Optimized Navigator Gated Sequence for 3D Contrast Enhanced Free-Breathing Coronary MRA: Application with the New Intravascular Contrast Agent B-22956

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Abstract

Free-breathing navigator-gated and corrected inversion recovery 3D coronary MRA was optimized for a successful combination with a new intravascular contrast agent B-22956. It was applied on six healthy adult volunteers and compared to baseline coronary MRA with T2 preparation. Intravascular contrast agent combined with the optimized sequence increased SNR by 39% ($P<0.05$) and a CNR by 95% ($P<0.01$).

Introduction

Magnetic resonance angiography (MRA) has been shown to be a promising technique for the visualization of the proximal coronary arteries. Among others, state of the art techniques include high-resolution 3D image acquisition, navigator-based scanning during free-breathing, and preparation pulses for fat suppression and myocardial suppression (T2prep). However, a further enhanced signal and improved contrast between blood and the myocardium may still be desirable, thereby the application of a contrast agent may be very helpful. This may be especially helpful for the visualization of more distal or branching vessels. Currently various intravascular contrast agents are being developed by various vendors. Intravascular contrast agents are characterized by reduced leakage into interstitial compartments, some of them – like B-22956 – also by a long plasma half life. Therefore they significantly reduce the T1 relaxation of blood and show only minor effects on the T1 relaxation of the myocardial muscle.

In the present work a 3D free-breathing navigator-gated and corrected gradient echo sequence was adapted for contrast enhanced coronary MRA using a new intravascular, low molecular weight Gd based chelate coded B22956[1] (Bracco S.p.A., Milan, Italy). The contrast agent was applied on six healthy volunteers and objectively compared with a T2 magnetization prepared scan without contrast agent administration.

Methods

Six healthy adult subjects were studied on a commercial 1.5T Philips Gyroscan ACS-NT system (Philips, Best, The Netherlands), equipped with a 5-element cardiac synergy-coil and a vector ECG. For each volunteer, double oblique 3D coronary MRA was performed 5 minutes after contrast agent administration. For comparison reason baseline coronary MRA with T2 preparation[2,3] (T2prep) were performed prior to the contrast agent scan. The imaging sequence post contrast was a free-breathing navigator-gated 3D segmented k-space gradient echo sequence[4]. A field-of-view of 360mm was sampled with a 512 x 512 matrix resulting in an in-plane spatial resolution of 0.7 x 0.7 mm^2. Ten 3mm slices were acquired and interpolated to twenty with a thickness of 1.5mm. TR was 7.5ms and TE 2.1ms. For non-contrast enhanced baseline coronary MRA, a T2prep was used and an inversion recovery pre-pulse was added to the contrast agent scan. The time delay between the inversion and the image acquisition part was adjusted in order to null the myocardial signal (TI=180ms).

Since the inversion pre-pulse is non-slice selective, it also affects the magnetization of the diaphragm used as an interface for navigator gating. Therefore we implemented an earlier described navigator-restore pulse[5] (NavRestore), which locally re-inverts the longitudinal magnetization of the navigator kernel immediately after the inversion pre-pulse. Prior to each navigator-gated scan, a preparation phase of 25 RF excitations is performed for the correct determination of the most cranial end-expiratory position of the diaphragm (=navigator preparation phase). In the subsequent acquisition part, this end-expiratory position is used to calculate the relative respiratory diaphragmatic displacement. In order to have similar magnetization conditions on the diaphragm during the preparation phase and during the actual imaging phase, the pre-pulses (T2Prep for non-contrast agent scan, inversion recovery and NavRestore for contrast agent scan) were also performed during the ECG triggered navigator preparation phase. For the contrast-enhanced examination 0.075 mmol/kg body weight of B22956 was administered intravenously over 150s. Data acquisition was started 5min after the end of the contrast agent injection.The evaluation of SNR, CNR and vessel sharpness was subsequently performed for the objective comparison of the pre- and post-contrast scans.

Results

The application of an inversion recovery pre-pulse very efficiently suppressed the myocardial muscle. While the increased relaxivity of the blood allowed for a good visualization of the coronaries, even for more distal segments or branching vessels (Fig. 1).

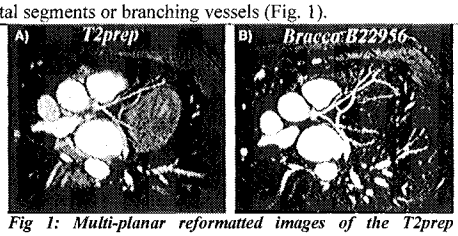

Fig 1: Multi-planar reformatted images of the T2prep acquisition (A) and the contrast agent enhanced inversion recovery acquisition (B) obtained in the same subject.

A comparison of the objectively determined image quality parameters shows increased values for the contrast-enhanced coronary MRA (Tab.1). The acquisition with B22956 in conjunction with the inversion recovery sequence resulted in a significant increase of SNR (39%, $P<0.05$), CNR (95%, $P<0.01$) and vessel sharpness (19%, $P<0.05$) when compared with the T2prep non-contrast enhanced scan.

	T2prep	B22956
SNR	36.2 ± 2.5	52.1 ± 5.7
CNR	23.8 ± 5.9	47.1 ± 5.8
vessel sharpness(%) LAD	47.0 ± 4.8	54.5 ± 3.8
vessel sharpness(%) LCX	46.1 ± 2.2	54.5 ± 3.8

Table 1: Evaluation of the image quality parameters (±SEM)

Due to its high proportion of biliary excretion, administration of B-22956 together with the NavRestore resulted in a high liver signal which facilitated the use of real-time navigator technology (Fig. 2). Further, the application of the magnetization preparation pulses (T2prep resp. Inversion and NavRestore) during the triggered navigator preparation phases ensured a reliable determination of the end-expiratory diaphragmatic position, during both preparation and scanning phase.

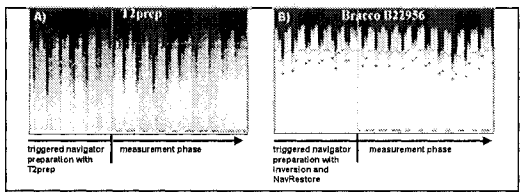

Fig.2: Navigator signal obtained in a volunteer. For the determination of the end-expiratory position, the preparation phase of the navigator is performed triggered an with the application of the magnetization pre-pulses: A) T2prep sequence; B) B22956 with inversion recovery and NavRestore pre-pulses.

Discussion

The new contrast agent B22956 could be successfully combined with a free-breathing navigator-gated and corrected inversion recovery 3D coronary MRA. The reduced T1 of the blood and the good intravascularity of the agent enabled the visualization of more distal segments and branching vessels of the left coronary arterial system while myocardial muscle signal was almost entirely suppressed.

References

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