# 13

# Cerebrovascular System

## CHAPTER OUTLINE



## Overview

The overlap between cerebrovascular distributions and functional organization of the brain makes understanding this system particularly relevant to speech-language pathologists and audiologists. Neural tissue requires a constant supply of oxygenated blood to carry out its roles. Thus, restrictions to blood flow result in changes or impairments to brain functions. As described in Chapter 3, neurons cannot store their own oxygen and thus are dependent on the vascular system to provide it. The bloodstream also carries nutrients to the neurons and glial cells to support their normal functions. Due to a protective structure called the blood–brain barrier, not everything that is in the bloodstream can get to the neural tissue.

Interruption to the blood supply will starve neurons of oxygen and impair their normal function. Learning the pattern of arteries and which arteries supply what areas of the brain is critical for understanding relationships between localization of damage and subsequent patterns of impairments.

## Blood Supply and Functional Organization

The relationship between cerebral blood supply and **functional organization** of cerebral structures is a key concept, particularly in clinical applications. As discussed in Chapter 1, basic sensory and motor functions can be precisely mapped within the cortex, whereas more complex functions such as language, communication, and cognition involve collaboration of multiple regions. Nevertheless, understanding the overlap between basic functional organization (e.g., Brodmann areas) and blood supply distributions does help predict functions/impairments when a blood supply is restricted (Figure 13–1). For instance, structures such as the motor strip, somatosensory strip, premotor area, Broca area, and Wernicke area all fall within the **middle cerebral artery (MCA)** distribution. We would predict that restrictions to MCA **perfusion** (the delivery of blood to tissues) would affect functions of these structures. Likewise, if we identified behavioral impairments related to these structures (e.g., aphasia, unilateral paralysis), we

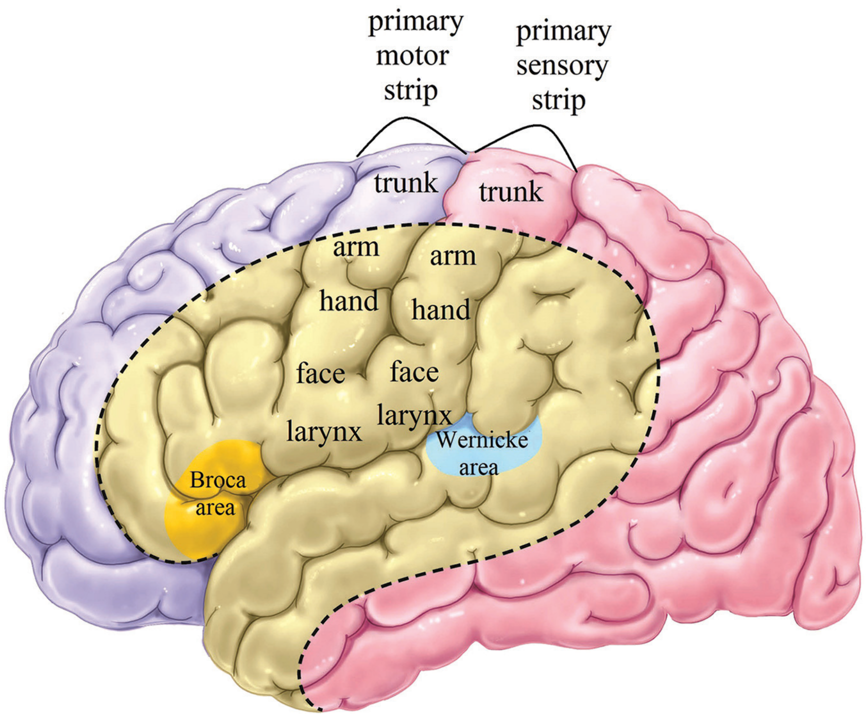


**FIGURE 13–1.** Overlap between cerebral blood supply and topographical organization. The *yellow*, center region is the middle cerebral artery distribution; the *blue*, anterior/dorsal region is the anterior cerebral artery distribution; and the *pink*, posterior/inferior region is the posterior cerebral artery distribution.

could predict that MCA blood supply may have been disrupted (acknowledging that not all etiologies are vascular in nature). To understand this concept more deeply, it is helpful to understand the source and tributaries of the cerebrovascular system.

The blood supply to the brain consists of two pairs of major arteries that carry blood from the heart, up the neck, and into the cranium. On the inferior surface of the cerebrum, they join with other arteries to form the **circle of Willis**, from which branches extend out to supply the entire brain.

