The role of multidetector CT in local staging and evaluation of retroperitoneal surgical margin involvement in colon cancer

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PURPOSE
We aimed to evaluate preoperative T and N staging and retroperitoneal surgical margin (RSM) involvement in colon cancer using multidetector computed tomography (MDCT).

METHODS
In this retrospective study, preoperative MDCTs of 141 patients with colon adenocarcinoma were evaluated in terms of T and N staging and retroperitoneal surgical margin involvement by two observers. Results were compared with histopathology.

RESULTS
In determining extramural invasion, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of MDCT were 81%, 50%, 95%, 26%, and 81% for observer 1 and 87%, 75%, 97%, 27%, and 84% for observer 2, respectively. Moderate interobserver agreement was observed (κ=0.425). In determining T stage of the tumor, accuracy of MDCT was 55% for observer 1 and 51% for observer 2. In the detection of lymph node metastasis, sensitivity, specificity, PPV, NPV, and accuracy of MDCT were 84%, 46%, 60%, 74% and 64% for observer 1 and 84%, 56%, 65%, 78%, and 70% for observer 2, respectively. Interobserver agreement was substantial (κ=0.650). RSM was involved in six cases (4.7%). When only retroperitoneal colon segments were considered, 1.6% of subjects demonstrated RSM involvement. Four of the six RSM-positive tumors were located on sigmoid colon and one tumor was on transverse colon and caecum. Considering all colon tumors, in the detection of RSM involvement, sensitivity and specificity of MDCT were 33% and 81% for observer 1 and 50% and 80% for observer 2. Interobserver agreement was moderate (κ=0.518).

CONCLUSION
MDCT is a promising technique with moderate interobserver agreement in detection of extramural invasion, lymph node metastases, and RSM involvement in colon carcinomas.

With the advent of technological improvements, computed tomography (CT) became one of the important diagnostic tools in the evaluation of local characteristics, preoperative staging, and prognostic factors of colon cancers (1). CT is recommended by EURECCA consensus group for staging of colon cancers (2). Extramural invasion (EMI) is an important factor affecting the prognosis in patients with colon cancer (3). Preoperative CT can detect EMI in colon cancers with high sensitivity (4). In addition, CT-based T staging can be used to stratify patients into good and poor prognosis (4, 5).

Correlation between local recurrence and circumferential resection margin involvement in rectal cancer suggests the importance of retroperitoneal surgical margin (RSM) involvement in retroperitoneal ascending and descending colon tumors. RSM involvement is defined as less than 1 mm distance between RSM and primary adenocarcinoma or metastatic retroperitoneal lymph node in descending and ascending colon cancers (6). Studies suggest that RSM positivity may be a predictor and an independent prognostic indicator showing local recurrence in colon cancers (7).

Classical colon cancer treatment is based on histopathologic prognostic factors in the resected specimen (1). However, at the present time, with the development of more effective chemotherapeutic agents and higher accuracy in preoperative staging, neoadjuvant treatments are preferred in patients with high-risk colon cancer (2, 8). Preoperative radiologic assessment of EMI and RSM positivity can decrease the local recurrence risk through timely recommendation of neoadjuvant chemotherapy which would lead to regression of met-

astatic lymph nodes, retroperitoneal extension, and tumor burden (6–8). Since severe adverse effects can be observed, neoadjuvant treatment should be administered to patients who would benefit the most from it. The aim of this study was to evaluate preoperative T and N staging and RSM involvement in colon cancer using multidetector CT (MDCT) and compare them with histopathology results.

Methods

Patients

All consecutive patients with histopathologically diagnosed colorectal cancer in the pathology database and colonic mass in the radiology archive of our hospital were evaluated between January 2008 and January 2012. Exclusion criteria were rectal or rectosigmoid tumors, CT or histopathologic evaluation performed at another hospital, inoperable patients, and postoperative histopathologic diagnosis not revealing carcinoma despite radiologic findings suggesting colon cancer.

One hundred ninety-four patients met the inclusion criteria. Patients were examined with three different (4-, 16-, or 64-slice) MDCT scanners. Due to low z-axis resolution of 4-slice CT reformat images, 49 patients who underwent CT examination with 4-slice MDCT were left out of evaluation. Of 145 patients, one who had carcinoma in situ and three who (pT1N0, pT2N0, pT3N0) were noted of having no colonic tumor in CT scans by both observers, were left out of analysis. The remaining 141 patients (58 female and 83 male; age range, 24–92 years; mean age 66.7±11.67 years) were included in this study. Ethical approval for the study was granted by the institutional review board.

Main points

- MDCT can reliably detect extramural invasion, which is an important prognosic factor in colon cancer.

- Retroperitoneal surgical margin (RSM) involvement is defined to be less than 1 mm as the shortest distance between RSM and primary adenocarcinoma or metastatic retroperitoneal lymph node.

- Low frequency of RSM involvement may have been the main cause of low sensitivity in the evaluation of RSM.

- Not only retroperitoneal ascending and descending colon cancers, but also sigmoid and transverse colon cancers should be kept in mind for possible RSM involvement.

