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Contrast behavior and image quality of magnetic resonance cholangiopancreatography imaging using variable echo times at 3.0 T

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Abstract

Twenty-five volunteers were examined at three different echo times (TE) using magnetic resonance cholangiopancreatography (MRCP) images obtained with half-Fourier-acquired single-shot turbo spin echo (HASTE) thick-slab and multislice HASTE to identify the optimal TE at 3.0 T. No significant difference in the overall image quality was found comparing three different TEs within commonly used ranges. We observed an almost identical duct visibility with different TEs, while we found a trend toward superior visibility of the cystic duct at shorter TE.

Keywords: High-field MRI; Magnetic resonance cholangiopancreatography; MR pulse sequence; Image contrast

1. Introduction

Recently, there have been considerable research interests in the clinical evaluation of magnetic resonance imaging (MRI) using higher magnetic field strengths [1–3]. Some investigators have demonstrated that spatial resolution and signal-to-noise ratio (SNR) could be improved significantly with the development of high-field MRI scanners. Whole-body MR scanners at 3.0 T are available even for upper abdominal imaging, including MR cholangiopancreatography (MRCP) imaging [4–6]. According to these preliminary results, MRCP imaging at 3.0 T has the potential to improve contrast-to-noise ratio (CNR) and the visualization of anatomic details compared to at 1.5 T [6–8].

On MRCP imaging, in addition to spatial resolution and SNR, T2 contrast is an important factor in image quality. T2 decreases slightly at higher magnetic field strengths [9–11]; T2 relaxation time was 8% shorter for the liver, spleen, and fat at 3.0 T when comparing at 1.5 T [11]. Therefore, optimal MRCP imaging parameters at 3.0 T may significantly differ from those obtained at 1.5 T. However, no reports have focused on the optimization of MRCP imaging protocols at 3.0 T. The aim of this study was to identify the optimal TE for MRCP and heavily T2-weighted images at 3.0 T assessing different TEs.

2. Materials and methods

2.1. Volunteers

From September 2005 to July 2007, 25 normal adult volunteers participated in the study. The study was approved by the local institutional review board of our institution, and all volunteers gave their written informed consent for the study protocol. The group consisted of 21 men and 4 women with an age range from 25 to 60 years (mean age 38.5±8.9 years). All volunteers fasted for at least 3 h before the scan.

2.2. MR imaging

All studies were performed on a whole-body 3.0-T imaging system (Magnetom Trio; Siemens, Erlangen, Germany) with an eight-channel body phased-array coil.

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The images were obtained using a dielectric pad made by filling a 1.6-l capacity nutrition bag with aqueous solutions of 50 g manganese sodium to prevent any signal inhomogeneity [5]. The MRCP protocol included was breath-hold two-dimensional half-Fourier-acquired single-shot turbo spin echo (2D HASTE), and acquired thick-slab MRCP imaging as well as heavily T2-weighted imaging using breath-hold multislice HASTE were performed in the coronal plane. To stay with in the accepted SAR range at 3.0 T MR scanner, the flip angle was selected at 120° instead of 180°. Fat saturation was applied in 2D HASTE thick-slab MRCP, but not in heavily T2-weighted images.

Two-dimensional HASTE thick-slab MRCP imaging was performed with the following parameters: effective TE, 672, 900, and 1120 ms; flip angle, 120°; matrix, 384×384; field of view, 220 mm; slab thickness, 50 mm; in-plane image resolution, 0.6×0.6 mm; echo train length, 384; echo spacing, 12.0 ms; readout bandwidth, 130 Hz/pixel; and acquisition time, 4 s.

Heavily T2-weighted imaging using breath-hold multislice HASTE was performed with the following parameters: effective TE, 68, 88 and 106 ms; flip angle, 120°; matrix, 320×320; field of view, 400 mm; slice thickness, 1.4 mm; in-plane image resolution, 1.3×1.3 mm; echo train length, 256; echo spacing, 6.8 ms; readout bandwidth, 558 Hz/pixel; and acquisition time, 22 s.

2.3. Data analysis

To quantify the image quality, one experienced radiologist (HL) performed operator-defined region-of-interest (ROI) measurements. We calculated the standard deviation (S.D.) of the liver as the noise (SD_{noise}). A single ROI drawn as large as possible for signal measurement of the liver was located in a homogenous portion of the liver and set in an area devoid of vessels and prominent artifacts. To minimize coil inhomogeneity errors, a small ROI for signal measurement of the bile duct was set in the right intrahepatic bile duct (IHBD) close to the ROI drawn for signal measurement of the liver. As there would be inhomogeneous signal intensity (SI) on thick-slab MRCP images due to coil inhomogeneity, quantitative analysis was performed on heavily T2-weighted images obtained with breath-hold multislice HASTE.

ROIs were drawn three times in the liver and right IHBD, and the mean SI values were obtained on images. The SNR was calculated with the following formula:

$$\mathrm{SNR} = \mathrm{SI}_{\mathrm{liver}}/\mathrm{SD}_{\mathrm{noise}}.$$

The bile duct–liver CNR was calculated with the following formula:

$$\mathrm{CNR} = (\mathrm{SI}_{\mathrm{bile\ duct}} - \mathrm{SI}_{\mathrm{liver}})/\mathrm{SD}_{\mathrm{noise}}.$$

As an independent visual assessment, MR images were evaluated by two experienced radiologists. One operator (YH) had 11 years of experience at the beginning of this study, and the other (SA) had 7 years' experience. The evaluators were blinded to the TE and to the identity of the volunteers. The readers were asked to rate the images with consensus using a five-point scale. All images were scored for visualization of the right IHBD, cystic duct, common bile duct (CBD), pancreatic duct, and overall image quality. The visualization of ducts was scored as follows: 0=ductal structure not visible, 1=detection of ductal structure almost impossible, 2=ductal structure partially visible, 3=most of the ductal structure visualized, 4=ductal structure perfectly visible. The image quality was ranked as follows: 0=nondiagnostic, 1=poor, 2=fair, 3=good, 4=excellent. The image noise and image contrast between fluid and tissues were also scored using the above five-point scale.

2.4. Statistical analysis

Statistical analysis was conducted with the SPSS software (version 11.5, SPSS, Chicago, IL, USA). The Wilcoxon matched-paired signed rank test was used to analyze the differences in qualitative and quantitative evaluations. In these analyses, a P value of less than .05 was considered to indicate a significant difference.

3. Results

MRCP at 3.0 T was performed safely in all volunteers without any complications. The results of SNRs and bile duct–liver CNRs obtained with different TE values are shown in Table 1. Tables 2 and 3 show comparative visual assessments of image quality rating for acquisition protocols. Figs. 1 and 2 show examples.

3.1. SNR and CNR measurements

On heavily T2-weighted images using breath-hold multislice HASTE, liver SNR increased by 10% for intermediate TE and short TE, as compared with SNR at long TE. On the other hand, images with both long TE and intermediate TE showed higher CNR values than short TE. However, no significant differences in both SNR and bile duct–liver CNR were observed on multislice HASTE obtained with three different TEs at 3.0 T.

Table 1
Quantitative assessment of liver SNR and bile duct–liver CNR with different TEs on multislice HASTE images

TE	106	88	68	P value
SNR	4.2±1.0	4.6±1.3	4.6±1.0	*P=.30, **P=.24, ***P=.91
CNR	16.2±4.5	15.9±6.2	14.0±4.2	*P=.98, **P=.11, ***P=.19

* P value between long TE and intermediate TE.
** P value between long TE and short TE.
*** P value between intermediate TE and short TE.