Microsurgical anatomy of the middle cerebral artery

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The microsurgical anatomy of the middle cerebral artery (MCA) was defined in 50 cerebral hemispheres. The MCA was divided into four segments: the M1 (sphenoidal) segment coursed posterior and parallel to the sphenoid ridge; the M2 (insular) segment lay on the insula; the M3 (opercular) segment coursed over the frontoparietal and temporal opercula; and the M4 (cortical) segment spread over the cortical surface. The Sylvian fissure was divided into a sphenoidal and an operculoinsular compartment. The M1 segment coursed in the sphenoidal compartment, and the M2 and M3 segments coursed in the operculoinsular compartment. The main trunk of the MCA divided in one of three ways: bifurcation (78% of hemispheres), trifurcation (12%), or division into multiple trunks (10%). The MCA's that bifurcated were divided into three groups: equal bifurcation (18%), inferior trunk dominant (32%), or superior trunk dominant (28%). The MCA territory was divided into 12 areas: orbitofrontal, prefrontal, precentral, central, anterior parietal, posterior parietal, angular, temporo-occipital, posterior temporal, middle temporal, anterior temporal, and temporopolar. The smallest cortical arteries arose at the anterior end and the largest one at the posterior end of the Sylvian fissure. The largest cortical arteries supplied the temporo-occipital and angular areas. The relationship of each of the cortical arteries to a number of external landmarks was reviewed in detail.

KEY WORDS □ microsurgical anatomy □ middle cerebral artery □ cerebrovascular disease □ cerebral hemisphere □ microneurosurgery

The middle cerebral artery (MCA) is the largest and most complex of the cerebral vessels. Some of its branches are exposed in most operations in the supratentorial area, whether the approach be to the cerebral convexity, parasagittal region, or along the cranial base. In the past, surgical interest in the MCA has been directed at avoiding damage to its branches during operations within its territory, but micro-operative techniques have now made reconstruction of the bypass to the MCA an important method of preserving and restoring blood flow to the cerebrum. The increasing use of surgical magnification for operations in the territory of the MCA has created a need for a better understanding of its microsurgical anatomy. To meet this need, we have extended our previous studies of the cerebral arteries to the MCA.19,48

Materials and Methods

Fifty cerebral hemispheres from 25 adult cadaveric brains were examined using × 3 to × 20 magnification.
and posterior to the division of the olfactory tract into the medial and lateral olfactory striae (Figs. 1–3). From its origin, it coursed laterally below the anterior perforated substance and parallel, but roughly 1 cm posterior, to the sphenoid ridge. It divided within the Sylvian fissure and turned sharply posterosuperior at a curve called the "genu" to reach the surface of the insula. At the periphery of the insula, the branches passed to the medial surface of the opercula of the frontal, temporal, and parietal lobes. Its branches passed around the opercula to reach the cortical surface and supplied the majority of the lateral surface and some of the inferior surface of the cerebral hemisphere.

**Sylvian Fissure**

The initial segments of the MCA are located in and are best discussed in terms of the anatomy of the Sylvian fissure (Fig. 4). The Sylvian fissure is not a simple longitudinal cleft as its name implies. It has a superficial and a deep part. The superficial part is visible on the surface of the brain and the deep part, often referred to as the Sylvian cistern, is hidden below the surface.

The superficial part has a stem and three rami. The stem extends medially between the frontal and temporal lobes. The posterior margin of the sphenoid ridge projects backward against the stem. At the lateral end of the sphenoid ridge, the stem divides into the posterior, anterior ascending, and anterior horizontal rami. The posterior ramus extends backward between the frontal and parietal lobes, above, and the temporal lobe, below. The two anterior rami divide the inferior frontal gyrus into the pars orbitalis, the pars triangularis, and the pars opercularis.

The deep (cisternal) part of the fissure is more complex. The depths of the fissure are divided into an anterior part, called the "sphenoidal compartment," and a posterior part, called the "operculoinsular compartment." The sphenoidal compartment is a narrow space posterior to the sphenoid ridge between the frontal and temporal lobes that communicates medially with the cisterns surrounding the carotid artery and the optic nerve. The operculoinsular compartment is formed by two narrow clefts: the opercular cleft between the opposing lips of the frontoparietal and temporal opercula, and the insular cleft between the insula and the opercula. The insular cleft has a superior limb located between the insula and the frontoparietal operculum and an inferior limb located between the insula and the temporal operculum. Anteriorly, the superior limb has a greater vertical height than the inferior limb, but posteriorly the height of the inferior limb equals or is greater than the height of the superior limb (Fig. 4).

**Segments of the MCA**

The MCA in the hemispheres studied was divided into four segments as previously proposed. These segments are the M1 or sphenoidal segment, the M2 or insular segment, the M3 or opercular segment, and the M4 or cortical segment.

**The M1 (Sphenoidal) Segment.** The M1 segment began at the origin of the MCA and extended laterally within the depths of the Sylvian fissure (Figs. 1–4). It lay an average of 9.4 mm (range 4.3 to 19.5 mm) posterior to the sphenoid ridge in the sphenoidal compartment of the Sylvian fissure. This segment terminated at the site of a 90° turn, the genu, located at the junction of the sphenoidal and operculoinsular compartments of the Sylvian fissure. The horizontal orientation of this segment, roughly parallel to the sphenoid ridge, has led to its being referred to as either the horizontal or the sphenoidal segment. The M1 segment was subdivided into a pre-bifurcation and post-bifurcation part. The pre-bifurcation segment was composed of a single main trunk that extended from the artery's origin to its bifurcation. The post-bifurcation trunks of the M1 segment ran in a nearly parallel course, diverging only minimally, prior to reaching the genu. This bifurcation occurred proximal to the genu in 86% of hemispheres. The small cortical branches arising from the main trunk proximal to the bifurcation are referred to as early branches.

**The M2 (Insular) Segment.** The M2 segment included the trunks that lay on and supplied the insula (Figs. 4 and 5). It began at the genu of the MCA where the trunks of the MCA passed over the limen insulae and terminated at the circular sulcus of the insula. The greatest branching of the MCA occurred at the anterior part of the insula, distal to the genu. The branches passing to the anterior cortical areas had a shorter path across the insula than those reaching the posterior cortical areas: the branches to the anterior frontal and anterior temporal areas crossed only the anterior part of the insula, but the branches supplying the posterior cortical areas coursed in a nearly parallel but diverging path across the length of the insula. The frontal branches coursed over the short gyri only before leaving the insular surface, whereas a branch supplying the posterior parietal or angular region passed across the short gyri, the central sulcus, and the long gyri of the insula before leaving the insular surface.

