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Correlation of CT Cerebral Vascular Territories with Function:

I. Anterior Cerebral Artery

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Schematic displays of the cerebral territories supplied by branches of the anterior cerebral artery as they would appear on axial and coronal CT scan sections are presented. Companion diagrams of regional cerebral function are also provided to simplify correlation of clinical deficits with coronal and axial CT abnormalities. Selected examples illustrate that these facilitate more detailed and precise CT interpretation in clinical practice.

Knowledge of vascular territories can help in differentiating infarction from other pathologic processes. If, for example, the position and extent of a lesion and the usual position and extent of a vascular territory are incongruous, the diagnosis of infarction should receive a relatively low priority and vice versa. Knowledge of vascular territories can also facilitate correct interpretation of cerebral angiograms by pinpointing specific vessels for particularly close attention. For example, analysis of a patient's clinical findings in terms of functional neuroanatomy can improve detection of subtle lesions by pinpointing specific territories for special attention on CT and specific vessels for attention on angiograms.

This series of reports is designed to present functional anatomy and vascular territories in a form directly applicable to CT. (Parts II and III will deal with the middle and posterior cerebral arteries, respectively). The illustrations created for the series are intended to simplify correlation of clinical signs and symptoms, vascular territories, and CT images in everyday practice.

Discussion

This report correlates the vascular territories of the anterior cerebral artery with the neurologic functions ascribed to those territories by mapping the territories on schematic illustrations of axial and coronal* CT planes (figs. 1 and 2). These planes are then indicated on a map of the vascular territories as they would appear on the medial surface of the cerebral hemisphere (fig. 3A) and on a similar map of the medial hemispheric surface on which regions serving particular neurologic functions are delineated (fig. 3B).

The branches of the anterior cerebral artery have been divided into three groups: (1) the medial lenticulostriate arteries; (2) the pericallosal branches to the corpus callosum; and (3) the branches to the cerebral hemisphere.

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* The plane of coronal CT scans obtained depends on head positioning. If the coronal image is a reconstruction, the plane is perpendicular to the axial scans which may vary in their orientation. Therefore, we have chosen to illustrate the vascular territories in the anatomic coronal plane. The reader must correct for minor differences in scanning angle. This will be facilitated by a review of coronal slices illustrated by Matsui and Hirano [1].

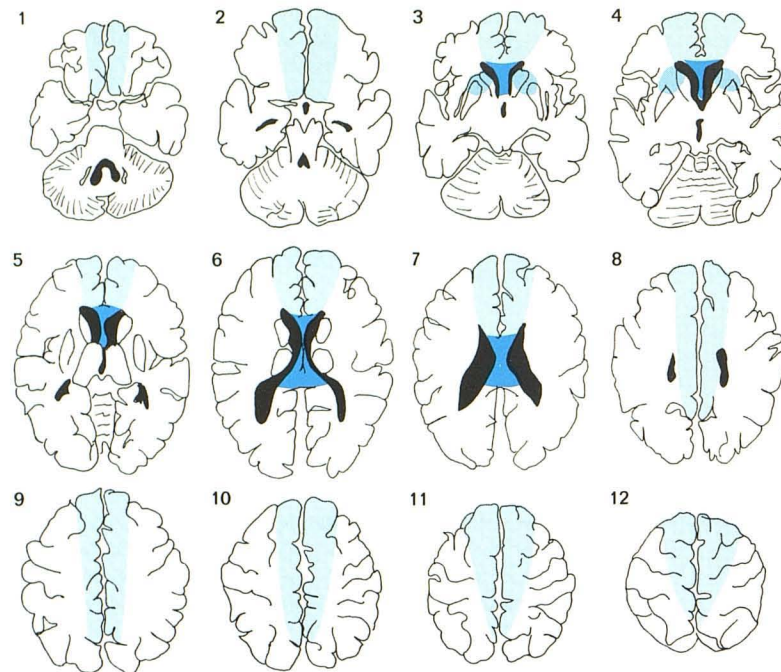


Fig. 1.—Axial CT scan diagrams arranged in sequence from base to vertex. Angle and levels of scan planes are shown in fig. 3. Territory of anterior cerebral artery is divided into three regions: medial lenticulostriate (*medium blue*), callosal (*dark blue*), and hemispheric (*light blue*).

