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The primary aim of *World Journal of Gastrointestinal Oncology* (WJGO, *World J Gastrointest Oncol*) is to provide scholars and readers from various fields of gastrointestinal oncology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJGO mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal oncology and covering a wide range of topics including liver cell adenoma, gastric neoplasms, appendiceal neoplasms, biliary tract neoplasms, hepatocellular carcinoma, pancreatic carcinoma, cecal neoplasms, colonic neoplasms, colorectal neoplasms, duodenal neoplasms, esophageal neoplasms, gallbladder neoplasms, *etc.*

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Retrospective Study

Pattern of colorectal surgery and long-term survival: 10-year experience from a single center

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Abstract

BACKGROUND

The incidence of colorectal cancer (CRC) has increased in recent decades, and ranks fourth among males and third among females in China. Surgical resection remains the most important treatment modality for curative intent in CRC. Several studies found that surgeon volumes and specialization appeared to be associated with improved overall survival (OS). Moreover, numerous reports have suggested that specialization and minimally invasive surgery have gained increased popularity in CRC surgery. However, few studies have specifically examined the role and long-term survival of all stage CRC in a real-world study.

AIM

To evaluate the effect of surgeon specialization on survival changes and minimally invasive surgery utilization in a real world study.

METHODS

A retrospective analysis on the association between surgeon specialization and OS between 2008 and 2013 in Zhongshan Hospital CRC database was performed. Standard demographic, clinicopathologic, surgical and follow-up data were obtained from the CRC database. Surgeon specialty was categorized as colorectal surgeon (CS) and general surgeon (GS). CRC patients who underwent primary surgical resection were enrolled.

RESULTS

A total of 5141 CRC patients who underwent primary surgical resection between 2008 and 2013 were evaluated, 1748 (34.0%) of these by CS. The percentage of minimally invasive procedures in the CS group showed an increasing trend. There was no benefit associated with surgeon specialization for stage I, II and IV patients. Surgeon specialization exhibited a significant association with OS solely among stage III patients, with 5-year OS rates of 76% and 67% for the CS and GS

groups, respectively ($P < 0.01$). Further analyses found that surgeon specialization was significantly associated with survival only in stage III rectal patients, and the 5-year OS rate in the CS group and GS group was 80% and 67%, respectively ($P < 0.01$).

CONCLUSION

Surgeon specialization is associated with improved OS after primary surgery in stage III rectal patients. An appropriate surgical technique, perioperative program and adjuvant therapy may contribute to survival benefit in these patients.

Key Words: Colorectal surgery; Minimally invasive surgery; Primary location; Overall survival; Tumor stage; Follow-up

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Core Tip: This investigation is the largest real-world study comparing colorectal cancer surgery patterns and overall survival (OS) in a Chinese tertiary university hospital. A total of 5141 colorectal cancer patients who underwent primary surgical resection between 2008 and 2013 were evaluated, 1748 (34.0%) of these by a colorectal surgeon (CS). The percentage of minimally invasive procedures in the CS group showed an increasing trend. We found that surgeon specialization is associated with improved OS after primary surgery in stage III rectal patients. An appropriate surgical technique, perioperative program and adjuvant therapy may contribute to survival benefit in these patients.

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INTRODUCTION

The incidence of colorectal cancer (CRC) has increased in recent decades, and ranks fourth among males and third among females in China[1]. Despite the emergence of a variety of effective chemotherapy and targeted drugs for CRC, surgical resection remains the most important treatment modality for curative intent. Furthermore, the effectiveness of surgical care depends heavily on the experience of the surgical team. Numerous reports have suggested that higher hospital and surgeon volumes are associated with improved survival outcomes[2,3]. In addition, several studies also found that surgeon specialization appeared to be associated with improved overall survival (OS)[4-6].

Since first introduced in 1991, laparoscopic colon resection can significantly reduce surgical trauma, promote recovery, and provide equivalent long-term oncological outcome, compared with open surgery[7-9]. Therefore, laparoscopic colon resection has been recommended as the standard procedure in national and international guidelines. However, adoption of the laparoscopic approach for rectal cancer still remains controversial, as quality data on long-term survival is limited [10-13]. Newly emerged in this century, robotic surgery is generally easier to learn, improves the probability of autonomic nerve preservation, and produces similar perioperative outcomes in oncologic procedures to conventional laparoscopic surgery[14-16].

