MRS: Phosphorus MRS of Muscle

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Highlights:

- Transitions between rest and exercise place unique demands on the metabolism of skeletal muscle compared to other tissues.
- ^{31}P-MRS measurement of phosophocreatine kinetics is a surrogate measure of muscle oxygen consumption kinetics.
- The use and misuse of ATP saturation transfer in muscle.
- Strategies for ^{31}P imaging of muscle.

Target Audience: Researchers and clinicians interested in studying skeletal muscle adaptations in response to exercise training and disease.

Objectives: To provide the physiological background for understanding the application of dynamic 31P-MRS to the study of muscle energetics, and to give an overview of current methods and controversies in the field.

Summary: The first ^{31}P-NMR spectra of mammalian muscle were published by Hoult et al in 1974 (1), and since that prescient paper, ^{31}P-MRS has become the standard method to assess the metabolic fitness of skeletal muscle. For example, muscle mitochondrial oxidative capacity is now routinely estimated from measurements of phosphocreatine kinetics during rest-exercise transitions, and this presentation will explain the rationale and experimental support for these measurements in detail. The same dynamically acquired spectra can yield estimates of the energy cost of muscle contraction, and the muscle glycolytic rate, both of which vary with the fiber type distribution of muscles. Although less commonly performed, specialized methods such as ATP saturation transfer can provide unique insight into the activity of creatine kinase and other muscle enzymes. Finally, the presentation will discuss why spectral localization can be important to the interpretation of dynamic muscle MRS studies, and consider strategies for dynamic ^{31}P imaging of muscle (e.g., Figure, ref. 2).

References:

1. Hoult, DI, Busby, SJW, Gadian, DG, et al, Observation of tissue metabolites using ^{31}P nuclear magnetic resonance. *Nature* 1974; 352: 285-287.

2. Slade, JM, Towse, TF, DeLano MC, el al, A gated 31P NMR method for the estimation of phosphocreatine recovery time and contractile ATP cost in human muscle. *NMR Biomed.* 2006; 19: 573-580.