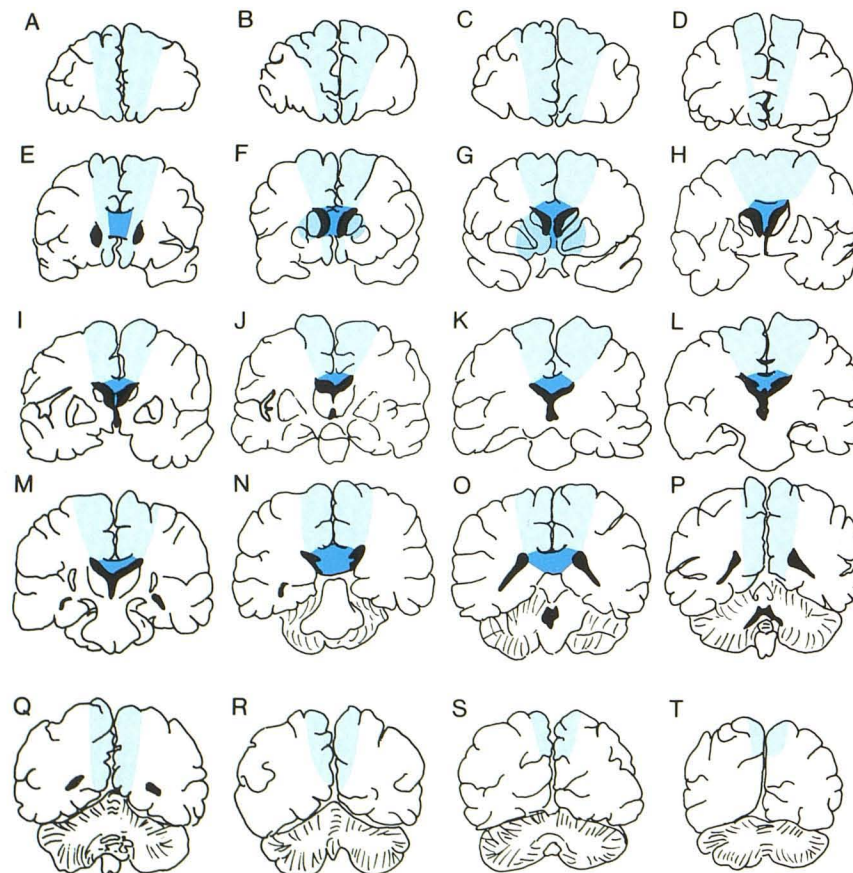


Fig. 2.—Coronal CT scan diagrams arranged in sequence from front to back. Angle and levels of scan planes are shown in fig. 3. Territory of anterior cerebral artery is divided into three regions: medial lenticulostriate (*medium blue*), callosal (*dark blue*), and hemispheric (*light blue*).

