The Lateral Perforating Branches of the Anterior and Middle Cerebral Arteries*

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It is well known that aneurysms occur at the site of branching of the large vessels at the base of the brain. Two relatively common sites are in the region of the anterior communicating vessel and the site of branching of the main stem of the middle cerebral artery. Unfortunately, these sites frequently are the location of important lateral perforating vessels which irrigate large cell masses enclosing bands of traversing axone fiber bundles, namely the internal capsule. Frequently, the small perforating vessels are not well visualized at operation and damage to them will, at times, produce severe neurological deficits. These vessels can be well demonstrated in autopsy specimens of fresh brain by gross dissection and roentgenography, after injection of radiopaque substances. In order to define the precise location of the lateral perforating vessels, it was thought helpful to present a brief overall survey of certain vascular relationships to the brain.

Anatomy

The anatomico-vascular relationship of the central nervous system follows a well organized pattern. The brain can be described as a multi-segment unit arbitrarily formed caudo-rostrally by 5 territories: the myelencephalon, metencephalon, mesencephalon, diencephalon, and telencephalon. In horizontal cross-section it can be described again as a multi-segment unit containing a central base, lateral base and dorsal supra-segmental portion (Fig. 1a and b).

While functionally the adult human brain can still be considered in terms of its primitive state, anatomically the numerous gyrations of the cell masses in their attempt to accommodate to the relatively small cranial cavity present a grossly different final form. Nevertheless, anatomically the adult rostral brain can be described by depicting the cerebral hemispheres as dorsal overgrowths from the rostral segment of the neural tube expanding in all directions to cover the rest of the brain; the basal ganglia, the rostral base segment of the neural tube from which the hemispheres grow dorsally, as caudolateral expansions about the diencephalon; and the white matter from the base of the brain as a lateral outgrowth from the neural tube. The latero-caudal expansion from the midline of the rostrally situated basal ganglia, therefore, encloses a large group of white fibers between itself and the thalamus to produce

Fig. 1. Diagrams of basic design of the brain. (a) Lateral view showing the various components of the brain in relation to its basic segmentation. (b) Cross-section of primitive brain. (c) Dorsal view of rostral brain indicating formation of the internal capsule by growth of the basal ganglia lateral to the white matter.
The vascular pattern of this primitive-type brain can be shown as a double “four-segment” unit (Fig. 2). The caudal “four-segment” unit is made up proximo-distally by the posterior inferior cerebellar, anterior inferior cerebellar, superior cerebellar and mesencephalic arteries, all arising from the vertebro-basilar artery. The rostral “four-segment” unit is made up of the posterior cerebral (posterior communicating), anterior choroidal, middle cerebral, and anterior cerebral arteries arising from the internal carotid artery. Each of the major vessels which go to make up a “four-segment” vascular unit is similar in design. Each large vessel gives off first central perforators to the central base cells, then single, or at times multiple, lateral perforators to the lateral cell mass, and finally distal perforators to the supra-segmental cell mass on the dorsum of the neural tube. Using this overall basic pattern of the brain, it now can be seen that the lateral perforators of the anterior and middle cerebral arteries will irrigate primarily the most rostral ventro-lateral cell masses of the brain.

The most rostral part of the lateral cell mass in the neural tube, the head of the caudate nucleus and rostro-mesial part of the putamen, is irrigated by the lateral perforating vessel of the most distal segment of the internal carotid artery, the anterior cerebral artery. This lateral perforating branch from the anterior cerebral artery is often referred to as Heubner’s artery. It usually arises from the lateral aspect of the anterior cerebral vessel at about the level of the anterior communicating artery, but actually may arise from any site on the lateral aspect of the proximal portion of the anterior cerebral artery (Fig. 3). It passes caudo-laterally alongside, or dorsal to, the main proximal portion of the anterior cerebral artery. Heubner’s artery then continues laterally to reach the rostro-mesial portion of the anterior perforated substance. At this site it begins to divide and send perforating branches into the cerebral substance immediately rostral to the perforating branches of the middle cerebral artery. On entering the cerebral substance the vessel courses rostro-mesially to irrigate the most rostro-mesial portion of the lateral cell mass (Figs. 4 and 5). Its terminal branches supply the antero-mesial aspect of the head of the caudate nucleus and adjoining putamen, part of the septal nucleus, and cells in the rostro-lateral area of the olfactory trigone. Fiber tracts lying in the domain of the ramifications of this vessel are the fronto-pontine fibers of the anterior limb of the internal capsule, the intermediate olfactory stria and fibers of the ventral portion of the internal capsule passing through
FIG. 3. Heubner’s artery arising from the anterior cerebral artery bilaterally. The proximal portion of the anterior cerebral artery of one side is torn from its attachment to the carotid and pulled caudally to expose Heubner’s artery. The optic nerves have been cut off. The retracted proximal portion of the anterior cerebral artery can be seen lying on the optic chiasm. H—Heubner’s artery; DAC—distal anterior cerebral artery; ACo—anterior communicating artery; GR—gyrus rectus of base of frontal lobe of brain; MC—middle cerebral artery; ICA—internal carotid artery; PAC—proximal anterior cerebral artery; Mam—manifullary body; Hyth—hypothalamus.

the rostral lamina of the corpus callosum.

