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

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

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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 MRI, particularly using endoscopic and endoscopic ultrasonography\(^3-4\). Among these techniques, CT can play an important role in detecting the lesion, and metastasis to the liver and distant lesions\(^5-9\). However, CT is unable to demonstrate detailed layers of the colorectal wall, and an accurate diagnosis of local extension is difficult\(^10-11\).

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 Criteria\(^2\) divided the study group into 9 type 2 (ulcerated type with clear margin) and 1 type 3 (ulcerated type with infiltration).

Histopathological depth of tumor invasion was classified into 1 mp (tumor invasion of muscularis propria), 4 a1 or ss (tumor invasion through muscularis propria into non-peritonealized part or tumor invasion to subserosa), 4 a2 (tumor invasion of non-peritonealized, pericolic, or perirectal tissue), and 1 ai (direct tumor invasion of other organs or structures)\(^12\). Histologically, there were 6 well-differentiated adenocarcinomas...
and 4 moderately differentiated adenocarcinomas (Table 1). CT was performed on a GE High-Speed Advantage SP/SG (General Electric Medical System, Milwaukie, 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 (300mg/ml, Omnipaque, Daiichi Pharmaceutical, Japan) from a dorsal vein of the hind at a rate of 3ml/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 5mm beam width, 5mm/sec table speed, and 5mm 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.

<table>
<thead>
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<th>case</th>
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<th>type</th>
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<td>2</td>
<td>3 × 2</td>
<td>a1</td>
</tr>
</tbody>
</table>

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

Fig. 1 Concept of SmartPrep application. Helical CT scanning is performed during continuous monitoring of the ROI placed in the abdominal aorta. Time-density curve is obtained after the injection of contrast material.
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 6 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 9 specimens, the low density zone was partially or totally obliterated at the primary cancer, which was the area of extraluminal invasion. All of these 9 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% (37, 40). This low sensitivity was probably due to the difficulty of separating tumor invasion from inflammatory and necrotic 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 (38-40). 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 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 left 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 × 1) shows tumor invasion limited to the submucosa layer.

Fig. 4 A 78-year-old man with rectal cancer, type 2. (A) Barium enema shows an irregular mass in the left lateral wall of the rectum. (B) CT shows a markedly enhanced tumor with a preserved low-density zone posterior to the tumor (arrows). (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 extrauninal invasion was present. In all of the specimens, obliteration or disruption of a low density zone corresponding to extraluminal invasion and pericolorectal fat infiltration. We concluded that the irregularity of the edge of the cancer and linear strands extending into the pericolorectal fat tissue were not accurate signs of extraluminal invasion of the cancer. Angiela reported that the diagnosis of wall invasion by colorectal cancer could be improved by filling the colon with a large amount of water. We did not use any premedication or bowel preparation. These preparation may increase CT room occupying time and may create patient’s discomfort. Our results indicated that occult extension of the colorectal cancer could be evaluated without expansion nor filling of the colon. With regard to the enhancement patterns and histologic differentiation, Sunakawa stated that well-differentiated adenocarcinoma was enhanced homogeneously, while that of 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 by helical CT, colorectal cancer showed strong enhancement, regardless of size or histologic differentiation. The preserved colorectal 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 pericolorectal fat tissue. The clinical use of early phase images in the diagnosis of local extension of colorectal cancer appears to be justified.

Acknowledgments

The authors are grateful to Rino Hirayama, M.D. and his colleagues, Department of 2nd Surgery, Saitama Medical School, Saitama, Japan, for supplying valuable clinical cases.
Fig. 6  A 59-year-old woman with rectal cancer, type 2. (A) Barium enema shows an elevated mass in the r. lateral wall of the rectum. (B) CT shows a markedly enhanced tumor without marginal irregularity. Low density zone is disrupted at the tumor site (arrows). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, × 1) demonstrates a disrupted muscular layer and deeply extended tumor (arrowsheads).

Fig. 7  A 41-year-old woman with rectal cancer, type 2. (A) Barium enema shows an elevated mass in the r. lateral wall of the rectum. (B) CT shows enhanced tumor without marginal irregularity. Low density zone is disrupted at the tumor site (arrow). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, ×1) 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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LDZ: low density zone

References