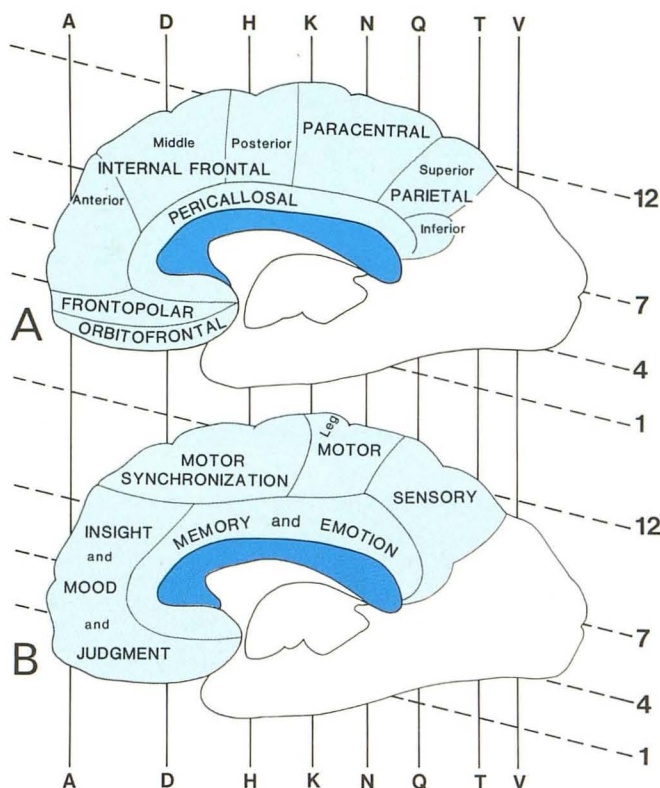


Fig. 3.—A, Regions supplied by nine hemispheric branches of anterior cerebral artery localized on medial view of cerebral hemisphere. B, Functional regions supplied by anterior cerebral artery localized on medial view of cerebral hemisphere. See axial and coronal scan levels in figs. 1 and 2 for correlation.

The largest possible area supplied by the vessel(s) of a single territory is indicated in figures 1 and 2. Therefore a vascular occlusion should not produce a lesion larger than that defined in those illustrations. In fact, collateral supply, which often interfaces at the distal periphery of an infarction, may cause the area of involvement to be smaller than that schematically defined. Furthermore, the area of involvement may have a patchy appearance because only selected branches within a territory may be occluded by emboli.

Medial Lenticulostriate Arteries

The medial lenticulostriate arteries include the artery of Heubner and basal branches of the anterior cerebral artery. The artery of Heubner supplies the anterior aspects of the putamen and caudate nucleus, as well as the anteroinferior part of the internal capsule. Infarction causes weakness of the contralateral face and arm without sensory loss. A transient aphasia is often seen in which spontaneous speech is lost while repetition and comprehension are preserved [2]. Occasionally there is dysarthria. Although the lower extremity is unaffected, there is a halting gait because of difficulty in initiating movements [2, 3].

The basal branches supply the dorsal aspect of the chiasm and the hypothalamus. Infarction of the hypothalamus may cause transient memory disorders or more protean

psychological manifestations of anxiety, agitation or a feeling of weakness [3].

If there is bilateral occlusion of the lenticulostriate arteries, a profound alteration of mental activity develops, at times resulting in a state of akinetic mutism (a comalike condition in which the patient's eyes remain open causing him to appear awake to superficial inspection). More commonly a classical picture of coma evolves [4, 5].

Infarction of the medial lenticulostriate arteries is much less common than hypertensive hemorrhage from these vessels. Unlike infarction, hemorrhage which arises medial to the putamen *ignores* vascular boundaries, destroys the hypothalamus, and ruptures into the ventricle. Therefore the radiologist can differentiate a hemorrhagic infarct, in which hemorrhage occurs secondarily, from a primary hemorrhage (intracerebral hematoma).

Pericallosal Branches

The callosal arteries arise from the pericallosal branch of the anterior cerebral artery and penetrate the upper surface of the corpus callosum, extending thence inferiorly into the septum pellucidum. Usually there are 7–20 short callosal branches, although these are sometimes replaced by a single artery. Infarction can result in isolation of the language-dominant left hemisphere from the right hemisphere which mediates function of the left side of the body. As a result, the patient experiences difficulty in moving the left side of his body in response to verbal commands (ideomotor apraxia), even though there may be no paralysis. Furthermore, the patient cannot recognize words written on the left side of his body though his sensation may be unimpaired (tactile agnosia), and he has difficulty in writing with his left hand (left-sided agraphia) [6, 7].

Hemispheric Branches

There are usually nine hemispheric branches (fig. 3A), each supplying a segment of the medial surface of the hemisphere. The medial surface of the hemisphere can be supplied in whole or in part by either anterior cerebral artery. (Sometimes both hemispheres are supplied by a single pericallosal artery, the so-called azygous artery, occlusion of which results in infarction of the medial surfaces of both hemispheres.)

Considering the large number of branches and numerous variations of cross-perfusion that can occur, one might expect the compromise of hemispheric branches could lead to a wide variety of possible clinical sequelae. However, the patterns of infarction can be simplified by comparing the vascular territories of figure 3A with the functional areas of figure 3B.

