BRIEF ARTICLE

Importance of *b* value in diffusion weighted imaging for the diagnosis of pancreatic cancer

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Received: July 14, 2013   Revised: September 2, 2013
Accepted: September 16, 2013
Published online: October 21, 2013

Abstract

AIM: To investigate the use of multi-*b*-value diffusion-weighted imaging in diagnosing pancreatic cancer.

METHODS: We retrospectively analyzed 33 cases of pancreatic cancer and 12 cases of benign pancreatic tumors at the Second Affiliated Hospital of Kunming Medical University from December 2008 to January 2011. The demographic characteristics, clinical presentation, routine magnetic resonance imaging and diffusion weighted imaging (DWI) features with different *b* values were reviewed. Continuous data were expressed as mean ± SD. Comparisons between pancreatic cancer and benign pancreatic tumors were performed using the Student's *t* test. A probability of *P* < 0.05 was considered statistically significant.

RESULTS: Thirty-three patients with pancreatic cancer were identified. The mean age at diagnosis was 60 ± 5.6 years. The male: female ratio was 21:12. Twenty cases were confirmed by surgical resection and 13 by biopsy of metastases. T1 weighted images demonstrated a pancreatic head mass in 16 patients, a pancreatic body mass in 10 cases, and a pancreatic tail mass with pancreatic atrophy in 7 cases. Eight patients had hepatic metastases, 13 had invasion or envelopment of mesenteric vessels, 4 had bone metastases, and 8 had lymph node metastases. DWI demonstrated an irregular intense mass with unclear margins. Necrotic tissue demonstrated an uneven low signal. A *b* of 1100 s/mm^2 was associated with a high intensity signal with poor anatomical delineation. A *b* of 700 s/mm^2 was associated with apparent diffusion coefficients (ADCs) that were useful in distinguishing benign and malignant pancreatic tumors (*P* < 0.05). *b* values of 50, 350, 400, 450 and 1100 s/mm^2 were associated with ADCs that did not differentiate the two tumors.

CONCLUSION: Low *b* value images demonstrated superior anatomical details when compared to high *b* value images. Tumor tissue definition was high and contrast with the surrounding tissues was good. DWI was useful in diagnosing pancreatic cancer.

Core tip: In this study, we retrospectively analyzed the conventional magnetic resonance imaging and diffusion weighted imaging (DWI) characteristics of 33 cases of pancreatic cancer using different *b* values, and assessed the value of the DWI examination in differentiating pancreatic cancer from benign pancreatic tumors.

Hao JG, Wang JP, Gu YL, Lu ML. Importance of *b* value in diffusion weighted imaging for the diagnosis of pancreatic cancer. *World J Gastroenterol* 2013; 19(39): 6651-6655 Available from:

INTRODUCTION

Pancreatic cancer is the fourth leading cause of cancer-related deaths[1] and accounts for 80% to 90% of exocrine gland malignant tumors[2]. Most patients present without symptoms and have a median survival of approximately 6 months. There is an urgent need for early diagnosis and accurate assessment of this disease. Magnetic resonance imaging (MRI) is a sensitive and specific imaging modality. MRI has been used to assess tumor macroscopic morphology, microscopic metabolism, and functional status[3,4]. Diffusion weighted imaging (DWI) is an imaging technique that is sensitive to water diffusion in living tissues. DWI was originally used to diagnose acute stroke[5,6]. DWI has also been used to diagnose liver, kidney, breast, prostate and uterine disease. DWI is frequently used to diagnose pancreatic diseases[7-10]. We retrospectively analyzed the conventional MRI and DWI characteristics of 33 patients with pancreatic cancer and 12 with benign pancreatic tumors to evaluate the value of DWI.

MATERIALS AND METHODS

Study patients

Thirty-three patients with pancreatic cancer were hospitalized at the Second Affiliated Hospital of Kunming Medical University between December 2008 and January 2011. Twenty patients had their diagnosis confirmed by pathological examination of the resected specimen and 13 by biopsy of metastases. There were 21 male and 12 female patients with an average age of 60 ± 5.6 years. Sixteen patients had a mass in the pancreatic head, 10 in the pancreatic body, and 7 in the pancreatic tail. Clinical symptoms included abdominal pain, abdominal discomfort, jaundice, abdominal mass, significant weight loss and loss of appetite. Control cases with benign pancreatic tumors were confirmed by histopathology.

