Searching for Non-Alcoholic Fatty Liver Disease (NAFLD) Biomarkers in Magnetic Resonance Imaging

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Introduction: Non-alcoholic fatty liver disease (NAFLD) is defined as an accumulation of lipids within the liver cells and, if untreated, can lead to cirrhosis and liver failure. In western countries, NAFLD prevalence is thought to be 20-30% and this figure is increasing [1]. The current 'gold-standard' for diagnosing NAFLD is liver biopsy, which only analyses 0.002% of the total liver volume. Furthermore, the test has a 0.6% morbidity rate (major bleeding events) and a mortality rate of 0.01% (within 7 days) [2], representing a small but not insignificant risk. This preliminary study aimed to assess the feasibility of discovering NAFLD biomarkers in MRI images. In future, this could enable patients to avoid risks presented by invasive surgical diagnostic procedures and expedite treatment and allow monitoring of interventions.

Methods: The Investigation of Synbiotic Treatment in NAFLD (INSYTE) [3] is a randomised interventional clinical trial recruiting NAFLD patients to assess the effects of a synbiotic supplement on their condition, for which there is currently no treatment [4]. Single-slice T1 In-Phase (IP) images and T1 relaxation time maps (using the shortened Modified Look Locker Inversion – shMOLLI sequence) were acquired from 100 NAFLD patients scanned with a 1.5T MRI scanner (Siemens Avanto) as part of INSYTE. An in-house pipeline for segmenting and extracting data from liver regions has been developed in Python. This system has been employed to extract T1 data per-slice and per-functional segment (using a geometric method based on the Couinaud system). Liver ROIs were segmented from IP images through the employment of morphological operations, k-means clustering and a watershed-based region-growing algorithm. Liver ROIs were translated onto T1 maps to extract mean T1 values for each region.

Results: A total of 13 features, including mean T1 relaxation time values from 7 liver regions, were extracted from the T1 maps. An example of such an extraction is shown in Figure 1. An exploratory data analysis was undertaken as a preliminary assessment of feature importance. No significant inter-correlations were found between features extracted from the T1 map images. However, of particular interest were the feature comparisons with the least correlation. Several functional segments were particularly poorly correlated with each other (e.g. lobes 6 & 7 vs lobes 2 & 3 with a Pearson's correlation coefficient = 0.2 and $p < 0.0005$).

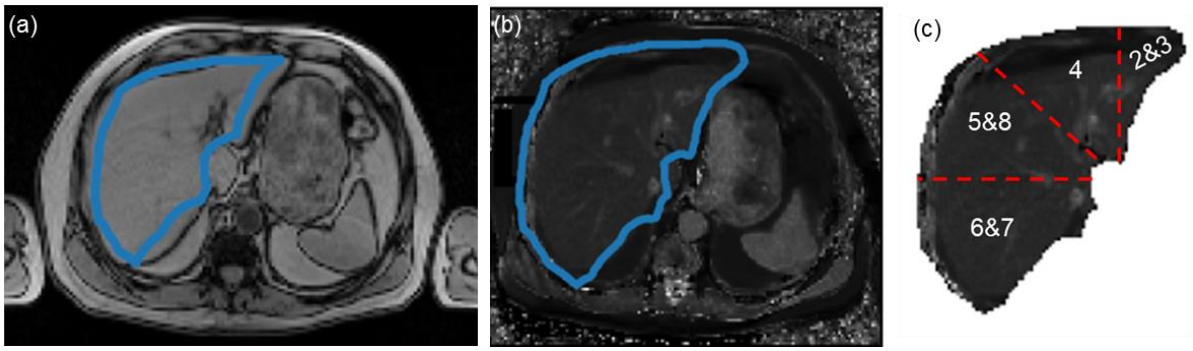

Figure 1 - The three stages of liver feature extraction (a) segmentation of the liver region from T1 IP image, (b) mapping of the ROI to T1 time image, (c) division of functional segment data from extracted T1 region

Discussion: These data highlight the patchiness of liver disease in NAFLD and provide evidence that lipid deposition within the liver is not homogeneous. The data also illustrate the importance of replacing liver biopsy as the flawed 'gold standard' for assessing disease severity in NAFLD. Once all data from the INSYTE trial has been collated (pre- and post-intervention), this initial exploratory analysis will enable more advanced machine learning analyses to be undertaken.

References:

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