In order to get a clear understanding of the system, begin with the source—the heart. Fresh, oxygenated blood begins in the heart and respiratory system. The aorta distributes that blood, branching off into the left and right subclavian and **common carotid arteries**. The subclavian arteries branch off into the left and right **vertebral arteries**, which merge near the inferior pons to form the **basilar artery**. The basilar artery serves the posterior portion of the circle of Willis and supplies blood to the posterior and inferior regions of the brain. The common carotids give rise to the **internal** and **external carotid arteries**. The left and right internal carotids supply the anterior portions of the circle of Willis and, by extension, the brain (Figures 13–2 through 13–4). Note that we have provided several images because perspective is crucial to understanding where these vessels are situated in the neck and head.

## Circle of Willis

The circle of Willis is a crucial distributor system in the cerebrum (see Figures 13–2 through 13–5). The internal carotid and basilar arteries bring oxygenated blood into the circle of Willis, and that blood is distributed to the brain through **cerebral arteries.** The circle itself is created by these major arteries and anastomoses called **communicating arteries**. **Anastomoses** are small-diameter, connecting

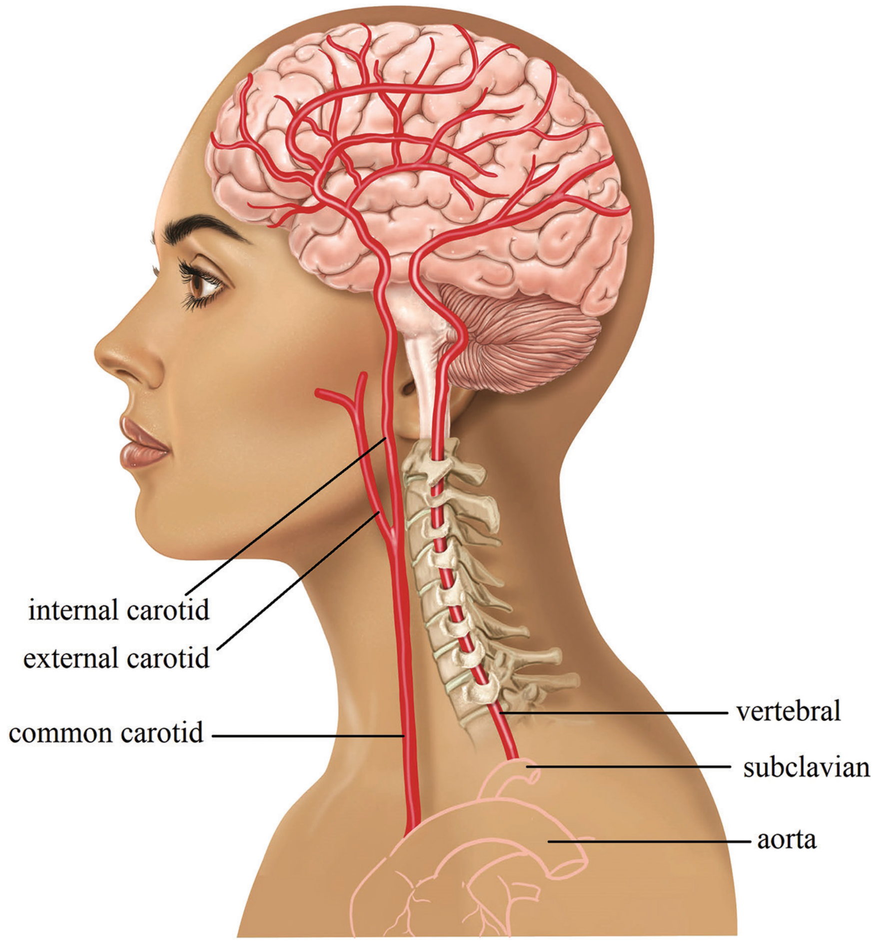


**FIGURE 13–2.** Arteries extending from the heart to the brain.

blood vessels that span between two larger vessels. In the case of the circle of Willis, anastomoses connect the main arteries, allowing for collateral circulation—a protective mechanism that may provide perfusion to major blood supply territories given a short-term obstruction. The **basilar artery** serves the **posterior cerebral artery** (PCA) distribution and is joined to the anterior distribution through the **posterior communicating artery** (PCoA or PComA; the posterior anastomosis). The **internal carotid** serves both the **middle cerebral artery** (MCA) and the **anterior cerebral artery** (ACA) distributions. Those distributions are joined through the **anterior communicating artery** (ACoA or AComA; the anterior anastomosis). It is worth noting that there are variations across individuals; some individuals have larger or smaller diameter anastomosis lumens connecting major arteries, and in up to 50% of people, the circle is incomplete, such as when the ACoA that connects left and right ACA distributions is absent.

