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# PERSISTENT TRIGEMINAL ARTERY - ANATOMICAL FEATURES AND CLINICAL SIGNIFICANCE

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**Abstract**

Persistent trigeminal artery is the most common primitive carotid basilar anastomosis that persists in adulthood. The overall incidence of persistent trigeminal artery (PTA) is between 0.2 to 0.76%. PTAs are known to be associated with a wide range of pathology.

The aim of this study was to describe the morphological characteristics of PTA and to emphasize its clinical significance. We examined radiographs from patients who had CT angiography undertaken for a variety of clinical reasons, performed as a part of their medical treatment at the University Institute of Radiology in Skopje, RN Macedonia. The study included 234 patients, 130 males and 104 females, with the mean age of 57.8 years. In one patient we found a PTA, with an overall incidence of 0.42%. CTA revealed a left PTA that arose from the internal carotid artery and communicated with the basilar artery between the origin of the anterior inferior cerebellar artery and the superior cerebellar artery.

Besides the fact that brain arteries are of interest to the anatomists, awareness of their variations is clinically important for radiologists and surgeons for performing safe procedures, as well as for forensic pathologists since they may have forensic consequences.

***Keywords:*** anatomy, persistent trigeminal artery, computed tomography

## Introduction

Several fetal anastomoses have been described between the carotid and vertebrobasilar circulations [1-11]. These anastomoses regress while the P1 segments develop, but they can occasionally persist in adult age [1-11]. The persistent trigeminal artery (PTA) is the most common anastomosis found in about 85% of cases [1-11]. Variants of PTA arising from the internal carotid artery (ICA) and terminating as cerebellar arteries are extremely rare [1-11]

As the vascular system evolves, they are quickly remodelled, with the trigeminal artery being the last to disappear. Rarely, anastomoses persist into adulthood [1-11].

Currently, PTA is attracting the attention of neurosurgeons, radiologists and anatomists. The aim of this study was to present morphological features of PTA and to emphasize its clinical significance during routine clinical work.

## Material and Methods

The study included 234 patients referred to the University Institute of Radiology in Skopje, R.N. Macedonia for computed tomography angiography (CTA) during a five-year period. Of these 234 patients, 104 were females and 130 were males, with the mean age of 57.8 years.

An anatomical analysis of CTA images was realized for a medically justified goal, with the approval of the Macedonian Ethics 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). In the process of post-processing, we used the SYNGO software.

**Results**

In this study we evaluated CT angiographic images of 234 patients, and image quality in all patients was sufficient for the evaluation of the presence of PTA. In one patient we found a PTA with an overall incidence of 0.42%. CTA revealed a left PTA that arose from the internal carotid artery and communicated with the basilar artery between the origin of the anterior inferior cerebellar artery and superior cerebellar artery.

Distance between superior cerebellar artery and PTA was 7.4 mm. and the distance between PTA and anterior inferior cerebellar artery was 6 mm.

The PTA diameter was 1.6 mm and PTA length was 17 mm. On the right side, we noticed a unilateral duplication of the right superior cerebellar artery (SCA), while on the left side the SCA arose as a single truck. posterior cerebral artery (PCA) on the side of PTA was of normal caliber, while PCA on the opposite site of the PTA was hypoplastic. A fenestration of the anterior communicating artery was observed. According to Saltzman's classification of PTA, the PTA we encountered was of Saltzman type 2.

**Figure 1.** CT angiography showing a persistent trigeminal artery

**Discussion**

In 1844, Richard Quain gave the first anatomical description of a PTA on autopsy, while in 1950 Sutton made the first demonstration of PTA on angiography [5, 7, 9].

PTA is generally determined incidentally during investigations for unrelated reasons. In fact, most types have been published in the literature as case reports. In a recent large-scale study conducted with DSA, MRA or CTA, the incidence of PTA was in the range between 0.2 and 0.76% [1,2,11,12,14,15].

But, if we take into account undiagnosed and unreported cases, the incidence will probably reach up to 1%. In our study, the incidence of PTA was 0.42%, which correspond with the previous published data in the literature.