**The M3 (Opercular) Segment.** The M3 segment began at the circular sulcus of the insula and ended at the surface of the Sylvian fissure (Figs. 1–5). The branches forming the M3 segment were closely adherent to and coursed over the surface of the frontoparietal and temporal operculum to reach the superficial part of the Sylvian fissure. The branches that were directed to the brain above the Sylvian fissure underwent two 180° turns called a "double flexion" by Lazorthes, et al. The first turn was located at the circular sulcus, where the vessels coursing upward over the insular surface
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Fig. 1. Relationship of the middle cerebral artery to the sphenoid ridge, Sylvian fissure, and temporal lobe. Upper: Anterosuperior view with frontal lobes removed to show the relationships of the M1 segment to the temporal lobe (Temp.Lobe) and sphenoid ridge, the M2 segment to the insula, and the M3 segment to the transverse temporal gyri (Trans.Temp.Gyr.). The lateral ventricles (Lat.Vent.) and the anterior cerebral (A.C.A.) and recurrent arteries (Rec.A.) are above the carotid arteries (C.A.) and optic (O.N.) and olfactory (I) nerves. The lenticulostriate arteries (Len.Str.A.) arise from the M1 segment and enter the anterior perforated substance (Ant.Perf.Subst.). The limen insulae is at the junction of the insula and the anterior perforated substance. The M1 segment courses in the sphenoidal compartment (Sph.Comp.) of the Sylvian fissure, and the M2 and M3 segments course in the operculoinsular compartment (Operc. Ins. Comp.). Lower: Inferior view with the poles of the temporal lobes removed to expose the M1 and M2 segments of the middle cerebral arteries. The olfactory sulcus (Off.Sul.) separates the gyrus rectus (Gyr.rectus) and the orbital gyrus (Orb.Gyr.). The lenticulostriate arteries arise from the posterosuperior side of the M1 segment and enter the anterior perforated substance. The basilar artery (B.A.) is in front of the pons and gives rise to the superior cerebellar (S.C.A.) and the posterior cerebral (P.C.A.) arteries. The posterior communicat-ting arteries (P.Co.A.) and the oculomotor nerves (III) are seen lateral to the pituitary stalk (Stalk).
FIG. 2. Anterosuperior views of the right middle cerebral artery. **Upper**: The right frontal lobe has been removed to show the relationship of the M1, M2, M3, and M4 segments to the temporal lobe (Temp.Lobe) and the insula. The M1 segment crosses the upper surface of the anterior pole of the temporal lobe and divides into a superior (Sup.Tr.) and inferior (Inf.Tr) trunk. The M2 segment lies on the insula, the M3 segment crosses the transverse temporal gyri (Trans.Temp.Gyr.), and the M4 segment passes inferiorly across the superior (Sup.Temp.Gyr.) and middle temporal gyri (Mid.Temp.Gyr.). The anterior cerebral artery (A.C.A.) arises from the carotid artery (C.A.) and passes above the optic nerve (O.N.) and chiasm (O.Ch.) where it gives rise to the recurrent artery (Rec.A.). The lenticulostriate arteries (Len.Str.A.) enter the anterior perforated substance (Ant.Perf.Subst.). An early branch (Early Br.) to the temporal lobe arises from the M1 segment. The frontal horns of the lateral ventricles (Lat.Vent.) lie above the anterior cerebral arteries. **Lower**: The relationship of the middle cerebral artery to the sphenoid ridges and temporal lobes. The M1 segments course posterior to the sphenoid ridges. The olfactory nerves (1) are seen above the optic nerves. The inferior limb (Inf.Limb) of the insular cleft lies between the temporal operculum and the insula.
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FIG. 3. Inferolateral views of the left cerebral hemisphere. *Upper:* Inferolateral view with the pole and operculum of the temporal lobe (Temp.Lobe) removed. The main trunk (Main Tr.) of the middle cerebral artery gives rise to an early branch (Early Br.) and bifurcates to give rise to a small superior trunk (Sup.Tr.) and a dominant inferior trunk (Inf.Tr.). The branches pass around the frontal (Fr.Operc.) and parietal (Par.Operc.) opercula to reach the surface of the frontal (Fr.Lobe) and parietal (Par.Lobe) lobes. The lenticulostriate arteries (Len.Str.A.) enter the anterior perforated substance (Ant.Perf.Subst.). The carotid arteries (C.A.) are seen below the olfactory nerves (I) and lateral to the optic nerves (O.N.). *Lower:* Inferior view. The M₁ segment gives rise to the lenticulostriate arteries, which enter the anterior perforated substance. The branches forming the M₂ segment enter and the M₃ branches exit the superior limb (Sup.Limb) of the insular cleft. The posterior cerebral (P.C.A.), posterior communicating (P.Co.A.), and basilar (B.A.) arteries are medial to the temporal lobe.

The arteries supplying the cortical areas below the Sylvian fissure pursued a less tortuous course: these branches, upon reaching the circular sulcus, ran along its inferior circumference before turning upward and laterally on the medial surface of the temporal operculum, thus producing a less acute change in course at the inferior margin of the circular sulcus. Upon reaching the external surface of the Sylvian fissure, these branches turned downward on the surface of the temporal lobe (Fig. 4).

The M₄ (Cortical) Segment. The branches forming the M₄ segment began at the surface of the Sylvian fissure and extended over the cortical surface of the cerebral hemisphere (Figs. 2–6). The more anterior branches turned sharply upward or downward after leaving the Sylvian fissure. The intermediate branches
FIG. 4. Relationship of the M1 (blue), M2 (green), M3 (yellow), and M4 (red) segments of the middle cerebral arteries to the insula and Sylvian fissure. *Upper Left and Right:* Suprolateral view of the right cerebral hemisphere with the anterior half of the frontal lobe and part of the frontoparietal and temporal opercula removed. *Upper Left:* The removal exposes the anterior one-fourth of the insula. *Upper Right:* The removal exposes the whole surface of the insula. The Sylvian fissure is divided into a sphenoidal compartment which is located posterior to the sphenoid ridge and in which the M1 segment courses. The M2 and M3 segments course in the operculoinsular compartments of the Sylvian fissure. The operculoinsular compartment is divided into an insular and an opercular cleft. The opercular cleft is located between the frontoparietal and the temporal opercula. The insular cleft is located between the insula and the opercula. The insular cleft is divided into a superior limb (Sup.Limb) located medial to the frontoparietal operculum and an inferior limb (Inf.Limb) located medial to the temporal operculum. The circular sulcus is located at the periphery of the insula. The short gyri (Short Gyr.) of the insula are located above the central sulcus of the insula and the long gyri (Long Gyr.) are located below. The carotid arteries (C.A.) and anterior perforated substance (Ant.Perf.Subst.) are at the medial end of the Sylvian fissure. The lateral ventricles (Lat.Vent.) are above the optic nerves (O.N.). A through D are anterior views of coronal sections of the right cerebral hemisphere. The central diagram shows the level of the sections. *A:* Coronal section at the level of the M4 segment. The M1 segment courses in the sphenoidal compartment; the M2 segment courses on the insula; the M3 segment passes over the deep surface of the operculum, and the M4 segment courses on the cortical surface. At this anterior level, the frontal operculum covers more of the insula than the temporal operculum. *B:* Coronal section at the midportion of the Sylvian fissure where the frontal and temporal opercula are of nearly equal height. *C:* Coronal section at a more posterior level where the temporal operculum covers more of the insula than does the frontoparietal operculum. *D:* Coronal section from the posterior end of the Sylvian fissure. Only the opercular cleft remains; the insular cleft has disappeared.
followed a gradual posterior incline away from the fissure, and the posterior branches passed backward in nearly the same direction as the long axis of the fissure.

