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Diagnostic value of the delayed phase image for iso-attenuating pancreatic carcinomas in the pancreatic parenchymal phase on multidetector computed tomography

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Abstract

Purpose: To assess the value of the delayed phase (DP) in pancreatic carcinomas which appear iso-attenuating in the pancreatic parenchymal phase (PPP).

Materials and methods: Fifty-seven preoperative MDCT studies of pancreatic carcinomas were retrospectively reviewed. The size of the tumors, and the Hounsfield unit (HU) of the tumors and pancreatic parenchyma were measured. The tumor-to-pancreas contrast (TPC: |HU [tumor] − HU [normal pancreas]|) was calculated.

Results: Eight cases (14.0%) showed iso-attenuation and 49 showed hypo-attenuation in the PPP. The DP images revealed seven of eight (87.5%) iso-attenuating tumors to be hyper-attenuating. The size of iso-attenuating tumors was smaller than that of hypo-attenuating tumors (mean ± S.D.: 12.4 ± 4.8 mm vs. 30.3 ± 9.0 mm, $p < 0.0001$). In hypo-attenuating tumors, TPC in the PPP (60.2 ± 24.6 HU) was higher than those in the portal venous phase (PVP, 40.5 ± 23.0 HU, $p < 0.0001$) and DP (18.3 ± 11.8 HU, $p < 0.0001$). In contrast, in iso-attenuating tumors, TPC in the DP (26.0 ± 4.9 HU) was higher than those in the PPP (9.2 ± 3.7 HU, $p = 0.0003$) and PVP (7.1 ± 4.7 HU, $p = 0.001$) phases.

Conclusion: The DP image is helpful in depicting small iso-attenuating pancreatic carcinomas as slightly hyper-attenuating tumors.

Keywords: Computed tomography (CT); Pancreas cancer; Contrast enhancement

1. Introduction

Contrast-enhanced computed tomography (CT) is a widely accepted imaging modality for the detection and local staging of pancreatic carcinomas. Owing to the higher spatial and temporal resolutions, the introduction of multidetector CT (MDCT) has improved the quality of pancreatic CT studies [1–3].

The biphasic pancreatic protocol usually consists of the pancreatic parenchymal and portal venous phases. The maximal enhancement of the pancreatic parenchyma and optimal tumor-to-pancreas contrast are obtained in the pancreatic parenchymal phase [4–7]. The acquisition of these two-phase images has been considered sufficient to evaluate tumor detection, vascular invasion [6,7] and metastatic spread.

Prokesch et al. [8] described that some pancreatic carcinomas in their series showed iso-attenuation even though high resolution MDCT with an appropriate biphasic protocol was obtained. They utilized curved planar reformation, attempting to show the secondary sign of iso-attenuating pancreatic carcinomas (the interrupted duct sign) [8]. However, if the attenuation difference between the tumor and pancreas could be visualized in this particular type of pancreatic carcinoma, this would be more effective for the tumor detection.

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It is well known that areas of delayed or prolonged enhancement within the intrahepatic cholangiocarcinoma of the liver correspond to fibrotic stroma due to the retention of contrast material [9–12]. Since pancreatic adenocarcinomas commonly contain fibrosis [13], there were several reports describing delayed enhancement of pancreatic carcinomas in the era of single-slice helical CT [14–16]. However, in these studies, a wider collimation of 7–10 mm was utilized for the delayed phase image. Furthermore, little attention was paid to the value of the delayed phase images in multi-phase pancreatic MDCT studies.

The purpose of this study was to evaluate whether the delayed phase image is of value in the diagnosis of iso-attenuating pancreatic carcinomas in the pancreatic parenchymal phase.

2. Materials and methods

2.1. Patient population

At our institution, the institutional review board (IRB) does not require approval for retrospective studies. Between December 1999 and December 2005, 60 patients underwent preoperative contrast-enhanced MDCT studies and surgical resection of the pancreatic carcinomas at our institution. Two patients who had undergone preoperative chemotherapy between the date of MDCT studies and surgery were excluded. One patient was excluded because the study was technically inadequate. Therefore, the study group consisted of 57 patients.

