Intraoperative Observations of Anatomic Variations of the Posterior Communicating Artery: A Microsurgical Approach

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Summary

Background: Course and territory supplied by the posterior communicating artery (PCoA) are well known but its origin and calibre are quite variable. Increasing incidence of microsurgical operations in the areas that are supplied by PCoA requires detailed knowledge about the anatomic variations of this artery. The aim of the present study is to examine the anatomical variability of the PCoA, with special emphasis on patients that underwent surgery via the pterional approach.

Methods: The variability of the PCoA was studied intraoperatively in 30 patients selected from a series of 130 individuals that were operated via the pterional approach at our center. Skull base surgery was performed via either the right or left pterional approach. The findings were recorded during surgical intervention and documented by slides and videotapes of the operations. The commencement and dimension of the PCoA were examined.

Results: In all individuals selected, the PCoA constantly arose from the internal carotid artery (ICA). In 70% of the patients, it arose from the posteromedial aspect, in 23.3% from the posterolateral aspect, and 6.6% from the anterolateral aspect of the ICA, respectively. In terms of its diameter, the PCoA showed a considerable amount of variation. Thus, the adult (regular) type was present in 66.6%, the fetal (hyperplastic) type was observed in 26.6%, and the hypoplastic type was seen in 6.7% of the patients.

Conclusion: Knowledge of the variations of PCoA will help the neurosurgeon in design of aneurysm surgery and of reconstruction and revascularization procedures concerning the posterior cerebral circulation.

Key words: Anatomy, microsurgery, posterior communicating artery, pterional approach

Posterior Komünikan Arterin Anatomik Varyasyonları: İntraoperatif Çalışma

Özet

Amaç: Posterior komünikan arterin (PKA) seyri ve beyinde besletiği alanlar iyi bilinmekle beraber kökeni ve çapı oldukça değişkenlik göstermektedir. PKA'nın beslediği bölgelerde yapılan mikroşirirjikal ameliyatların sayısındaki artış, bu arterin anatomik varyasyonlarının detaylı bilinmesini gerektirmektedir. Bu çalışmanın amacı, pteriyonal yaklaşımla ameliyat edilen hastalarda PKA'nın anatomik varyasyonlarını incelemektir.


Bulgular: Seçilen tüm olgularda PKA, internal karotid arterden çıkıyordu. Sırasıyla hastaların %70'inde internal karotid arterin posteromedial yüzünden, %23.3'ünde posterolateral yüzünden, %6.6'sında ise anterolateral yüzünden çıktı. Bununla birlikte, PKA çapı
The posterior communicating artery (PCoA) usually originates from the posterior-medial wall of the supraclinoid segment of the internal carotid artery (ICA). It passes through the chiasmatic and the interpeduncular cisterns. Branches of PCoA supply the optic chiasm and tract, the tuber cinereum, the mamillary body, the subthalamus, the posterior hypothalamus and the anterior and ventral parts of the thalamus\(^{13,22}\). Occlusion of the PCoA or its branches results in hemiballismus and thalamic syndrome\(^{13}\).

Knowledge of the microvascular anatomy of the PCoA is essential in dealing with tumoral and vascular lesions of this region. The course and the areas supplied by the branches of the PCoA are well known, but its commencement and dimension are prone to a considerable amount of variation. The results hitherto published are based on data derived either from formalin-fixed and polyester resin-injected specimens or from angiograms\(^{1,4-7,11,13,14,16,17}\). Microsurgery of the brain only offers a very limited operation field which, in turn, depends on the surgical approach selected.

The PCoA and its perforating branches cross the operation field suitable for the surgical therapy of sphenoid wing tumors, hypophyseal adenomas, sellar and parasellar tumors, as well as aneurysms of the anterior cerebral circulation and basillary tip\(^{2,3,10,18,20}\). Better understanding of the microvascular anatomy and type of PCoA is helpful in operations of these areas.

The present study was undertaken in order to analyze the anatomic variants of the PCoA in a series of patients operated via the pterional approach.

MATERIAL AND METHODS

During the period of last five years, a total of 130 patients were operated via pterional approach at our center. Informed consent was obtained from the patients. PCoA was observed in 30 patients. Of the 30 patients, 18 were female and 12 were male who ranged between 20 and 60 years of age. 25 patients were operated via right pterional approach and 5 were operated via left pterional approach.