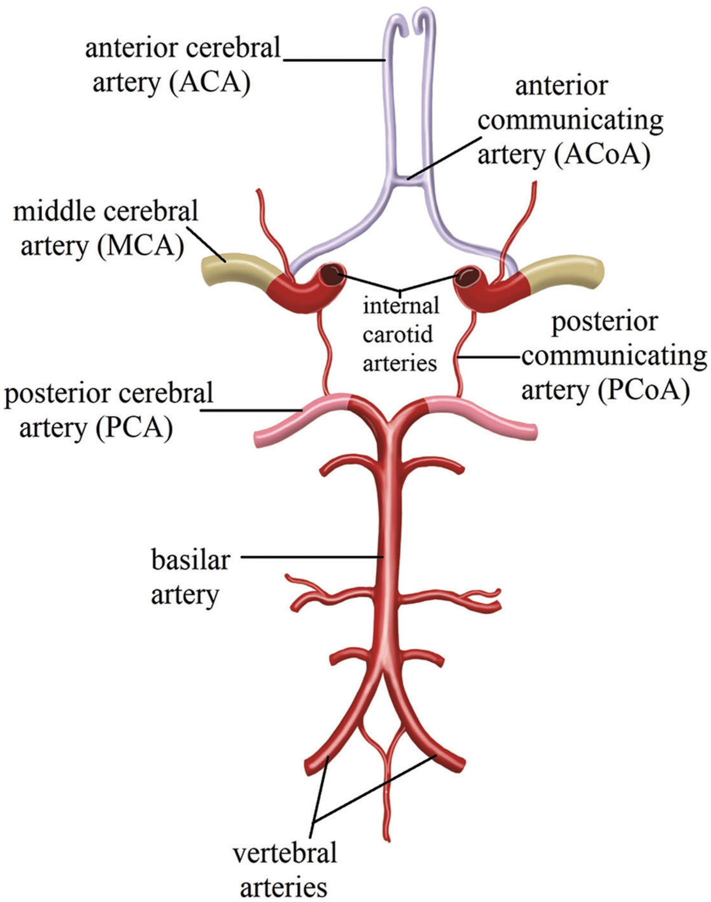


**FIGURE 13–3.** Arteries within the circle of Willis.

### Box 13–1. Arteries of the Circle of Willis

The arteries leading into the circle of Willis are the bilateral internal carotids and the single basilar (created by merging of the bilateral vertebrals). The arteries leading out of the circle of Willis to the brain are the bilateral anterior, middle, and posterior cerebral arteries. A single anterior communicating artery connects the right and left anterior cerebral arteries, and the paired posterior communicating arteries connect the middle to the posterior cerebral arteries.

