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POSTERIOR CEREBRAL ARTERY – VARIATION IN THE ORIGIN AND CLINICAL SIGNIFICANCE

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Abstract

With the introduction of new techniques in diagnostic and interventional radiology and progress in micro-neurosurgery, accurate knowledge of the brain blood vessels is essential in daily clinical work. The aim of this study was to describe the different types of PCA origin, their diameter, and to emphasize their clinical significance.

In this study we examined radiographs of 53 patients who had CT angiography undertaken for a variety of clinical reasons, performed as a part of their medical treatment at the University Radiology Clinic in Skopje, R. Macedonia. This study included 24 females and 29 males, ranging in age from 32 to 73 years; mean age 55.3 ± 11.5 years.

The results showed that the diameter of the posterior cerebral artery was 1.74 ± 0.317 mm on the right side and 1.98 ± 0.408 mm on the left side. The adult configuration was present in 37 (69.81%); foetal configuration was present in 12 (22.64%) and transitional configuration was present in 4 (7.54%) of the patients. We found two patients with bilateral foetal type and ten with unilateral foetal type (six on the right side and four on the left side).

Despite the limitations of the study, we found that the foetal variant was presented in 22.64% of patients. Thorough knowledge of the anatomy of the intracranial vessels is important to clinicians as well as basic scientists who deal with problems related to intracranial vasculature on a daily basis.

Key words: posterior cerebral artery, anatomy, variations, circle of Willis.

Introduction

The posterior cerebral artery (PCA) is a terminal branch of the basilar artery formed at the upper pontine border where it joints the posterior communicating artery (PComA) to help complete the posterior part of the *circulus arteriosus* Willis at the base of the brain in human beings [1]. The PCA supplies not only the posterior part of the cerebral hemispheres, as its names implies, but also sends critical branches to the thalamus, midbrain, and other deep structures, including the choroids plexus and walls of the lateral and third ventricles [2].

The PCA is divided into four segments, P1 to P4. The P1 segment, also called the pre-communicating segment, extends from the basilar bifurcation to the junction with the PComA. Depending of the development of the P1 segment of the artery we can distinguish three different types of occurrence of the PCA: foetal, transitional and adult. The P2 segment begins at the PComA, lies within the crural and ambient cisterns, and terminates lateral to the posterior edge of the midbrain. The P3 or quadrigeminal segment proceeds posteriorly from the posterior edge of the lateral surface of the midbrain and ambient cistern to reach the late-

ral part of the quadrigeminal cistern and ends at the anterior limit of the calcarine fissure. The P4 segment includes the branches distributed to the cortical surface. Posteriorly, it begins at the anterior end of the calcarine sulcus [2, 3].

With the advances in micro-neurosurgery and radiology, and a more effective ability to tackle diseases of the intracranial arteries, accurate knowledge of the intracranial vascular anatomy is becoming increasingly important [4]. So far no data exists for the Macedonian population about the PCA, so the authors think that it is worthwhile undertaking pioneering research on the PCA. The aim of this study was to describe the different types of PCA origin, their diameter, and to emphasize their clinical significance.

Material and Methods

The study population included 53 patients referred to the University Radiology Clinic in Skopje, R. Macedonia for computed tomography angiography (CTA) during the period January to August 2013. This study included 24 females and 29 males, ranging in age from 32 to 73 years; mean age 55.3 ± 11.5 years. This was an anatomical analysis of CTA images realized for a medically justified goal, with the approval of the Macedonian Ethical Committee. The CTA was obtained using a CT scanner Somatom Definition AS Siemens Healthcare, Erlangen, Germany. Contrast material was injected through an 18- to 20-gauge IV catheter inserted into an arm vein, a total of 100 ml. at a rate of 3 ml/s with a pressure injector, followed by a flush of 40 ml of saline administered at the same injection rate. After the contrast medium was injected, by use of bolus tracking software, scanning was carried out automatically. The data were transferred to a workstation for post-processing. Reconstruction included the following: maximum intensity projection-MIP; four-dimensional CTA with volume rendering; reformatted multiplanar reformation-MPR performed through the artery. In the process of post-processing for the measurement of the external diameter of the blood vessels we used SYNGO software. The posterior cerebral artery was clearly and directly shown in the high quality images, and satisfied the requirements of our study. In the total of 53 patients, the course of the artery extending from its origin to its end was clearly observed.

Each of the CT images was analysed by two independent examiners. The CT scans were evaluated for evidence of the following: origin and diameter of the artery.

