Clinical Experience with Gadoxetate-Enhanced T1 Weighted Hepatobiliary Imaging in Primary Sclerosing Cholangitis

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Introduction: Primary sclerosing cholangitis (PSC) is a chronic inflammatory condition of the extra- and intra-hepatic biliary ducts that results in a classic beaded appearance of the biliary tree due to alternating strictures and dilatations. The exact etiology is unknown and the disease can progress to cirrhosis and liver failure, with liver transplantation often the only definitive treatment. Heavily T_2-weighted magnetic resonance cholangiopancreatography (T_2-MRCP) is an effective, noninvasive imaging method for diagnosis and evaluation of PSC [1]. With the recent FDA approval of gadoxetate (Gd-EOB-DTPA, Eovist, Bayer Pharmaceuticals, Wayne, NJ), a hepatobiliary contrast agent with 50% biliary excretion, and development of optimized high-resolution T_1 weighted sequences for imaging gadoxetate-enhanced livers [2], there are new opportunities to evaluate the biliary tree with T_1 weighted 3D MR cholangiography (T_1-MRC) in PSC. The purpose of this work is to evaluate the added diagnostic clinical utility of using high spatial resolution, gadoxetate-enhanced 3D T_1-MRC compared to 3D T_2-MRCP, in patients with PSC.

Methods: After obtaining IRB approval, a retrospective study was performed in 29 patients with 34 MRI exams of the liver in patients imaged between September 2008 and September 2009. All patients with a known or suspected diagnosis of PSC and were imaged with both T_2-MRCP and high resolution gadoxetate-enhanced T_1-MRC.

All imaging was performed at 1.5T (TwinSpeed HDx, GE Healthcare, Waukesha, WI) using an 8-channel cardiac or torso phased array coil and investigational 3D T_2-MRCP and 3D T_1-MRC acquisitions. Free-breathing respiratory triggered 3D T_2-MRCP images were acquired prior to the administration of contrast, and specific imaging parameters included: coronal oblique slab, FOV=32 cm, TE_{eff}=762 ms, 288 x 288 matrix with 60 slices, slice thickness=1.8 mm, and BW=±31.25 kHz. Fat and vessel suppression were enhanced through use of a T2Prep preparation pulse [3]. A 2D parallel imaging method (ARC) [4] was used to accelerate the acquisition time with an acceleration factor of 1.81. Total scan time was 3-5 minutes.

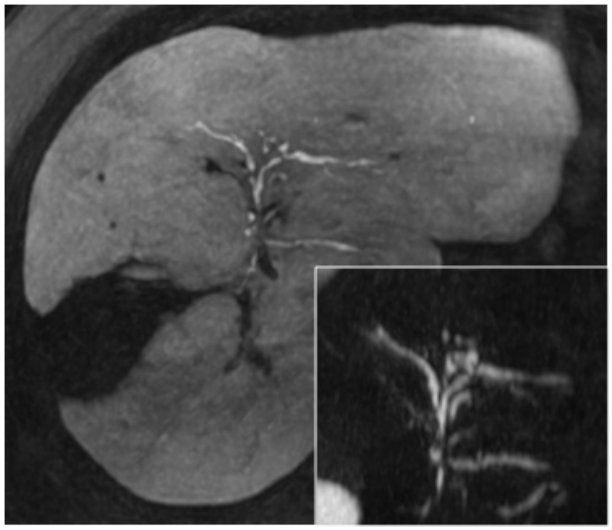

Figure 1: *Thin-slab MIP axial images from a 3D T_1-MRC and 3D T_2-MRCP (inset) in a patient with PSC demonstrates excellent anatomic concordance with diseased bile ducts.*

High resolution navigator 3D T_1-MRC imaging was performed 20 minutes after the injection of 0.05mmol/kg gadoxetate during the hepatobiliary phase using a recently described optimized high resolution, T_1 weighted, navigator based, 3D spoiled gradient echo (SPGR) with intermittent spectrally selective partial inversion recovery fat suppression [2]. Specific imaging parameters include: axial slab, FOV=35cm, TR/TE=5.8/2.7ms, 288 x 256 matrix with 108 slices, slice thickness=1.8mm, and BW=±41.67 kHz. A flip angle of 40^o was used to maximize contrast between the bile ducts and the liver as previously shown [2]. Although this sequence is compatible with ARC, no parallel imaging acceleration was used to maximize SNR performance. Total scan time was 5-6 minutes.

A total of 29 patients with 34 exams (5 patients have follow-up exams) were included. Age range was 16-81 (average=45), and 19 males, 10 females. Two experienced fellowship-trained abdominal imagers independently reviewed the 3D T_2-MRCP and 20 minute delayed gadoxetate-enhanced 3D T_1-MRC images for each study. T_1-MRC and T_2-MRCP acquisitions were evaluated concurrently on PACS (McKesson, San Francisco, CA) using a subjective 3-point scale for duct visibility (0-nonvisualized, 1-poor visualization, 2-acceptable visualization, 3-excellent visualization), a 3-point scale of overall exam quality (0-nondiagnostic, 1-poor, 2-average, 3-excellent), and a 3-point diagnostic "helpfulness" scale to assess the added information from the gadoxetate-enhanced T_1 weighted images (0-not helpful, 1-confirmatory or mildly helpful, 2-moderately helpful, 3-very helpful). Overall preference for T_2-MRCP vs T_1-MRC was also evaluated.

Results: An example of T_2-MRCP and the corresponding T_1-MRC images are shown in figure 1, in a patient with severe PSC demonstrating excellent subjective anatomical concordance between the two methods, with the typical features seen with PSC seen in both imaging methods.

Reviewers found gadoxetate-enhanced T_1-MRC to be moderately or very helpful in 76% of the cases while in 24% of the cases helpfulness was deemed minimal to non-existent. The T_2-MRCP was preferred 61% of the time while T_1-MRC was preferred 39% of the time.

Preliminary results indicate that gadoxetate-enhanced T_1-MRC was highly complementary to T_2 weighted MRCP imaging, but would not replace conventional T_2-MRCP. Not only did T_1-MRC often provide functional information for obstructed bile ducts but it also provided a "second" look at bile duct anatomy, providing additional visualization of pathology not seen well with T_2-MRCP. Central stenoses often appear more severe with T_2-MRCP relative to T_1-MRC, suggesting that T_2-MRCP may exaggerate the appearance of strictures. In 7 cases the gadoxetate-enhanced images demonstrated no biliary enhancement peripheral to the stenotic segment. While this suggests a very severe, functionally relevant stenosis, it also does not provide visualization of these ducts. Thus the T_1-MRC and T_2-MRCP images are highly complementary.

Discussion: This clinical study demonstrates that high-resolution 3D T_1-weighted gadoxetate-enhanced hepatobiliary phase MR cholangiography is an excellent adjunct to 3D T_2 weighted MRCP. Not only do gadoxetate-enhanced images provide anatomical visualization of biliary tree and associated disease but also offer useful functional/physiologic information that was tremendously helpful in many cases. The combination of T1-MRC and T2-MRCP is used routinely in our clinical practice for the evaluation of PSC. On-going work will compare the utility of T_1-MRC and T_2-MRCP with ERCP (available in 9 of the patients in this study).

References: **1.** Ernst O, et al. AJR 1998;171:1027-1030 **2.** Nagle et al ISMRM 2009 pg 2076, **3.** Busse et al ISMRM 2006 pg 392, **4.** Brau et al MRM 2008 59:382-95

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