Effect of Gd-EOB-DTPA on T1-weighted dual echo In-phase and opposed-phase MR images for focal liver lesion detection

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Target Audience: Radiologist and research scientist interested in liver imaging

Background: The T1-weighted (T1W), dual gradient-echo in-phase (IP)/opposed-phase (OP) imaging sequence has become a routine part of every hepatic MR imaging protocol [1]. It is primarily used to identify common pathological conditions and detect pathological entities. The diagnosis of a variety of other abdominal lesions, including hepatocellular carcinoma (HCC), angiomyolipomas and focal fatty infiltration of the liver may be assisted by IP/OP imaging. This sequence is conventionally performed before intravenous contrast injection. Gd-EOB-DTPA (Primovist, Bayer-Schering, Berlin, Germany) is a FDA approved liver-specific gadolinium compound. It can be eliminated roughly in equal portion via the biliary and renal systems. When Gd-EOB-DTPA is used, hepatic-phase imaging can be acquired ~20 minutes after the injection of the contrast material [2]. To streamline the overall protocol and decrease the total imaging time, it has been shown that acquiring T2-weighted (T2W) and diffusion–weighted imaging (DWI) data during this time wait is acceptable and helpful [3]. To further shorten the scan time and increase clinical throughput, it is also desirable to move the T1-weighted dual echo sequence from pre-contrast to post-contrast. However, there has been no investigation about the influence of intravenous administration of Gd-EOB-DTPA on T1-weighted in-phase and opposed-phase gradient echo sequence. The aim of this study is to compare dual-echo data pre and post contrast and evaluate its effect in detecting focal liver lesions.

Methods: The study was approved by our institutional review board. Informed consent was obtained from all the recruited patients. 58 patients (35 male, 23 female, age 37-79, average age 56.1) with normal liver function were recruited. All of them underwent abdominal liver imaging with intravenous Gd-EOB-DTPA administration. In these patients, 70 pathologically proved focal liver lesions were evaluated.

All MR exams were performed on a GE Signa Excite TwinSpeed 1.5T scanner (GE Medical system, Milwaukee, WI, USA) with a 4-channel phased-array coil. Dual-echo in-phase in-phase/opposed-phase imaging were acquired both before and 15 minutes after the administration of Gd-EOB-DTPA (0.025 mmol/kg of body weight). The MR protocols include: 1) Axial fast imaging employing steady-state acquisition; 2) Axial T1W dual-echo GRE, TR=203ms, TE=2.2ms (OP)/4.4ms(IP), flip angle 80°, section thickness=6mm, matrix size=256× 256, FOV=30 cm × 38 cm; 3) T1W fast spoiled phase gradient-recalled (FSPGR) sequence with or without fat-saturation, 4) 3D liver acquisition with volume excitation dynamic contrast enhance series consisted of three volume data sets acquired at pre-contrast, arterial-phase (15~20 secs), portal-vein-phase (50~60 secs), and equilibrium-phases (3 mins); 5) post-contrast T2W fast spin echo sequence; 6) post-contrast DWI; 7) 15 mins after contrast, the T1W dual-echo GRE were repeated; 8) 20 min post-contrast LAVA hepatocyte phase, the same parameter with 4). Either respiratory triggering or breath-hold was used to overcome motion artifacts.

All MR images were reviewed by two radiologists in consensus. They are blinded to the clinical laboratory and histological findings. Three 1-cm^2 circular regions of interest (ROIs) were drawn on both the lesions and the liver parenchyma respectively on various slices. Mean pixel signal intensities (SI) from IP and OP images were obtained from the selected ROIS. Necrosis and cystic areas were avoided. Care was also taken to keep away from areas with vessels, motion and artifacts too. All ROIs were placed at anatomically matched locations on paired images using a co-registration tool available on the PACS workstation. **SIR** (nodule/liver) is the average nodule signal intensity divided by the average liver parenchyma signal intensity. Nodule fat detection was quantified as the percentage of relative SI loss of the liver on OP images, with the following formula:

$$\mathbf{SII=[(|SIRin-SIRopp|)/(2\times SIRin)]\times 100.}$$

A statistical comparison of mean values was performed with the Student's t-test for paired samples. Statistical significance was assumed at $p<0.05$ in all cases.