Imaging data

Imaging was performed using a Siemens Sonata 1.5 T superconducting scanner with a body phased-array surface coil. A T1WI-FLASH sequence (repetition time, TR 124 ms and echo time, TE 2.47 ms) and T2WI-HASTE sequence (TR 1000 ms and TE 93 ms) were used with 18-24 layers, a thickness of 4-8 mm, spacing between 0 and 1.6 mm, and a field of view (FOV) of 240-280 mm × 300-380 mm. The matrix was 320 × 256. Scan time was 13-18 s.

DWI scanning was performed using a SE-EPI sequence (TR 4000 ms, TE 85-95 ms, Matrix 128 × 128, FOV 230 mm × 230 mm, thickness 5 mm, spacing 0.5 mm) with fat suppression, flow compensation and chemical shift saturation. The b value (apparent diffusion coefficient) was varied (50, 350, 400, 450, 700 and 1100 s/mm^2) to capture images. Slice selection was performed using frequency encoding and phase encoding in 3 directions. Images were processed using MR software. Scan time was 13-18 s.

Data analysis

The original DWI scanning data and automatically generated apparent diffusion coefficients (ADC) were transferred to the workstation. The value of the ADC was measured from the ADC image of each region of interest (ROI). Solid tumor ROIs were not less than half of the lesion and located in the center of the mass. Areas of necrosis, the main pancreatic duct, vascular branches and chemical shift artifacts were avoided. Three ADCs were measured from each ROI and averaged.

Statistical analysis

All statistical analyses were performed using SPSS, version 17.0 for Windows. Continuous data were expressed as mean ± SD. The differences in ADC values of pancreatic cancer and benign pancreatic tumors were evaluated using the Student's t test. All reported P values were two-sided. $P < 0.05$ was considered statistically significant.

RESULTS

Conventional MRI-T1W1

Sixteen patients had a pancreatic head mass, with a local or diffuse low intensity signal (Figure 1A). 10 had a pancreatic body mass with a low intensity signal (Figure 1B) and 7 patients had a pancreatic tail mass with pancreatic atrophy. Eight patients had liver metastases, 13 demonstrated invasion into or enveloping local mesenteric vessels, 4 had bone metastases and 8 had lymph node metastases.

DWI

DWI demonstrated an uneven intense signal with margins that were not clearly delineated. The central necrotic tissue had an irregular low intensity signal. A low b value image provided better anatomical detail than a high b value image. Tumor tissue definition was high, and there was sharp contrast with the surrounding tissue (Figure 2). A b of 1100 s/mm^2 was associated with a high value signal and poor definition of anatomic structures. A b of 700 s/mm^2 was associated with benign pancreatic tumors and pancreatic cancer ADCs that were significantly different ($P < 0.05$). The two tumor types had similar ADCs when b values of 50, 350, 400, 450 and 1100 s/mm^2 were used for imaging ($P > 0.05$) (Table 1).