Cortical Distribution

The cortical territory supplied by the MCA included the majority of the lateral surface of the hemisphere, all of the insular and opercular surfaces, the lateral part of the orbital surface of the frontal lobe, the temporal pole, and the lateral part of the inferior surface of the temporal lobe. The MCA territory did not reach the occipital or frontal poles or the upper margin of the hemisphere along the superior longitudinal fissure, but it did extend around the inferior margin of the cerebral hemisphere onto the inferior surfaces of the frontal and temporal lobes (Figs. 6 and 7).

The narrow peripheral strip on the lateral surface of the cerebral hemisphere that was supplied by anterior and posterior cerebral arteries rather than the MCA extended along the entire length of the superior mar-
FIG. 6. Lateral view of the left cerebral hemisphere showing the major gyri and sulci in the area supplied by the middle cerebral artery. The central sulcus (Cent.Sul.) separates the precentral gyrus (Pre.Cent.Gyr.) from the postcentral gyrus (Post.Cent.Gyr.). The precentral gyrus, a vertically oriented gyrus, forms the posterior part of the frontal lobe, and lies between the central and precentral sulci (Pre.Cent.Sul.). The larger anterior portion of the frontal lobe is formed by the three horizontal convolutions: the superior (Sup.Fr.Gyr.), middle (Mid.Fr.Gyr.), and inferior (Inf.Fr.Gyr.) frontal gyri. The superior frontal sulcus (Sup.Fr.Sul.) separated the superior and middle frontal gyri, and the inferior frontal sulcus (Inf.Fr.Sul.) separated the middle and inferior frontal gyri. The Sylvian fissure (Sylv.Fiss.) has a stem that runs medially between the frontal and temporal lobes and three rami: the posterior ramus (Post.Ramus) separates the frontal and parietal lobes above from the temporal lobe below, the anterior horizontal ramus (Ant.Hor.Ramus) separates the pars orbitalis (Pars Orb.) from the pars triangularis (Pars Tri.), and the anterior ascending ramus (Ant.Asc.Ramus) separates the pars triangularis from the pars opercularis (Pars Operc.). The lateral surface of the temporal lobe is composed of three gyri and two sulci, all oriented in the direction of the posterior ramus of the Sylvian fissure. The superior temporal (Sup.Temp.Gyr.) and middle temporal (Mid.Temp.Gyr.) gyri are separated by the superior temporal sulcus (Sup.Temp.Sul.), and the middle and inferior temporal gyri (Inf.Temp.Gyr.) are separated by the inferior temporal sulcus (Inf.Temp.Sulc.). The inferior temporal gyrus overlaps onto the inferior surface of the hemisphere. The lateral surface of the parietal lobe has an anterior part formed by the vertically oriented postcentral gyrus that lies between the central and postcentral sulci (Post.Cent.Sul.). The larger posterior part of the lobe is formed by the obliquely oriented superior (Sup.Par.Lobule) and inferior parietal lobules (Inf.Par.Lobule) that are separated by the interparietal sulcus (Int.Par.Sul.). The inferior parietal lobule has three parts: the anterior part is formed by the supramarginal gyrus (Supramarg.Gyr.) which surrounds the posterior ramus of the Sylvian fissure, the middle part is formed by the angular gyrus (Ang.Gyr.) located at the posterior end of the superior temporal gyrus, and the posterior part extends backward to the occipital lobe. The lateral surface of the occipital lobe is divided by the lateral occipital sulcus (Lat.Occ.Sul.) into superior (Sup.Occ.Gyr.) and inferior occipital gyri (Inf.Occ.Gyr.). The cortical arteries are the orbitofrontal (Orb.Fr.A.), prefrontal (Pre.Fr.A.), precentral (Pre.Cent.A.), central (Cent.A.), anterior parietal (Ant.Par.A.), posterior parietal (Post.Par.A.), angular (Ang.A.), temporo-occipital (Temp.Occ.A.), temporopolar (Temp.Pol.A.), and the anterior temporal (Ant.Temp.A.), middle temporal (Mid.Temp.A.), and posterior temporal arteries (Post.Temp.A.).

MCA continued around the occipital pole and onto the posterior part of the lateral surface of the temporal lobe. This strip narrowed and disappeared anteriorly on the temporal lobe where the branches of the MCA extended around the lower border of the hemisphere.
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Fig. 7. Classification of the cortical areas used in this study (see references 18 and 19). The territory of the middle cerebral artery is divided into 12 areas: orbitofrontal (Orb.Fr.), prefrontal (Pre.Fr.), precentral (Pre.Cent.), central (Cent.), anterior parietal (Ant.Par.), posterior parietal (Post.Par.), angular (Ang.), temporo-occipital (Temp.Occ.), posterior temporal (Post.Temp.), middle temporal (Mid.Temp.), anterior temporal (Ant.Temp.), and temporopolar (Temp.Pol.).

onto the inferior surface of the temporal lobe and the orbital surface of the frontal lobe.

The MCA territory is best described in terms of the lobes it supplies (Fig. 6): the frontal lobe, the parietal lobe, the temporal lobe, and the occipital lobe.

**Frontal Lobe.** The MCA supplied the lateral half of the orbital surface and the area between the Sylvian fissure below, the superior frontal sulcus with frequent overlap onto the superior frontal gyrus above, and the central sulcus posteriorly and near, but stopping short of the frontal tip anteriorly. The branches of the MCA did not reach the superior margin nor the medial surface of the frontal lobe in any hemisphere in this study.

**Parietal Lobe.** The MCA supplied the area bounded anteriorly by the central sulcus, inferiorly by the Sylvian fissure, and superiorly by the inferior half of the superior parietal lobule. Posteriorly, the area supplied by the MCA extended backward onto the lateral surface of the occipital lobe.

