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

Hao JG *et al*. DWI and pancreatic cancer

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**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 pancreatic benign 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 a mean ± SD. Comparison between pancreatic cancer and pancreatic benign tumors were performed using a Student's *t* test. A probability of *P*< 0.05 was considered statistically significant.

**RESULTS:** About 33 patients with pancreatic cancer were identified.The mean age at diagnosis was 60 ± 5.6 years. The male: female ratio was 21:12. 20 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. 8 patients had hepatic metastasis, 13 had invasion or envelopment of mesenteric vessels, 4 had bone metastasis, and 8 had lymph node metastases. DWI demonstrated an irregular intense with unclear margins. Necrotic tissue demonstrated an uneven low signal. A *b* of = 1100 s/mm2 was associated with a high intensity signal with poor anatomical delineation. A *b* of = 700 s/mm2 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/mm2 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.

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**Key words:** Pancreatic cancer; Magnetic resonance imaging; *b*-value; Apparent diffusion coefficient; Diffusion weighted imaging

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

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**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 [symptom](app:ds:symptom)s 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](app:ds:assess" \t "_self) 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 being used more frequently 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. About 20 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 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 as 50, 350, 400, 450, 700 and 1100 s/mm2 to capture images. Slice selection was performed using frequency encoding and phase encoding in 3 directions. Images were processed using MR software. Scanning 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 ADC). Solid tumor ROI 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 windows 17.0. Continuous data were expressed as a mean ± AD. The differences in ADC value of pancreatic cancer and pancreatic benign tumors were evaluated using 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 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 metastasis, 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/mm2 was associated with high value signal and poor definition anatomic structures. A *b* of = 700 s/mm2 was associated with pancreatic benign tumors and pancreatic cancer apparent diffusion coefficients 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/mm2 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 about 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 poor prognosis, with a five year survival of only 1%-3%[11]. Patients are generally male and 40-70 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 endoscopic ultrasound fine needle aspiration for pancreatic adenocarcinoma[17] in early studies has been more than 85%. Further studies are needed. [Egorov](http://www.ncbi.nlm.nih.gov/pubmed?term=Egorov%20VI%5BAuthor%5D&cauthor=true&cauthor_uid=23717744) *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 of 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 were mainly used to evaluate fluid composition, pancreatic duct dilation, and pseudocyst formation. It was 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/mm2 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 ADC with small *b* values were not useful in diagnosing pancreatic tumors. A *b* value of = 1100 s/mm2 was not useful in generating ADC that could differentiate benign and malignant pancreatic tumors. This may be due to decline in image quality seen with high *b* values. A *b* value of = 700 s/mm2 was useful in generating ADC that could differentiate the two tumor types. The amount of tumor fibrosis, necrosis, cell proliferation, and changes 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 (MRI) technique that can be used to evaluate liver, kidney, breast, prostate and uterine tissue, especially useful in evaluating the upper abdomen.

***Innovations and breakthroughs***

The authors retrospectively analyzed the DWI characteristics of 33 cases of pancreatic cancer in multi-*b*-value in order to find out 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 molecules diffusion. It can non-invasively 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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**B**

**A**

**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.



A B



C D

**Figure 3 Tumor tissue definition was high, and there was sharp contrast with the surrounding tissue.** A: *b* = 50 s /mm2; B: *b* = 400 s /mm2; C: *b* = 700 s /mm2; D: *b* = 1100 s /mm2. A high intensity signal was seen.

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

|  |  |  |  |
| --- | --- | --- | --- |
| ***b* (s/mm2)** | **Apparent diffusion coefficients (10-3s/mm2)** | | |
|  | **Benign pancreatic tumors** | **Pancreatic cancer** |
| *b* = 50 | 2.273 ± 0.298 | 2.006 ± 0.194 |
| *b* = 350 | 1.705 ± 0.227 | 1.489 ± 0.306 |
| *b* = 400 | 1.590 ± 0.553 | 1.376 ± 0.276 |
| *b* = 450 | 1.544 ± 0.194 | 1.333 ± 0.218 |
| *b* = 700 | 1.519 ± 0.1251 | 1.118 ± 0.1021 |
| *b* = 1100 | 1.380 ± 0.249 | 1.085 ± 0.163 |

1Indicates statistically significant difference, *P* < 0.05.