

Microanatomy of the Premamillary Artery *

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Summary

The premamillary artery was studied in 50 unfixated human brain hemispheres (51 vessels were found) which were injected with polyester resin and dissected under the operating microscope. In one hemisphere there was duplication of the premamillary artery. There were premamillary arteries arising from the posterior communicating artery (PCoA) in 49 cases and from the posterior cerebral artery in the remaining two. The arteries originated from the superior and lateral surfaces of the PCoA and coursed superiorly, laterally, and posteriorly to enter a triangular perforated space limited by the mamillary body and tuber cinereum medially, the optic tract anterolaterally, and the cerebral peduncle posterolaterally. This space is called the paramedian perforated substance.

The premamillary artery had an outer diameter of 0.6 ± 0.2 mm on the right side and 0.6 ± 0.1 mm on the left. The length of the premamillary artery was 12.0 ± 2.0 mm on the right side and 12.7 ± 1.9 mm on the left. Sixty-three percent of the premamillary arteries gave off branches that supplied the cerebral peduncles, optic tract, and paramedian perforated space.

The clinical importance of these anatomical data in the symptomatology and management of vascular and neoplastic diseases in and around the posterior circle of Willis is discussed.

Keywords: Cerebral arteries; posterior communicating artery; posterior cerebral artery; premamillary artery.

Introduction

Increased knowledge of the microanatomical features of the circle of Willis has been required by neurosurgeons due to its great importance when approaching vascular lesions. In spite of being the largest and most constant branch of the posterior

communicating artery, the premamillary artery had not been previously studied in an isolated fashion, and data concerning it were fragmentary, often within the context of broader studies.

This study of the anatomy of the premamillary artery involves detailed measurement of the outer diameter and length, as well as definitions of the branching patterns, points of penetration, and anatomical variations of the vessel and its branches.

Materials and Methods

Twenty-five unfixated human brains were obtained at routine autopsy four to eight hours post mortem from adults without signs of central nervous system disease. After the brains were immersed in Ringer's solution, the basilar artery was cannulated with 18 gauge polyethylene catheters positioned immediately anterior to the origin of the superior cerebellar arteries. The supraclinoid internal carotid arteries, the middle cerebral arteries, and both anterior cerebral arteries were ligated with 3-0 suture. The arteries were flushed with 300 cm³ of normal saline and injected with polyester resin * according to the previously reported technique used in our laboratory^{8, 25, 26}. A Zeiss OPI surgical microscope ** with a Pentax K-1000 camera *** attached was used for the dissection of the paramedian perforated space. The basal cisterns were opened to expose the ventral surface of the brain. Designations of superior, inferior, anterior, and posterior were assigned in accordance with conventional anatomical positions (Fig. 1). The paramedian perforated substance is penetrated by the premamillary artery and its branches, and by other arteries arising from the posterior communicating artery (PCoA). Our study has

* Russ Simpson Co., Warren, Michigan.

** Carl Zeiss, Inc., New York, N.Y.

*** Honeywell, Inc., Photographic Products Division, Littleton, CO.

* Supported in part by the Bauervic Foundation (West Bloomfield, Michigan), the Sheldon G. Hayes Stroke Research Fund (Detroit, Michigan), and the Harris Foundation (Detroit, Michigan).

included the paramedian perforated substance as well as the origin, course, outer diameter (OD), and branching pattern of the arteries that penetrate it. Detailed schematic drawings of the findings were made, and photographs of the anatomical dissections were taken.

