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The Middle Meningeal Artery in Man

by

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(With two Plates)

THE exact point of division of the middle meningeal artery has an important practical bearing. There is, however, no agreement regarding the normal or the variable points of division of this artery. Giuffrida-Ruggeri (1913) described three principal branches for the middle meningeal artery and following a study of 175 skull halves of Italian subjects classified the branches into four fundamental types. He based his classification on the points of division of the main vessel, the relative size of the anterior and posterior division and the presence or absence of their branches. His types are as follows :—(Fig. 1).

Type 1 (31.9%). Division at pterion and where the ramus bregmaticus gave rise to ramus lambdaticus, ramus obelicus and possibly a pre-obelic ramus.

Type 2*a* (10.1%). Division at the pterion and where the ramus obelicus arose from the ramus lambdaticus.

Type 2*b* (27.7%). Division at the middle cranial fossa and where the ramus obelicus took origin from the ramus lambdaticus.

Type 3 (27.7%). Where the ramus lambdaticus was given off in the middle cranial fossa, with no branches.

Type 4 (2.5%). Where there were two obelic branches, the pre-obelic from the ramus bregmaticus and the ramus obelicus from the ramus lambdaticus in the middle cranial fossa.

Types 1 & 3 were instances of anterior preponderance while type 2 was a case of posterior preponderance—Type 4 was regarded as neutral.

Adachi (1925) who also distinguished three main branches, however, described three types of branching in Japanese subjects. He based his classification mainly on the varieties and size of the ramus medius.

Type A (51%). Where ramus posterior and ramus medius arose separately. (Types 1 and 3 of Giuffrida-Ruggeri).

Type B (40%). Where the ramus posterior and ramus medius arose together. (Type 2 of Giuffrida-Ruggeri).

Type C (9%). Where there were two rami medii arising directly from the main stem and the other together with the ramus posterior. (Type 4 of Giuffrida-Ruggeri).

This study which was undertaken in view of the surgical importance of the middle meningeal artery, deals with the points of division of the main vessel and also provides a classification of the arterial pattern in English subjects, on the basis of two main branches.

Material and Methods

In all 100 skulls were studied ; 50 skulls from infants, 20 adults from the dissecting room and 30 dried adult specimens, making a total of 200 sides. The infant material was injected with indian ink (Raven brand) through the ascending aorta, at a temperature of 37°C employing a pressure not exceeding 150 mm. Hg. The brains were hardened in some specimens by injections of 10% formalin. The vessels were displayed by careful dissection. In the majority of specimens the heads were hardened in carbon dioxide snow after injection, and sawn across sagittaly. The brain matter was removed in running water leaving the dura mater against the bones. The scalp was then dissected away from the bone and the sections dehydrated through repeated changes in ascending grades of alcohol. Finally the specimens were cleared in tetrahydronapthalene. Stereoscopic radiography was employed in the study of the dried skulls. Photographs or drawings were made after displaying the artery and its branches. A careful note was made of the sites of division of the main vessel, the number and course of its branches and any abnormalities found.

Findings

The sites of division of the middle meningeal artery observed in a total of 200 sides are set out in Table I.

Table I. Site of division of the middle meningeal artery

Point of division of artery	Infant	Adult
Near foramen spinosum	33 sides 33%	42 sides 42%
Below antero-lateral fontanelle	45 sides 45%	
Below pterion		40 sides 40%
Mid point of antero-lateral fontanelle	17 sides 17%	
At pterion		16 sides 16%
Above antero-lateral fontanelle	3 sides 3%	
Above pterion		1 side 1%

This table accounts for only 98 infant and 99 adult sides. The remaining 2 sides in the infant and one in the adult were instances when the anterior division of the middle meningeal artery arose from the ophthalmic artery.

The artery divides most often just below the pterion or somewhere between this point and its site of entry through the foramen spinosum. In the infant the distance covered by the artery on its course from the foramen spinosum to the antero-lateral fontanelle is between 2½—3 cms. In the adult the distance varies from 5.7 to 7.6 cms. In each case approximately half this distance lies on the floor of the middle cranial fossa and half on the lateral wall of the cranium. When the artery divides close to the foramen spinosum, the point of bifurcation is either immediately after its entry in both infants and adults, or about 1 cm. away in the case of the infant and 2.5 cms. in the adult. This site of division was seen in 37.5% of all specimens examined. The division below the pterion occurred in 42.5% of the total number studied. In 16.5% of the total the artery divided at the pterion. In 3 infant specimens the artery divided above the antero-lateral fontanelle, and in two of these the middle meningeal arose from the ophthalmic artery.

