenoma   | Trainee  |
| 3        | CSP    | 62        | M   | Yes                  | No                    | CKD 5        | 7         | Rt. side | Superficial | Trainee   | Trainee  |
| 4        | CSP    | 59        | M   | Yes                  | No                    | HD           | 6         | Lt. side | Protruded   | Trainee   | Trainee  |
| 5        | CSP    | 52        | M   | No                   | No                    | HD           | 5         | Rt. side | Protruded   | Trainee   | Trainee  |
| 6        | CSP    | 59        | M   | No                   | No                    | HD           | 10        | Lt. side | Protruded   | Trainee   | Trainee  |
| 7        | CSP    | 55        | M   | Yes                  | No                    | HD           | 6         | Rectum   | Protruded   | Trainee   | Trainee  |
| 8        | CSP    | 60        | M   | No                   | No                    | HD           | 6         | Rt. side | Protruded   | SSL       | Trainee  |
| 9        | CSP    | 55        | F   | Yes                  | No                    | HD           | 6         | Rectum   | Protruded   | Trainee   | Trainee  |
| 10       | CSP    | 55        | F   | No                   | No                    | HD           | 6         | Rectum   | Protruded   | Trainee   | Trainee  |
| 11       | CSP    | 48        | F   | No                   | No                    | HD           | 5         | Rt. side | Protruded   | SSL       | Trainee  |
| 12       | EMR    | 60        | F   | No                   | No                    | HD           | 4         | Rt. side | Superficial | Trainee   | Trainee  |
| 13       | EMR    | 59        | M   | Yes                  | No                    | HD           | 5         | Lt. side | Superficial | Trainee   | Trainee  |
| 14       | EMR    | 44        | F   | No                   | No                    | No          | 10        | Rt. side | Superficial | Trainee   | Trainee  |
| 15       | EMR    | 58        | M   | No                   | No                    | HD           | 6         | Lt. side | Superficial | Trainee   | Trainee  |
| 16       | EMR    | 40        | M   | Yes                  | No                    | HD           | 7         | Rt. side | Superficial | Trainee   | Trainee  |
| 17       | EMR    | 47        | F   | No                   | No                    | CKD 5        | 5         | Rt. side | Protruded   | Trainee   | Trainee  |
| 18       | EMR    | 63        | M   | Yes                  | No                    | HD           | 7         | Rt. side | Protruded   | Trainee   | Trainee  |
| 19       | EMR    | 63        | M   | No                   | No                    | HD           | 6         | Rt. side | Protruded   | Trainee   | Trainee  |
| 20       | EMR    | 68        | M   | No                   | No                    | CKD 5        | 5         | Lt. side | Protruded   | Trainee   | Trainee  |
| 21       | EMR    | 47        | M   | No                   | No                    | CKD 5        | 7         | Rt. side | Protruded   | Trainee   | Trainee  |
| 22       | EMR    | 54        | M   | No                   | No                    | HD           | 5         | Rt. side | Protruded   | Trainee   | Trainee  |
| 23       | EMR    | 47        | M   | No                   | No                    | HD           | 7         | Lt. side | Protruded   | Trainee   | Trainee  |
| 24       | EMR    | 47        | M   | No                   | No                    | HD           | 5         | Rt. side | Protruded   | SSL       | Trainee  |
| 25       | EMR    | 57        | M   | No                   | No                    | HD           | 6         | Rt. side | Protruded   | SSL       | Expert   |
| 26       | EMR    | 48        | M   | No                   | No                    | HD           | 6         | Lt. side | Protruded   | SSL       | Expert   |

ESRD, end-stage renal disease; CSP, cold snare polypectomy; PD, peritoneal dialysis; HD, hemodialysis; SSL, sessile serrated lesion; HD, hemodialysis; HP, hyperplastic polyp; EMR, endoscopic mucosal resection

### Supplementary Table 3: Characteristics of delayed bleeding cases

| Case no. | Method | Age (yrs) | Sex | Use of Anti platelet | Use of Anti coagulant | Type of ESRD | Size (mm) | Location | Morphology | Operator |
|----------|--------|-----------|-----|----------------------|-----------------------|--------------|-----------|----------|------------|----------|
| 1        | EMR    | 71        | M   | No                   | No                    | HD           | 5         | Lt. side | Protruded   | Trainee   |

ESRD, end-stage renal disease; EMR, endoscopic mucosal resection; HD, hemodialysis.