REVIEW ARTICLE

Retrospective Study on Spectral CT Parameters of Primary Tumors and Lymph Nodes for Predicting Tumor Deposits in Colorectal Cancer

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ABSTRACT

INTRODUCTION

Tumor deposits (TDs) are an independent predictor of poor prognosis in colorec- tal cancer (CRC) patients. Enhanced follow-up and treatment monitoring for TD+ patients may improve survival rates and quality of life. However, the detection of TDs relies primarily on postoperative pathological examination, which may have a low detection rate due to sampling limitations.

AIM

To evaluate the spectral computed tomography (CT) parameters of primary tu- mors and the largest regional lymph nodes (LNs), to determine their value in predicting TDs in CRC.

METHODS

A retrospective analysis was conducted which included 121 patients with CRC whose complete spectral CT data were available. Patients were divided into the TDs+ group and the TDs- group on the basis of their pathological results. Spectral CT parameters of the primary CRC lesion and the largest regional LNs were measured, including the normalized iodine concentration (NIC) in both the arte- rial and venous phases, and the LN-to-primary tumor ratio was calculated. Stati- stical methods were used to evaluate the diagnostic efficacy of each spectral para- meter.

RESULTS

Among the 121 CRC patients, 33 (27.2%) were confirmed to be TDs+. The risk of TDs positivity was greater in patients with positive LN metastasis, higher N stage and elevated carcinoembryonic antigen and cancer antigen 19- 9 levels. The NIC (LNs in both the arterial and venous phases), NIC (primary tumors in the venous phase), and the LN-to-primary tumor ratio in both the arterial and venous phases were associated with TDs ($P < 0.05$). In mul- tivariate logistic regression analysis, the arterial phase LN-to-primary tumor ratio was identified as an independent predictor of TDs, demonstrating the highest diagnostic performance (area under the curve: 0.812, sensitivity: 0.879, specificity: 0.648, cutoff value: 1.145).

CONCLUSION

The spectral CT parameters of the primary colorectal tumor and the largest regional LNs, especially the LN-to-primary tumor ratio, have significant clinical value in predicting TDs in CRC.

KEYWORDS

Spectral computed tomography; Colorectal cancer; Tumor deposits; Predicting effectiveness

INTRODUCTION

Colorectal cancer (CRC) ranks as the third most commonly diagnosed cancer and the second leading cause of cancer-related deaths globally, with approximately 900,000 fatalities each year primarily due to tumor recurrence or metastasis. This contributes to a low five-year postoperative survival rate among patients (1). Tumor deposits (TDs)—also referred to as peritumoral deposits or cancer nodules—are defined by the 8th edition of the American Joint Committee on Cancer (AJCC) guidelines as isolated tumor foci located in the pericolic or perirectal fat, or in nearby mesenteric fat, without histological evidence of remaining lymph nodes or identifiable vascular or neural structures within the nodules. The guidelines(2,3) classify CRC patients with TDs+ and nega- tive LN metastasis as N1c, which is considered stage III, and consequently, adjuvant chemotherapy is required. For early-stage rectal tumors with TDs+, total mesorectal excision is recommended as the definitive surgical approach rather than local excision techniques, such as transanal local excision or transanal endoscopic microsurgery(4). Studies(3,5-7) have demonstrated that TDs are an independent predictor of poor prognosis in CRC patients, with TDs+ patients exhibiting lower disease-free survival and overall survival. Moreover, a greater number of TDs correlates with a worse prognosis(7, 8). Multiple studies(9-12) have shown that neoadjuvant chemoradiotherapy can reduce the number of TDs in rectal cancer patients, convert TDs+ patients to TDs- patients, and lower the rate of local recurrence. Enhanced follow-up and treatment monitoring for TDs+ patients may improve survival rates and quality of life. Currently, TDs detection relies primarily on postoperative pathological examination, which may have a low detection rate due to sampling limitations. Thus, the use of imaging examinations for preoperative TDs diagnosis has significant clinical importance.

