Variations in Cerebrovascular Anatomy

Part 1. Introduction

This chapter is, in part, an updated revision of sections of Congenital Anomalies of the Carotid Artery (175). Intracranial aneurysms are an integral part of the cerebral arterial circulation. This chapter describes some of the important variations in the vascular anatomy derived from embryologic growth and aberrations. The various carotid-basilar anastomoses, carotid-vertebral anastomoses, internal carotid aplasias, and carotid-anterior cerebral anastomoses are discussed. Many are associated with cerebral aneurysms. Finally, the superior orbital branch of the middle meningeal artery (the meningo-orbital artery), now commonly seen by surgeons drilling down the sphenoid wing for basal exposures, is described.

The use of cerebral angiography enables us to better study a larger number of normal and abnormal vascular patterns. Advanced techniques such as arch aortography, four-vessel angiography, and catheterization or cannulation of branches of the carotid tree, in combination with the subtraction technique invented by Ziedses des Plantes (341), have facilitated the angiographic demonstration of congenital anomalies of the carotid and vertebo-basilar systems. In addition, tomography of the base of the skull has given a more accurate picture of the course of an anomalous vessel.

A better knowledge of these congenital arteries assists in the recognition of pathologic appearances on the angiograms. In a book on intracranial aneurysms it is important to have a review of these abnormal patterns, anatomically and angiographically, as they give a quite different collateral circulation at the base of the brain. Persistence of transitory branches and anastomoses found in the embryo account for most of the recorded abnormalities of the carotid and vertebo-basilar tree. For a better understanding of these anomalies, a short review of the embryologic development of the cranial arteries is essential. The embryologic data are derived from the monumental work of D. H. Padget (225) on the development of the cranial arteries in the human embryo. See Chapter 12 for additional discussion.

Part 2. Embryology of the Cranial Arteries

In an early state the vessels are laid down as a network. From this, the large arteries, arterioles, and veins develop. In embryos of 3-mm length, the first aortic arches serve as channels supplying the primitive internal carotid arteries. The hindbrain at this stage is fed by the primitive trigeminal arteries which are also branches of the first aortic arches. In the 4-mm stage (Fig. 15.1) when the first and second arches start to regress, the primitive internal carotid arteries may be seen extending from...
the two dorsal aortas. From here, each artery proceeds cranially toward Rathke’s pouch and divides at the level of the optic vesicle into a cranial branch and a caudal branch.

The cranial branch gives off the anterior choroidal artery and the middle cerebral artery and then terminates as the primitive olfactory artery and the developing anterior cerebral artery. The latter artery makes a medial curve to communicate with its opposite fellow by means of the anterior communicating artery. The caudal branch gives rise to the posterior choroidal, the diencephalic, and mesencephalic arteries.

Dorsal and parallel to the internal carotid arteries at the base of the hindbrain develop two longitudinal neural arteries. They receive their blood supply from the carotid system and the dorsal aortas by means of a number of communicating branches: the caudal divisions of the internal carotid arteries; the primitive trigeminal arteries; the primitive otic arteries; the primitive hypoglossal arteries; and the proatlantal intersegmental arteries.

After communication has taken place between the caudal branches and the longitudinal arteries (embryo of 5–6 mm), the primitive arteries become obliterated: firstly the primitive otic artery, followed in turn by the hypoglossal and trigeminal arteries. The caudal parts of the neural arteries are for the time supplied by the proatlantal arteries until this function is taken over by the developing vertebral arteries (embryo of 7–12 mm). At this stage the basilar artery is formed by the fusion of the two longitudinal neural arteries.

The caudal communicating branch of the internal carotid artery, which starts as a slender vessel (embryo of 4 mm), becomes a prominent artery (embryo of 9 mm) while its caudal part diminishes in size to remain as the posterior communicating artery. In embryos of 18 mm the anterior communicating artery is still plexiform, but it becomes a definitive single channel at the 21–24 mm stage. As the basilar artery has already been formed at the 7–12-mm stage, the formation of the circle of Willis is now complete.