**Temporal Lobe.** The MCA supplied the entire lateral surface except for a small posteroinferior strip. In addition, it supplied the lateral part of the inferior surface of the temporal lobe, the temporal pole, the uncus, and adjacent part of the parahippocampal gyrus. The temporal branches of the MCA frequently extended onto the lateral surface of the occipital lobe.

**Occipital Lobe.** The branches of the MCA supplying the parietal and temporal lobes overlapped onto the lateral occipital gyri, but they did not extend to the occipital pole.

**Cortical Areas**

Several different subdivisions of the surface area supplied by the cortical branches of the MCA have been proposed.\(^7,8,12,20,27,29\) Two classifications that are widely used are those offered by Ring\(^26\) and Waddington,\(^31\) with seven areas, and Michotey, et al.,\(^17,18\) with 12 areas. The 12 areas proposed by Michotey, et al., and the ones used for tabulating the results of this study, are as follows (Figs. 6 and 7):\(^17,18\)

1. **Orbitofrontal area:** The orbital portion of the middle and inferior frontal gyri and the inferior part of the pars orbitalis
2. **Prefrontal area:** The superior part of the pars orbitalis, the pars triangularis, the anterior part of the pars opercularis, and most of the middle frontal gyrus
3. **Precentral area:** The posterior part of the pars opercularis and the middle frontal gyrus, and the inferior and middle portions of the precentral gyrus
4. **Central area:** The superior part of the precentral
gyrus and the inferior one-half of the postcentral gyrus.

5. Anterior parietal area: The superior part of the postcentral gyrus, frequently the upper part of the central sulcus, the anterior part of the inferior parietal lobule, and the anteroinferior part of the superior parietal lobule.

6. Posterior parietal area: The posterior part of the superior and inferior parietal lobules, including the supramarginal gyrus.

7. Angular area: The posterior part of the superior temporal gyrus, variable portions of the supramarginal and angular gyri, and the superior parts of the lateral occipital gyri (the artery to this area is considered the terminal branch of the MCA).

8. Temporo-occipital area: The posterior one-half of the superior temporal gyrus, the posterior extreme of the middle and inferior temporal gyri, and the inferior parts of the lateral occipital gyri.

9. Posterior temporal area: The middle and posterior part of the superior temporal gyrus, the posterior one-third of the middle temporal gyrus, and the posterior extreme of the inferior temporal gyrus.

10. Middle temporal area: The superior temporal gyrus near the level of the pars triangularis and pars opercularis, the middle part of the middle temporal gyrus, and the middle and posterior part of the inferior temporal gyrus.

11. Anterior temporal area: The anterior part of the superior, middle, and inferior temporal gyri.

12. Temporopolar area: The anterior pole of the superior, middle, and inferior temporal gyri.

**Branching Patterns**

The main trunk of the MCA divided in one of three ways: bifurcation into superior and inferior trunks; trifurcation into superior, middle, and inferior trunks; or division into multiple (four or more) trunks (Tables 1 and 2, Figs. 8 and 9). In this study, 78% of the MCA's divided in a bifurcation, 12% divided in a trifurcation, and 10% divided by giving rise to multiple trunks. Thus, this and other studies differ from the classical description of the initial branching of the MCA as one of trifurcation. The distal division of the MCA also generally occurred in a series of bifurcations. The small arteries that arose proximal to the bifurcation or trifurcation and were distributed to the frontal or temporal pole were called "early branches."

**Types of Bifurcation**

The MCA's that bifurcated were divided into three groups based on the diameter and the size of the cortical area of supply of their superior and inferior trunks. These groups were designated: equal bifurcation, superior trunk dominant, and inferior trunk dominant (Tables 1 and 2, Figs. 8 and 9).

**Equal Bifurcation.** In 18% of hemispheres, the MCA bifurcated to yield two trunks with nearly equal diameters and size of cortical area. The inferior trunk supplied the temporal, temporo-occipital, and angular areas, and the superior trunk supplied the frontal and parietal regions. The superior trunk usually supplied the orbitofrontal to the posterior parietal areas, and the inferior trunk usually supplied the angular to the temporo-occipital areas (Figs. 8 upper left and 9 upper left).

**Inferior Trunk Dominant.** In 32% of hemispheres, the MCA bifurcated to yield a larger inferior trunk that supplied the temporal and parietal lobes and a smaller superior trunk that supplied all or part of the frontal lobe. The maximal area perfused by the inferior trunk included all of the territory between and including the precentral and temporo-occipital areas (Figs. 8 upper right and 9 upper right).

**Superior Trunk Dominant.** In 28% of hemispheres, the MCA bifurcated to yield a larger superior trunk that supplied the frontal and parietal regions and a smaller inferior trunk that supplied only the temporal lobe. The most common area supplied by the dominant superior trunk included the orbitofrontal to the angular areas. The next most common and maximal area supplied by the dominant superior trunk included the orbitofrontal to the temporo-occipital areas (Figs. 8 center left and 9 center left).

**Stem Arteries**

The stem arteries arose from the trunks and gave rise to the individual cortical branches (Table 3, Fig. 10). They arose from the main trunk and the two or more trunks formed by a bifurcation, trifurcation, or division into multiple trunks. There was considerable variation in the number and size of the area supplied by the stem arteries. The most common pattern was made up of eight stem arteries per hemisphere (range, six to 11).

The individual stem arteries gave rise to one to five cortical arteries. The most common pattern was for one of the 12 cortical areas to be supplied by a stem artery which supplied one or two adjacent areas. The cortical areas most commonly receiving a stem artery serving only that area were the temporo-occipital, angular, and central areas. Stem arteries supplying
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TABLE 2
Cortical branches of the middle cerebral artery: origin by branch pattern and trunk*

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<th>Inferior Trunk</th>
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*Of the 50 hemispheres studied, 39 (78%) had a bifurcation branching pattern, six (12%) had a trifurcation pattern, and five (10%) had a multiple-branch pattern.

four or five of the cortical areas were most commonly directed to the area below the Sylvian fissure.

The stem arteries supplying each lobe were also examined.

Frontal Lobe. The frontal lobe was supplied by one to four stem arteries; one was found in 10% of hemispheres, two in 40%, three in 30%, and four in 20%. The most common pattern, a two-stem pattern, had one stem giving rise to the orbitofrontal, prefrontal, and precentral arteries, and the other stem giving rise to the central artery.

Parietal Lobe. The parietal lobe and the adjoining part of the occipital lobe were supplied by one to three stem arteries: one stem was found in 6% of hemispheres, two in 54%, and three in 40%. The most frequent pattern was for each of the three cortical areas to have its own stem. In the most frequent two-stem pattern, one stem gave rise to the anterior and posterior parietal arteries and the other stem to the central artery.