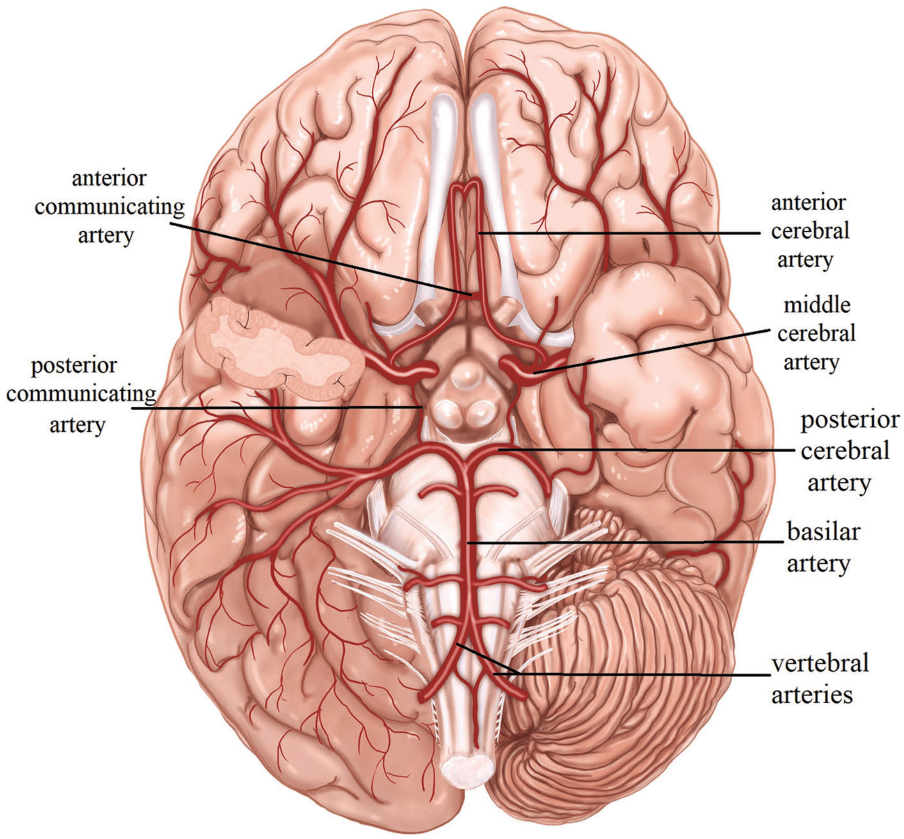


**FIGURE 13–4.** Circle of Willis in the context of the inferior surface of the brain.

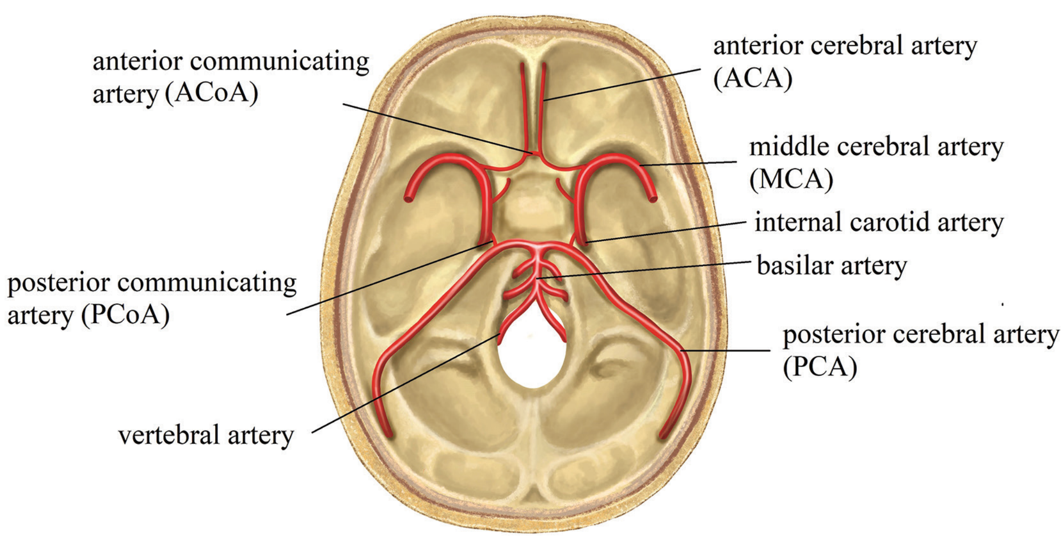


**FIGURE 13–5.** Circle of Willis in the context of the base of the skull.

## Cerebral Blood Supply Distributions

Three main paired vessels account for the majority of cerebral blood supply: the ACA, MCA, and PCA (Figures 13–6 and 13–7). The anterior choroidal artery, a small branch off of the MCA, accounts for a small distribution. Arising out of the internal carotid, the ACA and MCA supply much of the lateral surfaces of the cerebrum. Although only accounting for a small portion of the lateral surface, the ACA supplies most of the anterior half of the medial

