

Balanced MR Cholangiopancreatography with Motion-Sensitized Driven-Equilibrium: Feasibility of Post-contrast Biliary Examination with Gadolinium Ethoxybenzyl Diethylene Triamine Pentaacetic Acid (Gd-EOB-DTPA)

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Introduction

In this study, a balanced steady-state free precession (SSFP) sequence with motion-sensitized driven-equilibrium (MSDE) preparation was used as an alternative technique for magnetic resonance cholangiopancreatography (MRCP). Conventional T2-weighted MRCP at a high spatial resolution can visualize the pancreatobiliary anatomy in detail. However, recent studies have shown that the image quality of T2-weighted MRCP is substantially degraded by the use of gadolinium ethoxybenzyl diethylene triamine pentaacetic acid (Gd-EOB-DTPA), a commonly used liver-specific contrast agent, because of T2-shortening effect due to the agent excreted into the biliary system. In such cases, 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, the high signal intensity of blood vessels is problematic, since blood vessels can hide the biliary system, especially on maximum intensity projection (MIP) images. The suppression of blood vessel signals would greatly simplify the radiologists' reading process, and likely improve their diagnostic performance. We applied the MSDE technique to a balanced SSFP sequence aiming for "vessel-free" balanced MRCP imaging (ISMRM2010, poster 2614). The purpose of this study was to evaluate the effectiveness of MSDE-balanced MRCP with the use of Gd-EOB-DTPA by comparing it to conventional T2-weighted MRCP.

Materials and Methods

Fifteen patients (8 women, 7 men; mean age 65.8) prospectively underwent Gd-EOB-DTPA enhanced liver MRI study. All examinations were performed using a 1.5-T clinical unit and a 32-channel body array coil. For each patient, MRCP images were obtained after hepatobiliary-phase image acquisition (15-40 minutes after Gd-EOB-DTPA injection) using the following 2 navigator-triggered sequences: 1) for conventional 3D turbo spin-echo T2-weighted MRCP, TR/TE=3000-8000/550 ms, echo train length=129, FOV= 28 × 28 cm; matrix=256 × 256, slice thickness= 1 mm and volume thickness=80 mm, and 2) for MSDE-balanced MRCP, TR/TE=4.49/2.25 ms, VENC= 3 cm/s for Z-direction (oblique A-P direction), FOV=35 × 35 cm, matrix=224 × 224, slice thickness=1 mm 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) and liver tissue excluding visible peripheral vessels (LT) on the MIP images. The contrast-to-noise ratio (CNR) of CHD to LT was calculated by dividing the difference in the mean signal intensity between CHD and LT by the standard deviation of LT. For the qualitative analysis, two radiologists evaluated the depiction scores of the biliary system—CHD, cystic duct, right hepatic duct, left hepatic duct, right second-order biliary branch and left second-order biliary branch—and main pancreatic duct (MPD), using a three-point scale: 1, no visualization; 2, faint or partial visualization; and 3, full visualization. Signal suppression of the main trunk and first branch of the portal vein (PV) and hepatic vein (HV) on MSDE-balanced MRCP were also scored using a three-point scale: 1, poorly suppressed and problematic for biliary evaluation; 2, incompletely suppressed but not problematic for biliary evaluation; and 3, well suppressed. Statistical comparisons of CNR and the depiction scores between the 2 sequences were performed using t- tests for paired data and the Wilcoxon signed rank test, respectively.

Results

MSDE-balanced MRCP showed significantly higher CNR (35.2 ± 17.5) than T2-weighted MRCP (10.6 ± 10.5) ($p < 0.05$). **Table 1** shows depiction scores of 7 structures. For all biliary structures, depiction scores of MSDE-balanced MRCP were significantly higher than those of T2-weighted MRCP ($p < 0.01$), while depiction scores of MPD with MSDE-balanced MRCP were significantly lower than those of T2-weighted MRCP ($p < 0.05$). Signal suppression scores of PV and HV were either 2 or 3 in all cases (**Table 2**), meaning clinically sufficient signal suppression. **Fig. 1** shows MIP images of T2-weighted MRCP and MSDE-balanced MRCP.

Discussion

T2-weighted MRCP was associated with poor visualization of the biliary systems due to excreted Gd-EOB-DTPA, as previously reported. Use of MSDE-balanced MRCP resulted in higher CNR and better visualization of biliary structures than T2-weighted MRCP. Moreover, problematic vessel signals such as those of the PV and HV were sufficiently suppressed by the MSDE technique. In conclusion, we demonstrated the usefulness of MSDE-balanced MRCP in a Gd-EOB-DTPA post-contrast study.

Table 1 Structure visualization.

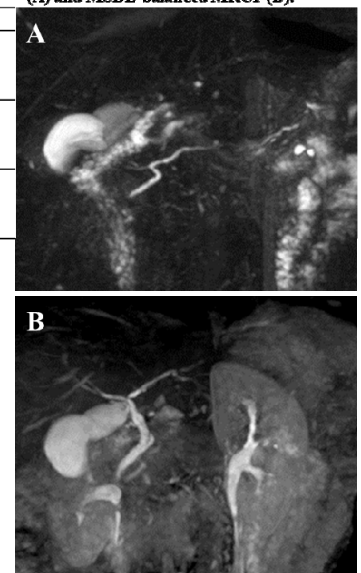
Structure	n	T2-weighted MRCP	MSDE-balanced MRCP	Pvalue
Common bile duct	14	1.64 ± 0.63	2.86 ± 0.36	0.0016
Cystic duct	13	1.14 ± 0.36	2.64 ± 0.74	0.0013
Right hepatic duct	14	1.07 ± 0.27	2.36 ± 0.84	0.0024
Left hepatic duct	15	1.13 ± 0.35	2.67 ± 0.26	0.0008
Right second-order branch	14	1.07 ± 0.26	2.27 ± 0.70	0.001
Left second-order branch	15	1.54 ± 0.88	2.62 ± 0.77	0.0083
Main pancreatic duct	14	2.86 ± 0.36	2.35 ± 0.63	0.0196

Data are means \pm standard deviations. One patient received right lobe hepatectomy, and another patient received choledochectomy and pancreaticoduodenectomy.

Table 2 Signal suppression of vessels on MSDE-balanced MRCP.

Structure	Score	n
Portal vein	1	0
	2	1
	3	14
	1	0
	2	3
Hepatic vein	3	12
	1	0
	2	7
	3	8

Fig. 1 MIP images of T2-weighted MRCP (A) and MSDE-balanced MRCP (B).



Note the signal decrease of biliary system on A and good visualization on B.