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Diffusion weighted MR imaging of pancreatic islet cell tumors

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ABSTRACT

Purpose: The aim of our study is to demonstrate the feasibility of body diffusion weighted (DW) MR imaging in the evaluation of pancreatic islet cell tumors (ICTs) and to define apparent diffusion coefficient (ADC) values for these tumors.
Materials and methods: 12 normal volunteers and 12 patients with histopathologically proven pancreatic ICT by surgery were included in the study. DW MR images were obtained by a body-phased array coil using a multisection single-shot echo planar sequence on the axial plane without breath holding. In addition, the routine abdominal imaging protocol for pancreas was applied in the patient group. We measured the ADC value within the normal pancreas in control group, pancreatic ICT, and surrounding pancreas parenchyma. Mann–Whitney *U*-test has been used to compare ADC values between tumoral tissues and normal pancreatic tissues of the volunteers. Wilcoxon Signed Ranks Test was preferred to compare ADC values between tumoral tissues and surrounding pancreatic parenchyma of the patients.
Results: In 11 patients out of 12, conventional MR sequences were able to demonstrate ICTs succesfully. In 1 patient an indistinct suspicious lesion was noted at the pancreatic tail. DW sequence was able to demonstrate the lesions in all of the 12 patients. On the DW images, all ICTs demonstrated high signal intensity relative to the surrounding pancreatic parenchyma. The mean and standard deviations of the ADC values ($\times 10^{-3}$ mm^2/s) were as follows: ICT ($n = 12$), 1.51 ± 0.35 (0.91–2.11), surrounding parenchyma ($n = 11$) 0.76 ± 0.15 (0.51–1.01) and normal pancreas in normal volunteers ($n = 12$), 0.80 ± 0.06 (0.72–0.90). ADC values of the ICT were significantly higher compared with those of surrounding parenchyma ($p < 0.01$) and normal pancreas ($p < 0.001$).
Conclusion: DW MR imaging does not appear to provide significant contribution to routine MR imaging protocol in the evaluation of pancreatic islet cell tumors. But it can be added to MR imaging protocol to detect the lesion in a limited number of patients with clinical suspicion for pancreatic ICT with negative or suspicious imaging findings.

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1. Introduction

Islet cell tumors (ICT) are neuroendocrine tumors of the pancreas originating from totipotential stem cells or from pancreatic mature endocrine cells [1]. ICT are clinically important because they have a high rate of malignancy, which ranges from 60% to 92% [2]. They are subclassified into functioning (those that secrete various hormones) and non-functioning tumors. Functioning tumors are diagnosed in earlier stages due to the symptoms related to the secreted hormone. Non-functioning tumors may remain hidden until they reach a significant size to cause a mass effect or to metastasize [3].

ICT, especially functioning ones, are often problematic to detect and localize on imaging studies due to their small size. Different studies proposed and evaluated different imaging techniques to increase the conspicuity of these lesions [3]. Dynamic, enhanced computed tomography (CT) and magnetic resonance (MR) imaging are common noninvasive preoperative radiologic techniques used in the evaluation of islet cell tumors [4]. The tumors often have characteristic features on these modalities but sometimes variable imaging findings may be present [3].

Diffusion weighted (DW) MR imaging has been used in the evaluation of cystic and solid pancreatic tumors [5–7]. To our knowledge, no study has ever determined the value of DW MR imaging on pancreas ICT. The aim of our study was to demonstrate the feasibility of body DW MR imaging in the evaluation of pancreatic islet cell tumors and to define apparent diffusion coefficient (ADC) values for these tumors.

2. Materials and methods

2.1. Subjects

12 patients (five women and seven men; age range 42–63 years; mean 50 years) with histopathologically proven pancreatic ICT by surgery were included in the study. Also, 12 normal volunteers with

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Table 1
The features of the pancreatic lesions on conventional MR sequences and DW MR sequences.

Sequence	Signal intensity of islet cell tumor[a]			
	Low	Intermediate	High	Tumor not seen or indistinct suspicious
T1-weighted ($n = 12$)	9	–	–	3
T2-weighted ($n = 12$)	–	2	8	2
Fat-saturated T1-weighted ($n = 12$)	9	–	–	3
DW ($b = 800$) ($n = 12$)	–	–	12	–
Postcontrast sequences	The degree of enhancement of islet cell tumor[b]			
	Minimal	Moderate	Intense	Tumor not seen or indistinct suspicious
Arterial phase ($n = 12$)	–	2	4	6
Venous phase ($n = 12$)	1	3	1	7
Delayed phase ($n = 12$)	–	3	6	3