Temporal Lobe. The temporal lobe, along with the adjoining part of the occipital lobe, was supplied by one to five stem arteries: one stem was present in 2% of hemispheres, two in 10%, three in 32%, four in 44%, and five in 12%. This lobe has more stem arteries than the other lobes supplied by the MCA.

Cortical Arteries

The cortical arteries arose from the stem arteries and supplied the individual cortical areas. Generally, one, or less commonly, two cortical arteries (range, one to five) passed to each of the 12 cortical areas (Table 4).

The smallest cortical arteries arose at the anterior end of the Sylvian fissure and the largest ones at the posterior limits of the fissure (Tables 4 and 5). The cortical branches to the frontal, anterior temporal, and anterior parietal areas were smaller than those supplying the posterior parietal, posterior temporal, temporo-occipital, and angular areas. The smallest arteries supplied the orbitofrontal and temporopolar areas, and the largest ones supplied the temporo-occipital and the angular areas. There was an inverse relationship between the size and number of arteries supplying a cortical area. The temporo-occipital area had the smallest number of arteries, but they were the largest in size, and the prefrontal area had the greatest number of arteries, but they were smaller.

TABLE 3
Middle cerebral artery: number of stem arteries per lobe*

<table>
<thead>
<tr>
<th>Lobe</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% No.</td>
<td>% No.</td>
<td>% No.</td>
<td>% No.</td>
<td>% No.</td>
</tr>
<tr>
<td>frontal</td>
<td>10</td>
<td>5</td>
<td>40</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>parietal†</td>
<td>6</td>
<td>3</td>
<td>54</td>
<td>27</td>
<td>40</td>
</tr>
<tr>
<td>temporal†</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>32</td>
</tr>
</tbody>
</table>

*Percentages are of the 50 hemispheres studied.
†Includes adjoining part of the occipital lobe.
Fig. 8. Branching patterns of the middle cerebral artery.
The main trunk divided in a bifurcation in 78% of hemispheres and in a trifurcation in 12%. In the remaining
10% the main trunk divided into multiple (four or more) branches. Upper Left: Bifurcation: equal trunk pattern
(18% of hemispheres). The main trunk divides into superior (red) and inferior (blue) trunks that are of approximately the
same diameter and supply cortical areas of a similar size. The superior trunk supplies the frontal and parietal areas,
and the inferior trunk supplies the temporal and temporo-occipital areas. Upper Right: Bifurcation: inferior trunk
dominant (32% of hemispheres). The inferior trunk (blue) has a larger diameter and area of supply than the superior
trunk (red). The inferior trunk supplies the temporal, occipital, and parietal areas, and the superior trunk supplies
the frontal areas. Center Left: Bifurcation: superior trunk
dominant (28% of hemispheres). The superior trunk (red)
has the largest diameter and area of supply; it supplies the
frontal, parietal, temporo-occipital, and posterior temporal
areas, and the smaller inferior trunk (blue) supplies the
temporopolar through the middle temporal areas. Center
Right: Trifurcation pattern (12% of hemispheres). The main trunk of the middle cerebral artery divides into three trunks. The
superior trunk (red) supplies the frontal areas, the middle trunk (yellow) supplies the areas around the posterior end of the Sylvian
fissure, and the inferior trunk (blue) supplies the temporal areas. Lower Right: Multiple trunks (10% of hemispheres).
The main trunk gives rise to multiple smaller trunks. Two trunks supply the frontal areas (red and yellow), two supply the
parietal areas (light green and dark green), and three supply the temporal and occipital areas (purple, brown, and blue).
Anatomy of the middle cerebral artery

Fig. 9. Branching patterns of the middle cerebral artery (MCA). These drawings of MCA’s dissected from five cerebral hemispheres show the different branching patterns of the main trunk. The main trunk divided in a bifurcation in 78% of hemispheres, in a trifurcation in 12%, and in a multiple branch pattern (four or more trunks) in 10%. The drawings show the main (Main Tr.), superior (Sup.Tr.), middle (Mid.Tr.) and inferior (Inf.Tr.) trunks. These trunks give rise to the lenticulostriate (Len.Str.A.), orbitofrontal (Orb.Fr.A.), prefrontal (Pre.Fr.A.), precentral (Pre.Cen.A.), central (Cent.A.), anterior parietal (Ant.Par.A.), posterior parietal (Post.Par.A.), angular (Ang.A.), temporo-occipital (Temp.Occ.A.), posterior temporal (Post.Temp.A.), middle temporal (Mid.Temp.A.), anterior temporal (Ant.Temp.A.), and temporopolar (Temp.Pol.A.) arteries. Upper Left: Bifurcation: equal trunks (18% of hemispheres). The main trunk divides into superior and inferior trunks that are of approximately the same diameter and supply cortical areas of similar size. The superior trunk gives rise to the orbitofrontal arteries through the angular arteries, and the inferior trunk gives rise to the temporo-occipital through the temporo-occipital arteries. Upper Right: Bifurcation: inferior trunk dominant (32% of hemispheres). The inferior trunk has a larger diameter and area of supply than the superior trunk. The superior trunk supplies the orbitofrontal through the anterior parietal areas, and the inferior trunk supplies the posterior parietal through the temporopolar areas. Center Left: Bifurcation: superior trunk dominant (28% of hemispheres). The superior trunk has a larger diameter and area of supply than the inferior trunk. It supplies the orbitofrontal through the temporo-occipital areas, and the inferior trunk supplies the temporal areas except for the temporopolar area which is supplied by an early branch (Early Br.) that arises from the main trunk. Center Right: Trifurcation pattern (12% of hemispheres). The main trunk of the MCA divides into three trunks. The superior trunk supplies the orbitofrontal and prefrontal areas, the middle trunk supplies the precentral through the posterior parietal areas, and the inferior trunk supplies the angular through the anterior temporal areas. The temporopolar artery arises from the main trunk as an early branch. Lower Right: Multiple trunks (10% of hemispheres). The main trunk gives rise to more than three trunks. There are five trunks in the specimen shown.
The temporopolar, temporo-occipital, angular, and anterior, middle, and posterior temporal arteries usually arose from the inferior trunk; the orbitofrontal, prefrontal, precentral, and central arteries usually arose from the superior trunk. The anterior and posterior parietal arteries had an origin evenly divided between the two trunks and usually arose from the dominant trunk (Table 4).

