Quantification of Regional Human Leg Muscle Perfusion Using First-pass Magnetic Resonance Imaging

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Introduction

The evaluation of the spatial and temporal aspects of skeletal muscle perfusion in lower limb is relevant to our understanding of several common disease, especially peripheral arterial disease. Although currently available methods such as strain-gauge plethysmography, radioactive tracer, and thermodilution techniques provide information related to bulk blood flow, they do not provide sufficient spatial perfusion information.

It has been shown previously that tissue blood flow changes at the level of microvasculature can be followed in tissue with first-pass magnetic resonance imaging (MR) imaging technique (1-4). Dynamic susceptibility contrast-enhanced imaging techniques offer the unique possibility of combining the good spatial resolution of MR imaging with the ability of positoron emission tomography to assess tissue microcirculation. Noninvasive high resolutional MR perfusion imaging is potentially ideal for the assessment of leg ischemia. However, this technique has not yet been applied to human leg muscle perfusion.

Accordingly, the purpose of this study is to apply first-pass magnetic resonance imaging (MRI) to quantify leg muscle perfusion.

Methods

Twelve legs of 6 volunteers were scanned at 4 below-knee levels using a new multi-slice spiral T1-weighted sequence. MR imaging was performed on a 1.5T MR scanner (Signa, General Electric Medical System, Milwaukee, WI) using the standard head coil. We used a newly developed multislice, multiphase, and fast spiral sequence with spoiled gradient for first-pass MR imaging. Spiral readouts used in this sequence allows multislice acquisition with high temporal resolution.

We scanned four levels of below knee including calf, ankle and foot with this sequence. The pulse sequence parameters were as follows: FOV = 24 x 24 cm, slice thickness = 10 mm, TR = 36 ms, TE = 2.2 ms, flip angle = 90 degrees. An image consisting of 30 interleaves of spiral readouts at each anatomic position was acquired within 1.1 seconds, with a total of 60 images at each of the four different levels.

Perfusion was assessed by bolusly injecting the contrast agent Gd-DTPA (Magnevist; Berlex Laboratories, Wayne, NJ), via the antecubital vein after the fifth image. We used an approach based on reports by Larsson et al to quantitate first-pass MR perfusion (2, 3). For each subject, region of the interest (ROI) excuding all visible vessels was placed in muscle tissue and signal intensities were read. Signal intensity time course was calculated after baseline and background subtraction for each ROI placed in muscles. Arterial input function was obtained by placing the ROI onto the anterior tibial artery. Ki (first-order transfer constant from arterial plasma to tissue for Gd-DTPA) was determined for each ROI by means of deconvolution of perfusion curve with the respective arterial input function.

In this study, ROI was placed on each muscles at each of the four different levels of calf and Ki was calculated from the perfusion curves. In addition, Ki map is computed on a 6 pixels-by-6pixels basis.

Results

Perfusion (Ki) maps with highly spatial resolution of 5mm x 5mm were successfully obtained from all legs. Calculated Ki showed no significant difference between each muscles. (Tibialis anterior: 73±27 ml/min/100mL, Peroneus longus: 107±23 ml/min/100mL, Soleus: 65±23 ml/min/100mL, Gastrocnemius: 93±26 ml/min/100mL).

Figure 1 and Figure 2 show the examples of calculated perfusion maps for the middle of the calf. Perfusion variations within individual muscles and regional variations of each muscle group between different levels were observed.

Discussion

We demonstrated that quantification of muscle perfusion using first-pass MR imaging was feasible and calculated perfusion map provided useful spatial information of muscle perfusion. Newly developed multislice, multiphase, and fast spiral sequence allowed multislice quantification of muscle blood flow, which showed regional heterogeneity within the muscles. Although our approach is not yet validated in all details, this study suggested that first-pass MR imaging can be used for the assessment of leg ischemia.

References