CT technique

Examinations were performed with a 16- or 64-slice MDCT scanner. Intravenous contrast agent (100 mL water-soluble nonionic contrast agent) was given in supine position to all patients, except three patients with renal failure. Imaging was performed with a 16-slice CT in 56 patients and a 64-slice CT in 85 patients. Before imaging, oral positive contrast agent was administered to 59 patients and oral negative contrast agent was administered to 82 patients. Rectal contrast agent was administered to patients who tolerated it (61 patients).

Abdominal CT was performed during arterial phase for the upper abdomen (from base of the thorax until the iliac crista) and during portal venous phase for the whole abdomen (from base of the thorax to the pubic bone). Imaging was performed at 120 kVp; 240–430 mA; FOV, 35–50 cm in accordance with the patients; matrix, 512×512. Axial images were performed with slice thickness of 1–2 mm. Coronal reformat images were obtained from source images.

Radiologic evaluation

Age and gender of the patients, duration between CT and surgery, oral, rectal, positive or negative contrast usage were noted. Tumor localization, perforation, T and N stages, and RSM involvement were assessed retrospectively and independently by two observers (observer 1, a fourth year radiology resident; observer 2, an abdominal radiologist) using axial and coronal reformat images. Tumor localizations were categorized under eight regions: cecum, cecum-ascending colon, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, and sigmoid colon.

T staging with MDCT was evaluated according to 2010 TNM system. T1 stage was described as intraluminal extension without intestinal wall thickening, T2 stage was evaluated as asymmetrical wall thickening with clear adjacent pericolonic fat tissue and T3 stage was described as smooth or nodular extension of a discrete mass through the intestinal wall into pericolonic tissues. With the last TNM revision, T4 lesions were reevaluated as T4a (tumor penetrates to visceral peritoneal surface) and T4b (tumor invades other organs or structures) (9) (Fig. 1a, 1b). The pathology reports before 2010 TNM staging were revised in light of these changes.

In line with 2010 TNM system, radiologic N staging was performed without separating N1 and N2 stages to subgroups. A size criteri-on of 5 mm maximum short axis nodal diameter was used to differentiate benign nodes from metastatic ones. N1 was evaluated as one to three lymph nodes with a short axis larger than 5 mm or three or more abnormally clustered normal-sized lymph nodes; N2 was evaluated as four or more lymph nodes with a short axis larger than 5 mm (9).

On CT, RSM involvement was recorded as positive if the minimum distance between the tumor or metastatic lymph node and the retroperitoneal parietal fascia was less than 1 mm (6) (Fig. 1c).

Pathologic evaluation

Macroscopic perforation, histologic type, pT and pN stage of the tumor, and the number of metastatic lymph nodes were recorded. RSM was histopathologically evaluated according to Standardization Scheme of Royal College 1998 guideline (10).

Statistical analysis

The frequency distribution of all variables was checked. Taking the pathologic data as the reference standard, McNemar test was used on paired nominal data (in dependent groups). Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy (DA), and diagnostic odds ratio (DOR) were calculated. Statistical significance level was accepted as $P < 0.05$. DOR was calculated with 95% confidence interval (CI).

Radiology-pathology correlation and agreement between observers were evaluated using the kappa analysis. Kendall's tau-b nonparametric correlation analysis was performed to compare T stage findings of both observers with histopathology findings. For N stage, radiology-pathology comparison was evaluated by chi-square analysis.

Variance analysis was performed to evaluate the effect of duration between CT and surgery on T staging (understaging, accurate, and overstaging). Since the number of patients in the groups was fewer than 30 for the first observer, the evaluation was performed using the nonparametric Kruskal-Wallis test. The effect of negative or positive contrast use on T staging and the effect of rectal contrast use on T staging in sigmoid tumors were evaluated by chi-square test.

Results

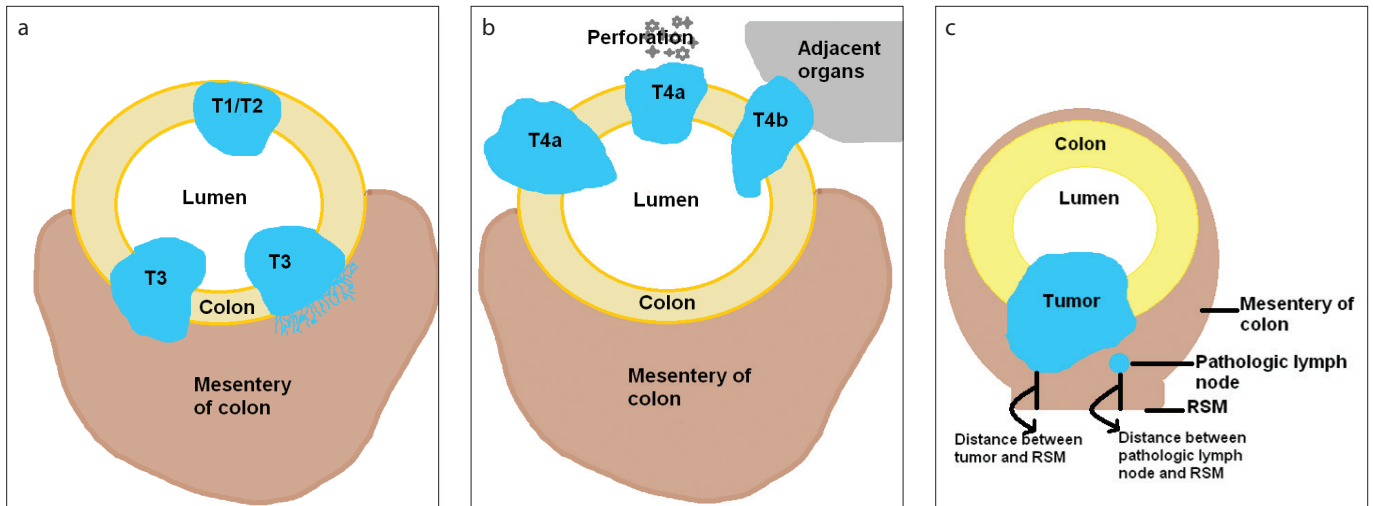Tumors were located in the sigmoid colon (n=53, 37.6%), ascending colon (n=21,

