Balanced MR Cholangiopancreatography with Motion-Sensitized Driven-Equilibrium (MSDE): Feasibility and Optimization of Imaging Parameter

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Introduction

In this study, a balanced steady-state free precession (SSFP) sequence with motion-sensitized driven-equilibrium (MSDE) was used as an alternative technique for MR cholangiopancreatography (MRCP). The anatomical evaluation of biliary system is a major objective of preoperative MRCP. Conventional T2-weighted MRCP at a high spatial resolution can visualize detailed pancreatobilialy anatomy, but the evaluation of fine biliary structures such as cystic duct is sometimes difficult mainly due T2 shortened bile. MRCP based on balanced SSFP (balanced MRCP) may improve the contrast of MRCP because the image contrast of balanced SSFP sequences depends on T2/T1 rather than T2. However, on balanced MRCP, high signal intensity of blood vessels is a disturbing factor, since they can hide biliary system, especially on maximum intensity projection (MIP) images. Suppression of blood vessel signal may greatly simplify the radiologists' reading process, and therefore should improve their diagnostic performance. The MSDE sequence was first optimized for more efficient residual blood signal suppression in the imaging of arterial wall. We applied the MSDE technique to a balanced SSFP sequence aiming for "vessel-free" balanced MRCP imaging. Our purposes were to demonstrate the feasibility of MSDE-balanced MRCP and to determine the optimum velocity encoding (VENC) value.

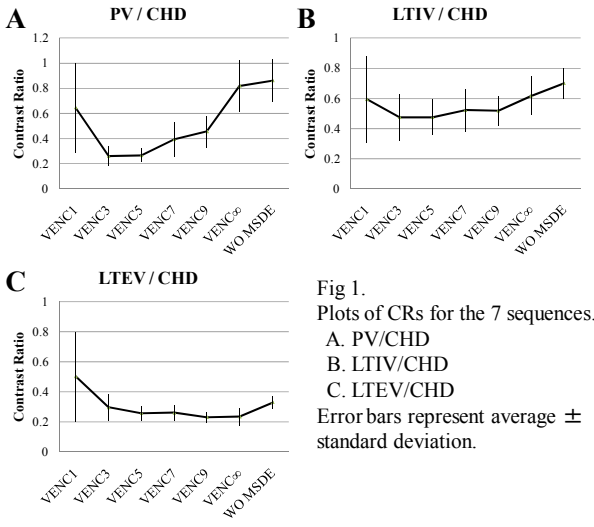

Fig 1.
Plots of CRs for the 7 sequences.
A. PV/CHD
B. LTIV/CHD
C. LTEV/CHD
Error bars represent average ± standard deviation.

Materials and Methods

Nine healthy volunteers underwent MRI study using a 1.5 T clinical unit (Intera Achiva nova dual, Philips Medical Systems) and a 32-channel body array coil. For each volunteer, images were obtained using the following 7 respiratory-triggered sequences: **1)** balanced MRCP without MSDE; TR/TE=4.00/2.00 ms, **2)-7)** balanced MRCP with MSDE; TR/TE=4.30/2.15 ms, VENC= 1, 3, 5, 7, 9 and ∞ cm/s, echo time of T2 preparation pulse=20 ms, and reforcusing pulse=1. These 7 sequences shared the following parameters: 3D acquisition, flip angle=90 degree, TFE factor=128, SENSE factor=2x1.5, NSA=2, with SPIR, FOV=35 x 35 cm, matrix=224x224, 512x512 image reconstruction, slice thickness=2 mm, slice interval=-1mm, and volume thickness=100 mm. Imaging time was 4-6 min for each scan. For the quantitative evaluation, ROIs were placed within the common hepatic duct (CHD), portal vein (PV), liver tissue including visible peripheral vessels (LTIV), and liver tissue excluding visible peripheral vessels (LTEV). Since MRCP images are usually evaluated on MIP images, we measured the maximum signal intensity within each ROI. We compared contrast ratios (CRs) of PV/CHD, LTIV/CHD and LTEV/CHD among the 7 sequences. Statistical comparisons were performed using t- test for paired data.

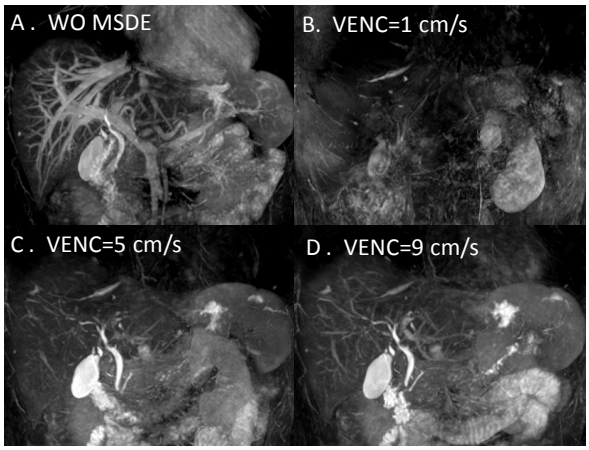

Fig 2. MIP images of A) balanced MRCP without MSDE, B) MSDE-balanced MRCP with VENC=1 cm/s, C) 5 cm/s, and D) 9 cm/s.

Results

Fig 1 shows plots of CR of PV/CHD, LTIV/CHD, and LTEV/CHD for the 7 sequences. The lowest CR of PV/CHD (i.e., the best suppression of PV signal compared to CHD) was achieved at VENCs of 3 cm/s and 5 cm/s (**Fig 1A**), with significant differences from other sequences ($P<0.05$). CR of LTIV/CHD monotonically increased with increasing VENC between VENC=3 and ∞ cm/s (**Fig 1B**). CR of LTEV/CHD was minimized at a VENC of 9 cm/s, and no significant difference was found among the VENCs of 3,5, and 7 cm/s (**Fig 1C**). **Fig 2** shows MIP images of balanced MRCP without MSDE, and MSDE-balanced MRCP at different VENC settings.

Discussion

We found the optimum VENC values to be 3 or 5 cm/s, with lower CRs of PV/CHD and LTIV/CHD, representing better suppression of relative PV signals at trunk and peripheries to bile ducts. At a lower VENC value (1 cm/s), CRs of PV/CHD, LTIV/CHD and LTEV/CHD increased. This is probably due to the CHD signal suppression due to minimal biliary flow. Higher VENC values (> 7 cm/s) resulted in failure of PV signal suppression. In conclusion, we demonstrated the feasibility of MSDE imaging for balanced MRCP. Optimum VENC value was considered either 3 or 5 cm/s. Clinical usefulness of this new MRCP sequence needs to be verified by further studies.