The diagnostic accuracy of pericolonic fat extension and attenuation for colorectal tumors

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ABSTRACT

Objective: To evaluate the utility of quantitative analysis of the extension and attenuation of pericolonic fat in the local staging of colorectal cancer (CRC) using multi detector computed tomography (MDCT).
Materials and methods: This was a retrospective study of 110 patients who were operated due to pathologically proven CRC from January 2007 to January 2010, and who underwent preoperative MDCT of the abdomen and pelvis with administration of intravenous contrast material and image acquisition during the portal venous phase. The mean age was 69 years (range of 38–90 years). Pathological reports were reviewed for TNM staging. All MDCT studies were reviewed by two certified radiologists for maximal and minimal tumor diameter, extent of the infiltrated pericolonic fat (measured in mm), attenuation of the infiltrated pericolonic fat (measured in Hounsfield units), and attenuation of normally appearing fat next to the tumor. The sensitivity and specificity of these parameters in detecting patients with $\geq$ T3 CRC were calculated.
Results: The overall sensitivity, specificity, and accuracy of pericolonic fat infiltration in detecting patients with $\geq$T3 stage were 95% (95% CI, 89.0–98.7%), 20% (5.8–43.7%), and 81.9% (74.7–89%) respectively. The mean extent and attenuation of the infiltrated pericolonic fat, in addition to the maximal tumor diameter, were higher in the $\geq$T3 group ($p < 0.05$). By defining threshold values to these parameters, the positive predictive value for detecting $\geq$T3 stage tumors approaches 100%.
Conclusion: Quantitative analysis of pericolonic fat increased the accuracy of MDCT in the detection of local tumor spread in CRC.

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1. Introduction

Imaging plays an important role in diagnosis, staging, treatment planning, and follow-up of patients with CRC [1]. According to the American College of Radiology (ACR) guidelines, pretreatment staging is most appropriate with computed tomography (MDCT) of the chest, abdomen, and pelvis with administration of contrast material [2]. The utility of MDCT in identifying distant metastases (M stage) is well established, with sensitivity and specificity rates in the ranges of 64–84% and 95–99%, respectively [3–5]. Yet, the value of MDCT for T and N staging is controversial. Reported sensitivity and specificity of MDCT for T staging are 41–82% and 42–80%

respectively; and for N staging, 22–96% and 75–96%, respectively [6–8].

Pericolonic fat infiltration may indicate tumor extension beyond the serosal layer (T2 vs T3) [9,10]. However, this finding is nonspecific and may represent inflammatory reaction, fibrosis, or congestion [11]. A study by Ng et al. [12] reported the sensitivity of pericolonic fat infiltration in identifying tumor extension beyond the muscle layer as 80%. Yet, the association between the presence of pericolonic fat infiltration on MDCT and extramuscular extension of tumor was not found to be statistically significant. Kim et al. [13] recently reported pericolonic fat infiltration and its configuration (hazy, linear, nodular) to be predictive of tumor differentiation (poorly vs moderately and well differentiated).

The main objective of this study was to evaluate the capability of quantitative assessment of the pericolonic fat, including its extent and attenuation, in enhancing the accuracy of MDCT in predicting the locoregional extent of CRC.

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2. Materials and methods

Our institutional review board approved this retrospective study and waived the requirement for informed consent.

2.1. Patients

A search of the surgical database at our institution was performed to identify all patients who were operated due to histopathologically proven adenocarcinoma of the colon and rectum between January 2007 and January 2010. Only patients who underwent abdominopelvic MDCT and subsequent surgery were included in the study. Patients were excluded if they were found to have peritoneal spread, synchronous tumor, or a missing or inconclusive histological report. Surgical and pathological reports were reviewed for tumor localization, histopathological diagnosis, and staging according to the TNM classification. The mean time interval between MDCT and surgery was 14.8 ± 18.8 days (range, 1–60 days).

2.2. MDCT technique

All MDCT studies were performed using a 64-MDCT scanner (Brilliance-64, Philips Healthcare, Cleveland, Ohio, USA). Patients were studied in the supine position after ingestion of 1200–1500 mL of oral contrast material at least 1 h before scanning. Contrast-enhanced MDCT studies used approximately 100 mL of iodinated contrast material (Iomeron 350 mg/mL, Bracco, Milan, Italy) at 3 mL/s; scanning started at 70 s, with a slice thickness of 3–5 mm and the creation of axial, coronal, and sagittal reformatted images.

