Article

Prognostic Performance of Lymph Node Ratio and Log Odds of Positive Lymph Nodes in Colorectal Cancer: A Comparative Analysis with pN Stage

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AIM: The lymph node ratio (LNR) and the log odds of positive lymph nodes (LODDS) have been proposed as alternative indicators of nodal burden that may enhance prognostic stratification beyond conventional pN stage. This study aimed to evaluate the prognostic impact of LNR and LODDS on disease-free survival (DFS) and overall survival (OS) after curative resection for colorectal cancer, and to compare their performance with pN stage and total lymph nodes examined.
METHODS: This retrospective study included 154 patients who underwent curative-intent resection for stage I–III colorectal cancer between 2016 and 2022. Demographic, surgical, pathological, and follow-up data were analyzed. Patients were stratified according to pN stage, LNR, and LODDS categories. DFS and OS were evaluated using Kaplan–Meier survival analysis and Cox proportional hazards regression models. Receiver operating characteristic (ROC) analyses were also performed to assess the discriminatory ability of nodal parameters.
RESULTS: The median number of lymph nodes removed was 28, and adequate lymph node dissection ($\geq$12 lymph nodes) was achieved in 94.8% of patients. During the follow-up period, 18 recurrences and 12 deaths occurred. In the DFS analysis, patients in the LNR 1–2 group showed lower 2-year DFS rates compared to the LNR 0 group (91.0% vs 96.6%). Cox regression analysis indicated a borderline increase in relapse risk in the LNR 1–2 group (hazard ratio (HR): 2.431, 95% confidence interval (CI): 0.963–6.135, $p = 0.060$). Although advanced pN stage was associated with lower DFS rates, statistical significance was not achieved in the regression analysis. LODDS was not significantly associated with DFS. In the exploratory multivariate analysis, the model including LNR and age showed the best discriminatory performance, and LNR remained independently associated with the risk of recurrence even after adjusting for age (HR: 2.535, 95% CI: 1.004–6.402, $p = 0.049$). For OS, increasing age was significantly associated with a higher risk of death (HR: 1.076, 95% CI: 1.006–1.150, $p = 0.032$). In addition, patients undergoing rectal surgery had a lower risk of death compared with those undergoing right/extended colectomy (HR: 0.178, 95% CI: 0.037–0.849, $p = 0.030$). Neither LNR nor LODDS showed a significant association with OS. ROC analysis showed limited prognostic discrimination overall, but the LNR demonstrated relatively higher predictive performance for DFS compared to pN stage and LODDS.
CONCLUSIONS: Among the lymph node parameters evaluated, LNR showed a trend toward improved prognostic discrimination for short-term DFS, whereas LODDS did not demonstrate significant prognostic value in this cohort. However, the overall discriminatory performance of all lymph node indices remained limited. Therefore, these findings should be interpreted with caution, particularly given the relatively low number of outcome events.

Keywords: colorectal cancer; disease-free survival; overall survival; lymph node ratio; log odds of positive lymph nodes; prognostic factors

Introduction

Colorectal cancer (CRC) is the third most common malignancy worldwide and ranks second among causes of cancer-related deaths [1]. Although the implementation of widespread screening programs in developed countries has increased the detection of early-stage colorectal cancer, the risk of recurrence and metastasis remains a significant clinical challenge [2]. Therefore, the accurate identification of prognostic parameters is essential for optimizing treatment strategies and personalizing postoperative follow-up.

The TNM staging system, developed by the American Joint Committee on Cancer (AJCC) and the Union for International Cancer Control (UICC), remains the standard method for prognostic assessment in colorectal cancer and is pri-

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marily based on the number of resected and metastatic lymph nodes [3]. However, its prognostic accuracy may be limited, particularly in cases of inadequate lymph node dissection or variability in surgical and pathological practices. Alternative lymph node-based indices have been proposed to overcome these limitations. The lymph node ratio (LNR), defined as the ratio of metastatic lymph nodes to the total number of lymph nodes examined, and the log odds of positive lymph nodes (LODDS), which incorporates both positive and negative lymph nodes using a logarithmic transformation, have been proposed as potential tools to improve risk classification [4,5].

