Rapid flow measurements in the coronary sinus at 3T using parallel imaging - initial results

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Introduction

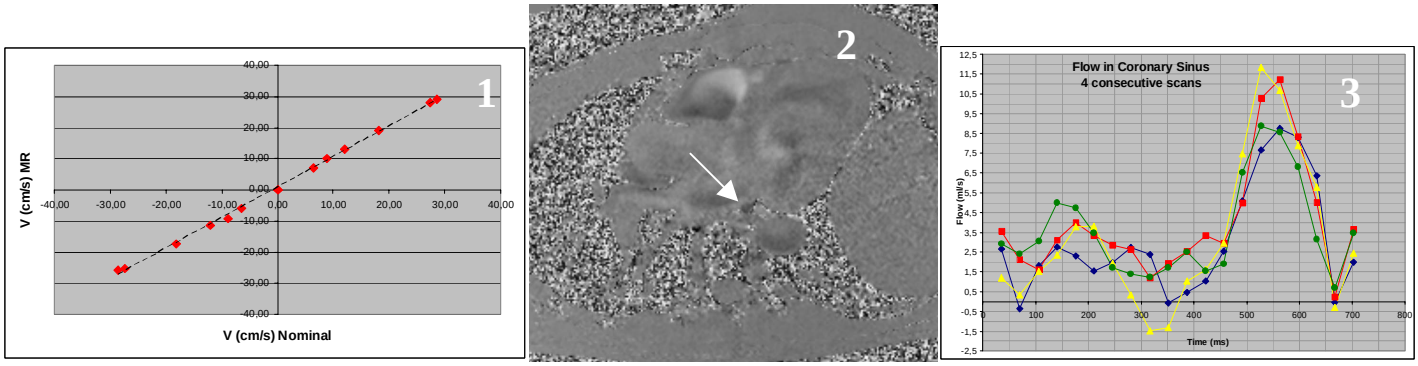
The MR velocity mapping technique has been proposed and extensively reviewed for functional heart disease evaluation (1). However, when this technique is used together with prospective or retrospective electrocardiography (ECG) synchronization alone, respiratory vessel motion remains a problem in, for example, the coronary vessels. Segmented gradient-echo sequences for velocity quantification in combination with breath-holding have been developed and evaluated in models as well as in vivo (2,3), however, it has been pointed out that the long acquisition windows introduced by the segmentation technique may cause unacceptable blurring as well as erroneous velocity measurements (4) in coronary vessels which move significantly due to heart motion in spite of breath holding. Recently, velocity mapping at 3T has been demonstrated (5) and the concept of parallel imaging has been evaluated in phase contrast imaging (6). The aim of this study was therefore to combine high field strength, parallel imaging technique and segmented k-space velocity mapping to achieve short acquisition windows but still reasonable total acquisition times and signal-to-noise ratios for the assessment of flow in the coronary sinus.

Material and Methods

Flow was measured quantitatively in phase images in vitro (tube diameter 4.8 mm, wall size <= 0.1 mm) and repetitively in the coronary sinus of one healthy volunteer during breath-holding. Retrospectively triggered segmented GRE velocity mapping sequences were used (TE/TR 3.9/5.6 ms, 10 segments (k-space lines per heartbeat), acquisition window 50 ms, FA 10°, BW 801 Hz/Pix, resolution 1.44x1.55x8.00 mm^3, VENC 30-50 cm/s, total acquisition time 14 seconds) on a Philips Gyroscan Intera 3.0 T system. A built-in cardiac simulator was used for the phantom study, while vector ECG was applied in vivo. A phased-array cardiac coil provided by the manufacturer was used for parallel imaging (SENSE) with reduction factor R=2. In addition, left ventricular (LV) mass was measured on the same volunteer using a steady-state GRE sequence (balanced FFE, α=60°) during breath-holding on a Philips Gyroscan Intera 1.5T system. Software provided by the manufacturer was used for region-of-interest based flow evaluation and for wall mass determination.

Results

In vitro, the linearity between values measured with MR and with stop-clock and measuring glass was good (y=0.983x+0.778, r^2 = 0.998) in the velocity range 0-30 cm/s, corresponding to a flow range of 0-300 ml/min (Fig.1).



In vivo, phase maps showed reasonable homogeneity (fig 2, arrow at the coronary sinus) and measurement repeatability (fig. 3). The average flow after phase background correction in the coronary sinus was measured to be 205 ± 25 ml/min over 4 consecutive measurements (the corresponding value without background correction was 175 ± 32 ml/min). The LV mass of the volunteer was measured to be 194 g, thus average LV perfusion (average coronary sinus flow divided by LV mass) was 1.06 ml/(min*g).

Conclusion

Segmented k-space velocity mapping in combination with respiratory gating has been reported for coronary flow assessment (7,8), however the concept of segmentation in combination with breath-holding remains a rapid and attractive alternative. In this study, we have demonstrated that a segmented k-space velocity mapping strategy designed for breath-hold studies gives accurate results using parallel imaging (R=2) at 3T in vitro as well as in a first in vivo case.

References

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