DISCUSSION

Pancreatic cancer is one of the most common malignant tumors of the pancreas, accounting for approximately 75%-90% of tumors. It is the most common gastrointestinal malignant tumor[10]. The retroperitoneal location and lack of symptoms prevents early detection. Pancreatic cancers have a poor prognosis, with a five year survival of only 1%-3%[11]. Patients are generally male and 40-70
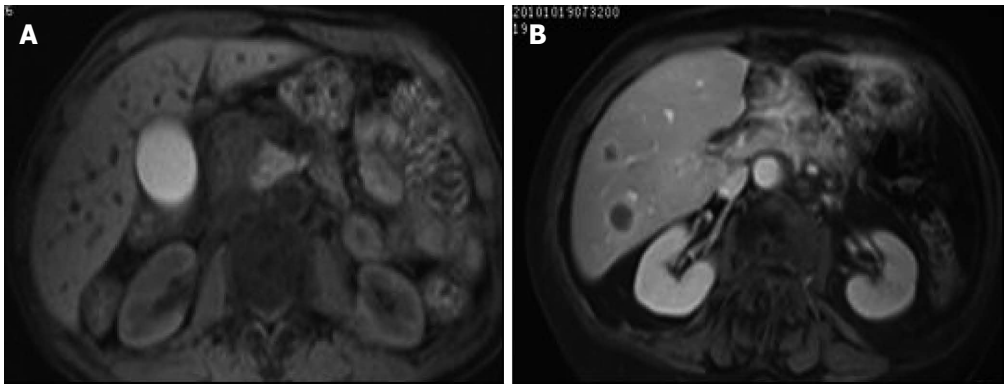
Figure 1 T1 weighted image. A: T1 weighted image. The margins were not sharp; B: T1 weighted image with contrast. There was obvious enhancement. Two nodules in the right liver demonstrated ring enhancement.
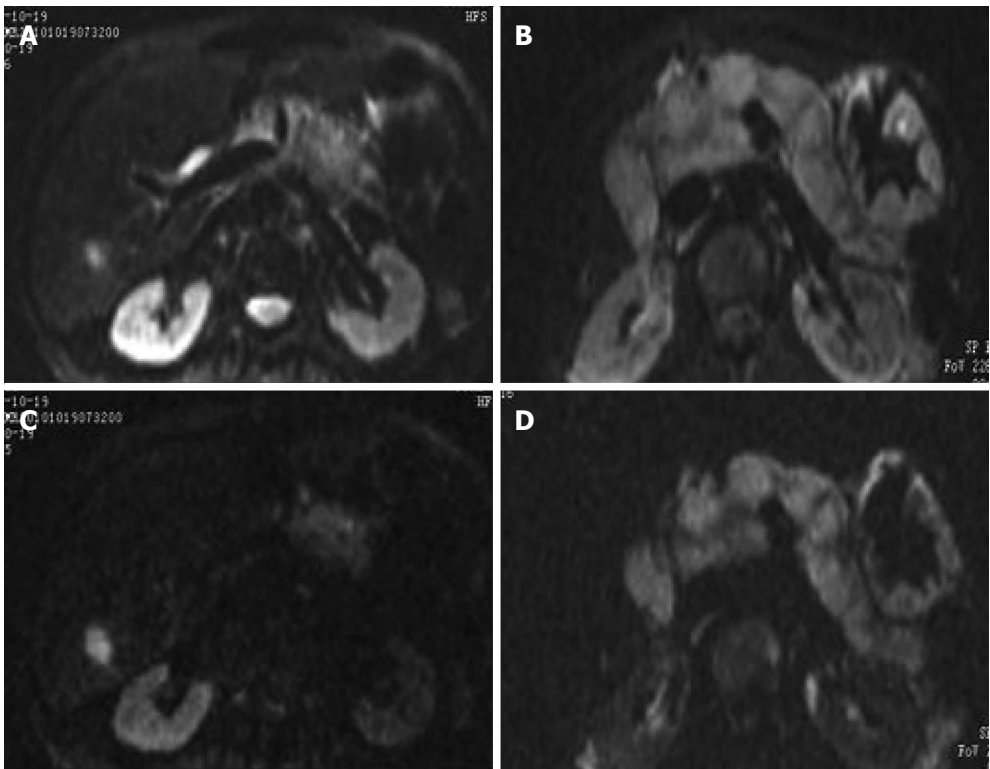

Figure 2 Tumor tissue definition was high, and there was sharp contrast with the surrounding tissue. A: $b = 50$ s /mm^2; B: $b = 400$ s /mm^2; C: $b = 700$ s /mm^2; D: $b = 1100$ s /mm^2. A high intensity signal was seen.

Table 1 Evaluation of apparent diffusion coefficients in pancreatic cancer and benign pancreatic tumors using different *b* values

b (s/mm^2)	Apparent diffusion coefficients (10^{-3} s/mm^2)	
	Benign pancreatic tumors	Pancreatic cancer
50	2.273 ± 0.298	2.006 ± 0.194
350	1.705 ± 0.227	1.489 ± 0.306
400	1.590 ± 0.553	1.376 ± 0.276
450	1.544 ± 0.194	1.333 ± 0.218
700	1.519 ± 0.125[1]	1.118 ± 0.102[1]
1100	1.380 ± 0.249	1.085 ± 0.163

[1]Indicates statistically significant difference, $P < 0.05$.

years of age. Only a minority of patients are candidates for surgery at the time of diagnosis[12].