Taken together, specialization and minimally invasive surgery have gained increased popularity in CRC surgery. However, few studies have specifically examined the role and long-term survival of all stage CRC in a real-world study. Thus, the purpose of this retrospective study was to evaluate and compare the effect of surgeon specialization on survival changes and minimally invasive surgery utilization.

MATERIALS AND METHODS

Patients and methods

We obtained data of all patients diagnosed with colon or rectal adenocarcinoma who underwent surgical resection of CRC between 2008 and 2013 from Zhongshan Hospital CRC database. All patients in the CRC Database provided written informed consent. This retrospective study was reviewed by the institutional review board of Zhongshan Hospital, Fudan University.

Standard demographic, clinicopathologic, surgical and follow-up data were collected for each patient from the CRC database, and, when necessary, from patient records. The primary outcome was OS, and our primary interest was the association between surgeon specialization and OS. Prior to analysis, we also defined patient (age and gender), tumor (location and TNM stage) and surgical approach (minimally invasive surgery) characteristics, which may be associated with OS.

The surgeons were categorized as colorectal surgeons (CSs) and general surgeons (GSs) based on the subspecialty of the surgeon. The CS performed more than 120 colorectal resections each year, and colorectal cases comprised more than 80% of their surgical caseload. Mortality was defined as death occurring within 30 days after colorectal surgery. Survival time was calculated from the date of colorectal surgery to death or until December 31, 2018. We censored observations of patients who were alive at the end of follow-up. The median follow-up time was 60.0 months.

Statistical analysis

Categorical data were compared using the chi-square test, and continuous data with the independent-samples *t*-test. Survival rates were calculated using the life-table method, and compared with Kaplan-Meier survival curves and log-rank tests. To investigate OS, we compared survival between patients undergoing surgery by CS to those by GS using the log-rank test. A *P* value < 0.05 was considered statistically significant. All statistical calculations were performed using SPSS software, version 16.0 (SPSS Inc., Chicago, IL, United States).

RESULTS

We identified 5141 CRC patients who underwent primary surgical resection between 2008 and 2013. Of these, 1748 patients (34.0%) had colorectal resection performed by a CS. The patient demographics and tumor characteristics between the CS group and GS group are shown in Table 1. There were more male patients, and the median age was approximately 61 years. Not unexpectedly, nearly half of the patients had rectal cancer, and the vast majority of patients were TNM stage II and III. There were no significant differences in terms of gender, age, primary cancer location or TNM stage of primary cancer between the two groups. The postoperative 30-day mortality was 0.3% (6/1748) in the CS group, and 0.5% (18/3393) in the GS group, with no significant difference.

In the early period (2008-2010), the proportion of minimally invasive procedures in the CS group (8.0%) was fewer than that in the GS group (12.5%). However, in the late period (2011-2013), this showed an increasing trend in the CS group and reached 32.3%, compared to 27.7% in the GS group (Table 2). This was mainly due to the widespread use of robotic surgery in CRC.

Survival in the CS and GS groups varied by TNM stage. In stage I CRC patients, 5-year OS was 94% following surgery by a CS, and 94% following surgery by a GS (*P* = 0.30). A lower significant difference was noted in stage II patients where 5-year OS rates in the CS and GS groups were 88% and 87%, respectively (*P* = 0.33). The 5-year OS rate of stage IV patients in the CS group was 35%, greater than 30% observed in the GS group; however, the difference was not significant (*P* = 0.98). There was no benefit associated with surgeon specialization for stage I, II and IV patients. Surgeon specialization exhibited a significant association with OS only in stage III patients, with 5-year OS rates of 76% and 67% in the CS and GS groups, respectively (*P* < 0.01; Figure 1).

Additional analyses were conducted to assess the variation in the aforementioned survival advantage among stage III CRC patients. In stage III right-sided colon cancer patients, the 5-year OS rate was 68% in the CS group and 64% in the GS group (*P* = 0.29). In stage III left-sided colon cancer patients, there was no significant survival benefit associated with CS (75% vs 68% in the GS group, *P* = 0.27). Surgeon specialization was significantly associated with survival only in stage III rectal patients, and the 5-year OS rate in the CS group and GS group was 80% and 67%, respectively (*P* < 0.01; Figure 2). Surgeon specialization was associated with a 43% reduction in the risk of death in stage III rectal cancer patients (HR = 0.57, 95%CI: 0.42-0.76). The *P* value regarding the interaction between surgeon specialization and tumor location for OS was 0.01.