Results

The main diameter of the P1 segment of the right PCA was 1.74 ± 0.317 mm and of the left PCA was 1.98 ± 0.0.408 mm. The adult configuration was the most frequent, and it was found in 37 (69.81%) patients in this study. Foetal configuration was present in 12 (22.64%) and transitional configuration was present in 4 (7.54%) of the patients.

Ten patients with unilateral foetal type were found. In six of these patients foetal type PCA was present on the right side, and in four patients on the left side. Bilateral foetal type PCA was present in only two patients in our study.

In the present study there was no significant gender or side difference in the appearance of foetal type of PCA.

Figure 1 – CT angiography of the brain arteries with adult type of PCA

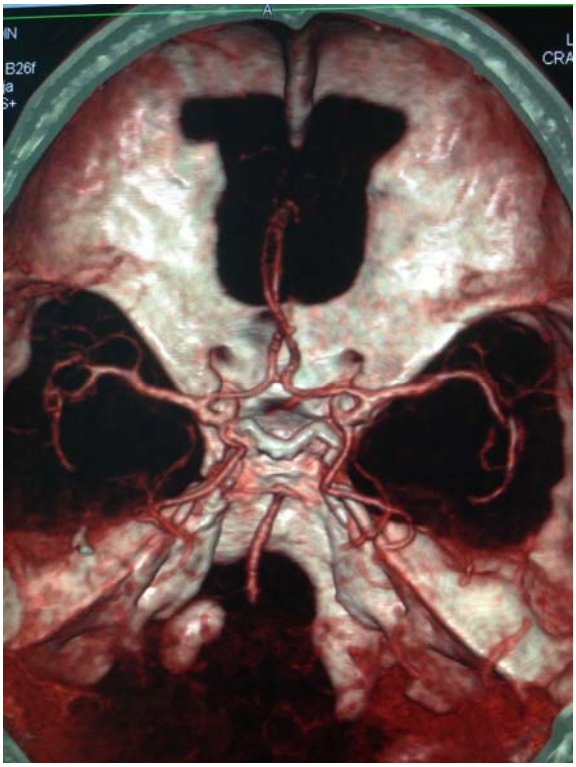

Figure 2 – CT angiography of the brain arteries with fetal type of PCA

Discussion

Variations in the origin, termination and distribution of the arteries at the base of the brain are numerous and have been described extensively [5, 6]. The most important variation is the variable origin and diameter of the PCA, other variations are rare and mentioned as isolated cases [7].

Based on measurements on cadavers, the diameter of the PCA was 2.1 ± 0.7 mm on the right side and 2.2 ± 0.6 mm on the left side in the Kamath study [8], Krishnamurthy et al. found that the mean diameter of the PCA was 1.7 ± 0.7 mm [6], and Songur et al. found that the diameter was 1.83 ± 0.50 on the right side and 1.88 ± 0.53 on the left side [9]. The results of the measurements of external diameter of the PCA in this study correspond with the previously published data.

Three basic configurations of the PCA have been described: foetal, transitional and adult [10]. In the foetal configuration the diameter of the P1 segment is less than the diameter of PComA, so that the blood supply is mainly via the internal carotid arteries [11]. The term foetal-type is used when there is still a communication with the basilar artery through a hypoplastic P1 segment of the PCA. Others refer to it only when the P1 segment is not visible or the PCA does not fill after contrast injection of a vertebral artery. Van Raamt et al. propose the following definitions. In a full foetal-type the P1 segment is not visualized on CT or MRI or does not fill after injection of contrast in a vertebral artery. A partial foetal-type is when the P1 segment is smaller than the PComA [12]. Reviewing the available literature, we found that the foetal configurations of the PCA have a prevalence in 4.4% of the cases according to De Silva, in 9% according to van Overbeeke, in 14.3 % of the cases according to Milisavljevic et al., in 24.5% of cases according to Yasargil, in 30% of the cases in the Saeki and Rhoton study and up to 40% of cases in the Zeal and Rhoton study [2, 3, 10–13].

In transitional configuration the PComA is equal in diameter to the P1 segment of the PCA [11]. This configuration was found in 2.2% of cases according to De Silva, in 8% according to Yasargil and in 11.4% in the study conducted by Milisavljevic [10, 12].

In the adult configuration, the P1 has a diameter larger than the PComA so that the blood supply is mainly via the vertebrobasilar system [14]. Adult configuration occurs in 58% of cases in Zeal and Rhoton, in 65.7% according to Milisavljevic, in 67.5% according to Yasargil, in 70% according to Saeki and Rhoton and up to 93.3% in the De Silva study [2, 3, 10, 12].

Clinical application of the anatomy of the PCA

The degree of contribution from the vertebro-basilar and carotid systems to the origin of the PCA is of clinical and anatomical importance and may have clinical implications [11, 15].