After division, the anterior branch, which represents the continuation of the main artery, passes upwards just behind the anterior margin of the parietal bone. Having reached the superior sagittal sinus it bends forward to anastomose with the terminal branches of the homolateral median meningeal artery (branch of the anterior ethmoidal) over the sinus. Several branches are given off from its terminal part and some of these anastomose over the sinus with corresponding vessels from the opposite side. Others pass downwards lateral to the sinus to be distributed to the falx cerebri. In its course the anterior division gives off two or more branches from its anterior aspect and several from its posterior margin; of these anterior vessels one is constant and usually arises just above and rarely below the antero-lateral fontanelle. This branch was seen in 3 instances to arise in the middle cranial fossa from the main vessel prior to its division.

The posterior division of the middle meningeal artery runs backwards on the lateral wall of the middle cranial fossa, either below the upper margin of the squamous part of the temporal bone or just above the inferior margin of the parietal bone. Ultimately, it reaches the postero-inferior angle of the parietal bone and then bends upwards close to the posterior margin of the parietal bone to divide into several terminal branches on reaching the superior sagittal sinus. These branches pass both forwards and backwards; some cross over the sinus to anastomose with vessels from the opposite side and others pass downwards lateral to the sinus to enter the falx cerebri. Several of the terminal branches run backwards to supply in relation to the interparietal part of the occipital bone and they anastomose with the meningeal branches of the occipital and vertebral arteries. The area between the two main divisions of the middle meningeal artery is supplied chiefly by one or two branches which are invariably large, extending to the region of the superior sagittal sinus. They may be termed intermediate branches. Five different patterns of intermediate branching can be recognised. They are classified below as A, B, C, D, and E in order of their frequency of occurrence.

Type A 44% Fig. 2

One intermediate branch arising from the anterior division. This arrangement was present in 46 infant and 42 adult sides. This single intermediate branch usually arose above the pterion but in 8 infant and 11 adult sides it arose below.

Type B 34% Fig. 3

One intermediate branch arising from the posterior division. This pattern was found in 31 infant and 37 adult sides.

Type C 12% Fig. 4

Two intermediate branches, one arising from the anterior division and the other from the posterior. This arrangement was seen on 12 sides in each of the infant and adult specimens.

Type D 8.5% Fig. 5

Two intermediate branches both taking origin from the posterior division. This type was seen in 8 infant and 9 adult sides.

Type E 1.5% Fig. 6

Two intermediate branches both arising from the anterior division one above the pterion and the other below.

A constant vessel arose from the middle meningeal artery immediately after its entry into the cranium. This passed backwards along the petro-squamous junction to supply the tentorium and the dura mater of the posterior cranial fossa around the sigmoid sinus. The orbital branches were one or two in number and arose from the main vessel, its anterior division or from both sources. These traversed the superior orbital fissure to supply some of the orbital structures and sometimes replaced the lacrimal artery. The origin of the latter vessel from the middle meningeal was observed in 16 infant specimens.

The middle meningeal arteries travel in the substance of the dura mater and anastomose anteriorly with the meningeal branches of the anterior and posterior ethmoidal arteries above they unite with the middle meningeal artery of the opposite side ; behind with the posterior meningeal arteries ; and in the middle cranial fossa with the meningeal branches of the internal carotid and recurrent branches of the ophthalmic and lacrimal arteries, and with the accessory meningeal artery when present. Apart from this, the branches of each middle meningeal artery divided into a large number of arterial twigs which by their anastomoses formed complicated networks in the substance of the dura mater.

The middle meningeal artery rarely arises from the ophthalmic artery inside the orbit and passes backwards through the superior orbital fissure to be distributed to the dura mater of the middle zone. This anomalous origin was seen in 3 infant specimens, two were right sided and the third left. The foramen spinosum was absent in these cases. The anterior division of the middle meningeal artery alone is at times replaced by a vessel

arising from the ophthalmic artery. This arrangement was seen in 3 subjects (2 infant and 1 adult), once on each side. The vessel which entered through the foramen spinosum represented the posterior division of the middle meningeal artery in its distribution.

Discussion

Quain (1948) mentioned the pterion as the site of division of the middle meningeal artery; Patarjet (1909) noted it to be close to the foramen spinosum and Buchanan's Manual of Anatomy records the point of division as 1—1½ inches from the foramen spinosum. This investigation, however, shows that the division occurs about equally at two sites : (*a*) below the pterion (42.5%) and (*b*) close to the foramen spinosum (37.5%). It is important to note that the division also occurs though infrequently (16.5%) at the pterion itself. It is at least noteworthy that in half the number of cases (4) where the primary division took place above the pterion, the middle meningeal artery arose from the ophthalmic artery.

