Evaluation of Blood Flow Rates With Phase Contrast Magnetic Resonance Angiography before and after Intracranial Stent Placement

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Introduction

Occlusive cerebrovascular disease is one of the most common causes of ischemic stroke. In order to assemble a complete diagnostic picture necessary for defining a treatment option, the physician has to obtain accurate information about the extent of vascular involvement and the impact that it has on blood supply to the brain [1]. Important components of this information include blood flow rate, blood velocity and the perfusion of the parenchyma supplied by a diseased (stenosed) artery.

Vascular stenting as a revascularization procedure is widely used in different parts of the vascular system including the cerebral vasculature. Phase contrast magnetic resonance angiographic (PCMRA) measurements can determine blood flow velocities and volumetric flow rates in vitro and in vivo [2]. The accuracy of these measurements are believed to be determined by factors including partial volume and curved-flow effects [3]. In order to minimize the influence of those factors, the slice position at which blood velocity and flow rate are to be measured has to be perpendicular to the direction of the vessel. As the intracranial vessels show high tortuosity, this is sometimes not easy to achieve which has limited the use of PCMRA for cerebrovascular vessels as part of a standard clinical MRI or MRA examination. We here report our experiences of using the NOVA system (Vassol, Inc.) for evaluating blood flow in diseased vessels before and after vascular stenting.

Methods

In 18 patients with intracranial stenosis in the cerebral vessels (6 internal carotid artery (ICA) , 4 middle cerebral artery (MCA), 5 basilar artery (BA) and 3 vertebral artery (VA)) blood flow and blood velocity measurements were performed before and after stent application. Retrospective peripherally cardiac gated PCMRA in combination with the NOVA system was used. Blood velocity profiles were acquired distal to the stenosis to evaluate the effect of the stent placement. If possible, blood flow was measured in several vessels distal to the stenosis. Coordinates for these PCMRA measurements were derived semi-automatically by the software based on a 3D surface rendered reconstruction of the vasculature calculated from a 3D time-of-flight (TOF) acquisition (head) or a 2D TOF acquisition (neck), ensuring that the slice positions were perpendicular to the vessel axis. A total of 24 phases were reconstructed for one cardiac cycle. For each of those images, the vessel boundaries were outlined automatically and changed manually through the NOVA interface if needed. The average volumetric blood flow rate was obtained by summing the contributions for each phase and dividing by the number of phases.

Results

The range of distal blood flow rates in the diseased vessels before stenting were 98-236 ml/min (ICA), 13-94 ml/min (MCA), 20-199 ml/min (BA) and 60-116 ml/min (VA). Measured blood flow rates after stenting were 143-313 ml/min (ICA), 88-170 ml/min (MCA), 78-233 ml/min (BA) and 138-158 ml/min (VA). In all cases, stenting increased blood flow in the distal vessel segments (mean 166 %, stddev: 286 %). The figure shows the distribution of the distal blood flow rates relative to the normal flow rates in the investigated vessels.

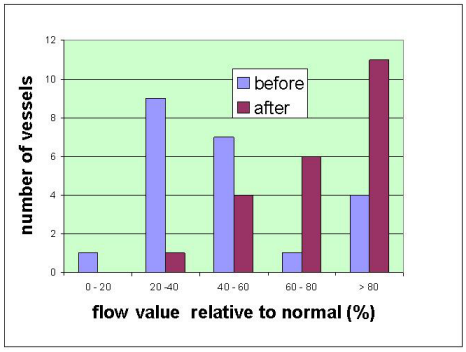

Figure: Distribution of blood flow rate values measured in vessels distal to stenosis before and after stent placement.

Discussion

PCMRA in combination with the NOVA system has been found to be easily applicable to measure blood flow rates as part of a clinical MRI or MRA exam. Total exam time varied from 45 min to 90 min and was influenced by the number of PCMRA measurements taken and the coils used. As shown in the figure, more vessels show flow rates with higher values after stent placement and the number of vessels with low flow rates has decreased. Our results indicate that the quantitative determination of blood flow using PCMRA may be a useful diagnostic tool in the evaluation of intracranial stenosis both before and after revascularization treatment.

References

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