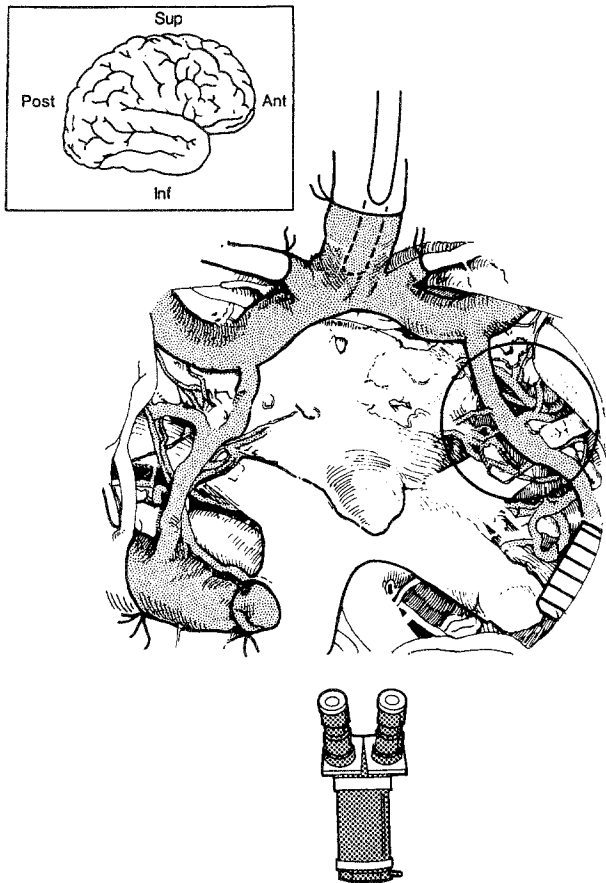


Fig. 1. Relationships of the premamillary artery as seen in the standard anatomical position and from the ventral surface of the brain

Results

The paramedian perforated substance was a well-defined space in every hemisphere studied. It was shaped almost like an equilateral triangle, limited by the mamillary body and tuber cinereum medially, by the optic tract anterolaterally, and by the cerebral peduncle posterolaterally (Fig. 2). The dimensions of the paramedian perforated substance are shown in Table 1.

The vessels penetrating the paramedian perforated substance originated from the PCoA. Eighty of these vessels were found in the 50 hemispheres studied; there were 51 premamillary arteries and 29 other vessels.

The premamillary artery was seen as a single vessel, except in one hemisphere, where it was found to be doubled (Fig. 3 A). In 49 cases it arose from the PCoA, and in two hemispheres (one on each side) it arose from the posterior cerebral artery (PCA) beyond the points of junction with the PCoA. The distance from the origin of the PCoA to the origin of the premamillary artery was 6.7 ± 2.5 mm on the right side and 6.0 ± 1.9 mm

Table 1. *The Paramedian Perforated Substance*

Wall	Length (mm)	
	Right	Left
Medial (mamillary)	5.0 ± 0.3	5.1 ± 0.4
Anterolateral (optic)	5.1 ± 0.5	5.0 ± 0.6
Posterolateral (peduncular)	5.2 ± 0.4	5.3 ± 0.6

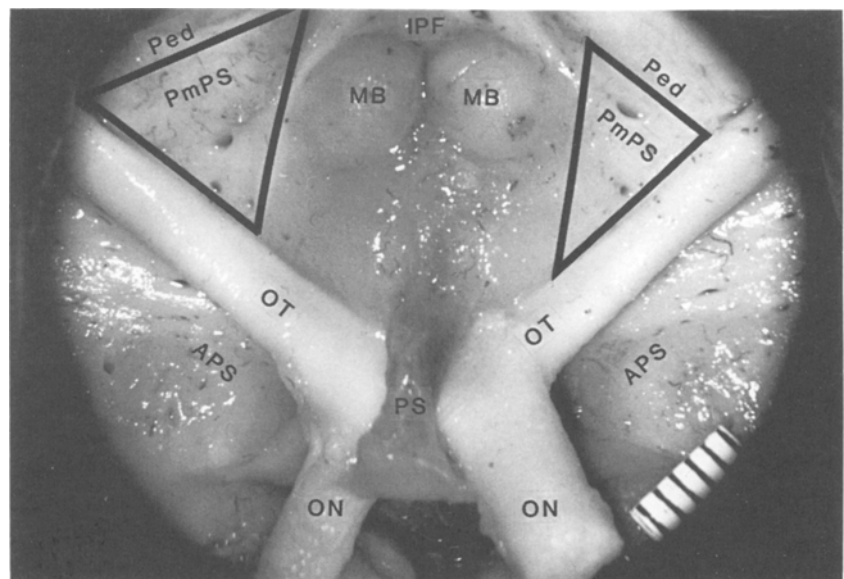
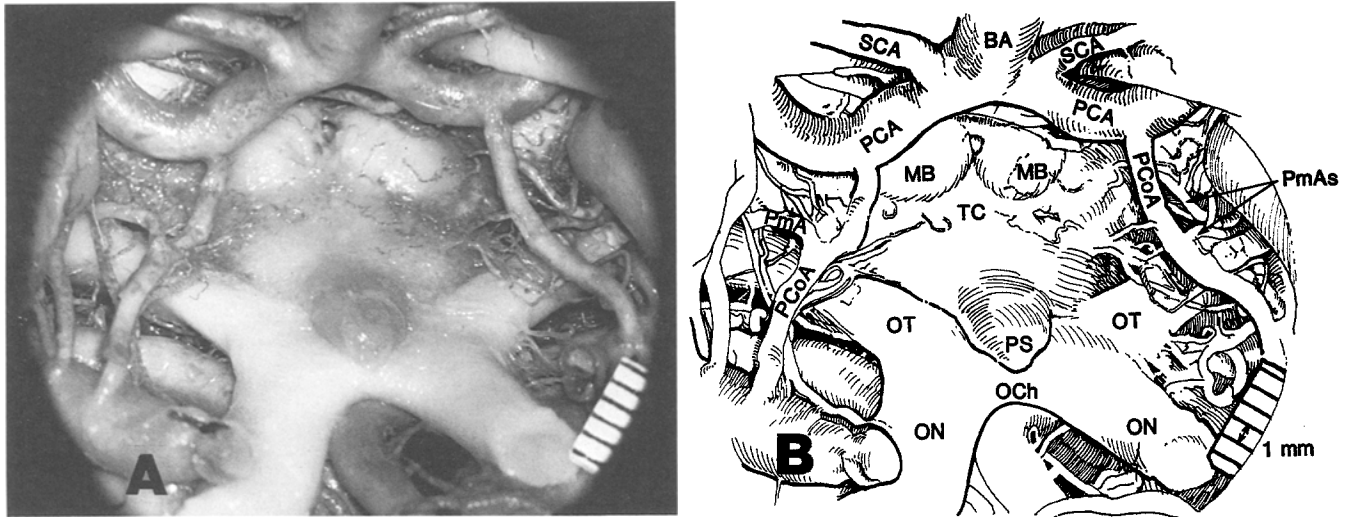


