MR compatible Doppler-ultrasound device to trigger the heart frequency in Cardiac MRI: comparison to ECG

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Intrduction

Cardiac MR imaging has rapidly developed in the past few years, by which the evaluation of many different scopes, like coronary arteries and myocardial infarctions has been realized. 2D CINE steady-state free precession (SSFP) imaging is the most reliable and used technique for leftventricular (LV) function assessment in practical use. In order to assess the LV function correctly, speed and synchronization of data acquisition with the cardiac cycle to avoid artefacts due to cardiac motion and flow constraints are required. Usaually, to avoid the motion artefacts caused by cardiac motion, electrocardiography (ECG) triggering technique is used to synchronize data acquisition with the cardiac cycle (1). ECG, however, may carry different risks of interference with the MR system (2). Therefore a triggering alternative is an important issue for future studies.

In the here presented feasibility study, a newly developed MRI compatible Doppler ultrasound device stable enough during the whole scanning time was introduced for the first time. A commercially available cardiotocogramm (CTG) was modified, so that the heart beat could be recorded during the whole scanning time without any artifacts. The aim of this study was to perform cardiac MR imaging with triggering of the heart beat with a novel MR compatible Doppler ultrasound device in a sheep model.

Material and Methods:

MR imaging of the heart:

MR imaging was performed on 6 sheep on a 1.5 T MR scanner. The Doppler-ultrasound sensor was placed on the chest above the heart and fixed gently with a belt. The recorded signal was transferred to the ECG trigger unit of the MRI scanner and used for cardiac triggering. Additionally conventional ECG triggering was recorded. Cardiac MRI was performed using both triggering methods consecutively. For cardiac MRI cardiac triggered cine MRI sequences with steady-state free precession (SSFP) (TR 34.91 ms; TE 1.34 ms; Flip-angle 55°; slice thickness 3 mm) of the heart were achieved in short axis view, two, four and three chamber view. From the short axis view the left ventricular volumes (LV) and ejection fraction (EF) were measured. MR images acquired with Doppler-ultrasound and conventional ECG triggering were evaluated separately by two radiologists concerning image quality and functional assessment.

Triggering using CTG: The ultrasound transducer (HP 15245A) of a standard CTG (model HP 8040A, Hewlett Packard, Palo Alto, USA) was employed for cardiac MRI triggering instead of the routine 4-lead ECG. In a first step, all magnetically perturbing components of the CTG's ultrasound transducer were replaced by non-magnetic materials and components of low magnetic signature. In the second step, the CTG signal was protected against the electrical and magnetic fields' interference of the MRI. In the last step, an additional optical transmission and standardization of the heart signal was used to put the analogue signal back to the ECG-unit of the MRI.

Results:

Cardiac MR imaging was possible in all 12 examinations, 6 using the Doppler-ultrasound device and 6 using ECG triggering. The novel MR compatible CTG allowed a stable signal during the whole MRI measurement. Using Doppler-ultrasound for triggering image quality was comparable to ECG **(Figure 1 a-d)**. All anatomical structures could be clearly evaluated. For functional evaluation the LV and the EF were assessed. There was no significant difference between both methods: LV 128 ml (SD±0.2) and EF 48.2% for Doppler-ultrasound and LV 130 ml (SD±0.2) and 46.6% for ECG.

Discussion and Conclusion:

The novel MR compatible Doppler-ultrasound device is a new triggering method for cardiac MRI. There was no difference between Doppler-ultrasound and ECG in the evaluation of anatomical structures and functional information. It might be faster and easier in the application compared to ECG.

References:

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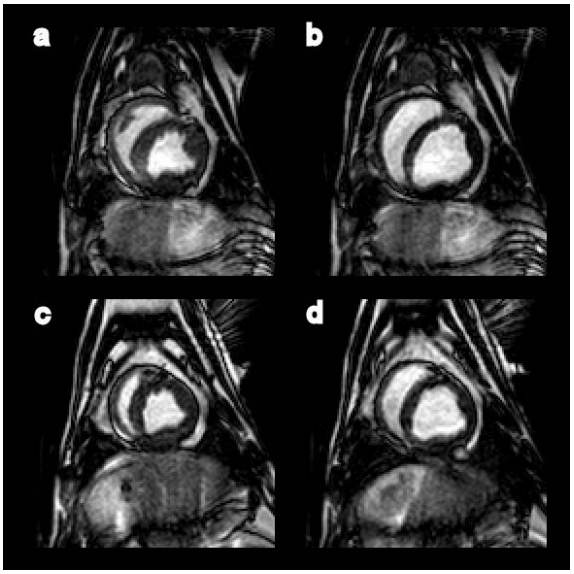

Figure 1: Short axis view of the heart in systole (a, c) and diastole (b, d). There was no difference between sequences triggered by Doppler-ultrasound (a, b) and ECG (c, d).