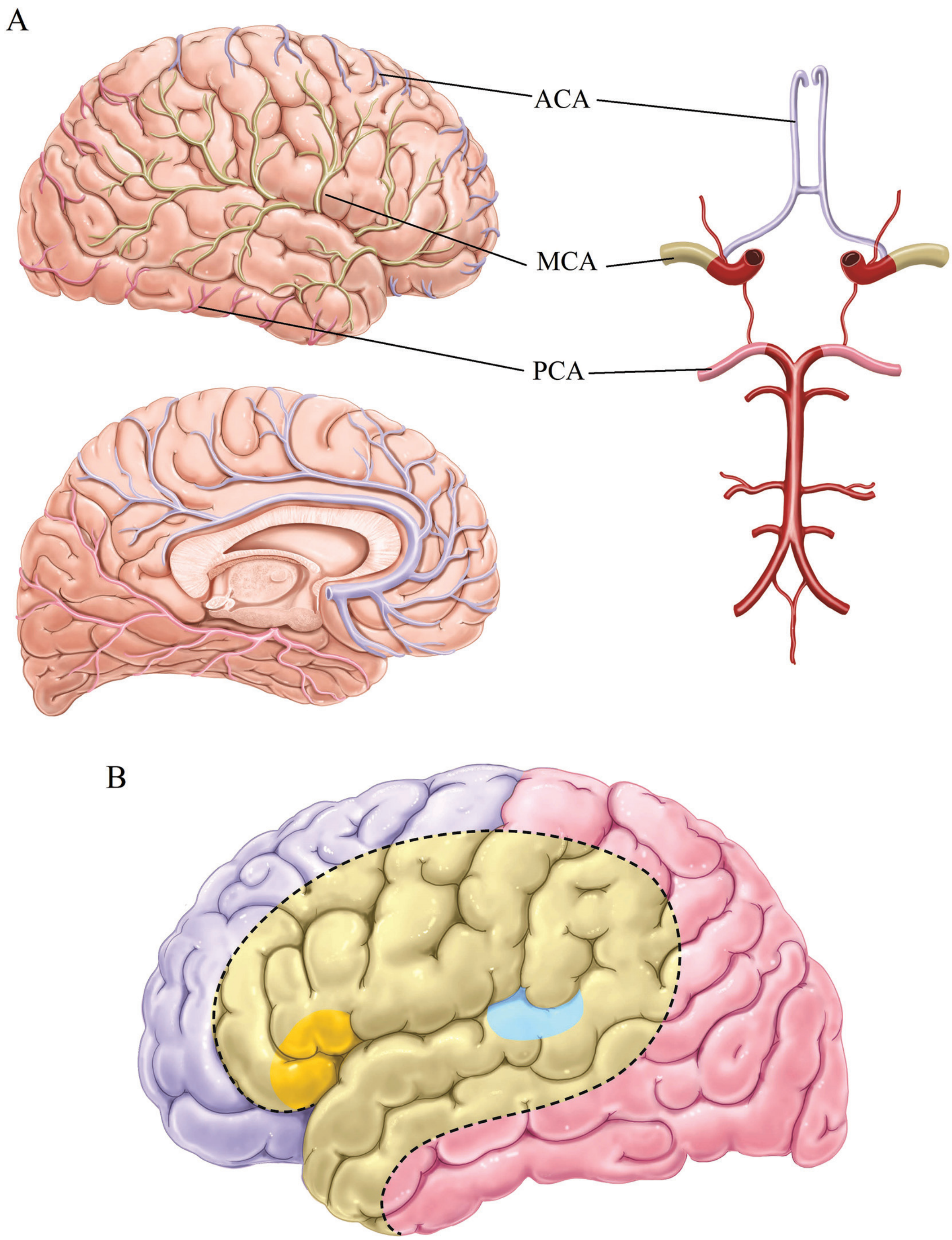


**FIGURE 13–6. A.** Cerebral artery branches on the lateral, medial, and inferior surfaces of the brain. **B.** Blood supply distributions on the lateral surface of the left hemisphere. *continues*