Fig. 2. The paramedian perforated substance (*PmPS*). The *PmPS* is triangularly shaped, limited by the mamillary body and tuber cinereum medially, by the cerebral peduncle posterolaterally, and by the optic tract anterolaterally. *IPF* interpeduncular fossa, *Ped* cerebral peduncles, *MB* mamillary body, *OT* optic tract, *APS* anterior perforated space, *ON* optic nerve, *PS* pituitary stalk



Figs. 3 A and B. Premamillary arteries arising from the posterior communicating artery (*PCoA*). The right *PCoA* has two premamillary arteries branching from it, with the left *PCoA* being the parent vessel for one premamillary artery. *BA* basilar artery, *SCA* superior cerebellar artery, *PCA* posterior cerebral artery, *MB* mamillary body, *TC* tuber cinereum, *PS* pituitary stalk, *PmA* premamillary artery, *OT* optic tract, *OCh* optic chiasm, *ON* optic nerve

Table 2. Premamillary Artery Origin

	Right	Left
<i>PCoA segment</i>		
Anterior third	8% (4)	10% (50)
Middle third	35% (17)	33% (16)
Posterior third	8% (4)	6% (3)
<i>PCoA wall</i>		
Superior	14% (7)	18% (9)
Lateral	37% (18)	31% (15)

on the left side. The location of the premamillary artery origin is detailed in Table 2. Of the two hemispheres where the premamillary artery originated from the *PCA*, it arose from the superior wall in one and from the anterior wall in the other. The artery was always tortuous, following an upward course. Although the initial course could follow a lateralward path, it always ended medial to its origin. The course in the sagittal plane was variable, depending on the relationship between the premamillary artery origin and the paramedian perforated substance.

In most instances, the artery had a uniform outer diameter along its length. The OD at its origin was 0.6 ± 0.2 mm on the right side and 0.6 ± 0.1 mm on the left. The OD when it penetrated the brain surface was 0.6 ± 0.2 mm on the right side, and 0.6 ± 0.1 mm on the left. The length of the premamillary artery was

