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Endoscopic electrocautery as a viable therapeutic option for early-stage colorectal cancer: A population-based cohort study

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Abstract

Background

Technological advances have enabled endoscopic management of early-stage colorectal cancer (CRC) in preference to radical surgery; however, the indications remain largely unclear. This study aimed to explore the prevalence and outcomes of endoscopic electrocautery for CRC.

Methods

Patients diagnosed with early-stage primary CRC and treated with endoscopic electrocautery were retrospectively identified from the Surveillance, Epidemiology, and End Results program. Overall survival (OS) and disease-specific survival (DSS) were compared with those after segmental resection.

Results

A total of 1,648 CRC patients who underwent endoscopic electrocautery were included. In patients with Tis-stage rectal cancer (RC), endoscopic electrocautery provided more favorable OS and DSS than segmental resection (5-year OS: 89.6% vs. 86.5%, p = 0.037; 5-year DSS: 99.4% vs. 95.6%, p = 0.00086). In patients with Tis-stage colon cancer and T1-stage RC, endoscopic electrocautery exhibited similar OS and DSS to segmental resection (**Tis-stage colon cancer**: 5-year OS: 86.2% vs. 89.7%, p = 0.12; **T1-stage RC**: 5-year OS: 90.6% vs. 89.9%, p = 0.98). For T1-stage colon cancer, there was significant oncological disadvantage after endoscopic electrocautery (5-year OS: 82.5% vs. 89.9%, p = 0.013).

Conclusion

For patients with Tis/T1-stage RC and Tis-stage colon cancer, endoscopic electrocautery was oncologically equivalent to segmental resection. Endoscopic electrocautery is a promising technique for early-stage CRC.

Introduction

Colorectal cancer (CRC) is the third most common cancer worldwide, accounting for 10.0% of new cancer cases and 9.4% of new cancer deaths in 2020[1]. CRC remains a great health concern, especially in developed countries, with a high number of older men in the general population having the condition. In countries with a high human development index, the incidence of CRC was 29.0 per 100,000 population in men and 20.0 per 100,000 population in women in 2020, both significantly higher than in countries with a low human development index[1]. In the United States, CRC was estimated to account for 149,500 new cancer cases and 52,980 new cancer deaths by 2021[2].

Currently, treatment of early-stage colorectal cancer presents surgeons and multidisciplinary teams with a dilemma[3]. With advances in screening techniques and the advent of nationwide colorectal cancer screening programs, a high curative rate is expected for these patients[4]. A balance should be established between high-quality tumor clearance obtained by major surgical resection and the underlying risk of postoperative morbidity and mortality. Major surgical resection of CRC is associated with an increased risk of anastomotic leak and poor functional outcome and may lead to higher 30-day postoperative morbidity and longer postoperative hospital stays[5–8]. Technological advances have enabled endoscopy and endoscopy-based local resection to take precedence over radical resection in the treatment of early cancer[3, 9–11]. Initially used to treat frail patients, it is now gaining popularity and greater priority as a first-line curative treatment option.

Endoscopic electrocautery, a procedure that uses heat from an electric current to destroy abnormal tissue, such as those of a tumor or other lesions, is a new technique that utilizes endoscopy to treat benign gastrointestinal lesions and polyps[12]. Endoscopic electrocautery has the advantages of minimal invasiveness, reduced trauma, reduced breeding, and shortened hospitalization. However, there are major concerns that local excision could lead to incomplete excision or subsequent recurrence, namely, treatment failures, which prevent the extension of endoscopy-based tumor resection. It remains controversial whether endoscopic management techniques, including electrocautery, are associated with reduced survival of patients with CRC[3, 10, 13, 14]. Concerns that treatment failures may lead to poor survival outcomes, the undefined scope of local excision, and the lack of high-quality controlled trial data indicate the need for further research to refine the definition of the exact group of patients that might benefit from endoscopic electrocautery without compromising prognosis.

This study aimed to use a population-based dataset to explore the prevalence and outcomes of endoscopic electrocautery for CRC and to investigate the exact group of patients who might benefit from endoscopic electrocautery.

Materials and methods

Data sources and study population

This retrospective population-based, real-world study was performed using data from the Surveillance, Epidemiology, and End Results (SEER) program. The SEER database is a population-based cancer registry that covers nearly 30% of the US population and collects cancer demographics, incidence, survival, and treatment data. Since the SEER database is publicly available, access to the data requires a signed research data agreement form.

Data of all patients diagnosed with the first primary malignant CRC (site codes: C18.0, C18.2-C18.7, C19.9, C20.9) between 2000 and 2017 were extracted from the SEER 18 database (2020 submission) [15]. Patients diagnosed only through autopsy or death certificates were excluded from the study. Positive microscopic confirmation of the tumor was required. We further excluded patients without

complete follow-up information, including the follow-up duration and age at diagnosis. Patients younger than 40 years were also excluded because of the low incidence of CRC. To accurately evaluate the effects of surgical operations, we further excluded patients with advanced-stage cancer or those with cancer of unknown stage; thus, only patients with Tis/T1 -M0-N0 CRC were included in this study. Patients with appendiceal tumors (site codes: C18.1) were not included, as endoscopic electrocautery is not applicable to appendiceal tumors (**Figure S1**). We included all feasible cases treated with endoscopic electrocautery, and cases treated with segmental resection were included as the control group.

Definition of variables

All patients were observed between the time of the first primary diagnosis of CRC and the time of death, exiting the study alive, or at the end of the study (December 31, 2017). Among the patients included in this study, the following variables were evaluated: age at diagnosis, sex, race, year of diagnosis, cancer stage, American Joint Committee on Cancer Staging (AJCC) TNM stage, surgical therapy, histological grade, urban/rural residency at diagnosis, median household income, follow-up time, and vital status at the end of follow-up.

CRC types were categorized into colon cancer and rectal cancer (RC), and colon cancer was further divided according to anatomical site: proximal colon cancer (PCC) and distal colon cancer (DCC). PCCs included cancers of the cecum (site code: C18.0), ascending colon (site code: C18.2), hepatic flexure (site code: C18.3), and transverse colon (site code: C18.4). DCCs included cancers of the splenic flexure (site code: C18.5), descending colon (site code: C18.6), and sigmoid colon (site code: C18.7). RCs included cancers of the rectosigmoid junction (site codes: C19.9) and the rectum (site codes: C20.9).

TNM stage information was based on AJCC 3rd stage codes for patients diagnosed between 2000 and 2003, AJCC 6th stage codes for patients diagnosed between 2004 and 2009, AJCC 7th stage codes for patients diagnosed between 2010 and 2015, and SEER combined stage for patients diagnosed in 2016 and 2017[16].

The SEER program provides detailed site-specific surgical information on the included patients[17, 18]. The interventions for CRC were divided into two major groups: endoscopic electrocautery and major surgery (i.e., segmental resection)[19–21].

