High-Resolution MRI with a new cardiac and respiratory gating system for contrast-enhanced MRI of the carotids in the ApoE-/- mouse

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Introduction

Though atherosclerosis develops in a preferential way and initially at the level of the aortic root and the carotids origin, the visualization of this area in mice remains challenging due to the absence of effective gating [1]. Cardiac gating using ECG detection minimizes the influence of cardiac motion. Respiratory motion has also to be avoided for high resolution imaging of the vascular wall at the level of the aortic arch [2]. In this study, we propose to evaluate contrast enhancement of the carotid wall in ApoE$^{-/-}$ mice using efficient cardiorespiratory gating.

Methods

The ECG acquisition was made using optical ECG sensor at 1 KHz sampling rate. For respiratory signal detection, a solid-state ultra low-pressure sensor (SURSENSE^{TM}, Honeywell, USA) was linked to a home made latex probe adapted to the mouse size. Real-time environment was implemented using Simulink (MathWorks, Inc) and was optimized to acquire and process the physiologic signals and parameters with an automatic trigger level adjustment. ECG gated images were acquired in the stable expiratory phase. High relaxivity contrast agent Vistarem (P792, Guerbet, France) (r_1= 29 mM^{-1}(Gd).s^{-1}, MW of 5 kDa and fast renal elimination) was injected at a dose of 16µmol Gd/kg. MRI experiments were performed on a 2 Tesla magnet with a home made alderman-Grant coil. 2D GE axial and coronal images were acquired with cardiac and respiratory gating. Pre and post contrast high resolution T1 SE were acquired in ApoE$^{-/-}$ and C57BL/6 mice at the carotid origin (6 slices, TR=R-R ms; TE, 18 ms; 1 mm slice thickness, in plane resolution of 89 µm and four signal average). For MR angiography (MRA), a 3D-fast gradient echo was used in the coronal plane with the following parameters: TR/ TE= 13/3 ms; flip angle, 30°, and pixel size of 211×211×234 µm^3. Signal enhancement was measured from pre- and post-contrast T_1 weighted images by the use of the Creatools software dedicated to arterial wall analysis and normalized to reference signal and pre contrast values (gain) [3].

Results

Real-time efficient trigger signal was extracted from contaminated ECG, with gating parameters such as stable expiratory phase, systole/diastole window, R-R period and delay. Optimal processing technique with updated threshold was selected, resulting in double gated images with better resolution and fewer artifacts (figure 1). Signal of the carotid wall in ApoE$^{-/-}$ mouse increased after contrast agent injection and reaches its maximum 30 to 40 min post contrast (mean gain 2.4±0.98 at peak) and decreased after 60 min (figure 2). In C57BL/6 mice, the thickness of carotid wall was below the pixel size and there was no contrast enhancement.

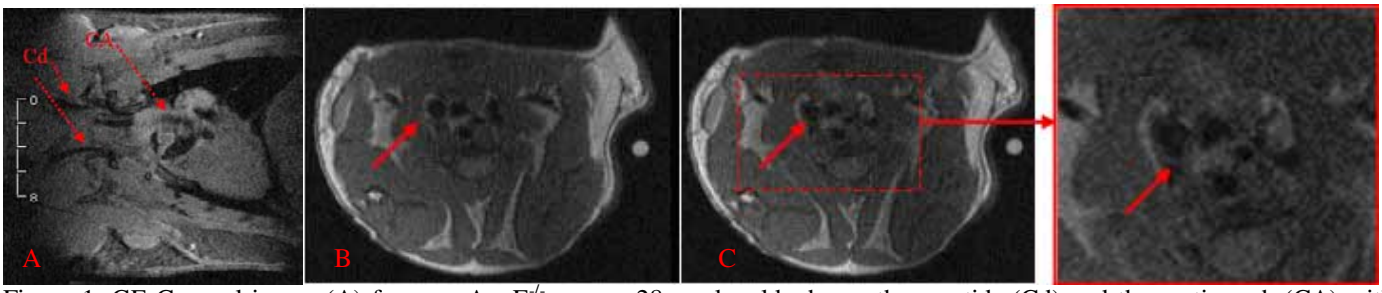

Figure 1: GE Coronal image (A) from an ApoE$^{-/-}$ mouse, 28 weeks old, shown the carotids (Cd) and the aortic arch (CA) with pixel size of 89µm, axial T_1 weighted images from the same mouse acquired (B) before and (C) at 28 min post-contrast injection, Arrow indicates the left carotid.

Conclusion

This study demonstrates the efficiency of the cardiac and respiratory gating system. The real time processing ensures considerable time saving compared to available cardiorespiratory gating systems. The method allows analysis of vessel wall enhancement in the mouse at the level the aortic root and the carotids origin. It will be applied to molecular imaging of atherosclerosis lesions in mice.

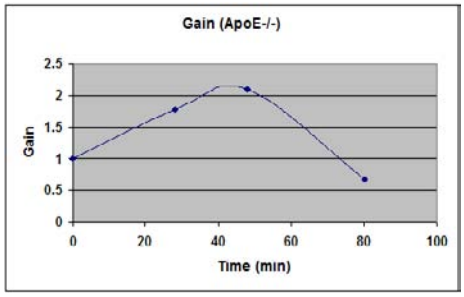

Figure 2: Gain measurement in the carotid wall of the same ApoE$^{-/-}$ mouse pre- and post injection of the P792 contrast agent

References

1. F. Wisemann and all. MRM; 2003; 50:69-74.
2. P.D. Hokings and all. Circulation; 2002; 106:1716-1721.
3. L. Chaabane and all. MRM 2004 Feb; 51(2):370-9.

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