Early Branches

The cortical arteries arising from the main trunk proximal to the bifurcation or trifurcation were called "early branches" (Table 6, Figs. 2, 3, and 9). The early branches were distributed to the frontal or temporal lobes. Three MCA's (6% of hemispheres) gave early branches to the frontal lobe, and 24 (48%) sent early branches to the temporal lobe. The frontal branches terminated in the orbitofrontal and prefrontal areas. The temporal branches usually supplied the temporopolar and anterior temporal areas. Two MCA's had early branches to both the frontal and temporal areas. Five MCA's had two early branches to the temporal lobe. The distance between the origin of the early branches to the frontal and temporal lobes and the bifurcation or trifurcation of the MCA was as follows: early branches to the frontal lobe averaged 5.5 mm (range, 5.0 to 6.0 mm), and early branches to the temporal lobe averaged 11.2 mm (range, 3.5 to 30.0 mm).

Anomalies

Anomalies of the MCA are less frequent than anomalies of the other intracranial arteries. The anomalies consisted of either a duplicate or an accessory MCA. A duplicated MCA is a second artery that arises from the internal carotid artery and an accessory MCA is one that arises from the anterior cerebral artery. Both the duplicate and accessory MCA's send branches to the cortical areas usually supplied by the MCA. The accessory MCA's usually arise from the anterior cerebral artery near the origin of the anterior communicating artery. The accessory MCA is differentiated from a recurrent artery of Heubner by the fact that the recurrent artery, although arising from the same part of the anterior cerebral artery as an accessory MCA, enters the anterior perforated substance, but the accessory MCA courses lateral to this area and sends branches to cortical areas normally supplied by the MCA. The only anomalies found in this study were in one hemisphere that had both an accessory and a duplicate MCA. The accessory MCA arose from the lateral aspect of the anterior cerebral artery distal to, but near, the anterior communicating artery. It ran laterally without sending branches to the anterior perforated substance and terminated in the orbitofrontal and prefrontal areas. The duplicate artery originated from the internal carotid artery at the level of the anterior choroidal artery and was distributed to the temporopolar and the anterior and middle temporal areas. Jain and Crompton found the incidence of anomalies of the MCA to be about 3%. Crompton found 11 anomalies in his study of 347 hemispheres: 10 duplicate and one anomalous artery. Jain found 10 anomalies in 300 hemispheres: two duplicate and eight anomalous arteries.
Anatomy of the middle cerebral artery

### TABLE 4

<table>
<thead>
<tr>
<th>Cortical Area</th>
<th>No. Cortical Arteries/Area</th>
<th>Diameter (mm)</th>
<th>Distance from Standard Points to Most Proximal Portion of Vessels Superficial Course (mm)</th>
<th>Length on Cortical Surface (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Average Range</td>
<td>Average Range</td>
<td>Average Range</td>
</tr>
<tr>
<td>frontal lobe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>orbitofrontal</td>
<td>1.2</td>
<td>1-3</td>
<td>0.8</td>
<td>0.4-1.5</td>
</tr>
<tr>
<td>prefrontal</td>
<td>3.1</td>
<td>1-5</td>
<td>1.0</td>
<td>0.3-1.5</td>
</tr>
<tr>
<td>precentral</td>
<td>1.6</td>
<td>1-3</td>
<td>1.2</td>
<td>0.4-2.0</td>
</tr>
<tr>
<td>central</td>
<td>2.0</td>
<td>1-4</td>
<td>1.2</td>
<td>0.5-2.0</td>
</tr>
<tr>
<td>parietal &amp; occipital lobe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>anterior parietal</td>
<td>1.2</td>
<td>1-2</td>
<td>1.2</td>
<td>0.4-1.9</td>
</tr>
<tr>
<td>posterior parietal</td>
<td>1.1</td>
<td>1-2</td>
<td>1.3</td>
<td>0.7-2.0</td>
</tr>
<tr>
<td>angular</td>
<td>1.2</td>
<td>1-3</td>
<td>1.4</td>
<td>0.6-2.1</td>
</tr>
<tr>
<td>temporal &amp; occipital lobe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>posterior temporal</td>
<td>1.0</td>
<td>1-2</td>
<td>1.5</td>
<td>0.6-2.4</td>
</tr>
<tr>
<td>middle temporal</td>
<td>1.2</td>
<td>1-3</td>
<td>1.2</td>
<td>0.3-2.4</td>
</tr>
<tr>
<td>anterior temporal</td>
<td>1.1</td>
<td>1-2</td>
<td>1.2</td>
<td>0.5-1.6</td>
</tr>
<tr>
<td>temporopolar</td>
<td>1.3</td>
<td>1-3</td>
<td>0.9</td>
<td>0.4-1.6</td>
</tr>
</tbody>
</table>

*For a description of the three standard points on the cortex, see text and Figs. 11 and 12.

**Topographical Anatomy**

We measured the distances between three standard points on the cortex, called A, B, and C, and the proximal end of the segment of each cortical artery that lay on the cortical surface and would have been accessible for an extracranial-intracranial artery bypass (Table 4, Figs. 11 and 12). Point A was located at the anterior end of the Sylvian fissure, where the anterior horizontal, anterior ascending, and posterior rami joined; Point B was located at the posterior end of the Sylvian fissure where the supramarginal gyrus wrapped around the posterior ramus; and Point C was located at the intersection of a line drawn through Points A and B, with a line beginning at the external auditory canal and drawn perpendicular to the canthomeatal line (the line joining the lateral canthus of the eye and the external auditory canal). Point C varied in location from 17 mm anterior to 19 mm posterior to Point B (average, 2.3 mm posterior to Point B). Point C was located posterior to Point B in 50% of hemispheres, and anterior in 22%. Points B and C were located within 1 mm of each other in the remaining 28% of hemispheres. The length of the line between the external auditory canal and Point C averaged 6.6 cm (range, 5.0 to 7.9 cm).

The arteries supplying the 12 cortical areas usually exited the Sylvian fissure along the line connecting Points A and B, and, in that case, a measurement between Points A, B, and C and the proximal end of the cortical arteries was along the line connecting Points A and B. However, some cortical arteries exited the Sylvian fissure in a sulcus and did not appear on the surface for a variable distance above or below the Sylvian fissure, and, in those cases, the measurement was between the three points and the point at which the cortical artery appeared on the surface, rather than along the line connecting Points A and B.

The vessels exiting the Sylvian fissure nearest to Point A were the orbitofrontal, prefrontal, temporopolar, and the anterior and middle temporal arteries; the arteries arising nearest to Points B and C were the anterior parietal, posterior parietal, angular, and temporo-occipital arteries. The cortical arteries located at the posterior end of the Sylvian fissure near Points B and C included the three largest cortical arteries.