Although various studies have reported that LNR and LODDS may provide additional prognostic information beyond traditional pN staging, the results are heterogeneous and their clinical benefits have not been clearly established. In particular, data comparing the prognostic performance of LNR, LODDS, and traditional pN staging in cohorts with low event rates and adequate lymph node dissection are limited. Furthermore, the relative prognostic value of these lymph node indices for short-term disease-free survival (DFS) and overall survival (OS) remains uncertain. Therefore, the aim of this study is to evaluate the prognostic value of LNR and LODDS for DFS and OS following curative resection for colorectal cancer and to compare their performance with traditional clinicopathological parameters, including pN staging.

Methods

Study Population and Data Collection

Inclusion criteria: Patients aged 18 years and older who underwent curative surgery and had sufficient clinical-pathological and follow-up data, with histopathologically confirmed colorectal adenocarcinoma, were included in the study. Exclusion criteria: Patients who underwent emergency surgery, had metastatic disease detected during surgery, had insufficient postoperative pathology data, or were lost to follow-up were excluded from the study. Of the 210 patients initially evaluated, 56 were excluded from the study: 10 patients underwent emergency surgery and metastatic disease was detected intraoperatively, 14 patients had insufficient postoperative pathology data, and 32 patients were lost to follow-up and survival outcomes could not be evaluated. The final study group consisted of 154 patients. Demographic characteristics (age and gender), tumor location, type of surgical intervention, histological grade (G1–G4), tumor stage (pT and pN), and number of resected and positive lymph nodes were recorded.

Surgical and Pathological Procedures

All patients underwent open or laparoscopic colorectal resection according to standard oncological surgical principles. Tumor staging and lymph node assessment were performed by experienced gastrointestinal pathologists according to routine institutional protocols and the 8th edition of the AJCC classification system.

Table 1. Demographic, surgical, and pathological features of the patients.

Variable	Value
Age (median, range)	66 (36–87)
Gender	
Male	98 (63.6%)
Female	56 (36.4%)
Type of surgery	
Right/extended	57 (37.0%)
Left-sided	50 (32.5%)
Rectal	47 (30.5%)
Histological subtype	
Adenocarcinoma NOS	122 (79.2%)
Others	32 (20.8%)
Histopathological grade	
G1, G2	142 (92.2%)
G3, G4	12 (7.8%)
Retrieved lymph nodes	
$<$12	8 (5.2%)
$\geq$12	146 (94.8%)
pT stage	
T1–T2	20 (13.0%)
T3–T4	134 (87.0%)
pN stage	
N0	95 (61.7%)
N1	41 (26.6%)
N2	18 (11.7%)
LNR category	
LNR 0	113 (73.4%)
LNR 1–2	41 (26.6%)
LODDS category	
LODDS 0	141 (91.6%)
LODDS 1–2	13 (8.4%)

NOS, not otherwise specified; LNR, lymph node ratio; LODDS, log odds of positive lymph nodes.

Definition of Variables

LNR was calculated by dividing the number of positive lymph nodes by the total number of lymph nodes removed. LODDS was calculated as the logarithm of [(number of positive lymph nodes + 0.5) / (number of negative lymph nodes + 0.5)]. Patients were divided into three groups based on previously defined cutoff values in the literature for both LNR and LODDS [6]. LNR categories were defined as follows: LNR 0 $\leq$0.05, 0.05 $<$ LNR 1 $\leq$ 0.20, and LNR 2 $>$0.20. LODDS categories were defined as follows: LODDS 0 $\leq$–1.36, –1.36 $<$ LODDS 1 $\leq$ 0.53, and LODDS 2 $>$0.53. Due to the limited number of outcome events and the small number of patients in some subgroups, LNR 1 and LNR 2 were combined into a single category (LNR 1–2), and LODDS 1 and LODDS 2 were combined into a single category (LODDS 1–2) for survival analyses.

Table 2. Clinicopathologic characteristics and univariate Cox regression analysis for 2-year disease-free survival (N = 154, events = 18).

