
Vertebral Artery Hypoplasia: Importance for Stroke Development, the Role of the Posterior Communicating Artery, Possibility for Surgical and Conservative Treatment

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The importance of vertebral artery hypoplasia for brain perfusion is discussed in the current study. The attention is paid to the hypoplasia of the vertebral artery, as it can be followed by anatomical changes in the circle of Willis. This study is based on 47 cases of vertebral artery hypoplasia. The case histories of the patients were selected and analysed. Eight patients had previous surgical treatment – periarterial desympatisation of vertebral arteries. The results of the study show that in the case of absence of the posterior communicating arteries, patients with pathological vertebral arteries are at a higher risk of cerebrovascular insufficiency. The conservative treatment of vertebrobasilar ischemia provided by vertebral artery hypoplasia is more effective than hypoplastic vertebral artery desympatisation.

Key words: posterior communicating artery, hypoplasia of the vertebral artery, stroke, vertebrobasilar circulation, circle of Willis

INTRODUCTION

A lot of risk factors that influence cerebrovascular insufficiency are being researched. Although not fully investigated, congenital anomalies of cerebral vessels are known to be able to lead to cerebrovascular ischemia as well. There are reports that 5–10% of the population have hypoplasia of the vertebral arteries (1). Hypoplasia of a vertebral artery is diagnosed when its diameter is 2 mm or less. The diameter of a hypoplastic vertebral artery is 2–2.8 mm (2). Approximately 3% of the patients with vertebral artery pathology are detected to have hypoplasia (3).

The communicating arteries of the circle of Willis play the main role in ensuring the blood flow to every part of the brain. The posterior communicating artery (PCoA) is the junction between the vertebrobasilar and carotid systems. However, the posterior part of the circle of Willis (including the posterior cerebral arteries and the posterior communicating arteries) is characterized as the most

variable structure (4). Only in 15–52% of the patients the circle of Willis is visualized without alterations (5–8). The functioning posterior communicating arteries are found in 78% of people (9). In about 10% of cases congenital changes of posterior communicating arteries such as absence, hypoplasia or doubled are detected (1).

The aim of our study was to evaluate the influence of the posterior communicating arteries (PCoA) on vertebrobasilar circulation in the group of patients with vertebral artery hypoplasia and to investigate the possibilities for surgical and conservative treatment of cerebrovascular ischemia created by vertebral artery hypoplasia.

PATIENTS AND METHODS

This is a retrospective and hospital-based study. It is based on 47 patients with vertebral artery hypoplasia. The case histories of these patients have been selected and analysed. Eight patients had previous surgical treatment – periarterial desympatisation of vertebral arteries. The diameter of one or both vertebral arteries was less than 2.8 mm on ultrasound investigation. In 39 patients CT- or MRI angiogra-

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phy was carried out for the circle of Willis visualization. Age, sex, findings of the lipidograms (total cholesterol, triglycerides, HDLP, LDLP) as well as smoking habits and alcohol consumption were evaluated. The importance of the concomitant diseases (diabetes mellitus, arterial hypertension, ischemic heart disease) was also investigated. The operated on patients with vertebral artery hypoplasia made a separate group. All operated a patients had had transient ischemic attack (TIA) or stroke in vertebrobasilar region. These patients were analysed separately for follow-up results only.

Thirty-nine patients were divided into two groups: study and control. Patients of the study group were diagnosed as having vertebrobasilar symptoms. According to WHO criteria (1980), they were divided into 3 subgroups: 1. With transient ischemic attacks (TIA); 2. With reversible ischemic neurological deficit (RIND); 3. Stroke in the vertebrobasilar circulation.

Thirty patients with vertebrobasilar symptoms (research group) were distributed as follows: 43.3% (13 patients) had undergone stroke, 36.7% (11) – RIND and 20% (6) of the study group patients had suffered from TIAs. There were 9 patients in the control group and 8 patients in the operated on group. The study and the control groups were compared. In both groups females prevailed. The average age of the patients in the study group was 58.4 years and in control 52.3 years.

No vertebrobasilar symptoms in the patients of the control group were detected. These patients were accidentally visualized as having hypoplasia or they had undergone stroke in carotid circulation. In each group the variations of PCoA (the absence of both PCoA, one PCoA or both PCoA) were evaluated.

The dependence of each group on the alterations of the posterior communicating arteries were statistically analyzed.