Dual-energy spectral computed tomography (CT) can generate multiparameter images, providing more quantitative information on biological characteristics, and has been widely used in diagnosing and treating malignant tumors such as gastric cancer, liver cancer, and CRC(13). Studies(14-18) have proven the clinical value of spectral CT in determining the CRC stage, degree of LN metastasis, degree of differentiation, degree of microsatellite instability, and degree of lymphovascular tumor thrombus. The selection of the region of interest (ROI) currently includes two methods: Primary tumor(14,15) or peritumoral LNs(17,19). A recent study(20) utilized CT radiomics to analyze the largest peritumoral nodule and the primary tumor lesion, distinguishing TDs from LN metastasis in rectal cancer. Recent studies(21-23) using 18F-Fluorodeoxyglucose positron emission tomography (PET)/CT measured the standardized uptake value (SUV) of both LNs and primary tumors, utilizing a new indicator, the LN-to-primary tumor SUV ratio (NTR), to predict the prognosis of patients with malignant tumors. Currently, methods of simultaneously measuring LNs and primary tumors, as well as the NTR, have not yet been applied in studies involving spectral CT. This study aims to explore the predictive value of spectral CT parameters of the primary tumor and the largest regional LN in CRC for predicting TDs.

MATERIALS AND METHODS

Patient characteristics

This retrospective study was approved by Huizhou Central People's Hospital ethics committee (No. ky112024034), and the requirement for informed consent was waived. We analyzed 121 CRC patients at Huizhou Central People's Hospital, including 64 men and 57 women aged 35-89 years (mean age 65 years), from February 2022 to February 2024. The inclusion criteria were as follows: (1) Underwent radical CRC surgery for the first time, with postoperative pathology confirming CRC; (2) Underwent 256-slice Revolution CT dual-phase enhanced spectral CT scan within two weeks before surgery; and (3) No preoperative radiotherapy, chemotherapy, or other antitumor treatments. The exclusion criteria were as follows: (1) Poor image quality unsuitable for spectral analysis; (2) Primary tumor volume too small to be detected via
imaging; and (3) Regional LNs with short diameters of less than 3 mm. The patient recruitment flowchart is shown in Figure 1.

Spectral CT imaging

All patients underwent dual-phase enhanced spectral CT scans with a GE 256-slice Revolution CT. The scanning range was from the dome of the diaphragm to the pubic symphysis. The scanning parameters were as follows: Spectral scanning mode with instant switching of the tube voltage from 80 kVp to 140 kVp, a tube current of 400 mA, a detector width of 80 mm, a slice thickness of 5 mm, an interslice distance of 5 mm, a tube rotation time of 0.8 seconds, and a pitch of 0.992: 1. Enhanced scanning was performed with iodixanol (100 mL: 35 g, produced by Jiangsu HengRui Medicine Co., Ltd.), which was injected into the patient's elbow vein via a high-pressure dual-barrel injector. The contrast agent dose was set at 1.0 mL/kg, with a flow rate of 3.5 mL/s. Real-time intelligent tracking technology was used to monitor the CT value of the abdominal aorta, and when the CT value reached 120 HU, an arterial phase spectral scan was automatically initiated to obtain arterial phase images. Venous phase scanning was performed 30 seconds after the completion of arterial phase scanning to obtain venous phase images. All the images were reconstructed via the standard (Stnd) algorithm, with the slice thickness and interslice distance adjusted to 1.25 mm to optimize image quality.