For example, figure 3 reveals that the frontal association areas that mediate judgement, insight, and mood receive arterial supply from the orbitofrontal, frontopolar, and anterior internal frontal arteries, and to a lesser extent, middle internal frontal arteries [8]. (The posterior internal frontal and paracentral territories may sometimes include a small part of the frontal association area—insight, mood, and judgement, fig. 3B). These functions would be impaired by

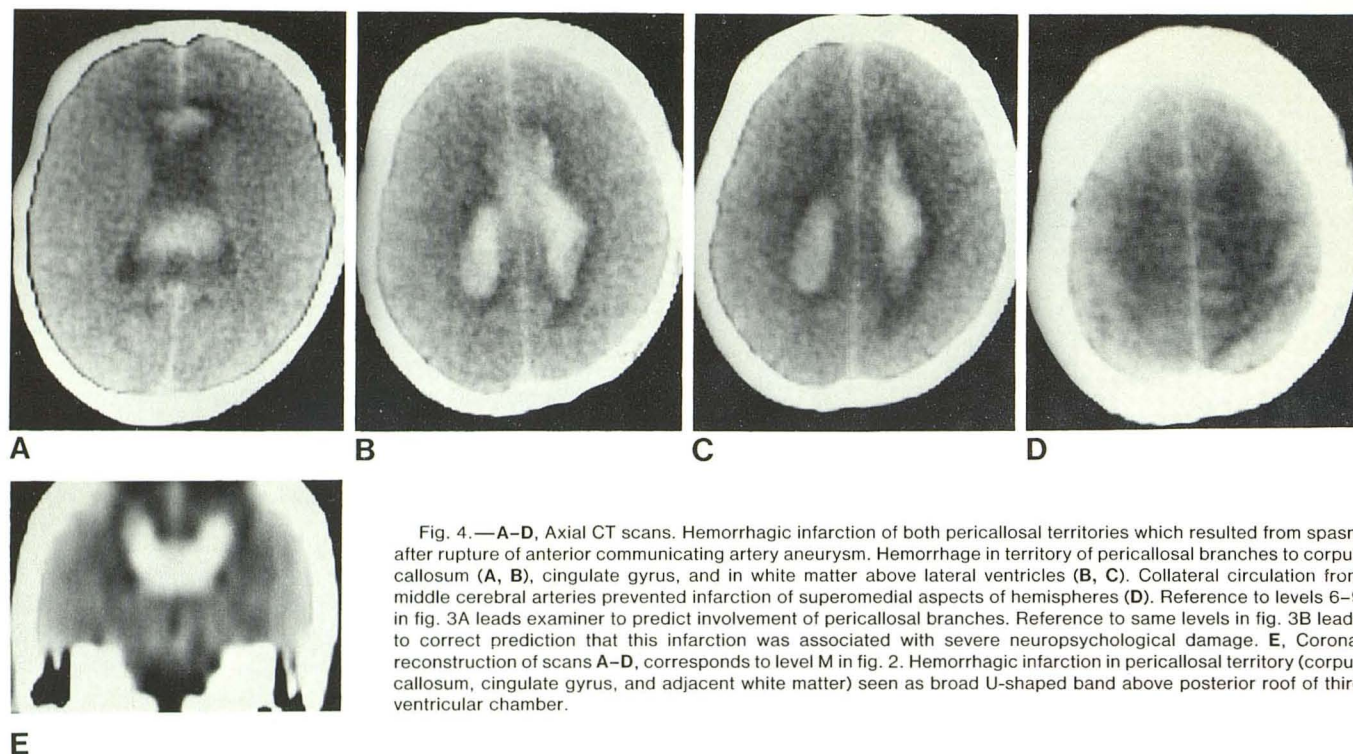


Fig. 4.—A–D, Axial CT scans. Hemorrhagic infarction of both pericallosal territories which resulted from spasm after rupture of anterior communicating artery aneurysm. Hemorrhage in territory of pericallosal branches to corpus callosum (A, B), cingulate gyrus, and in white matter above lateral ventricles (B, C). Collateral circulation from middle cerebral arteries prevented infarction of superomedial aspects of hemispheres (D). Reference to levels 6–9 in fig. 3A leads examiner to predict involvement of pericallosal branches. Reference to same levels in fig. 3B leads to correct prediction that this infarction was associated with severe neuropsychological damage. E, Coronal reconstruction of scans A–D, corresponds to level M in fig. 2. Hemorrhagic infarction in pericallosal territory (corpus callosum, cingulate gyrus, and adjacent white matter) seen as broad U-shaped band above posterior roof of third ventricular chamber.

occlusion of those branches. Aphasia may develop because the arterial supply of subjacent white matter is also disturbed. A release of grasping, groping, and sucking reflex patterns may be seen in addition to impairment of those functions indicated in figure 3B [2].