The cause of cerebral aneurysms is apparently multifactorial and has not been fully clarified [16]. Several studies have found a relationship between the anomalies of the circle of Willis and the development of aneurysms by producing haemodynamic changes in blood-flow and inducing strain on the weak point of the arteries' bifurcation [17]. When the PCA is

dominantly supplied by the internal carotid artery, increased flow must occur in the internal carotid artery proximal to the PComA and in the PComA itself, resulting in increased shear stress, which tends to promote aneurysm formation at these sites [16, 18]. Complex turbulent flow will also occur in the carotid siphon, which may be involved in aneurysm formation, even on the wall unrelated to the bifurcation [19, 20].

Perfusion imaging is becoming more commonplace for the triage and management of acute stroke. Unilateral foetal-type PCA produces substantial left-right asymmetry on perfusion imaging. Knowledge of this variation is critical for the radiologist performing and interpreting perfusion images, as such asymmetry may mimic cerebrovascular pathology [21].

The presence of anomalous origin of PCA may assume considerable significance if one is to ligate internal carotid, or common carotid, or in cases of obstruction of these arteries by embolus [6]. When the PCA arises from the internal carotid, thrombosis or embolism affecting the carotid territory may cause infarction of the occipital pole and, conversely, such an anatomical arrangement will prevent occipital pole infarction in basilar thrombosis [6].

An important consequence of the foetal variant of PCA could be an increased stroke risk in patients with obstructive arterial disease, because leptomeningeal collaterals cannot develop in the foetal variant of PCA, since both the middle cerebral artery and the PCA are connected to the internal carotid system and not to the vertebrobasilar system [13, 22].

Several studies in the past years have indicated that the foetal type of PCA and occipital lobe infarcts are related. In an autopsy study of brains with infarct and without infarct, more foetal type PCA was found in brains with infarcts than in brains without [23, 24, 25, 26, 27]. The study conducted by de Monye does not provide arguments for an increased risk of ischemic stroke in the territory of the PCA in patients with a foetal origin of the PCA [28]. In our opinion, further research is needed in the assessment of the presence of foetal PCA and increased risk of occipital lobe infarct.

Since the internal carotid artery contributes to the blood flow in the PCA, internal carotid artery stenosis should be considered as a cause of occipital lobe infarct. In these patients carotid endarterectomy has proven benefit for the prevention of recurrent stroke [29, 30].

Conclusions

In this study, we have presented the anatomical features of the PCA and we have highlighted their clinical significance. The frequency of foetal type PCA was present in 22.64%. Left PCA was dominant among the patients, and its diameter was 1.98 mm.

Thorough knowledge of the anatomy and variants of PCA is essential for clinicians as well as basic scientists who deal with problems related to intracranial vasculature on a daily basis in education, training, diagnosis and treatment of cerebral-vascular diseases.

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Резиме

ЗАДНА МОЗОЧНА АРТЕРИЈА – ВАРИЈАЦИИ ВО ПОТЕКЛОТО И КЛИНИЧКО ЗНАЧЕЊЕ

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Со воведувањето нови техники во дијагностичката и интервентната радиологија и напредокот во микрохирургијата, се наметнува потребата од добро познавање на анатомијата на мозочните крвни садови во секојдневната клиничка работа. Целта на оваа студија е да се испита дијаметарот на задната мозочна артерија, различните типови потекло и да се нагласи нивното клиничко значење.

За реализирање на оваа студија, 53 пациенти од Универзитетската клиника за радиологија од оправдани медицински причини беа

прегледани со компјутеризирана томографска ангиографија. Во студијата беа вклучени 24 жени и 29 мажи, на возраст од 32 до 73 години, со просечна возраст од 55,3 ± 11,5 години.

Резултатите од студијата покажаа дека дијаметарот на задната мозочна артерија изнесува 1,74 ± 0,317 mm на десната страна и 1.98 ± 0,408 mm на левата страна. Кај 37 (69,81%) пациенти се утврди базиларно потекло на артеријата, а кај 12 (22,64%) пациенти артеријата потекнуваше од каротидната артерија. Интермедиерно потекло беше утврдено кај 4 (7,54%) пациенти.

Познавањето на анатомијата и варијациите на задната мозочна артерија е битно во базичните науки како што е анатомијата во процесот на едукација, но и клинички апликативно и значајно за лекарите кои се занимаваат со патологијата на интракранијалните крвни садови во секојдневната клиничка работа.

Клучни зборови: задна мозочна артерија, анатомија, варијации, Вилисов круг.