Non-gated Single Breath-Hold MR cholangiopancreatography (MRCP) with 3D bSSFP: Comparison with Respiratory Gated 3D FSE

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INTRODUCTION: Three-dimensional (3D) MRCP with fast spin echo (FSE) is widely used for the non-invasive evaluation of biliary or pancreatic ducts. However, data acquisition would fail in a case with insufficient respiratory gaiting, which results in the degradation of the image quality (1). Recently, MRCP using breath-hold 3D balanced SSFP (bSSFP), which has the characteristics of short acquisition time and high SNR, reported to improve the visualization of bile duct. However, it would be difficult to suppress the signal of portal vein completely, which might interfere with the visualization of bile ducts.

In this study, we developed a non-gated single 15-sec breath-hold 3D-MRCP technique using bSSFP and the feasibility of the proposed method for the visualization of bile ducts, which was compared to respiratory gated 3D-FSE MRCP with several minutes of scan time.

MATERIALS and METHODS: Institutional review board approval and informed consent were obtained. A total of 48 patients (18 male, 30 female, mean age: 66.8 y.o.) with suspected biliary disease was included in this study.

MR examinations were performed on a 3T-clinical imager (Toshiba Vantage Titan™ 3T, Japan) using an Atlas SPEEDER body and an Atlas SPEEDER spine coils. For 3D bSSFP in MRCP, the intrinsic T2/T1 contrast of bSSFP for long T2 component of bile fluid was utilized; however, there were a couple issues to be solved, such as contrast of fluid vs. blood signal, suppression of blood signal especially inflowing portal vein signals with maintaining the scan time of one breath-hold about 15 sec. Flip angle of bSSFP was optimized to 40 deg., which gave high signal of fluid with reduced blood signal. The number of segmentation was optimized to 2, which gave higher signal of fluid over inflowing portal vein signal. Breath-hold 3D bSSFP (bSSFP-MRCP) was used with parameters as follows: TR=4.8 msec, TE =2.4 msec, section thickness of 2 mm (with ZIP interpolation), field of view=33 x 33 cm, matrix=256 x 256, parallel imaging factor=2.0, segment=2, and flip angle=40 deg. Respiratory gated 3D FSE (FSE-MRCP) was used with parameters as follows: TR=5000-7000 msec, TE=572 msec, TI=200 msec, section thickness of 1.1 mm, field of view=33 x 33 cm, matrix=320 x 320, and parallel imaging factor=2.0.

MIP image of bSSFP-MRCP was evaluated with regards to suppression of blood signal of portal vein (PV), intrahepatic portal vein (IHPV), and hepatic vein (HV) with 4-point scale as follows; “excellent”, blood signal is almost suppressed; “good”, some blood signals remain which does not interfere the evaluation of bile duct; “fair”, some blood signals remain which interfere the evaluation; and “poor”, most of the blood signals are not suppressed. The visualization of bile ducts of bSSFP-MRCP was compared with that of FSE-MRCP using the 4-point scale as follows; grade 4, bSSFP is clearly superior to FSE; grade 3, bSSFP is slightly superior to FSE; grade 2, bSSFP is equal to FSE; and grade1 bSSFP is inferior to FSE.

RESULTS: Figure 1 and 2 show image quality of venous suppression of each area of MRCP and visualization of bile ducts in two methods, respectively. The signals of PV and HV were considerably suppressed in bSSFP-MRCP. Although small signals of the IHPV distal to the second-order branches remained in some cases, there were no cases in which the remaining blood signal was interfered with the evaluation of the bile ducts. bSSFP-MRCP was equal to FSE-MRCP in the visualization of common bile duct and intrahepatic bile duct, in 52.9 % and 67.8%, respectively. In the visualization of cystic duct, all cases showed that SSFP-MRCP was superior to FSE-MRCP. In gall bladder, bSSFP-MRCP was superior in 69.3% of the cases. Figure 3 shows a typical case of MRCP images of bSSFP-MRCP and FSE-MRCP.

DISCUSSIONS: bSSFP-MRCP clearly visualized the gallbladder and common bile duct which contained the bile with high protein concentration, which could not be delineated well by FSE-MRCP. The reason of high image contrast of bSSFP could be due to an intrinsic T2/T1 character of bSSFP so that concentrated bile signal was visualized by bSSFP-MRCP. Binding artifacts overlapped the liver degraded the visualization of intrahepatic bile duct in some cases, which might be overcome by precise shimming. In two cases, the image quality of bSSFP-MRCP was poor because of the breath-hold failure, which indicates that further reduction of the breath-hold acquisition time is required in some patients.

CONCLUSION: 15-sec. breath-hold MRCP with 3D bSSFP provides clear bile and pancreatic duct images with high SNR, high special resolution, and sufficient suppression of blood signals.

References: (1)Lavdas E, Vlychou M, et al. Clinical Imaging. 2013; 37(4): 697-703. (2)Lee CU, Glockner JF. Proc. ISMRM. 2009. (3)Glockner JF, Saranathan M, et al. MRI. 2013; 31(8): 1263-70.

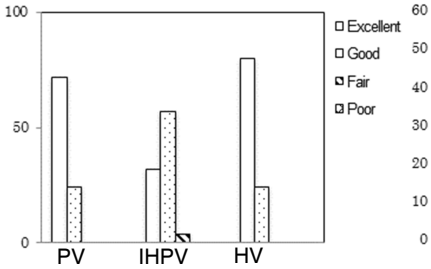


Fig 1. Suppression of venous signal
PV: portal vein, IHPV: intrahepatic portal vein, HV: hepatic vein.

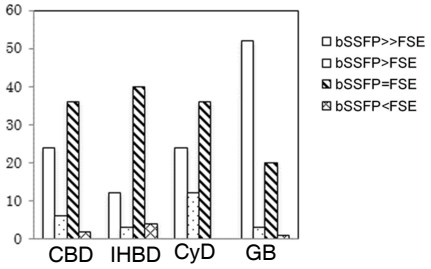
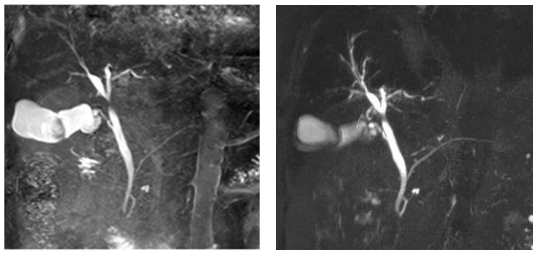


Fig 2. Comparison of bSSFP-MRCP and FSE-MRCP.
CBD: common bile duct, IHBD: intrahepatic bile duct, CyD: cystic duct, GB: gall bladder.



bSSFP-MRCP **(15 seconds)** FSE-MRCP **(4.5 minutes)**

Fig 3. Visualization of biliary tree in bSSFP-MRCP and FSE-MRCP