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Identification of predictors for lymph node metastasis in T2 colorectal cancer: retrospective cohort study from a high-volume hospital

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Abstract

Background Colorectal cancer (CRC) is the most prevalent malignant tumor of the digestive system globally, ranking third in incidence and second in mortality. In previous studies, the rate of lymph node metastasis (LNM) in T2 CRC ranged from 18.0 to 28.0%. We aim to identify T2 CRC patients without LNM and thereby mitigate the complications and potential impact on the quality of life associated with surgery.

Methods In this retrospective study, 787 cases with T2 CRC were selected. The preoperative and postoperative clinicopathological features were retrospectively studied. Univariate analysis and multivariate analysis were performed using binary logistic regression to determine the predictive factor for LNM. Odds ratio (OR) and 95% confidence interval (CI) were conducted.

Results 184 (23.4%) patients were diagnosed with LNM, including 144 (78.3%) patients with N1stage and 40 (21.7%) patients with N2 stage. According to univariate analysis and multivariate analysis, poorly differentiated tumors ($p=0.003$, OR = 4.405, 95%CI: 1.632–11.893), perineural invasion ($p=0.001$, OR = 4.789, 95%CI: 1.958–11.716), and lymphovascular invasion ($p=0.001$, OR = 2.779, 95%CI: 1.497–5.159) were independent risk factors of LNM, while male ($p=0.017$, OR = 0.652, 95%CI: 0.459–0.926) and elevated preoperative PLR ($p=0.048$, OR = 0.996, 95%CI: 0.993-1.000) seemed to be independent protective factors. Larger tumor size did not show significant association with LNM.

Conclusions Approximately three-quarters of T2 CRC patients are likely to avoid unnecessary surgery. Female, poorly differentiated tumors, perineural invasion, and lymphovascular invasion are expected to be used as predictors of LNM in T2 CRC.

Keywords Colorectal cancer, Lymph node metastasis, T2 stage, Risk factors, Predictors

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Introduction

Colorectal cancer (CRC) is the most prevalent malignant tumor of the digestive system globally, ranking third in incidence and second in mortality [1, 2]. In the subgroup-specific to gender, CRC ranks third in both incidence and mortality. Despite the continued overall declines of morbidity and mortality, there is a rapid shift in CRC diagnosis towards a younger age, more advanced stage, and localization in the left colon/rectum [3]. The majority of CRCs develop through the adenoma-carcinoma sequence, emphasizing the importance of early diagnosis and treatment in effectively curing CRC [4]. Complete surgical resection plays a crucial role in the treatment of tumors and contributes to prolonged survival [5, 6]. However, endoscopic resection, represented by endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD), is a curative treatment approach for early CRC and its precursor lesions.

The 8th Edition Staging System of the American Joint Committee on Cancer (AJCC) has revised the TNM staging of CRC [7]. Submucosal invasive (T1) CRCs are recommended to undergo endoscopic resection, when there is no clinical evidence for lymph node metastasis (LNM) and distant metastasis (N0M0). Surgical resection with regional lymph node dissection is recommended for muscularis propria invasive (T2) CRCs, due to the lack of reliable preoperative prediction of lymph node involvement. However, patients with T2 CRC who undergo surgical resection are at risk of experiencing numerous complications, including anastomotic fistula, bleeding, incision infection, pulmonary infection, intestinal obstruction, venous thromboembolism, and even mortality [8, 9]. Hence, an accurate preoperative prediction of LNM in T2 CRC is crucial for determining the eligibility of patients for minimally invasive endoscopic resection and avoiding the necessity for surgical resection.

In this study, we investigated the preoperative and postoperative clinicopathological characteristics of patients with T2 CRC in order to establish a preoperative prediction of LNM. Our comprehensive model may offer new aspects of selecting the appropriate therapeutic strategy for patients with T2 CRC.

Materials and methods

Patients' selection

Consecutive CRC patients who underwent surgical resection for treatment at the First Medical Center of the Chinese People's Liberation Army (PLA) General Hospital from January 2018 to June 2023 were screened. Related patients meeting the following criteria were selected: (1) an obvious pathologic diagnosis of CRC with T2 stage; (2) primary cases without history of other CRCs; (3) accepted radical surgery treatment without tumor residual; (4) ≥ 12 lymph nodes examined. The exclusion criteria were as follows: (1) patients receiving neoadjuvant therapy; (2) patients with tumor recurrence; (3) patients with incomplete clinical data. This study was conducted in accordance with the Declaration of Helsinki and approved by the Medical Ethics Committee of the First Medical Center of the Chinese PLA General Hospital.