Spectral CT image analysis

The reconstructed images were automatically transferred to the GE AW4.7 workstation for analysis. An abdominal radiologist with six years of experience used the GSI Viewer software package to analyze and measure quantitative parameters of arterial- and venous-phase spectral CT images. The measurements were reviewed by a senior radiologist with over ten years of diagnostic experience, and disagreements on ROI placement were resolved through discussion. Both radiologists were blinded to all the clinical and pathological information. First, a circular ROI was placed in the solid component area of the primary tumor (avoiding hemorrhage, necrosis, vessels, and intestinal contents), and this process was repeated three times. The minimum area of each ROI was 20 mm^2, and maintained a 2 mm distance from the tumor edge. The average values were calculated to minimize measurement bias. The mean area of all ROIs was 106.43 mm^2; range, 21.78-832.59 mm^2. Second, the largest regional LN in the lymphatic drainage area of the primary tumor was selected, and the ROI was placed on the largest slice of the LN, covering the entire LN as much as possible. Parameters were measured, and the long diameter, short diameter, and area of the LN were recorded. Third, a circular ROI was placed in the arterial phase (abdominal aorta or external iliac artery) to calculate the normalized iodine concentration (NIC). These ROIs were copied into arterial and venous phase images, with slight adjustments if necessary to exclude respiratory or gastrointestinal movement effects. The following spectral parameters were automatically measured by the software: The iodine concentration (IC) and the NIC (calculated as IC_tumor/IC_artery). NTR is calculated as NIC_LN/ NIC_tumor. The spectral CT images and the ROIs for the assessment of the quantitative measurements are shown in Figures 2 and 3.

Clinical and pathological data

Clinical and pathological data were collected through the electronic medical records system. The clinical data included patient sex, age, preoperative carcinoembryonic antigen (CEA) level (normal level: 0-5 ng/mL), and preoperative cancer antigen (CA)19-9 level (normal level: 0-30 U/mL). The pathological data included tumor location, degree of differentiation, LN metastasis status, TD status, T stage and N stage.

Statistical analysis

Statistical analysis was performed using SPSS 27.0 software. The quantitative data are expressed as the means ± SD, and independent sample *t* tests were used. Categorical data are expressed as frequencies and percentages, and the $\chi 2$ test or Fisher's exact test was used. Rank data were analyzed using the rank-sum test. $P < 0.05$ was considered statistically significant. Parameters with statistical significance in the univariate analysis were included in the multivariate logistic regression analysis (method: Forward: LR). Receiver operating characteristic (ROC) curves and areas under the curve (AUCs) were used to evaluate the diagnostic efficacy of the model, by calculating cutoff values, sensitivity, and speci- ficity.

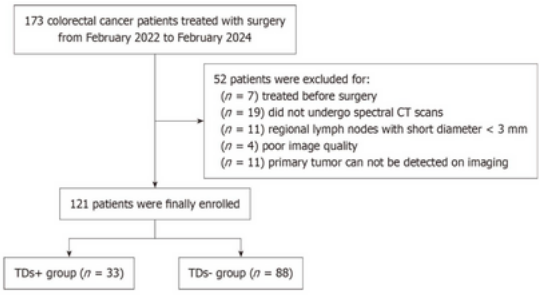


Figure 1 Flowchart of the patient recruitment process. TDs: Tumor deposits.

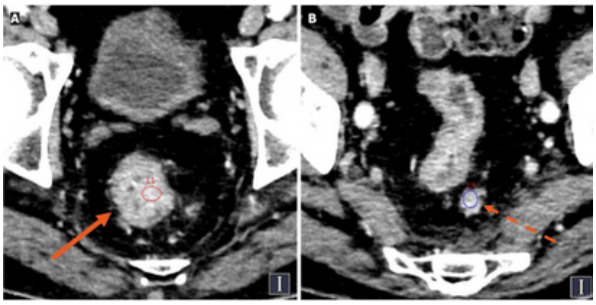


Figure 2 Illustration of venous phase segmentation. The 74-year-old male patient with tumor deposits+. In the arterial and venous phases, the normalized iodine concentration of region of interest. A: Primary tumors (arrow) = 0.16, 0.49; B: The largest regional lymph nodes (dashed arrow) = 0.17, 0.48. Lymph node-to- primary tumor ratio = 1.09, 0.98.

RESULTS

Pathological and clinical characteristics of the patients

A total of 121 CRC patients were included in the study, consisting of 33 TDs+ patients (27.3%) and 88 TDs- patients (72.7%). Patients with LN metastasis, advanced N stage and elevated CEA levels had a greater risk of being TDs+ ($P < 0.05$). An elevated CA19-9 level demonstrated edge statistical significance ($P = 0.52$). There were no statistically significant differences between the groups in terms of sex, age, tumor location, gross tumor type, degree of differentiation, or T stage ($P > 0.05$). The clinical and pathological characteristics of the patients are illustrated in Table 1.

