Dynamic Contrast Enhancement in MSK: Technical Aspects – How to Do It

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Dynamic contrast-enhanced MRI (DCE-MRI) generally refers to a series of T1-weighted images acquired before, during and after injection of an intravenous low molecular-weight paramagnetic contrast agent. While DCE-MRI has been performed to assess the status of a variety of disease states, including inflammatory conditions, the most prominent use of DCE-MRI is in oncologic imaging, where it can be used to diagnose and characterize malignant tumors from surrounding tissues.

During DCE-MRI, tumors demonstrate rapid and intense signal enhancement compared to normal tissue, and high spatial and temporal resolution imaging methods are critical for accurate quantitative analysis. In this presentation, I will cover the overall technical aspects of DCE-MRI by describing common methods for acquiring and analyzing DCE-MRI data.

1. Data Acquisition

A common data acquisition approach for DCE-MRI is to acquire T1-weighted images, inject a gadolinium contrast agent, and continuously acquire a time series of T1-weighted images as the contrast agent circulates through the tissue microvasculature. 3D images are typically obtained every few seconds for 5 to 6 min, and the contrast medium is injected intravenously after 4 - 10 baseline images using a power injector.

Several trends in DCE-MRI acquisition have emerged, expected to increase the ability of clinical investigators to utilize DCE-MRI, especially the option for non-Cartesian k-space acquisition and compressed sensing. These provide opportunities to improve temporal resolution without sacrificing spatial resolution or volumetric coverage.

Before the contrast agent injection, pre-contrast T1 measurements are also necessary to obtain to convert the dynamic MR data into the gadolinium concentration, where the gadolinium concentration changes over time can be used to extract semi-quantitative or quantitative microvascular properties.

2. Data Analysis

The pharmacokinetic model can provide ways to quantify parameters related to the underlying vascular physiology. One common model is the two-compartment pharmacokinetic model, where a contrast agent is assumed to only diffuse from the vascular space into the extravascular, extracellular space (EES), and then slowly leak back into the vascular space. Based on the simple rate equation, the transfer rate constants can be derived from the two-compartment model, where these constants describe the rate of accumulation (K^{trans}) and wash-out (k_{ep}) of the contrast agent in EES.

In addition, novel analytic approaches that move beyond the two-compartment model provide additional values for DCE-MRI data analysis. Multi-compartment models have enabled investigators to gauge the effects of tumor therapies not just on flow and vascular permeability, but also tumor vascular volume fraction as well as the dynamics of water exchange. Such modeling requires more complex computation methods, but may allow for more robust analysis of the tumor vascular microenvironment.