

Purpose: Changes of venous blood oxygenation level leads to direct changes in the magnetic susceptibility of veins. The oxygenation level reflects the physiological state of a given vein. Therefore, susceptibility quantification of veins has been a strong interest in MRI. Here we will demonstrate a general approach to extracting magnetic susceptibilities of veins at arbitrary orientations from only two or three echoes of a standard 3D gradient echo sequence.

Methods: The complex sum method is used. The complex MR signal of each voxel is added around a long cylindrical object of interest. Previous work has accurately quantified effective magnetic moments of given cylindrical objects. If an object has no MR signal, its volume and susceptibility can be further determined by the spin echo approach. On the other hand, when an object of interest (e.g., vein) has an MR signal, the susceptibility of the object and its volume may be uniquely solved using this method. Images acquired with two different echo times in a typical gradient echo sequence are sufficient to quantify the magnetic susceptibility and volume of veins. Several small isolated human cerebral veins were measured at TE=11.6 ms and 19.2 ms in 4.0T. Due to low signal to noise ratio, images at TE=19.2 ms were Bilateral filtered, to preserve the edge but reduce noise. The uncertainties of magnetic susceptibilities were quantified by the error propagation method.

Results: The measured susceptibility of veins at two different echo times agrees with the value in the textbook (0.40 ppm) within the uncertainty. The volumes of venous vessels, the spin density inside and outside these vessels are also obtained.

Conclusions: The in-vivo measurements demonstrate our method can be used to quantify the magnetic susceptibility of a given narrow and long cylindrical object in human imaging.