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CLINICAL SIGNIFICANCE OF THE VERTEBRAL ARTERY HYPOPLASIA

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Abstract

Because of their anatomical localization, vertebral arteries were neglected in research for a long period of time. Vertebral arteries are responsible for about 30% of the brain blood supply. The aim of this study was to analyze the normal and variable dimensions of the vertebral artery size such as hypoplasia and aplasia, and to emphasize the clinical importance of these congenital variations. For the purpose of this study we examined radiographs of 30 patients who had CT angiography undertaken for a variety of clinical reasons, performed as a part of their medical treatment at the University Clinic for Radiology in Skopje, R. Macedonia. We analyzed CT reports for the diameter of the vertebral artery. The diameter of the left vertebral artery was from 1.6-5.20 mm, average 3.35 mm. The diameter of the right vertebral artery was from 1.64-5.40 mm, average 3.19 mm. Hypoplasia of the vessel was found in four patients. We found no aplasia of the vessel in this series. Vertebral artery hypoplasia is common in the Macedonian population and can be reliably diagnosed on CT scans. Our study has highlighted the clinical significance of vertebral artery hypoplasia in stroke and migraine.

Key words: vertebral artery, anatomy, hypoplasia, stroke, migraine

Introduction

The brain normally derives its blood supply from the two internal carotid arteries and the paired vertebral arteries responsible for about 30% of the brain blood supply [1]. Vertebral artery is the first and the largest branch of the subclavian artery arising from the posterosuperior aspect of its first part, and it is divided into four segments. The first segment is pre-transverse segment, the second segment is inter-transverse segment, the third segment is atlanto-occipital and the fourth segment is intracranial [2].

Variations of the vertebral arteries have been described extensively, concerning origin of the vertebral arteries, level of entrance into the transverse foramen, tortuosity in their course, and size of the vertebral arteries. Different congenital anatomic variations of the vertebral artery size are described in the literature, such as vertebral artery hypoplasia and aplasia [1, 2].

For the first time vertebral artery hypoplasia was described in the 19th century [3]. Congenital vertebral artery hypoplasia is an uncommon embryonic variation of posterior circulation [4]. Given the importance of these vascular variations, it is astonishing how little is known about their clinical relevance [5].

The aim of this study was to describe the normal and variable dimensions of the vertebral artery size such as hypoplasia and aplasia, and to emphasize the clinical importance of these congenital variations.

Material and methods

During a 6-month period, from February 1st 2010 to July 31st 2010, 30 patients from the University Clinic for Radiology in Skopje, R. Macedonia were investigated. This was an anatomical analysis of CTA images realized for a medically justified goal. This study included 14 females and 16 males, ranging in age between 19 and 75 years, mean age of 57.8±13.02 years. Patients were investigated with computed tomography angiography (CTA). CTA was performed with CT scanner Somatom, Volume Zoom, Simens, multislice 4. Contrast material was injected by using intravenous catheter placed in a peripheral vein, a total of 100 ml. at a rate of 3 ml/s with a pressure injector. After the contrast medium was injected, by use of bolus tracking software, scanning was carried out automatically in one breath. 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 each of the VA.

We analyzed CT reports for the diameter of the VA. We made the measurements at three different points. The diameter of each vessel was calculated as the average of the three measurements. By measuring the average diameter of the vessel, asymmetry, hypo- or hyperplasia and aplasia of the VA can be defined. The criterion for the VA asymmetry was side-to-side diameter difference of more than 1 mm. The VA having a larger diameter was defined as dominant. The criteria for VA hypoplasia (VAH) were defined as a lumen diameter of 2 mm or less.

Results

The diameter of VA on the left side was in the range between 1.60- 5.2 mm, mean 3.33±0.89 mm, and on the right side from 1.64 - 5.40 mm, mean 3.19±0.98 mm. The VAs on both sides were equal in diameter in seven (23.3%) patients. The right VA (RVA) was larger in nine (30%) patients, and the left VA (LVA) was larger than the right in 14 (46.6%) patients. Hypoplasia of the vessel was found in 4 (6.67%) patients. In two patients hypoplasia was on the right side, in one patient on the left side, and in one patient we found bilateral hypoplasia of the vessel on the left and right side. In this study aplasia of the vessel was not found.

Table 1. Diameter of the vertebral artery reported in the literature

Author	Right	Left
Bartels	3.81±0.46 mm.	3.88±0.47 mm
Matula	2.2-5.5 mm (4.1 mm)	3.3-6.2 mm. (5.0 mm)
Sastry	1.5-7.3 mm. (4.09 ±1.78)	2.0-5.2 mm. (3.06±1.25)
Huzijan	3.37±0.60 mm.	3.55±0.61 mm.

