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Utility of Diffusion-Weighted MRI to Detect Changes in Liver Diffusion in Benign and Malignant Distal Bile Duct Obstruction: The Influence of Choice of b-Values

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Abstract

Purpose: The study sought to evaluate the potential of diffusion-weighted magnetic resonance imaging to detect changes in liver diffusion in benign and malignant distal bile duct obstruction and to investigate the effect of the choice of b-values on apparent diffusion coefficient (ADC).
Methods: Diffusion-weighted imaging was acquired with b-values of 200, 600, 800, and 1000 s/mm^2. ADC values were obtained in 4 segments of the liver. The mean ADC values of 16 patients with malignant distal bile duct obstruction, 14 patients with benign distal bile duct obstruction, and a control group of 16 healthy patients were compared.
Results: Mean ADC values for 4 liver segments were lower in the malignant obstruction group than in the benign obstruction and control groups using b = 200 s/mm^2 ($P < .05$). Mean ADC values of the left lobe medial and lateral segments were lower in the malignant obstruction group than in the benign obstructive and control groups using b = 600 s/mm^2 ($P < .05$). Mean ADC values of the right lobe posterior segment were lower in the malignant and benign obstruction groups than in the control group using b = 1000 s/mm^2 ($P < .05$). Using b = 800 s/mm^2, ADC values of all 4 liver segments in each group were not significantly different ($P > .05$). There were no correlations between the ADC values of liver segments and liver function tests.
Conclusion: Measurement of ADC shows good potential for detecting changes in liver diffusion in patients with distal bile duct obstruction. Calculated ADC values were affected by the choice of b-values.

Résumé

But : L'étude vise à évaluer le potentiel de l'imagerie par résonance magnétique (IRM) de diffusion pour détecter les variations de la diffusion dans le foie de tumeurs malignes et bénignes obstruant l'extrémité distale du canal cholédoque. Elle étudie également l'effet du choix des valeurs de facteur b sur le calcul du coefficient de diffusion apparent (CDA).
Méthodes : Acquisition d'IRM de diffusion à partir de valeurs de facteur b de 200, 600, 800 et 1 000 s/mm^2. Des valeurs du CDA ont été obtenues dans quatre segments du foie. Les valeurs moyennes de 16 patients présentant une tumeur maligne obstruant l'extrémité distale du canal cholédoque, de 14 patients présentant une tumeur bénigne obstruant l'extrémité distale du canal cholédoque et d'un groupe de contrôle formé de 16 patients en bonne santé ont été comparées.
Résultats : Les valeurs moyennes du CDA dans les quatre segments étaient inférieures pour le groupe de patients présentant une obstruction par tumeur maligne comparativement aux deux autres groupes avec une valeur de facteur b de 200 s/mm^2 ($P < 0,05$). Les valeurs moyennes du CDA dans les segments médial et latéral du lobe gauche étaient inférieures pour le groupe de patients présentant une obstruction par tumeur maligne comparativement aux deux autres groupes avec une valeur de facteur b de 600 s/mm^2 ($P < 0,05$). Les valeurs moyennes du CDA dans le segment postérieur du lobe droit étaient inférieures pour les groupes de patients présentant une obstruction par tumeur maligne et par tumeur bénigne comparativement au groupe de contrôle avec une valeur de facteur b de 1 000 s/mm^2 ($P < 0,05$). À une valeur de facteur b de 800 s/mm^2, les valeurs du CDA des quatre segments n'affichaient pas de différence significative selon le groupe ($P > 0,05$). Il n'y avait pas de corrélation entre les valeurs du CDA des segments du foie et les résultats des épreuves de la fonction hépatique.

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Conclusion : La mesure du CDA présente un bon potentiel de détection des changements de la diffusion dans le foie chez les patients qui présentent une obstruction de l'extrémité distale du canal cholédoque. Le choix des valeurs de facteur b a influé sur les valeurs calculées du CDA.

