Pitfalls and Optimisation of Breath-hold Single-shot Fast Spin-echo MR Cholangiopancreatography

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Introduction
Magnetic Resonance Cholangiopancreatography (MRCP) has been used to depict the biliary and pancreatic ducts using heavily T2-weighted single-shot fast spin-echo (SSFSE) pulse sequences with Half-Fourier acquisition (HASTE). Several authors have compared MRCP to conventional Endoscopic Retrograde Cholangiopancreatography examinations (ERCP) [1-2], and the use of the former is currently growing in clinical practice.

Objectives
The objective of this study is to optimise the SSFSE pulse sequences currently used in breath-hold MRCP examinations, taking into account likely artifacts, signal-to-noise ratio (SNR) and clinical performance. In addition to the clinical evaluation, artifacts were simulated and demonstrated with test objects.

Methods
The biliary anatomy was depicted within a single breath-hold by scanning either a series of thin contiguous coronal slices or a single thick coronal slice containing the volume of interest.

Simulations/Test Objects: Software was developed in Visual Basic and C++ to simulate a straight duct at an arbitrary angle with the coronal image plane, volume, containing a spherical filling defect of arbitrary size. The effects of a imperfect slice profile, T2 decay and truncation of the acquisition matrix were investigated on individual slices and on the maximum intensity projection (MIP). A test object consisting of water filled plastic tubes of up to approximately 5 mm internal diameter containing spherical filling defects of different sizes was imaged to demonstrate the limitations of the technique.

Clinical Evaluation: Clinical indication for the study was either failure of ERCP or previous gastric/pancreatic surgery. 11 patients (7 male, 4 female, aged 38 to 74, average weight 74 kg, range 52 to 106 kg) were scanned after 7 hours of fasting. Three MRCP sequences were employed over 3 consecutive breath-holds.

A. A single slice (18 mm thick) obtained with a SSFSE (TEeff = 650 ms), receiver bandwidth 62.5kHz and 256 x 256 acquisition matrix.

B. A series of 3mm thick slices obtained with a series of SSFSE (TEeff = 639 ms), receiver bandwidth 31.25 kHz and 192 x 256 acquisition matrix.

C. A series of 3mm thick slices obtained with a series of SSFSE (TEeff = 650 ms), receiver bandwidth 64kHz and 256 x 256 acquisition matrix.

Maximum intensity projection (MIP) images of the 3mm thick slices (B and C) were calculated and all five sets of images were analysed. Examinations were clinically evaluated by a single observer (SH) for image quality and pancreaticobiliary pathology. The SNR was also calculated for all protocols and MIPs. Any evidence of motion artifacts (slice misregistration) and edge enhancement artifacts was also recorded.

Results
Computer simulations and the test object images demonstrated that MRCP using a single thick slice (A) is more likely to provide reliable information on small filling defects due to imperfect slice profiles. The detection of small filling defects on thin slices (B and C) is highly dependent on the individual geometry.

All 11 MRCP examinations present evidence of slice cross-talk (protocols B and C). 7 of the examinations present evidence of edge enhancement of the biliary ducts with either protocol B or C. These generate artifacts of difficult interpretation on MIPs. The SNR associated with the thick slice obtained with protocol A is on average 4 times higher than that of the MIP calculated for the same volume obtained with a series of 3 mm thick slices using the same pulse sequence (protocol C). In average, protocol B provides MIPs with an SNR 1.3 times higher than those obtained with protocol C, but edge enhancement artifacts are more noticeable.

Clinically, the 3 sets of breath-hold images were technically adequate; the poorer SNR of protocol C did not alter diagnosis. Misregistration of consecutive images gave 2 poor MIP reconstructions (B) and the false impression of changes of chronic pancreatitis in the main pancreatic duct. Edge enhancement artifacts gave false positive results in protocols B and C for 2 patients by suggesting stents were present in the common bile duct. Subjectively the thicker slice images gave the best image quality. However, in one case the distal common bile duct was not well visualised due to an overlying pseudocyst.

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References