Data collection

The preoperative and postoperative clinicopathological features were retrospectively studied. The baseline information included the following variables: gender, age at diagnosis, body mass index (BMI), a history of hypertension, a history of diabetes, a history of heart disease, a history of abdominal operation, a history of cancer, a history of smoking, a history of alcoholism, family history of CRC. The preoperative laboratory examination included Neutrophil-to-Lymphocyte Ratio (NLR), Platelets-Lymphocyte-Ratio (PLR), Lymphocyte-to-Monocyte Ratio (LMR), carcinoembryonic antigen (CEA), alpha fetoprotein (AFP), carbohydrate antigen 125 (CA125), 19 – 9 (CA19-9), 153 (CA153), 724 (CA724). The postoperative clinicopathological features included the primary site of the tumor, degree of differentiation, tumor size, mucinous adenocarcinoma, tumor necrosis, multifocality, perineural invasion, lymphovascular invasion, and LNM. The expressions of Ki67, MSH6, MSH2, PMS2, MLH1, HER2, and HER1 were detected by immunohistochemistry detection, and the gene mutations including KRAS, BRAF, NRAS, PIK3CA were tested.

The condition of LNM (including the N1 stage and N2 stage) was the main outcome indicator, and the included CRC cases were divided into the N0 group and N1/2 group.

Statistical analysis

All statistical analyses were performed using the IBM SPSS Statistics 26.0 software (SPSS Inc, Chicago, IL, USA). Numerical data with normal distribution were expressed as the mean ± standard deviation (SD) and numerical data without normal distribution were expressed as median (interquartile range, IQR). Categorical data are presented as absolute numbers and percentages. Univariate analysis and multivariate analysis were performed using binary logistic regression to determine the predictive factor for LNM. Odds ratio (OR) and 95% confidence interval (CI) were conducted. *P*-values were two-tailed, and $P < 0.05$ was accepted as statistically significant.

Results

Patients' characteristics

After a rigorous screening, a total of 787 CRC patients with T2 stage have undergone radical operations

between January 2018 and June 2023 in our medical center. According to postoperative pathology, 184 (23.4%) patients were diagnosed with LNM, including 144 (78.3%) patients with N1 stage and 40 (21.7%) patients with N2 stage. The steps of patient selection are shown in Fig. 1.

Univariate analysis and multivariate logistic regression of factors associated with LNM

787 CRC patients were categorized into two groups: N0 and N1/2, comprising 603 and 184 cases, respectively. The median number of lymph nodes dissected was 15 and 14, respectively. By gender, 35.3% ($n = 213$) patients with the N0 stage were female, and 64.7% ($n = 390$) patients were male, within the M: F ratio was 1.83. However, in patients with the N1/2 stage, female patients (44.0%, $n = 81$) accounted for a higher proportion, with the M: F ratio being 1.27 ($p = 0.003$, OR = 0.472). For the history of heart disease, patients with positive exposure appeared to have a lower rate of LNM ($p = 0.044$, OR = 0.468). By PLR, we observed that N1/2 groups of patients had lower levels ($p = 0.042$, OR = 0.989). There was no significant association found between LNM and age, BMI, history of hypertension, history of diabetes, history of abdominal operation, history of cancer, history of smoking, history of alcoholism, family history of CRC, NLR, LMR, CEA, AFP, CA125, CA19-9, CA153, CA724 with a p-value greater than 0.05, as shown in Table 1.

