Target:

WCIO 2011 conference -- Imaging category (500 word limit, 25 words counted for figure)

Title:

Multi-phasic Contrast-Enhanced MRI Quantitative Volumetric Hepatic Tumor Viability Assessment – Initial Results

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Objective:

Multi-phasic contrast enhanced MRI is used as the imaging gold standard to evaluate treatment success and to plan subsequent transcatheter arterial chemoembolization (TACE) sessions. Specifically, the EASL criteria is applied to the MRI and % quartiles are qualitatively assigned to the amount of signal intensity enhanced in the tumor with respect to healthy liver tissue. This method is applied to one axial slice (typically where the tumor shows the largest axial diameter) of the entire tumor volume. This work proposes initial results on two improvements on the standard EASL criteria: 1) quantitative measures are used to describe the tumor enhancement, and 2) the measures are performed for the entire tumor volume.

Methods:

Multi-phasic contrast-enhanced MRI scans was performed in a 69-y.o. female (Child-Pugh = 5/class A, no cirrhosis) with a hepatocellular carcinoma mass occupying liver segments IVa/IVb, V, and VIII. MR imaging was performed using a 1.5T MR unit (CV/I, GE Medical Systems, Milwaukee, WI, USA) and a phased array torso coil. Axial breath-hold contrast-enhanced (0.1 mmol/kg IV of gadolinium, Omniscan, General Electric, Princeton, NJ) T1-weighted 3D fat-suppressed spoiled gradient-echo images (TR/TE, 3.7/1.8msec; field of view, 40.0cm²; matrix size, 512x512, slice thickness, 3mm; receiver bandwidth, 64kHz; flip angle, 12°) captured the arterial and portal venous phases (20 and 70 seconds after contrast administration, respectively). Immediately before the multi-phasic contrast-
enhanced MRI, a non-contrast scan was performed using the same imaging parameters. On MR, the mass was 9.4x8.3cm with 0-25% enhancement. Portal veins were patent. Two sessions of transcatheter arterial chemoembolization was performed leading up to the MRI.

The quantitative volumetric measure of hepatic tumor viability was performed as follows:
1) In the pre- and 70-sec contrast enhanced MRI, reference backgrounds (10x10x10 pixels region of interest) of healthy liver tissue were selected. The reference background signal intensity of the 70-sec scan was subtracted by the pre-contrast scan, resulting in the amount of healthy liver tissue signal enhancement due to contrast injection.

2) From the 70-sec contrast enhanced MRI, a semi-automatic tumor segmentation employing non-Euclidean radial basis functions was used by an interventional radiologist to segment the 3D tumor volume. The 20-sec contrast enhanced MRI used the same segmentation mask.

3) A direct voxel-to-voxel intensity subtraction was done between the 3D segmented tumor volumes. Specifically, 70-sec MINUS 20-sec contrast enhanced MRI. The signal intensity change was then presented as a color map overlay on the 70-sec contrast enhanced MRI. The threshold of color change was set to the calculated reference background signal intensity found in #1 above. In addition, quantitative metrics were derived from the tumor segmentation and color map.
Results:

The tumor was 507.7 cm$^3$. The healthy tissue reference background signal enhancement due to the contrast injection was 322.8±47.1. The tumor volume that showed more signal intensity than the reference background was 97.2 cm$^3$, 19.1% of the entire tumor volume (agreeing with the EASL 0-25% quartile at one axial slice).

In the figure, signal intensity change color maps of the segmented tumor are overlayed on three representative axial slices of the 70-sec contrast enhanced MRI. The color bar was set so that the green color represents areas where the signal intensity is <322 (reference background value) and are likely necrotic/treated tumor. The magenta line in the color bar is the reference background value (322). The yellow/red color bar are for areas where the signal intensity is >322 and are likely viable tumor.

Conclusions:

Quantitative volumetric analysis of tumor viability assessment from multi-phasic contrast enhanced MRI is possible. The benefits of this method over the standard EASL criteria are that 1) the image enhancement is measured quantitatively rather than in qualitative quartiles, and 2) the quantitation is performed over the entire tumor volume rather than one axial slice. This work could be used for further stratification of the EASL criteria image enhancement quartiles.