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Assessment of cerebral embolism and vascular reserve parameters in patients with carotid artery stenosis

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ABSTRACT

Aim: Carotid artery stenosis can result in the brain tissue injury related to the intracranial aterial flow disturbances as well as microembolic complications. The choice of the proper therapy in patients with carotid artery stenosis, especially asymptomatic, remains still a significant clinical problem. The study aim was an assessment of the cerebral embolism and brain vascular reserve parameters in patients with carotid artery stenosis regarding the occurrence of the clinical symptoms, the degree of stenosis as well as plaque morphology.
Methods: The study included 60 patients, with internal carotid artery stenosis. The degree of stenosis, the atherosclerotic plaque surface and morphology were assessed by the means of Duplex Doppler ultrasound. Cerebrovascular reactivity (vasomotor reactivity reserve test and Breath Holding Index) and monitoring of the microembolic signals (MES) were assessed with transcranial Doppler ultrasound examination (TCD).
Results: The vasoreactivity parameters were significantly lower in the group of patients with stenosis ≥70% and in patients with ulcerations on the plaque surface. Microembolic signals were recorded significantly more often in symptomatic patients; in patients with stenosis ≥70%; in patients with ulcerations on the plaque surface and those with hypoechogenic plaque structure.
Conclusions: Microembolic signals in patients with symptomatic carotid stenosis are one of the ultrasound features of unstable carotid stenosis. Worse reactivity parameters of the cerebral arteries are associated with the presence of a large degree of carotid artery stenosis.

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1. Introduction

Carotid artery stenosis >50% is identified by an ultrasound examination in more than 5% of people over 65 years of age, twice as often in men [1,2]. According to most investigators, the annual risk of cerebral stroke on the side of stenosis is at the level of 1–5% [3–5]. The degree of stenosis, the plaque morphology (stability) as well as the probability of thrombus formation at the site of stenosis and also the development of collateral circulation and presence of other risk factors for stroke, all influence on the occurrence of neurological symptoms resulting from internal carotid artery stenosis [6].

The basic method used for diagnostic in patients with carotid artery stenosis is the Duplex Doppler ultrasound examination which allows to assess the degree of stenosis and morphology of stenotic lesions [7,8]. The ultrasound characteristics of atherosclerotic plaque associated with higher incidence of cerebral ischemic symptoms include: hypoechogenic, or predominantly hypoechogenic plaque structure and irregularities or ulcerations on the surface of the plaque. However, in the recently published literature, the discussion concerning the definition of the so called ''unstable'' or ulcerated carotid plaques continues [9–11].

Carotid Duplex Doppler ultrasound is not always a sufficient method to estimate the real risk of cerebral ischemic events. Among available additional diagnostic methods are neurosonological examinations with trancranial Doppler (TCD) ultrasound. TCD enables the assessment of hemodynamic changes in cerebral circulation, development of collateral circulation and detection of microembolic signals (MES) which may be caused by unstable atherosclerotic plaque in carotid arteries [12,13].

Arterio-arterial embolism is the main mechanism of ischemic cerebral stroke in patients with internal carotid stenosis. An important role is also played by hemodynamic changes caused by impaired blood inflow and exhaustion of the compensatory abilities of cerebral circulation associated with the presence of significant internal carotid artery (ICA) stenosis [14,15]. Tests for cerebrovascular reactivity in patients with cerebral circulation insufficiency due to decreased flow resulting from stenosis of the ICA make it possible to assess the vascular reserve. Decrease in the vascular reserve indicates that the adaptation capabilities of the local cerebral flow have been exhausted in response to hypoperfusion and inefficient collateral circulation. Diagnosing such events in patients with ICA stenosis may serve as an additional argument for the necessity of interventional treatment to restore extracranial patency [16–18]. Both factors, microembolisation as well as vascular reserve decrease can coexist in patients with carotid stenosis, however, the prediction of the main factor responsible to the brain ischemic complication in the clinical setting remains still very difficult. The aim of the study was to assess cerebral embolism and vascular reserve parameters with the use of Doppler examination in patients with symptomatic as well as asymptomatic carotid artery stenosis.

2. Materials and methods

The study included 60 patients (18 women and 42 men), mean age 66.29 years (±SD 7.77), with symptomatic (38 individuals) or asymptomatic [22] atherosclerotic internal carotid artery stenosis above 50%. In the group of symptomatic patients, neurological symptoms including stroke, reversible ischemic neurological deficit or transient ischemic attack were diagnosed within 6 months before the inclusion into the study (the onset of the neurological complains from 15 to 154 days before the ultrasound examination and carotid artery stenosis diagnosis).

The study inclusion criteria covered: unilateral atherosclerotic internal carotid artery stenosis above 50% confirmed by the means of with the US Duplex Doppler examination. The exclusion criteria included: non-atherosclerotic stenosis; occlusion or stenosis ≥50% ICA on the contralateral side; potential causes of cerebral embolism other than atherosclerotic lesions in the carotid artery (atrial fibrillation, mitral and/or aortic valve stenosis, mechanical heart valve, previous myocardial infarction, persistent foramen ovale or another defect, interatrial septal aneurysm, hypo/akinesia of the cardiac walls, cardiac cavity myxoma, thrombus in the left ventricle or atrium, carotid artery dissection or intraluminal thrombosis) – visible in the US examination and brain damage other than of a vascular origin (according to the assessment of the computed tomography or magnetic resonance imaging of the head – imaging study performed in all subjects). All the patients were also rated in relation to the occurrence of stroke risk factors and comorbidities which included: arterial hypertension, ischemic heart disease, diabetes, obesity, peripheral artery disease, chronic kidney disease, lipid disorders and nicotinism.

All the patients included into the study went through: Duplex Doppler ultrasound examination of the carotid and vertebral arteries as well as transcranial Doppler examination of cerebral arteries with assessment of vascular reactivity and monitoring of the middle cerebral artery for the presence of microembolic signals. The duplex carotid and vertebral artery test was performed with the 7.5 MHz linear array probe of PHILIPS ENVISOR C02 along with the assessment of the degree of stenosis and atherosclerotic plaque morphology. Grading of carotid stenosis was based on morphological information (B-mode images, color flow imaging), velocity measurements (in a stenosis and poststenotic segment) and the assessment of collateral flow according to combined criteria for grading internal carotid stenosis published by von Reutern et al. [19].

Plaque echogenicity was based on the Gray-Weale classification and evaluation of the Greyscale Median (GSM) after the normalization of ultrasound images [20,21]. Basing on ultrasound examinations the plaque echogenicity was divided into two categories: hypoechogenic (GSM ≤ 25) and hyperechogenic (GSM > 25). The presence of ulcerations on the surface of atherosclerotic plaque was also assumed as a characteristic of unstable atherosclerotic plaque. Ulceration was determined as a plaque surface niche or crater filled with reversed flow visible in a longitudinal and a transverse plane. Flow disturbances on the plaque surface were imaged using color-coded duplex sonography. Retrogade flow components within a niche were