Figure 1. a–c. Schematic images of T staging **(a, b)** according to 2010 TNM and evaluation of retroperitoneal surgical margin (RSM) involvement **(c)**. RSM involvement was evaluated as being present if the minimum distance between the tumor or metastatic lymph node and the RSM was less than 1 mm.

14.9%), descending colon (n=21, 14.9%), cecum (n=17, 12.1%), cecum and ascending colon (n=12, 8.5%), transverse colon (n=7, 5%), hepatic flexure (n=6, 4.3%), and splenic flexure (n=4, 2.8%). Tumors included 129 adenocarcinomas, six mucinous adenocarcinomas, three signet ring cell carcinomas, one medullary adenocarcinoma, one adenocarcinoma with neuroendocrine differentiation, and one adenocarcinoma with squamous differentiation.

According to histopathologic T staging, two tumors were T1 (1.4%), 10 were T2 (7.1%), 64 were T3 (45.4%), 48 were T4a (34%), and 17 were T4b (12%). In terms of invasion, patients were classified as EMI negative (T1 and T2) and EMI positive (T3 and T4). Histopathologically, EMI was detected in 91.5% of patients. In EMI evaluation, the sensitivity of MDCT was 81% and 87% for observers 1 and 2; specificity was 50% and 75% for observers 1 and 2. There was slight agreement between the findings of pathology and radiology (κ=0.260, $P = 0.001$ for observer 1; κ=0.314, $P < 0.001$ for observer 2). The agreement between the observers was moderate (κ=0.425, $P < 0.001$). DOR was 6.58 for observer 1 and 13.13 for observer 2 (Table 1).

In terms of T stage prediction, pathology-radiology correlation was 0.391 ($P < 0.001$) for observer 1, 0.362 ($P < 0.001$) for observer 2, while interobserver agreement was 0.564 ($P < 0.001$). Correct diagnosis ratios of T1, T2, T3, and T4 stages were 0%, 40%, 67.2%, and 46.1% for observer 1 and 50%, 70%, 29.7%, and 69.2% for observer 2. While observer 1 staged T3 cases most accurately, observer 2 staged T2 and T4 cases most accurately (Table 2).

Table 1. Radiologic evaluation of extramural invasion

EMI	Sensitivity %	Specificity %	PPV %	NPV %	DA %	Observer and pathology agreement κ /DOR (95% CI)
1st Observer	87	50	95	26	84	0.260/6.58 (1.9041–22.7957)
2nd Observer	81	75	97	27	81	0.314/13.13 (3.3024–52.1636)

EMI, extramural invasion; PPV, positive predictive value; NPV, negative predictive value; DA, diagnostic accuracy; DOR, diagnostic odds ratio.

Table 2. Radiologic-pathologic correlation of T stage for the first and second observer

		pT1	pT2	pT3	pT4a	pT4b	Total
1st Observer	T2	2 (8.7)	4 (17.4)	10 (43.5)	7 (30.4)	0 (0)	23
	T3	0 (0)	6 (7.8)	43 (55.8)	23 (29.9)	5 (6.5)	77
	T4a	0 (0)	0 (0)	7 (35)	12 (60)	1 (5)	20
	T4b	0 (0)	0 (0)	4 (19)	6 (28.6)	11 (52.4)	21
2nd Observer	T1	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	1
	T2	1 (3)	7 (21.2)	13 (39.4)	12 (36.4)	0 (0)	33
	T3	0 (0)	2 (6.9)	19 (65.5)	8 (27.6)	0 (0)	29
	T4a	0 (0)	0 (0)	23 (51.5)	18 (40)	4 (8.9)	45
	T4b	0 (0)	1 (3)	9 (27.3)	10 (30.3)	13 (39.4)	33
Total		2 (1.4)	10 (7.1)	64 (45.4)	48 (34)	17 (12.1)	141

Radiologic T staging was categorized as understaging, accurate staging, and overstaging in comparison with histopathology (Figs. 2, 3). T4a and T4b stages were accepted as T4. The number of understaged, accurately staged, and overstaged patients was 45 (31.9%), 77 (54.6%), and 19 (13.4%) for observer 1 and 33 (23.4%), 72 (51.1%), and 36 (25.5%) for observer 2, respectively. Forty-eight patients were staged accurately by both observers. Agreement between the observers was slight (κ=0.351, $P < 0.001$).