There were 38 male patients and 19 female patients. The age ranged from 36 to 86 (mean ± standard deviation [S.D.]: 67 ± 9 years old). The tumor was found in the pancreatic head ($n = 36$), body ($n = 14$), tail ($n = 6$), and head and body ($n = 1$). Fifty-six patients had ductal adenocarcinomas, and the remaining one patient had adenosquamous cell carcinoma. The tumor grades are summarized in Table 1. The pathology reports described the size of the tumor in 47 of 57 patients, which ranged from 1.0 to 6.5 cm (mean ± S.D.: 3.2 ± 1.3 cm). Before MDCT studies, percutaneous biliary drainage ($n = 10$) and biliary stent placement ($n = 3$) were performed in 13 patients. In these 13 cases, there was no image deterioration in the evaluation of pancreatic tumors. In addition, there was no case that had undergone pancreatic stent placement.

2.2. Imaging techniques

Quadruple phase MDCT studies were performed for all of the 57 patients with a four-slice MDCT (Aquilion: Toshiba Medical Systems, Tokyo, Japan; or Somatom Plus 4 Volume Zoom: Siemens-Asahi Medical Technologies, Tokyo, Japan) with a gantry rotation time of 0.5 s. The interval between preoperative MDCT study and surgery ranged from 1 to 45 days (mean ± S.D.: 20 ± 12 days). There were two different protocols in the preoperative evaluation of pancreatic cancers (the former and the new protocols).

The former protocol was performed in 41 patients. After precontrast images through the liver and pancreas were obtained, each patient received 100 ml of intravenous nonionic contrast material containing 370 mg I/ml Iopamidol (Iopamiron; Schering, Osaka, Japan) or 350 mg I/ml Iohexol (Omnipaque 350; Daiichi Pharmaceutical, Tokyo, Japan) by means of an automated power injector at a rate of 2.5 ml/s (fixed injection duration of 40 s). In the Aquilion unit, the scan parameters were as follows: section collimation, 2 mm; section thickness, 3 mm; reconstruction interval, 3 mm; helical pitch, 5.5; 300 mA; and 120 kVp. In the Somatom Plus 4 Volume Zoom unit, the scan parameters were as follows: section collimation, 2.5 mm; section thickness, 3 mm; reconstruction interval, 3 mm; table feed, 13.8 mm/gantry rotation; 110 effective mAs; and 120 kVp. The pancreatic parenchymal phase was obtained at a fixed delay of 45 s after the initiation of IV contrast material injection. The portal venous and delayed phases were acquired at 70 and 240 s, respectively, after the initiation of contrast material injection.

The new protocol was performed in 16 patients with the Aquilion unit. After obtaining pre-contrast images, intravenous nonionic contrast material containing 370 mg I/ml Iopamidol (Iopamiron; Schering, Osaka, Japan) was administered by means of an automated power injector with a fixed injection duration of 30 s. The dose of contrast was based on the patient's body weight (1.62 ml/kg; maximum, 100 ml). Although the injection rate varied in each patient, it was approximately 3 ml/s. The pancreatic parenchymal, portal venous, and delayed phases were obtained by 1 mm collimation with at 36 s, 2 mm collimation at 65 s, and 2 mm collimation at 240 s after initiation of the contrast injection, respectively. Raw data were reconstructed on a console unit into slices with the same thickness as the collimation and 3 mm thick slices without any overlaps. We utilized the thinner-slice images for multiplanar reformation and the 3 mm slice images for hard copy filming and axial image interpretation.

2.3. Imaging analysis

Axial MDCT images were retrospectively reviewed on a computer workstation (CIS-Image/Viewer for Windows version 2.6.13; IBM Japan, Tokyo, Japan) by two experienced abdominal imaging radiologists in a consensus fashion. For this retrospective review, 3 mm axial images were utilized because the former protocol was insufficient to create or interpret multiplanar reformation images.

The attenuations of the pancreas carcinomas relative to the pancreatic parenchyma in the pancreatic parenchymal, portal venous, and delayed phases were subjectively assessed. Based on the attenuation of pancreatic carcinoma in the pancreatic parenchymal phase, pancreas carcinomas were classified into hypo- and iso-attenuating pancreatic carcinomas.

The quantitative assessments were also performed at the level which demonstrated the largest area of pancreatic carcinomas. If a tumor could not be detected on the MDCT studies, it was excluded from the quantitative assessment. The quantitative assessment was performed by one experienced abdominal imaging radiologist. The measurements were performed twice and the average data were recorded.