Role of Early Phase Helical CT Images in the Evaluation of Wall Invasion of Colorectal Cancer: Pathological correlation

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SmarPrep法により至適化されたhelical CT early phase imageの大腸癌の壁深進度診断に対する有効性について検討した。対象は注腸または内視鏡検査にて大腸癌と診断され、CTにて病変の同定が可能であった10症例である。

Early phase imageはSmartPrepアプリケーションにより撮像した。これにより造影剤注入後のCT値の上昇を連続的にモニターし、適当なscan delay timeを得る手法である。病理組織標本はCTと同じスライス面、スライス厚で作成し、また病変の造影効果についても測定を行った。全ての病変が遮蔽の大きさに関わらずearly phaseにて強い造影効果を呈した（81.4-112HU, mean95.1HU）。病理組織標本との対比では、CTにて強い造影効果を呈する領域はマクロ標本の病変部分に一致していた。

CTにて病変部の外側にて認められた低密度zoneは非病変の筋層に一致し、同部位では腫瘍の周囲浸潤は認められなかった。Low density zoneが断続した部分では、全厚で腫瘍の周囲浸潤への浸潤が認められた。以上より、大腸癌の病変深進度診断においては、積極的にearly phase imageを撮像することが、より正確な局所深進度診断のために有用と考えられた。

Introduction

In patients with primary colorectal cancer, the accurate preoperative diagnosis of tumor invasion into the colorectal wall is essential. Over the years, barium enema and colonoscopic evaluation of the colorectal wall have been joined by cross-sectional evaluations such as CT and MRL, particularly using endoscopic and exoscopic ultrasonography³, ⁴. Among these techniques, CT can play an important role in detecting the lesion, and metastasis to the liver and distant lesions³, ⁵. However, CT is unable to demonstrate detailed layers of the colorectal wall, and an accurate diagnosis of local extension is difficult³, ⁴. In the present prospective study of colorectal cancer, early phase images by helical CT were used to evaluate local invasion. Early phase images were obtained using SmartPrep software, and the results were compared with histopathologic findings.

Materials and methods

From August 1987 to September 1998, 10 consecutive patients with barium enema- and/or colonoscopy-proven colorectal cancer underwent CT for the evaluation of primary tumor and local extension. The study included 6 men and 4 women ranging in age from 45 to 77 years (mean 61.0 years). The histopathologic diagnosis was confirmed in each case from surgical specimens. The primary site of the cancer was the rectum (n = 8) and the sigmoid colon (n = 2). Macroscopic classification based on the Japanese Classification of Colorectal Carcinoma Criteria³ divided the study group into 9 type 2 (ulcerated type with clear margin) and 1 type 3 (ulcerated type with infiltration). Histopathologic depth of tumor invasion was classified into I mp (tumor invasion of muscularis propria), 4a1 or 4b (tumor invasion through muscularis propria into non-peritonealized part or tumor invasion to subserosa), 4b2 (tumor invasion of non-peritonealized, pericolic, or perirectal tissue), and 1 ai (direct tumor invasion of other organs or structures)³. Histologically, there were 6 well-differentiated adenocarcinomas

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Table 1 Patients List of Colorectal Cancer

<table>
<thead>
<tr>
<th>case</th>
<th>age/sex</th>
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<th>type</th>
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<tr>
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<td>2</td>
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<td>rectum</td>
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<td>3</td>
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<tr>
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<td>rectum</td>
<td>moderate</td>
<td>2</td>
<td>3 x 2</td>
<td>a1</td>
</tr>
</tbody>
</table>

well: well-differentiated adenocarcinoma, moderate: moderately differentiated adenocarcinoma

and 4 moderately differentiated adenocarcinomas (Table 1). CT was performed on a GE High-Speed Advantage SP/5G (General Electric Medical System, Milwaukee, WI). A precontrast scan covered the entire area of the lesion based on a barium enema. Patients received 100 ml of non-ionic iodinated contrast material (300 mg/ml, Omnipaque, Daiichi Pharmaceutical, Japan) from a dorsal vein of the hind at a rate of 3 ml/sec. Early phase images were obtained using SmartPrep software. Placing the ROI in the abdominal aorta at the level of L2/3, the CT number of the ROI was monitored continuously (Fig. 1). The lesion was scanned immediately at the time the density curve started to increase. Scanning parameters included 5 mm beam width, 5 mm/sec table speed, and 5 mm reconstruction thickness. Delayed images were obtained 150 sec after the initiation of contrast injection. The evaluation was made from the images on cancer enhancement by measuring the CT number of the lesion, adjacent normal colorectal wall and glutea muscle. The CT number of the cancer averaged 3 points within the lesion.
The CT numbers of the adjacent normal colorectal wall and gluteal muscle were measured with same method. Standard deviation of CT numbers were calculated from averaged CT number of each ROIs. Attention was paid to a low density zone adjacent or posterior to the cancer. If this zone was obliterated or disrupted, further attention was paid to the irregularity of the cancer edge (Fig. 2). For the evaluation of the low density zone and cancer edge, relatively narrow window setting was used to obtain good contrast between the tumor and low density zone. A histopathological analysis was made using specimens, which were sectioned close to the same plane and at the same slice thickness as the CT images, to determine the cancer location and depth of invasion. The findings by CT images and histopathological analysis were compared with regard to primary tumor location and depth of invasion of the cancer.