RESULTS

There was noted that 13 patients had undergone stroke, 11 patients – RIND, 6 patients – TIA and 9 patients were included into the control group. Eight patients were operated on for vertebrobasilar ischemic event prophylaxis and were included into a separate group. No comparison was made for this group, because we don't have follow-up results for other patients at present. Due to the concomitant pathology (arterial hypertension, ischemic heart disease and diabetes mellitus) there was no statistically significant difference among the groups. The data of lipidograms were analyzed too. According to total cholesterol, HDLP and LDLP findings in both groups didn't differ, either. Although there was a

difference among the groups in the level of triglycerides, higher values were detected in the control group. The average of vertebral artery diameter in the study and control groups was found to be equal – 2.5 mm. The highest value was 2.7 mm and the lowest 2.0 mm. Besides hypoplasia, additional pathology of a vertebral artery was also detected. Angulations were detected most frequently, whereas occlusions, scleroses, stenoses, kinks, posterior originations and deviations of were found to occur not so often.

When no statistically significant difference between the study and the control groups was found, variations of posterior communicating arteries and their role in the type of vertebrobasilar circulatory disorders were analyzed.

Of the study group patients, 66.7% had alterations in PCoA: up to 50.0% of them were detected to lack both PCoA (Fig. 1), 16.7% had only one PCoA (Fig. 2), and 33.3% of the patients were found to have both PCoA (Fig. 3). In the case of absence of both PCoA even 60% of our study group

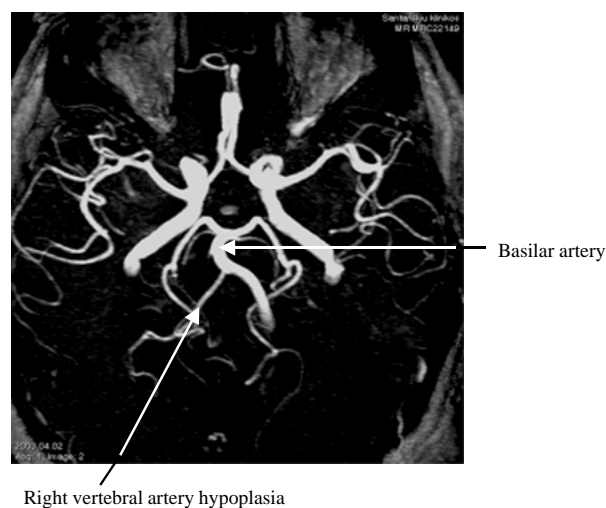


Fig. 1. Abnormality of the circle of Willis: no both PCoA

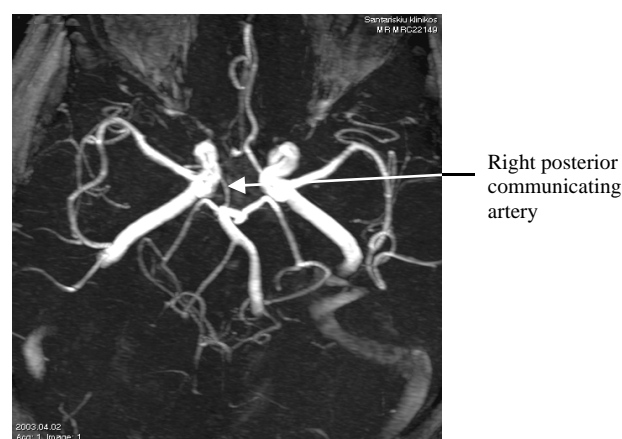


Fig. 2. Abnormality of the circle of Willis: no one PCoA

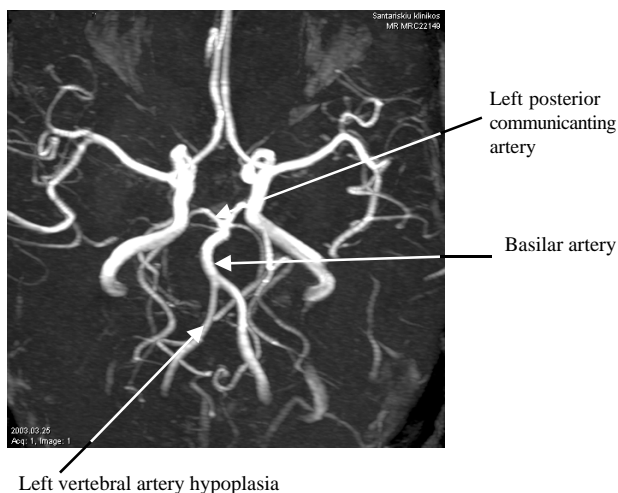


Fig. 3. The normal circle of Willis

patients had been diagnosed as having stroke, in the presence of one PCoA 40% of patients had undergone stroke, and in the presence of both PCoA stroke occurred only in 20% of patients (Fig. 4).