Variable	n (%)	Events	2-year DFS %	p (log-rank)	HR (95% CI)	p (Cox)
Age				0.321		
<65	72 (46.8%)	11	93.6		1.611 (0.623–4.160)	0.325
≥65 (ref)	82 (53.2%)	7	96.5		Reference	
Gender				0.303		
Male (ref)	98 (63.6%)	13	93.1		Reference	
Female	56 (36.4%)	5	98.1		0.585 (0.208–1.643)	0.309
Type of surgery				0.968		
Right/extended (ref)	57 (37.0%)	6	93.1		Reference	
Left-sided	50 (32.5%)	5	95.2		1.016 (0.310–3.332)	0.979
Rectal	47 (30.5%)	7	97.1		0.889 (0.296–2.670)	0.834
Histological subtype				0.822		
Adenocarcinoma NOS (ref)	122 (79.2%)	15	95.1		Reference	
Others	32 (20.8%)	3	94.4		0.867 (0.251–2.998)	0.822
Histopathological grade				0.277		
G1, G2 (ref)	142 (92.2%)	16	96.5		Reference	
G3, G4	12 (7.8%)	2	77.1		2.226 (0.507–9.774)	0.289
Retrieved lymph nodes				0.296		
<12 (ref)	8 (5.2%)	2	100.0		Reference	
≥12	146 (94.8%)	16	94.8		0.465 (0.107–2.027)	0.308
pT stage				0.255		
T1–T2 (ref)	20 (13.0%)	1	100.0		Reference	
T3–T4	134 (87.0%)	17	94.3		3.043 (0.405–22.879)	0.280
pN stage				0.256		
N0 (ref)	95 (61.7%)	8	96.0		Reference	
N1	41 (26.6%)	6	100.0		1.365 (0.472–3.945)	0.566
N2	18 (11.7%)	4	80.8		2.667 (0.802–8.873)	0.110
LNR category				0.052		
LNR 0 (ref)	113 (73.4%)	9	96.6		Reference	
LNR 1–2	41 (26.6%)	9	91.0		2.431 (0.963–6.135)	0.060
LODDS category				0.763		
LODDS 0 (ref)	141 (91.6%)	16	95.7		Reference	
LODDS 1–2	13 (8.4%)	2	88.9		1.254 (0.288–5.461)	0.763
LODDS (continuous, per unit)					1.250 (0.866–1.804)	0.232

2-year DFS %: Kaplan–Meier estimate at 24 months. Right/extended: right hemicolectomy + subtotal + transverse colectomy. Left-sided: left hemicolectomy + anterior resection. Rectal: low anterior resection + abdominoperineal resection. Others: mucinous, signet ring cell, tubulopapillary, micropapillary adenocarcinoma. DFS, disease-free survival; HR, hazard ratio; ref, reference.

These classifications were used to evaluate the prognostic performance of lymph node-related indices in terms of both DFS and OS.

Statistical Analysis

Statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Shapiro–Wilk test. Continuous variables are expressed as the median (range) or mean ± standard deviation, while categorical variables are expressed as counts and percentages. OS and disease-free survival were estimated using the Kaplan-Meier method, and differences between survival curves were compared using the log-rank test. The two-year survival rates reported in the tables were derived from Kaplan-Meier estimates rather than crude incidence rates. Potential prognostic factors associated with DFS and OS were evaluated using univariate Cox proportional hazards regression analysis. Variables that were clinically significant or showed borderline statistical significance in the univariate analysis were subsequently included in exploratory multivariate Cox regression models. Due to the limited number of outcome events, the number of variables included in the multivariate models was restricted to prevent overfitting and instability of the model. For pN stage, LNR, and LODDS, separate multivariate models were created due to potential multicollinearity among these lymph node parameters. Model performance was evaluated using Harrell's fit index (C-index) and the Akaike Information Criterion (AIC). Receiver operating characteristic (ROC) curve anal-

Table 3. Clinicopathologic characteristics and univariate Cox regression analysis for 2-year overall survival (N = 154, events = 12).

Variable	n (%)	Events	2-year OS %	*p* (log-rank)	HR (95% CI)	*p* (Cox)
Age (continuous, per year)					1.076 (1.006–1.150)	0.032
Age group				0.027		
<65	72 (46.8%)	2	98.6		0.211 (0.046–0.966)	0.045
≥65 (ref)	82 (53.2%)	10	93.6		Reference	
Gender				0.295		
Male (ref)	98 (63.6%)	9	96.6		Reference	
Female	56 (36.4%)	3	95.2		0.504 (0.136–1.863)	0.304
Type of surgery				0.028		
Right/extended (ref)	57 (37.0%)	8	92.8		Reference	
Left-sided	50 (32.5%)	2	98.0		0.303 (0.064–1.430)	0.132
Rectal	47 (30.5%)	2	97.6		0.178 (0.037–0.849)	0.030
Histological subtype				0.337		
Adenocarcinoma NOS (ref)	122 (79.2%)	11	96.4		Reference	
Others	32 (20.8%)	1	93.8		0.381 (0.049–2.948)	0.355
Retrieved lymph nodes				0.065		
<12 (ref)	8 (5.2%)	2	100.0		Reference	
≥12	146 (94.8%)	10	95.8		0.263 (0.057–1.211)	0.086
pN stage				0.950		
N0 (ref)	95 (61.7%)	7	96.6		Reference	
N1	41 (26.6%)	4	96.4		1.058 (0.308–3.633)	0.928
N2	18 (11.7%)	1	93.3		0.743 (0.091–6.045)	0.781
LNR category				0.756		
LNR 0 (ref)	113 (73.4%)	9	95.6		Reference	
LNR 1–2	41 (26.6%)	3	97.0		0.812 (0.220–3.006)	0.756
LODDS category				0.538		
LODDS 0 (ref)	141 (91.6%)	12	95.7		Reference	
LODDS 1–2	13 (8.4%)	0	100.0		— †	
LODDS (continuous, per unit)					0.873 (0.512–1.488)	0.617