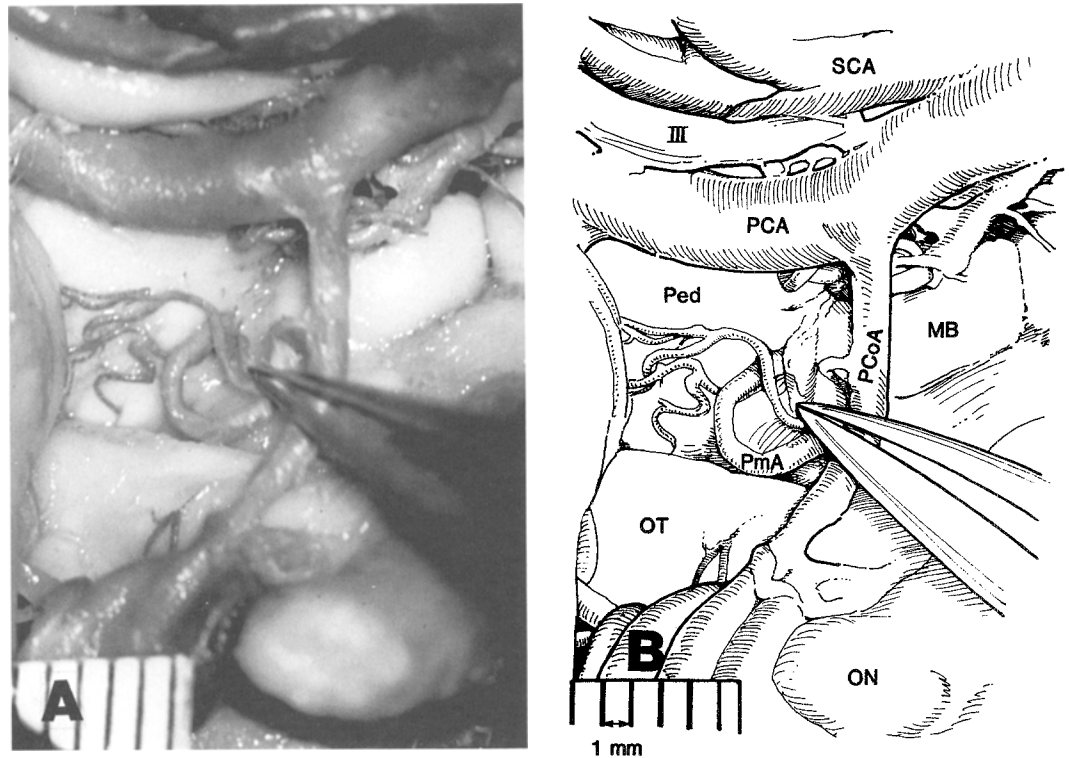
12.0 ± 2.0 mm on the right, and 12.7 ± 1.9 mm on the left side.

Of the 51 premamillary arteries found, 37% did not have branches. The remaining 63% were the origins for 97 branches before penetrating the paramedian perforated substance (Figs. 4 A and B). The numbers of branches, ODs, and distances along the premamillary artery where they were found are detailed in Table 3.

There were 29 other arteries penetrating the paramedian perforated substance and originating from the *PCoA*, 59% on the right and 41% on the left. Their ODs were significantly smaller than that of the premamillary artery, 0.2 ± 0.1 mm on the right, and 0.2 ± 0.1 mm on the left. Their lengths were 11.7 ± 2.1 mm on the right and 10.2 ± 2.4 mm on the left. They originated 6.9 ± 3.4 mm (right) and 7.6 ± 2.0 mm (left) from the origin of the *PCoA* and they gave branches mainly to the optic tract.

Discussion

There have been few detailed descriptions of the anatomical features of the extracerebral portion of the premamillary artery; most have been in the context of the blood supply of the diencephalic structures, and have neglected the extracerebral anatomical features. Many of these studies were done before the microscope was used in dissection, and the brains were fixed or noninjected; as a result, the descriptions are inconclusive.



Figs. 4 A and B. Branching of the premamillary artery (*PmA*). The *PmA* has been displaced anteriorly to allow visualization of the point of penetration into the paramedian space. *SCA* superior cerebellar artery, *PCA* posterior cerebral artery, *PCoA* posterior communicating artery, *III* oculomotor nerve, *MB* mamillary body, *Ped* cerebral peduncle, *OT* optic tract, *ON* optic nerve

Table 3. *Premamillary Artery Branches*

Point of penetration	Number of branches	Outer diameter (mm)	Length (mm)
Cerebral peduncles:			
right	36	0.2 ± 0.03	9.6 ± 1.3
left	29	0.2 ± 0.02	10.8 ± 2.6
Sulcus:			
right	9	0.2 ± 0.02	9.7 ± 2.0
left	9	0.2 ± 0.1	10.0 ± 1.3
Paramedian perforated substance:			
right	12	0.2 ± 0.04	8.0 ± 2.3
left	4	0.2	9.3

In 1874, Duret reported that the anterior internal optic arteries originated from the PCoA and supplied the anterior wall of the third ventricle^{3, 4}. They were referred to as the “premamillary or thalamotuberal pedicle” by Foix and Hillemand in 1925, who reported that they were composed of a dozen trunks of variable size originating from the PCoA or from the PCA at regular intervals; or less frequently, as common trunks supplying the medial and ventral thalamus⁵. This artery was later identified as the largest and longest

branch of the PCoA by Lazorthes^{12–15}. Percheron^{16–18} called it the “thalamic polar artery”.

