Fat quantification in the liver

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In this presentation, we will review:

1. The clinical relevance of diagnosis and quantification of liver fat
2. The available MR sequences for diagnosis of liver fat, an how these perform for liver fat quantification

Introduction-clinical relevance

Since the 1980s, obesity has become an epidemic in the United States (1-4). The prevalence of obesity was estimated to be 27% in 1999 (5). Overweight and obesity account for nearly 17% of all deaths in the US (6). Obesity is significantly associated with diabetes, insulin resistance, and nonalcoholic fatty liver disease (NAFLD). NALFD is estimated to occur in 30 to 100% of obese adults (7), and includes a spectrum of liver abnormalities from steatosis to nonalcoholic steatohepatitis (NASH). NASH has a poorer prognosis compared with simple steatosis, leading to cirrhosis in up to 25% of cases (8), with the risk of liver failure, and hepatocellular carcinoma. NASH is diagnosed by the presence of inflammation and fibrosis, compared to simple steatosis.

Diagnosis and quantification of liver fat with MRI and Proton MR Spectroscopy (MRS)

Among the MRI methods used to date, the two-point Dixon method (in and out-of-phase imaging) (9) provides an accurate assessment of liver fat as shown in previous studies, with correlation coefficients of 0.86-0.98 (10-12). However, fat quantification measured with in- and out-of-phase imaging may be inaccurate when there is a high amount of liver fat (13) and concomitant iron deposition (14), and in those cases MRS should be used in conjunction with in- and out-of-phase imaging to resolve fat-water predominance. 3-point Dixon method (9) and the iterative decomposition of water and fat with echo asymmetry and least-squares estimation (IDEAL) method (15,16) have better accuracy for fat quantification in the liver, compared to 2-point Dixon method.

MRS is a potential noninvasive alternative to biopsy for assessing the degree of lipid accumulation within the liver (17-22). It allows in vivo evaluation of metabolites such as water and fat within a selected volume of interest. Signals from protons in different molecular groups have different resonant frequencies or different chemical shifts within a spectrum. Proton signals from water and fat are well separated with a chemical shift of 3.5 ppm or 225 Hz at 1.5T. MRS can be used to directly quantify fat fraction. Spectroscopic evaluation of liver FF may be achieved during a single breath-hold in portions of the liver, and requires the evaluation of the two dominant peaks within the unsuppressed spectrum, water at 4.7 ppm and lipid at 1.0-1.5 ppm. Livers containing increased lipid content demonstrate an increase in the lipid peak relative to normal liver. Quantitative analysis requires the correction for factors that affect signal intensity, such a signal decay from T2 relaxation and accounting for unsaturated lipids, as a small portion of the MR signal from these molecules overlaps with the water resonance at 4.7 ppm. Signal saturation from incomplete T1 relaxation is minimized by using long TR.

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