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ABSTRACT

Objective: **To determine the size, course, distribution and anomalies of the middle cerebral artery in adult Nigerians.**
Design: **A retrospective study.**
Setting: **Department of pathology, University College Hospital, Ibadan between April and September 1999.**
Subjects: **One hundred middle cerebral arteries from patients' asymptomatic for central nervous system lesions, obtained at autopsy from fifty adult Nigerians were examined.**
Results: **The MCA arose as the wider of the two terminal branches of the internal carotid artery (ICA). Its mean diameter was 3.49 mm (CI = 3.39 - 3.59mm), while the mean pre-division length was 15.43 mm (CI = 14.59 - 16.27mm). In 92% of specimens, the first branches were perforators. The early branches were destined solely to the temporal lobe pole in most hemispheres (85%). In most specimens, (81%) the main trunk bifurcated while in 13% it trifurcated. One accessory MCA, and the early branches were given off before the perforators in two middle cerebral arteries, making an incidence of anomalies of 3%. There was no aneurysm.**
Conclusion: **These results are similar to what has been described in the literature for Caucasians. It buttresses the assertion that anatomical anomalies of the MCA are rare. The rarity at autopsy of aneurysms of the MCA in asymptomatic Nigerian Africans is not explained by the gross morphology of this vessel.**

INTRODUCTION

The middle cerebral artery (MCA) is the continuation of the internal carotid artery (ICA) after the latter has given off the anterior cerebral artery(1). It is the larger and more direct of the terminal branches of the ICA. Of all the cerebral arteries, it is the most complex. The MCA is usually described in four segments. The sphenoidal (MI) segment begins at the origin of the MCA and terminates at the site of a 90° turn (genu), while the insular (M2) segment lies on the insula. The opercular (M3) segment lies over the lips of the Sylvian fissure, while the cortical (M4) segment consists of the distributions of the branches over the supero-lateral surface of the hemisphere. Approximately 80% of the total blood supply to the brain comes through the MCA(1). It is the artery most frequently associated with cerebral infarction(2). Embolism is a more frequent cause of occlusion of this vessel than thrombosis, with an approximate ratio of 13:1(3).

Anomalies of the MCA are less frequent than anomalies of other intracranial arteries. The anomalies consist of either a duplicate MCA or an accessory middle cerebral artery(4,5).

Intracranial aneurysms are common incidental findings at routine necropsies in the Western world with a prevalence ranging from 1 - 6% among adults in large autopsy series(6). The prevalence of incidental intracranial aneurysms among adults undergoing cerebral angiography is between 0.5 and 1%(7). They are most commonly located at the branching points of the major arteries coursing through the subarachnoid space.

The majority of intracranial aneurysms (80 to 85%) are located in the anterior circulation, most commonly at the junction of the internal carotid artery and the posterior communicating artery, the anterior communicating - anterior cerebral artery complex, or the trifurcation of the middle cerebral artery(8). Multiple intracranial aneurysms, usually two or three in number are found in 20 to 30% of patients(8). The relative incidence of middle cerebral artery aneurysms (MCAAs) varies with different populations. In a series of 1314 consecutive patients with cerebral aneurysms from a catchment area in Finland, with a population of 870,000, middle cerebral artery aneurysms were present in 561(43%). Most of the MCAAs (81%) were located at the vessel's bifurcation(9). In the Japanese,

MCAAs make up nearly a quarter (23.5%) of intracranial aneurysms(10) while amongst the Taiwanese, cerebral aneurysms are located in the distributions of the MCA in about a fifth (19.6%) of patients(11). The relative incidence among Caucasians (17.2%) is similar(12). Hence, in most populations, the MCA is a frequent site for cerebral aneurysms. The current theories for the pathogenesis of intracranial saccular aneurysms propose either a congenital or a degenerative basis.

The available information on the morphology and pathology of the MCA of the African is scanty. The purpose of this study is to define and document in the Nigerian Africans, the origin, size, distribution and anomalies (including aneurysms) of the MCA.

MATERIALS AND METHODS

Study population: The target population for this study was Nigerian adults 18 years and above who had consecutive postmortem examination at the Pathology Department of University College Hospital (UCH), Ibadan. In all, we studied one hundred fixed cerebral hemispheres.

Sample selection and data collection: Information regarding demography and medical history was obtained from case notes. Specimens from patients with an ante-mortem evidence of meningitis or atherosclerosis were excluded. The MCAs were injected with Congo red dye after adequately ligating the distal one-third of the internal carotid artery (ICA) and the proximal one-third of the posterior communicating artery. The four segments of the MCA namely, sphenoidal (M1), insular (M2), opercular (M3) and the cortical (M4) segments were first identified. The origin, diameter at origin, length before bifurcation or trifurcation, course distribution and anomaly were studied and recorded by free-hand line drawing and photography, after adequately dissecting off the leptomeninges. The diameter of origin and the length before division were measured with a graduated scale with 0.05mm division.