Note: data are the number of lesions.
[a] Compared with that of normal pancreatic parenchyma.
[b] Compared with that of normal pancreatic parenchyma.

similar age range (five women and seven men; age range 42–63 years; mean 50 years) were included as control group. Age matching was important because different studies reported different ADC values for the pancreas [5,8–10] and Yoshikawa et al. [5] attributed this difference to age-related pancreatic changes including pancreatic atrophy, fatty infiltration and fibrosis. The same imaging protocol for diffusion weighted imaging was used for both healthy volunteers and the patients. Patients were scanned prior to the surgery. Histopathologic examination of the surgical specimens revealed insulinoma in 8 patients (4 at pancreatic head or uncus, 2 in pancreatic body, and 2 at the tail) and non-functioning tumor in 4 patients (1 at pancreatic head, 2 in pancreatic body and tail, and 1 occupying the pancreas in its entirety). The diameter of the tumors ranged from 11.0 to 27.3 mm (mean 18.2 mm) for insulinomas. Non-functioning tumors ranged from 51.2 to 213 mm (mean 88.5 mm).

2.2. MR protocol

All scans were performed on the same 1.5 T imaging system (Magnetom Symphony, Siemens Medical Solutions, Germany). The system provides a maximum gradient strength of 30 mT/m with a peak slew rate of 100 mT/(m ms). DW MR images were obtained by a four-element-phased array multicoil for the body, using a multisection single-shot echo planar sequence on the axial plane without breath holding. The following parameters were used for DW sequence: parallel imaging reduction factor of 2; TR/TE = 4400/85 ms; section thickness, 6 mm; intersection gap, 1 mm; matrix size, 128 × 128; field of view, 400 mm × 400 mm; partial Fourier factor, 6/8; bandwidth, 1370 Hz per pixel; seven excitations, water excitation with b value of 50, 400 and 800 s/mm^2. Fat saturation was used to avoid chemical shift artifacts. The whole sequence consisted of 30 sections. The study was performed during normal respiration. In addition, the routine abdominal imaging protocol for pancreas was applied in the patient group, which included axial and coronal breath-hold T2-weighted HASTE sequences, axial in-phase and opposed-phase images, and breath-hold T1-weighted fat-suppressed spoiled gradient-echo shared prepulse sequences acquired before contrast administration and during the arterial phase (15–20 s) and venous and delayed phases (60 and 180 s) after contrast administration.

2.3. Image analysis

All clinical MR images were analyzed retrospectively following surgery. The ability of routine abdominal MR imaging and DW MR imaging to identify pancreatic islet cell tumors was determined by comparison to operative and histopathologic findings.

Two radiologists (B.B. and A.P.) retrospectively examined the MR images to determine diameter, location, and number of tumors by consensus reading. Signal intensity on DW images, precontrast images and intensity of enhancement on postgadolinium images were also evaluated. Subjective evaluation of signal intensity on DW ($b = 800$), T1-weighted, T2-weighted, and postcontrast images were determined in relation to background pancreatic tissue. The degree of enhancement was also determined in relation to background pancreas. Low signal represents lower signal intensity than background pancreas, intermediate represents signal intensity comparable to pancreas, and high signal refers to higher signal intensity than background pancreas. Intense enhancement refers to enhancement greater than pancreas, and close to that of the aorta, moderately intense refers to an enhancement level between aorta and pancreas, moderate refers to enhancement comparable to pancreas, and minimal refers to enhancement less than pancreas. The presence and characteristics of liver metastases and other distant disease were also recorded. All tumors included in the study had histopathologic correlation. Histological type was determined from the records of our Department of Pathology and also the results were combined with laboratory values of hormone levels.

The number of patients where conventional MR sequences detected ICTs, liver metastases and other distant diseases has been noted. Also, the number of patients where DW MR imaging was

Table 2
ADC values of islet cell tumors compared to ADC values of normal pancreatic tissue in volunteers. ADC values in islet cell tumors were higher (1.51 ± 0.35) compared with normal pancreatic tissue in volunteers (0.80 ± 0.06). Mann–Whitney U-test demonstrated this difference to be statistically significant ($p < 0.001$).

	ADC values
ICT	
Mean	1.51
S.D.	0.35
Median	1.54
Minimum	0.91
Maximum	2.11
Normal volunteers pancreas tissue in control group	
Mean	0.80
S.D.	0.06
Median	0.78
Minimum	0.72
Maximum	0.90
Mann–Whitney U-test	
z	4.162
p	0.0001**

ICT = islet cell tumors; ADC = apparent diffusion coefficient; S.D. = standard deviation.
** $p < 0.001$.

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