Several studies have indicated a statistically significant sex predilection of PTA occurrence showing that PTA is more common in females than in males [13,14,15]. Though the overall incidence of the PTA is low, it occurs mostly on one side, usually on the left one [1,2,5,11]. Bilateral presence of PTA is an extremely rare condition [12].

So far, several classifications of PTA have been proposed, but most widely accepted classifications of PTA were proposed by Saltzman, Salas and Weon.

In 1959, Saltzman proposed an angiographic classification of the PTA into three main types, depending on the presence or absence of posterior communicating artery (PComA) and the status of PCA [16].

The Saltzman type 1 or the so-called fetal PTA joins the basilar artery between the superior cerebellar arteries and the anterior inferior cerebellar arteries. This type is characterized by the basilar artery proximal to the junction, which is usually hypoplastic. The posterior communicating arteries are absent or poorly opacified. Also, the entire basilar artery system distal to the anastomosis is filled through PTA which becomes the main supply to the distal BA, PCA, and SCA territories [1-16].

The Saltzman type 2 or adult-type PTA joins the basilar artery between the superior cerebellar arteries and the anterior inferior cerebellar arteries. The posterior communicating arteries are present and supply the posterior cerebral arteries. The distal end of the basilar artery is angiographically poorly visualized [1-16].

The Saltzman Type 3 is considered a combination of types 1 and 2, with the anastomosis supplying the superior cerebellar arteries bilaterally as well as the contralateral PCA. The ipsilateral PCA in these cases is supplied by the PCom [1-13].

The PTA variants represent anastomoses between internal carotid artery (ICA) and cerebellar arteries, without interposition of the basilar artery. PTA variants are subdivided into three types: type 3a PTA terminating directly in the SCA, type 3b PTA supplying the anterior inferior cerebellar artery (AICA) and type 3c PTA feeding the PICA. Among the PTA variants, the majority fall under type 3b with termination at the AICA; with types 3a and 3c being extremely rare. The PTA variants are included in Saltzman type 3 [1,2,5,6,7, 8,9,13,14,15].

The relative incidence of Saltzman type 1 and type 2 has been reported to be more or less equal. However, in a recent review of 25 PTA cases, the incidence of type I was 24% while that of type II was only 16% and of type III 60% [3, 6, 11, 12, 13].

Salas *et al*. distinguished two types of PTA regarding their relationships to the abducent nerve; a lateral or petrosal and medial or sphenoidal variations [14].

When the PTA courses laterally to the abducens nerve, the artery arises from the posterolateral aspect of the C4 segment of the ICA and crosses underneath the nerve which may be displaced superiorly by the PTA. This lateral variation of PTA pierces the dura just medially to the sensory root of the trigeminal nerve. When the PTA courses medially to the abducens nerve, the artery arises from the posteromedial aspect of the C4 segment of the ICA and pierces the dura of the dorsum sellae (sphenoid variation). Clinically, the lateral variant may be associated with brainstem ischemia, ophthalmoplegia, and trigeminal neuralgia. The medial variant can be associated with posterior fossa symptoms secondary to a steal phenomenon. Surgeons should also be aware of a medial PTA during a transsphenoidal surgery to avoid severe hemorrhage [1,5,7,14]. The lateral PTA type is more frequent than the medial one [4,5,11,14].

Weon *et al*. have made several modifications to Saltzman's classification and differentiated five types of PTA. Types 1 and 2 are similar to Saltzman's types 1 and 2, respectively. In type 3, the contralateral PCA is supplied by the PTA and the ipsilateral PCA receives its blood flow via the anterior circulation through the PComA. In type 4, the ipsilateral PCA is supplied by the PTA and the contralateral PCA receives its blood flow via the anterior circulation through the PComA.

Type 5 represents all PTA variants that include the SCA (type 5a), the AICA (type 5b) and the posterior inferior cerebellar artery (PICA) (type 5c) [5,15].

In most cases described in the literature, the PTA was not presented with clinical symptoms. Although usually asymptomatic, PTAs are known to be associated with a wide range of pathology including: ischemic cerebrovascular accidents in the posterior brainstem and occipital area [6,13,15,16,17,1,19,20,21], trigeminal neuralgia [13,15,22, 23,24,25,26], cranial nerve palsy [6,22], hyperprolactinemia and other pituitary disorders [27,28], carotid cavernous fistulas [12,29,30,31,32,33,34], aneurysms [1,2,5,15,35,36,37], vascular steal [1,3], arteriovenous malformations [22], intrasellar chordoma [38], craniopharyngioma [39], tinnitus [40], basilar artery hypoplasia [15, 41].

