# Analysis of flow in artificial stenosis models of mid-sized arteries using 3D PC-MRI

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## Purpose

The aim of this work was to investigate whether tri-directional encoded velocity information could be applied to support the grading of stenosis in mid-sized arteries.

## Background

Phase contrast MRI allows access to tri-directional encoded velocity information and therefore, measurement of flow in the human hemodynamic system. This information can be used to characterize flow patterns of complex vessel structures and to describe hemodynamic pathologies like stenosis or aneurysm but large vessels were successfully analyzed [1]. However, also in small vessels like the renal artery, stenoses are often observed making 3D PC-MRI interesting. Furthermore, in stenosis one has to deal with signal loss due to turbulent flow and large flow gradients mostly influenced by the vessel size and flow rates [2]. This work was performed to analyze the feasibility of 3D PC-MRI in small vessels like the renal artery.

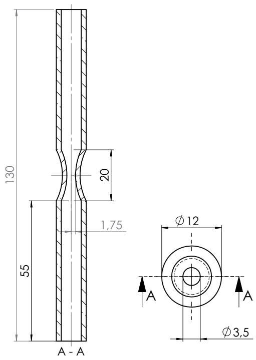


*Fig.1: Scheme of the artificial stenosis model. All measures are in mm.*

## Materials and Methods

Using a specially constructed flow phantom and a stenosis model with tube diameter of 8 mm and a stenosis of 50% (cf. Fig. 1), experiments at different flow rates (180 - 640 ml/s), slice thickness (1 – 4 mm), field strength (1.5 and 3.0 T), and multi-slice as well as 3D volume acquisition were acquired. Imaging was performed using a 3D Flash Sequence and tri-directional flow encoding [3] with parameters TE/TR/FA=5.5ms/8.5ms/15° at 1.5T and TE/TR/FA=5.7ms/8.7ms/15° at 3.0T and in-plane resolution of 0.59x0.59mm². The VENC in x and y direction was 10 cm/s, in z-direction the acquisition volume was separated in two areas, before and after stenosis with VENC of 20 cm/s and 80 cm/s for flow rates below 400 ml/min and 30 cm/s and 120 cm/s for the higher flow rates. A detailed setup is described elsewhere [4]. The observations were assessed visually and evaluated by signal-to-noise (SNR) ratios in regions before and after the stenosis.

## Results

Our results show that typical flow patterns like a central beam and areas of recirculation can be observed after the stenosis (cf. Fig. 2). However, at 1.5T already at 400 ml/min and for 3T at 500 ml/min a strong signal loss is observed as seen by the measured SNR (cf. Fig. 3). In comparison, no detectable differences in the flow patterns of the 2D and 3D acquisition could be observed. Varied slice thickness reduces intra-voxel dephasing (lower SNR ratio before and after stenosis, data omitted) but does not influence the overall signal loss [4].

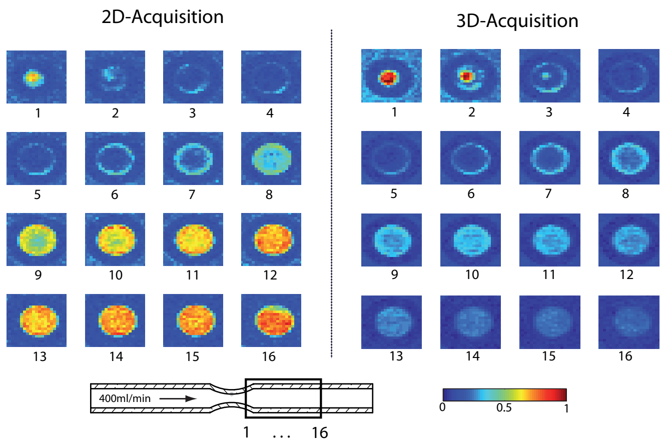


*Fig. 2: Series of magnitude images obtained from 2D and 3D acquisition at flow rate of 400 ml/min at 1.5T. Signal loss can be observed at images no. 2 – 8. For the 3D acquisition, signal decay can be observed the more distant the imaging slice is positioned from the stenosis (see also the scheme of slice positioning).*

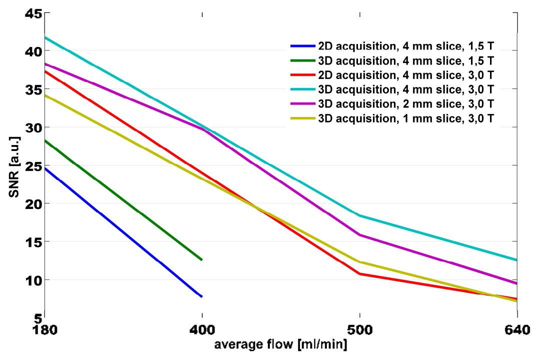


*Fig.3: Plot of SNR for flow rates between 180 ml/min and 640 ml/min. SNR calculated and averaged in images recorded in a range of 20mm after stenosis in flow direction. Each line represent the different settings (acquisition, field strength, slice thickness) investigated. For flow rates above 400 ml/min and 1.5T no measurements were performed.*

## Discussion

In summary, 3D PC-MRI of mid-sized vessels with stenosis is feasible for certain flow rates. The obtained results show that examinations should be performed at high field (3.0 T) and at flow rates up to 500 ml/min without hampering the measurements by areas of signal loss. The presented results could be seen as guidance for in vivo situations to assess if an examination of a patient is reasonable in terms of outcome.

## References

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4. Scheuer, S., et al., *Analysis of flow in artificial stenosis models of mid-sized arteries using 3D PC-MRI.* Z Med Phys, 2009, in press.