Comparison of the spectral CT parameters between the TDs+ and the TDs- groups

The long diameter, short diameter, and area of the LNs in the TDs+ group were greater than those in the TDs- group ($P < 0.05$). The LN NIC in both the arterial and venous phases was lower in the TDs+ group than in the TDs- group ($P < 0.05$). The NIC of the primary tumor in the venous phase was greater in the TDs+ group than in the TDs- group ($P < 0.05$). Regardless of the arterial or venous phase, the NTR in the TDs+ group was lower than that in the TDs- group ($P < 0.05$). There was no statistically significant difference in the NIC of the primary tumor in the arterial phase between the two groups ($P > 0.05$). The spectral CT parameters are illustrated in Table 2.

Table 1 Clinical and pathological characteristics of the tumor deposits+ group and tumor deposits- group, *n* (%)

Characteristics		TDs+ group, *n* = 33	TDs- group, *n* = 88	Total, *n* = 121	*P* value
Gender	Male	17 (51.5)	47 (53.4)	64 (52.9)	0.853
	Female	16 (48.5)	41 (46.6)	57 (47.1)	
Age (years)		63.9 ± 11.6	65.2 ± 11.4	64.8 ± 11.4	0.602
CEA	Normal	11 (37.9)	55 (63.2)	66 (56.9)	0.018
	Elevated	18 (62.1)	32 (36.8)	50 (43.1)	
CA19-9	Normal	18 (62.1)	65 (80.2)	83 (75.5)	0.052
	Elevated	11 (37.9)	16 (19.8)	27 (24.5)	
Tumor location	Right colon	8 (24.2)	23 (26.1)	31 (25.6)	0.920
	Left colon	14 (42.4)	39 (44.3)	53 (43.8)	
	Rectum	11 (33.3)	26 (29.5)	37 (30.6)	
Differentiation degree	Low	7 (21.2)	10 (11.4)	17 (14)	0.127
	Moderate	25 (75.8)	72 (81.8)	97 (80.2)	
	High	1 (3)	6 (6.8)	7 (5.8)	
Lymph node metastasis	Negative	13 (39.4)	63 (71.6)	76 (62.8)	0.003
	Positive	20 (60.6)	25 (28.4)	45 (37.2)	
T stage	T1/T2	3 (9.1)	18 (20.5)	21 (17.4)	0.142
	T3/T4	30 (90.9)	70 (79.5)	100 (82.6)	
N stage	N0	0 (0)	61 (69.3)	61 (50.4)	< 0.001
	N1	27 (81.8)	23 (26.1)	50 (41.3)	
	N2	6 (18.2)	4 (4.5)	10 (8.3)	

Five patients' carcinoembryonic antigen (CEA) results were missing; eleven patients' cancer antigen (CA)19-9 results were missing. The normal range for CA19-9 is 0-30 U/mL, and the normal range for CEA is 0-5 ng/mL. TDs: Tumor deposits; CEA: Carcinoembryonic antigen; CA: Cancer antigen.

Table 2 Spectral computed tomography parameters of the tumor deposits+ group and tumor deposits- group

Parameters	TDs+ group	TDs- group	*T*	*P* value
Lymph node long diameter	10.38 ± 4.77	8.25 ± 3.11	-2.874	0.014
Lymph node short diameter	7.96 ± 3.61	6.18 ± 2.00	-3.45	< 0.001
Lymph node area	57.39 ± 42.73	38.15 ± 25.22	-3.049	< 0.001
AP-NIC-LN	0.16 ± 0.05	0.22 ± 0.08	3.57	0.085
AP-NIC-T	0.19 ± 0.04	0.18 ± 0.05	-0.977	0.497
AP-NIC-NTR	0.89 ± 0.24	1.27 ± 0.37	-5.573	0.016
VP-NIC-LN	0.48 ± 0.12	0.56 ± 0.16	2.632	0.018
VP-NIC-T	0.54 ± 0.11	0.49 ± 0.11	-2.14	0.034
VP-NIC-NTR	0.90 ± 0.15	1.16 ± 0.26	5.39	0.004

TDs: Tumor deposits; AP: Arterial phase; VP: Venous phase; NIC: Normalized iodine concentration; LN: Lymph node; T: Primary tumor; NTR: Lymph node-to-primary tumor ratio.