Statistical analysis

We analyzed the characteristics of patients with CRC who underwent endoscopic electrocautery and compared them with those of patients who underwent segmental resection. We adopted propensity score matching (PSM) method to match patients treated with endoscopic electrocautery and those undergoing segmental resection[22]. The 1:2 matched patient cohort was used in the survival analyses. The following variables were adopted in the PSM: age, sex, race, Hispanic origin, year of diagnosis,

rural/urban residence, median house-hold income, AJCC T stage, tumor grade, and subsite of tumor. We analyzed the overall survival (OS) and disease-specific survival (DSS) of the patients using the Kaplan-Meier method. The OS rate is defined as the percentage of survivors (all-cause death) after follow-up. The DSS rate is defined as the percentage of patients who have not died from CRC (rather than from other causes) in a defined period [23]. The comparison of OS and DSS between different groups was performed using log-rank tests. Independent of PSM method, COX regression models were used to further assess the significance of differences in OS and DSS analyses. To further avoid the influence of patients' baseline characteristics, tumor characteristics, and socioeconomic factors, OS and DSS analyses were performed using a COX regression model adjusted for age at cancer diagnosis, sex, race, year of diagnosis, median household income, urban/rural residency at diagnosis, tumor grade, tumor stage, and tumor site.

All analyses were performed using the SEER*Stat software version 8.3.8 and R 3.6.3. Tests were two-tailed, with a p-value of less than 0.05 considered statistically significant.

Results

Baseline characteristics

From 543,326 patients with first primary CRC, we identified 2,517 (0.5%) patients treated with endoscopic electrocautery. Following the inclusion and exclusion criteria, we selected 1,648 eligible cases for analyses, among whom 277 died (16.8%) (Table 1, **Table S1**, Fig. 1, and **Figure S1**). The median follow-up time was 5.5 (range:0-17.8) years. Compared with the considerable number of patients with CRC who underwent segmental resection (N = 28,367), the number of patients undergoing endoscopic electrocautery was small. Among the patients with CRC treated with endoscopic electrocautery, 56.0% (N = 923) had RC, 35.0% (N = 577) had DCC, and 9.0% (N = 148) had PCC. About 49.4% of the patients undergoing endoscopic electrocautery had Tis-stage cancer, while the remaining 50.6% had T1-stage diseases (Table 1).

Compared to those undergoing segmental resection, the patients receiving endoscopic electrocautery were younger (40–59 years: 47.3% vs. 39.9%, $p < 0.001$), diagnosed more recently (2010–2017: 57.3% vs. 40.8%, $p < 0.001$), with earlier-stage tumor (Tis-stage: 49.4% vs. 21.9%, $p < 0.001$), and with a tumor located more in rectum (RC: 56.0% vs. 36.0%, $p < 0.001$) (Table 1).

Table 1
Characteristics of CRC patients treated with endoscopic electrocautery from 2000 to 2017.

Characteristics	Interventions				p[1]
	Endoscopic electrocautery		Segmental resection		
No. of patients (%)	No. of deaths (%)		No. of patients (%)	No. of deaths (%)	
Total	1,648 (100%)	277 (100%)	28,367 (100%)	6,522 (100%)	
Age at diagnosis					< 0.001
40–59	780 (47.3%)	47 (17.0%)	11,323 (39.9%)	1,120 (17.2%)	
60–79	868 (52.7%)	230 (83.0%)	17,044 (60.1%)	5,402 (82.8%)	
Sex					0.06
Female	689 (41.8%)	110 (39.7%)	12,539 (44.2%)	2,531 (38.8%)	
Male	959 (58.2%)	167 (60.3%)	15,828 (55.8%)	3,991 (61.2%)	
Race					< 0.001
White	1,235 (74.9%)	223 (80.5%)	22,712 (80.1%)	5,423 (83.1%)	
Black	191 (11.6%)	31 (11.2%)	2,734 (9.6%)	674 (10.3%)	
American Indian/Alaska Native	7 (0.4%)	2 (0.7%)	169 (0.6%)	33 (0.5%)	
Asian or Pacific Islander	174 (10.6%)	21 (7.6%)	2,595 (9.1%)	389 (6%)	
Unknown	41 (2.5%)	0 (0%)	157 (0.6%)	3 (0.05%)	
Hispanic origin					0.9
Non-Hispanic	1,496 (90.8%)	261 (94.2%)	25,717 (90.7%)	6,020 (92.3%)	
Hispanic	152 (9.2%)	16 (5.8%)	2,650 (9.3%)	502 (7.7%)	
Notes:					

Characteristics	Interventions				p[1]
	Endoscopic electrocautery		Segmental resection		
No. of patients (%)	No. of deaths (%)		No. of patients (%)	No. of deaths (%)	
Year of diagnosis					< 0.001
2000–2004	213 (12.9%)	84 (30.3%)	8,225 (29.0%)	3,395 (52.1%)	
2005–2009	490 (29.7%)	114 (41.2%)	8,581 (30.2%)	2,140 (32.8%)	
2010–2017	945 (57.3%)	79 (28.5%)	11,561 (40.8%)	987 (15.1%)	
Rural/Urban status					< 0.001
Rural	314 (19.1%)	70 (25.3%)	3,796 (13.4%)	1,039 (15.9%)	
Urban	1,333 (80.9%)	206 (74.4%)	24,522 (86.4%)	5,472 (83.9%)	
Unknown	1 (0.1%)	1 (0.4%)	49 (0.2%)	11 (0.2%)	
Median household income					0.048
Low	24 (1.5%)	2 (0.7%)	513 (1.8%)	140 (2.1%)	
Median	1,176 (71.4%)	205 (74.0%)	19,323 (68.1%)	4,543 (69.7%)	
High	448 (27.2%)	70 (25.3%)	8,525 (30.1%)	1,836 (28.2%)	
Unknown	0 (0%)	0 (0%)	6 (0.02%)	3 (0.05%)	
AJCC T stage					< 0.001
Tis	814 (49.4%)	149 (53.8%)	6,202 (21.9%)	1,530 (23.5%)	
T1	834 (50.6%)	128 (46.2%)	22,165 (78.1%)	4,992 (76.5%)	
Grade					< 0.001
Notes:					

Characteristics	Interventions				p[1]
	Endoscopic electrocautery		Segmental resection		
No. of patients (%)	No. of deaths (%)		No. of patients (%)	No. of deaths (%)	
Grade I/II	739 (44.8%)	115 (41.5%)		19,982 (70.4%)	4,550 (69.8%)	
Grade III/IV	67 (4.1%)	13 (4.7%)		1,643 (5.8%)	360 (5.5%)	
Ungraded	842 (51.1%)	149 (53.8%)		6,742 (23.8%)	1,612 (24.7%)	
Anatomic sites						< 0.001
PCC	148 (9.0%)	47 (17.0%)		4,740 (16.7%)	1,144 (17.5%)	
Cecum	33 (2.0%)	11 (4.0%)		1,640 (5.8%)	394 (6.0%)	
Ascending Colon	58 (3.5%)	12 (4.3%)		1,374 (4.8%)	314 (4.8%)	
Hepatic Flexure	18 (1.1%)	4 (1.4%)		271 (1.0%)	56 (0.9%)	
Transverse Colon	39 (2.4%)	20 (7.2%)		1,455 (5.1%)	380 (5.8%)	
DCC	577 (35.0%)	110 (39.7%)		13,411 (47.3%)	2,979 (45.7%)	
Splenic Flexure	11 (0.7%)	2 (0.7%)		438 (1.5%)	106 (1.6%)	
Descending Colon	69 (4.2%)	16 (5.8%)		1,047 (3.7%)	225 (3.4%)	
Sigmoid Colon	497 (30.2%)	92 (33.2%)		11,926 (42.0%)	2,648 (40.6%)	
RC	923 (56.0%)	120 (43.3%)		10,216 (36.0%)	2,399 (36.8%)	
Rectosigmoid Junction	97 (5.9%)	14 (5.1%)		3,812 (13.4%)	899 (13.8%)	
Rectum	826 (50.1%)	106 (38.3%)		6,404 (22.6%)	1,500 (23.0%)	
Notes:						

