RETROSPECTIVE RECONSTRUCTION OF BLACK-BLOOD GOLDEN RATIO RADIAL IMAGING FOR VISUALIZATION OF HEART VALVES AT ARBITRARY DYNAMIC TIME POINTS

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INTRODUCTION: MRI facilitates the comprehensive assessment of valvular heart disease providing several pathophysiological parameters and the direct visualization of the valve leaflet morphology [1]. For the latter, usually a black-blood acquisition is applied to reduce flow related artifacts [2]. However, accurate timing is crucial for the adequate visualization of the opening and/or closing phase, requiring accurate trigger delay timing. Black-blood cine images can be use to overcome this problem but they often suffer from flow artifacts and fading signal intensities due to magnetization loss throughout the cardiac cycle. As an alternative, here we propose the use of a radial trajectory with golden ratio profile order [3] to retrospectively select and reconstruct a high spatial resolution image that coincides with the opening/closing of the valve. This acquisition scheme allows the retrospective reconstruction of two different image sets from the same acquired data: a) dynamic images with high temporal resolution that cover a selected part of the cardiac cycle allowing the selection of the right timing and b) a high spatial resolution image at the selected time point.

METHODS: In radial acquisition with golden angle profile order the angular step between two consecutives profiles is constant and given by the golden ratio of $\theta_{GR}=111.246°$. This approach ensures a quasi-optimal distribution of profiles for any number of projections, allowing the flexibility to reconstruct images at arbitrary timings with different temporal resolutions. A prolonged cardiac acquisition window is used to acquire data around the time points of interest (e.g. early-diastole for aortic valve closure and atrioventricular valve opening). Several time frames with high temporal resolution are reconstructed retrospectively using a sliding window approach to identify the best timing for reconstruction, yielding to a black-blood dynamic sequence over the selected part of the cardiac cycle. A high spatial resolution (and therefore lower temporal resolution) image is then reconstructed at the selected time points (Fig1).

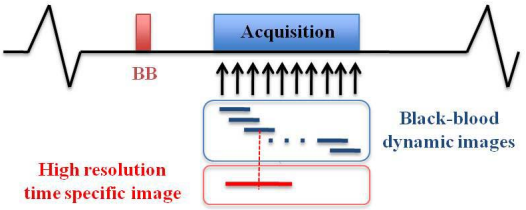


Fig1: Data is collected after a black-blood prepulse (BB) over a long acquisition window (black arrows). A dynamic sequence is reconstructed with a high temporal resolution using sliding window (blue bars). After selecting the time point of interest a high spatial resolution image is reconstructed (red bar).

The feasibility of this approach was tested in three healthy volunteers on a 1.5T Philips scanner using a 32-channel receiver coil. In all cases, a 2D black-blood three-chamber view encompassing the aortic and atrioventricular valve plane was acquired. Relevant scan parameters include: Double inversion recovery radial BTFE sequence, FOV= *256×256mm*, resolution=*1×1mm*, slice thickness=*5mm*, TR/TE/flip angle= *4.34/2.17ms/60*, subject specific early-diastolic trigger delay. Images were acquired every second heartbeat using an average inversion time of *550ms*. To compensate for SNR loss due to the prolonged cardiac acquisition window (*~200-250ms*) pseudo signal averaging (or oversampling) was performed by acquiring approximately *800* radial profiles. Sixteen dynamic frames were reconstructed for each volunteer with a temporal resolution of *12ms* using a sliding window approach. After selection of the optimal trigger delay a specific time frame was reconstructed over a cardiac window of *~45ms*. For comparison purposes a conventional radial acquisition with a predefined trigger delay (and therefore predefined reconstruction timing) was acquired in each case with similar parameters but with *45ms* cardiac acquisition window.

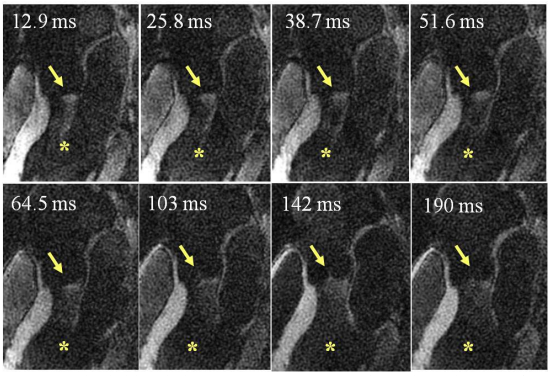
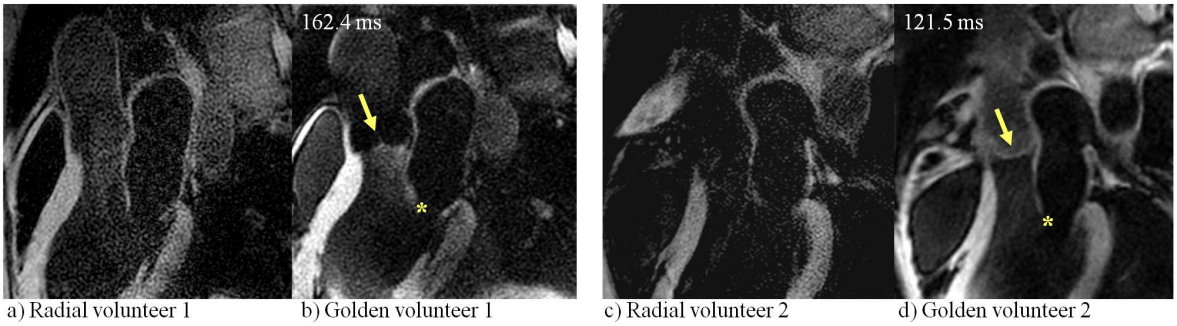


*Fig2: Black-blood dynamic images over the selected part of the cardiac cycle. Arrows indicate the motion in the aortic valve, whereas * has been included has a reference at first position in of the atrioventricular valve.*

RESULTS: Black-blood dynamic images over the selected part of the cardiac cycle are shown in Fig.2 for one volunteer. Magnified views are shown for better visualization of the valves. Good overall quality image is achieved for all frames with a slight SNR loss at the end of the acquired time-window. A selected time frame to depict aortic valve closure is shown in Fig.3b and Fig.3d for two volunteers. For comparison purposes the conventional radial acquisition is also included in Fig.3a and Fig.3c. A wrong timing for aortic valve closure is observed for the 2nd case, due to the difficulty to identify the valve dynamics. However adequate visualization of valve closure and better image quality was obtained with the proposed approach.

CONCLUSIONS: We demonstrate that adequate visualization of the heart valves can be achieved using a golden radial acquisition with retrospective reconstruction. This approach allows the reconstruction of a high spatial resolution image at any specific time point during valve opening and closure. In future work we will validate the proposed approach in patients.



a) Radial volunteer 1 b) Golden volunteer 1 c) Radial volunteer 2 d) Golden volunteer 2

*Fig3: a)-c) Radial and b)-d) Golden radial acquisitions for two different volunteers. Adequate visualization of the aortic valve (see arrows) is shown with the proposed approach, however a wrong timing for the closing of the aortic valve is observed with the radial acquisition. Leaflets of the atrioventricular valve are indicated by *.*

REFERENCES: [1] Cawley et al., Circulation 2009; 119: 468-478, [2] Arai at al., JMRI 2007; 10(5):771-7, [3] Winkelmann et al., IEEE TMI 2007; 26(1): 68-76.