Magnetic Resonance Spectroscopy in the Body

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Target audience: Clinicians and imaging scientists using or considering body MRS applications

Highlights:
- Body MRS provides distinct technical challenges compared to brain MRS
- Body MRS is most widely used in breast and prostate cancers
- Future developments for body MRS include high-field MR, hyperpolarization, and metabolomics

Course Objectives:
- Describe methods for body MRS
- Survey applications of MRS in the body
- Identify topics of future development in body MRS

Magnetic resonance spectroscopy (MRS) is a non-invasive diagnostic modality that can measure chemical information from a targeted region in the body. The predominant species measured with ^{1}H MRS are water and lipids, but low-concentration metabolites that give insight into metabolism can be measured in many tissues.

The techniques used for acquiring and analyzing body MRS have generally been adapted from brain applications. There are several practical aspects of MRS that tend to make body MRS more challenging than brain MRS, and these require special consideration. Physiologic motion of cardiac, respiratory, and peristaltic origin can have a substantial impact and require alternate acquisition and processing strategies. The presence and inter-subject variability of adipose tissues can produce large lipid signals and may be particularly problematic when measuring low concentration metabolites. The combination of motion, lipids, and the presence of air spaces (lungs, intestinal gas) can make careful shimming of the B_0 field challenging. Additionally, a variety of different receive coil configurations are used when measuring body regions, which in general provide less uniform coverage and lower signal-to-noise than is available for brain MRS studies. These factors, combined with variations in size, location, and chemical composition, have generally lead to different acquisition and analysis approaches for different target organs and their associated clinical or research questions.

The most common clinical uses of MRS in the body are in prostate and breast cancer, for which several vendors provide standard protocols. In prostate cancer, 3D MR spectroscopic imaging can be used to acquire spectra from the entire prostate. Prostate spectra exhibit choline-containing metabolites, creatine, citrate, and polyamines (particularly spermine). Choline is typically elevated in cancerous regions, whereas citrate and polyamines are indicators of normal prostatic function and are diminished in malignancy. Combined with MR imaging data, MRSI has been used identify, localize, stage, and grade prostate cancer (1,2). In the breast, MR spectroscopy can be used to measure the total choline resonance, which is typically elevated in cancer. This has been used for diagnosis as well as monitoring response to chemotherapy (3). Single-voxel spectroscopy has been commonly used, but use of spectroscopic imaging for improved spatial coverage is increasing (4).

While breast and prostate cancer are the most common targets, MRS has been explored for assessing extracranial malignancies such as liver (5), renal, rectal, gynecologic, and metastatic cancers. Outside of cancer, ^{1}H MRS has been used for lipid quantification and characterization in liver, cardiac, marrow, and skeletal muscle, while ^{31}P MRS can give information on metabolism and energetics in skeletal muscle, myocardium, and the liver.

Future technical developments include the use of high-field MR systems and hyperpolarized agents to improve SNR and measure compounds that are impractical with conventional methods. Clinical applications of body MRS are expected to benefit from greater standardization of acquisition and analysis methods, and improved understanding of metabolomics through correlations between *in vivo* and *ex vivo* MRS.

References (reviews)
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