Most authors agree that the premamillary artery enters the brain in front of^{6, 7, 23} or lateral to^{5, 22} the mamillary bodies, but only Percheron^{17, 18} has described the point of penetration as a triangular space between the mamillary body, optic tract and cerebral peduncle. Our findings show that this triangular space is a constantly found perforated substance, which we have designated the paramedian perforated substance.

It is perforated by the premamillary artery and some of its branches along with other small branches from the PCoA. The most reliable parameter in differentiating the premamillary artery from other PCoA branches, aside from its being the largest branch, is that the premamillary artery is the artery that enters the paramedian perforated substance.

We found the premamillary artery in every hemisphere in our study, although in two cases it did not arise from the PCoA but from the PCA distal to the junction of the P1 segment and the PCoA, as seen by Foix and Hillemand⁵. This 100% incidence of occurrence of the premamillary artery is higher than previously reported^{9, 14, 21}.

Very few authors have addressed the length and diameter, point of exit, course, and branching pattern of the premamillary artery. Saeki *et al.*²¹ found the premamillary artery to measure 0.6 mm in OD and noted that it arose from the middle third of the PCoA in 50% of the cases studied, from the anterior third in 17% of the cases, and from the posterior third in the remaining 13%. They did not state that any branches arose from the artery, as we have seen in 63% of the 51 premamillary arteries in our study. Stephens and Stilwell²³ did not give any measurements, but reported that there were a few branches from the premamillary artery to the hypothalamus. However, this view was not held by Percheron¹⁵, who stated that the premamillary artery does not participate in the blood supply of the hypothalamus. Percheron further stated^{17, 18} that the premamillary artery is always a single artery, unlike the findings in our study of a 2% incidence of duplicated premamillary arteries (Figs. 3 A and B). Stephens and Stilwell²³ found the premamillary artery originating from the posterior half of the PCoA, while Percheron¹⁷ noted that it originated from the medial third of the PCoA. Only Foix and Hillemand⁵ have pointed out an origin from the PCA, as we have seen in 4% of the cases in our study. From our data, we can state that the premamillary artery is the largest branch of the PCoA, it is usually found as a single branch, it originated from the middle third of the PCoA in more than 50% of our cases, it has branches that lead to the cerebral peduncles, optic tracts, and paramedian perforated space, and it always penetrates the brain at the paramedian perforated substance.

Most assessments of the territory supplied by the premamillary artery have been undertaken using radiological^{14, 15} or histological studies^{9, 10, 12, 16–20, 22, 23}. In reviewing these studies, the differences that arise are due primarily to the different nomenclature used.

Despite these differences, there is general agreement that the premamillary artery supplies the lateral and medial anterior thalamus, although some investigators have not found proof of irrigation of the anterior nucleus^{16, 19, 20}. Percheron¹⁶ states that the premamillary artery does not supply the hypothalamus, but this view is not supported by others^{9, 10, 12, 14, 15, 17–20, 22, 23}.

The premamillary artery has received little attention in most discussions of surgical procedures involving the posterior circle of Willis. It is most important that surgeons be aware of the risk of premamillary artery injury when using the subtemporal approach² or its pterional and sylvian variations^{11, 22, 24, 27} for lesions which are located at or near it, such as pituitary, hypothalamic, and upper brainstem neoplasms, or PCoA and distal basilar artery aneurysms. Although Percheron^{16, 17} stated that clinical manifestations of an infarct in the territory supplied by the premamillary artery are rare, Hayman¹⁰ was of the opinion that neurology in premamillary artery infarction is severe, including memory loss and personality changes, loss of endocrine function, anorexia, rage attacks, and disorders of temperature regulation and consciousness.

The premamillary artery clearly is an important component of the posterior circle of Willis, and must be taken into account when surgery is being planned in that region. With a detailed and comprehensive knowledge of his vessel's extracerebral anatomical features, complications resulting from injury to the premamillary artery could be avoided.

Acknowledgements

We would like to thank the people who helped make this study possible: Jay Knipstein for his art work and Elizabeth Kiselev for her editorial assistance.

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