# TOF MR angiography at 3.0 Tesla during acetazolamide provocation demonstrates decreased vasomotor reactivity ipsilateral to a carotid artery stenosis

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## Introduction

Cerebral autoregulation is the capability of the cerebrovascular system to keep the cerebral blood flow (CBF) constant during fluctuations in the arterial blood pressure. Compensation for changing perfusion pressures is possible through vasodilatation of the cerebral arteries and arterioles [1]. Studies have shown this vasomotor reactivity (VMR) is impaired in patients with steno-occlusive carotid artery disease and that an impaired VMR is an important predictor of stroke and TIAs [2-4]. Thus far, studies that have directly investigated the VMR of the cerebral vessels have focused on the proximal cerebral vasculature. With ultrasound and traditional angiography, reported increases in the vessel diameter of the proximal cerebral vasculature ranged from 0 to 5% [5-7]. By combining high-resolution MR angiography (MRA) with a vasodilatory challenge it is possible to assess the VMR of the small cerebral vasculature, which may contribute to a better understanding of the aetiology and pathogenesis of an impaired dilatory capacity of the distal cerebral vasculature. The aim of our study was to investigate VMR of both the proximal and distal cerebral vasculature using high-resolution MR angiography in patients with a symptomatic stenosis of the internal carotid artery (ICA) and healthy control subjects after an intravenous administered acetazolamide challenge.

## Methods and materials

Twelve functionally independent patients with a symptomatic stenosis of the ICA (7 males / 5 females; mean age ± SD, 69.3±7.4 years) and 24 healthy control volunteers (7 males / 17 females; 60.0±7.9 years) underwent MRA before and 20 minutes after intravenous administration of 14 mg/kg acetazolamide (maximum dosis 1200 mg). All patients had had a TIA or a non-disabling ischemic stroke (modified Rankin score of 1 - 2) in the supply territory of the stenotic ICA within three months prior to inclusion. MRA was performed on a 3 Tesla MRI scanner (Achieva, Philips Medical Systems) with a 3-dimensional time-of-flight (3D-TOF) sequence (TR/TE, 23/3.5ms; SENSE, 2.0; FOV, 200x200x100 $mm^3$; matrix, 304x200 with 100 slices $mm^3$; reconstructed voxel size, 0.39x0.39x1 $mm^3$). VMR of multiple vessels was assessed by measuring the increase in vessel diameter after administration of acetazolamide. The VMR of the following arteries was measured: the ICA, the A1 and A2 segment of the anterior cerebral artery (ACA), the pericallosal artery, the callosomarginal artery, the M1, M2 and M3 segment of the middle cerebral artery (MCA) and the P1 and P2 segment of the posterior cerebral artery (PCA) and the superior cerebellar artery (SCA). The diameter of a vessel was defined on the transversal MRA source images as the full-width-at-half-maximum (FWHM), calculated from an intensity profile through the centre of the vessel (Figure 1). The study was approved by the institutional review board, and informed consent was obtained.

## Results

No differences in diameter increase were found between the left and right hemispheres in healthy subjects, for which reason the increase in diameter was averaged between both hemispheres. In the healthy control group there was a significant increase ($p<0.05$) in vessel diameter in 10 out of 11 vessels (Figure 2). In the patients with a symptomatic stenosis of the ICA, there was no increase in vessel diameters in the hemisphere ipsilateral to the stenosis. In the hemisphere contralateral to the symptomatic ICA stenosis there was a significant increase in vessel diameter in the pericallosal artery (mean increase±SEM, 4.8±1.7%, $p=0.02$) and 2 segments of the anterior cerebral artery (ACA); the A1 segment (5.8±1.8%, $p=0.01$) and A2 segment (6.4±1.5%, $p<0.01$). The VMR was significantly lower in the A1 segment of the ACA (mean increase ± SEM, 0.3±2.8% vs 9.5±1.1%, $p<0.01$) and P2 segment of the posterior cerebral artery (PCA) (0.8±1.9%, vs 5.6±1.1%, $p<0.01$) of the hemisphere ipsilateral to the symptomatic ICA stenosis when compared to the healthy subjects. There was no difference between the VMR of the contralateral hemisphere and control subjects.

## Conclusion

The most important finding of this study is that by combining high-resolution MR angiography with a vasodilatory challenge, impairment of VMR can be assessed in patients with a symptomatic stenosis of the carotid artery. In the hemisphere ipsilateral to the symptomatic ICA stenosis there was no significant increase in vessel diameter, whereas vessel diameter increased significant in the proximal vasculature of the contralateral hemisphere. Furthermore, a significant diameter increase in the proximal and distal cerebral vasculature was measured in the healthy control subjects. As a non-invasive tool for assessing the autoregulative capacity of the cerebral vasculature, MRA combined with a vasodilatory challenge may contribute to a better understanding of vasomotor reactivity in, and status of, the distal cerebral vasculature.

## References

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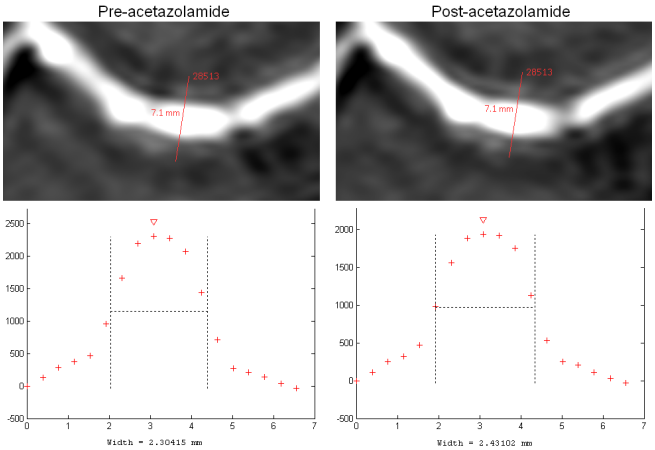


**Figure 1.** *Diameter measurement of the M1-segment using the FWHM-method*

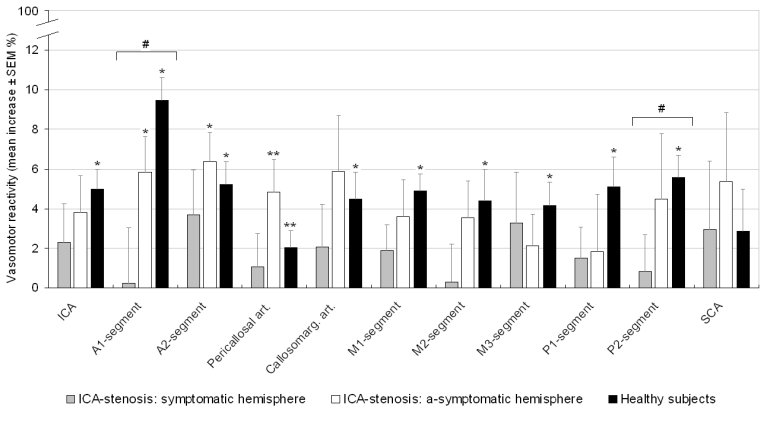


**Figure 2.** *Vasomotor reactivity. A significant diameter increase in the corresponding vessel is indicated by * ($p<0.01$) or ** ($p<0.05$); # indicates a significant difference of the symptomatic hemisphere compared to the control group ($p<0.05$)*