Finally, we performed analyses of surgical and perioperative management elements in all stage III rectal cancer patients (Table 3). In this cohort, few patients received neoadjuvant radiotherapy or radiochemotherapy, and almost one in five underwent minimally invasive rectal surgery. The surgeons used the perioperative enhanced recovery after surgery (ERAS) program in 215 patients (74.9%) of the GS group, and none in the CS group. Two hundred and three patients (70.7%) in the GS group and 352 (61.9%) in CS group had more than 12 lymph nodes removed. After primary surgery, more patients received adjuvant chemotherapy or radiochemotherapy in the GS group (89.2% vs 64.7%).

DISCUSSION

This study examined a university hospital cohort of over 5000 CRC patients who underwent CRC resection by CSs or GSs. Several studies have demonstrated that increased specialization significantly contributed to lower perioperative mortality rates and the observed improvement in longer-term survival following CRC surgery[17-19]. However, to the best of our knowledge, this represents the initial large-scale study investigating stage-dependent differences in survival associated with specialization in a single university hospital in China. It was demonstrated that those patients who underwent CRC resections performed by CSs had better survival.

In our analysis, we observed no association between surgeon specialization and survival for stage I or II CRC. However, a national study, which only enrolled patients aged between 66 and 99 years, found that CSs seemed to confer a notable survival advantage in patients diagnosed with stage II rectal cancer, which is different to our findings[5]. The authors attributed the observed survival benefit to technical proficiency with total mesenteric excision, multidisciplinary treatment decisions and guideline-adherent surveillance. The above study data were from the SEER Medicare files, where nearly half of which were from non-teaching hospitals, while our study was conducted at a single university hospital.

Table 1 Patient demographics, tumor characteristics and surgeon specialization

	CS group (n = 1748)	GS group (n = 3393)	P value
Male: Female	1045:703	2029:1364	> 0.05
Median age (years)	62.0 (23-87)	61.0 (17-90)	> 0.05
Primary cancer location			> 0.05
Right-sided colon, n (%)	466 (26.7)	882 (26.0)	
Left-sided colon, n (%)	472 (27.0)	971 (28.6)	
Rectum, n (%)	791 (45.3)	1495 (44.1)	
Multiple, n (%)	19 (1.1)	45 (1.3)	
TNM stage, n (%)			> 0.05
<i>In situ</i>	41 (2.3)	91 (2.7)	
I	259 (14.8)	626 (18.4)	
II	590 (33.8)	1199 (35.3)	
III	579 (33.1)	1199 (35.3)	
IV	279 (16.0)	278 (8.2)	

CS: Colorectal surgeon; GS: General surgeon.

Table 2 Surgical procedures in different periods, n (%)

	CS group	GS group
2008-2010 (the early period)		
Laparoscopic	54 (7.3)	166 (12.5)
Robotic	5 (0.7)	0
Open	676 (92.0)	1160 (87.5)
Total	735	1326
2011-2013 (the late period)		
Laparoscopic	159 (15.7)	572 (27.7)
Robotic	168 (16.6)	0
Open	686 (67.7)	1495 (72.3)
Total	1013	2067

CS: Colorectal surgeon; GS: General surgeon.

GSs at our center have also been standardly well trained and experienced; thus, we consider that surgeon specialization does not affect survival in relatively early stage II CRC based on our observations. Therefore, it is not surprising that given the inherently good prognosis for stage I and II CRC, external surgeon specialization may be less likely to significantly impact survival.

Survival benefit was associated with surgeon specialization in stage III CRC, and especially in stage III rectal cancer. Those advanced CRC patients were recommended to undergo radical resection and adjuvant chemotherapy or radio-chemotherapy. Total mesorectal excision can reduce local recurrence rates and improve survival, and has been widely used as the new gold standard for rectal cancer[20]. Recently, Japanese D3 resection and European complete mesocolic excision with central vascular ligation have both been performed with superior oncological outcomes[21,22]. CSs may be more familiar with these surgical techniques, and the proportion of rectal cases who had more than 12 lymph nodes removed in the CS group was greater than that in the GS group.

Although the percentage of minimally invasive procedures in the CS group was lower than that in the GS group, there was an obvious increasing trend in the late period, due to the introduction of robotic surgery. Thus, the switch from open to minimally invasive surgery may start late, but develops quickly especially for experienced CSs. Patients can achieve improved short-term outcomes and recover easily after minimally invasive CRC surgery.

