Introduction:

Measurement of mesenteric blood flow in response to meal challenge is a useful diagnostic test for small bowel ischemia. Blood flow in the superior mesenteric artery (SMA) and vein (SMV) can be assessed with a variety of methods but flow rate quantitation with cine phase-contrast (PC) MRI has been found accurate [1]. However, cine PC imaging is time-consuming and requires cardiac gating. In a significant number of patients, this cannot be performed because of cardiac arrhythmia or poor gating signals.

We developed a color-flow real-time MRI system [2] where velocity is color-mapped onto grayscale images much like duplex color Doppler ultrasound. Since its imaging rate is faster than the cardiac cycle, no gating is needed. We employ this technique to measure mesenteric blood flow in response to meal challenge. Results are compared with those obtained with cine-PC imaging and ultrasound.

Material and Methods:

Three healthy male volunteers, after six hours of fasting, underwent baseline measurement of their SMA and SMV flows. Flow velocities were obtained with Doppler ultrasound while flow rates were measured with conventional cine PC imaging and color-flow real-time MRI. Each volunteer was given a meal challenge consisting of 360 calories of liquid diet supplement. After 30 minutes, the SMA and the SMV flows were reassessed in a similar fashion.

The color-velocity real-time MRI sequence is composed of two sets of interleaving spiral trajectories, with and without velocity encoding. New grayscale images and velocity maps were generated at a rate of 2.8 pairs per second. Using a sliding window technique, 11 frames of color-coded images were displayed per second. These images were processed to calculate flow rates at the SMA and the SMV.

Results:

Figure 1 shows a typical tracing of flow rate at the SMA. The systolic interval varies normally. Before the meal challenge, the tracing shows a high-resistive pattern with a low diastolic flow. In contrast, after the meal challenge, the tracing shows a low-resistive pattern with an increased diastolic flow. This finding suggests vasodilation of the mesenteric vascular bed.

Figure 2 shows the flow rates in the SMV. The SMV flow is modulated by respiration. After the meal challenge, there is a marked increase in flow consistent with increased mesenteric perfusion.

Flow velocity measurements from ultrasound and flow rate calculations from cine PC imaging show similar adaptive responses.

Discussion:

This experiment shows that color-flow real-time MRI is useful for quantitative blood flow measurement. Unlike ultrasound, velocity-encoding direction can be arbitrarily chosen, and it is not limited by probe orientation. This is a significant advantage because the longitudinal orientation of the SMA and the SMV are unfavorable for Doppler ultrasound. Compared with cine PC, real-time MRI is far more efficient. Since the imaging plane can be searched interactively, no localizing sequence is needed. Once the SMA and the SMV are found, five seconds of data acquisition generate all the data needed for the flow analysis. Finally, since no setup for respiratory or cardiac gating is needed, examination time is shortened.

References: