Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/pjnns

Original research article

Brain perfusion evaluated by perfusion-weighted magnetic resonance imaging before and after stenting internal carotid artery stenosis in asymptomatic and symptomatic patients

Maria Małowidzka-Serwińska [a,*], *Magdalena Żabicka* [b], *Adam Witkowski* [c], *Zbigniew Chmielak* [c], *Tomasz Deptuch* [c]

[a] *Unit of Neurology, Institute of Cardiology, Warsaw, Poland*
[b] *Department of Radiology, Military Institute of Medicine, Warsaw, Poland*
[c] *Department of Interventional Cardiology and Angiology, Institute of Cardiology, Warsaw, Poland*

ARTICLE INFO

Article history:
Received 22 January 2015
Received in revised form
31 July 2015
Accepted 12 October 2015
Available online 24 October 2015

Keywords:
Magnetic resonance imaging
Perfusion-weighted imaging
Carotid artery stenosis
Carotid stenting
Cerebral hemodynamics

ABSTRACT

Purpose: To evaluate the brain perfusion with MRI perfusion weighted imaging (PWI) before and after ICA stenting in asymptomatic and symptomatic patients.
Materials and methods: PWI was performed 3–21 days before and 3 days after ICA stenting in 31 asymptomatic patients with ICA >70% stenosis – Group I, and in 14 symptomatic patients with ICA >50% stenosis – Group II. PWI was evaluated qualitatively and quantitatively in 5 cerebral territories with: mean transit time (MTT), cerebral blood volume (CBV) and cerebral blood flow (CBF). Mean values of perfusion parameters were measured before and after stenting ΔMTT, ΔCBV, ΔCBF were calculated as subtraction of after-treatment values from those before treatment.
Results: In qualitative evaluation after ICA stenting perfusion was normalized in 21 patients (80.8%) in Group I and in 8 patients (80%) in Group II.

In quantitative estimation MTT decreased significantly after CAS on stented side vs. non-stented side in all examined patients regardless of the group, $p < 0.05$. MTT decreased more in Group II than in Group I in all territories ($p < 0.05$) with the exception of temporal lobe. CBV and CBF have shown insignificant differences.
Conclusions:

1. In MRI the most useful parameters to assess brain perfusion are MTT and ΔMTT: regardless whether patients are asymptomatic or symptomatic.

* *Corresponding author at*: Unit of Neurology Institute of Cardiology, Alpejska 42, 04-628 Warszawa, Poland. Tel.: +48 601851631; fax: +48 223434506.
E-mail address: m.malowidzka@ikard.pl (M. Małowidzka-Serwińska).
http://dx.doi.org/10.1016/j.pjnns.2015.10.005

2. There were no significant differences in CBV and CBF after stenting in both groups of patients.
3. The positive effect of ICA stenting measured with decrease of MTT, CBV values and increase of CBF value is more prominent in symptomatic patients.

Keypoints:

Perfusion MRI can provide clinically useful information. The best indicator of perfusion changes is MTT. Decrease of MTT is more prominent in symptomatic patients.

1. Introduction

Internal carotid artery (ICA) stenosis can cause both acute ischemic stroke and chronic brain ischemia.

Severe ICA stenosis discriminates cerebral perfusion in the distal part of ICA vascularity – in vascularity territory of middle cerebral artery and/or anterior cerebral artery.

The increase of cerebral perfusion disturbances depends first of all on the rate of the stenosis increase, the efficiency of the circle of Willis, collateral circulation and also systemic blood pressure. It depends less, and in the opinion of some investigators does not depend at all, on carotid stenosis severity [1–3].

The longer carotid artery atherosclerosis lasts the more cerebral autoregulation is damaged, which in turn increases the stroke risk [4].

The findings of a growing number of randomized clinical studies show that ICA stenting improves cerebral perfusion. The changes of cerebral perfusion are seen just after intervention in symptomatic patients, while their influence is less pronounced in asymptomatic patients [3,5–8].

The reports on perfusion with MRI are not numerous. It especially refers to asymptomatic patients where the number of patients examined is insufficient to estimate credibly the value of stenting in primary stroke prophylaxis and risk for hyperperfusion syndrome, microhemorrhages or micro-strokes producing the possibility of developing dementia in the future.

An open question is whether asymptomatic patients benefit approximately just as symptomatic patients do, and in which cases the risk of hyperperfusion syndrome exists after stenting.

In most patients brain perfusion after ICA dilatation increases by 20–40% over the baseline value. This increase takes place in the first few hours after intervention and is mostly asymptomatic [9,10].

In some patients, most often 3–4 days after stenting, the increase of perfusion evaluated with computer tomography (CT) is above 100–200% of initial value found in the contralateral hemisphere, which results in cerebral hyperemia and clinical hyperperfusion syndrome [9].

In most reports, hyperperfusion syndrome occurs in 0–3% of cases [3,9]. It is a rare but dangerous complication of carotid dilatation. This complication is considered as abnormal, worse cerebral vascular bed reactivity as a result of prolonged reduced perfusion on the stenosed artery side.

It is not more common in patients with severe ICA stenosis or coexisting contralateral ICA stenosis [9,11,12]. Clinical symptoms range from severe to almost none, through headache, nausea, vomiting, blurred vision, epileptic seizures, focal neurological symptoms to acute cerebral edema, intracranial hemorrhage. But also an opposite phenomenon is seen: in spite of clinical symptoms of hyperperfusion syndrome increased cerebral perfusion does not appear [9].

PWI and DWI with MRI help detect perfusion disturbances, ischemic changes at their earliest phase without changes in cerebral tissue, give an insight into stroke dynamics in vivo [13].

There are two commonly used methods to measure MRI perfusion [14–17]. The more popular is dynamic susceptibility contrast imaging (DCS–MRI). It uses rapid measurements of MRI signal change in the brain during the first pass of a paramagnetic contrast bolus injected intravenously. Either T1, T2 or T2* weighted sequences can be used. The deconvolution of an arterial input function is necessary to obtain the tissue response function and to produce maps of perfusion parameters: MTT, CBV and CBF. T_0 (time to arrival) and TTP (time to peak) could be estimated to show the local variations of contrast arrival time. Usage of a standard dose 0.1 mmol/kg b.w. of high relaxivity contrast agent or a double dose of conventional contrast agent improve the signal to noise ratio [15,18] resulting in high quality of obtained images.

The other technique is arterial spin labeling ASL. It is an endogenous tracer method in which the magnetically labeled protons in inflowing blood exchange with tissue protons producing the change of signal. The image of cerebral blood flow can be obtain by measuring signal changes between labeled and baseline unlabeled images.

The study of perfusion parameters before and after ICA stenting can bring the knowledge about pathophysiological factors of stroke, cerebral autoregulation disturbances in asymptomatic and symptomatic patients with ICA stenosis, help identify patients at risk for hyperperfusion syndrome [3,11]. The information from DWI, PWI imaging can be used in choosing treatment methods and evaluating complications [19–21].

DWI, PWI and their correlation with neurological state seem to allow physicians to detect a patient's profile, risk factors, characteristics predicting the onset of such complications as hyperperfusion syndrome, vegetative disturbances, and can improve patients' selection who will benefit from revascularization [22].