

# Ultra-high-field imaging of the biliary tract at 7 Tesla: initial results of Gd-EOB-DTPA-enhanced MRCP

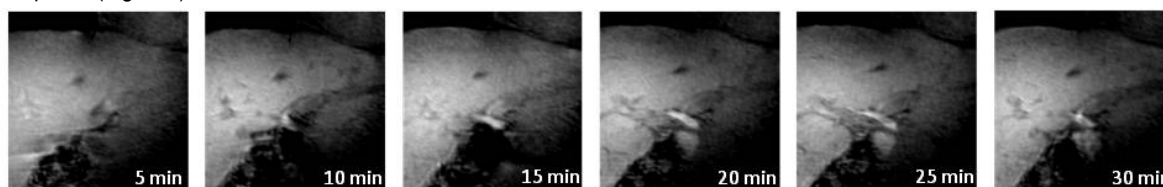
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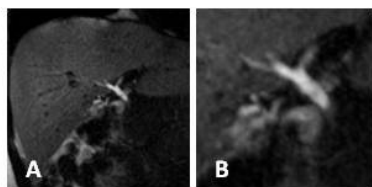
**Introduction:** Within the last years, Magnetic Resonance Cholangiopancreatography (MRCP) has gained an important role as a noninvasive imaging tool for the evaluation of the intra- and extrahepatic biliary tract. MRCP imaging is based on heavily T2-weighted (T2w) sequences, but does not allow any functional assessment. First studies of ultra-high-field body imaging have demonstrated the diagnostic potential of abdominal and liver MRI at 7 Tesla, as well as strong limitations for T2w imaging which currently hamper utilization of ultra-high-field MRCP imaging [1]. With the introduction of hepatocytic specific contrast media, trials at lower field strength have showed the diagnostic potential of these media for the evaluation of the biliary tract [2]. The aim of this study was to assess the feasibility and diagnostic potential of imaging of the biliary tract using biliary secreted Gadoteric acid at 7 Tesla in comparison to T2w MRCP at 3 Tesla.

**Methods:** 10 healthy volunteers were examined on a 7T whole-body MR system (Magnetom 7T, Siemens Healthcare Sector, Erlangen, Germany) in supine position. For image acquisition, a custom-built 8-channel RF transmit/receive body coil was used, consisting of two arrays with 4 elements each placed ventrally and dorsally on the upper half of the abdomen [3]. The following sequences were included: T1w 3D FLASH VIBE, 3D FLASH with inversion recovery (IR), and T2w TSE in coronal orientation. After obtaining non-enhanced images, the acquisition of a dynamic series started after 20, 70, and 120 seconds, with additional acquisitions performed at 5, 10, 15, 20, 25 and 30 minutes after injection of the contrast medium for T1w sequences. Gadoteric acid (Gd-EOB-DTPA, Primovist®, Bayer Healthcare) was administered with a clinical standard dosage of 0.025 mmol / kg bodyweight. Additionally, all volunteers underwent a non-enhanced T2-weighted MRCP on a 3T MR system (Skyra 3T, Siemens Healthcare Sector, Erlangen, Germany) with the following clinical sequence protocol: T2w HASTE and triggered T2w MRCP in coronal orientation. Qualitative image evaluation was performed with regard to the delineation of the biliary tract (D. hepaticus dexter and sinister, D.hepaticus communis, D. choledochus) and presence of artifacts using a 5-point scale (5=excellent delineation to 1=non-diagnostic). For quantitative image evaluation, the signal of the ductal lumen and surrounding liver tissue were obtained to calculate contrast ratio ( $CR = [S_{\text{biliary}} - S_{\text{liver}}] / [S_{\text{biliary}} + S_{\text{liver}}]$ ) for each time point.

**Results:** B1 field inhomogeneities could be successfully shifted out of the main portions of the biliary tract utilizing relative B1 maps and individualized transmit phase settings [4]. Dynamic contrast-based MRCP at 7T showed a homogeneous depiction of the intra- and extrahepatic biliary tract. During dynamic image acquisition, maximum signal intensity was reached on average about 15 minutes after the administration of Gadoteric acid (Fig. 1). While T1w 3D VIBE imaging provided a moderate delineation of the biliary tract (mean score 3.24), it also yielded near isointense liver tissue and vasculature (Fig. 2). In contrast, 3D FLASH imaging with inversion recovery enabled the high-quality assessment of the biliary duct due to a strong saturation of hepatic tissue and vessels (Fig. 3 & 4), reflected in contrast ratio values (for common hepatic duct (CHD) at 15 min p.i.  $CR_{\text{VIBE}}$  0.08,  $CR_{\text{3DFLASH IR}}$  0.26). An inversion time (TI) of 150 ms was found to be optimal. Qualitative image analysis revealed equivalent depiction of the central parts of the ducts in 3D FLASH IR in comparison to T2w MRCP at 3T (mean score at 15 min p.i.  $DHC_{7T}$  4.46,  $DHC_{3T}$  4.51), as well as the superiority of 3T in imaging of the peripheral duct segments (mean score image quality at 15 min p.i.  $D.\text{hep.dex.}_{7T}$  3.31,  $D.\text{hep.sin.}_{7T}$  3.17,  $D.\text{hep.dex.}_{3T}$  4.32,  $D.\text{hep.sin.}_{3T}$  4.27) (Fig.4 A, B). T2w TSE at 7T showed only poor to moderate image quality (mean score 2.65), but the main structures of the biliary tract could be depicted (Fig. 4 C).



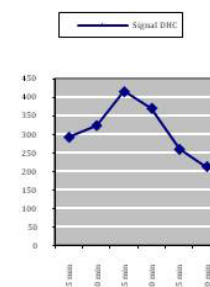
**Fig. 2:** T1w 3D VIBE in coronal orientation acquired 5-30 minutes after administration of Gadoteric acid with maximum signal intensity in the central biliary ducts at 15 min. p.i. The gallbladder was increasingly contrasted in later series. Liver tissue and vasculature showed relatively high signal throughout the dynamic series.



**Fig. 3:** 3D FLASH IR enabled good saturation of liver tissue and liver vasculature with homogeneous, hyperintense depiction of the central biliary tract (A), showing a trifurcation of the Ductus hepaticus communis (B).



**Fig. 4:** Due to homogenous contrast enhancement, 7T imaging shows good delineation of the Ductus choledochus in 3D FLASH IR imaging (A). Figure B shows corresponding T2w MRCP MIP at 3 Tesla with better depiction of peripheral ducts (B). T2w TSE at 7T reveals the biliary tract in poor to moderate image quality (C) compared to (A) and (B).



**Fig. 1:** Maximum signal intensity was reached 15 min p.i.

**Discussion:** Our results demonstrate the feasibility of contrast-enhanced imaging of the biliary tract at 7 Tesla. Contrast-enhanced 7T duct imaging showed equivalent imaging results of the central duct segment in comparison to 3T MRCP imaging, but poorer depiction of peripheral duct segments. In particular 3D FLASH MRI with inversion recovery enabled high-quality assessment of the biliary tract. Further improvement of the parameters of contrast-enhanced MRCP and examination of patients with biliary disease should be the focus of future trials.

**References:** [1] Umutlu et al. Eur J Radiol. 2011 Aug 20. [Epub ahead of print] [2] Holzapfel et al. Radiologe. 2007. 47:536–544. [3] Orzada et al. ISMRM 2009 p.2999. [4] Van de Mortelee et al. ISMRM 2009 p.367.