According to histopathology, lymph node status was N0 in 70 patients (50.4%), N1 in 44 patients (31.6%), and N2 in 25 patients (18%). Histopathologic N stage could not be evaluated in two patients. Lymph node metastasis was detected in 69 patients (49.6%). The number of metastatic lymph nodes ranged 1–25, with an average of 4.3 metastatic nodes. Both observers evaluated 36 patients as N0, 47 patients as N1, and 17 patients as N2.

Lymph node status was accurately staged in 68 patients (48.9%) by observer

1 and 72 patients (51.8%) by observer 2. Accurate staging ratios for N0, N1, and N2 were 45.7%, 47.7%, and 60% for observer 1 and 55.7%, 59.1%, and 28% for observer 2, respectively. Compared with pathologic staging, observers 1 and 2 erred towards understaging in 14.4% and 20.1% of patients and overstaging in 36.7% and 28.1% of patients, respectively (Fig. 4).

Lymph node status was analyzed in two groups (N0 and N1–2). In radiologic evaluation of lymph node metastasis, sensitivity, specificity, PPV, NPV, and DA values of MDCT were 84%, 46%, 60%, 74%, and 64% for observer 1 and 84%, 56%, 65%, 78%, and 70% for observer 2. Agreement between the findings of pathology and the observers was slight (κ=0.297, $P < 0.001$ for observer 1; κ=0.397, $P < 0.001$ for observer 2; Table 3). There was good agreement between the observers (κ=0.650, $P < 0.001$).

Pathologic RSM data were available in 127 of 141 patients (90.1%). Six patients (4.7%) were reported to have RSM involvement (Figs. 5 and 6). When RSM status was evaluated only in cecum, ascending colon, and descending colon tumors (retroperitoneal parts of the colon), RSM data were available in 64 of 71 patients (90.1%). Only one of these 64 patients (1.6%) had RSM involvement. Among the six RSM-positive patients, localization of the tumor was sigmoid in four patients, transverse colon in one patient, and cecum-ascending colon in the other patient.

For RSM involvement, tumors in all segments of the colon and the retroperitoneal sections of the colon were compared with pathology separately. In the evaluation of retroperitoneal colonic segment tumors, the sensitivity was 0% for observer 1 and 100% for observer 2. The agreement between the observers was moderate for RSM evaluation of 64 cases having pathologic data (κ=0.473, $P < 0.001$) (Fig. 7). In the evaluation of RSM positivity without considering the localization of the tumors, sensitivity and specificity were 33% and 81% for observer 1 and 50% and 80% for observer 2 (Table 4). In RSM evaluation of 127 cases with pathologic data, agreement between the observers was moderate (κ=0.465, $P < 0.001$).

The average duration between CT and surgery was 8.31±11.29 days (0 to 76 days). No effect of duration between CT and surgery on T staging accuracy was detected ($P = 0.190$, observer 1; $P = 0.242$, observer 2).

Use of negative or positive contrast agent did not affect diagnostic accuracy ($P = 0.311$ and $P = 0.461$, for observers 1 and 2). Simi-
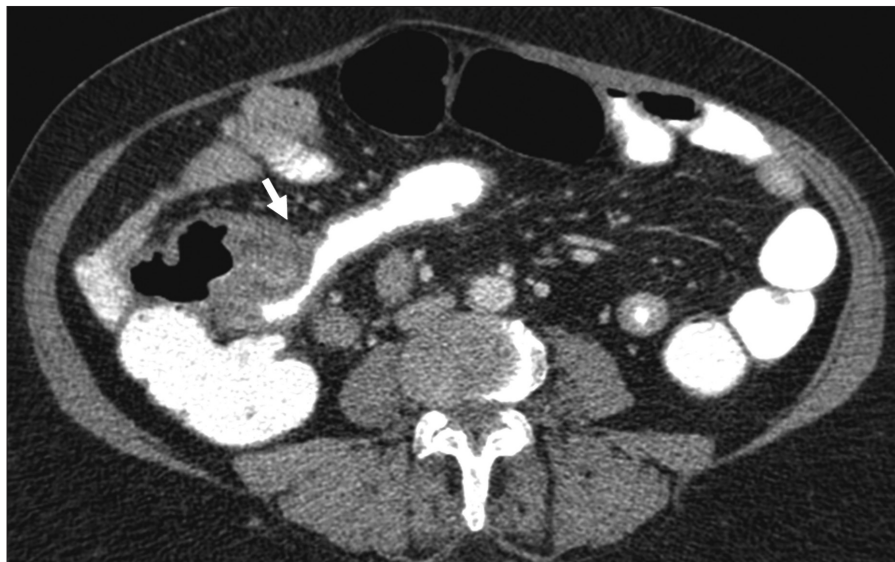

