In Vivo Coronary Artery Imaging in Mice

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Introduction

Coronary artery imaging remains technically difficult in mice in vivo and only a few studies were reported so far. Ruff J *et al* used approximate 1hr multi-slab 3D GE sequence to image coronary arteries of a living mouse, and reconstructed 3D coronary arteries [1]. However, such 3D method is usually time-consuming and presents a practical limitation for MRI study of coronary arteries in mouse models of various cardiovascular diseases. The current study aims to develop a rapid and robust 2D procedure to visualize both left and right coronary arteries (LCA and RCA) of mice in vivo. In addition, contrast agent of Gd-DPTA by rapid intraperitioneal (i.p.) injection was examined for its ability to improve the quality of LCA and RCA visualization.

Method

Imaging experiments were conducted on a 7T Bruker PharmaScan (Bruker BioSpin). ICR adult mice (~40g, either sex) were anesthetized with 1.0% isoflurance. ECG electrodes were attached to the front paws and the mice were placed over a respiratory sensor. T1-weighted short-axis slices from base to apex were imaged using multi-stack 2D FLASH sequences. Parameters are: TR/TE=20.7/2.5ms, slice thickness=0.5mm, slice gap=0mm, flip angle=90º and in-plane resolution=0.156×0.156mm^2, NEX=4. Slice acquisition order was set from apex to base, which was inverse to blood flow direction to maximize blood inflow T1 effect. Protocol described above was used to image coronary arteries. For coronary artery which was difficult to localize within one slice, three slices were used and the slice thickness was reduced to 0.3mm with 30% slice thickness overlapping. Maximum intensity projection (MIP) was performed. Each slice imaging took ~3 minutes at the heart rate of ~350bpm. Imaging was conducted before and 0, 10, 20, 30, 40 and 50 minutes after i.p. injection of a bolus of Gd. Different dosage of Gd was evaluated. Signal intensity of coronary arteries ($SI_{Coronary\ artery}$), myocardium ($SI_{Myocardium}$) and standard deviation of background noise ($SD_{Background\ noise}$) were measured. Contrast to noise ratio (CNR) was calculated by the formula: $(SI_{Coronary\ artery}-SI_{Myocardium})/SD_{Background\ noise}$. LCA of an infarct mouse with LCA ligation for one month was also imaged pre- and post- Gd i.p. injection.

Results

LCA was usually easy to be captured in one 0.5mm slice; however, RCA was relatively difficult to image within one slice. Three thinner slices (0.3mm) with 30% overlapping and MIP could provide better visualization (Fig.1). The entire protocol was within 30 minutes (T1-weighted short-axis slice imaging of whole heart was ~12min, LCA ~3 min and RCA ~10 min), which was much faster than one-hour 3D method. RCA and LCA images conducted before and after Gd i.p. injection were shown in Fig.2. Time courses of CNR with different dosage of Gd were plotted in Fig.3. Results demonstrated that CNR increased gradually after i.p. injection of Gd and kept larger than baseline for about 40 minutes and decreased afterwards. Largest CNR enhancement percentage usually appeared at 20 minutes after Gd i.p. injection. Maximum CNR enhancement percentage increased with increase of dosages (39.1%, 61.7% and 79.3% and 88.5% for dosage of 0.017, 0.025, 0.033 and 0.040µmol, respectively). 0.04µmol Gd i.p. injection was selected and applied to an infarct mouse of which LCA had been ligated for one month. LCA imaging was compared before and after Gd i.p. injection (Fig.4). Longer LCA was observed after Gd i.p. administration and location of LCA ligation could be identified.

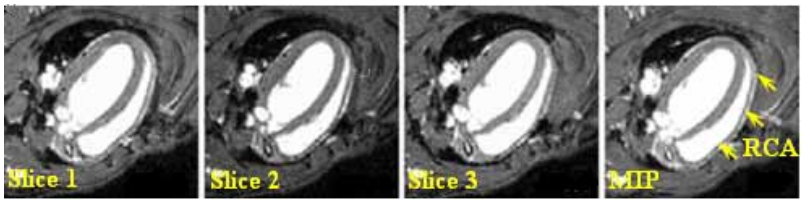

Fig.1 MIP of RCA from three slices. total scan time ~10min

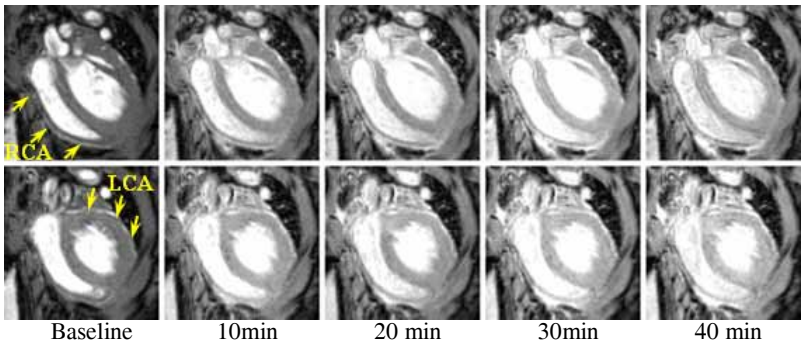

Fig.2 RCA (top row) and LCA (bottom row) imaging before and 10, 20, 30 and 40 minutes after i.p. injection of Gd (0.025µmol)

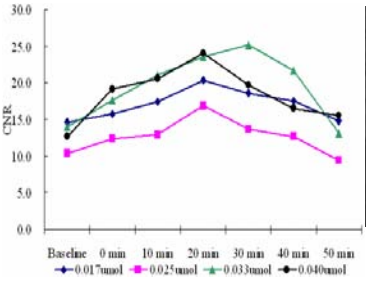

Fig.3 CNR courses of different doses

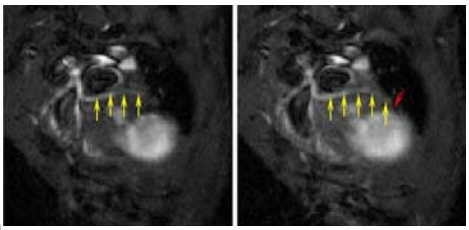

Fig.4 LCA images (yellow arrows) of an infarct mouse before (left) and after (right) i.p. injection of Gd. Location of ligation could by seen after Gd enhancement (red arrow).

Discussion

Full path of LCA could be easily visualized within a plane with thickness of 0.5mm. Although entire RCA visualization was difficult, it could be achieved after MIP processing of three thinner overlapping slices. In practice, mouse LCA and RCA could be visualized with satisfactory quality within 30 minutes using these procedures. With the aid of Gd, CNR enhancement percentage increased and better visualization of coronary arteries was obtained. Higher dosage of Gd offered better contrast between coronary artery and myocardium. In addition, i.p. injection was adopted in current study because it could be easily performed and was reproducible for longitudinal study. The current study demonstrated the feasibility of rapid MRI examination of coronary arteries of mice in vivo using 2D method and i.p. injection of contrast agent.

References

[1] Ruff J *et al*, Journal of Magnetic Resonance, 2000