[1] The p-values were calculated by Fisher exact test or Person chi2 test. The p-values were 2-sides.

Survival analysis of endoscopic electrocautery for CRC

The tumor characteristics significantly differed between patients receiving endoscopic electrocautery and those undergoing segmental resection (Table 1), thus we adopted PSM method to select 1:2 matched patients' cohort in the subsequent survival analyses (Figs. 2, Fig. 4 **and** Fig. 6). We have now compared the standardized mean differences before and after PSM. Nearly all of the standardized mean differences were minimized to a particularly low level after PSM, indicating the sample selection in the two groups was balanced (**Figure S2, Table S2**).

In patients with colon cancer, endoscopic electrocautery exhibited significantly worse OS but similar DSS to segmental resection (5-year OS: 84.9% vs. 90.4%, p = 0.00089; 5-year DSS: 98.0% vs. 98.5%, p = 0.34) (Fig. 2A-2B). In patients with RC, endoscopic electrocautery was associated with similar OS but significantly improved DSS than segmental resection (5-year OS: 90.2% vs. 89.3%, p = 0.41; 5-year DSS: 98.0% vs. 95.6%, p = 0.019) (Fig. 2C-2D).

We then performed univariable COX analyses for patients with colon cancer (DCC and PCC) and rectal cancer, respectively. In univariable COX analyses of OS in patients with colon cancer, OS after endoscopic electrocautery was similar as that after segmental resection in DCC (HR = 1.09, 95% CI: 0.90–1.32, p = 0.4), while OS after endoscopic electrocautery was significantly worse than that after segmental resection in PCC (HR = 1.91, 95% CI: 1.43–2.56, p < 0.001) (Fig. 3A). In univariable COX analyses of OS in patients with RC, OS after endoscopic electrocautery was significantly prolonged than that after segmental resection (HR = 0.76, 95% CI: 0.63–0.92, p = 0.003).

To avoid the influence of patients' baseline characteristics, analyses of tumor characteristics, and socioeconomic factors, OS were further performed for colon cancer (DCC and PCC) and RC, using a COX regression model adjusted for age at cancer diagnosis, sex, race, year of diagnosis, median household income, urban/rural residency at diagnosis, cancer stage, and tumor grade (all the adjusted COX models used these factors thereafter). For RC and DCC, there was no significant difference in the OS between endoscopic electrocautery and segmental resection after adjustments (RC: HR = 0.87, 95% CI: 0.72–1.05, p = 0.1; DCC: HR = 1.18, 95% CI: 0.97–1.43, p = 0.1). For PCC, OS after endoscopic electrocautery remained significantly worse (PCC: HR = 2.30, 95% CI: 1.71–3.10, p < 0.001) (Fig. 3B). The trends in the univariable and multivariable COX analyses were similar (Fig. 3A-3B).

In COX analyses of DSS of patients with DCC, DSS after endoscopic electrocautery was significantly improved than that after segmental resection in both unadjusted and adjusted COX models (unadjusted: HR = 0.49, 95% CI: 0.32–0.73, p = 0.0005; adjusted: HR = 0.55, 95% CI: 0.36–0.83, p = 0.004) (Fig. 3C-3D).

Survival analysis of endoscopic electrocautery for Tis-stage CRC

In patients with Tis-stage colon cancer, endoscopic electrocautery exhibited similar long-term OS and DSS to segmental resection (5-year OS: 86.2% vs. 89.7%, p = 0.12; 5-year DSS: 98.3% vs. 99.0%, p = 0.6) (Fig. 4A-4B). In patients with Tis-stage RC, endoscopic electrocautery was associated with significantly prolonged OS and DSS than segmental resection (5-year OS: 89.6% vs. 86.5%, p = 0.037; 5-year DSS: 99.4% vs. 95.6%, p = 0.00086) (Fig. 4C-4D).

In univariable COX analyses of OS in patients with Tis-stage RC, OS after endoscopic electrocautery was significantly better than that after segmental resection (**RC**: HR = 0.67, 95% CI:0.50–0.89, p = 0.006). In univariable COX analyses of OS in patients with Tis-stage colon cancer, OS after endoscopic electrocautery was similar to that after segmental resection in Tis-stage DCC (DCC: HR = 1.04, 95% CI:0.80–1.34, p = 0.8), while OS after endoscopic electrocautery was significantly worse than that after segmental resection in Tis-stage PCC (PCC: HR = 1.94, 95% CI: 1.34–2.80, p < 0.001) (Fig. 5A). In multivariable COX analyses of OS in patients with Tis-stage RC, OS after endoscopic electrocautery was similar to that of segmental resection (RC: HR = 0.75, 95% CI: 0.56–1.01, p = 0.06). In multivariable COX analyses of OS in patients with Tis-stage colon cancer, there was no significant difference in the OS between endoscopic electrocautery and segmental resection in and Tis-stage DCC (DCC: HR = 1.14, 95% CI: 0.88–1.48, p = 0.3), while OS after endoscopic electrocautery was significantly worse than that after segmental resection in Tis-stage PCC (**PCC**: HR = 2.11, 95% CI: 1.45–3.07, p < 0.001) (Fig. 5B).

The DSS of patients with Tis-stage RC who underwent endoscopic electrocautery was significantly higher than that of patients who underwent segmental resection in both univariable and multivariable COX analyses (univariable: HR = 0.25, 95% CI: 0.10–0.61, p = 0.002; multivariable: HR = 0.29, 95% CI: 0.12–0.72, p = 0.007) (Fig. 5C-5D). There was no significant difference in DSS between endoscopic electrocautery and segmental resection in both Tis-stage DCC and Tis-stage PCC (all p > 0.05) (Fig. 5C-5D).

Survival analysis of endoscopic electrocautery for T1-stage CRC

In patients with T1-stage colon cancer, endoscopic electrocautery was associated with significantly worse long-term OS and similar DSS than segmental resection (5-year OS: 82.5% vs. 89.9%, p = 0.013; 5-year DSS: 97.4% vs. 98.8%, p = 0.38) (Fig. 6A-6B). In patients with T1-stage RC, OS and DSS after endoscopic electrocautery were similar to segmental resection (5-year OS: 90.6% vs. 89.9%, p = 0.98; 5-year DSS: 96.8% vs. 94.9%, p = 0.5) (Fig. 6C-6D).