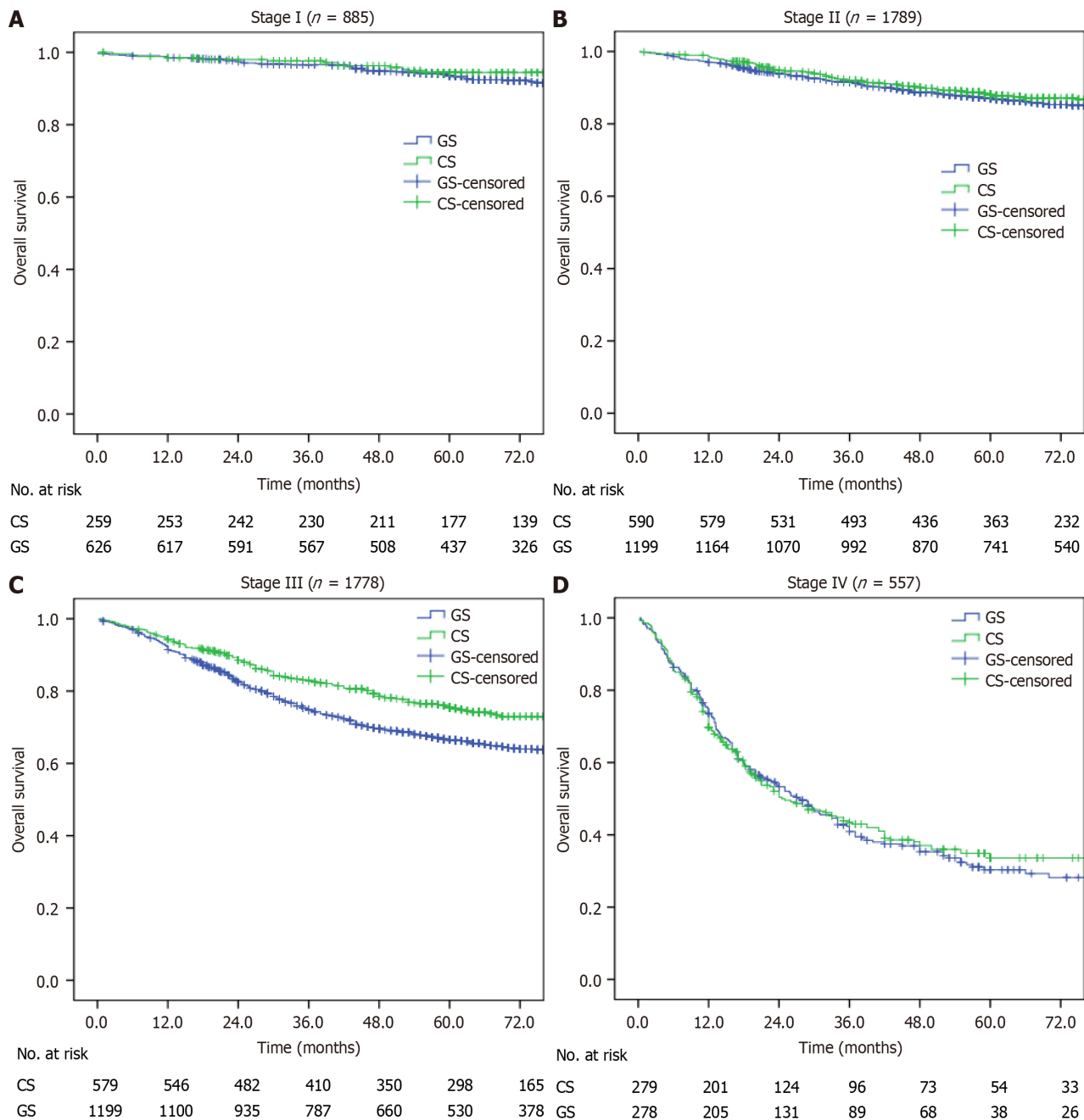


Figure 1 Overall survival of different stage colorectal cancer patients after primary resection. A: In stage I colorectal cancer (CRC) patients, overall survival (OS) was not significantly different between the colorectal surgeon (CS) and general surgeon (GS) groups ($P = 0.30$); B: In stage II CRC patients, a less significant difference was noted between the two groups ($P = 0.33$); C: In stage III CRC patients, OS in the CS group was better than that in the GS group ($P < 0.01$); D: In stage IV CRC patients, differences in OS between the CS and GS groups were not significant ($P = 0.98$). CS: Colorectal surgeon; GS: General surgeon.