Diagnostic performance of spectral CT parameters for predicting TDs

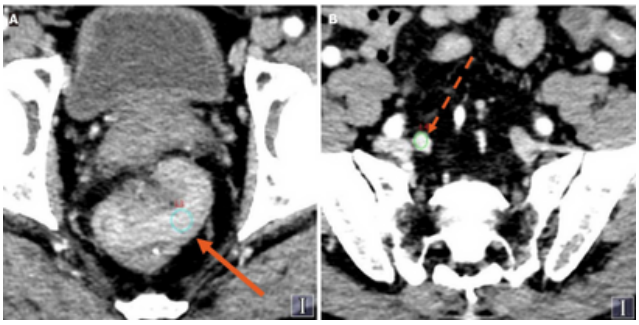
The results of the ROC analysis of the long diameter, short diameter, and area of the LNs and the quantitative spectral CT parameters of the primary tumor and LNs are shown in Table 3 and Figure 4. The AUC of the short diameter of the LNs was 0.658 (sensitivity: 0.485, specificity: 0.864, cutoff value: 7.750 mm), which was greater than that of the long diameter and area of the LNs. In both the arterial and venous phases, the AUC of the combined parameter NTR, which includes the
primary tumor and the largest regional LN parameters, was significantly greater than the spectral CT parameters of any single region (AUC, 0.631-0.721). Among all the quantitative parameters, the AUC of the arterial phase (AP)-NIC-NTR was the highest at 0.812 (sensitivity: 0.879, specificity: 0.648, cutoff value: 1.145). All parameters with statistical significance in the univariate analysis were included in the multivariate logistic regression analysis (method: Forward: LR). As shown in Table 4, AP-NIC-NTR was an independent predictor of TDs.

Table 3 Results of the receiver operating characteristic analysis of the quantitative parameters for the differential diagnosis of the tumor deposits+ group and tumor deposits- group

Parameters	AUC	95%CI	Sensitivity	Specificity	Cutoff value	*P* value
Lymph node long diameter	0.651	0.535-0.766	0.606	0.705	8.750	0.011
Lymph node short diameter	0.658	0.538-0.777	0.485	0.864	7.750	0.008
Lymph node area	0.647	0.531-0.763	0.515	0.773	45.419	0.013
AP-NIC-LN	0.721	0.625-0.817	0.939	0.432	0.225	< 0.001
AP-NIC-T	0.587	0.479-0.695	0.818	0.386	0.155	0.141
AP-NIC-NTR	0.812	0.730-0.895	0.879	0.648	1.145	< 0.001
VP-NIC-LN	0.634	0.528-0.740	0.879	0.364	0.610	0.024
VP-NIC-T	0.631	0.527-0.736	0.576	0.659	0.514	0.026
VP-NIC-NTR	0.803	0.724-0.881	0.909	0.614	1.090	< 0.001

AP: Arterial phase; VP: Venous phase; NIC: Normalized iodine concentration; LN: Lymph node; T: Primary tumor; NTR: Lymph node-to-primary tumor ratio; AUC: Area under the curve.

Figure 3 Illustration of venous phase segmentation. The 66-year-old male patient with tumor deposits-. In the arterial and venous phases the normalized iodine concentration of region of interest: A: Primary tumors (arrow) = 0.14, 0.38; B: The largest regional lymph nodes (dashed arrow) = 0.20, 0.65. Lymph node-to- primary tumor ratio = 1.39, 1.73.



DISCUSSION

The presence of TDs is an independent indicator of poor prognosis in CRC patients(3,5-7). However, predicting TDs through imaging remains challenging. Thus, accurate prediction of TDs by spectral CT is crucial, as it aids in treatment planning and prognosis assessment. Our study demonstrated that the spectral CT quantitative parameters of the primary tumor and the largest regional LNs were related to TDs. The new indicator, the NTR had greater diagnostic value for preoperatively predicting TDs.