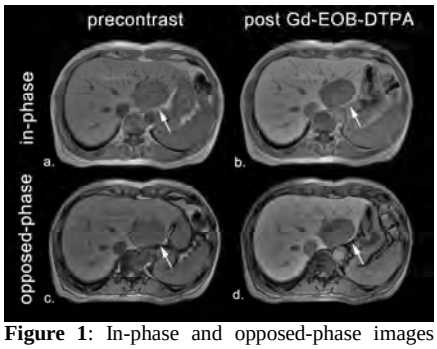

Figure 1: In-phase and opposed-phase images acquired before (a,c) and after (b,d) contrast injection in a patient with histopathologically proven HCC in the right liver lobe.

value	pre-contrast	post-contrast	p-value
SIR_{in}	0.89±0.13	0.84±0.15	0.005*
SIR_{opp}	0.83±0.23	0.79±0.19	0.032*
SII	2.75±11.13	3.04±6.62	0.768

Table 1: SIR and SII values for pre and post contrast

Results: Average SIRin and SIRopp of nodules and liver, and SII values measured before and after administration of Gd-EOB-DTPA are shown in Table 1. SIR values for IP and OP after contrast were lower compared to non-enhanced IP and OP pre-contrast. Both differences reached a statistically significant level. SII values after contrast were similar compared to pre-contrast values. There is no statistically significant difference. A representative case obtained from a patient with histopathologically proven HCC in the right liver lobe is shown in Fig.1.

Discussion and conclusion: The current study demonstrates that signal intensity ratio of the lesion and liver (SIR values) on both in-phase ($p<0.05$) and opposed-phase ($p<0.05$) before and after administration of Gd-EOB-DTPA is statistically significantly different in patients with normal liver function. This is probably due to the distinct uptake patterns of hepatocyte-selective agents in normal liver parenchyma and in focal liver lesions (e.g. adenoma, HCC) of hepatocellular origin [4]. In the hepatocyte phase using Gd-EOB-DTPA, signal intensity of surrounding liver parenchyma is different from the lesions with abnormal hepatocytes, which in most cases improves the tumor-to-liver contrast [2, 4]. The enhanced contrast can be helpful in detecting and localizing the lesion more easily and accurately.

The nodule fat detection index (SII values) is not statistically significantly different post-contrast from pre-contrast ($P>0.05$). This result shows that dual-echo sequence performed after the injection of Gd-EOB-DTPA will not affect the detection of nodule fat content.

For more accurate intracellular lipid detection after the contrast, a T1-independent IDEAL based method with T2* correction [5] is probably more suitable. The comparison of this technique pre and post-contrast will be included in our future investigation.

In summary, post-contrast in-phase/opposed-phase imaging can replace pre-contrast in-phase/opposed-phase imaging using Gd-EOB-DTPA agent. For focal liver lesion, the post-contrast dual-echo sequence even provides better nodule-to-liver contrast. Moving this single breath-hold sequence into the time frame between the portal vein phase and the hepatic phase during the Gd-EOB-DTPA dynamic contrast study will shorten total scan time and improve patient throughput.

References: [1] Merkle EM, et al, RadioGraphics 2006; 26:1409 –1418. [2] Bernard VE, et al, J. of Hepatology 2012;56: 421–429. [3] Saito K, et al, JMRI 2010; 32:229-234. [4] Campos JT, Insights Imaging. 2012 Oct;3(5):451-74. [5] Hines CD, J Magn Reson Imaging. 2011 Apr;33(4):873-81.