In univariable COX analyses of OS in patients with T1-stage RC, OS after endoscopic electrocautery was similar as that after segmental resection (HR = 0.81, 95% CI: 0.64–1.03, p = 0.09). In univariable COX analyses of OS in patients with T1-stage colon cancer, OS after endoscopic electrocautery was similar as that after segmental resection in T1-stage DCC (HR = 1.18, 95% CI: 0.88–1.60, p = 0.3), while OS after endoscopic electrocautery was significantly worse than that after segmental resection in T1-stage PCC (HR = 2.15, 95% CI: 1.31–3.53, p = 0.002) (Fig. 7A). In multivariable COX analyses of OS in patients with T1-stage RC, there was no significant difference in OS between endoscopic electrocautery and

segmental resection (HR = 1.16, 95% CI: 0.79–1.40, p = 0.1). In multivariable COX analyses of OS in patients with T1-stage colon cancer, there was no significant difference in OS between endoscopic electrocautery and segmental resection for T1-stage DCC (HR = 0.96, 95% CI: 0.75–1.22, p = 0.7); however, for T1-stage PCC, OS after endoscopic electrocautery remained significantly unfavorable (HR = 2.70, 95% CI: 1.62–4.48, p < 0.001) (Fig. 7B). In univariable and multivariable COX analyses of DSS for T1-stage RC/DCC/PCC, there was no significant difference between endoscopic electrocautery and segmental resection in T1-stage RC/DCC/PCC (all p > 0.05) (Fig. 7C-7D), probably due to low number of events.

Discussion

The CRC cohort from SEER provided us with a sufficient number of cases treated with endoscopic electrocautery to explore the applications and efficacy of endoscopic electrocautery for early-stage CRC. The key findings suggest that although the application rate of endoscopic electrocautery was relatively low (0.5%), the prognosis of patients who underwent endoscopic electrocautery was equivalent or superior to that of segmental resection in Tis/T1-stage RC and Tis-stage colon cancer. However, endoscopic electrocautery exhibited a significant oncological disadvantage for PCC. These findings will assist in the exploration of the indications for endoscopic electrocautery for CRC.

Our results suggest that endoscopic electrocautery provides excellent tumor control for RC, and its applications in RC can be extended to T1-stage disease. The endoscopic procedure was superior to major resection because of the preservation of organ function and reduction of surgical trauma. The current evidence on endoscopic management of CRC is mainly restricted to endoscopic excision: there is insufficient high-quality evidence on endoscopic electrocautery[3, 10, 24, 25]. Endoscopic managements have the advantages of limited invasiveness, lower operative time, minimal blood loss, minimized damage to muscle tissue, lower risk of complications, reduced healing times, fewer post-operative side effects, and smaller scars after surgery compared to open surgery. A retrospective comparison of endoscopic management and open surgery for early colorectal cancer indicated a better quality of life for patients after endoscopic procedures[26]. For RC, endoscopic management was easier to be conducted due to the short distance to the anus. Our study revealed that the prognosis after endoscopic electrocautery in Tis-stage RC was better than major resection.

For colon cancer, the application of endoscopic electrocautery should be limited to Tis-stage lesions. Especially for early-stage PCC, major resection remains more curative than endoscopic electrocautery. Although increasing evidence supports endoscopic resection in CRC[31, 32], there is nearly no evidence to support endoscopic management of PCC[33]. Besides, patients with PCC are likely to be older and female and present with advanced diseases, larger tumor sizes, and more poorly differentiated tumor cells than those with DCC[34–36]. The disparities in characteristics of PCC and DCC are thought to be generated from the differences in embryologic origin, fecal exposure, and delayed detection time[34]. Most studies have indicated that PCC was associated with a higher recurrence and lower survival rate than DCC[34, 37, 38]. Therefore, radical or segmental resection with complete tumor clearance might be

the optimized choice for patients with PCC. Another interpretation of this phenomenon might be the increased implementation difficulty of endoscopy-based procedures for proximal colon due to the accumulated distance from anus, which would not only restrict the therapeutic efficiency of endoscopic electrocautery for PCC, but also reduce the application of transanal endoscopic microsurgery in PCC. Only 4–25% of colonoscopy scopes reach the ascending colon, and colonoscopies are often terminated in the sigmoid colon (22–43%) or rectum (6–10%)[39–42]. Our results also show the lack of favor for the application of endoscopic electrocautery for PCC, indicating a less frequent application rate and unfavorable prognosis.

Although endoscopic electrocautery showed oncological superiority for Tis/T1-stage rectal cancer and Tis-stage colon cancer, caution should be exercised in clinical practice to avoid treatment failure. Strict selection criteria should be developed to identify patients who might benefit from these technological advances, and their long-term outcomes should be monitored to ensure safety. Timely salvage surgery is required when early failure after endoscopic electrocautery is discovered [43]. A comprehensive assessment should be performed before the procedure to evaluate the possibility of complete tumor clearance. Active post-surgery endoscopic surveillance for CRC patients undergoing endoscopic electrocautery can also promptly detect recurrence [44]. Endoscopic managements had the risks of recurrence from undetected lymph node involvements, some of which cannot be identified via radiology. Endoscopic electrocautery relies on imageology to exclude the underlying lymph node involvements, but some lymph node involvements must be identified via pathologic approach. Adjacent radiotherapy or chemotherapy was needed for the high-risk patients.

There are some limitations to this study. Firstly, given to its descriptive and retrospective study design, we could not prospectively assess the effects of surgical interventions in patients with CRC, and could not draw causal inferences. Secondly, we could not assess the physical conditions, comorbidities and other health factors of the patients. Thirdly, our data only included data on malignant cancers, but in the absence of data on the type of polyps. This may have an effect on the findings, and researchers should take caution regarding further interpretations of the data.

Conclusions

In conclusion, although endoscopic electrocautery is less frequently adopted for CRC, it is oncologically equivalent to segmental resection in Tis/T1-stage RC and Tis-stage colon cancer. For colon cancer, endoscopic electrocautery can only be adopted for Tis-stage lesions, and the application of endoscopic electrocautery for RC can be extended to T1-stage tumors. However, the efficacy of endoscopic electrocautery for PCC is unsatisfactory. Advances in endoscopic electrocautery make it a promising technique for early-stage CRC, and selection criteria should be developed to identify patients who might benefit from it.

Declarations

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Data availability statement: All data used in this study can be freely accessed from the SEER program (https://seer.cancer.gov/).