The lateral perforating branch of the middle cerebral artery likewise may vary in the site of origin from the main stem, depending on the distance of the division of the main stem of the middle cerebral artery from the carotid artery. In a recent study of more than 50 specimens, the middle cerebral artery was seen to divide into its first large segments anywhere from 1 to 4 cms. from its origin at the internal carotid artery. The position of branches of the middle cerebral artery varied from side to side in the same specimen. The lateral perforator, or perforators, arose from the middle or lateral third of the main stem of the middle cerebral artery where it split about 3 cms. from the internal carotid artery. The lateral perforator arose just proximal to or at the site of the major vessel division in specimens with branching at 2 1/2 cms. or less (Fig. 6b) and from one of the main divisions of the middle cerebral artery (primarily from the anterior division), in specimens with branching at a distance of 1 1/2 cms. or less from the internal carotid artery (Fig. 6a).

The lateral perforating vessels of the middle cerebral artery arise at an acute angle as single or multiple branches directed medially and then laterally to penetrate the brain substance (Fig. 7a and b). They finally are seen to course dorso-medially in the brain substance in large curving patterns of numerous small branches.
Fig. 4. Roentgenogram of antero-posterior view of coronal section of autopsied human brain with both Heubner's arteries injected with radiopaque material. The lateral ventricles are visualized.

Fig. 5. Roentgenogram of base view of autopsied human brain with both Heubner's arteries injected with radiopaque material. The heavier stems coursing laterally are the proximal portion of Heubner's arteries arising from the anterior cerebral arteries.
Fig. 6. Middle cerebral arteries. (a) Bifurcation (BMC) of the middle cerebral artery (MC) with a lateral striate artery (LSA) arising from one of the divisions. The lateral striate artery divides immediately into numerous branches. (b) Lateral striate artery (LSA), branching immediately from its origin, is arising from the main stem of the middle cerebral artery (MC) shortly before the bifurcation (BMC). The anterior choroidal artery (ACh) can be seen.

The cell masses that may receive their arterial blood supply from the lateral perforating vessel of the middle cerebral artery are the lateral third of the globus pallidus, the putamen, part of the head of the caudate nucleus caudal to the body of the caudate nucleus, and the claustrum. The fiber tracts passing through this region are the anterior commissure, internal capsule adjacent to the lenticular nuclei and the ansa lenticularis. Arteries of the brain are destined primarily for the nourishment of nerve cells. The white matter is secondarily damaged following arterial occlusion only when it happens to pass directly through an infarcted cell area. Occlusion of Heubner's artery would cause infarction of the most rostral portion of the head of the caudate nucleus and adjoining putamen, together with the internal capsule rostral to the motor fibers. Occlusion of the lateral perforator of the middle cerebral artery would produce an infarction of the more caudal portion of the basal ganglia together with the intervening pyramidal fibers of the internal capsule.

Summary

The lateral perforating vessels of the anterior and middle cerebral arteries are not infrequently located in regions close to the sites of formation of cerebral aneurysms. Anatomical studies suggest that occlusion of the lateral perforator from the anterior cerebral artery (Heubner's artery) probably will demonstrate very little, if any, objective neurological findings. Occlusion of the lateral perforator of the middle cerebral artery in the human, by damaging the pyramidal fibers, would be expected to produce weakness of the extremities of the opposite side. In operations for obliterating aneurysms at the bifurcation at the middle cerebral artery, the lateral perforator of the middle cerebral artery always should be carefully looked for in
Roentgenograms of perforating branches of a middle cerebral artery in a human autopsied brain after injection of the middle cerebral artery with a radiopaque substance. The middle cerebral artery was ligated just distal to emergence of the perforating branches. (a) Lateral view of perforating branches of a middle cerebral artery. (b) Antero-posterior view of the perforating branches of a middle cerebral artery in one hemisphere of a brain.

those instances where the main stem of the middle cerebral artery divides within a distance of 2 cms. from the internal carotid artery.

References