

# Segmentation of Normal Liver Volume using Dynamic Contrast Enhanced Gd-EOB-DTPA Time Intensity Curves

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**Introduction:** Automated liver segmentation is of clinical utility in monitoring viable liver regeneration after surgical resection or embolization. Measurement of the volume fraction of normal vs. tumor infiltrated liver is of importance in oncologic prognosis. Liver size is used in the response assessment criteria in the treatment of lymphoma. Recent developments in MR acquisition techniques have enabled the study of whole organ perfusion kinetics with high temporal and spatial resolution. Our study segments the liver by correlating voxel wise time intensity curves (TIC) with a reference Dynamic Contrast Enhanced curve from each slice.

**Methods:** Fourteen DCE-MRI data sets were acquired from Hepatitis-C subjects [54.3±8.8 yrs, 7M/7F] on a 1.5T General Electric Excite HDx MRI scanner with an 8-channel phased array coil. One subject was excluded having an abnormal wedge shaped segment of uptake in the liver. A liver-specific gadolinium-based contrast agent, Gd-EOB-DTPA (Eovist), was injected at a standard dose of 0.025 mmol/kg at a rate of 1cc/s followed by a saline flush. A 3D spiral sequence was reconstructed to yield 2 seconds/frame for the first 90 seconds and sampled every 1 minute out to 20 minutes post-contrast for a total of between 35-55 frames. Acquisition parameters included: TR/TE = 5.6 ms/0.4 ms, 256x256x24 matrix, 40 cm FOV, 8 mm slice thickness. A rigid body 6 parameter spatial registration across time was performed using SPM5. A reference DCE time intensity curve (TIC) was placed in each slice avoiding vascular contamination (Figure 1A,B). A Pearson's  $R^2$  correlation coefficient was calculated for each voxel creating a parametric map (Figure 1C). Voxels having an  $R^2$  below a specified cutoff were then identified (Figure 1D). Manual tracing of liver volumes was performed independently by two observers and the average liver volume compared with the DCE segmented results.

**Results:** Figure 2 compares the semi-automated DCE segmentation technique using a cutoff of ( $R^2 < 0.65$ ) and that of manual tracing ( $R^2 = 0.82$ ,  $p = 2E-05$ ). The cutoff value was optimized to exclude non-hepatic tissue while avoiding vascular contamination.

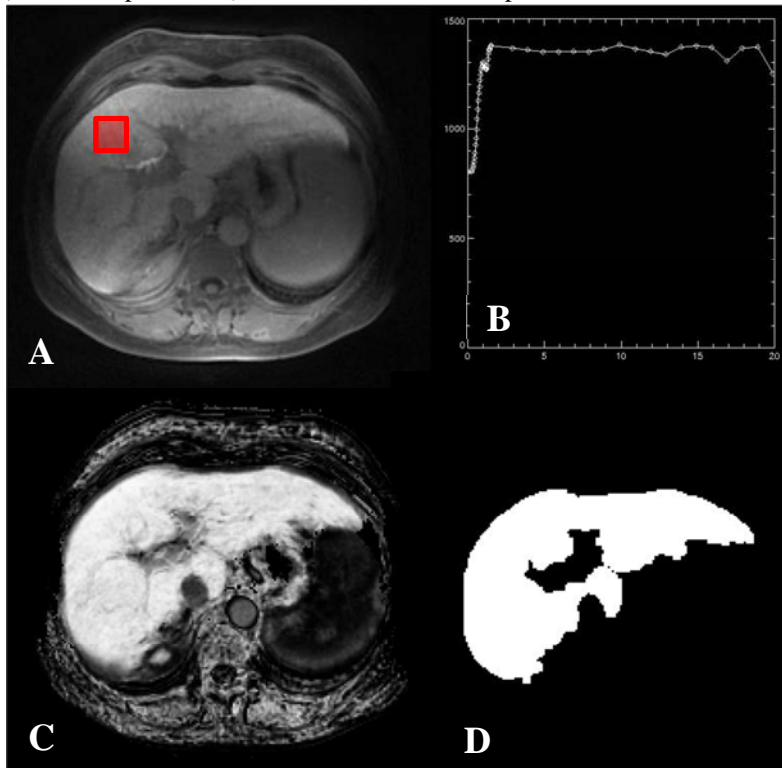


Figure 1

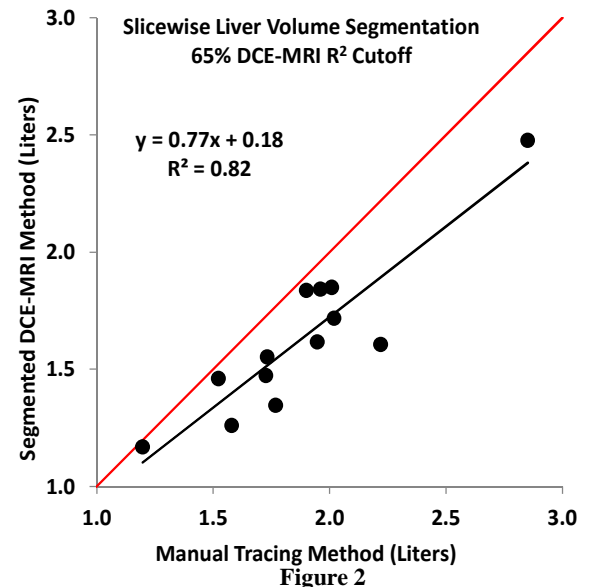


Figure 2

Figure 1: A) Displays the fixed reference TIC region for this slice. B) The reference TIC illustrates constant uptake of EOB in the hepatocytes to 20 min. C) The Pearson's  $R^2$  map shows correlations (0-1) for each voxel with the reference TIC. D) The final liver segmentation is shown after erosion and dilation.

Figure 2: Correlation of the semi-automated DCE-MRI liver segmentation is shown versus the manual tracing method.

**Discussion:** One study incorporated k-means clustering for segmentation of renal Gd-DTPA DCE-MRI data using a single 3D slice and 3 time points in the time series covering the 15-20 second wash-in phase.[1] However, with EOB, correlation of each voxel with all points in the TIC was essential for accurate liver segmentation. This DCE-MRI segmentation technique produced accurate liver volumetrics while excluding voxels with vascular contamination. The systematic reduction in volume from the manual tracing method is primarily due to this removal of vasculature. Future applications may have utility in segmenting other organs and tracking patient specific changes in organ volume during therapy.

**References:** 1) Zollner FG, Sance R, Rogelj P. et.al. Comp Med Imag Graph 2009;33:171-181.