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Figures

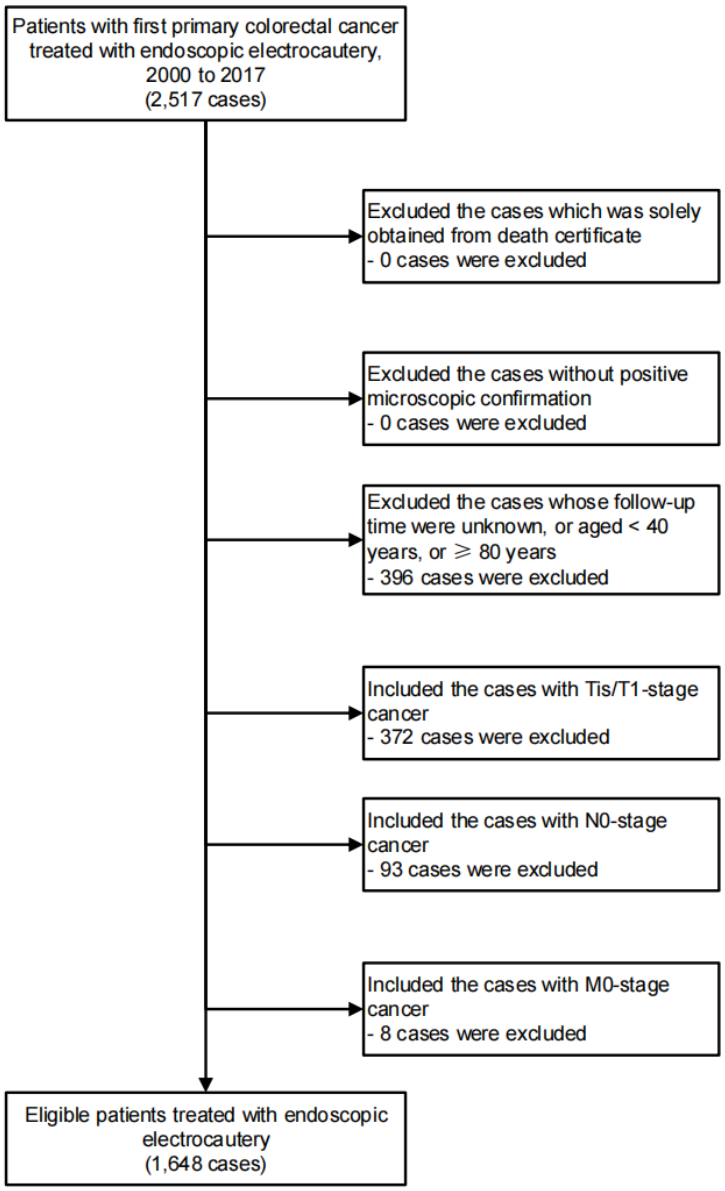


Figure 1

Inclusion and exclusion criteria for CRC patients treated by endoscopic electrocautery.

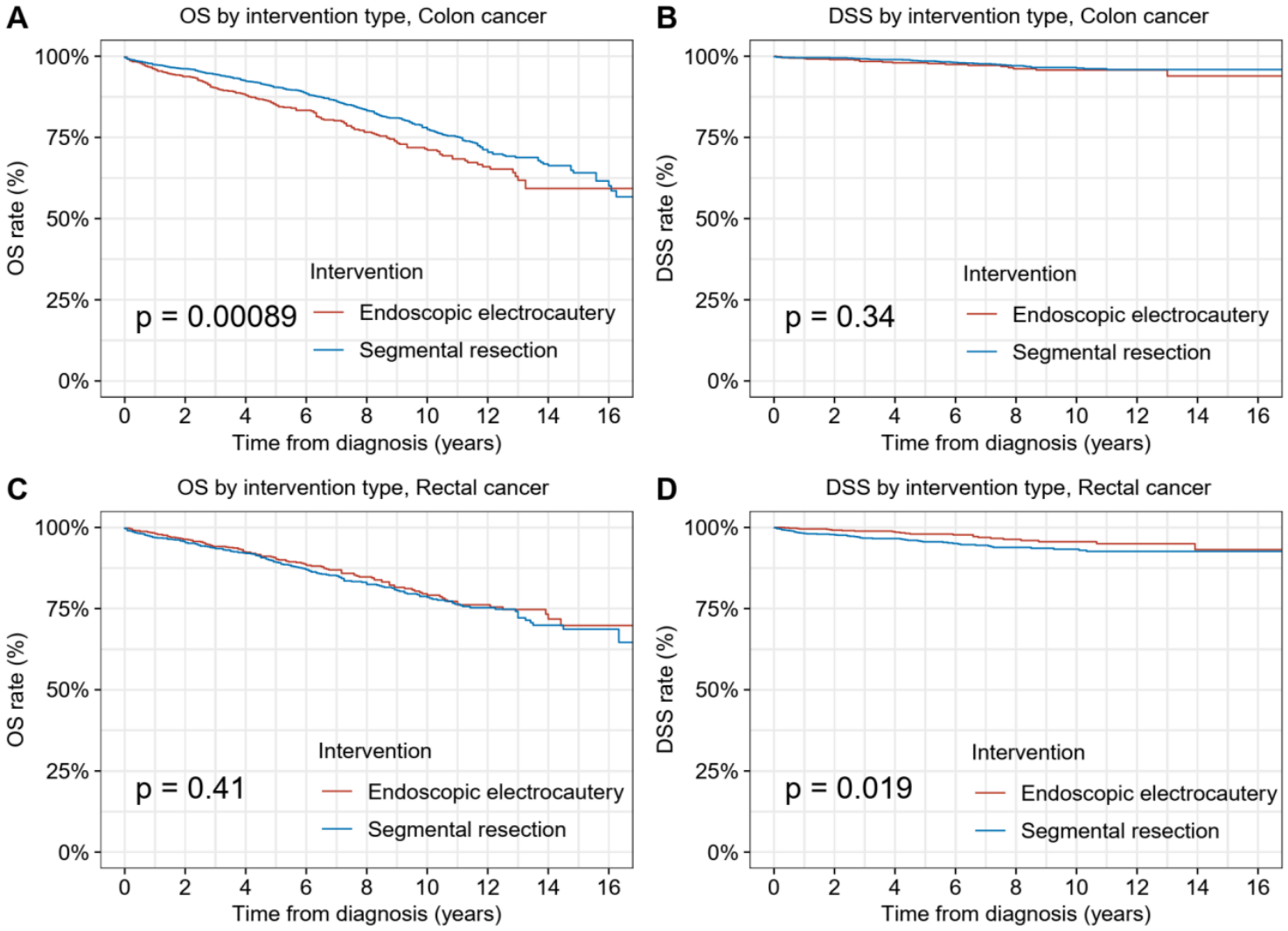


Figure 2

Overall survival (OS) and disease-specific survival (DSS) of patients with early-stage colon cancer and rectal cancer treated by endoscopic electrocautery and segmental resection. (A) OS and (B) DSS of patients with early-stage colon cancer treated by endoscopic electrocautery and segmental resection. (C) OS and (D) DSS of patients with early-stage rectal cancer treated by endoscopic electrocautery and segmental resection.