For postoperative clinicopathological characteristics, as shown in Table 2, univariate analysis revealed that poorly differentiated tumors ($p = 0.003$, OR = 4.471), perineural invasion ($p = 0.001$, OR = 4.491), and lymphovascular invasion ($p = 0.002$, OR = 2.749) were identified as potential risk factors for LNM. Additionally, it was observed that patients in the N1/2 groups had smaller tumor sizes compared to those in the N0 groups (3.000 cm vs. 3.500 cm, $p = 0.021$). Furthermore, a multivariate analysis was conducted using binary logistic regression to identify the predictive factors for LNM in CRC patients (Table 3). Poorly differentiated tumors ($p = 0.003$, OR = 4.405, 95%CI: 1.632–11.893), perineural invasion ($p = 0.001$, OR = 4.789, 95%CI: 1.958–11.716), and lymphovascular invasion ($p = 0.001$, OR = 2.779, 95%CI: 1.497–5.159) were independent risk factors of LNM, while male ($p = 0.017$, OR = 0.652, 95%CI: 0.459–0.926) and elevated preoperative PLR ($p = 0.048$, OR = 0.996, 95%CI: 0.993-1.000) seemed to be independent protective factors. Larger tumor size did not show significant association with LNM. In order to intuitively demonstrate the rate of LNM, we conducted a subgroup analysis based on risk factors (Table 4). The lowest rate of LNM (17.6%) was observed in males with well or moderately differentiated tumors, and without perineural invasion and lymphovascular invasion. We then investigated the risk factors for patients with N2 versus N1 disease (Supplementary Table 1). It was found that CA153 levels were significantly elevated in N2 stage patients ($p = 0.046$, OR = 1.084, 95%CI: 1.002–1.173), while no other significant differences were observed between the two groups of patients.

The immunohistochemistry detection and genetic mutation of CRC patients

A total of 753 cases underwent immunohistochemistry detection, including Ki67, MSH6, MSH2, PMS2, MLH1, HER2. The univariate logistic regression revealed that tumors with high expression of MSH2 were significantly more likely to LNM, while there were no significant differences observed in the expression of Ki67, MSH6, PMS2, MLH1, and HER2 between the two groups. 317 cases underwent HER1 immunohistochemistry detection. However, there were also no significant differences observed between the two groups. By gene mutation, a total of 426 cases received relevant examinations, including KRAS, BRAF, NRAS, PIK3CA. The gene most commonly mutated was found to be KRAS, and the mutation rates in the two groups were 45.8% and 38.8%, respectively. However, we found no significant association between genetic mutations and LNM (Table 5).

Discussion

Although numerous studies have recommended surgical resection with regional lymph node dissection is necessary, the optimal treatment for T2 CRC still warrants further exploration [6, 7]. CRC Patients with LNM were typically diagnosed at a later stage, had a higher likelihood of experiencing local recurrence and distant metastasis, and required postoperative adjuvant therapy. Wu et al. [10] proposed that a minimum of 8 lymph nodes was necessary for T2 CRC patients to confidently confirm the presence of occult nodal disease with 90% confidence. However, LNM complicated the operation and prolonged the duration of the procedure. Due to the typical distribution of lymph nodes along blood vessels, lymph node dissection was more likely to result in intraoperative and postoperative complications, such as bleeding, lymphatic leakage, and anastomotic fistula. These potential complications should be carefully considered and managed during surgical procedures. On the contrary, previous studies have not established a consistent understanding of the LNM rate of T2 CRC, which has been reported to range from 18.0 to 28.0% [10–12]. Based on the principles of precision medicine, we aimed to identify T2 CRC patients without LNM and thereby mitigated the complications and potential impact on the quality of life associated with surgery.

In recent decades, there has been an increasing incidence of CRC among patients under the age of 50 (early-onset CRC), accounting for 10–12% of all new