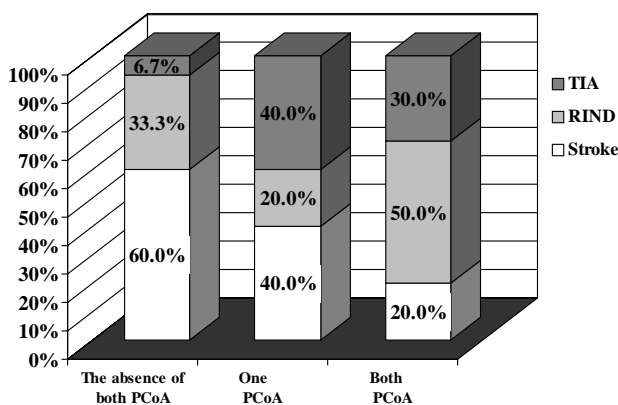


Fig. 4. Type of disorder in vertebrobasilar circulation and variations of PCoA

In the group of patients with TIAs most frequently both PCoA were visualised. In the group with RIND the presence as well as the absence of both PCoA was visualised equally often. Only 15.4% out of stroke group patients had both PCoA, and in 69.2% both PCoA were absent (Fig. 5).

From these findings, the final results can be formulated: as compared with the control group, patients with stroke more frequently had neither of the PCoA (vertebrobasilar stroke 69.2% versus control group 11.2%; $p < 0.001$). A tendency that patients suffering from RIND in the vertebrobasilar basin more often have neither of the PCoA (45.5% versus 11.2%; $p = 0.07$) was detected. No statistically significant difference between the patients with TIAs and the control group (16.7% versus 10.5%) was found.

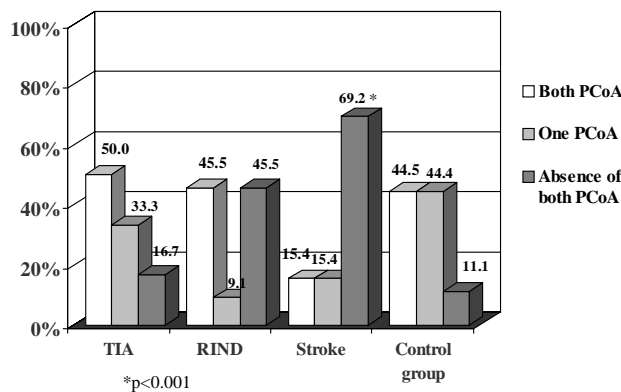


Fig. 5. Influence of PCoA on the type of disorder of vertebrobasilar circulation (%)

All 8 operated on patients were followed up from one to 72 months. TIA recurrence was less after surgery in 4 patients, for the other 4 patients TIA recurrence was the same.

DISCUSSION

Since the circulatory supply of the brain was started to be investigated in detail by Th. Willis and the capability for collateral circulation was emphasized, the interest in the posterior circulation arteries of the brain was started to rise (10). During the past decades the possibility of a better imaging of the posterior fossa structures made the investigation of infarctions of the vertebrobasilar territory to be more feasible. The Transcranial Doppler ultrasound and MR angiography enabled studies of vertebral or basilar arteries and the circle of Willis. Using these methods we found that patients with hypoplasia of the vertebral artery and with the absence of both posterior communicating arteries are at a higher risk of developing stroke in the vertebrobasilar area.

One study states an important role of vertebral artery hypoplasia in migraine pathogenesis (11). A higher frequency of hypoplastic vertebral arteries in migraine with aura was observed. Vertebral artery hypoplasia is suggested to be an additional factor leading to hypoperfusion of the posterior circulation during the aura phase (11).

Arterial blood flow to the brain can be disturbed by congenital anomalies of blood vessels; therefore good circulation through anastomoses is known to be vitally important. The circle of Willis joins the blood vessels between both cerebral hemispheres. In the case of absence of some segments of arteries (vertebral or carotid) that are responsible for the blood supply to the brain, the circle of Willis is known to have the decisive importance for the cerebrovascular accidents (8). Predisposition to is-

chemia of posterior circulation for patients with hypoplastic vertebral or basilar arteries is emphasized in other studies, too. The case of bilateral vertebral artery hypoplasia leading to posterior fossa ischemia is described (12). Recommendations regarding critical neck positions to decrease the probability of recurrent ischemic events in such cases should be given (12). Vertebral artery hypoplasia, limiting the potentialities of compensatory blood circulation, is known to play a negative role in the cases of occlusion of major brain vessels (13). Another study shows that a hypoplastic basilar artery is frequently accompanied by vertebral artery hypoplasia and congenital changes in the anatomy of the posterior communicating arteries. Such patients are considered to be at a higher risk of cerebral ischemia (14).