Important factors in selecting a cortical artery for a bypass procedure are its diameter and the length of artery available on the cortical surface (Tables 4 and 5). The largest cortical artery was the temporo-occipital artery: 63% were 1.5 mm or greater in diameter, and 90% were 1 mm or greater in diameter. The smallest cortical artery was the orbitofrontal artery:
TABLE 5
Middle cerebral artery: cortical artery diameter*

<table>
<thead>
<tr>
<th>Cortical Branch</th>
<th>Cortical Artery Diameter (mm)</th>
<th>( \geq 2.0 )</th>
<th>( \geq 1.5 )</th>
<th>( \geq 1.0 )</th>
<th>( \geq 0.8 )</th>
<th>( \geq 0.3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>orbitofrontal</td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>62</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>prefrontal</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>17</td>
<td>82</td>
<td>100</td>
</tr>
<tr>
<td>precentral</td>
<td>2</td>
<td>17</td>
<td>82</td>
<td>94</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>central</td>
<td>1</td>
<td>26</td>
<td>85</td>
<td>95</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>anterior</td>
<td>0</td>
<td>23</td>
<td>82</td>
<td>93</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>parietal</td>
<td>2</td>
<td>31</td>
<td>77</td>
<td>94</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>posterior</td>
<td>10</td>
<td>47</td>
<td>87</td>
<td>94</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>parietal</td>
<td>2</td>
<td>31</td>
<td>77</td>
<td>94</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>angular</td>
<td>10</td>
<td>47</td>
<td>87</td>
<td>94</td>
<td>100</td>
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<tr>
<td>temporo-occipital</td>
<td>14</td>
<td>63</td>
<td>90</td>
<td>98</td>
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<tr>
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<td>9</td>
<td>33</td>
<td>68</td>
<td>86</td>
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<td>69</td>
<td>94</td>
<td>100</td>
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<td>temporopolar</td>
<td>0</td>
<td>2</td>
<td>38</td>
<td>69</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

*Percentage of total number of cortical arteries to each area in 50 hemispheres.

The relationship of the cortical arteries to several points on the canthomeatal line called D and E was also examined. Point D was located where a line beginning at Point A and drawn perpendicular to the canthomeatal line crossed the canthomeatal line. Point E was located where a line beginning at Point B and drawn perpendicular to the canthomeatal line crossed the canthomeatal line (Table 4, Figs. 11 and 12).

Discussion

The MCA is one of the most common sites of saccular aneurysms. Most saccular aneurysms of the MCA are located on the distal part of the M1 segment near the genu at the first or second major division of the artery. Saccular aneurysms only rarely arise distal to the proximal part of the M2 segment. Traumatic aneurysms resulting from either penetrating or blunt head injuries, or bacterial aneurysms associated with endocarditis or other infections, are located most commonly on the cortical, or M3, segment.

The majority of intracranial arteriovenous malformations (AVM's) receive part of their blood supply from branches of the MCA. Of 453 cases of intracranial AVM's analyzed by Perret and Nishioka, 93% were supratentorial and 7% were infratentorial. Most of those in the supratentorial area had branches from the MCA. The most common site of involvement was the parietal region, followed by the frontal and temporal regions, in that order.

Occlusion of the individual cortical branches of the MCA, depending on the area supplied, may cause the following complications: motor weakness due to involvement of the corticospinal tract in the central gyrus; sucking and grasping reflex due to involvement of the premotor area; motor aphasia resulting from involvement of the posterior inferior surface of the frontal cortex of the dominant hemisphere; changes in mentation and personality due to involvement of the prefrontal area; visual field defects caused by a disturbance of the geniculocalcarine tract in the temporal, parietal, and occipital lobes; impairment of discriminative sensations and neglect of space and body parts resulting from involvement of the parietal lobes; finger agnosia, right-left disorientation, agraphia, and agnosia (Gerstmann's syndrome) due to involvement of the junctional area between the parietal and occipital lobes of the dominant hemisphere; or a receptive aphasia caused by disturbance of the dominant temporoparietal area.

Reports of specific clinical syndromes associated with occlusion of the individual cortical branches are rare. Occlusions of the individual cortical arteries are difficult to identify on angiograms, but, when detectable, they frequently correlate well with the neurological deficit. Embolism is a more frequent cause of occlusion of the MCA than thrombosis. In series of angiographically and autopsy-proven occlusions of the branches and trunks of the MCA, the ratio of embolic to thrombotic occlusions is approximately 13:1 to 16:1.9,10,16

Fisher described the syndromes of obstructing the superior and inferior trunk of the MCA as follows:
Anatomy of the middle cerebral artery

**FIG. 11.** Cortical branches of the middle cerebral artery exposed by removing the cranial cap. *Upper Left:* Lateral view of right cerebral hemisphere showing standard points used in tabulating the results of this study. The distances between three standard points on the cortex, called A, B, and C, and the proximal end of the segment of each cortical artery that lay on the cortical surface and would have been accessible for an extracranial to intracranial artery bypass, were measured. Point A was located at the anterior end of the Sylvian fissure (Sylv.Fiss.) where the stem, the anterior horizontal (Ant.Hor.Ramus), anterior ascending (Ant.Asc.Ramus), and posterior (Post.Ramus) rami joined. Point B was located at the posterior end of the Sylvian fissure where the supramarginal gyrus wrapped around the posterior ramus. Point C was located at the intersection of a line drawn through Points A and B with a line beginning at the external auditory canal and drawn perpendicular to the canthomeatal line (the line between the lateral canthus of the eye and the external auditory canal). Point C varied from 17 mm anterior to 19 mm posterior to Point B (average, 2.3 mm posterior to Point B). The two points (B and C) were located within 1 mm of each other in the remaining 28% of hemispheres. The relationship of the cortical arteries to several points on the canthomeatal line, called D and E, was also examined. Point E was located where a line drawn perpendicular to the canthomeatal through Point B crossed the canthomeatal line. Point D was located where a line drawn perpendicular to the canthomeatal line through Point A crossed the canthomeatal line. The arteries supplying the 12 cortical areas usually exit the Sylvian fissure along the line connecting Points A and B, and in that case a measurement between Points A, B, and C and the proximal end of the cortical artery would be along line AB (Table 2). However, some cortical arteries exited the Sylvian fissure in a sulcus and did not appear on the surface for a variable distance above or below the Sylvian fissure, and, in those cases, the measurement would be between the three points and the site at which the cortical artery appeared on the surface, rather than along the line connecting Points A and B. The vessels exiting the Sylvian fissure nearest Point A were the orbitofrontal (Orb.Fr.A.), prefrontal (Pre.Fr.A.), temporopolar (Temp.Pol.A.), and anterior temporal (Ant.Temp.A.) arteries; the vessels arising nearest to Point C were the anterior parietal (Ant.Par.A.), posterior parietal (Post.Par.A.), angular (Ang.A.), and temporo-occipital (Temp.Occ.A.) arteries. The latter group of arteries located at the posterior end of the Sylvian fissure included the three largest cortical arteries. The precentral (Pre.Cent.A.), central (Cent.A.), middle temporal (Mid.Temp.A.), and posterior temporal (Post.Temp.A.) arteries exited the fissure between Points A and B. The stem of the Sylvian fissure (Sylv.Fiss.) extended medially along the sphenoid ridge. The part of the Sylvian fissure on the surface divides into three rami: the anterior horizontal (Ant.Hor.Ramus), anterior ascending (Ant.Asc.Ramus), and the posterior (Post.Ramus) rami. The sphenoid ridge terminates at the junction of these three rami with the stem of the Sylvian fissure. The central sulcus (Cent.Sul.) separates the frontal and parietal lobes. The posterior temporal artery is the largest cortical branch on the surface of this hemisphere. *Upper Right:* Lateral view of another right cerebral hemisphere showing the relationship of the 12 cortical arteries to the Sylvian fissure and cerebral convexity. *Lower Right:* Left cerebral hemisphere. The branches of the anterior cerebral artery (A.C.A.) extend from the medial to the lateral surface of the cerebral hemisphere in the region of the superior frontal gyrus.