Several studies in the past years have indicated a relationship/association between PTA and infarctions [4,16,17,18,19,20]. Despite the above observations, Ito *et al*. claimed a possible protective effect of the PTA on brainstem infarctions by saving blood supply to the brainstem from internal carotid artery [21].

Along its course, PTA is intimately related with the trigeminal nerve or with its ganglion, which provides a situation for potential neurovascular conflict [22].

Trigeminal neuralgia resulting from compression by a PTA is rare; however, reviewing the available literature we found case reports describing trigeminal neuralgia caused by vascular compression with PTA [22,23,24,25]. Using MRA, de Bondt *et al*. evaluated 136 patients with diagnosed trigeminal neuralgia and found a PTA on the same side of the neuropathic pain in three patients. This corresponds to a prevalence of 2.2%, which is higher than in the general population [26].

Similarly, the close anatomical relationships of the PTA with the oculomotor, abducens, and trochlear nerves may explain cases of cranial nerves paresis in the presence of a PTA [6, 22]. Symptomatic trigeminal nerve compression can be treated with microvascular *decompression surgery [1,2,5,6,15,22]*.

*Ekinici et* al. reported a case of PTA compressing the left side of the pituitary gland, resulting in hormonal disturbances that may produce hyperprolactinemia due to a stalk effect [27].

Harman *et al*. reported a case of PTA compressing the right side of the pituitary gland in a patient with hormonal disorder. Tungaria *et al*. reported a case of hypopituitarism consequent to a giant, thrombosed, sellar-suprasellar ICA aneurysm with an associated PTA on the side of the aneurysm [28].

The relationship between PTA and trigeminal cavernous fistula or carotid-cavernous fistula was extensively described by Chen, Miller, Asai, Kim, Jin, Hurst, Ali *et al*. [12,29,30,31,32,33,34]. They may develop either spontaneously or after a traumatic event, presenting most commonly with ocular symptoms [1,3].

The association between concomitant intracranial aneurysms and PTA is controversial. Kai reported higher frequencies of cerebral aneurysms in patients with a PTA (15.3%) [29].

In the study conducted by Arráez-Aybar *et al*., the incidence of aneurysms approached 22% that was higher than in the general population [5]. Weon demonstrated that the proportion of aneurysms in the presence of a PTA increased to 29% [15]. Opposite to this study, other studies affirmed that there was no increased prevalence of intracranial aneurysms in patients with a PTA. O'uchi *et al*. found that the frequency of intracranial aneurysms coexisting with a PTA was 3.9%, similar to that in the general population [16].

In our opinion, further research is needed for assessment of the association between the presence of PTA and aneurysms.

Aneurysms of the PTA are rare [29,4]. Cerebral aneurysms associated with PTA have been reported to occur in relation to the bifurcations formed by the PTA and either the ICA [35] or the BA [36]. Aneurysms may also be present in other locations of the cerebral circulation [37]. Patients may present with isolated diplopia (sixth nerve palsy), trigeminal neuralgia, subarachnoid

hemorrhage, or carotid cavernous fistula secondary to ruptured aneurysms [1,3,4,15,21,31,32,33,34,42].

Patients with PTA-associated pathological processes may need surgical treatment. Therefore, the relationship of PTA with the skull base must be well characterized, and CT angiography is a good method for simultaneous visualization of bone and vascular structures [41,42]. Moreover, during the planning of surgical approaches to the skull base, it is important to evaluate the vascular anatomy of the sellar and parasellar regions, searching for PTA. The unnoticed presence of a PTA may result in disastrous outcomes following approaches to the sellar or parasellar regions, the cavernous sinus or Gasserian ganglion [22].

**Conclusions**

We have presented an anatomical study of PTA and its clinical significance. Besides the fact that brain arteries are of interest to the anatomists, awareness of their variations is clinically important for radiologists and surgeons for performing safe procedures, as well as for forensic pathologists since they may have forensic consequences.

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