Free Breathing Navigator Gated Cine Cardiac MR at 3T: Feasibility study in patients.

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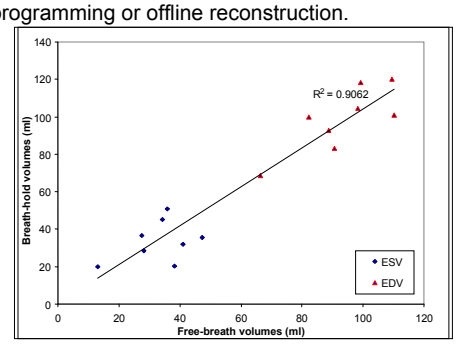
Purpose: To demonstrate that free-breathing (FB) cine cardiac function with respiratory navigator gating is possible at 3T and comparable in both objective and subjective measures to the traditional breath holding (BH) technique, hence can be used as an alternative for children and patients that cannot tolerate the traditional BH cine approach.

Introduction: Advancement in MR has allowed for its increased used in cardiac applications, such as the assessment of congenital heart disease, pericardial disease, ventricular and valvular functions as well as the assessment of myocardial wall motion. This procedure is necessary for proper patient management; however the repeated BH steps add difficulty in obtaining good quality images. Also, repeated BH steps preclude the use of the BH cine technique in children and patients with medical conditions that prevent them from breath-holding. As such the need exist for a technique that demonstrates similar quality on both objective (ESV, EDV, EF) and subjective (Image quality scoring) measure but allows the patient to breath freely within clinically reasonable scanning time. Seeger et al[1] demonstrated the possibility of obtaining 3D cine free breathing techniques at 1.5T without respiratory navigation in infants which was possible due the little respiratory motion in this patient group (average age 2.2 years) which would not be feasible in an older patient group. Furthermore, in an old subject group, Peters etal[2] showed the FB cine technique at 1.5T that requires sophisticated dual navigator technique that require software manipulation and offline reconstruction while allowing for acquisition of only 16 cardiac phases. We aim to use the higher signal to noise ratio (SNR) of 3T in conjunction with parallel imaging (SENSE) to circumvent this manipulation while not compromising on the cardiac phases obtained.

Methods: 8 subjects (6 F and 2 M, aged 12-46) were recruited to undergo cardiac MR to assess myocardial wall motion on a 3 T Philips Achieva with 6 channel coil (Philips Medical Systems, Best, NL). A healthy volunteer was imaged to determine the appropriate sequence technique using various settings of one and two averages with and without respiratory navigation. All subjects signed informed consent for this institutional review board approved protocol. The 8 subjects were imaged with both the conventional 2D cine BH and 1 average and FB navigator gated technique with 2 averages on the same 3T scanner. The respiratory navigator was placed on the right hemi-diaphragm with an acceptance window of 3mm for the FB technique. Other wise the scan parameters were identical: TR/TE/θ = 5.93ms/3.57ms/15° acquiring 30 phases of the cardiac. The acquired spatial resolution was 1.8 x 2.4x 5mm. The image was obtained using parallel image technique (sense factor of 2) and10 slices were acquired in the short axis orientation to cover the entire left ventricle. Images derived from both techniques were randomized and scored for image quality by an experienced cardiologist blinded to the techniques. A 4 level scoring system used by Seeger etal[1] was used. The scale is as follows: (1= poor, ventricular borders are markedly blurred; 2= good, ventricular borders are moderately blurred; 3= very good, borders are mildly blurred; 4= excellent, sharply defined borders). The left ventricular end systolic and end diastolic volumes (LVESV and LVEDV) were measured in the short axis orientation using the Virtual place, AZE software. The ventricular mass and ejection fractions were also calculated with the same software. Each patient underwent a trans-thoracic echocardiogram to evaluate their ejection fraction. Results from the FB and BH techniques were compared, as well as the EF from the echocardiogram. A two tailed Student t-test was used with $p< 0.05$ considered as significant. Bland- Altman analysis assessed the limit of agreement between the two techniques.

Results: The correlation coefficients was R=0.9 for the LVESV and LVEDV between the two techniques (figure 1). The difference in the LVESV, LVEDV and the EF assessed by the BH, FB and echocardiography was not statistically significant (p=0.5, 0.8, 0.9) respectively. There is good correlation of LV volumes with the limits of agreement (±2SD = ±22.36) as depicted in figure 2. The average acquisition time (for the 10 slices) including resting intervals needed between breath-holds for the BH technique and to complete the FB technique were 7.8minutes and 12.8minutes respectively and were statistically significance (p=0.004). Figure 3 depicts the short axis slices with the BH and the FB cine techniques. The FB technique scored an average of 2.15 on image quality assessment while the BH cine images scored an average of 2. There was no statistically significant difference (p= 0.76) in image quality between the two techniques.

Discussion and Conclusion: In this study we demonstrated the feasibly of acquiring FB cardiac cine images is possible using a respiratory navigator gated technique at 3Tand can be used as an alternative technique to the conventional BH technique especially in children and patients who are unable to hold their breath or follow instructions. Although the FB acquisition times significantly longer, the times were clinically reasonable, tolerated and successfully completed in all the patients. The limits of agreement using this method are comparable to other studies measuring ES V and EDV using other MRI imaging sequences[3]. Furthermore, this FB technique demonstrated comparability to the traditional BH technique on both the quantitative (ESV, EDV, and EF) and qualitative measurements (image quality scoring) without statistical significance between the two methods. Due to the higher SNR at 3T, we are capable of acquiring single navigator gated FB cardiac cine images with up to 30 cardiac phases using techniques that don't require programming or offline reconstruction.



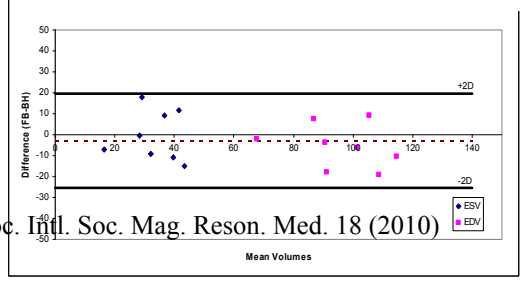


Figure 1 (top) Figure 2 (bottom): Scatter plot (top). Bland-Altman comparing ESV and EDV (bottom).

References:

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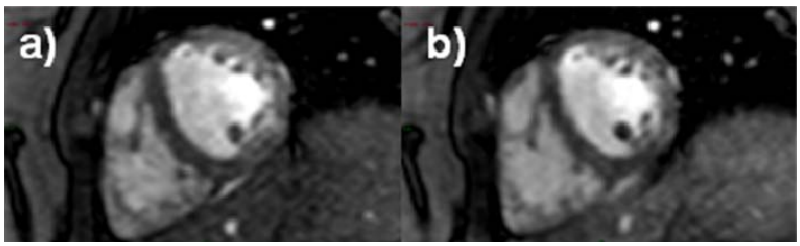

Figure 2. a) Breath-holding cine image from a patient. b) Free-breathing cine image from the same patient at the same position. Note the similarity in image quality between the two techniques.