† Zero events in the LODDS 1–2 subgroup; hazard ratio could not be estimated from Cox regression. Histopathological grade and pT stage were also excluded from this table for the same reason (zero events in one subgroup). Multivariate analysis was not performed for OS due to insufficient events (n = 12; events-per-variable <10). OS, overall survival.

yses were performed for pN stage, LNR, and LODDS separately to predict 2-year disease-free survival and OS. The area under the curve (AUC) was calculated for each parameter. Proportional hazards models and log-minus-log survival plots were evaluated manually. A *p*-value of <0.05 was considered statistically significant.

Results

Patient Characteristics

The study included a total of 154 patients who underwent curative surgery for colorectal cancer. The median age of the patients was 66 years (range: 36–87), and 63.6% were male. In terms of surgical procedures, 37.0% of the patients underwent right/extended colectomy, 32.5% underwent left-sided colectomy, and 30.5% underwent rectal surgery. Histopathological evaluation revealed that the majority of tumors were adenocarcinoma not otherwise specified (NOS) (79.2%). Most patients had well- or moderately differentiated tumors (G1–G2, 92.2%). The median number of lymph nodes removed was 28, and adequate lymph node dissection (≥12 lymph nodes) was achieved in 94.8% of patients. In terms of pathological staging, 87.0% of patients were classified as T3–T4, while 61.7% were classified as N0. According to the LODDS classification, 91.6% of patients were classified as LODDS 0, and 73.4% as LNR 0 (Table 1).

Disease-Free Survival Analysis

In the 2-year disease-free survival analysis, no significant association was found between DFS and age, sex, type of surgery, histological subtype, histopathological grade, number of lymph nodes removed, or pT stage (all $p >$ 0.05). In terms of lymph node staging, patients with N2 disease showed lower DFS rates compared to those with N0 disease; however, this association did not reach statistical significance in the Cox regression analysis (hazard ratio

(HR): 2.667, 95% confidence interval (CI): 0.802–8.873, p = 0.110). When evaluating LNR categories, the LNR 1–2 group showed lower 2-year DFS rates compared to the LNR 0 group (91.0% vs 96.6%). Univariate Cox regression analysis indicated a trend toward increased relapse risk in the LNR 1–2 group, but this association remained marginally significant (HR: 2.431, 95% CI: 0.963–6.135, p = 0.060). No significant association was observed between LODDS categories and DFS (HR: 1.254, 95% CI: 0.288–5.461, p = 0.763). Similarly, the analysis of LODDS as a continuous variable did not indicate prognostic significance for DFS (HR: 1.250, 95% CI: 0.866–1.804, p = 0.232) (Table 2).

Overall Survival Analysis

In the 2-year OS analysis, increasing age was found to be associated with a significantly higher risk of death (HR: 1.076, 95% CI: 1.006–1.150, p = 0.032). The Kaplan-Meier analysis showed significantly higher OS rates in patients younger than 65 years compared to older patients (98.6% vs 93.6%, p = 0.027). Cox regression analysis also showed a significantly lower risk of death in patients under 65 years of age (HR: 0.211, 95% CI: 0.046–0.966, p = 0.045). By surgical type, patients who underwent rectal surgery had better OS compared to the right/wide colectomy group (HR: 0.178, 95% CI: 0.037–0.849, p = 0.030). No significant association was found between left-sided colectomy and OS (p = 0.132). Gender, histological subtype, number of resected lymph nodes, pN stage, and LNR category were not significantly associated with overall survival (all $p > 0.05$). In the categorical LODDS analysis, hazard ratios could not be estimated because no deaths were observed in the LODDS 1–2 subgroup. The continuous LODDS analysis also failed to demonstrate prognostic significance for overall survival (HR: 0.873, 95% CI: 0.512–1.488, p = 0.617) (Table 3).

