Intra-individual crossover comparison of dose of gadoxetic acid for liver MRI: Parameter optimization and quantitative relaxometry in normal volunteers

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Target audience: Radiologists who are interested in liver imaging

Purpose: To conduct a quantitative intraindividual crossover comparison to evaluate the relative performance of 0.025mmol/kg and 0.05mmol/kg for gadoxetic acid-enhanced liver MRI.

Methods: Eleven healthy volunteers underwent liver MRI on two separate days with ≥28 days apart (mean of 57 days, range of 28−76 days) with 0.025 and 0.05mmol/kg gadoxetic acid. 3D gradient-echo T_1-weighted images (3D-GRE) were obtained before the injection, and 3, 10 and 20 minutes after injection of contrast agent. To measure signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) performance, multi-echo / multi-TR STEAM MRS was also obtained at these times points to quantify T1 and T2. During dynamic phase, highly time-resolved 3D-GRE was used to estimate relative CNR (CNR_{rel}) of the hepatic artery and portal vein relative to liver [1]. MR acquisitions parameters were as follows; ***3D-GRE*** with dual-echo chemical shift encoded water-fat separation, TR/TE1/TE2 = 5.5/1.15/2.3ms, slab volume = 40 (R/L) × 32 (A/P) × 24 (S/I) cm, matrix = 224 × 140 × 48, flip angle of 15º, and partial k_z (0.75) acquisition. Scan time = 23s, no parallel imaging or B_0 sensitivity correction to allow for absolute SNR measurements[2]; ***STEAM-MRS***, 21s breath-hold for obtaining varying TRs (150−1000ms) and TEs (10−110ms) [3], in order to enable independent measurement of T_1 and T_2 of water and fat (if present), voxel = 20×20×20mm^3 in the right lobe; ***Highly time-resolved 3D-GRE*** using interleaved variable density (IVD) undersampling[3], *k*-space corner-cutting, data-driven parallel imaging and a dual-echo chemical shift encoded water-fat separation, TR/TE1/TE2 = 3.9/1.2/2.3ms, slab volume = 38 (R/L) × 34 (A/P) × 26 (S/I) cm^3, matrix = 320 × 202 × 100, flip angle of 15º , and partial k_z (0.75) acquisition, 2×2 data-driven parallel imaging acceleration, scan time= 24s for 11 time frames (temporal resolution=~2s). The scan delay was fixed at 13s after the beginning of the gadoxetic acid injection. The results obtained from measurements made for the different doses were compared with paired t-tests.

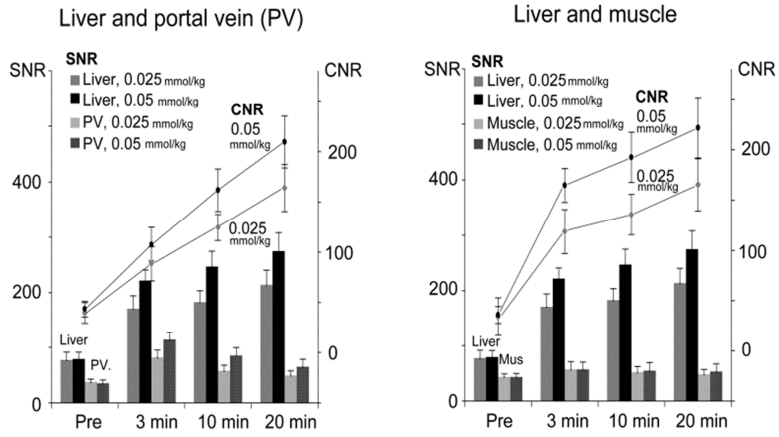
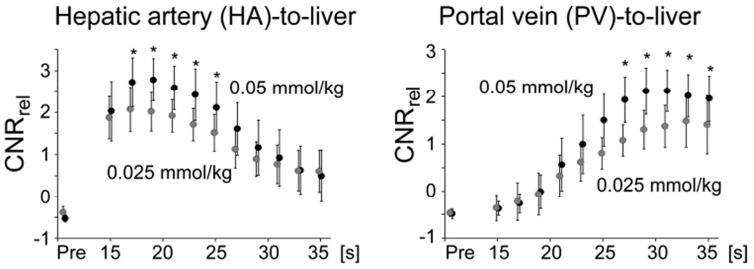


Fig 1*. Absolute SNR and CNR performance for delayed T1 weighted imaging for 0.025mmol/kg and 0.05mmol/kg of gadoxetic acid. Signal-to-noise ratios (SNR) of the liver were significantly higher using 0.05mmol/kg than 0.025mmol/kg at every time point (p<0.001). Both liver-to-portal vein and liver-to-muscle contrast-to-noise ratios (CNR) were significantly higher with 0.05mmol/kg than with 0.025mmol/kg at every time point (p<0.002).Note, higher CNR for 0.05mmol/kg at 10 minutes than for 0.025mmol/kg at 20 minutes.*



P values by paired t-test (0.05 vs. 0.025 mmol/kg)

	Pre	15	17	19	21	23	25	27	29	31	33	35
HA-to-liver	0.101	0.719	**0.035**	**0.019**	**0.031**	**0.009**	**0.035**	0.119	0.423	0.702	0.975	0.761
PV-to-liver	0.805	0.928	0.843	0.865	0.540	0.346	0.056	**0.013**	**0.008**	**0.007**	**0.025**	**0.025**

Fig2*. Time-intensity graph of the hepatic artery (left) and portal vein (right) showed significantly higher relative CNRs against the liver with a 0.05mmol/kg dose than with a 0.025mmol/kg at 17−26 s delay for the hepatic artery and 29−36 s delay for the portal vein.*

Results: During hepatobiliary phase, higher SNRs of the liver (p<0.001), and higher liver-to-PV and liver-to-muscle CNR (p<0.002) were observed using 0.05mmol/kg compared to 0.025mmol/kg. (**Fig.1**) T1 value of the liver was significantly shorter with 0.05mmol/kg than with 0.025mmol/kg at all time points. The mean T_1 value for 0.05mmol/kg at 10 minutes delay (248ms) was significantly shorter than that for 0.025mmol/kg at 20 minutes (284ms, p<0.001). During dynamic phase, peak CNR_{rel} for hepatic artery and portal vein were higher using 0.05mmol/kg (p=0.007−0.035). (**Fig.2**)

Discussion: In this work we quantified a significant improvement in T_1 shortening, and in SNR and CNR performance during both the dynamic and hepatobiliary phases by increasing the dose from 0.025mmol/kg to 0.05mmol/kg. Interestingly, greater T_1 shortening effect and higher liver-to-muscle CNR were also observed at 10 minutes using 0.05mmol/kg than at 20 minutes using 0.025mmol/kg.

Conclusion: A dose of 0.05mmol/kg gadoxetic acid leads to significantly higher SNR and CNR performance than 0.025mmol/kg. Quantitatively, a 10 minute post-injection delay may be feasible for hepatobiliary-phase imaging when using 0.05mmol/kg of gadoxetic acid.

References; 1. Salmani Rahimi M, et al. Magn Reson Med 2014 [E-pub]; Reeder SB, et al. Magn Reson Med 2005;54:748-754. 2. Hamilton G, et al. ISMRM2013. Salt Lake City, UT; p.1517. 3. Wang K, et al. Magn Reson Med 2011;66:428-436.

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