ERAS, a multimodal perioperative treatment pathway of evidence-based care items, can attenuate surgical stress response and accelerate postoperative recovery[23,24]. When first introduced in China, CSs widely adopted the perioperative ERAS program [25]. Together, minimally invasive surgery combined with ERAS multimodal management has been shown to be the best perioperative strategy[26,27]. Therefore, patients can recover quickly and receive adjuvant chemotherapy earlier. A meta-analysis demonstrated that a 4-week increase in time to adjuvant chemotherapy was associated with a significant decrease in both OS and disease-free survival[28]. CSs may also appropriately pay more attention to chemotherapeutic decision making and sequence therapy compliance, and more stage III rectal patients received adjuvant chemotherapy or radiochemotherapy in the GS group after primary surgery. Therefore, our results highlight the fact that professional surgical technique, optimal perioperative care and standardized adjuvant therapy may primarily dictate survival of stage III rectal cancer.

Patients with stage IV metastatic CRC are recommended to undergo multidisciplinary team (MDT) treatment in China [29]. CSs are more inclined to implement MDT treatment than GSs. Recent significant improvements in outcome of patients with metastatic CRC seem to be associated with the sequential increase in the use of hepatic resection in selected patients and advancements in medical therapy[30,31]. CSs frequently offer intense comprehensive treatment for initially

