Validation of Phase Contrast Measurements with Combined Parallel Imaging and Partial Fourier Acquisition

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Introduction

Gated, fast cine phase contrast (PC) MR imaging provides the ability to measure blood flow in vessels within a single breath-hold period. To further reduce the scan time of a phase contrast measurement, partial Fourier acquisitions with zero-filling of the missing data can be used. Parallel imagaing techniques in combination with multi-channel receiver coils can also be used to reduce the scantime. A sequence utilising both partial Fourier acquisition and parallel imaging technique (ASSET) was implemented on a whole body 1.5 T scanner. It was the aim of this study to show the reliability of this sequence in a routine clinical setting. In vitro validation was also done using a flow phantom.

Methods

The standard FastCine PC GRE phase contrast sequence was modified to allow for partial Fourier acquisition (0.5 NEX resembling 60% k-space filling) and factor 2 parallel imaging technique ASSET (Array Spatial Sensitivity Encoding Technique). Sequence parameters were as follows: Retrospective gating, 30 frames per RR-cycle reconstructed. TR/TE 7.2ms /3.4ms. 8 views per segment k-space segmentation. Flip angle 20°. Measurements were done using this sequence as well as the standard FastCine PC GRE Sequence with the same sequence parameters but without the modifications described above. A 4-channel receive phase- array surface coil (TORSO) was used in all measurements

In 8 healthy volunteers as well as 20 consecutive patients (prospective study) cardiac output in the ascending Aorta was measured with and without the combination of parallel imaging and partial Fourier acquisition. Each of the two measurements was repeated three times. The relative deviation of mean flow volume, maximum velocity, SNR and scantime was calculated.

A laminar flow phantom was used to evaluate the sequence in vitro utilizing a 4 channel Neurovascular coil. SNR as well as accuracy and precision were calculated at different flow rates of 2 to 6.8 l/min. All measurements were repeated 5 times.

Images were analysed using the software CV Flow© (medis®, Leiden, Netherland). All measurements were analysed by two experienced radiologists. Automatic contour detection with manual correction as necessary was used for the in vivo measurements.

Results

1. There was a tendency to overestimate the cardiac output by 5% if measured with combined partial Fourier acquisition and parallel imaging that was not found in the in vitro measurements (1.8 %, $p<0.001$). Interobserver variability was 0.4% for standard sequence and 0.6% for combined parallel imaging and partial Fourier acquisition in the in vivo measurements.
2. Significant reduction of SNR by 12% ($p<0.01$) was seen with combined parallel imaging and partial Fourier acquisition in comparison to the standard sequence. Scantime was reduced by a mean 64% utilizing both parallel imaging and partial Fourier acquisition. (Fig 1 and 2)
3. The in vitro measurements demonstrated a high precision of the repeated measurements. (Table 1).

Discussion

Flow measurements utilizing a combination of parallel imaging and partial Fourier acquisition technique are reliable in clinical routine. Scan time can be reduced by a mean of 64%. Mild overestimation of flow volume measurements and a significant drop in signal to noise ratio are the main trade-offs of this technique.

Precision	1 Nex	1 Nex Asset	0.5 Nex Asset
1.5 T	0.14	0.36	0.19
Accuracy	1 Nex	1 Nex Asset	0.5 Nex Asset
1.5 T	--	+0.10 n.s.	+2.25
SNR	1 Nex	1 Nex Asset	0.5 Nex Asset
1.5 T	--	-26.5	-12.2

Table 1: Precision, accuracy and SNR of flow measurements with and without parallel imaging and partial Fourier acquisition in *vitro*. (n.s. = not significant). Numbers given are expressed as mean deviation in % to measurements with 1 NEX

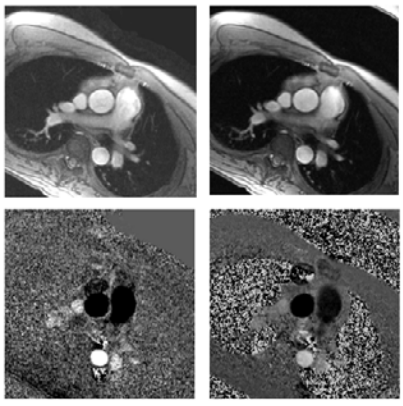

Figure 1: Flow measurements in the ascencding Aorta. Left row with combined parallel imaging technique and partial Fourier acquisition. Right row with standard sequence. Loss of SNR in magnitude and velocity images is easily detected.

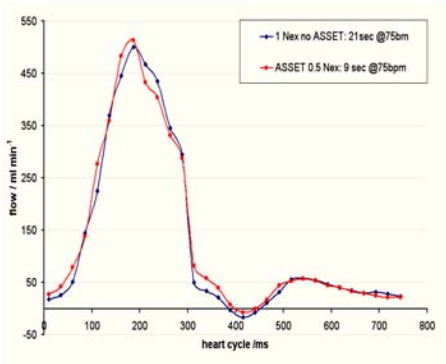

Figure 2: Flow volume in the ascending Aorta measured with standard sequence (blue) and combined ASSET and partial Fourier acquisition (red).