In all cases, a right or left pterional craniotomy was used. After craniotomy, sylvian microdissection techniques described by Yasargil were employed in all cases\(^{19,21}\). After dural opening, proximal sylvian fissure was opened and the laterobasal frontal lobe is gently retracted medially to expose the optic nerve and internal carotid artery. The carotid cisterns were opened to release cerebro-spinal fluid (CSF) and to gain optimal relaxed brain condition and microdissection is continued distally to the internal carotid artery bifurcation. The thickened arachnoid bands were divided and the lamina terminalis cistern was opened if it wasn't occluded by tumors or aneurysm to allow the frontal lobe to be retracted. After that, according to the lesion dissection was completed.

The commencement and dimension of the PCoA were examined on the basis of the operative findings. The findings were recorded during surgical intervention and documented by slides and videotapes of the operations.
RESULTS
In all individuals selected, the PCoA constantly arose from the internal carotid artery (ICA). In 70% (n=21) of the patients, it arose from the posteromedial aspect (Figure 1), in 23.3% (n=7) from the posterolateral aspect (Figure 2), and 6.6% (n=2) from the anterolateral aspect of the ICA (Figure 3), respectively. Moreover, in terms of its diameter, the PCoA showed a considerable amount of variation. Thus, the adult (regular) type was present in 66.6% (n=20) (Figure 1), the fetal (hyperplastic) type was observed in 26.6% (n=8) (Figure 4), and the hypoplastic type was seen in 6.7% (n=2) (Figure 5) of the patients. The results of the study are shown in Table 1.

Figure 1: PCoA arising from the posteromedial aspect of ICA.

Figure 2: Adult type PCoA arising from the posterolateral aspect of ICA.

Figure 3: PCoA arising from the anterolateral aspect of ICA.

Figure 4: Fetal type PCoA.

Figure 5: Hypoplastic type PCoA.
DISCUSSION
The PCoA can be exposed after opening the Liliequist's membrane over the interpeduncular cisterna. This arachnoid membrane was first described by Key and Retzius in 1875\(^\text{(11)}\). PCoA is surrounded by the same membrane covering the oculomotor nerve\(^{\text{(8,9,22)}}\). According to Yasargil, this membrane is similar to the membrane of the oculomotor nerve and it is a fold of the interpeduncular cistern\(^{\text{(22)}}\). Some authors claim PCoA to have its own cistern, which is observed as a thickened membrane following a subarachnoid hemorrhage\(^{\text{(5,17)}}\).

PCoA exits the carotid cistern at its origin and extends inferiorly in the interpeduncular cistern. As many other arteries, it is secured in the cistern by various arachnoidal bands. PCoA extends posteromedially and joins the posterior cerebral artery (PCA) below the tuber cinereum and above the sella turcica and the oculomotor nerve. Along its course, it proceeds close to the dura mater above the posterior clinoid process. These adhesions prevent excessive movement of the artery during aneurysm surgery and facilitate intervention\(^{\text{(22)}}\). In their study examining 25 cadavers, Gibo et al. have found that PCoA originates from the posteromedial part of the ICA in 44\%, from the posterior part in 30\%, from the posterolateral part in 22\%, and from the medial part in 4\%\(^{\text{(7)}}\). Bisaria et al. have performed a similar study in 126 cadaver specimens and

Table 1: The results of the variations of posterior communicating artery in our study
reported that in 110 of the cadavers, both PCoAs originated from the posteromedial part of the ICAs, in 12 cadavers, one PCoA originated from the posteromedial part and the other from the medial part, and in 2 cadavers, both PCoAs originated from the posterior part \(^4\). In their study, Uz et al. found PCoA originating from the posteromedial part of the ICA in 66.6% of 15 cadavers, from posterolateral part in 26.6%, and from the anterior part in 6.6% \(^{16}\). Our study is one of the rare intraoperative studies. We observed that PCoA originates from the posteromedial part of the ICA in 70% of cases, from the lateral part in 23.3%, and from the anterolateral part in 6.6%.