Key Words: Biliary obstruction; Diffusion-weighted imaging; Liver fibrosis; Magnetic resonance imaging; b-value

Obstructive jaundice may induce liver and kidney dysfunction, infection, and multiple organ failure [1]. During obstruction, the liver undergoes functional and biochemical changes [2,3]. Bile duct obstruction leads to a reduction in bile flow. Elevation of potentially toxic bile acid in the liver and the blood cause rapid hepatocellular injury and over time, inflammation, bile duct proliferation, and fibrosis can occur [4]. Magnetic resonance imaging (MRI) has been used to evaluate the effects of biliary obstruction on the liver parenchyma: Liver segments associated with intrahepatic biliary obstruction show increased signal intensity on T1-weighted imaging, reflecting a probable change in tissue composition [5,6]. Diffusion-weighted imaging (DWI) is a technique that characterised water molecule diffusion in vivo. In biological tissue, diffusion is quantified by the apparent diffusion coefficient (ADC). However, in vivo, ADC is also affacted by capillary perfusion. Thus, DWI provides information on perfusion and diffusion simultaneously in biological tissue [7,8]. Currently, DWI is used for liver lesion detection and characterisation in combination with T2-weighted and contrast-enhanced MRI [9−11]. DWI is also effective to detect moderate and advanced fibrosis [10−13].

The purpose of our study was to assess the potential of noninvasive DWI to detect changes in liver diffusion in benign and malignant distal bile duct obstruction, and to investigate the influence of the choice of different b-values.

Materials and methods

Patients

This retrospective study was approved by our institutional review board, and informed consent was waived.

Between May 2011 and March 2012, 92 patients who suspected biliary obstruction underwent magnetic resonance cholangiopancreatography (MRCP), and abdominal MRI, including DWI were enrolled in the study. Patients with cirrhotic liver disease, focal liver lesions, or significant fatty changes in the liver segment (signal drop of >50% on in/on out of phase T1-weighted imaging) were excluded. Patients with intrahepatic and hilar bile duct obstruction or underwent biliary interventional procedures were also excluded. The final study population included 30 patients with distal biliary bile duct obstruction and showed dilatation of the extrahepatic bile duct at MRI. The mean diameter of the common bile duct measured at MRI was 15.7 mm (range 8-25 mm). They were treated surgically or with retrograde cholangiopancreatography in our hospital. Sixteen patients (9 men, 7 women; mean age 64 ± 12 years, range 50-80 years) with malignant distal bile duct obstruction and 14 patients (6 men, 8 women; mean age 66 ± 16 years, range 19-82 years) with benign distal bile duct obstruction were included in our study. The main symptom was jaundice and the mean duration of the symptom was 18 days (range 7-30 days) in patients with malignant bile duct obstruction, whereas the main complaint was abdominal or epigastric pain in patients with benign distal bile duct obstruction and the mean duration of the symptom was 12 days (1-20 days), except 1 patient with distal bile duct stricture who had epigastric pain about 6 months and 2 patients with retained stones following cholecystectomy who had abdominal pain for about 9 months. The control group included 16 patients (3 men, 13 women; mean age 59 ± 18 years, range 19-77 years) whose laboratory, MRCP, and MRI findings for the liver, bile duct, and pancreas were normal. In all 16 malignant lesions, a final diagnosis was made on the basis of histopathological findings after biopsy or surgery; these included pancreatic carcinoma (n = 4), ampullary carcinoma (n = 4), periampullary carcinoma (n = 3), bile duct carcinoma (n = 3), and duodenal carcinoma (n = 2). Of the patients with benign distal obstruction on retrograde cholangiopancreatography, 1 had distal bile duct stricture due to chronic pancreatitis, 13 patients had distal bile duct stones. Of these 13 patients, 5 had retained stones following cholecystectomy.

MRI Protocol

Magnetic resonance imaging was performed with a 1.5-T body system (Avanto; Siemens, Erlangen, Germany) with a 33-mT/m maximum gradient strength. A 12-element phased-array body coil was used. Axial, coronal turbo-spin echo T2-weighted, axial T2 turbo-spin echo with fat saturated, 2D gradient-echo T1-weighted in phase and out phase; and axial, breath-hold 3D gradient-echo T1-weighted with fat saturation sequences before and after the administration of intravenous gadolinium (0.1 mmol/kg bolus) were acquired. Before intravenous contrast material was used, axial abdominal DWIs were performed. We used the same orientation and plane in the routine sequences. A free-breathing single-shot echo-planar-imaging sequence with a chemical shift selective fat-suppression technique was acquired. Sequence parameters were repetition time (TR)/echo time (TE), 4500/88 ms; matrix, 132 × 192; field of view, 350-400 mm; slice thickness, 5 mm; interslice gap, 20% (1 mm); slice numbers, 24-38; echo train length (EPI factor) 156; and 2 excitations. The acquisition time was approximately 4 min, sensitivity-encoding factor was 2, and parallel acquisition imaging (generalized autocalibrating partially parallel