Comparison between Intravenous and Intraarterial Contrast Injection for Dynamic 3D MRI of Liver Tumors in the VX2 Rabbit Model

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Introduction:

While techniques involving dynamic MRI following intravenous (IV) injection of contrast agents are widely accepted for liver tumor imaging [1], these methods have limited capacity to detect and characterize small (<1 cm) lesions [2]. Catheter-directed injections of gadolinium (Gd) [3] might be one approach to improve MRI detection of these tumors, particularly in the setting of future MRI-guided oncologic interventions. Intraarterial (IA) injection offers the potential to target contrast agent delivery to specific lesions. In this study, we tested the hypothesis that catheter-based IA contrast injections improve tumor enhancement and conspicuity in a VX2 rabbit liver tumor model.

Methods:

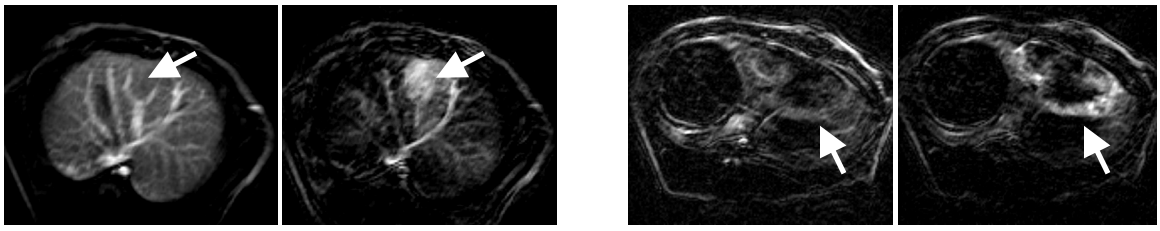
In this ACUC-approved study, we implanted VX2 carcinoma cells at multiple positions within the left and right liver lobes of 4 New Zealand white rabbits. Rabbits were followed for 2-4 weeks to allow tumor growth prior to imaging. Via femoral access under x-ray guidance, we placed a 2-F catheter in the hepatic artery for intraarterial injection of contrast agents. Rabbits were intubated for isofluorane anesthesia using a small animal ventilator (Harvard Apparatus, Holliston, MA). Rabbits were then moved to a 1.5T Magnetom Sonata clinical MR scanner (Siemens Medical Solutions, Erlangen, Germany) for imaging in the supine position using a flexible surface coil conforming to the shape of the abdomen.

We performed dynamic 3D inversion recovery (IR) GRE MRI following IA and IV Gd-DTPA (Berlex, Magnevist) contrast injections. Scans were performed after IA injection of 2 mL 20% Gd solution at 0.3 mL/s and after IV injection of 1mL 100% Gd solution (~0.1mmol/kg dosage) at 0.3 mL/s followed by a 5mL saline flush. 3D IR GRE imaging parameters: TR/TE/TI = 3.7/1.6/50 ms, 200×100 mm^2 FOV, 43 views/segment, 256×129 matrix, 490 Hz/pixel BW, 6/8 partial Fourier, 5 slices interpolated to 10 (5 mm thickness), 2.1 sec acquisition time for each 3D volume repeatedly sampled for 4 min following each injection. Tissue intensities were allowed to return to baseline values between injections.

After removal from the scanner bore, we euthanized each rabbit for subsequent necropsy. We harvested livers and stained sections using hematoxylin and eosin (H&E) to confirm tumor position. At each slice position containing tumor tissue, identical ROI were drawn in IA and IV image series to measure mean tumor signal (S_T) and mean liver signal (S_L) as well as relative noise (SD_{air}). For each image collected during the 4 min interval following injection, we calculated the relative tumor signal-to-noise ratio, $SNR_T = S_T/SD_{air}$, and the tumor-to-liver contrast-to-noise ratio, $CNR_{TL} = (S_T-S_L)/SD_{air}$. Peak SNR_T and CNR_{TL} for each corresponding IA and IV image series were compared using a paired two-tailed *t*-test with $\alpha = 0.05$.

Results:

Seven liver tumors (1.1-3.0 cm diameter) were imaged in four VX2 rabbits allowing ROI measurements at multiple slice positions for each rabbit (N=23 positions). Peak SNR_T and CNR_{TL} following IA injections, 23.1±6.7 and 18.1±6.7 (mean±SD), were significantly greater than peak SNR_T and CNR_{TL} following IV injections, 18.9±11.4 and 6.1±3.5 ($p<0.05$). While both IA and IV techniques demonstrated relatively wide variations in both peak SNR_T and CNR_{TL} dependent upon tumor morphology, IA techniques produced >60% increase in peak CNR_{TL} at each measured position with significant increases in peak CNR_{TL} at each position, IA_{CNR}-IV_{CNR}, of 12.1±7.6 (mean±SD). Representative liver tumor enhancement images following IV and IA contrast injections are shown for two rabbits in Fig. 1.



IV **IA** **IV** **IA**

Figure 1. Representative IR-prepared GRE liver tumor enhancement images in two rabbits acquired after intravenous contrast injection (IV) and intraarterial contrast injection (IA), tumor position indicated by arrows. Notice the significantly increased contrast between tumor tissue and normal liver parenchyma in each IA image.

Conclusions:

Using less overall contrast agent, IA injections significantly improve tumor contrast enhancement and conspicuity over conventional IV injection techniques using dynamic 3D MRI. This strategy might be employed to enhance detection of small liver tumors or to conserve contrast agent in the setting of future MRI-guided transcatheter liver interventions.

[1] Edelman et al. AJR 1989 153:1213-1219 [2] Matsuo et al. AJR 2001 177:637-643
[3] Strother et al. Radiology 2000 215(2):516-519