2.3. MDCT image analysis

Each study was retrospectively reviewed by two board-certified experienced (practicing longer than 10 years) radiologists who were blinded to the pathologic results. Image review was performed on a PACS station. During the consensus review, the two radiologists recorded the location of the CRC, the maximal and minimal diameter of the tumor, pericolonic fat involvement and its extent (measured in mm), and the pericolonic fat attenuation values (measured in Hounsfield units, HU). The extent of the pericolonic fat involvement was determined by measuring the maximal distance between tumor margins and normally appearing mesenteric fat. For measurements of the pericolonic fat attenuation: mean MDCT attenuation values of pericolonic fat adjacent to the tumor were obtained from the venous phase images by means of region-of-interest (ROI) analysis performed by two readers; decisions were made with consensus. The largest possible area was included in the ROI analysis. Care was taken to exclude macroscopic enhanced blood vessels and pericolonic lymph nodes from the ROI (Fig. 1). For each patient, normally appearing fat near the tumor was measured as control. Pericolonic fat that appear homogeneous and with no abnormalities such as fat infiltration, stranding or thickening was considered as normal.

2.4. Statistical analysis

The tumor T stage was classified into two categories; "<T3" (includes T_{is}, T1 and T2), and "≥T3"(includes T3 and T4). These categories were determined due to the greater relevance of pericolonic fat infiltration to T3 and T4 tumors. Not enough T4 tumors were included in this study for their separate analysis.

The Student's t-test and the Mann–Whitney test were used, as appropriate, to compare the MDCT parameters between the predefined two T stage categories. Associations between categorical variables were tested using the $\chi 2$ test or the Fischer exact test,
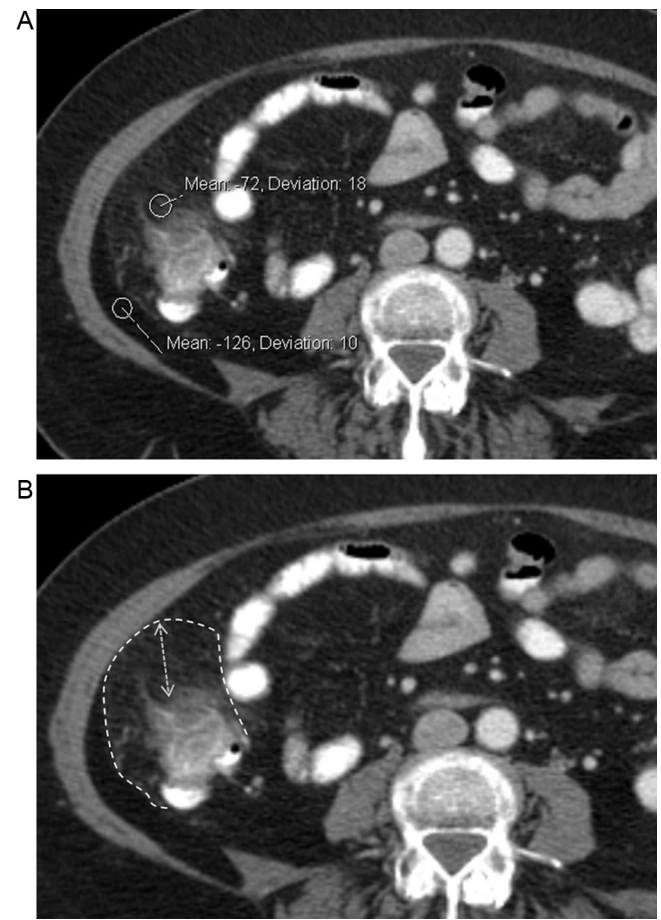

Fig. 1. Adenocarcinoma of ascending colon (stage: T3, N1, M1) in an 81-year-old woman.
A, Contrast-enhanced axial CT scan shows mean MDCT attenuation values (measured in Hounsfield units, HU) of the involved pericolonic fat adjacent to the tumor (−72HU). The normally appearing fat near the tumor is measured as control (−126HU). **B**, Axial MDCT image shows the pericolonic fat involvement and its extent (26 mm).

as appropriate. Pearson's r correlation coefficient and Spearman's rank ρ correlation coefficient were used, as appropriate, to test the relation between continuous variables. The area under the receiver characteristics curve (ROC) was calculated to assess and compare the discrimination ability of the MDCT parameters. The most accurate predictive threshold of each MDCT parameter was extracted from the ROC curves and used to estimate sensitivities, specificities, accuracy, PPV, and NPV of different combinations of these parameters along with the 95% confidence interval using the Clopper–Pearson exact method. Logistic regression was used to estimate the probabilities of stage ≥T3 tumors using pericolonic fat extension, pericolonic fat attenuation, and maximal tumor diameter as independent variables. The generated probabilities were used to calculate the area under the ROC curve in order to assess the combined discrimination ability of these parameters. P value of less than 0.05 for the 2-tailed tests was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics 21.0 and SAS version 9.3.

3. Results

3.1. Patients' characteristics

A total of 336 patients were operated at our institution due to histopathologically proven CRC during the study period. One-