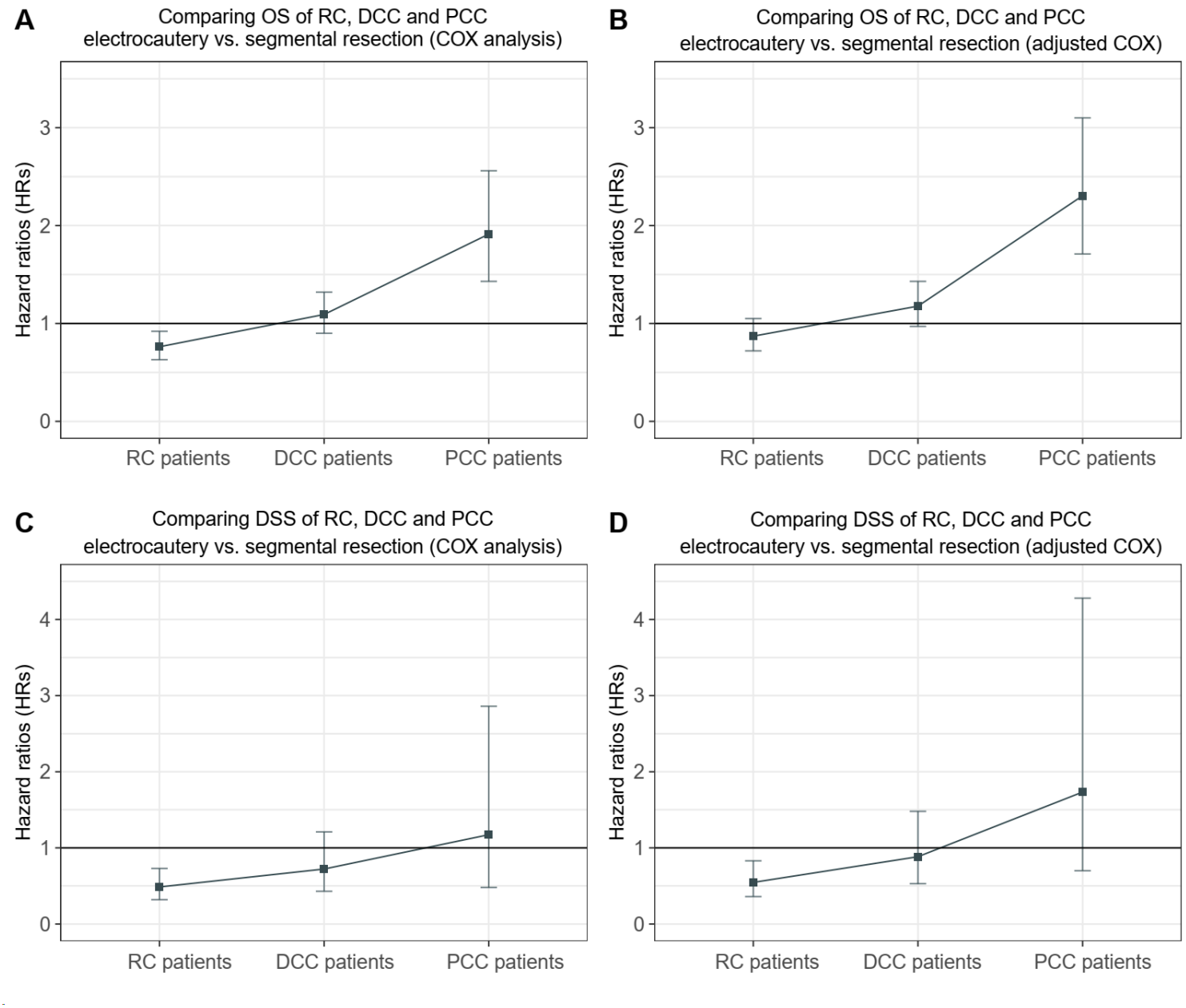


Figure 3

Univariable and multivariable COX analyses to compare overall survival (OS) and disease-specific survival (DSS) of patients with early-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection. (A) Univariable and (B) multivariable COX analyses to compare OS of patients with early-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection. (C) Univariable and (D) multivariable COX analyses to compare DSS of patients with early-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection.