The majority and current view that the middle meningeal artery has two primary branches is confirmed, although Schipault (1894), Fugisawa (1889), Angelotti (1910), Giuffrida-Ruggeri (1913), Kudo (1922) and Adachi (1925) have each described three branches—anterior, middle and posterior. The middle branch described by Schipault and others is a secondary branch. The term " intermediate " is more applicable to these secondary branches than " middle " as the latter term conveys the erroneous idea of the site of their origin. These intermediate branches are distinguished by their site of origin ; close to the pterion in case of branches arising from the anterior division and close to the inferior margin of the parietal bone, near its midpoint, for those arising from the posterior division.

It is on the basis of this distinction that the intermediate branching is classified into five types. The type 3 described by Giuffrida-Ruggeri is only a subdivision of his type 1 and hence these two types may be taken together as in Adachi's classification. Types D and E are not described by these two investigators. These types are indeed infrequent but nevertheless they are present.

These results based on a study of 50 injected infant subjects, 20 adult specimens and 30 dried skulls represent a sample of reasonable size. Giuffrida-Ruggeri and Adachi both studied the branching only in dried skulls and it is doubtful if this is adequate.

The incidence of the anomalous origin of the middle meningeal artery from the ophthalmic artery (3%) is the same as that observed by Jazuta (1905). Zuckerkandle (1876) has noted this anomaly in 4% cases.

Haller (1745-56) recorded the origin of the lacrimal artery from the middle meningeal in 4 out of 17 cases, while Meyer (1887) noted 5 in 20 cases. This arrangement was, however, seen only in 16% of the infant specimens.

Summary

1. The site of division, the distribution and branching of the middle meningeal artery ha been investigated in 50 infant and 50 adult specimens, making a total of 200 sides.

2. The division of the middle meningeal artery occurs at four different sites :—

(*a*)	below the pterion	42.5%
(*b*)	near the foramen spinosum	37.5%
(*c*)	at the pterion	16.5%
(*d*)	above the pterion	2%

3. The branching of the middle meningeal artery is classified into five types A, B, C, D and E in order of their frequency of occurrence.

4. The anomalous origin of the middle meningeal artery from the ophthalmic artery was noted in 3% of cases.

5. The origin of the anterior division of the middle meningeal artery alone from the ophthalmic artery was observed in 3% of cases.

6. The origin of the lacrimal artery from the middle meningeal was seen in 17% cases.

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*Not read in the original

EXPLANATION OF PLATES

PLATE I

Figure 1.—Photograph illustrating the types of branching of the middle meningeal artery.
After Giuffrida-Ruggeri (1913).

Figure 2.—Photograph of an injected and cleared left half of skull, viewed from inside.
AD—Anterior division of middle meningeal artery.
PD—Posterior division of middle meningeal artery.
I—Intermediate branch arising from the anterior division above antero-lateral fontanelle.

Figure 3.—Photograph of an injected and cleared right half of skull, viewed from inside.
PD—Posterior division.
I—Intermediate branch arising from posterior division.

PLATE II

Figure 4.—Photograph of drawing of an injected and cleared right half of skull, viewed from inside.
I_1—Intermediate branch arising from anterior division.
I_2—Intermediate branch arising from posterior division.

Figure 5.—Photograph of an injected and cleared right half of skull, viewed from inside.
I_1 I_2—Intermediate branches arising from the posterior division.

Figure 6.—Photograph of drawing of left half of brain with the meninges.
I_1 I_2—Intermediate branches arising from the anterior division—one above and the other below the pterion.

