Navigator Flip Angle Optimization for Navigator-Gated T1-Weighted Gadoxetic Acid-Enhanced Hepatobiliary Liver Imaging

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Introduction: The detection of liver lesions can be significantly improved using hepatobiliary contrast agents such as gadoxetic acid (Eovist®, Bayer-Schering AG, Germany), due to increased contrast between focal liver lesions and normal liver parenchyma **(1)**. In addition, image quality of the hepatobiliary phase images influences the detection rate of focal liver lesions. One promising technique for achieving motion free high-resolution images is the use of a navigator-gated 3D gradient echo with intermittent fat saturation. Previous work focused on optimizing the imaging flip angle has shown improved CNR using higher flip angle to improve T1 related contrast **(2)**. Using this approach, improved sensitivity of lesion detection can be achieved **(3)**. Additional optimization of the navigator flip angle can be used to improve contrast between the lung and liver signal is optimal for robust navigator edge detection algorithms. However, it is well know that the acquisition of navigator profiles using excitations with very high flip angles may saturate the signal within the liver tissue and lead to lesion-mimicking artifacts. Therefore, the purpose of this study was to characterize and optimize the navigator flip angle and the influence of the imaging flip angle, in order to maximize liver/lung contrast while avoiding image artifacts for gadoxetic acid-enhanced liver MRI.

Methods: **Methods**: Seven healthy volunteers, aged of 40.1 ± 11.4 years, consistent of 4 men and 3 women underwent a contrast enhanced liver MRI using a 3T MR system (Discovery MR750, GE Healthcare, Waukesha, WI, USA) and a 32 channel body phased-array coil. Investigational navigator-gated T1-weighted 3D GRE sequences (LAVA) were performed. A rapid protocol was designed to acquire multiple acquisitions in a short period of time using the following image parameters: TR/TE=3.1/1.5 ms (TRnavigator = 200ms), FOV=40 x 28cm, matrix = 256 x 160, BW=±83.3kHz, thickness=15mm). Randomized combinations of imaging (α) and navigator (β) flip angles **(table 1)** were performed prior to contrast, and in the hepatobiliary phase acquired 20-60 minutes after intravenous injection of gadoxetic acid (0.05mmol/kg, 0.1ml/kg/BW, flow rate 2 ml/sec. followed by saline flush (40ml, flow rate 2ml/sec). After data acquisition, region-of interest (ROI) based measurement of the signal intensity (SI) of liver and lung was performed for each acquisition using the retrospective saved raw signal from the navigator profiles. Relative contrast for the navigator profiles was calculated as follows: (CR_{relNav}) = [((SI(liver)-SI(lung))/SI(liver)]x100. Additionally, signal intensity of the artifact (location of the artifact was detected using respective series with β=90°) was measured for each β. The relative contrast of the artifacts was calculated relative to the signal acquired with no saturation artifact (β=10°): CR_{relA} = [((SI($\beta^{10°}$) – SI (β^{x})) / SI ($\beta^{10°}$)x100]. This normalization accounts for anatomical and coil signal differences.

MR – Scan Protocol

Time	Imaging flip angle (α) in °	excitation flip angle for the navigator profiles (β) in °
Pre-contrast	10	10,20,30,40,50,60,90
IV injection of gadoxetic acid (0.05mmol/kg, flow rate 2 ml/sec)		
20 minutes Post-contrast	0, 30	Randomized: 10,30,50,60,70,80,90

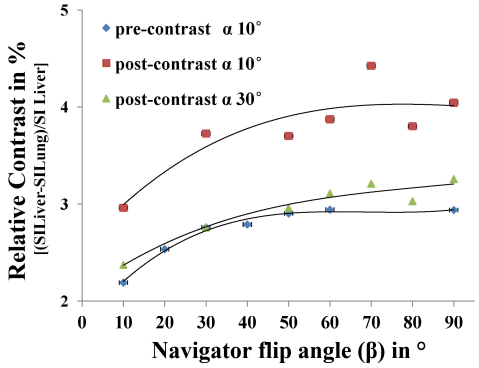

Figure 1: Relative contrast between liver and lung of the navigator profiles for the pre-contrast images (α=10°) and post-contrast images (α=10/30°) with different navigator flip angles (β). The maximum contrast in the navigator profile was observed pre-contrast α=10° using a β of 60°, post-contrast α=10° using a β of 70°, and post-contrast α=30° using a β of 90°.

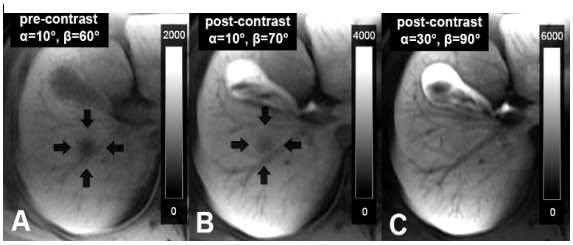

Figure 2: Smaller imaging flip angles lead to worse saturation artifacts even with gadolinium present (A,B). However, with a higher imaging flip angle (α=30°) no saturation artifacts were observed over the entire range of β=10-90°.

Results: **Figure 1** demonstrates that the relative contrast for the navigator profiles increases dramatically in the range of β=10-50°. Further, we observed a plateau for β between 50°-90°, independent of α. The optimal navigator flip angle depends on: (I) the imaging flip angle, and (II) whether gadolinium is present. The maximum relative navigator profile contrast for pre-contrast (α=10°) using β=60° was 2.9%), and post-contrast (α=10°) using β=70° was 4.4%, and post-contrast (α=30°) using β=90° was 3.3%. However, these settings for the navigator profile pre- and post-contrast α=10° result in an artifact visible in the images as shown in **figure 2**. These imaging artifacts were observed pre-contrast (α=10°) using a β>20°, post-contrast (α=10°) using a β larger than 50° **(figure 3)**. Post-contrast images with α=30° no visible image artifacts over the entire range of β 0-90° were observed, as shown in **figure 2C**.

Conclusions: The presence of saturation artifacts and the optimal navigator flip angle are highly dependent on the imaging flip angle and the presence of gadolinium contrast. The optimal navigator flip angle (β) for gadoxetic acid-enhanced hepatobiliary imaging using an imaging flip angle α=30° is 90°.

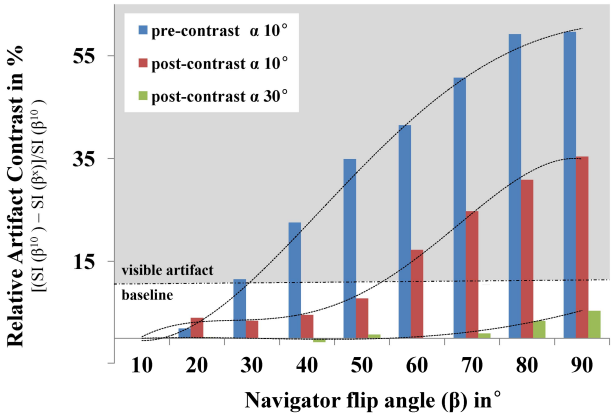

Figure 3: Saturation artifacts worsen with increasing navigator flip angle, but are highly dependent on the imaging flip angle and presence of gadolinium. Image artifacts were observed using pre-contrast imaging flip angle α=10°, starting with β>20°, and post-contrast (α=10°) starting with β>50°. No image artifacts were observed for the entire range of β using α=30°.

References:

(1) Vogl TJ et al. Radiology 1996, (2) Nagle SK et al. ISMRM 2009; (3) Bashir MR et al.J Magn Reson Imaging. 2011

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