Discussion

The two VA are usually different in caliber, with the left being more often larger or dominant [3]. Table 1 presents the results of the VA diameter obtained by different researchers.

Congenital variations in the arrangement and size of the VA are frequently recognized, ranging from asymmetry of both VA to severe hypoplasia or aplasia of the VA [6]. The VAs are commonly asymmetric. In 45% of people the LVA is larger, in 21% the RVA is larger, and in 24% the arteries are of equal size [7]. The study conducted by Karayenbuehel and Yasargil in 1957 demonstrated that VA had different diameters in 74% of the population, a dominant LVA in 42%, and a dominant RVA in 32% of the population. In 26% of the patients VA had equal diameters [3]. Touboul et al. found a dominant LVA in 24 out of 50 cases (48%), and the right in 7 out of 50 cases (14%) [8].

The percentage of VAH is in the range between 2 and 20% in the reports from different countries [9]. Up to now, there has been no agreement concerning the definition of VAH, although several have been proposed by some authors. However, the vessel caliber criteria used to diagnose VA hypoplasia remain a matter of debate. Operational definitions of VAH in a pathoanatomical ?? vary between diameters of less than 2 to less than 3 mm or an asymmetry ratio of equal or greater than 1:1.7. Matula et al, Sastry et al, Touboul et al, Buckenham et al, defined VAH as diameter < 3mm [2, 8, 10, 11]. Study conducted by Chen et al, Szarazova et al reported that a VA diameter d" 2.5 mm is an ideal value to define VAH [12, 13]. Jeng et al defined cut-off point for vertebral artery hypoplasia to <2.2 mm [14]. Most of the studies conducted by different authors consider the value of d" 2 mm as a cut off diameter for hypoplasia [6, 9, 15, 16, 17].

The reported frequency of VAH is dependent on the definition used for VAH. In the study conducted by Matula et al, a hypoplastic artery diameter < 3.5 mm was found in 16 (6.96 %) cases. Eleven (4.78%) cases of hypoplasia were found on the right side and five (2.17%) cases on the left side. Aplasia of the vessel was not found in the study [2].

Sastry et al defined value of < 3.5 mm in five cases (three on the right and two on the left side) or in 13.16% VA was found to be hypoplastic [10].

Jeng et al found the frequency of vertebral artery hypoplasia to be 11.6% in 447 subjects. Vertebral artery hypoplasia was present on the right side in 7.8% and on the left side in 3.8% [14].

Investigations for VAH conducted by Lovrencic-Huzijan et al showed vertebral artery hypoplasia in 14 persons; 2.34% prevalence in the general population. Hypoplasia of the right vertebral artery was found in 8/14 persons and hypoplasia of the left vertebral artery in 6/14 [15].

Karayenbuehel and Yasargil reported VAH in 25 (6.2%) cases on the RVA, in 18 (4.5%) cases on the LVA, and in 3 (0.75%) cases bilateral hypoplasia of the VA [3].

VA diameters described by other authors are in agreement with the measurements we made. In our study the diameter of the VA was larger on the left side than on the right side, but with no statistical significance. We decided that the best cut off diameter for definition of VAH is d" 2 mm. VAH was found in four cases (6.67%), one on the left and two on the right side. We found bilateral hypoplasia of the VAs in one patient.

Clinical significance of the vertebral artery hypoplasia

The clinical relevance and hemodynamic impact of vertebral artery hypoplasia have been under debate [18]. Traditionally, most physicians have regarded an asymmetric VA as a congenital variant or a clinically meaningless finding. The absence of vertebrobasilar insufficiency symptoms among people with vertebral artery hypoplasia indicates that even marked vertebral artery asymmetry is a normal variation, and has led to an underestimation of the incidence and clinical relevance of vertebral artery hypoplasia [19]. Although the importance of vascular variations in the vertebrobasilar system, in particular, VAH, is well recognized, its clinical relevance is unclear. However, recent studies have regarded that VAH is associated with different clinical symptoms such as posterior circulation stroke, migraine with aura, vestibular evoked myogenic potentials, etc [20, 21].

Association between vertebral artery hypoplasia and stroke

Stroke is the leading cause of death and disability worldwide, especially in the industrialized countries [5]. Approximately one-third of acute cases have a fatal outcome [7]. Keeping this in mind, investigation of vertebral arteries is important since 15% of all strokes occur in their irrigation territory [9]. Nevertheless, vertebral hypoplasia as a possible risk factor for pathology, particularly of stroke in the vertebrobasilar circulation territory, has received little emphasis.