Figure 2. Axial CT image of a 69-year-old woman whose cecal tumor was suspicious for invasion of ileum *(arrow)*. Both observers assessed the cecal lesion as T4b, but it was proven to be T3 tumor pathologically (overstaging).
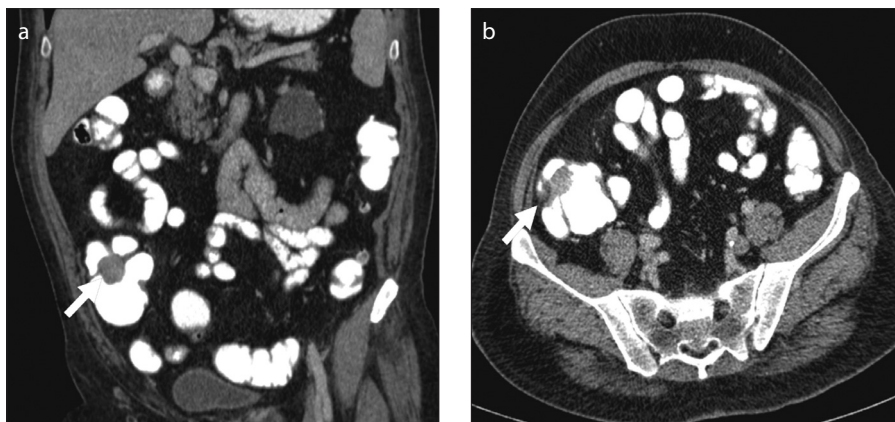

Figure 3. a, b. Reconstructed coronal **(a)** and axial **(b)** MDCT images of a 69-year-old man demonstrating no extramural invasion *(arrows)*. Both observers assessed the ascending colon tumor as T2. It was a pathologically proven T4a tumor (understaging).

Table 3. Radiologic detection of lymph node metastases

Lymph node metastasis	Sensitivity %	Specificity %	PPV %	NPV %	DA %	Observer-pathology agreement κ (P)
1st Observer	84	46	60	74	64	0.297 (<0.001)
2nd Observer	84	56	65	78	70	0.397 (<0.001)
PPV, positive predictive value; NPV, negative predictive value; DA, diagnostic accuracy.						

larly, rectal contrast use on sigmoid tumors (53 cases, 37.6% of tumors) did not affect T staging accuracy ($P = 0.218$ and $P = 0.271$, for observers 1 and 2).

Discussion

In our study EMI was detected with high sensitivity. In determining T stage of the

tumor, accuracy was 54.6% for observer 1 and 51.1% for observer 2. In the detection of lymph node metastasis, sensitivity was high (84%) and interobserver agreement was substantial (κ=0.650). In our study RSM was involved in six cases (4.7%). Four of the six RSM-positive tumors were located on sigmoid colon and one tumor was on transverse colon and caecum. In the
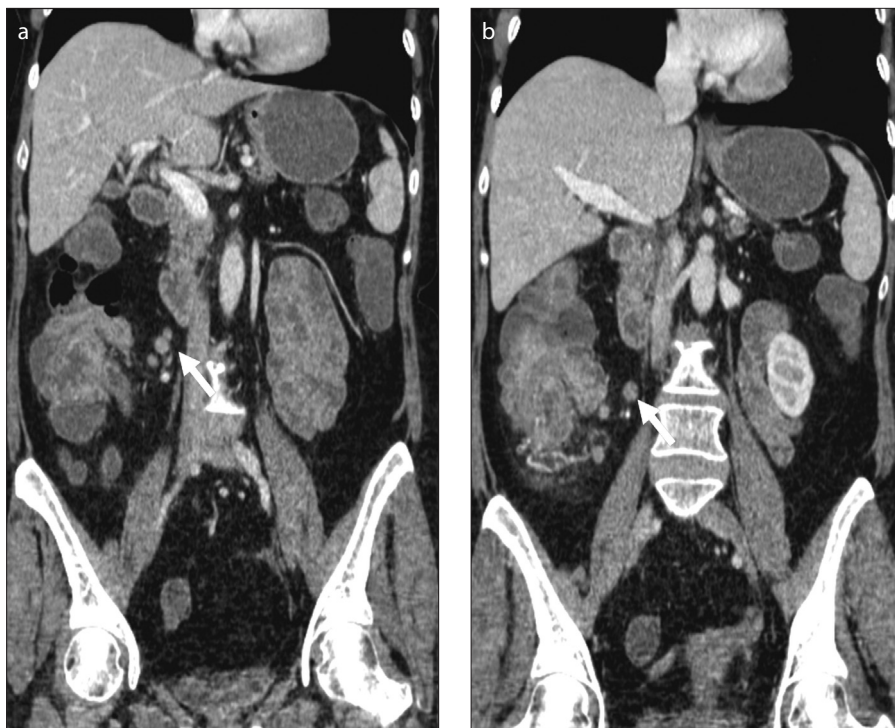
Figure 4. a, b. Coronal multiplanar reconstruction MDCT images **(a, b)** show cecal tumor and enlarged lymph nodes larger than 5 mm in size suggesting malignancy *(arrows)*. Both observers staged the lymph nodes as N1. However, pathology revealed that the lymph node enlargement was caused by a benign inflammatory reaction (N0).
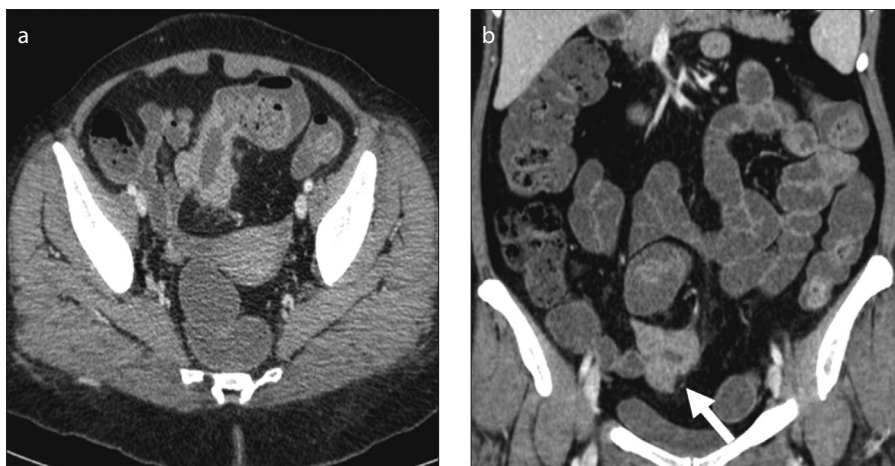