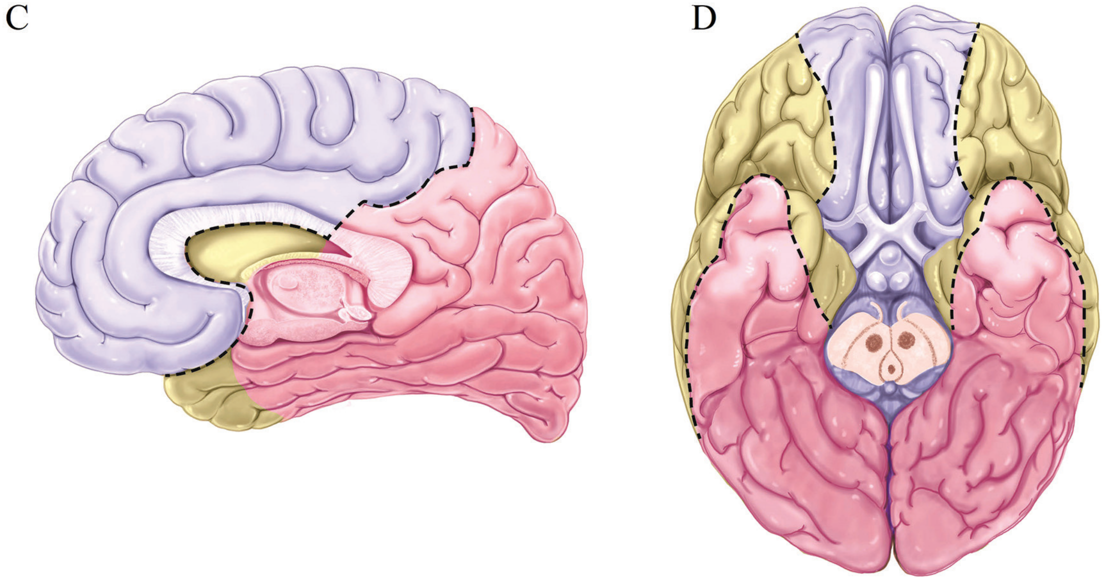


**FIGURE 13–6.** *continued* **C.** Blood supply distributions on the medial surface. ACA, anterior cerebral artery (*blue*); MCA, middle cerebral artery (*yellow*); PCA, posterior cerebral artery (*pink*).

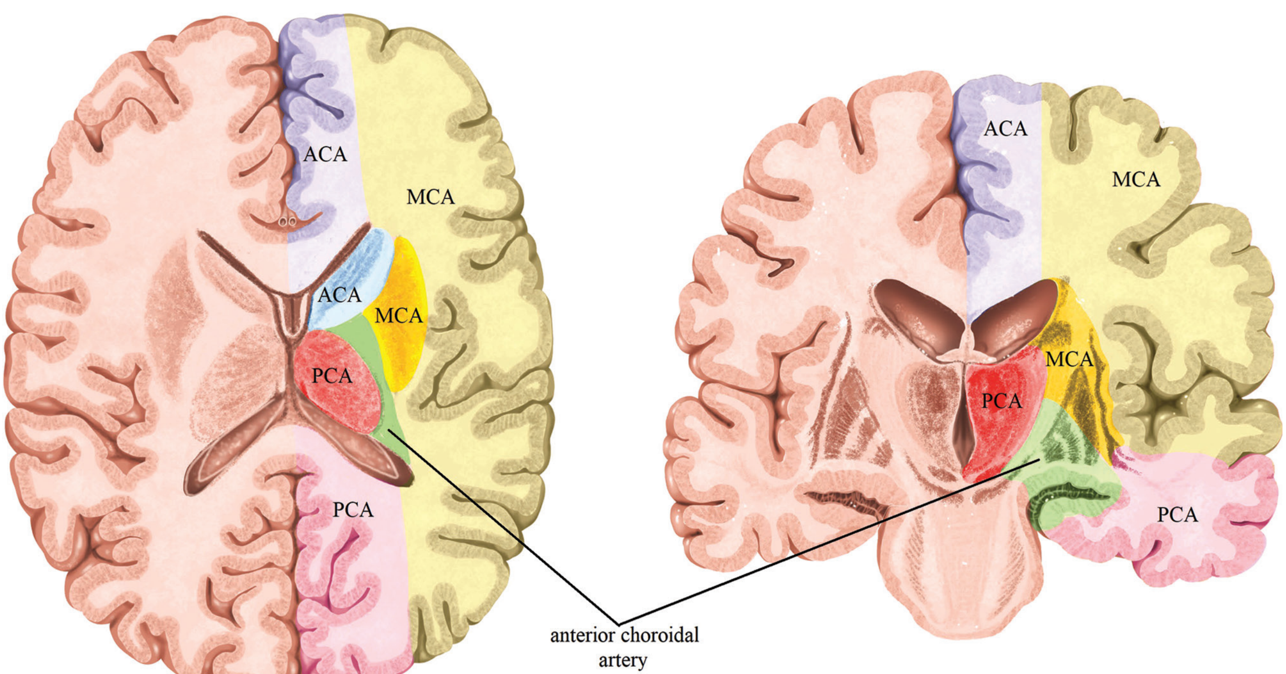


**FIGURE 13–7.** Blood supply distributions shown in horizontal and coronal slices. Distributions from deep branches of the cerebral arteries are shown in darker colors. The anterior choroidal artery is shown in *green*. ACA, anterior cerebral artery (*blue*); MCA, middle cerebral artery (*yellow*); PCA, posterior cerebral artery (*pink*).