Perren et al investigated 725 first-ever stroke patients, 247 had posterior circulation strokes and 478 strokes in other territories. They showed that vertebral artery hypoplasia was predominant on the right side and was diagnosed in 32 patients of posterior circulation strokes as opposed to only 22 patients with strokes in

other territories (13% vs. 4.6%). The distribution of all other risk factors as hypertension, hyperlipidemia, diabetes, smoking were comparable. They concluded that vertebral artery hypoplasia may be predisposed to posterior circulation stroke [5].

Park et al investigated the frequency and clinical relevance of HVA in 529 stroke patients (303 anterior circulation strokes and 226 posterior circulation stroke) and in 306 normal healthy people. Vertebral artery hypoplasia was detected in 186 (35.2%) patients, in 102 (19.3%) on the right side, in 66 (12.5%) on the left side and in 18 (3.4%) bilaterally among 529 patients with stroke. When classified by stroke location, patients with posterior circulation stroke (45.6%) showed more significant frequency of vertebral artery hypoplasia than those with anterior circulation stroke (27.1%) and normal healthy people (26.5%). The frequency of hypoplastic vertebral arteries in the normal healthy people was similar to that in patients with anterior circulation stroke. In terms of demographic features, risk factors, and laboratory findings, there were no significant differences [6].

Chuang et al examined 158 patients with hemispheric ischemic strokes and 33 patients with brainstem/cerebellum ischemic strokes which were confirmed with MRI. The diagnosis of vertebral artery hypoplasia was established with MRI in 22 patients. The incidence of VAH with brainstem/cerebellar ischemic strokes was 72.72% which was significantly higher than the 2.53% of hemispheric ischemic stroke patients and the 2.09% of the control group [4].

Szarova et al performed CTA or MRA to confirm the vertebral artery hypoplasia and the site of ischemia in 44 patients with posterior circulation stroke; 9 (20%) patients had a hypoplastic vertebral artery and 35 (80%) patients were without VAH. The frequency of other risk factors such as hypertension, diabetes mellitus and smoking did not differ. The current data on this topic show that there is a tendency of coincidence of posterior circulation stroke and the presence of vertebral artery hypoplasia [12].

Why does size matter and how the smaller artery are susceptible to occlusion? Size alone cannot be explained because many intracranial arteries are smaller than the hypoplastic arteries and they are not predisposed to occlude. An interaction between blood pressure, blood constituents and the rheology and physics of blood flow at various arterial locations might affect arterial occlusion. The HVA, which shows lower mean flow volume and decreased flow velocities, seems to be more susceptible to prothrombotic or atherosclerotic processes than normal or dominant VAs. Therefore, it is postulated that a HVA can result in the ipsilateral occlusion of this vessel due to a direct decrease in blood flow and easy collapse of the vessel caused by the smaller VA caliber. The HVA may further contribute to posterior circulation strokes, if additional risk factors such as hypertension, diabetes exist [22].

Association between vertebral artery hypoplasia and migraine

There are many theories concerning migraine pathogenesis. The extent and direction of cerebral blood flow changes (if any) during migraine attacks without aura are still a matter of debate [23].

Lovrencic et al examined the extracranial part of VA in 59 migraine patients (17 with and 42 without aura) using color Doppler. In migraine with aura, 29% of patients had hypoplasia of at least one VA, 23% had hypoplastic right and 6 left vertebral artery. In migraine without aura hypoplasia was found in 7% of patients and 8% of controls, which is within the common range of hypoplasia ratio in the healthy population [24].

Chuang et al reviewed the records of 250 migraine outpatients; the incidence of VAH in patients who had migraine with aura was 28.26%. The incidence of VAH in patients who had migraine with aura was 14 times higher than that of the normal controls (2.09%). There was no significant net VA flow volume reduction during the attack phase compared with the headache free period [25].

The investigation of Lovrencic et al showed that hypoplasia of the vertebral artery in migraine with aura is four times more frequent than in migraine without aura and controls [24]. A higher hypoplasia ratio in migraine with aura could be an additional factor contributing to hypoperfusion in the posterior circulation, and trigger and perpetuate cortical spreading depression, thus explaining neurological symptoms during the aura phase [24]. The study conducted by Chuang et al confirm the results of Lovrencic et al but argues against their hypothesis that hypoplastic vertebral artery leads to hypoperfusion during the aura phase. According to Chuang et al the net vertebral artery flow volume measured during the attack phase was satisfactory [25].

Zwetsloot et al found no difference in blood flow velocities in the vertebrobasilar system during migraine attacks and headache free periods [26].

Conclusion

In conclusion, vertebral artery hypoplasia is common in the Macedonian population and can be reliably diagnosed on CT scans. Although anatomically interesting, an awareness of the vertebral artery anatomy and variations is clinically important. We highlighted the clinical significance of this condition in stroke and migraine and we believe that this study will make an important contribution to the anatomical and clinical knowledge of the vertebral artery hypoplasia.

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