Multivariable Cox Regression Analysis

Multivariate Cox regression models were constructed for 2-year disease-free survival. In Model 1 (LNR + pN), neither LNR nor pN stage independently predicted recurrence (p = 0.182 and p = 0.566, respectively). This model demonstrated moderate discriminatory performance (C-index: 0.622; AIC: 153.43). In Model 2 (LODDS + pN), neither LODDS nor pN stage showed significant prognostic value (p = 0.916 and p = 0.275, respectively). This model exhibited the lowest discriminatory performance (C-index: 0.571) and the highest AIC value (AIC: 155.98). In Model 3 (LNR + age), LNR remained independently associated with recurrence after adjusting for age (HR: 2.535, 95% CI: 1.004–6.402, p = 0.049). Age itself was not independently significant within the model (p = 0.114). This model demonstrated the best discriminatory performance (C-index: 0.671) and the lowest AIC value (AIC: 151.23). When evaluated separately, pN stage alone did not show a significant prognostic value for DFS (HR: 1.698, 95% CI: 0.669–4.313, p = 0.265). Similarly, the model including only LNR did not reach statistical significance, but a trend toward increased recurrence risk was observed (HR: 2.431, 95% CI: 0.963–6.135, p = 0.060) (Table 4).

ROC Curve Analysis

The ROC analysis for 2-year DFS showed the highest discriminatory performance for LNR (AUC: 0.622), closely followed by pN stage (AUC: 0.617). LODDS demonstrated lower prognostic performance (AUC: 0.513) (Fig. 1). For 2-year OS prediction, all lymph node parameters showed poor discriminatory performance. The highest AUC value was observed for pN stage (AUC: 0.505), followed by LNR (AUC: 0.482) and LODDS (AUC: 0.454); this indicates the limited utility of these parameters for short-term OS prediction (Fig. 2).

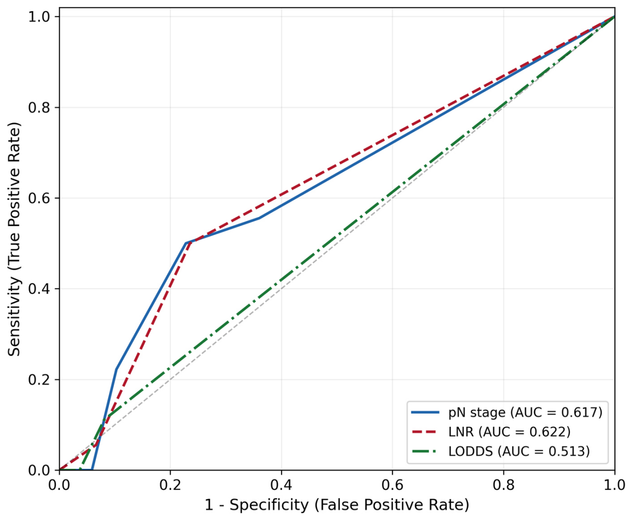

Fig. 1. ROC curves for 2-year disease-free survival. LODDS, log odds of positive lymph nodes; ROC, receiver operating characteristic; AUC, area under the curve; LNR, lymph node ratio.

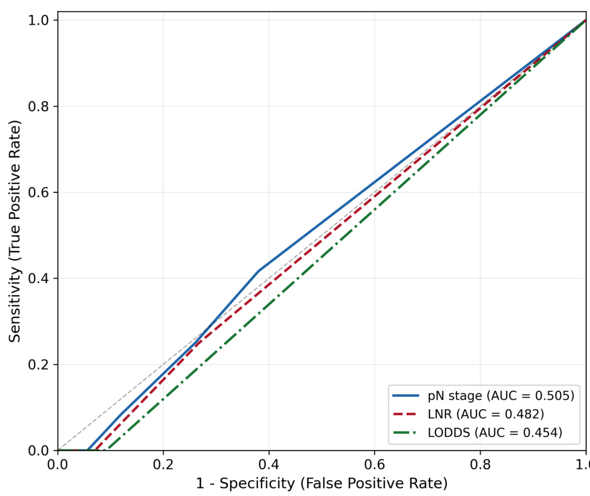

Fig. 2. ROC curves for 2-year overall survival.

