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CSC PhD thesis proposal

Title: Virtual liver biopsy for NAFLD monitoring by using mpMRI and spectroscopy based radiomic

Laboratory: CREATIS, team NMR and optics: From measure to biomarker

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Context

In the past decade, an epidemic increase in non-alcoholic fatty liver disease (NAFLD) prevalence has been observed (1). NAFLD is closely associated with the metabolic syndrome, defined by various features including central obesity, diabetes mellitus, raised blood pressure, increased triglyceride levels and decreased high-density lipoprotein-cholesterol (2). Nowadays, in Western countries, NAFLD is among the most common causes of chronic liver disease with a prevalence ranging between 17 and 46% (1). NAFLD includes simple steatosis and nonalcoholic steato-hepatitis (NASH). Whereas simple steatosis has good prognosis, NASH is associated with poor long-term outcome (3). About 20% of NASH patients eventually develop cirrhosis or hepatocellular carcinoma, so that NASH has become the fastest growing cause of liver-related morbidity/mortality worldwide (4). Despite these severe outcomes, NASH is often overlooked or neglected (5), which is in part explained by limitations in available diagnostic tools. Identification of patients with NASH would be useful to counsel them more intensively on diet and lifestyle changes and to propose new pharmacological treatments.

At histology, NASH is characterized by steatosis, hepatocyte ballooning, inflammatory infiltrates, with or without fibrosis. Liver biopsy is the reference for differentiating steatosis from NASH and for staging hepatic fibrosis (6). In this context, we have pioneered a method able to simultaneously probe these histological hallmark, at the macroscopic scale, through the quantification of fat content, fatty acid composition, transversal relaxation time and magnetic susceptibility from a single multiple echoes spoiled-gradient echo pulse sequence (7). Benefits are that data are acquired simultaneously, thus, they are insensitive to mis-registration artefacts linked to macroscopic motions, data are acquired in similar conditions and examination time is substantially reduced to remain compatible with a clinical routine. However, at this time, this approach has several limitations: (a) It is not able to finely classify fibrosis according to the conventional histological scores (METAVIR, NAS or ISHAK); (b) It is not able to assess inflammation (another key hallmark in NAFLD).

Beside, when present, iron overload constitute a confounding factor in the staging of liver fibrosis with magnetic susceptibility, due to its paramagnetic effect.

Overall objectives

The proposed PhD project will be devoted to the development of methods to address these limitations and develop the concept of virtual biopsy. Through this project, we propose to (i) include spectroscopy to add metabolic information, ultrafast IVIM and quantitative perfusion to probe tissue structure and vascular component such as previously developed in our institute (8-11); and (ii) to perform radiomic by using the quantitative maps as radiomic fingerprints and spectroscopy data to predict fibrosis and inflammation grade according to histological scores.

Through this project, the PhD student will implement the acquisition protocol and improve the previously developed processing pipeline to an integrated solution able to perform simultaneous reconstruction of all multiparametric maps, to correct susceptibility for iron, and to annotate images to build the future learning base. The designed acquisition strategy together with the integrated processing solution is intended to be applied on cohort of patients (in China-Shanghai vs Lyon).

Applicant skills

- Initial training in physics and signal processing.
- Matlab language
- Knowledge in magnetic resonance would be very much appreciated.
- Motivation to work in the medical imaging field and to bring knowledge to healthcare.
- Good level in English language

References

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