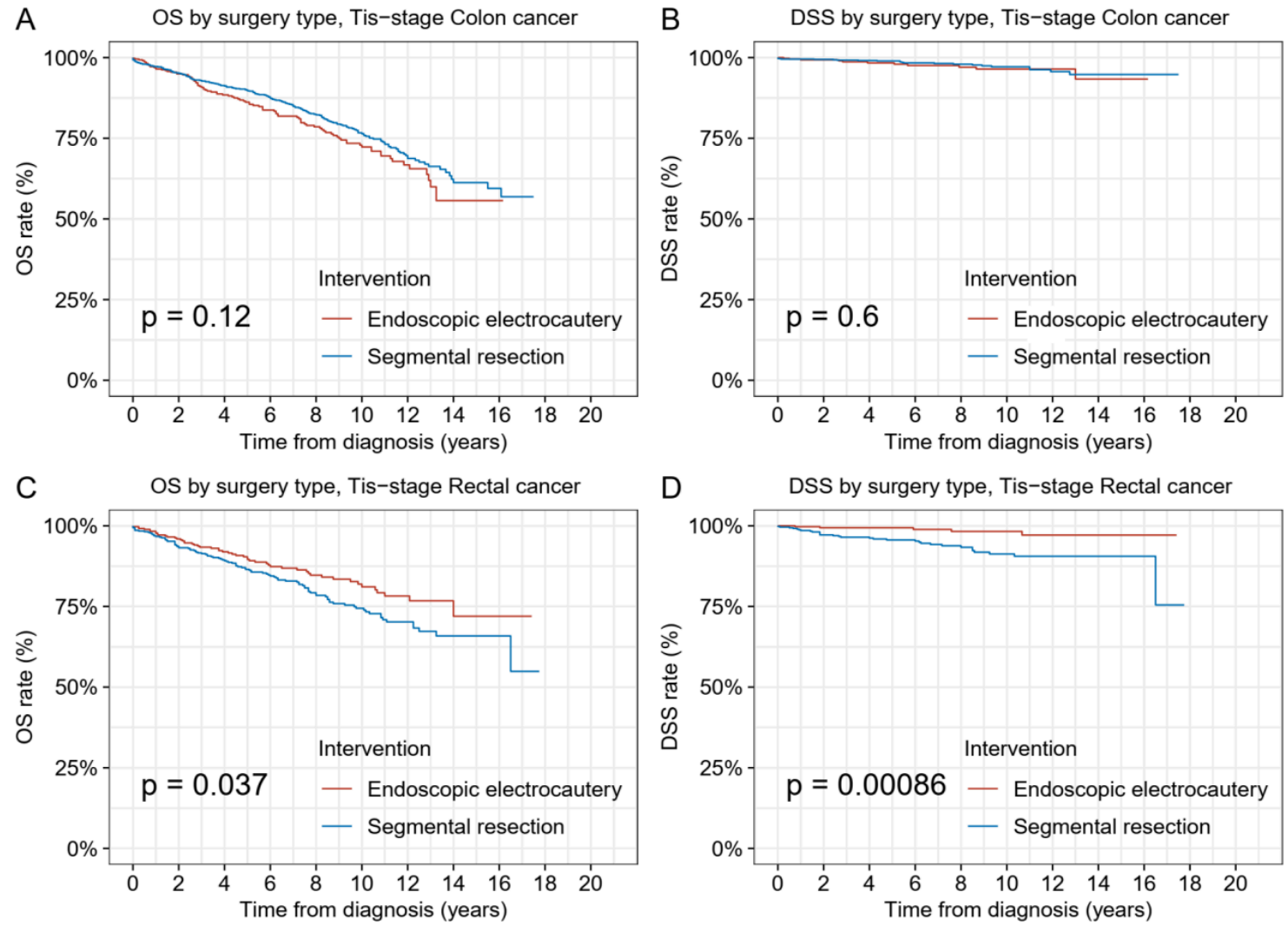


Figure 4

Overall survival (OS) and disease-specific survival (DSS) of patients with Tis-stage colon cancer and rectal cancer treated by endoscopic electrocautery and segmental resection. (A) OS and (B) DSS of patients with Tis-stage colon cancer treated by endoscopic electrocautery and segmental resection. (C) OS and (D) DSS of patients with Tis-stage rectal cancer treated by endoscopic electrocautery and segmental resection.

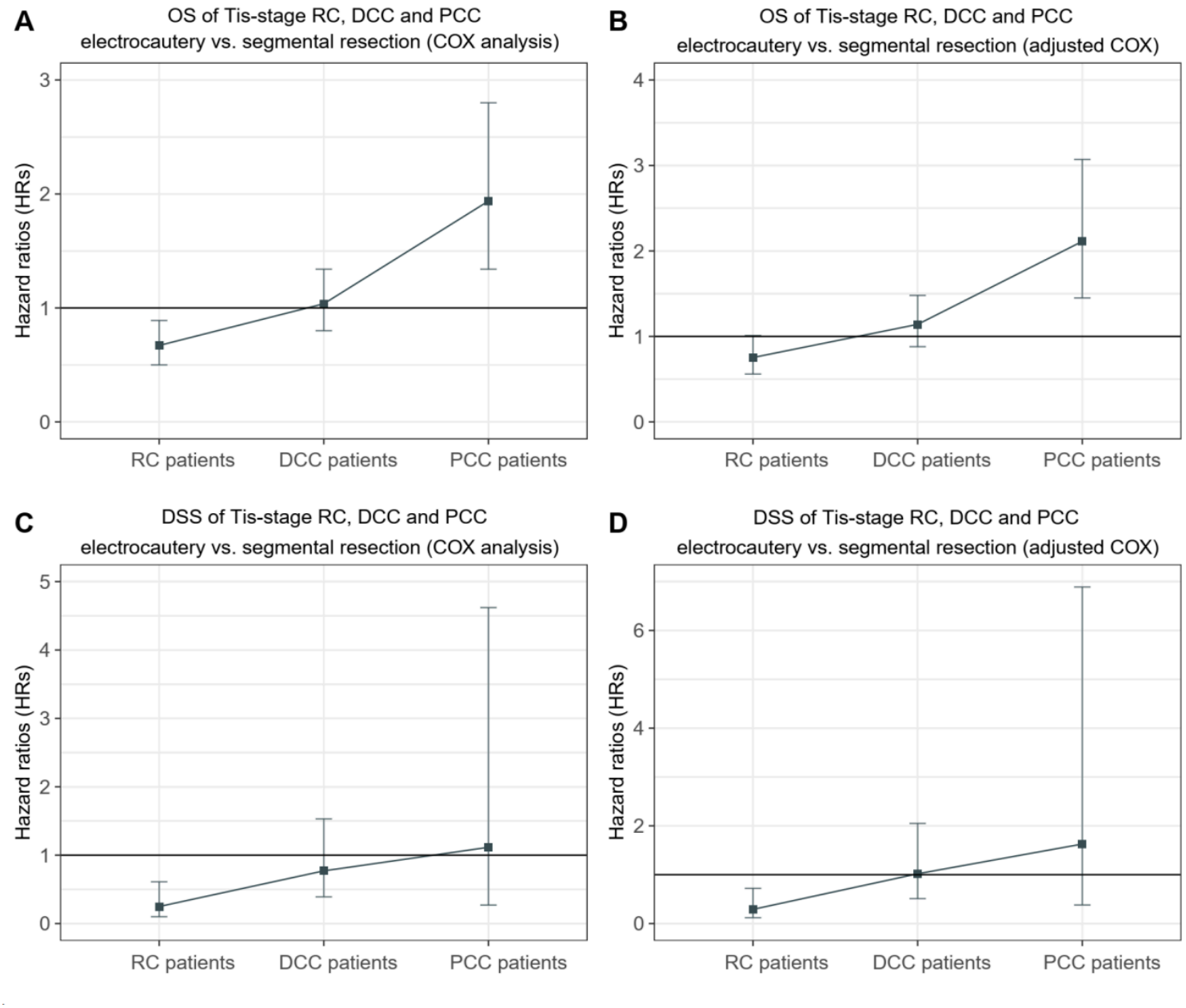


Figure 5

Univariable and multivariable COX analyses to compare overall survival (OS) and disease-specific survival (DSS) of patients with Tis-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection. (A) Univariable and (B) multivariable COX analyses to compare OS of patients with Tis-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection. (C) Univariable and (D) multivariable COX analyses to compare DSS of patients with Tis-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection.