Figure 5. a, b. Axial **(a)** and coronal reformatted **(b)** MDCT images of a 54-year-old-woman with pathologically proven pT4aN0, RSM-positive sigmoid colon tumor. Both observers assessed RSM as negative. First observer, T4aN0 RSM-; second observer, T4aN1 RSM-.

detection of RSM involvement, sensitivity was not high but interobserver agreement was moderate.

Prognostic factors and circumferential resection margin involvement in rectal cancer have been evaluated radiologically for many years. However, radiologic studies evaluating prognostic factors and RSM of colon cancer are limited. Our study included patients with colon cancer only. We excluded patients with rectal cancers due to

possibility of staging mistakes in patients who had preoperative chemoradiotherapy. Our study had a series of 141 cases. When compared with similar studies, it has the highest number of patients to date.

In a meta-analysis performed in 2010, the sensitivity and specificity of CT in the detection of EMI were 86% and 78%, respectively (4). Our findings are quite similar in the evaluation of EMI (sensitivity, 81% and 87%; specificity, 50% and 75%; DOR, 6.58 and

13.13). In a study of 33 patients Burton et al. (11) reported 86% sensitivity, 75% specificity, and DOR=18 for the detection of EMI. In the same study, T staging was accurate in 36% and 51.5% of patients, whereas it was accurate in 51.1% and 54.6% of patients in our study. In our study, EMI was positive in 91.5% of the patients and negative in 8.5%. The low number of EMI-negative patients may be the reason of low specificity for both observers. In addition, the presence of pericolonic inflammation and/or fluid in EMI-negative patients may be a specificity-reducing factor as well. The high number of true-positive cases and the low number of false-positive cases in the literature and in our study suggest that MDCT can reliably detect T3/T4 tumors. However, studies suggest that water-enema MDCT increases the sensitivity and specificity in detection of EMI compared with MDCT. In differentiating T1/T2 stage from T3/T4 stage using water-enema MDCT, Sibileau et al. (12) reported 97.7% sensitivity and 60% specificity, Venara et al. (13) reported 96% and 94% sensitivity and 83% and 88 % specificity.

In a systematic review involving only colon cancers, 11 studies and 759 cases were analyzed. Sample size-weighted sensitivity, specificity, and accuracy were 77%, 3%, and 67% for T staging, 76%, 55%, and 69% for N staging, 85%, 98%, and 95% for M staging, respectively. In this review, CT accuracy in T and N staging of colon cancer was found reasonable and accuracy in detection of distant metastasis was very high. In the same review, the main reason of very low specificity in T staging was attributed to understaging (14). In our study, accurate T staging was detected in 54.6% by observer 1 and in 51.1% by observer 2. Understaging was identified in 31.9% and 23.4%, respectively. Low specificity of CT in T staging originates from inability to display the intestinal wall sufficiently (15). In addition, the presence of micrometastasis results in CT false negativity.

In T staging, the agreement between the observers was slight in our study (κ=0.351) and similarly it was slight (κ= 0.214) in a study performed by Burton et al. (11). On the other hand, in Anderson et al. (16), agreement between three observers was moderate to substantial (κ=0.523, 0.540, and 0.712) when staging was performed on axial images. When axial images were combined with reformatted images, agreement between the observers was good to substantial (κ=0.600, 0.629, and 0.836).

Figure 6. a–c. Axial **(a)** and coronal reformatted **(b, c)** MDCT images of a 74-year-old man with sigmoid colon cancer. Both observers assessed RSM *(arrow)* as positive. Pathology, T4aN0 RSM+; first observer, T4aN1 RSM+; second observer, T4bN0 RSM+.
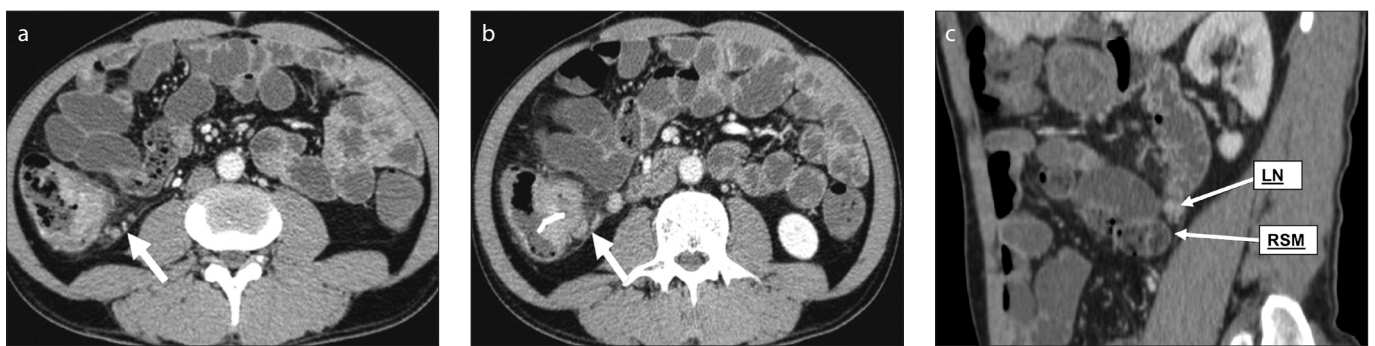