Figure 3 also shows that the motor synchronization area is supplied by the middle and posterior internal frontal branches and, to a small extent, by the anterior internal frontal and the paracentral branches. Infarction of the anterior part of the motor synchronization areas affects contralateral conjugate eye deviation, while involvement of the posterior part affects coordination of contralateral eye, head, and trunk movement [9].

Note that the motor function area is supplied by the paracentral branch. Unilateral damage causes weakness of the contralateral lower extremity. Bilateral damage causes incontinence as well [8].

Note further that the sensory function area is supplied by the paracentral and superior and inferior parietal branches. Rarely a parietooccipital branch (not shown in fig. 3) may supply the posterior part of this area. Damage of the anterior part of the sensory region impairs but does not abolish appreciation of primary sensory modalities, such as touch and pain. Damage in the posterior part impairs more complex sensory appreciation, such as recognition of objects by touch (stereognosis), recognition of shapes written on skin (graphesthesia), and two-point discrimination [10].

The supply of the cingulate gyrus which "controls" mem-

ory and emotion comes from the pericallosal, orbitofrontal, frontopolar, posterior internal frontal, paracentral, and superior and inferior parietal arteries. The cingulum fiber tract within this area is part of the limbic system, which is supplied by the posterior cerebral and the anterior cerebral arteries. Therefore, memory and emotional disturbances may occur as a result of damage to either vascular territory [2, 8].

Finally, infarction in the region of the parietooccipital fissure (which is sometimes supplied by the parietooccipital branch of the anterior cerebral artery) has been reported in one case of anterior cerebral artery compromise. In this instance the patient experienced disturbance of recognition in the contralateral visual field (visual agnosia), rare in association with anterior cerebral artery occlusion. This probably can be ascribed to the fact that the same area is usually well supplied by the posterior circulation [2].

With illustrative cases (figs. 4–6) the reader may practice using figures 1–3 to predict the vascular territories and clinical consequences of lesions of the anterior cerebral system.