surface. Likewise, the PCA supplies most of the posterior half of the medial surface, along with the perimeter of the lateral surface. It also supplies the inferior region of the temporal lobe. Cross-referencing the perspectives shown in the figures, you can see that the MCA distribution covers a substantial portion of the blood supply to the cerebrum.

**Box 13–2. Middle Versus Medial, Not Potay-Toe Versus Potah-Toe!**

This is one of those instances in which using anatomical terminology is critical. In everyday usage, middle means "between two things." The middle of the brain could be the center (along the midline), or it could be halfway between the front (anterior) and back (posterior). In anatomical naming, middle is always used in reference to other things that will clarify the location. The middle cerebral artery is located between the anterior and posterior cerebral arteries. This provides the context for you to know that middle is the region between the front and back of the brain. Remember that medial means "toward the midline" (another meaning of middle). The MCA does not supply blood to the midline; that's the job of the ACA.

The ACA distribution includes the lateral and medial surfaces of the prefrontal cortices, which house executive functions and working memory processes. It also supplies the anterior portion of the cingulate gyrus, lateral and medial portions of the supplementary motor area (motor planning), and lateral and medial portions of the motor strip/precentral gyrus (gross motor innervation to trunk, legs, and feet). Deep branches of the ACA serve the anterior limb of the internal capsule, the head of the caudate, and the hippocampal formation.

The MCA distribution serves the middle portion of the lateral surface of the cerebrum, including parts of the frontal, temporal, and parietal lobes. Anterior to the central sulcus and superior to the lateral sulcus is the superior branch of the MCA, which supplies portions of the motor strip/precentral gyrus (gross motor innervation to the hands, arms, and face); the premotor area (motor planning); and, in the left hemisphere, Broca area (language production). Posterior to the central sulcus and inferior to the lateral sulcus is the inferior MCA branch, which supplies the postcentral gyrus/primary somatosensory cortices (Brodmann areas 3, 1, and 2); somatosensory association cortices; Heschl gyrus (primary auditory cortex); and, in the left hemisphere, Wernicke area (language comprehension). Deep branches of the MCA serve the putamen and globus pallidus. The anterior choroidal artery serves the posterior limb of the internal capsule.

The PCA distribution serves the perimeter of the posterolateral cerebral surface, along with the majority of the posterior half of the medial surface. This includes the visual cortices (Brodmann areas 17–19) in the occipital lobes, superior and medial parietal lobes, and temporal lobes. It also supplies the inferior surface of the temporal lobe. Deep branches of the PCA serve the thalamus.

**Watershed regions** exist between each of the main cerebral blood supply distributions (Figure 13–8). A watershed region is an area of overlap between distributions, in which the brain tissue receives blood supply from both distributions through the final, smallest diameter branches of each artery. The anatomy provides both benefits and short-

**Box 13–3. Left Superior Branch of MCA Cerebrovascular Accident With tPA Therapy**

Darius was a 63-year-old male who experienced acute onset of right-sided weakness, confusion, and global aphasia (see Chapter 14) following a suspected left cerebrovascular accident (CVA). Imaging revealed a large ischemic stroke affecting the left superior branch of the MCA. Etiology was determined to be cardioembolic, secondary to atrial fibrillation. A "clot-busting" drug called tPA was administered. Darius' condition improved over the course of the initial 48 hours of hospitalization. Aphasia began to resolve toward a mild to moderate, nonfluent aphasia. Right hemiparesis persisted with upper extremity weakness worse than lower extremity weakness. Darius was transferred to inpatient rehabilitation, where he stayed for 2 weeks for physical, occupational, and speech therapy services. At discharge, he could walk independently with a four-point cane for household ambulation. He was able to dress himself with adaptive equipment from occupational therapy. Mild, nonfluent aphasia persisted at discharge. Atrial fibrillation was managed with an anticoagulant and calcium channel blocker post CVA. The arrhythmia resolved. (See Case 16–5 in Chapter 16 for an expanded version of this case.)