Comparison of non-invasive self-gated Flash (Intragate®) with prospectively triggered Flash cine sequences for the evaluation of aortic distensibility in mice at 9.4 T.

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Purpose

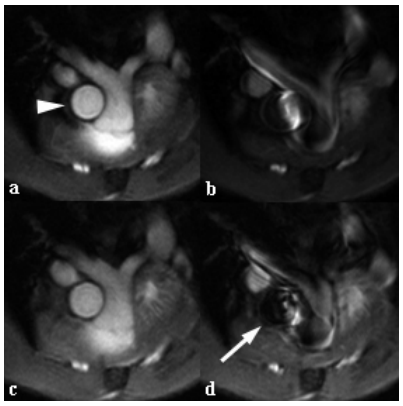
A critical problem in cardiovascular MRI in small rodents is adjusting the sequence acquisition parameters to the high heart and respiratory rates. There are two acquisition schemes available, one consists in using an external trigger device by monitoring the ECG with external leads and the respiration rate of the animals with an external pressure transducer. The acquisition in this setting will be performed with prospective triggering according to the R-peak of the ECG during exspiration. Another approach is based on a self-gated sequence without external monitoring device using the Intragate® technique (Bruker, Ettlingen, Germany). In this acquisition a saturation slice is acquired providing physiological information of the pulse and the respiration. This acquired information will be used to assign the acquired data of the cine sequence to certain intervals of the cardiac and respiratory cycle.
The aim of this study was to compare the noninvasive self-gated (NSG) Intragate® with the conventional prospectively triggered (PT) Flash sequences for Cine imaging of the ascending aorta in mice at 9.4T.

Material and Methods

Ten C57/BL6 mice were examined with a 9.4 Tesla MRI animal scanner (Bruker, Ettlingen, Germany) using a dedicated 2x2 phased-array surface coil. All MRI experiments were performed during general anesthesia using a mixture of isoflurane (2%) and oxygene (98%) applied by a mask covering nose and mouth of the animals. We acquired a NSG-Flash (Intragate®, TR/TE=6.5/2.5 ms, FA=10°, FOV=2x2cm, matrix=384x384, slice thickness= 1mm, 25 movie frames) perpendicular to the ascending aorta. At the same position we performed a PT-Flash sequence (TR/TE=6.5/2.1 ms, FA=10°, FOV=2x2 cm, matrix=384x384, slice thickness= 1mm). In this scan the max. number of movie frames had to be adjusted to the RR-interval with: No. of frames = RR-interval / TR, for example with a RR-interval of 150 ms a maximum number of 23 movie frames can be acquired. This had to be adjusted before starting the sequence. Cross-sectional vessel areas at endsystole (AES) and enddiastole (AED) were measured to determine aortic distensibility (AD, AD=AES-AED). In addition, the two imaging approaches were qualitatively evaluated in a blinded reading. Two readers rated the different sequences regarding the presence of flow and trigger artifacts and their influence on the depiction of the blood/vessel-wall-interface. Irregularities in displaying the cardiac cycle with the acquired movie frames and the overall suitability of the sequence for evaluation of AD were assessed using a 5-level ordinal scale. Statistical differences were analyzed using Student´s t-test and Wilcoxon signed rank test ($P<0.05$).

Results

The two techniques showed no significant differences regarding the measured vessel areas (AED (mean+/-SD, NSG: 1.57+/-0.13 mm^2, PT: 1.59+/-0.13, p=0.07), AES (NSG: 2.09+/-0.16 mm^2, PT: 2.086+/-0.154, p=0.34) and AD (NSG: 0.523+/-0.122 mm^2, PT: 0.496+/-0.12, p=0.11)). While the acquisition time for the NSG-Flash sequence was consistently 371 sec the total acquisition time for the PT-Flash sequence was significantly longer (mean+/-SD: 442+/-129 sec, range: 353 – 783 sec). However, there were no significant differences regarding the heart rate and the respiration rate during the acquisition of the two sequences (heart rate: NSG-Flash 446.5+/-45.7 /sec, PT-Flash: 451.9+/-46.6, p=0.06; respiratory rate: NSG-Flash: 34.5+/-6.1 /sec, PT-Flash: 33.5+/-4.4 /sec, p=0.24). The readers rated NSG-Flash superior regarding the presence and interference of flow artifacts (p=0.016 / p=0.004 respectively) as well as the presence and interference of trigger artifacts (p=0.016 / p=0.031 respectively) with the depiction of blood/vessel-wall-interface. In addition, NSG-Flash was rated superior regarding irregularities in displaying the cardiac cycle and the overall suitability for evaluation of AD (p=0.008 / p=0.004).



NSG-Flash (Intragate®) acquired perpendicular to the ascending aorta (arrowhead in a) during diastole (a) and systole (b). The corresponding PT-Flash sequence is displayed in c (diastole) and d (systole). Both sequences demonstrate flow artifacts within the pulmonary trunc and the aorta which are relatively pronounced due to the high field strength of the system (9.4 T). However, the interference of the artifacts with the depiction of the vessel wall/blood interface is more pronounced in the PT-Flash sequence (d) than in the NSG-Flash sequence (b).

Discussion

NSG-Flash (Intragate®) is a preferable technique for evaluation of AD being less prone to flow and trigger artifacts while providing the same quantitative data as the prospectively triggered Flash cine approach. NSG-Flash allows for a more homogeneous depiction of the cardiac cycle, which is most likely based on the differences of the acquired cine frames with the PT-Flash sequences which needed to be adjusted to the RR-interval. In addition, the acquisition time of the NSG-Flash sequences was lower than the prospective triggered sequence, which is most likely based on misregistrations of the respiratory cycle or the ECG by the external monitoring device. This effect may be even more pronounced in animals with disease models being less stable regarding heart and respiration rate during anesthesia for the MR imaging.