Investigating patients with internal-carotid occlusion, the importance of PCoA for the posterior circulation was also accentuated (15). The presence of PCoA measuring at least 1 mm in diameter was associated with the absence of watershed infarction, whereas infarctions for the patients with PCoA measuring less than 1 mm or with the absence of detectable flow in PCoA were diagnosed (15).

The frequency of anatomical changes in both vertebral arteries and in the posterior communicating arteries has been found to be associated with the embryology and the complicated neurovascular development. At the stage of 24 days of the embryo, two longitudinal neural arteries are known to appear along the hindbrain and later on join to form a basilar artery. At the stage of 29 days the caudal branch of the primitive internal carotid artery becomes the definitive posterior communicating artery, as it makes the anastomosis between the carotid artery and the ipsilateral longitudinal artery. There are transitory carotid-basilar anastomoses supplying the posterior part of the brain (6, 16). When the vertebral arteries develop and become the major blood supply to the posterior circulation, those anastomoses regress (6). In the case of disturbed development, different vascular anomalies are able to appear, the integrity of the circle of Willis can be changed and later on blood supply to the brain could be compromised. The present study shows the dependence of the depth of the neurovascular deficiency on the status of vascular development: the ischemic neurological damage to the brain is predisposed by the absence of both posterior communicating arteries.

Vertebral artery hypoplasia is a congenital abnormality. It is known that sympathetic nervous systems induced smooth muscle constriction. Therefore, increased stimulation of sympathetic nervous systems may evoke additional vertebral artery spasm.

Theoretically, surgical desympatization of the vertebral artery might reduce vertebral artery spasm and improve blood circulation in the vertebrobasilar region. However, no marked positive effect in the vertebral artery can be expected because of a congenitally small artery diameter. In our opinion, patients with vertebral artery hypoplasia should not undergo surgical desympatization for TIA or stroke prophylaxis. Due to a low number of patients with TIA and vertebral artery hypoplasia and the absence of follow-up data we perform no statistical analysis for these patients.

CONCLUSIONS

The absence of both posterior communicating arteries increases the risk of ischemic stroke in vertebrobasilar basin for patients with vertebral artery hypoplasia. Patients with vertebral artery hypoplasia should undergo examination of the circle of Willis to visualize the anatomical variations of the posterior communicating arteries. In the case of absence of both posterior communicating arteries, early prevention and treatment should be considered. The prophylactic surgical treatment for TIAs in patients with vertebral artery hypoplasia is not recommended.

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**SLANKSTELINIŲ ARTERIJŲ HIPOPLAZIJA:
REIKŠMĖ INSULTO IŠSIVYSTYIMUI, UŽPAKALINIŲ
JUNGANČIŲJŲ ARTERIJŲ VAIDMUO, CHIRURGINIO
IR KONSERVATYVAUS GYDYMO GALIMYBĖS**

S a n t r a u k a

Šiame darbe nagrinėjama slankstelinių arterijų hipoplazijos reikšmė galvos smegenų perfuzijai. Tirta tiek slankstelinių arterijų hipoplazija, tiek Vilizijaus rato anatomiciniai pokyčiai. Ištirti 47 pacientai su slankstelinių arterijų hipoplazija, išnagrinėtos jų ligos istorijos. Operuoti 8 pacientai – jiems buvo atlikta slankstelinės arterijos periarterinė desimpatizacija. Tyrimo rezultatai rodo, kad pacientams su slankstelinės arterijos hipoplazija ir nesant užpakalinių jungiančiųjų arterijų yra didesnė galvos smegenų kraujotakos sutrikimo išsivystymo rizika. Esant vertebrobazilinei išemijai slankstelinės arterijos hipoplazijos konservatyvus gydymas yra efektyvesnis lyginant su hipoplastiškos slankstelinės arterijos desimpatizacija.

Raktažodžiai: užpakalinė jungiančioji arterija, slankstelinės arterijos hipoplazija, insultas, vertebrobaziline kraujotaka, Vilizijaus ratas