### Results

All 10 cancers showed strong enhancement on early phase images regardless of their size. The CT number of the cancer ranged from 81.4 to 112 HU (average 95.1 ± 10.3 HU), which was significantly greater than that of adjacent normal colorectal wall (from 29.3 to 47.5 HU, average 41.0 ± 6.3 HU) (p < 0.05). The CT numbers for the different histological classifications were also significantly different: that for well-differentiated adenocarcinoma was 83.6 ± 1.9 HU, while that for moderately differentiated adenocarcinoma was 102.8 ± 5.4 HU (p < 0.05) (Table 2). A strongly enhanced area was correlated to the primary cancer, regardless of size and histologic differentiation. Fifteen histopathologic specimens from 10 cases were available for correlation. In 8 of these 15 specimens, a low density zone was present adjacent or posterior to the strongly enhanced primary cancer. This zone correlated to the preserved colorectal wall on histopathology. No extraluminal invasion of the cancer was observed in these cases (Fig. 3, 4). In the remaining 7 specimens, the low density zone was partially or totally obliterated at the primary cancer, which was the area of extraluminal invasion. All of these 7 specimens showed pericolorectal fat infiltration, while 5 showed irregularity at the edge of the primary cancer (Fig. 5) and 4 did not (Fig. 6, 7) (Table 3).

### Discussion

Previous reports have stressed the value of delayed phase images in the diagnosis of extraluminal invasion. Their findings were irregularity at the edge of the tumor and linear strands extending into the pericolorectal fat tissue. Using these findings, the sensitivity for detecting wall invasion ranged from 52 to 77% (33-36, 39). This low sensitivity was probably due to the difficulty of separating tumor invasion from inflammatory and scar changes and congested vessels. It is essential to clearly separate the primary tumor and the normal colorectal walls on CT images. Helical CT enabled us to scan wider areas with a short scan duration. This has already been applied to the diagnosis of gastric cancer and its wall invasion (30-34). However, there has been no previous report regarding the diagnosis of colorectal cancer wall invasion with early phase images. The current study revealed that the strongly enhanced lesion was accurately correlated with the histopathologic findings of the primary tumor. A preserved colorectal wall was demonstrated as a low density zone. As long as a low density zone was
Fig. 3 A 59-year-old woman with rectal cancer, type 2. (A) CT image shows a well-enhanced tumor in the right lateral wall of the rectum. The low-density zone posterior to the tumor is clearly preserved (arrows). B) Histopathologic specimen (hematoxylin-eosin stain; original magnification, × 10) shows tumor invasion limited to the submucosal layer.

Fig. 4 A 72-year-old man with rectal cancer, type 2. (A) Barium enema shows an elevated mass in the right lateral wall of the rectum. (B) CT shows a markedly enhanced tumor with a preserved low-density zone posterior to the tumor (arrow). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, × 1) demonstrates the tumor invading to the muscularis propria (arrowheads). No tumor extension into the perirectal fat is observed.
preserved adjacent to the primary tumor, no extraluminal invasion was present. In all of the specimens, obliteration or disruption of a low density zone corresponding to extraluminal invasion and perirectal fat infiltration. We conclude that the irregularity of the edge of the cancer and linear strands extending into the perirectal fat tissue were not accurate signs of extraluminal invasion of the cancer. Angelotta reported that the diagnosis of wall invasion by colon cancer could be improved by filling the colon with a large amount of water. We did not use any premedication nor bowel preparation. These preparation may increase CT room occupancy time and may create patient's discomfort. Our results indicated that ocular extension of the colorectal cancer could be evaluated without expansion of filling of the colon. With regard to the enhancement patterns and histologic differentiation, Funko stated that well-differentiated adenocarcinoma was enhanced homogeneously, while moderately differentiated adenocarcinoma was enhanced heterogeneously. We were unable to explain these different enhancement patterns based on the results of histopathology. SmartPrep was essential for the current study to obtain optimal early phase images using a personalized time-density curve.

In conclusion, in early phase images, extraluminal colorectal cancer showed strong enhancement, regardless of size or histologic differentiation. The preserved colonic wall adjacent to the cancer appeared as a low density zone. In cases where this zone was obliterated or disrupted, the cancer invaded beyond the colorectal wall into the perirectal fat tissue. The clinical use of early phase images in the diagnosis of local extension of colorectal cancer appears to be justified.

Acknowledgments

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Fig. 6 A 59-year-old woman with rectal cancer, type 2. (A) Barium enema shows an elevated mass in the right lateral wall of the rectum. (B) CT shows a poorly enhanced tumor with marginal irregularity. Low density zone is disrupted at the tumor site (arrows). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, ×10) demonstrates a disrupted muscular layer and deeply extended tumor (arrowheads).

Fig. 7 A 41-year-old woman with rectal cancer, type 2. (A) Barium enema shows an elevated mass in the right lateral wall of the rectum. (B) CT shows enhanced tumor without marginal irregularity. The low density zone is disrupted at the tumor site (arrow). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, ×10) demonstrates disrupted muscular layer and minimal tumor extension beyond the muscular layer (arrowheads).
Table 3  Correlation between CT Findings and Histopathological Results

<table>
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<tr>
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LDZ: low density zone

References