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Pancreatic ductal adenocarcinoma and chronic mass-forming pancreatitis: Differentiation with dual-energy MDCT in spectral imaging mode☆

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ABSTRACT

Objective: To investigate the value of dual-energy MDCT in spectral imaging in the differential diagnosis of chronic mass-forming chronic pancreatitis (CMFP) and pancreatic ductal adenocarcinoma (PDAC) during the arterial phase (AP) and the pancreatic parenchymal phase (PP).
Materials and methods: Thirty five consecutive patients with CMFP ($n=15$) or PDAC ($n=20$) underwent dual-energy MDCT in spectral imaging during AP and PP. Iodine concentrations were derived from iodine-based material-decomposition CT images and normalized to the iodine concentration in the aorta. The difference in iodine concentration between the AP and PP, contrast-to-noise ratio (CNR) and the slope K of the spectrum curve were calculated.
Results: Normalized iodine concentrations (NICs) in patients with CMFP differed significantly from those in patients with PDAC during two double phases (mean NIC, 0.26 ± 0.04 mg/mL vs. 0.53 ± 0.02 mg/mL, $p=0.0001$; 0.07 ± 0.02 mg/mL vs. 0.28 ± 0.04 mg/mL, $p=0.0002$, respectively). There were significant differences in the value of the slope K of the spectrum curve in two groups during AP and PP ($K_{CMFP}=3.27\pm0.70$ vs. $K_{PDAC}=1.35\pm0.41$, $P=0.001$, and $K_{CMFP}=3.70\pm0.17$ vs. $K_{PDAC}=2.16\pm0.70$, $p=0.003$, respectively). CNRs at low energy levels (40–70 keV) were higher than those at high energy levels (80–40 keV).
Conclusion: Individual patient CNR-optimized energy level images and the NIC can be used to improve the sensitivity and the specificity for differentiating CMFP from PDAC by use of dual-energy MDCT in spectral imaging with fast tube voltage switching.

1. Introduction

Surgical resection offers the only chance of a cure in patients with pancreatic carcinoma or, conversely, may result in unnecessary risk of morbidity and mortality for benign lesions, which constitutes 5–11% of pancreatoduodenectomies for presumed pancreatic malignancy that later proves to be a benign mass [1–3]. It is extremely important to make a correct diagnosis to avoid unnecessary operative procedures.

Although many diagnostic methods for the differential diagnosis of chronic mass-forming chronic pancreatitis (CMFP) and pancreatic ductal adenocarcinoma (PDAC) have been reported [4–6], it still remains the diagnostic dilemma of these entities. The most reliable diagnostic method for differentiating any mass-like lesions in the pancreas is a biopsy. However this method has some limitations, such as a significant false-negative rate and complications [7,8].

Recently a dual energy dual-energy MDCT in spectral imaging (DEsCT) imaging mode based on the rapid switching between high and low energy data sets from view to view was introduced to produce both the material decomposition images and monochromatic spectral images at energy levels ranging from 40 to 140 keV [9,10]. This imaging method has also been found to use in several clinical

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Table 1
Clinical characteristics of the 35 patients.

Group	Case (number)	Sex (male/female)	Age (mean ± SD)
CMFP	15	4:1	46 ± 12y
PDAC	20	1:1	55 ± 18y

Note: CMFP = chronic mass-forming chronic pancreatitis, PDAC = pancreatic ductal adenocarcinoma.

applications [9,11–14], including preoperative detection of insulinomas, differentiating hypervascular hepatic lesions and diagnosis of pulmonary embolism.

The purpose of our study was to preliminarily investigate the usefulness of CT spectral imaging in differentiating CMFP from PDAC.

2. Materials and methods

2.1. Subjects

The institutional review board of our institution approved this retrospective study and waived the requirement for informed consent. Subjects for CMFP and PDAC groups were selected from by reviewing the medical records between June 2008 and June 2013.

Pancreatic neoplasms other than adenocarcinoma were not included for evaluation in this study. A total of 282 patients were excluded from the study because of lesions measured under 1.5 cm, unsatisfactory imaging quality resulting from body movement and artifacts, the scan parameters, and necrosis or liquefied necrosis unsatisfactory for the measurement data. Therefore 35 patients were included in our study.

Thirty five consecutive patients with CMFP (15 cases, mean age 53 ± 11 years, male vs. female, 4:1, or PDAC (20 cases, mean age 66 ± 7 years, male vs. female, 1:1) underwent dual-phase CT imaging in the spectral imaging mode on a High Definition CT system (Discovery CT750HDCT, Milwaukee, GE Healthcare) (Table 1).