	Univariate		Multivariate	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
AP-NIC-LN	0.000 (0.000, 0.001)	< 0.001		
AP-NIC-NTR	0.013 (0.002, 0.086)	< 0.001	0.013 (0.002, 0.086)	< 0.001
VP-NIC-LN	0.019 (0.001, 0.424)	0.012		
VP-NIC-T	44.143 (1.226, 1589.062)	0.038		
VP-NIC-NTR	0.003 (0.000, 0.043)	< 0.001		

AP: Arterial phase; VP: Venous phase; NIC: Normalized iodine concentration; LN: Lymph node; T: Primary tumor; NTR: Lymph node-to-primary tumor ratio.

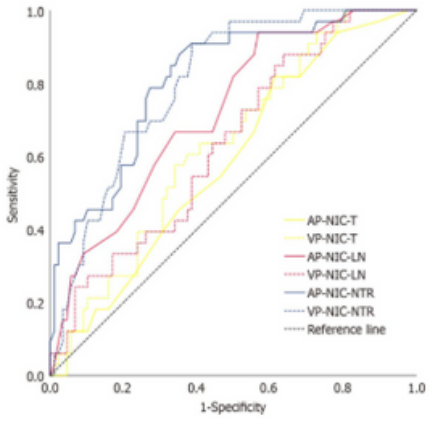


Figure 4 Receiver operating characteristic curves of the quantitative parameters used for the differential diagnosis of tumor deposits+ and tumor deposits- patients. The areas under the curve of arterial phase-normalized iodine concentration-lymph node-to-primary tumor ratio was the highest at 0.812 (sensitivity: 0.879, specificity: 0.648, cutoff value: 1.145). AP: Arterial phase; VP: Venous phase; NIC: Normalized iodine concentration; LN: Lymph node; T: Primary tumor; NTR: Lymph node-to-primary tumor ratio.

This study confirmed that TDs+ status is significantly positively correlated with LN metastasis, larger long and short diameters, the area of the LNs, advanced N stage and elevated CEA and CA19-9 levels, which is consistent with reports in the literature(3,5,24). Clinically, elevated CEA and CA19-9 levels indicate increased tumor aggressiveness and me- tastasis in CRC patients(25). More aggressive and metastatic tumors are more likely to have LN metastasis, distant metastasis, and TDs. A recent study(24) of 770 CRC patients also indicated that TDs were associated with LN metastasis, advanced T category, poorly differentiated tumors, microsatellite stable subtype, and lymphovascular and perineural invasion ($P < 0.05$). However, in our study, TDs were not associated with advanced T stage or poorly differentiated tumors ($P > 0.05$). This discrepancy might be due to two factors: First, primary lesions in T1/T2 stage tumors are relatively small, making them difficult to detect by imaging; thus, some patients were excluded from the study (the proportion of T1/T2 stage patients in our study was 14.7%, whereas that reported in the literature was 35.3%) (24). Second, the small sample size in our study may have introduced bias.