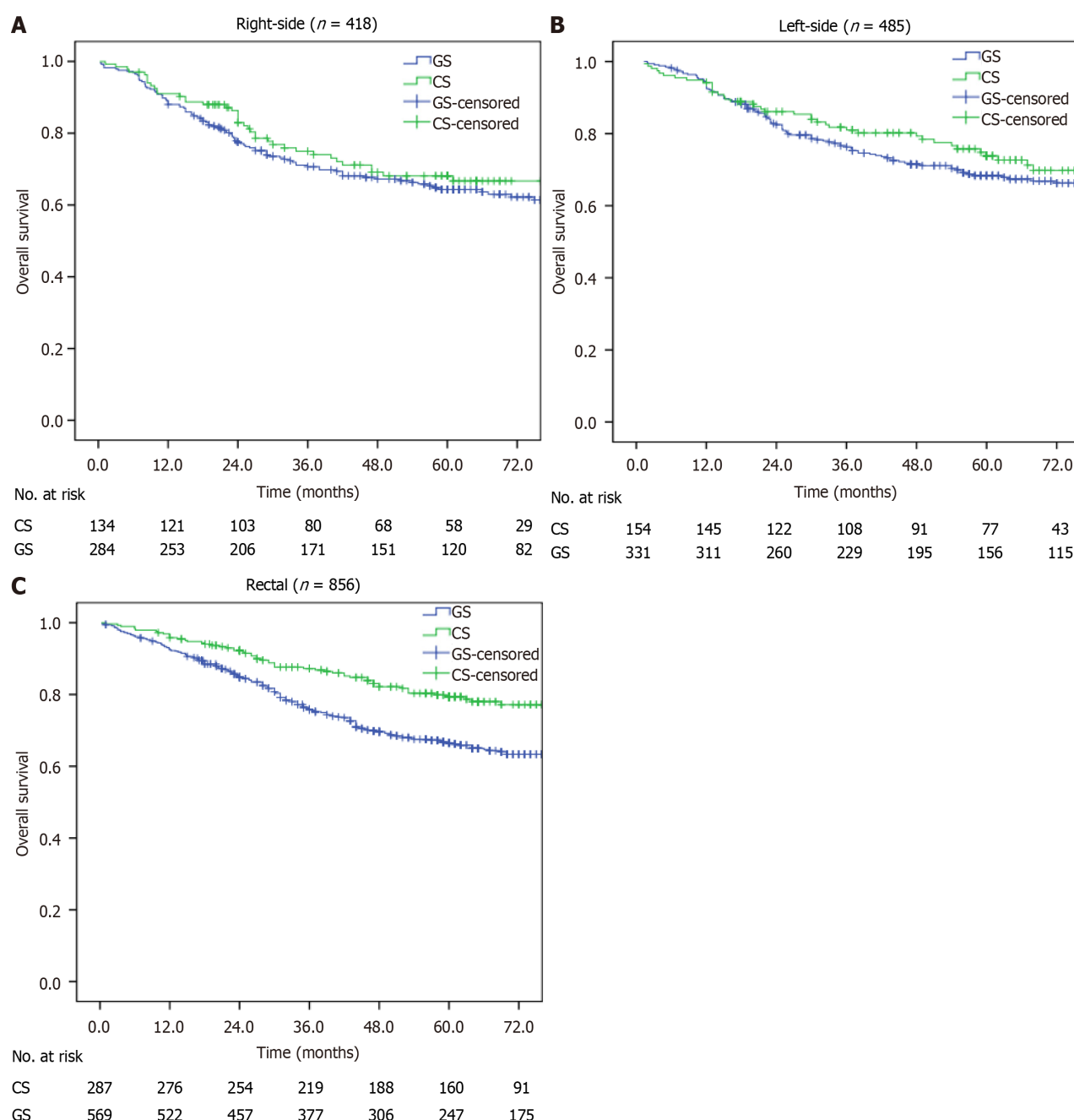


Figure 2 Overall survival after primary resection of patients with different locations of stage III colorectal cancer. A: In stage III right-sided colon cancer patients, overall survival (OS) was not significantly different between the colorectal surgeon (CS) and general surgeon (GS) groups ($P = 0.29$); B: In stage III left-sided colon cancer patients, a less significant difference was noted between the two groups ($P = 0.27$); C: In stage III rectal cancer patients, OS in the CS group was better than that in the GS group ($P < 0.01$). CS: Colorectal surgeon; GS: General surgeon.

unresectable patients under the guidance of MDT, and some convert to resectable and undergo conversion hepatectomy, with comparable survival to primary hepatectomy[32,33].

In this single center study, we demonstrated that colorectal specialization is linked to OS only in patients with stage III rectal cancer, but not in those with stage I, II or IV CRC, or stage III colon cancer. Our results highlight that the survival advantage for stage III rectal cancer is likely to represent a combination of improved technical proficiency, perioperative treatment pathway and adjuvant therapy execution.

The limitation of our study is that it is a retrospective study. We collected all the data from our large database, and errors in misregistration and omission could have occurred despite quality control. Moreover, we can only speculate on the reasons for the observed association between colorectal specialization and OS, and cannot determine causality for the demonstrated associations. Another potential limitation lies in the number of participants in the study, where local variations among a substantial number of diverse surgeons may impede generalizability.

Table 3 Surgical and perioperative management in stage III rectal cancer patients, *n* (%)

	CS group (<i>n</i> = 287)	GS group (<i>n</i> = 569)
Neoadjuvant radiotherapy/radiochemotherapy		
Yes	6 (2.1)	14 (2.5)
No	281 (97.9)	555 (97.5)
Surgical procedures		
Minimally invasive	47 (16.4)	149 (26.2)
Open	240 (83.6)	420 (73.8)
Perioperative ERAS treatment		
Yes	215 (74.9)	0
No	72 (25.1)	569 (100.0)
Number of lymph nodes removed		
< 12	84 (29.3)	217 (38.1)
≥ 12	203 (70.7)	352 (61.9)
Adjuvant chemotherapy/radiochemotherapy		
Yes	256 (89.2)	368 (64.7)
No	31 (10.8)	201 (35.3)

CS: Colorectal surgeon; GS: General surgeon.

CONCLUSION

The clinical implications of our findings in a real-world study suggest that surgeon specialization may play a crucial role in the survival of patients with stage III rectal cancer. The potential benefit of surgeon specialization for patients with stage I, II, and IV CRC, as well as stage III colon cancer, appears to be less definitive.

FOOTNOTES

Author contributions: Zhu DX, Xu JM conceptualized the study; Ren L, Xu JM provided study material or patients; Zhu DX, Chen M, Xu DH curated the data; Zhu DX, Chen M, Xu DH performed formal analysis; Xu JM acquired funding; Zhu DX, Chen M, Xu DH, Xu PP conducted the investigation; Zhu DX, Chen M, Xu DH developed the methodology; Qi Lin, Ren L, Xu JM administered the project; Zhu DX developed the software and performed visualization; Xu JM supervised and validated the study; Zhu DX, Chen M, Xu JM wrote and revised the manuscript; all authors accessed and verified the study data.

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