A novel MR contrast agent for angiography and perfusion: Hyperpolarized water

Magnetic Resonance Imaging (MRI) is an important tool in medical imaging, and is widely used for its high spatial and temporal resolution, and low safety concerns. However, the technique has its limitations due to the inherent low sensitivity, making it inferior to Computed Tomography (CT) in terms of spatial and temporal sensitivity and to nuclear medicine methods in terms of molecular imaging sensitivity. By hyperpolarization, the available signal can be enhanced by several orders of magnitude, and potentially close some of these gaps. In this thesis work, the purpose is to demonstrate that water, hyperpolarized by dissolution Dynamic Nuclear Polarization (d-DNP), can be applied as an MRI contrast agent for angiography and perfusion. The first part of the project focuses on development of a protocol for production of large samples of hyperpolarized protons in D2O. The samples are polarized and dissolved in a fluid path compatible with the installed base of commercial polarizers developed for clinical research. The solidstate DNP is optimized at 6.7 T and 1.2 K by microwave frequency modulation. A solid-state polarization of 70% is obtained. The dissolution procedure is optimized by introduction of a fluorinated solvent to accelerate the transition from solid to liquid state, and efficient radical extraction is obtained with a two-phase system of water and heptane. A final liquid state polarization of 13% in samples of 16 mL is obtained, suitable for large animal experiments. In second part of the project, hyperpolarized water is applied for angiographic imaging and perfusion measurements in a pig model. Renal angiography of 0.55 mm in-plane isotropic resolution is demonstrated and perfusion measurements provides values comparable to conventional Gd-T1-DCE analysis. Finally, it is demonstrated that the method can be applied to acquire dynamic coronary MR angiography with temporal resolution of less than 1 s, apparent Signal-to-Noise Ratio of 269±169 and coronary sharpness of 0.31±0.086 mm⁻¹, which is superior to coronary MRA available in today's clinical practice.

General information
State: Published
Organisations: Department of Electrical Engineering, Center for Magnetic Resonance, Center for Hyperpolarization in Magnetic Resonance
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Number of pages: 149
Publication date: 2016

Publication information
Publisher: Technical University of Denmark, Department of Electrical Engineering
Original language: English
Electronic versions:
Thesis2016_Lipsoe.pdf
Source: PublicationPreSubmission
Source-ID: 127840919