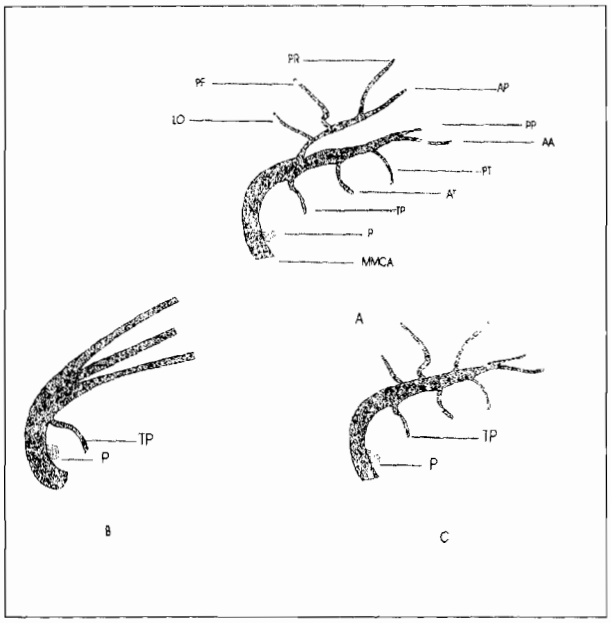
Statistical analysis: For the nominal variables (sex, side and division pattern) the percentage in each category were calculated. The data was analysed using student's t-test and Chi-square test. Confidence interval was calculated at 95% level. The level of significance was fixed at less than 5% probability for chance.

RESULTS

The origin of the MCA was located inferior to the anterior perforated substance, posterior to the olfactory trigone and lateral to the optic chiasm. It arose as the wider of the two terminal branches of the ICA. It passed over the anterior perforated substance and then superiorly and laterally, deep into the island of Reil. In most hemispheres (94%) it bifurcated or trifurcated distal to the genu after given off perforating branches (vessels that supply the deep white matter, basal ganglia and diencephalon) and an early branch (first branch from the MCA destined to the cerebral cortex before bifurcation or trifurcation of the main trunk of the MCA) before dividing into its primary branches which pass over the limen insula (Figure 1).

Figure 1

The middle cerebral artery and the branching pattern of the main trunk. Bifurcation pattern (Panel A), Trifurcation pattern (Panel B), single trunk pattern (Panel C). AA = Angular Artery; AP = Anterior Parietal Branch; AT = Anterior Temporal Branch; LO = Lateral orbito-frontal artery; MMCA = Main Trunk of Middle Cerebral Artery; P = Perforators; PF = Posterior Frontal Branch; PP = Posterior Parietal Branch; PR = Pre-Rolandic Branch; PT = Posterior Temporal Branch; TP = Temporal Polar Branch



The male: female ratio was 1.9:1 and a mean age of 44 years. Table 1 shows the mean values for MCA diameter and pre-division length of the study sample. The diameter of the entire collection ranged from 2.5mm to 5.0mm while the pre-division length ranged from 5.0mm to 27.0mm. The mean diameter and mean pre-division length were 3.49mm and 15.43mm respectively. There was no significant difference between the two sides in the diameter and pre-division length of both male and female MCA. There was also no significant sex difference in the diameter and pre-division length of the MCA.

Table 1

Mean (SD) values for MCA diameter and pre-division lengths, in adult Nigerian cadavers

Side	Sex	MCA diameter	Pre-division length
Right			
	Male (n=33)	3.41 (0.46)	14.45 (3.30)
	Female (n=17)	3.62 (0.65)	15.50 (5.36)
Left			
	Male (n=33)	3.47 (0.50)	15.63 (4.20)
	Female (n=17)	3.56 (0.59)	16.74 (4.20)
P>0.5 for both side and sex comparisons			

Table 2

Branching pattern of the middle cerebral artery

A	*First branch*	
	perforators	92
	early cortical branches	2
	both	5
	absent	1
	Total	100
B	*Early cortical branches*	
	temporal polar only	85
	lateral orbito-frontal only	2
	both	3
	absent	10
	total	100
C	*Main trunk branching pattern*	
	bifurcation	81
	trifurcation	13
	single trunk	6
	Total	100
D	*Trunk dominance*	
	inferior	41 (50.6%)
	superior	30 (37.0%)
	co-dominance	10 (12.4%)
	Total	81 (100%)

Table 2 shows the first branch(es) given off by the MCA - the first arterial branch(es) from the main trunk of the MCA. The antero-lateral perforators were the first branch of the MCA in 92 hemispheres. In one of the MCA's studies, the paraganglionic branches were given off after the bifurcation of the main trunk. There was no early branch in this particular vessel. In 90% of MCA's, early branches were present (Table 2). The early branches were either temporal polar artery or lateral orbitofrontal artery.