Table 4. Multivariate Cox regression models for 2-year disease-free survival (N = 154, events = 18).

Model	Variable	HR	95% CI	*p*	C-index	AIC
Model 1: LNR + pN					0.622	153.43
	LNR 1–2 vs 0	4.085	0.518–32.250	0.182		
	pN+ vs N0	0.544	0.068–4.354	0.566		
Model 2: LODDS + pN					0.571	155.98
	LODDS 1–2 vs 0	0.920	0.195–4.339	0.916		
	pN+ vs N0	1.728	0.647–4.614	0.275		
Model 3: LNR + Age					0.671	151.23
	LNR 1–2 vs 0	2.535	1.004–6.402	0.049		
	Age ≥65 vs <65	0.465	0.180–1.201	0.114		
Only pN (baseline)					0.570	153.99
	pN+ vs N0	1.698	0.669–4.313	0.265		
Only LNR					0.609	151.81
	LNR 1–2 vs 0	2.431	0.963–6.135	0.060		

AIC: Akaike Information Criterion. Multivariate analysis was not performed for overall survival due to insufficient events (n = 12).

Relationship Between LNR and LODDS

Scatter plot analysis revealed a positive, nonlinear relationship between LNR and LODDS. Increasing LNR values were associated with increasing LODDS values. In patients with low LNR values, particularly those with LNR = 0, a wider distribution of LODDS values was observed (Fig. 3).

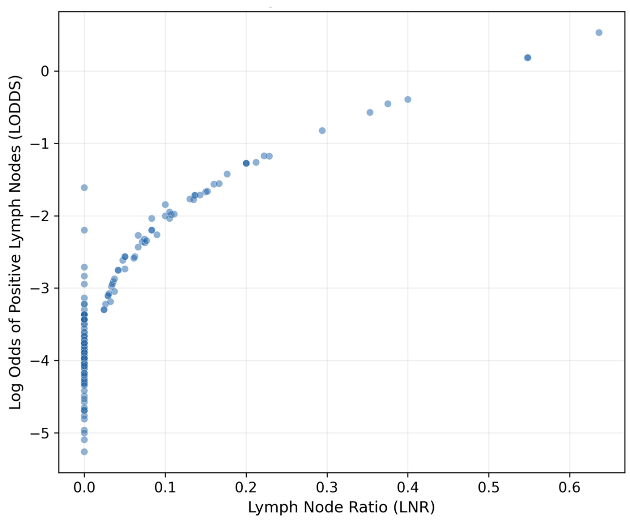

Fig. 3. Scatter plot—LNR vs LODDS.

Kaplan–Meier Survival Analysis

The Kaplan-Meier analysis revealed a distinction between DFS curves across LNR categories. While the LNR 1 group showed a more pronounced decline in DFS probability over time, the LNR 0 group maintained higher DFS rates throughout the follow-up period. According to LODDS categories, the LODDS 1 group showed a lower probability of DFS, while the LODDS 0 and LODDS 2 groups exhibited more stable survival patterns. However, these findings should be interpreted with caution due to the limited number of events in certain subgroups (Fig. 4). For OS, Kaplan-Meier curves did not show a clear distinction between LNR categories. Although a decline in OS probability over time was observed in the LNR 1 group, this difference was not statistically significant. Similarly, OS curves by LODDS category showed limited discriminatory capacity (Fig. 5).

Discussion

Lymph node involvement is considered one of the most important prognostic factors in colorectal cancer. Therefore, the accuracy of nodal staging is of critical importance for both survival prediction and decisions regarding adjuvant therapy. In recent years, alternative nodal indices such as LNR and LODDS have been developed to overcome some of the limitations of conventional pN staging [7]. A study in the literature has reported that these parameters may provide additional prognostic information compared to conventional pN staging [8].

In recent years, LNR has emerged as one of the notable alternative prognostic parameters for assessing lymph node burden in colorectal cancer. The number of studies evaluating the prognostic significance of LNR is steadily increasing. A study has reported that LNR may support prognostic differentiation compared to conventional pN staging and may provide additional prognostic information, particularly in patient groups with inadequate lymph node dissection [9]. Additionally, some researchers have suggested that LNR may provide a more balanced prognostic assessment because it considers not only the number of metastatic lymph nodes but also the total number of lymph nodes removed [10,11]. However, results in the current literature are not entirely consistent, and it is thought that the prognostic contribution of LNR may be influenced by factors such as patient population, follow-up duration, and the number of lymph nodes removed. In our study as well,