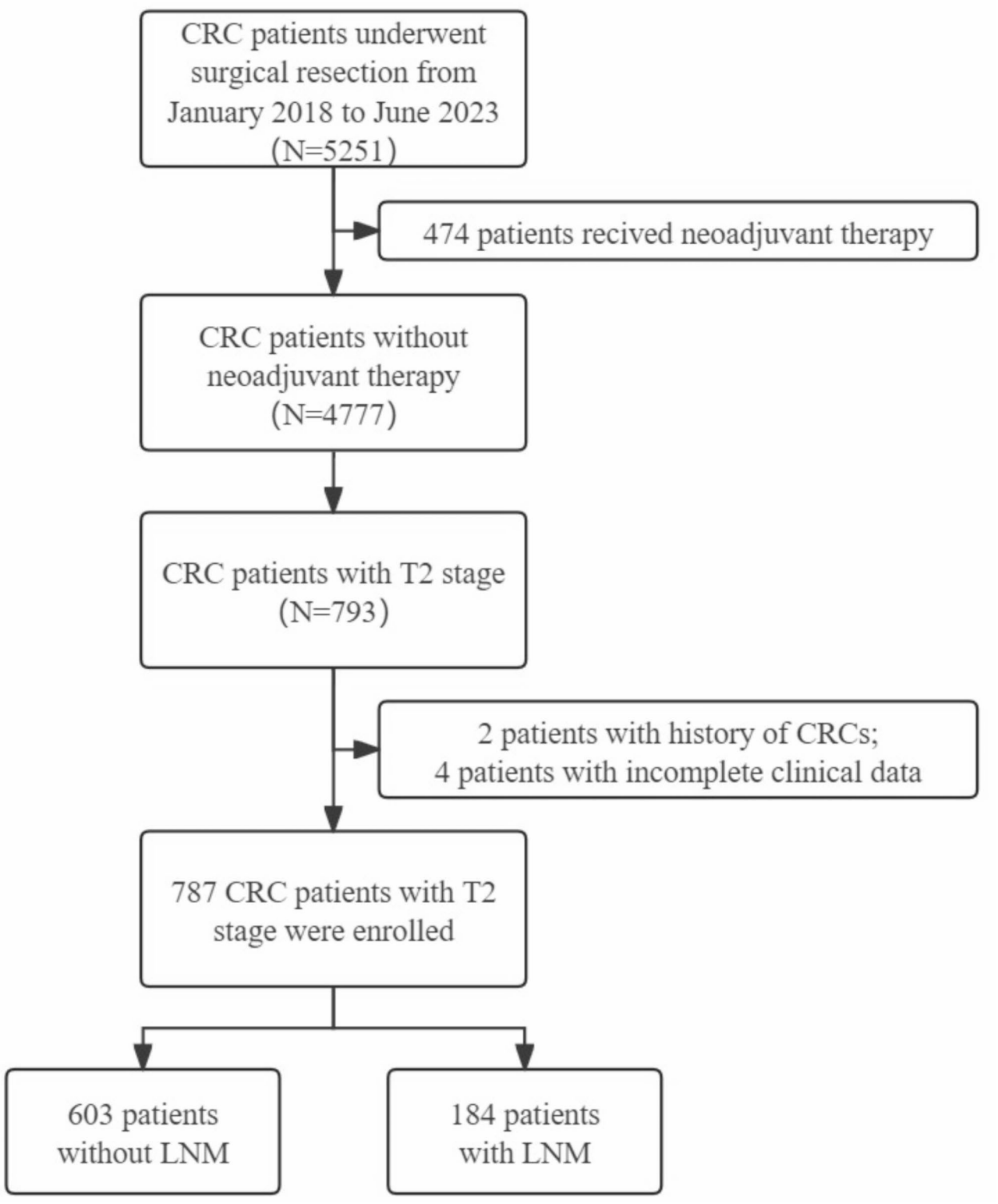

Fig. 1 The flow chart for patient selection

Table 1 The preoperative clinical characteristics of T2 CRC patients ($n = 787$)

		N0 $n = 603$ (%)	N1/2 $n = 184$ (%)	*P*-value	OR (95%CI)
Gender				0.003	0.472 (0.288–0.773)
	Female	213 (72.4)	81 (27.6)		
	Male	390 (79.1)	103 (20.9)		
Age [a]		61.47 ± 10.9	60.84 ± 11.2	0.460	
				0.328	
	< 50	69 (72.6)	26 (27.4)		
	≥ 50	534 (77.2)	158 (22.8)		
BMI [b]		24.50 (4.50)	24.55 (4.20)	0.774	
History of hypertension				0.639	
	No	395 (76.7)	120 (23.3)		
	Yes	208 (76.5)	64 (23.5)		
History of diabetes				0.757	
	No	480 (76.6)	147 (23.4)		
	Yes	123 (76.9)	37 (23.1)		
History of heart disease				0.044	0.468 (0.224–0.979)
	No	543 (75.8)	173 (24.2)		
	Yes	60 (84.5)	11 (15.5)		
History of abdominal operation				0.608	
	No	472 (76.7)	143 (23.3)		
	Yes	131 (76.2)	41 (23.8)		
History of cancer				0.194	
	No	587 (76.9)	176 (23.1)		
	Yes	16 (66.7)	8 (33.3)		
History of smoking				0.438	
	No	418 (76.6)	128 (23.4)		
	Yes	185 (76.8)	56 (23.2)		
History of alcoholism				0.366	
	No	439 (76.9)	132 (23.1)		
	Yes	164 (75.9)	52 (24.1)		
Family history of CRC				0.357	
	No	574 (76.9)	172 (23.1)		
	Yes	29 (70.7)	12 (29.3)		
NLR [b]		1.88 (1.07)	1.77 (1.08)	0.372	
LMR [b]		4.47 (2.46)	4.60 (2.46)	0.093	
PLR [b]		124.72 (57.42)	122.86 (52.78)	0.042	0.989 (0.978-1.000)
CEA [b]		2.47 (2.39)	2.95 (2.45)	0.302	
AFP [b]		2.72 (2.19)	2.76 (2.91)	0.670	
CA125 [b]		8.88 (5.44)	8.66 (5.19)	0.412	
CA19-9 [b]		9.81 (8.63)	10.68 (11.02)	0.176	
CA153 [b]		8.49 (5.31)	8.47 (5.67)	0.638	
CA724 [b]		2.07 (2.74)	2.02 (2.78)	0.158	