The majority of pancreatic cancers are adenocarcinomas. Ductal adenocarcinomas account for 85%-90% of pancreatic carcinomas and originate in the ductal epithelium. Ductal adenocarcinomas are avascular solid tumors that are locally invasive. About 70% of pancreatic cancers are located in the pancreatic head, neck and uncinate process, 20% are located in the body of the pancreas, and 5%-10% are located in the tail of the pancreas.

Abdominal imaging is used to diagnose pancreatic tumors, distinguish benign and malignant pancreatic tumors, and evaluate the resectability of pancreatic cancers

before surgery[13-15]. Endoscopic ultrasound (EUS) with zone sonography technology has been used in the diagnosis of pancreatic disease[16]. The sensitivity of EUS fine needle aspiration for pancreatic adenocarcinoma[17] in early studies was more than 85%. Further studies are needed. Egorov *et al*[18] demonstrated the utility of combined CT and EUS in the detection of arterial involvement by pancreatic cancer. Previous studies[19] have shown that DWI performed significantly better than multidetector-row CT in the detection of liver metastases in patients with pancreatic tumors. PET has also been useful as a diagnostic and predictive tool, but its efficacy in the staging of pancreatic cancer is not known[20]. A meta-analysis of pancreatic imaging[21] suggested that DWI was a potentially useful modality for differentiating malignant from benign pancreatic lesions. There are few studies on the effect of *b* value on DWI in the diagnosis of pancreatic cancer. Normal pancreatic tissue contains more water than pancreatic cancer, resulting in a high T1 weighted signal. Tumor liquefaction, necrosis and hemorrhage are associated with an irregular low intensity signal. T2 weighted images are mainly used to evaluate fluid composition, pancreatic duct dilation, and pseudocyst formation. These images are not specific for pancreatic cancer, eliciting low and high intensity signal. DWI is a noninvasive magnetic resonance imaging method, which can detect the irregular random movement of water molecules[22]. DWI can provide spatial information and evaluate the exchange rate of water molecules in tissues. ADCs have been used to describe and measure the activity of water molecules.

b values of 50 and 350 s/mm^2 were associated with clear DWIs, but the ADC value was not precise. With small *b* values, the proportion of diffusion is small and blood perfusion had a greater impact on DWI. While T2 was associated with an intense signal, DWI did not show a good margin between tumors and the surrounding tissue[23-25]. These factors affect the quality of DWI and the measurement of ADC.

DWI and ADCs with small *b* values were not useful in diagnosing pancreatic tumors. A *b* value of 1100 s/mm^2 was not useful in generating ADCs that could differentiate benign and malignant pancreatic tumors. This may be due to a decline in image quality seen with high *b* values. A *b* value of 700 s/mm^2 was useful in generating ADCs that could differentiate the two tumor types. The amount of tumor fibrosis, necrosis, cell proliferation, and changes in the nuclear/cytoplasmic ratio and membranous structure restricted the movement of water molecules in pancreatic cancers, decreasing the ADC values[26].

The small sample size of this study increases the possibility of a type 2 error. Randomized controlled trials are needed to verify the utility of specific *b* values to aid in the differential diagnosis of pancreatic cancer.

In conclusion, low *b* value imaging demonstrated anatomical details that were superior to high *b* value images. Tumor tissue definition was high and contrast with the surrounding tissue was good. DWI was useful in diagnosing pancreatic cancer.

COMMENTS

Background
Pancreatic cancer is the fourth leading cause of cancer-related deaths. Early detection, early diagnosis, and suitable treatment play an important role in extending patient survival. Diffusion weighted imaging (DWI) is a technically feasible measure to differentiate malignant from benign pancreatic lesions.

Research frontiers
DWI is a magnetic resonance imaging technique that can be used to evaluate liver, kidney, breast, prostate and uterine tissue, and is especially useful in evaluating the upper abdomen.

Innovations and breakthroughs
The authors retrospectively analyzed the DWI characteristics of 33 cases of pancreatic cancer using multiple *b* values in order to identify the optimal *b* value for differentiating malignant from benign pancreatic lesions.

Applications
The authors found that low *b* values provided superior anatomical details, a quality image, good tumor tissue definition, and good contrast with the surrounding tissue.

Terminology
DWI is an imaging technique sensitive to water molecule diffusion. It can noninvasively evaluate diffusion processes inside living cells.

Peer review
This is an interesting study with great promise. DWI appears useful in diagnosing pancreatic cancer.

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