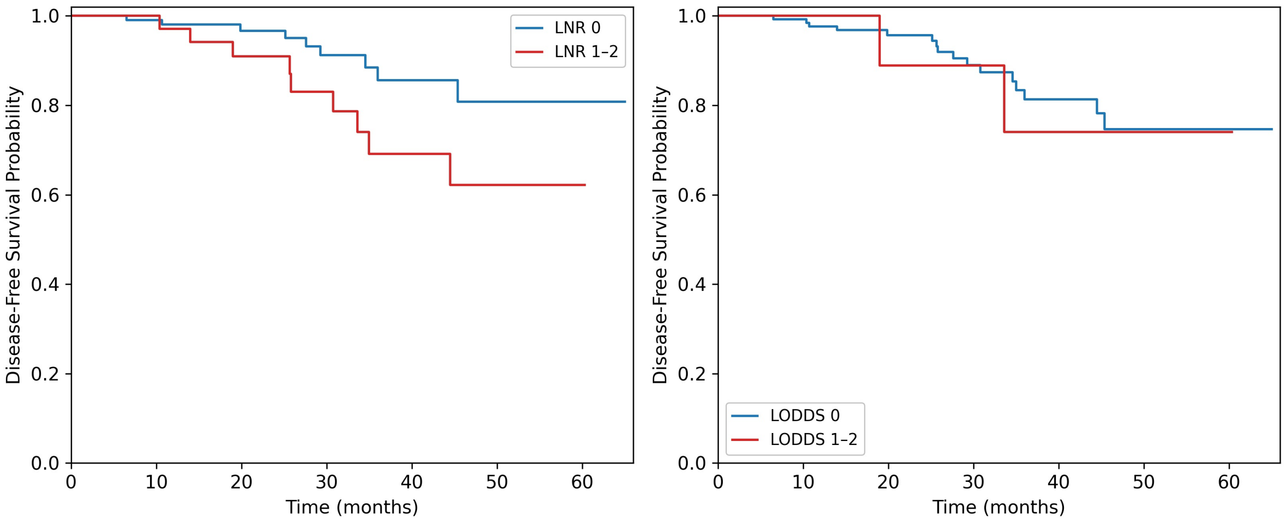

Fig. 4. Kaplan–Meier curves for DFS by LNR and LODDS. DFS, disease-free survival.

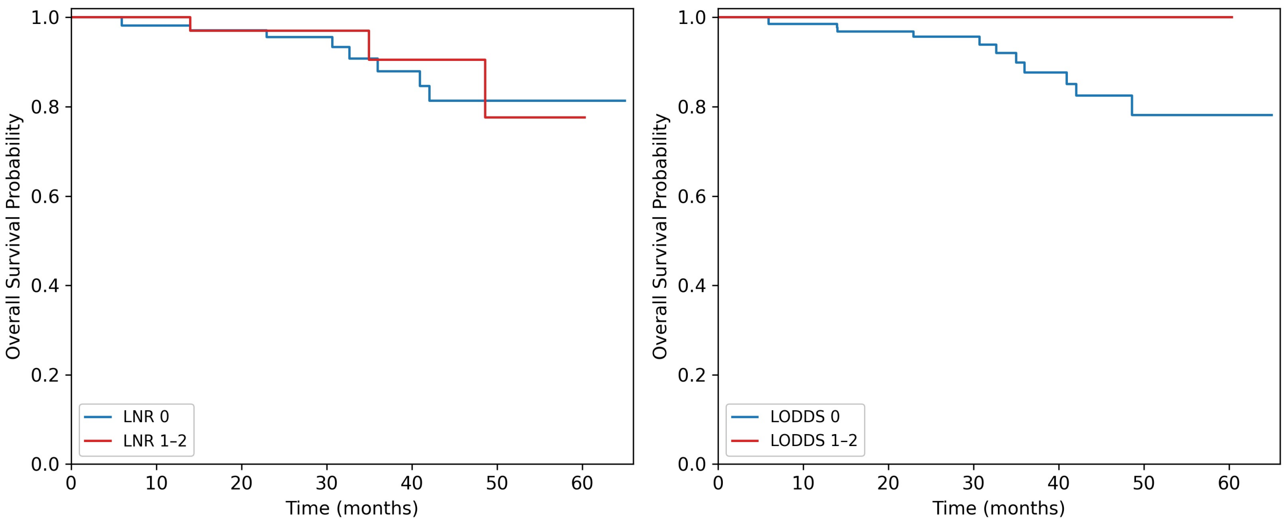

Fig. 5. Kaplan–Meier curves for OS by LNR and LODDS. OS, overall survival.