Various anatomical variations of the PCoA have been reported \(^{1,4,11,14,15,17,18,22}\). Aplasia of one or both of the arteries, duplication, triplication, fenestration and PCoA originating from the ophthalmic artery are among these variations. In embryonic life, PCoA continues as PCA; however, in adults PCoA leaves the basillary system. When the PCoA is the major origin of the PCA, then it is referred to as fetal type artery. On the other hand, if the artery is smaller, then it is referred to as adult type artery. If the diameter of the artery is smaller than 1 mm, it is referred to as hypoplastic artery \(^{13,14}\). Saeki et al. found 32% hypoplastic type, 22% fetal type and 46% adult type arteries in 50 cadavers \(^{14}\). Bisaria et al. examined 126 cadavers and reported 31.7% fetal type \(^4\). Pedroza et al. have reported 22% fetal type, and 34% hypoplastic type in 25 cadavers \(^{11}\). Vincentinelli et al. \(^{17}\) have reported 20% fetal type in 60 cadavers, and Gabrovsky et al. \(^5\) have reported 41.43% adult type, 47.14% hypoplastic type, and 11.43% fetal type arteries in 35 cadaver specimens. Yasargil et al. have reported these ratios as follows: 67.5% adult type, 24.5 fetal type, and in 8% PCoA and PCA having the same diameters \(^{21}\). According to Uz et al., there were 26.6% fetal type arteries in their study \(^{16}\). In their study evaluating MR angiographic images, Avci et al. have reported 34% hypoplastic type, 45% adult type, and 10% fetal type. Their study with 5 cadavers revealed 28% hypoplastic type, 30% adult type, 28% fetal type and 14% transitional type arteries \(^{15}\). In our study, we observed adult type arteries in 20 (66.6%) cases, fetal type in 8 (26.6%), and hypoplastic type in 2 (66.6%) cases. Our results are similar to those obtained in another intraoperative study performed by Yasargil.

The relationship between the PCoA and the oculomotor nerve is important. The nerve can be used as a reference point. Some authors have stated that the oculomotor nerve can be medially located if the artery is of fetal type \(^{7,14,16}\). On the other hand, some authors insist that the PCoA is never located lateral to the nerve \(^{4,11,17}\). It is claimed that utilization of an optico-carotid approach in the surgery of basillary bifurcation aneurysms will decrease the risk of oculomotor nerve injury \(^{4,11}\). The communicating segment of the supraclinoid segment is one of the most common locations where aneurysms occur, and these aneurysms originate from the posterolateral wall, just above the origin of the PCoA, and are located above the siphon. PCoA is located inferomedially to the aneurysm and superiolaterally to the anterior choroidal artery. They can compress the oculomotor nerve where it perforates the dura mater \(^{21}\). According to this point of view, the lower the number of perforating branches arising from the communicating segment, the more favorable the situation, since if the aneurysm enlarges, it may cause compression on the perforating branches extending to the PCoA, anterior choroidal artery and ICA \(^3\).

The lateral and the superior wall of the PCoA give rise to an average of 8 \(^{-14}\) perforating branches. These branches advance superiorly and supply the tuber cinereum, pre-mamillary part of the 3rd ventricle, posterior perforating substance,
interpeduncular fossa, optic tract, optic chiasm, thalamus, hypothalamus, subthalamus and the internal capsule. Perforating branches cruise along the PCoA, with more branches at the anterior part. The premamillary artery is the thickest branch of the PCoA. It advances between the mamillary body and the optic tract and perforates the roof of the 3rd ventricle. Two or three perforating branches end up in the premamillary region; however, the thickest of them is referred to as the premamillary artery. Some authors name this artery as the anterior thalamoperforating artery. The premamillary artery usually originates from the mid 1/3 portion and it supplies the posterior hypothalamus, anterior thalamus, posterior limb of the internal capsule, posterior perforating substance, and the subthalamic nucleus. Occlusion of the branches to the subthalamic nucleus leads to contralateral hemiballismus.

Branches of the PCoA can be injured during surgical interventions of tumors of the parasellar region, hypophysis tumors and aneurysm of the basillary tip. Hypothalamic disturbances, diabetes insipidus, somatostatic symptoms, weakness and movement disorders can be encountered following injury to these branches.

In conclusion, detailed knowledge of the anatomical variations of PCoA is of utmost importance during surgical intervention on the circle of Willis and will help neurosurgeons in constructing a safer microdissection plan.

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Received by: 23 June 2009
Revised by: 27 August 2009
Accepted: 28 August 2009

The Online Journal of Neurological Sciences (Turkish) 1984-2009
This e-journal is run by Ege University Faculty of Medicine,
Dept. of Neurological Surgery, Bornova, Izmir-35100TR
as part of the Ege Neurological Surgery World Wide Web service.
Comments and feedback:
E-mail: editor@jns.dergisi.org
URL: http://www.jns.dergisi.org
Journal of Neurological Sciences (Turkish)
Abbr: J. Neurol. Sci.[Turk]
ISSNe 1302-1664

REFERENCES

11. Pedroza A, Dujovny M, Artero JC, Umanovsky F, Berman SK, Diaz FG, Ausman Ji, Mirchandani