[a] Values are presented as mean ± SD

[b] Values are presented as median (IQR)

CRC, colorectal cancer; BMI, body mass index; NLR, neutrophil-to-lymphocyte ratio; PLR, platelets-lymphocyte-ratio; LMR, lymphocyte-to-monocyte ratio, CEA, carcinoembryonic antigen; AFP, alpha fetoprotein, CA, carbohydrate antigen

CRC diagnoses [13]. Meyer et al. [14] suggested that early-onset was a statistically significant predictor of an increased number of LNM for T2 rectal cancer. Similarly, Guo et al. [15] discovered that older individuals were correlated with a lower risk of LNM in comparison to younger patients for T1 CRC. However, despite the increased risk of LNM, there was no statistically significant difference in survival between early-onset CRC patients and older CRC patients, which was attributed to the fact that younger patients are more likely to receive aggressive treatment with surgery and postoperative adjuvant therapy [16]. In this study, the proportion of early-onset CRC patients was 12.1%, and there was no significant difference in LNM between patients

Table 2 The postoperative clinicopathological characteristics of T2 CRC patients ($n=787$)

		N0 $n=603$ (%)	N1/2 $n=184$ (%)	*P*-value	OR (95%CI)
Lymph node dissected [a]		15.00 (5.00)	14.00 (5.00)	0.780	
Primary site of the tumor				0.246	
	Ascending colon	63 (86.3)	10 (13.7)		
	Transverse colon	11 (84.6)	2 (15.4)		
	Descending colon	23 (85.2)	4 (14.8)		
	Sigmoid colon	131 (77.1)	39 (22.9)		
	Rectum	375 (74.4)	129 (25.6)		
Degree of differentiation				0.002	
	Well	45 (88.2)	6 (11.8)		
	Moderate	517 (77.6)	149 (22.4)	0.164	
	Poor	41 (58.6)	29 (41.4)	0.003	4.471 (1.638–12.200)
Tumor size [a]		3.50 (2.00)	3.00 (1.70)	0.021	0.853 (0.745–0.977)
Mucinous adenocarcinoma				0.646	
	No	535 (76.8)	162 (23.2)		
	Yes	68 (75.6)	22 (24.4)		
Tumor necrosis				0.776	
	No	563 (76.7)	171 (23.3)		
	Yes	40 (75.5)	13 (24.5)		
Multifocality				0.158	
	No	598 (76.9)	180 (23.1)		
	Yes	5 (55.6)	4 (44.4)		
Perineural invasion				0.001	4.491 (1.829–11.031)
	No	594 (77.9)	169 (22.1)		
	Yes	9 (37.5)	15 (62.5)		
Lymphovascular invasion				0.002	2.749 (1.468–5.145)
	No	577 (78.4)	159 (21.6)		
	Yes	26 (51.0)	25 (49.0)		

[a] Values are presented as median (IQR)

CRC, colorectal cancer

Table 3 Multivariate logistic regression of factors associated with LNM inT2 CRC patients ($n=787$)

		P-value	OR (95%CI)
Gender	Male	0.017	0.652 (0.459–0.926)
History of heart disease	Yes	0.058	
PLR		0.048	0.996 (0.993-1.000)
Tumor size		0.032	0.866 (0.760–0.988)
Degree of differentiation	Poor	0.003	4.405 (1.632–11.893)
Perineural invasion	Yes	0.001	4.789 (1.958–11.716)
Lymphovascular invasion	Yes	0.001	2.779 (1.497–5.159)

