Comparison of single ROI Vs whole liver determination of liver steatosis

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Purpose: Hepatic steatosis is the accumulation of more than 5% fat in the liver cells [1]. This can cause permanent liver damage due to scarring and hardening of the liver [2]. However, early diagnosis and treatment of steatosis can prevent the inflammation of the liver [3]. Current methods for determination of liver steatosis, generally only assess a small region of the liver. This can be via the current clinical gold standard invasive liver biopsy, or non-invasive methods such as magnetic resonance spectroscopy or imaging methods where a defined region-of-interest is selected [4]. This study compares whole liver estimation of liver steatosis with defined region of interest methods. Validation of non-invasive techniques has enormous benefits for patient management and research [3].

Methods: Patients that require a liver biopsy for clinical management at a teaching hospital were invited to enroll in this study. Enrolled patients underwent a single MR imaging session, prior to the biopsy, on a Siemens Avanto 1.5 T MRI system (Erlangen, Germany), located at the Princess Alexandra Hospital, Brisbane, Queensland, Australia, using the following standard protocols: 1. Single voxel PRESS MRS, two voxels were positioned within the liver, one anterior and one posterior in the right lobe, avoiding obvious vessels or pathology. 2. Dixon, in-phase/out- phase images were acquired axially through the whole liver with multiple breath-holds. 3. HASTE, T2 weighted images were acquired with and without fat suppression. Biopsy samples were examined by a single experienced pathologist who reported % hepatocytes with visible fat and iron content. A total of 97 patients have been enrolled in the study. For this report, only patients with clinically significant liver steatosis were selected, >5% hepatocytes with visible fat. This resulted in twenty-five patients (8 female, 17 male, mean ages: 48±11.37 years).

Analysis methods: The liver was manually segmented using the software program, Medical Image Processing, Analysis, and Visualization (MIPAV) (http://mipav.cit.nih.gov/). Major vessels and pathology were manually segmented and removed from the liver ROI. To limit edge effects, a previously optimized erosion of 4 mm for the IP/OP images and 2mm for the FS/no-FS images was performed on the liver ROI, and the first and last image to include visible liver was also excluded. Fat images were determined from IP/OP images using the following formula $[((S_{IP} - S_{OP})/(2xS_{IP}))x100]$ and for the FS/no-FS images using $[(S_{no\text{-}FS} - S_{FS})/ S_{no\text{-}FS})x100]$ in MIPAV. Finally, the standard deviation and mean was calculated for the whole liver by combining all data for each imaging technique. Single ROI determination of the liver steatosis from the imaging sequences was performed by manually placing a circular ROI, approximately 2cm in diameter, in the posterior region of a central slice of the liver. The liver steatosis was calculated using the equations above. The liver spectroscopy results were calculated as a ration of the peak integrals as follows (CH2+CH3)/ (CH2+CH3+H2O). The Z-score was determined for each data point to be used in the correlations. Correlations were investigated between the following: whole liver IP/OP and ±fat sat, single ROI liver IP/OP and ±fat sat, MRS, biopsy results using the percent of hepatocytes with visible fat.

Results

Table 1: The correlation coefficient and p-value between the following: whole liver IP/OP and ±fat sat, single ROI liver IP/OP and ±fat sat, MRS, biopsy results using the percent of hepatocytes with visible fat:

Techniques	Whole liver		Single ROI	
	R	P	R	P
IP/OP Vs. biopsy	0.81	$5.44x10^{-7}$	0.85	$4.65x10^{-8}$
IP/OP Vs. MRS	0.68	$1.44x10^{-4}$	0.80	$1.5x10^{-6}$
±fat sat Vs. biopsy	0.73	$2.53x10^{-5}$	0.86	$3.41x10^{-8}$
±fat sat Vs. MRS	0.71	$5.4x10^{-5}$	0.86	$2.2x10^{-8}$
IP/OP Vs. ±fat sat	0.89	$1.49x10^{-9}$	0.86	$2.11x10^{-8}$

The correlation coefficient and p-value are presented in Table 1. All methods tested for the determination of liver fat were highly correlated. There was not obvious improvement in the correlation using the whole liver determination of liver fat compared to single ROI determination for the imaging methods tested.

Conclusion

These results suggest a single ROI positioned in a central slice for the liver and avoiding obvious vessels or pathology does not increase the error in the estimation of liver steatosis using imaging methods. Estimation of the liver steatosis by selection of a single ROI can be easily performed on the MRI scanner immediately after the scans are completed and while the next scan is being acquired. Whole liver determination of the liver steatosis by manual segmentation is very time consuming and could not be performed during a normal scan session. IP/OP scans or HASTE images are often included in a normal liver imaging protocol, therefore would not increase the scan time of the patient. MRS adds several minutes to the scan time and required post processing of the spectrum. Single ROI determination of liver steatosis has been shown to be reliable and able to be incorporated into a normal scan session. This will enable comparison between the methods for estimation of liver fat by non-invasive imaging techniques.

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