Figure 7. a–c. Axial CT images **(a, b)** through the mid-ascending colon show the primary tumor, an enlarged lymph node, and the RSM *(arrows)*. Sagittal multiplanar reconstruction image **(c)** demonstrates the RSM and an enlarged lymph node (LN) abutting the RSM. Both observers assessed the tumor as RSM-positive. However, the enlarged lymph node that appears malignant on CT was reported as a benign node on histopathology. Pathology reported negative RSM.

Table 4. Radiologic RSM evaluation

RSM	Sensitivity %	Specificity %	PPV %	NPV %	DA %	Observer-pathology consistency κ (*P*)
RCS						
1st Observer	0	82.5	0	98.1	81.2	-0.029 (0.646)
2nd Observer	100	73	5.5	100	73.4	0.078 (0.111)
Whole colon						
1st Observer	33	81	8	88	79	0.057 (0.397)
2nd Observer	50	80	11	97	79	0.113 (0.81)

RSM, retroperitoneal surgical margin; PPV, positive predictive value; NPV, negative predictive value; DA, diagnostic accuracy; RCS, retroperitoneal colonic segment.

In clinical practice, preoperative T staging of colon cancer does not alter the treatment plan (14). However, with the introduction of laparoscopic surgery for tumor resection, the requirement and benefit of neoadjuvant treatment for this surgery have been recognized and the role of CT in T staging has been reevaluated. Long-term oncologic results of laparoscopic surgery are similar to open surgery, but it is seen as a less invasive method (17). With the widespread use of laparoscop-ic surgery in colon cancer, performing accurate preoperative T staging will be important. Since preoperative CT can indicate EMI, an important prognostic factor of colon cancer, with high accuracy, it will have a major role in deciding between treatment options in the future. In addition, with low false positivity rates in the detection of EMI, CT may prevent unnecessary neoadjuvant treatment in early stage tumors. So, it is useful in reducing the risk of this treatment.

The use of water enema in CT in patients with colon cancer was defined for the first time by Angelelli and Macarini (18) in 1988, and later by Gossios et al. (19). In a meta-analysis performed by Dighe at al. (4), the best sensitivity and specificity rates were found in studies expanding the colon with air/fluid. However, the results were not statistically significant. Unlike this meta-analysis, rectal contrast agent administration had no effect on the evaluation of sigmoid cancers' T staging in our study. This difference may be due to exclusion of rectal tumors in our study. Besides, according to our study results, negative or positive contrast agent use in CT was found to have no effect on T staging accuracy. As in the literature, oral contrast use had no effect on sensitivity and specificity of T staging in our study. These results should be taken into account when oral contrast agent administration is considered in patients who may not tolerate it.

One of the main limitations of CT in preoperative staging of colon cancer is the low accuracy rate in N staging (2). The presence of micrometastasis in normal sized lymph

nodes and lymph node inflammation-induced growth lead to misdiagnoses in size-dependent evaluation. In a meta-analysis of colorectal cancer staging by Dighe et al. (4) evaluation of lymph node metastasis was shown to have 70% sensitivity and 78% specificity. In addition, examinations with 5 mm or thinner sections were shown to have better results. In our study, evaluation of lymph node metastases by CT had 84% sensitivity for both observers, and 46% and 56% specificity, for observers 1 and 2, respectively. In our study, sensitivity was higher but specificity was lower compared with the meta-analysis. While the threshold value for pathologic lymph node is 1.0–1.5 cm in some studies, this value was determined to be 0.5 cm in our study.

Among studies evaluating patients with colon cancer only, using 5 mm or thinner slice thickness, Gazelle et al. (20) showed 90% sensitivity, 85% specificity (n=25), Harvey et al. (21) showed 55% sensitivity and 98% specificity (n=37) , and Cademartiri et al. (22) showed 55% sensitivity and 65% specificity (n=60) for N staging. In our study, the sensitivity was 84%, and the false negative results may have been caused by micrometastasis, which cannot be detected by CT. In addition, the reason of low specificity and a high false positive rate in the detection of lymph node metastasis may have been related to the selected threshold value.

For N staging, there was a good agreement between the observers (κ=0.650) in our study, whereas it was reported as fair (κ=0.341) by Burton et al. (11). In a study performed by Anderson et al. (16) interobserver agreement was moderate to substantial (κ=0.555, 0.604, and 0.683).