Table 2 also shows the various termination patterns of the main trunk of the MCA. Eighty one per cent of the MCAs bifurcated. Of the MCAs that bifurcated, 50.6% demonstrated inferior dominance while 37% demonstrated superior dominance (Table 2). In a trifurcation, the most inferior trunk of the MCA supplied the temporal pole.

The frequency of the termination patterns in both male and female are similar (Table 3).

Table 3

Termination pattern of the MCA in both sexes

Sex	bifurcation	trifurcation	Total
Male	52	8	60
Female	29	5	34
Both	81	13	94

$\chi 2=0.03$; $p=0.85$

Figure 1 demonstrates the various patterns of division of the MCA. In one hemisphere, an accessory middle cerebral artery was found arising from the anterior cerebral artery, medial to the recurrent artery of Heubner (medial striate artery).

DISCUSSION

The main aim of this study was to define and document the size, course, distribution and anomalies of the middle cerebral artery. Its origin was constant in all the cases we studied. They all arose as the larger of the terminal branches of the ICA. The diameter of the MCAs ranged from 2.5 to 5.0mm. The mean diameter of the MCA in our sample was 3.49mm with a confidence interval of 3.39 - 3.59mm. Parametric analysis showed no significant sex or side difference in the diameter. Jain recorded a range of 3 to 5mm(4). Herman and Jain noted a pre-division average length of 14mm and 16mm respectively(4,13). This is quite similar to our findings (Table 1).

The perforators were solely the first branches of the MCA in 92% of cases but they occasionally arose from the superior trunk of a bifurcated MCA (1%). Most of the early branches (85%) given off were directed solely to the temporal pole (Temporal Polar Branch), while in 2% of specimens the early branches were lateral orbito-frontal arteries. Occasionally the temporal polar artery and lateral orbito-frontal artery are both given off as early branches (3%). Ten of the total specimens had no early cortical branches. In 2% of cases, the early branches were given off before the perforators.

Crompton, found anomalies of the MCA in 3.2% of 347 hemispheres: ten of these were duplicated MCA and one accessory MCA artery(14). Jain recorded an incidence of 3% in his study of 300 hemispheres(4). We found one accessory MCA (1%). This further buttresses the rarity of anomalous MCA in general.

The MCA usually bifurcated (81%) but occasionally trifurcated (13%) and rarely gave out branches to the various parts of the cerebral hemisphere via a single trunk (6%). Bifurcation was accompanied by inferior dominance in most cases (50.6%). Sex or side had no significant difference on the division pattern of the MCA. In a study in Florida, Hirohiko *et al* examined 50 cadaveric cerebral hemispheres and noted that 78% of the MCA examined bifurcated. He also recorded 12% trifurcation of MCA, and 10% of the MCA giving cortical branches from a single trunk(15). Hirohiko also noted that 54% of the MCA that bifurcated demonstrated inferior trunk dominance. Our results are similar.

Approximately 12% of patients with intracranial aneurysms die before receiving medical attention(16). Forty percent of those hospitalised die within one month after the event(17). Hence, many patients will die before they get to a tertiary hospital. In our environment autopsies are hardly performed following deaths that occur at home or at primary or secondary hospitals. This is largely due to religious beliefs, over stretched facilities and paucity of pathologists. The apparent rarity of aneurysms in our sample may be due to a low autopsy rate.

The theories for the pathogenesis of intracranial aneurysms (including middle cerebral artery aneurysms) propose a congenital or acquired cause. Although genetic factors may be involved in cerebral aneurysms formation, cerebral vascular bifurcations have been shown to possess certain characteristics (poorly developed external elastic lamina and adventitia, thin media and defects in the media), which increase with age(18) and this suggest a role for acquired factors. Some of the known risks factors for the development and rupture of intracranial aneurysms include connective tissue disorders, hypertension, smoking, high cholesterol intake, sickle cell anaemia, bacteraemia, trauma, metastatic lesions to the brain and radiotherapy(19,20). These risk factors are very much present in our population but despite this intracranial aneurysms are relatively uncommon in Nigeria and there is presently no data on the microscopic features of cerebral vascular bifurcation in this population.

We conclude that in its dimensions, origin, branching, distribution and course up to the limen insula, the MCA of the Nigerian African is similar to that of Caucasians. The mean diameter was 3.49mm while the mean pre-division length was 15.43mm. Perforators are usually the first branches of the MCA even when they arise after the MCA has bifurcated. Early branches are usually present even in the trifurcated division pattern. Early branches usually supply the temporal pole and bifurcation with inferior dominance of the MCA is the commonest pattern of division of the MCA. MCA aneurysms are relatively uncommon at autopsy in our environment.

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