LNM, lymph node metastasis; CRC, colorectal cancer

Table 4 The LNM rate in different subgroups of T2 CRC patients ($n=787$)

		With lymphovascular invasion		Without lymphovascular invasion	
		With perineural invasion	Without perineural invasion	With perineural invasion	Without perineural invasion
All gender					
Poor differentiation	No	71.4%	31.4%	53.3%	19.8%
	Yes	100%	37.5%	100%	31.7%
Male					
Poor differentiation	No	40.0%	22.7%	50.0%	17.6%
	Yes	100%	100%	NA	27.8%
Female					
Poor differentiation	No	100.0%	46.2%	60.0%	23.5%
	Yes	NA	100%	100%	37.5%

LNM, lymph node metastasis; CRC, colorectal cancer

of varying ages. By gender, the incidence of CRC occurring in females has increased significantly in recent years, especially in rectal cancer [17]. Female CRC patients suffered from a higher mortality and a lower 5-year-survival [18] Similarly, we have observed female was an independent risk factor for LNM in T2 CRC patients (27.6% vs. 20.9%), which might be related to the physiological structure and hormone levels of female. Ghebrial et al. [19] found that previously had a hysterectomy, number of Papanicolaou tests in a lifetime, and history of pregnancy were factors that provided protection against late-stage diagnosis in females, while a history of menopausal hormone therapy was found to be significantly associated with the later-stage diagnosis. Conversely, several studies

Table 5 The immunohistochemistry and gene mutation of T2 CRC patients

		N0	N1/2	*P*-value	OR (95%CI)
Immunohistochemistry, *n* = 753					
Ki67 [a]		80.00 (10.00)	80.00 (15.00)	0.226	
MSH6 [a]		80.00 (10.00)	80.00 (10.00)	0.058	
MSH2 [a]		82.00 (10.00)	84.00 (10.00)	0.038	1.029 (1.002–1.057)
PMS2 [a]		80.00 (10.00)	80.00 (15.00)	0.710	
MLH1 [a]		80.00 (15.00)	80.00 (18.50)	0.435	
HER2				0.870	
	1-	164 (78.8)	44 (21.2)		
	1+	269 (76.0)	85 (24.0)		
	2+	137 (77.4)	40 (22.6)		
	3+	10 (71.4)	4 (28.6)		
HER1, *n* = 317				0.684	
	1-	22 (66.7)	11 (33.3)		
	1+	215 (77.3)	63 (22.7)		
	2+	2 (50.0)	2 (50.0)		
	3+	0	2 (100.0)		
Gene mutation, *n* = 426					
KRAS				0.227	
	No	175 (73.5)	63 (26.5)		
	Yes	148 (78.7)	40 (21.3)		
BRAF				0.906	
	No	318 (75.9)	101 (24.1)		
	Yes	5 (71.4)	2 (28.6)		
NRAS				0.913	
	No	308 (75.9)	98 (24.1)		
	Yes	15 (75.0)	5 (25.0)		
PIK3CA				0.805	
	No	315 (75.7)	101 (24.3)		
	Yes	8 (80.0)	2 (20.0)		

[a] Values are presented as median (IQR)

CRC, colorectal cancer

recommended menopausal hormone therapy was associated with a decreased risk of CRC [20, 21].

Generally, due to the longer growth time, deeper local invasion, and higher tumor burden, larger tumors indicated a worse degree of malignancy and were associated with a poorer prognosis. However, for early-stage CRC, the relationship between tumor size and LNM appeared to deviate from the commonly accepted understanding. Xiong et al. [22] suggested larger tumor size was significantly associated with the risk of LNM in T1 CRC. However, no significant association was observed in T2 CRC. In our study,