It is widely known that circumferential resection margin involvement is the indicator of local recurrence in rectal cancers and indication for preoperative radiotherapy in appropriate patients. However, there has been no study in the literature about RSM involvement until a study was performed by Bateman et al. (6) in 2005. In this study, 100 right hemicholectomy specimens were evaluated and 7% RSM involvement was present. Direct (non-nodal) involvement was detected in five of seven patients, whereas nodal involvement was reported in two patients. Local recurrence was shown to be 10% in tumors treated with right hemicholectomy only (23). When the above studies were evaluated together, RSM positivity was suggested to be a predictive factor in the local recurrence.

Distal cecum and proximal ascending colon may have a short mesentery; moreover, there may not be any mesentery in these colon segments in some individuals. Therefore, posterior surface of the ascending colon has areas of varying sizes without peritoneum (24). Bateman et al. (6) evaluated RSM involvement in cecum and ascending colon tumors histopathologically. In their study, RSM positivity was present in 7% whereas in our study, RSM was positive in only one of 64 tumors (1.6%) in the cecum, ascending colon, and descending colon (retroperitoneal colon sections). In a study performed by Bateman et al. (6), RSM involvement was detected only in circumferential or posterior wall invading tumors in 50 patients.

In a retrospective study by Scott et al. (25) involving 228 cases, it was concluded that RSM involvement was an indicator of advanced tumor stage in cecum and ascending colon and it was related to synchronous or metachronous tumors and distant metastasis. According to their study, RSM involvement was present in 19 of 228 patients (8.4%) and 10 of these were due to direct tumor extension. Similarly, in our study, one or few of the poor pathologic prognostic factors were detected in patients that had RSM involvement. Liver metastasis was present in three RSM-positive cases (50%) and two patients were staged as N2 (33%). Other poor prognostic factors in RSM-positive patients included extramural lymphatic invasion in three patients, extramural venous invasion in two patients, perforation in two patients, microsatellite instability in three patients, extramural extension unrelated to the main tumor in four patients, and perineural invasion in three patients.

To the best of our knowledge, there is only one imaging study that evaluated RSM in colon cancers to date. Thirty-three patients were included in that study and pathologically proven RSM involvement was reported in 3% of patients (11). The sensitivity and specificity of CT in the detection of RSM involvement in that study were 33% and 83% respectively. DA was 76% for the first observer and 79% for the second observer. While a poor agreement (κ=-0.128) was found between the findings of pathology and the first observer, a moderate agreement (κ=0.436) was found between the findings of pathology and the second observer (12). In our study, RSM was histopathologically evaluated in 127 patients and RSM involvement was present in 4.25% of the patients. Sensitivity was 33% and 50%, while specificity was 81% and 80% for our observers. DA was found to be 79% for both observers and there was poor agreement between the findings of pathology and both observers (κ=0.057 and κ=0.113). Our study has the largest series in which RSM was evaluated radiologically and compared pathologically, in the literature. Similar to Burton et al. (11), DA was found to be 79% in the evaluation of RSM involvement. Agreement with pathology was not very good in both studies. However, low frequency of RSM involvement may have been the main cause of low sensitivity in the evaluation of RSM in our study.

In advanced stages of colon and rectal cancer, there is evidence that postoperative radiotherapy prolongs survival (26). With high accuracy in preoperative staging and development of more effective chemotherapeutic agents, neoadjuvant treatments are preferred in high-risk colon cancer (8). Therefore, detection of preoperative RSM involvement with high accuracy is important. Preoperative radiologic detection of RSM may reduce the risk of local recurrence by providing regression of tumor load, retroperitoneal extension, and metastatic lymph nodes with neoadjuvant chemotherapy in these patients (8). In addition, patients can be protected from unnecessary neoadjuvant chemotherapy and its adverse effects with the detection of RSM negativity.

Due to several anatomic variations of sigmoid colon, cancers may be in the close vicinity of retroperitoneal surgical margin depending on localization. Related to this, RSM involvement may be present in some sigmoid colon tumors in the advanced stage. RSM involvement is evaluated in the retroperitoneal sections of the colon in the literature. To our knowledge, there are no case series to report RSM involvement in the sigmoid colon. In our study, four of six patients with RSM involvement had tumors located in the sigmoid colon. Considering individual anatomical differences in the colon, not only retroperitoneal ascending and descending colon tumors, but also sigmoid and transverse colon tumors should be kept in mind for possible RSM involvement. As consistent with the literature, colon tumors in our study are most commonly located in the sigmoid colon and with the accurate evaluation of RSM, CT can play an important role in the treatment of majority of colon cancers.

The main limitation of our study is its retrospective nature. Also, patients were

examined with three different scanners and patients examined with 4-slice MDCT were excluded. Finally, patients with CT or histopathologic evaluation performed at another hospital and inoperable patients were left out of evaluation.

In conclusion, MDCT is a promising technique in the evaluation of preoperative staging and prognostic factors of colon cancer. However, randomized controlled studies with large series are required to establish the utility of MDCT in staging and determining prognostic factors in colon cancer by MDCT. With these studies, new standards can be developed in preoperative staging and treatment of colon cancer.

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Conflict of interest disclosure

The authors declared no conflicts of interest.

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