Mean size of the lesions was 3.3 cm ± 1.5 (range, 1.9–4.8 cm) for CMFP, and 3.4 cm ± 1.1 (range, 2.3–4.5 cm) for PDAC. All CMFP and PDAC were proven pathologically by surgery and pathologic diagnosis.

2.2. CT scans

All patients underwent CT scanning craniocaudally in the supine position, and 1000 mL water was given over 15–20 min before the scanning. Unenhanced and two-phase contrast material enhanced CT examinations were performed by using the Discovery CT750HDCT system (64 detectors). The acquisition of the arterial (AP) covered the whole pancreas and that of the pancreatic parenchymal phase (PP) included the entire liver and pancreas. Unenhanced images were acquired following scout imaging with the conventional helical mode at a tube voltage of 120 kVp. Patients were then injected with a total of 80–100 mL nonionic contrast medium (iopamidol, Iopamiro 300; Shanghai BRACCO Sine Pharmaceutical, China) via antecubital venous access by using a power injector (Ulrich medical, Germany) at a rate of 3.0–4.0 mL/s (1.5 mL per kilogram of body weight) during the arterial (AP) and pancreatic parenchymal phase (PP). The imaging delay for AP imaging was determined using automatic image-triggering software (SmartPrep; GE Healthcare). AP imaging began 8s after the trigger attenuation threshold (80 Hu) was reached at the level of the supraceliac abdominal aorta. PP imaging began at a delay of 30 s after AP imaging. Arterial phase and pancreatic parenchymal phase imaging were performed in the spectral imaging mode with fast tube voltage switching between 80 and 140 kVp on adjacent views during a single rotation. Other imaging parameters were as follows: collimation thickness 0.625 mm, tube current 600 mA, rotation speed 0.6 s, helical pitch 0.983, CT dose index volume 21.8 mGy.

The CT Images were reconstructed with projection-based material decomposition software and a standard recon kernel. Water and iodine-based material decomposition images and monochromatic images at energy levels ranging from 40 keV to140 keV (with default level at 70 keV) were reconstructed from DEsCT acquisition. All images were reconstructed with 2.5 mm slice thickness.

Three types of images were reconstructed from the single dual-energy MDCT in spectral imaging acquisition for analysis: conventional polychromatic images obtained at 140 kVp, iodine- and water-based material decomposition images, and monochromatic images obtained at values ranging from 40 to 140 keV.

From the monochromatic image sets, an operation was first made to obtain an optimal energy level (keV) to provide the best contrast-to-noise ratio (CNR) between the panreatic lesion and the normal pancreatic parenchyma. In order to get the optimal keV images, two circular regions-of-interest (ROI) were placed by a radiologist on the lesion and the normal pancreatic parenchyma. The GSI Viewer (GSI viewer, GE Healthcare, Waukesha Wisconsin) software package automatically calculated and displayed the CNR values for the 101 sets of monochromatic images real time. From the CNR plot, the optimal single energy (keV) level for generating the best CNR between the lesion and the normal pancreatic parenchyma could be selected (Fig. 1).

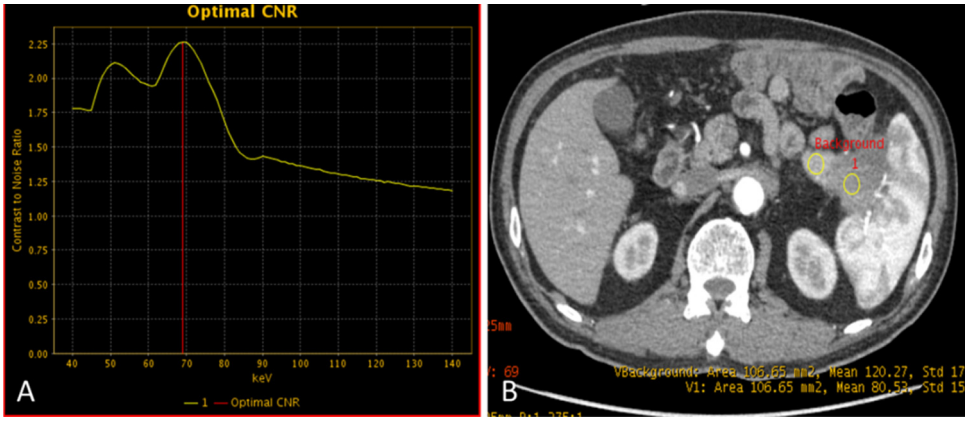

Fig. 1. Selecting the best contrast–noise-ratio (CNR) for displaying pancreatic ductal cancinoma with GSI Viewer analysis tool.
(A) Optimal monochromatic energy of 69 keV achieved the best CNR for the primary lesion. (B) ROI selections for the primary lesion and the normal pancreatic parenchyma on an axial image.