Angiographic Identification of the Motor Strip*

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The consequences of injuring the motor strip of the brain are so drastic that a simple and precise preoperative method of locating this area should be of considerable benefit in neurosurgery.

Since this area is directly anterior to the central sulcus (Rolandic fissure) its position is obvious if the central sulcus can be located. Older anatomists gave considerable attention to this matter and in the 18th edition of Gray’s Anatomy, published in 1896, a page and a half is devoted to various methods of determining the position of the central sulcus from topographical measurements. In 1900, Taylor and Haughton reported their system of locating the central sulcus by the use of radiographs. Although of considerable theoretical value, these measurements have been largely forgotten. Anatomy books no longer mention them, and Taveras and Wood, after describing the Taylor-Haughton lines, state that for various reasons they “are not as useful in clinical work as they otherwise might be.”

In a recent coordinated anatomical and angiographic study of the ascending frontal branch of the middle cerebral artery, we were consistently able to demonstrate an artery (or arteries) in the central sulcus that could be recognized on carotid angiograms in virtually all normal studies. Since its identification on carotid angiograms allows accurate mapping of the motor strip, this vessel becomes of much greater importance than its small size would indicate.

To locate the artery (or arteries) of the central sulcus, a full knowledge of the anatomy of the middle cerebral artery is essential. There are four major trunks of this vessel, the ascending frontal, posterior parietal, angular, and posterior temporal. Difficulty in separating the four branches on angiograms is due in part to their variation in origin. It is customary to identify arteries by finding them proximally and tracing them to their terminal arborizations. This is difficult and often impossible in the branches of the middle cerebral artery. In the simplest arrangement, one main trunk gives off the four branches, while at the other extreme, each branch arises separately at the mouth of the Sylvian fissure, often with one or two smaller accessory branches.

A method of simplifying the complexities of these branches was published in 1962. Based on dissection of vessels of 50 brain hemispheres and tracings of 100 normal carotid angiograms, it was found possible to assign zones to the areas of termination of the four major branches of the middle cerebral artery, since the terminal distribution was found remarkably constant despite the great variation in course and manner of division of the vessels. In this study the ascending frontal branch was treated as a unit.

A second study, also based on the coordination of brain dissections with tracings of normal carotid angiograms with particular emphasis on the ascending frontal branch, revealed the constancy of the artery to the central sulcus and allowed us to divide the ascending frontal branch into three components. These are: the orbital frontal branches that supply the orbital surface and anterolateral aspect of the frontal lobe; the opoculofrontal or candelabra branches that supply the lateral aspect of the frontal lobe after having been enfolded in the insula; and the most posterior branch (or branches) of the artery to the central sulcus. Although the template assigning zones to the branches was formed empirically by trial and error, it is in fact anatomical since the vessels have a constant relationship with the Sylvian fissure. The key point is in the axis of the Sylvian fissure, approximately corresponding to the

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angiographic Sylvian point. The template is formed in the following manner (Fig. 1).

A line is drawn parallel to and 1 inch inside the inner table of the skull. From the point corresponding to the internal occipital protuberance, a line is drawn anteriorly to the tuberculum sella. The next step is a line upward and posteriorly through the axis of the Sylvian vessels. This can be done on average-sized heads without undue magnification by using the clinoparietal line of Taveras,\(^6\) which is formed by measuring upward 9 cm from the internal occipital protuberance and drawing a line from this point to the tuberculum sella. The line from the tuberculum sella through the axis of the Sylvian vessels to the line parallel to the inner table is bisected, one line drawn posteriorly parallel to the line below it, another drawn upward parallel to the course of the coronal suture. This divides the surface into four zones: 1) the posterior-superior area (the area of the ascending frontal artery), 2) the posterior-parietal area (the area of the posterior parietal artery), 3) the angular area (the area of the angular artery), and 4) the posterior-inferior area (the area of the posterior-temporal artery).

The ascending frontal area can be divided into three subdivisions. From the central point on the Sylvian line, a line drawn to a point 1 inch anterior to the posterior-parietal area outlines a pie-shaped segment; the distal portion of the artery to the central sulcus will fall within this area. The remainder of the ascending frontal area is divided by measuring the curved line from the anterior limits of the area of the central sulcus artery.

[Fig. 1. Normal angiograph showing the template superimposed. The following abbreviations are used for labeling in this and subsequent illustrations:

- PCAL—Pericallosal vessels
- PC—Posterior cerebral artery
- OF—Orbitofrontal
- CAN—Candelabra group
- CS—Artery to the central sulcus
- PP—Posterior parietal
- ANG—Angular artery
- PT—Posterior temporal]