Obstruction of the superior trunk caused a sensory motor hemiplegia without receptive aphasia in the dominant hemisphere; obstruction of the inferior division caused a receptive aphasia in the absence of hemiplegia in the dominant side. Fisher's syndromes would apply if the trunks were nearly equal in size, with the superior trunk supplying the frontal and parietal regions and the inferior trunk supplying the temporal and occipital lobes. However, we found marked variation in the size of the superior and inferior trunks and...
Fig. 12. Drawing of the lateral view of the left cerebral hemisphere showing the standard points used in tabulating the results of this study. The distances between the points are listed in the table below the drawing. Point A was located at the anterior end of the Sylvian fissure where the stem, the anterior horizontal, anterior ascending, and posterior rami joined. The lateral end of the sphenoid ridge is also located at or near Point A. The "keyhole," another standard point used in planning a bone flap for a craniotomy, is shown. The "keyhole" is located just behind the junction of the temporal line and the zygomatic process of the frontal bone, 1 to 2 cm anterior to the pterion. A burr hole located here will expose the dura over the lower part of the frontal lobe in its upper half and the periorbita in its lower half. Point B was located at the posterior end of the Sylvian fissure where the supramarginal gyrus wrapped around the posterior ramus. Point C was located at the intersection of a line drawn through Points A and B, with a line beginning at the external auditory canal and drawn perpendicular to the canthomeatal line (the line between the lateral canthus of the eye and the external auditory canal). Point C varied from 17 mm anterior to 19 mm posterior to Point B (average, 2.3 mm posterior to Point B). Point C was located posterior to Point B in 50% of hemispheres and anterior in 22%. Points B and C were located within 1 mm of each other in the remaining 28% of hemispheres. Point D was located where a line drawn perpendicular to the canthomeatal line through Point A crossed the canthomeatal line. Point E was located where a line drawn perpendicular to the canthomeatal line through Point B crossed the canthomeatal line. The distance between the proximal part of the cortical arteries and Points A, B, and C is shown in Table 4.

The area that they supply. In a few hemispheres, the inferior trunk supplied the temporal and parietal lobes and extended forward onto the precentral motor area, and, in another group of hemispheres, a large superior trunk supplied the frontal and parietal lobes and extended onto the speech centers on the posterior part of the temporal lobe.

The site of an MCA anastomosis for an MCA branch, trunk, or stem occlusion should be selected only after a careful review of the angiogram. If an early branch to the temporal lobe were used as a recipient vessel for a bypass operation, in cases of MCA stenosis or occlusion near the bifurcation, the new flow would frequently be channeled into the MCA proximal to the occlusion, and none would have been delivered into the hypoperfused area distal to the occlusion. Some early branches, although arising proximal to the carotid bifurcation, may reach as far distally as the posterior temporal area. If one trunk of the MCA is stenotic or obstructed, an anastomosis to the other trunk will deliver blood to the proximal MCA and distally into the normal, rather than into the ischemic area.

Chater, et al., undertook an analysis of the cortical branches of the MCA available in three circular cortical zones with a diameter of 4 cm. These three zones were centered over the convexity of the frontal lobe, the tip of the temporal lobe, and the region of the angular gyrus, and were selected to be readily accessible by means of a small craniectomy. An external diameter of 1 mm was postulated to be the minimum required for long-term anastomosis patency. Chater found a cortical artery with a diameter of greater than 1.4 mm in the angular zone in 100% of hemispheres. The arteries over the tip of the temporal lobe and the frontal lobe were considerably smaller. In the temporal zone, an artery with a diameter of greater than 1.0 mm was present in 70% of hemispheres, and in the frontal zone an arterial diameter of greater than 1.0 mm was present in only 52%.

Chater also noted that the vessels in the region of the angular gyrus had the advantage of being located so as to be accessible for anastomosis not only with the superficial temporal artery, but also with the occipital artery. The frontal and temporal sites, if they could be reached by the occipital artery, would place it under considerable tension. Chater recommended that the craniectomy for exposing the cortical branches of the MCA be 4 cm in diameter, and that it be centered 6 cm above the external auditory canal. In this study, we found that the distance between the ear canal and the posterior end of the Sylvian fissure was 6.6 cm in length. Our findings also revealed that the area around the posterior end of the Sylvian fissure was 6.6 cm in length. Our findings also revealed that the area around the posterior end of the Sylvian fissure was the site of the largest cortical branches of the MCA.

Waddington measured the intraluminal diameter of the arteries found on the surface of the brain in a circle, 3 cm in radius and centered at the level of the transverse gyrus of Heschl. The central sulcal, posterior parietal, angular, and posterior temporal arteries were consistently within this circle. The percentage of hemispheres in which the following arteries were found to have an intraluminal diameter of 1 mm or greater was: angular artery, 86%; posterior temporal
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artery, 68%; posterior parietal artery, 52%; and central sulcal artery, 14%. The posterior temporal artery, in Waddington’s study, corresponds to the temporoparietooccipital artery of this study. Waddington recommended the use of the angular artery for bypass procedures, stating that if it was occluded as a result of the operation, the resulting deficit would be less than if the posterior temporal artery became occluded. Most surgeons utilize the angular, temporoparietooccipital, or posterior temporal branch of the MCA for a bypass.21,23 These were the three largest branches in this study.

References

This paper was supported in part by the National Institutes of Health, Grant NS 10878-03.

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