Three-dimensional visualization of the cardiac veins by means of intravascular contrast agent enhanced MRI.

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Abstract

With the upcoming interest in cardiac resynchronization therapy, the knowledge of the course of the coronary veins is considered to become important adjunct information for planning of the optimal implantation location of the left ventricular pacing lead (LV lead) and to guide the introduction of the LV lead into the target vein. The aim of this study is the evaluation of intravascular contrast agent enhanced MRI for the non-invasive visualization of the cardiac veins. It is shown in four volunteers that the suggested approach enables the visualization of the coronary sinus and its main tributaries and that the CNR and SNR can on average be improved by 330% and 155% in comparison to native imaging.

Introduction

In contrast to the coronary arteries, the variability of the coronary veins is much more pronounced [1] and approaches applied to coronary artery imaging, such as the subsequent acquisition of targeted sub-volumes each covering a certain segment of the coronary artery tree, are likely not applicable to the coronary veins. Instead, whole heart imaging protocols appear to be mandatory. Furthermore, the different oxygenation levels of venous blood cause a significant reduction of the T_2-relaxation, which makes the application of T_2 – based contrast enhancement between the vessels and the myocardium (so called T2 preparation) less efficient and the use of contrast agents will likely be required. To avoid significant enhancement of the myocardium over the long acquisition times resulting in whole-heart imaging, the application of intravascular contrast agents is likely required.

Methods

In the present work, the visibility of the coronary veins in native and contrast agent enhanced whole-heart, three-dimensional, free-breathing MRI is investigated. A comparison in four healthy volunteers is performed between the native and contrast agent enhanced imaging using the intravascular gadolinium (GD)-based chelete B-22956 [2] (Bracco Imaging S.p.A., Milan, Italy), which has recently been successfully applied to coronary artery imaging [3]. For the native MRI imaging a cardiac triggered, segmented, T2 prepared steady-state-free-precision (SSFP) technique is applied. For the contrast agent enhanced imaging, the T2 preparation is replaced by an inversion recovery preparation for nulling of the myocardial signal. Quantitative comparison of the resulting contrast-to-noise and signal-to-noise ratios are performed for the coronary sinus (CS), the mid cardiac vein (MCV) and the great cardiac vein (GCV). Three-dimensional visualization of the coronary veins is done by means of volume rendering.

Results

The cardiac veins comprising the CS, MCV, GCV and the lateral vein (LV) could be successfully visualized in all volunteers by means of contrast-agent enhanced MRI. In direct comparison (see Figure 1, left), contrast agent enhanced MRI provides a clear improvement in the delineation of the respective vein and ensured reproducible image quality in all investigated vein segments. Quantitative assessment of the CNR and SNR revealed a statistically significant average improvement of the CNR for all investigated segments (CS: 347%, $P<0.05$; MCV: 260%, $P<0.01$; GCV 430%, $P<0.05$) and an average improvement in the SNR in all investigated segments of 155%. The application of the IR sequence causes a significant reduction of the signal in the myocardium to about 25% ($P<0.001$). The resulting image quality was sufficient for three-dimensional visualization of the coronary sinus and its main tributaries in all volunteers (see Figure 1, right).

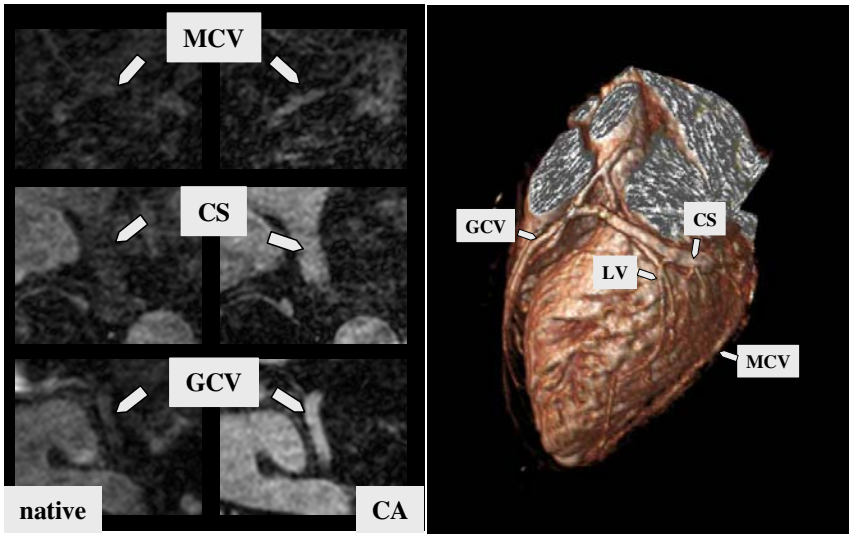

Figure 1: Comparison of native MRI and contrast-agent enhanced MRI (CA) for the mid cardiac vein (MCV), the coronary sinus (CS), and the great cardiac vein (GCV) (left); three-dimensional rendering of the coronary veins (right)**.**

Discussion

Three-dimensional visualization of the cardiac veins with reproducible image quality appears to be feasible by means of intravascular contrast agent enhanced whole-heart MRI. In combination with functional MRI, the combined visualization may enable an improved pre-interventional planning of cardiac resynchronization procedures. Furthermore, intra-procedural fusion of the vein maps with the X-ray fluoroscopy may further ease the introduction of the LV-lead into the target vein.

References

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