LNR emerged as a parameter providing limited prognostic discrimination, particularly in DFS analyses. However, the generally low discriminatory performance and the fact that statistical significance was borderline suggest that these findings should be interpreted with caution.

One of the most significant theoretical advantages of LODDS is that it takes into account both positive and negative lymph nodes, and is therefore thought to be less influenced by the total number of lymph nodes removed. In particular, some studies have reported that LODDS may improve prognostic discrimination in patients with a low number of lymph nodes or in subgroups where the LNR is limited [12,13]. However, in our study, LODDS was found to provide no significant prognostic contribution regarding either DFS or OS. Furthermore, in ROC analyses, the discriminatory performance of LODDS was found to be lower compared to LNR and the classic pN stage. This finding is thought to be related to the high rate of adequate lymph node dissection (94.8%), the limited number of events, and the short follow-up period in our study.

It was noteworthy that the classical pN stage also demonstrated a more limited prognostic performance than expected in our study. One possible reason for this may be the very high rate of adequate lymph node dissection in our cohort. The increased accuracy of nodal staging in patient groups where the number of resected lymph nodes was adequate may have diminished the additional contribution of alternative nodal indices. Additionally, the low number of events and short follow-up period may have limited the ability to clearly distinguish prognostic differences among the nodal parameters.

ROC analyses revealed that the discriminatory performance of all nodal parameters remained limited. In particular, the fact that AUC values were close to 0.50 in OS analyses indicates the limited contribution of nodal indices to the prediction of short-term mortality. However, the fact that the LNR had a relatively higher AUC value compared to LODDS and pN stage in the DFS analysis suggests that the LNR may provide some additional prognostic information, albeit limited, for predicting short-term recurrence. However, given that these differences are not significant, we believe the results should be interpreted with caution.

Limitations

This study has several limitations. First, because the study has a retrospective, single-center design, the generalizability of the results may be limited. Second, the low number of events observed during the follow-up period (18 recurrences and 12 deaths) may have led to reduced statistical power, particularly in multivariable analyses, and resulted in wide confidence intervals in some subgroup analyses. Therefore, the hazard ratios obtained should be interpreted with caution. Additionally, the short follow-up period may have limited the full assessment of the long-term prognostic impact of nodal parameters. The very high rate of adequate lymph node dissection in our study (94.8%) may have increased the accuracy of classical pN staging and reduced the additional prognostic contribution of alternative nodal indices. Finally, the categorical classifications used for LNR and LODDS are not standardized in the literature, and different cutoff values may lead to different results. Therefore, these findings need to be validated by larger, multicenter studies with longer follow-up periods.

Conclusions

In conclusion, this study found that LNR provided limited prognostic discrimination in terms of short-term disease-free survival, whereas LODDS did not demonstrate a significant prognostic contribution for either DFS or OS. However, the overall discriminatory performance of all the nodal parameters evaluated remained low. Given the particularly low number of events and short follow-up period, these findings should be interpreted with caution. Further studies involving larger patient cohorts and long-term follow-up are needed.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

VA was responsible for the overall study design, data collection, and statistical analysis, and led the drafting and revision of the manuscript. AOS and NB were responsible for clinical data collection, data validation, and assisted in organizing the original research database. MIA and ÖFK contributed to clinical case screening, data collection, and analysis, and participated in the proofreading of the manuscript. IE contributed to data collection, and data interpretation. EP and MD contributed to study conceptualization and methodology, provided guidance on study design, coordinated the study process, and supervised the research. All authors have been involved in revising the manuscript critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study was conducted in compliance with the Declaration of Helsinki and obtained ethical approval from the Ethics Committee of Kartal Koşuyolu Yüksek İhtisas Training and Research Hospital (approval number: 2025/10/1160; 17 June 2025). Written informed consent was obtained from all participating patients as part of routine institutional clinical practice after they were informed about the purpose of the study.

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Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in Manuscript Preparation

Artificial intelligence tools (ChatGPT, OpenAI) were used solely for language editing and grammar improvement. No AI tools were used for data analysis, statistical processing, figure or table generation, interpretation of results, or creation of scientific content. All scientific ideas, data, and conclusions presented in this manuscript are entirely generated by the authors.

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