Spectral CT switches instantaneously between tube voltages of 80 kVp and 140 kVp during a single scan, obtaining data at two energy levels and providing more quantitative information. The IC is a quantitative parameter reflecting the iodine content in tissues, indirectly indicating the tissue blood supply and providing insights into the angiogenesis and hemodynamic status of lesions(26). We used the NIC to minimize differences due to cardiac hemodynamics and body weight among patients. Our study revealed that in the largest regional LNs, the NIC in both the arterial and venous phases was lower in the TDs+ group than in the TDs- group. This may be because the largest regional LNs are more likely to be metastatic. Metastatic LNs have fewer blood vessels and are more prone to necrosis and liquefaction, leading to a reduced blood supply and lower NIC. Previous studies(27,28) have also shown that the IC in both the arterial and venous phases is significantly lower in metastatic CRC LNs than in non-metastatic LNs. Huang *et al*(29) reported that in lung cancer patients, the IC of mediastinal metastatic LNs was lower than that of non-metastatic LNs. The greater the degree of malignancy of a tumor, the greater its ability to metastasize. Tumors produce vascular endothelial growth factors and other substances to promote the formation of new blood vessels(30), leading to a richer blood supply and higher NIC in the primary tumor lesion. However, no studies have proved a direct correlation between TDs positivity and the blood supply to the primary tumor lesion; this correlation can only be indirectly inferred from LN metastasis, TNM stage, and degree of differentiation. Previous studies(31,32) have shown that a high angiogenesis intensity is closely related to invasive histopathological characteristics, such as LN metastasis and degree of differentiation. Cao *et al*(33) reported that the NIC of primary tumor lesions in both the arterial and venous phases was greater in the LN metastasis group than in the non-metastasis group. Our study revealed that only the NIC in the venous phase was significantly greater in the TDs+ group than in the TDs- group, whereas the NIC in the arterial phase was not statistically significant. We hypothesize that this may be because, in the arterial phase, the contrast agent is still present in larger blood vessels and has not yet diffused into the tumor microvessels and perivascular spaces. Chuang-Bo *et al*(18) reported that the NIC of highly differ- entiated CRC tumors was significantly lower than that of poorly differentiated tumors (18 patients in the highly differen- tiated group and 29 patients in the poorly differentiated group). The lack of significant differences in the degree of tumor differentiation between the groups in our study may be due to differences in grouping.

Recent studies(34) utilizing 18F- FDG PET/CT have revealed that the NTR (LN-to-primary tumor SUV ratio) is nega- tively correlated with poor prognosis in various malignant tumors,

including those of the head and neck, endometrium, lung, breast, and nasopharynx. However, our findings suggest a negative correlation between NTR and TDs. Previous studies have shown that TDs are positively correlated with poor prognosis in CRC patients. This discrepancy may be due to differences in the parameters measured; our study measured NIC via spectral CT, whereas PET/CT studies measured the SUV. Research by Kupik et al(35) demonstrated no correlation between spectral CT parameters and 18F-FDG PET/CT parameters in primary tumors and the LNs of patients with lung cancer. Additionally, in tumors smaller than 3 cm, a moderate negative correlation exists between the spectral CT parameters and 18F-FDG PET/CT parameters (r = -0.456, -0.527)(35). Therefore, we believe that spectral CT and 18F-FDG PET/CT parameters, such as NTR, reflect different tumor characteristics and cannot be directly compared. Our study innovatively introduced the new parameter NTR into spectral CT research. We found that the arterial- and venous-phase NTR had AUCs of 0.803-0.812, which were greater than those of the individual primary tumor and LN spectral parameters (AUC: 0.587-0.721). Among these, the AUC for AP-NTR-NIC was the highest (AUC 0.812, sensitivity, 0.879, specificity, 0.648; cutoff value, 1.145).

The diagnosis of TDs from imaging data is currently challenging. Most current studies have employed radiomic methods. Zhang et al(20) analyzed the radiomic features of the largest peritumoral nodule and the primary tumor via radiomics and reported that a combined radiomic model had the highest AUC for differentiating rectal cancer TDs from LN metastasis, surpassing models based solely on the largest peritumoral nodule or the primary tumor. Li et al(36) used intratumoral, peritumoral, and combined radiomics models, achieving an AUC of 0.773-0.874 in the validation set for diagnosing TDs. However, radiomics requires complex calculations of high-dimensional image data, making it difficult to apply widely in clinical practice. Our study utilized spectral CT parameters of the primary tumor and the largest regional LNs, which are more readily extractable. Compared with the high cost of 18F-FDG PET/CT, spectral CT provides both anatomical and functional information during a single enhanced CT examination.

Our study has several limitations. First, CRC patients with LNs smaller than 3 mm or undetectable LNs were not included. Second, despite measurements being performed by two radiologists, there might still be variability in ROI placement. Third, this was a single-center retrospective study with a relatively small number of cases, and further multicenter validation is needed in the future.

CONCLUSION

In conclusion, the spectral CT parameters of the primary colorectal tumor and the largest regional LN have clinical value in predicting TDs, with the new parameter NTR providing greater value than parameters of the primary tumor or LNs alone.

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