larger tumor size did not show significant association with LNM in T2 CRC. On the one hand, a larger tumor typically indicated a prolonged duration of growth within the body and was often associated with deeper invasion of the intestinal wall, suggesting a later stage of disease. However, in cases where the tumor has experienced an extended growth period, only the muscularis propria (T2) was found to be invasive. Consequently, these tumors tended to exhibit relatively lower aggressiveness and were therefore associated with fewer instances of LNM. In addition, more biologically aggressive phenotypes had a greater impact on tumor progression than tumor size [23]. The greater the invasion of the bowel wall, the more extensive the degree of perineural invasion and lymphovascular invasion. On the other hand, larger tumors were more likely to cause clinical symptoms, such as abdominal pain and blood in the stool, which prompted patients to seek medical attention early and undergo further examination, underscoring the importance of early detection and intervention in cases of large tumors. As for PLR, we observed higher PLR was a protective factor against LNM in T2 CRC, which was inconsistent with prior studies. However, the p-value was 0.048 and the OR was almost equal to 1 (0.996), which might be associated with the sample size and statistical methods. In a controlled study, the level of PLR in CRC patients was found to be significantly higher than that in healthy participants [24]. Yang et al. [25] also found higher PLR was significantly associated with poorer OS in left-sided colon cancer. PLR was a unique inflammatory index

associated with cancer-related inflammation, affecting the proliferation, differentiation, apoptosis, angiogenesis, and therapeutic efficacy of tumor cells.

Poorly differentiated, perineural invasion, and lymphovascular invasion, indicating more aggressive biological behavior, were independent risk factors for LNM in T2 CRC patients in our study and in line with previous reports [11, 12, 22]. Poorly differentiated CRC was characterized by the presence of clusters containing five or more tumor cells, with no formation of glandular structures. Poorly differentiated tumors were more likely to lead to recurrence and metastasis. For pT1 CRC patients treated by endoscopic resection, poorly differentiated had an increased risk of LNM [26]. Qi et al. [27] have identified that the degree of pathological differentiation of CRC was related to gut flora, and poorly differentiated CRC had some different bacterial flora. In a retrospective study of 1474 CRC patients, lymphovascular invasion was closely correlated with advanced T stage, N stage, and TNM stage. Furthermore, lymphovascular invasion was an independent biomarker for unfavorable overall survival [28]. The Japanese Society for Cancer of the Colon and Rectum guidelines have recommended that lymphovascular invasion and tumor grade, be included as risk factors for LNM in patients with T1 CRC [29]. Perineural invasion was characterized by tumor cells invading the nerve sheath and/or encircling more than 33% of the nerve circumference, which was recognized as pathological evidence of early metastasis in CRC [30, 31]. Perineural invasion disrupted the communication between nerve and cancer cells, leading to crosstalk between cells and neurons, and impacting the occurrence and development of tumors.

There were some limitations to our study. Firstly, the sample size in our study was relatively small. Secondly, we retrospectively analyzed the clinicopathological features of the recruited patients. There may be an inevitable selection bias. Besides, collaborative studies (encompassing both retrospective and prospective research) with specialists in gastroenterology and pathology were needed to further investigate the risk factors associated with T2 CRC.

Conclusion

The LNM rate of T2 CRC patients was 23.4%. Poorly differentiated tumors, perineural invasion, and lymphovascular invasion were independent risk factors of LNM, while male and elevated preoperative PLR seemed to be independent protective factors. Larger tumor size did not show significant association with LNM. In subgroup analysis, the lowest rate of LNM (17.6%) was observed in males with well or moderately differentiated tumors, and without perineural invasion and lymphovascular invasion.

Abbreviations

CRC	Colorectal cancer
LNM	Lymph node metastasis
EMR	Endoscopic mucosal resection
ESD	Endoscopic submucosal dissection
AJCC	The American Joint Committee on Cancer
PLA	The Chinese People's Liberation Army
BMI	Body mass index
NLR	Neutrophil-to-Lymphocyte Ratio
PLR	Platelets-Lymphocyte-Ratio
LMR	Lymphocyte-to-Monocyte Ratio
CEA	Carcinoembryonic antigen
AFP	Alpha fetoprotein
CA	Carbohydrate antigen
SD	Standard deviation
IQR	Interquartile range
OR	Odds ratio
CI	Confidence interval

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12885-025-14104-0.

Supplementary Material 1

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Author contributions

Rui Li: Data curation, Methodology, Formal analysis, Writing - original draft. Xu Sun: Data curation, Formal analysis, Investigation, Writing-review & editing. Zhiyuan Yu: Formal analysis, Investigation, Data curation, Methodology, Visualization. Xudong Zhao: Conceptualization, Project administration, Writing-review & editing. Peiyu Li: Conceptualization, Supervision, Methodology. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of the First Medical Center of the Chinese PLA General Hospital. All methods were carried out in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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