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Predictors of intracranial cerebral artery stenosis in patients before cardiac surgery and its impact on perioperative and long-term stroke risk

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ABSTRACT

Background: The aim of this prospective study was to determine the prevalence of stenosis within intracranial and extracranial arteries in patients before coronary artery bypass surgery (CABG), to evaluate the influence of intracranial artery stenosis on neurological outcome and to identify preoperative risk factors for these patients.

Methods: One hundred and seventy-five patients (71% males, mean age = 66.1) scheduled for CABG were enrolled for extracranial Doppler duplex sonography, transcranial color-coded duplex sonography (TCCS) and transcranial Doppler (TCD) examination.

Results: Twenty-six patients (14.7%) had extracranial stenosis or occlusion and 13 patients (7.3%) intracranial vascular disease. Six patients (3.5%) had both extra- and intracranial artery disease. The presence of peripheral artery disease and diabetes mellitus was a strong risk factor for extracranial artery stenosis but not for intracranial artery stenosis, which occurred independently also of typical atherosclerotic risk factors like age >70, male sex, hypertension, hyperlipidemia, hyperhomocysteinemia, smoking habit, obesity (BMI > 30) and waist to hip ratio >1. Functional neurological outcome of the patients with intracranial arterial disease evaluated 7 days after CABG was the same as the patients without extra- and intracranial stenosis. However, 12-months neurological follow-up revealed significantly more ischemic strokes in patients with intracranial artery stenosis compared to patients without intracranial stenosis ($p = 0.015$).

Conclusion: The occurrence of intracranial artery stenosis in CABG patients cannot be predicted by well-known atherosclerotic risk factors and seems not to be associated with perioperative stroke.

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Introduction

Stroke is a feared complication of coronary artery bypass graft (CABG) surgery, and despite the improvement in surgical techniques in the last decade, its incidence currently is estimated to be as high as 1.3% to even 4.3% [1]. Cerebral ischemia during the CABG is usually evoked by hypotension–hypoperfusion, embolic phenomena (cardiac or of the aorta), thromboembolism of extracranial and intracranial vessels, or most probably, by the combination of some of these factors [2].

It is well known, that the presence of carotid artery stenosis significantly increases the risk of perioperative stroke and carotid evaluation is currently recommended prior to CABG procedure, although there are still some controversies surrounding prophylactic carotid stenosis management [3]. However, the relevance of intracranial artery stenosis in the group of CABG patients is less clear, mostly because of limitation of available data. In general, intracranial atherosclerosis is believed to be one of the main causes of ischemic stroke and is frequently recognized in the patients with widespread vascular disease. It accounts for about 8–10% of all brain ischemic events. Patients with intracranial stenosis may have a risk of recurrent stroke as high as 20% in the first 2 years despite best medical therapy [4,5].

Thus, we aimed to determine the prevalence of intracranial artery stenosis in patients before elective CABG and to evaluate the influence of intracranial stenosis on perioperative neurological complications and long-time prospective neurological outcome. We also tried to identify predictors for cerebral artery stenosis in CABG patients.

Patients and methods

One hundred and seventy-five consecutive patients scheduled for elective CABG (on the basis of coronary angiography), were enrolled for carotid extracranial Doppler duplex sonography and transcranial color-coded duplex sonography (TCCS) (ESAOTE TECHNOS MPX), and transcranial Doppler (TCD) examination (VIASYS SONARA). Patients without severe coronary artery disease and with no adequate temporal window on TCCS/TCD were excluded from this study.

At each examination, a questionnaire requesting information on demographic background and medical history was completed. Clinical information was obtained directly from the patients and medical records at the time of ultrasound examination. We investigated the presence or absence of hypertension, diabetes mellitus, hyperlipidemia, peripheral artery disease (PAD) and the habit of smoking. Subjects were considered hypertensive if their systolic blood pressure (assessed on repeated measurements) was ≥140 mmHg, if their diastolic blood pressure was ≥90 mmHg or if they were taking antihypertensive medication. Subjects were defined as diabetic if their fasting glucose level was ≥7.00 mmol/L (126 mg/dL) at least twice within a 48 h interval or if they were taking antidiabetic medication. PAD was assessed based on the history of intermittent claudication defined as pain in the muscles of the leg with ambulation. They were classified as smokers if they smoked at least one cigarette per day, as non-smokers if they had never smoked or smoked shorter than 2 years and quit smoking >1 years prior to examination. Waist circumference was measured around the narrowest point between the coastal margin and the iliac crest. Hip circumference was measured at the level of the widest diameter around the gluteal region. Waist-to-hip ratio (WHR) is waist circumference divided by hip circumference. BMI and WHR were calculated for each subject on the day of ultrasound examination.

The neurological assessment before surgery consisted of an interview and neurological examination. The patients were reevaluated three times – 1 week after surgery (or earlier if necessary), 6 months and 12 months later, and followed by the same neurologist who performed the initial neurological examinations (PL). Development of any case of stroke and the final neurological outcome at discharge were determined (according to NIH Stroke Scale). Stroke was defined as a new and sudden onset of focal neurological deficits lasting >24 h with no apparent nonvascular causes.

The atherosclerotic risk factors were predefined according to the guidelines of the American Heart Association, The Third Joint Force of European and other Societies on Cardiovascular Disease Prevention in Clinical Practice [6,7] and our University Hospital laboratory's reference values. To investigate the relationship between the number of atherosclerotic risk factors and extracranial or intracranial artery stenosis we classified each patient according to the presence of single or multiple risk factors. Patients were considered to be at risk when one or more of criteria were fulfilled: total cholesterol (T-Chol.) > 200 mg/dL, LDL-C > 135 mg/dL, high density cholesterol (HDL-C) < 40 mg/dL, T-Chol./HDL ratio > 5, triglycerides > 200 mg/dL, BMI > 30 kg/m^2 as well as presence of hypertension, diabetes and smoking habits.

The degree of stenosis in the extracranial segment of internal carotid artery (ICA) and vertebral artery (VA) was classified as normal flow or <50% stenosis, 50–69% stenosis, 70–99% stenosis or occlusion. The degree of stenosis in the intracranial segments of the ICA (iICA) and VA (iVA) as well as the stenosis of the anterior cerebral artery (ACA), middle cerebral artery (MCA), posterior cerebral artery (PCA) and basilar artery (BA) were classified as normal flow or <50% or ≥50% stenosis or occlusion. The ultrasound examinations were performed by two neurologists (JW and PL, working in consensus). Locations of stenosis were categorized as being in the intracranial or extracranial vessels. The degree of the stenosis was established based on the peak systolic velocity, diastolic velocity and mean flow velocity as previously reported [8,9].

Univariate analyses were performed to assess the association between the prevalence of extracranial artery stenosis (EAS) and intracranial artery stenosis (IAS) with the possible risk factors. First, all variables were analyzed using Fisher's exact χ^2 and Mantel–Haenszel χ^2 tests as appropriate. The t-test was used to compare ages. A multiple logistic regression analysis was used to estimate independent effects of the predictive variables on the cerebral arterial occlusive disease. The analyses were performed separately for extracranial cerebral arteries and intracranial arteries, with each predefined abnormality as a dependent variable and with possible risk factors as independent variables. The level of significance