PLATE I

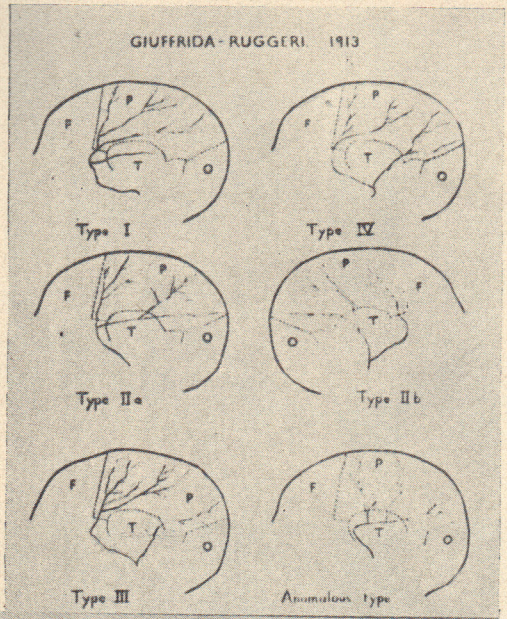

FIG. 1

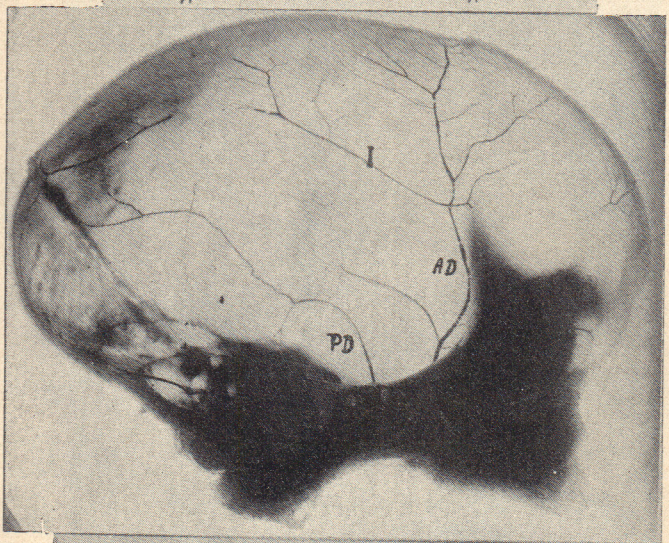

FIG. 2

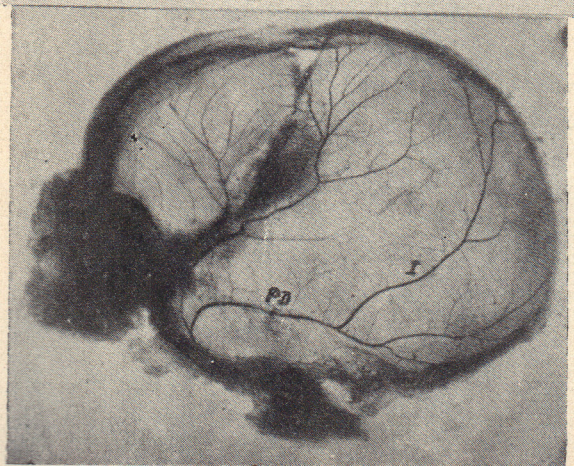

FIG. 3

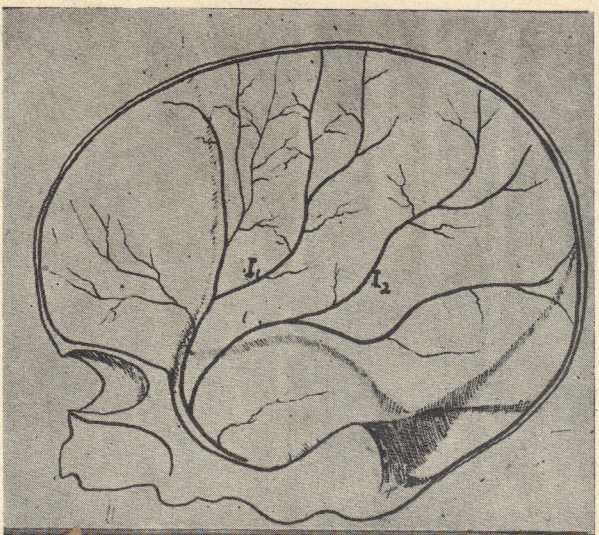

Fig. 4

Fig. 5

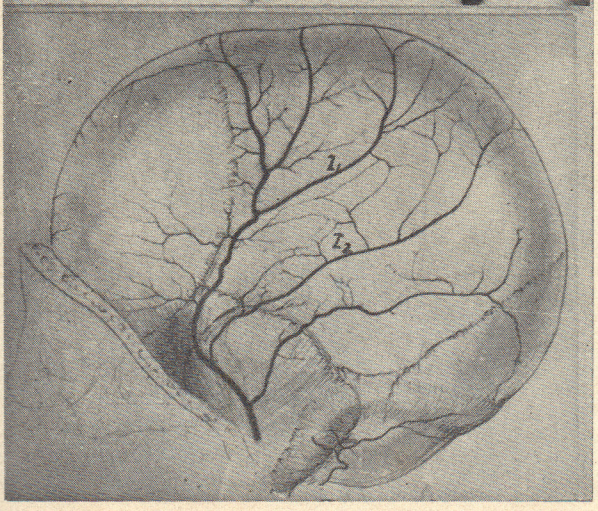

Fig. 6