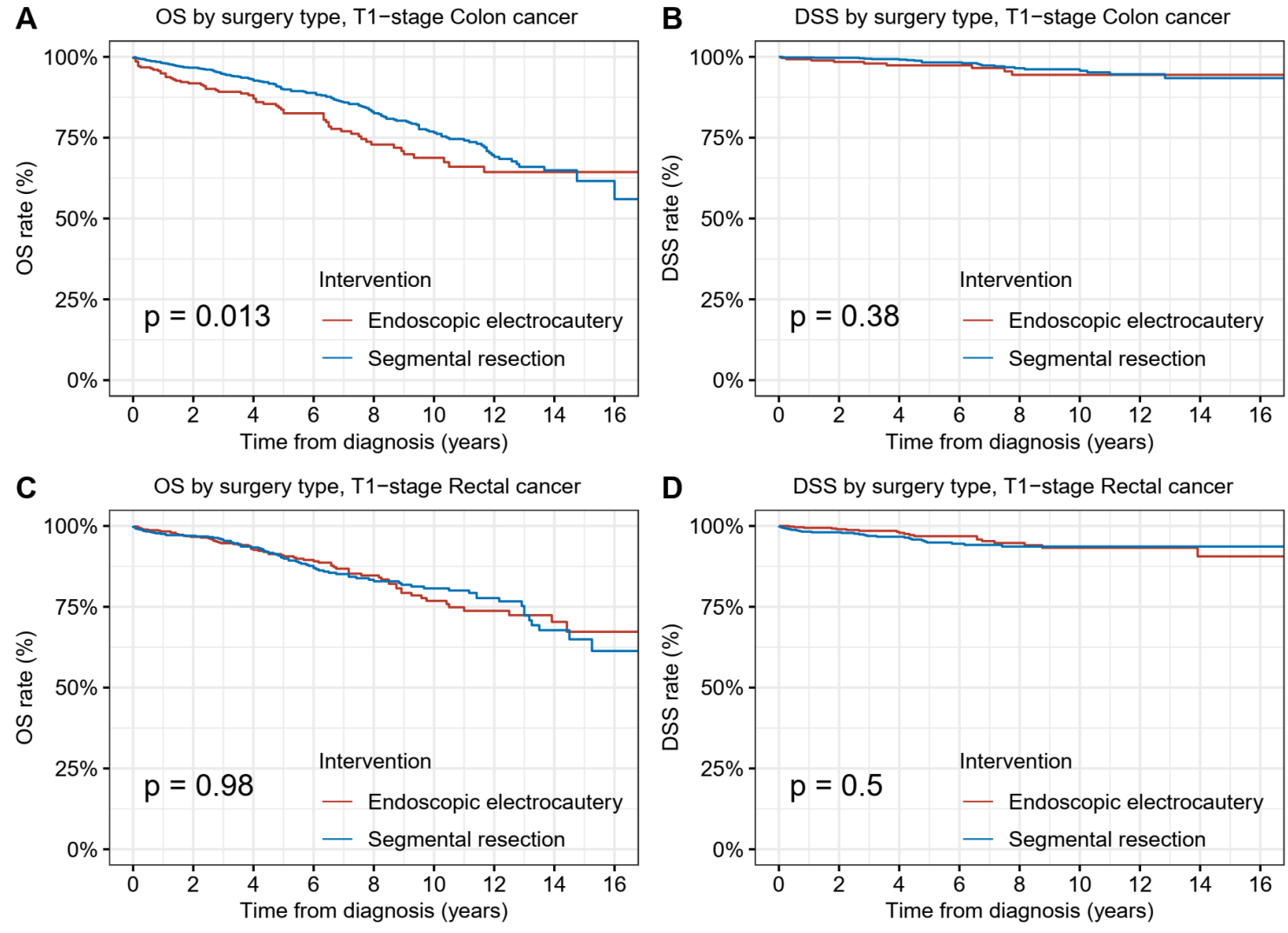


Figure 6

Overall survival (OS) and disease-specific survival (DSS) of patients with T1-stage colon cancer and rectal cancer treated by endoscopic electrocautery and segmental resection. (A) OS and (B) DSS of patients with T1-stage colon cancer treated by endoscopic electrocautery and segmental resection. (C) OS and (D) DSS of patients with T1-stage rectal cancer treated by endoscopic electrocautery and segmental resection.

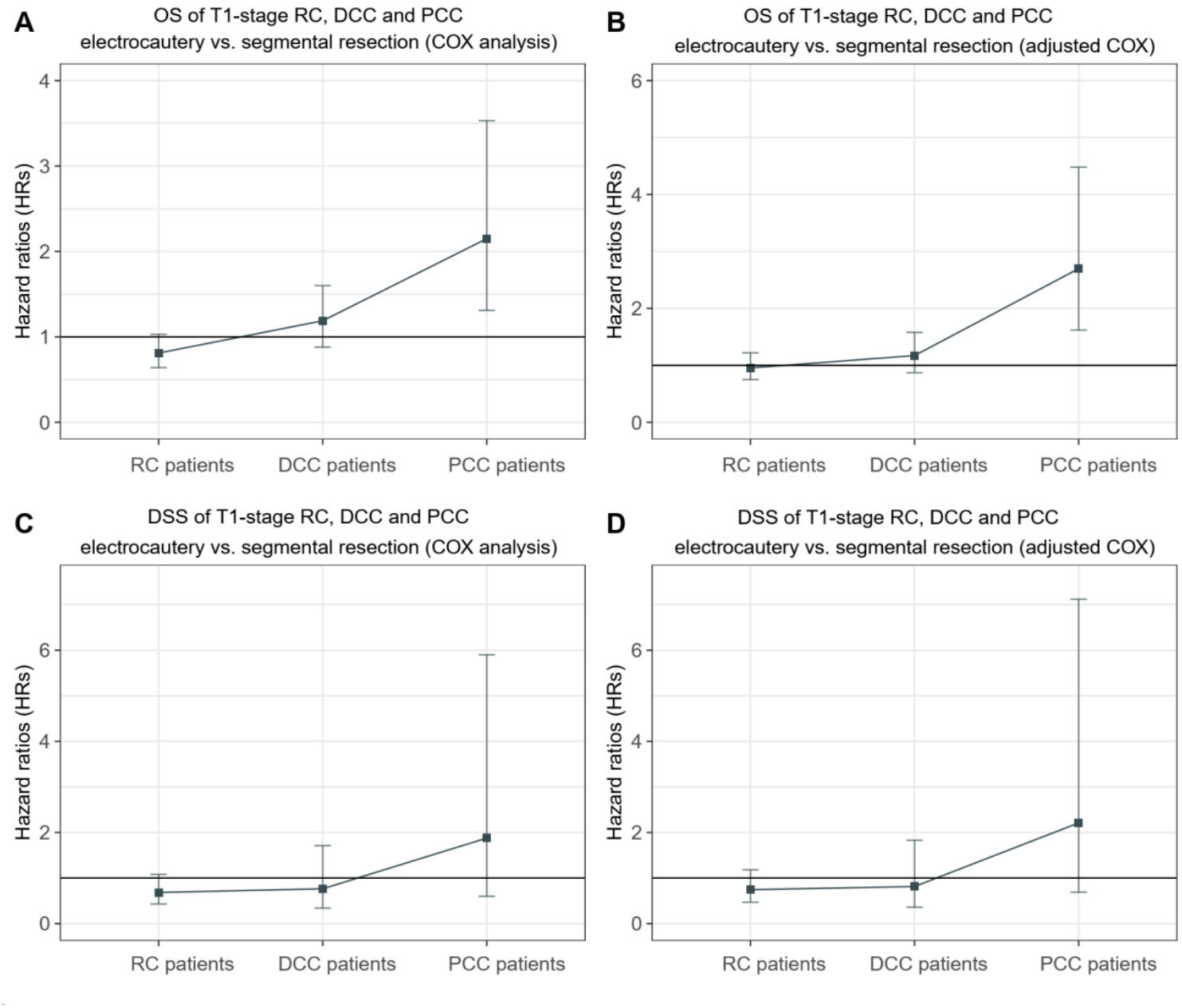


Figure 7

Univariable and multivariable COX analyses to compare overall survival (OS) and disease-specific survival (DSS) of patients with T1-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection. (A) Univariable and (B) multivariable COX analyses to compare OS of patients with T1-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection. (C) Univariable and (D) multivariable COX analyses to compare DSS of patients with T1-stage RC, DCC and PCC treated by endoscopic electrocautery and segmental resection.

Supplementary Files

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