

Voxel-based analysis of dynamic 3D perfusion images: preliminary results in chronic liver disease

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Introduction

Liver cirrhosis is characterized by progressive fibrosis leading to disruption of the normal anatomy and physiology of the liver. Perfusion-weighted imaging (PWI) has the potential to detect and characterize the global and regional perfusional changes from these alterations (1-3). However, data analysis is limited by complicated post-processing time and misregistration artifacts caused by breathing. Our purpose was to develop an automated voxel-based analysis technique to process 3D PWI liver perfusion data in patients with cirrhosis and with normal liver.

Methods

3D PWI of the liver was performed in 5 cirrhotic patients (4 women, mean age 54 y) and 5 patients with normal liver function (used as normal controls) (2 women, mean age 51 y). Dynamic coronal 3D PWI images of the liver were obtained at 1.5T using an interpolated 3D GE sequence (TR/TE/FA 2.67/1.16/12°, 153x192, 40 cm FOV, slice thickness 4 mm, parallel imaging factor (GRAPPA) 3). Following the injection of 10 mL of Gd-DTPA at 5 mL/sec (using an automatic injector), followed by 20 mL saline flush, 20 volumes were acquired continuously every 5.7 sec. for a total of 120 sec. Coronal-plane imaging minimized flow-related enhancement of the aorta. Post-processing was performed using an automated method (vector Vision) that enabled misregistration correction using liver edges identified by one observer. For each voxel, we compared the time from initial raise to peak (TTP) of contrast in liver parenchyma, and we compared between cirrhotic and normal livers. Because of the small dose of contrast used, a linear relationship between signal intensity and gadolinium concentration was assumed. 3D color maps overlays were then generated for visual inspection of TTP values. To assess the utility of the software in providing a global, quantitative measure of cirrhotic liver, large circular ROIs (200 voxels in size) were placed in the right hepatic lobe excluding large vessels. These regions were used to measure the distribution (mean and SD) of TTP within the liver. Values were compared between cirrhotic and non-cirrhotic patients.

Results

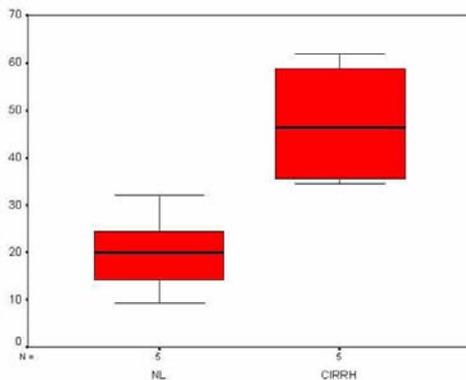
The automated program generates voxel-based TTP maps using 0-80 sec scale. Representative colors maps (Fig.) are shown in a cirrhotic and normal liver. TTP in cirrhotic livers was significantly longer than in normal livers: 47.7 ± 19.5 sec. vs. 20.0 ± 8.6 sec., respectively ($p < 0.005$, Mann-Whitney test). The heterogeneity of TTP as measured by its SD was larger in cirrhotic livers ($p < 0.005$). Regional variations in TTP could be easily assessed using the color maps and visual comparison was possible in the same liver or between patients.

Discussion

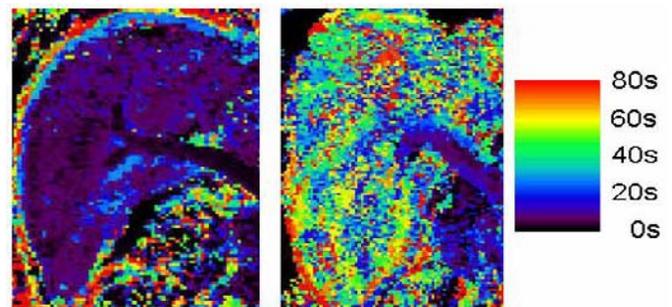
Our early experience shows a potential usefulness of a quick automated method for post-processing of liver perfusion data, with correction of misregistration. While the parameter used in our first study was simple (TTP), maps based on other parameters could easily be implemented. For example, arterial and portal venous perfusion measurements based on a dual input-single output compartmental model (2,3) could be used. Our preliminary data suggest that TTP is a sensitive parameter in differentiating between cirrhotic and non cirrhotic liver.

References

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2. Annet L, et al. Radiology 2003; 229:409-14.
3. Materne R, et al. Magn Reson Med 2002; 47: 135-42.



Distribution of liver TTP values between normal liver (left) and cirrhotic liver (right).



Coronal perfusion map displaying liver TTP in a normal liver (left) and cirrhotic liver (right). Cirrhotic liver shows higher TTP.