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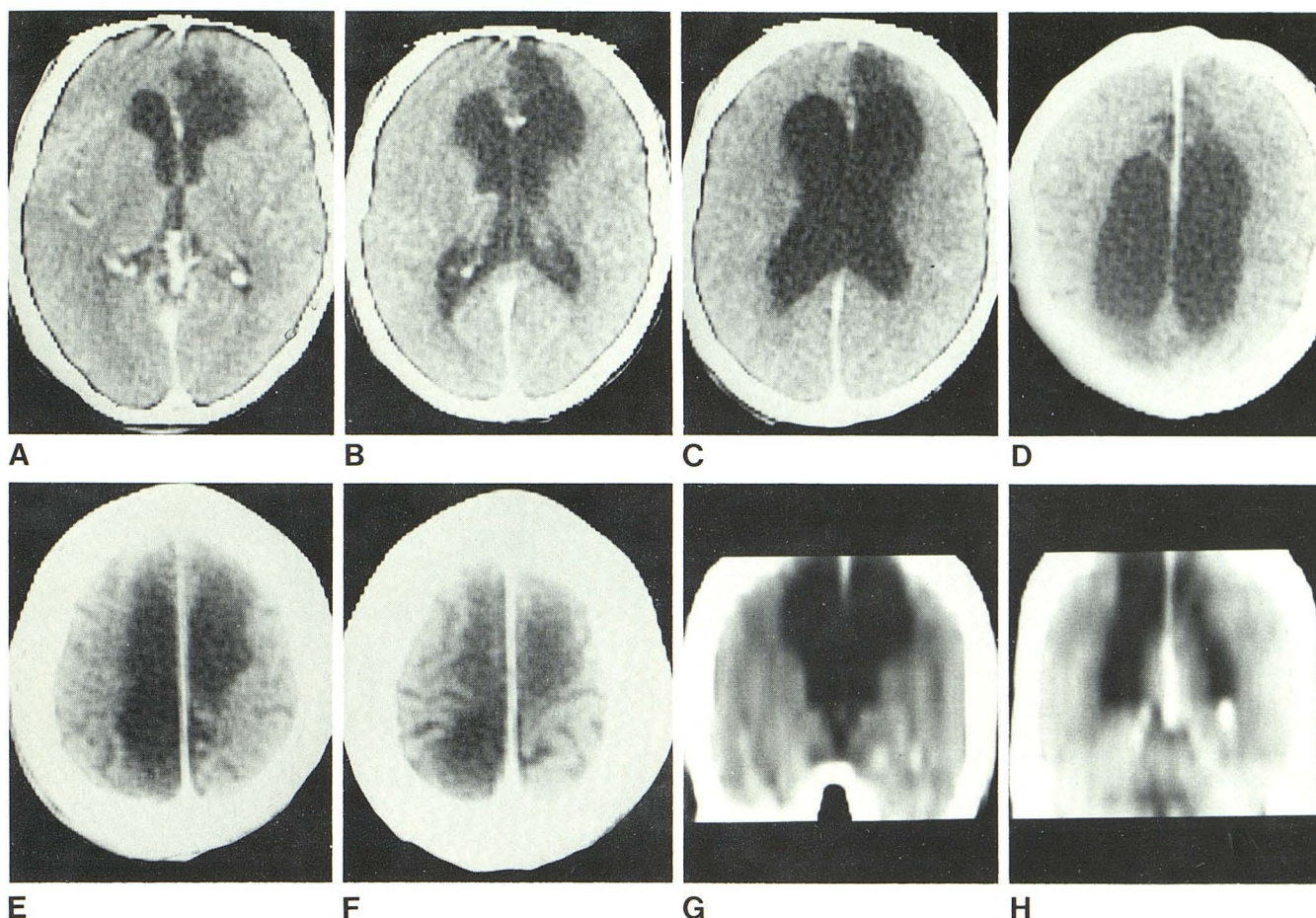


Fig. 5.—A–F, Axial CT scans. Ex vacuo enlargement of ventricles (B–D) after distal anterior cerebral artery infarction. Infarction of left aspect of genu (A) and medial aspects of both cerebral hemispheres (E, F). Reference to levels 4–12 in fig. 3A leads examiner to predict involvement of posterior internal frontal, paracentral, and superior parietal branches on right and all internal frontal and paracentral branches on left. Reference to same levels in fig. 3B leads to correct prediction of bilateral lower limb weakness, incontinence, motor synchronization difficulty, and sensory and neuropsychiatric deficits. G and H, Coronal reconstructions of scans A–F. G corresponds to level I in fig. 2 through foramina of Monro as they enter the third ventricle. Ex vacuo enlargement of superior aspects of both lateral ventricular chambers blends with infarction of medial surface of both hemispheres. H corresponds to level Q in fig. 2 through occipital horns of lateral ventricles. Superior aspects of medial hemispheric surfaces are infarcted. Inferior aspects of medial hemispheric surfaces are spared because of collateral supply from posterior cerebral arteries.

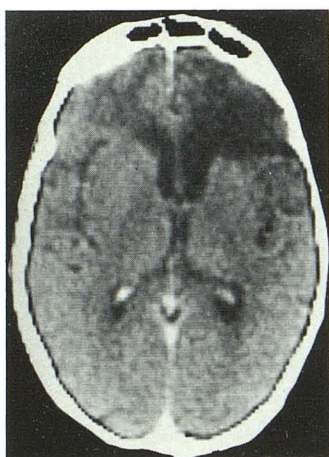


Fig. 6.—Axial CT scan. Bilateral frontal lobe damage which resulted from trauma. Areas of damage do not correspond to anterior cerebral territory. Zone of destruction extends beyond territory of anterior cerebral, and medial frontal cortex is involved (see levels 5 and 6 in fig. 1).

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