

Measurement of Regional Brain Blood Circulation by Computed Tomography

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Approach and Perspective

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The fact that cerebral blood flow (CBF) measurements have not become generally used clinically after two decades suggests that a basic problem exists. There has been much emphasis on technological development; however, we believe that the basic problem is not technological but one of approach and perspective. The approach has been directed principally to the refinement of complex machinery and of theoretical formulation and to brain perfusion almost as an abstract phenomenon. The perspec-

tive has been narrow, focused on the cerebral hemisphere, and centered on the middle cerebral artery; it has not been directed to the brain as a whole nor to the collateral system through which the extracranial arteries supply the brain. Regional brain perfusion is the bottom line, but compromise of that perfusion can find its genesis at every level of the cerebrovascular system, from the heart and cardiovascular system to the arteries of the neck, the circle of Willis, the arteries of the brain, and, finally, to the brain itself. Blood flow is a complex physiological phenomenon in its own right, so it is extremely doubtful that technological expertise alone can solve clinical problems. The dearth of clinical application by advanced technologies supports this contention.

In addition, an altered perspective of physiology and anatomy appears useful. The perfusion of brain structure must be considered separately from the arterial tree and from the hemodynamics of the brain and the vessels of the neck, and then these analyses must be brought together in a clinically meaningful fashion. Since the predominant blood supply to

the occipital lobe and portions of the temporal lobe is from the vertebral system, this portion of the brain is best considered as part of that system despite its physical continuity with the cerebral hemisphere. Clinicians recognize the validity of this position. Bilateral visual field defects and temporal lobe cerebral dysrhythmia are commonly considered to be manifestations of vertebral basilar insufficiency, so that if the designation *hindbrain* were to include the occipital and temporal lobes and the contents of the posterior fossa it should not be upsetting. It would then follow that the designation *forebrain* would include only the part of the brain supplied by the anterior and middle cerebral arteries.

Computed tomographic regional brain blood circulation (CT-rBBC) can only identify the location of ischemia within the structure of the brain. The ischemia, if regional, can then be related to the arteries directly supplying the brain that are consistent in their distribution; e.g., the frontal lobe is supplied by the anterior cerebral artery. When the intracranial and extracranial arterial patterns are defined, and only at that time, is it possible to speak precisely of the territory normally supplied by a specified extracranial artery, accommodating to whatever variations in vascular anatomy may be present in the given case.

With the intervention of arterial obstruction, it is necessary to address the circle of Willis and the collateral system that exists at that level. Let us illustrate the problem. If a supratentorial CT-rBBC study localizes ischemia to the right parietal and occipital lobe, the right-sided forebrain and hindbrain ischemia can be pinpointed to the distribution of the right middle (RMCA) and right posterior cerebral (RPCA) arteries, respectively. Then if the angiogram demonstrates that the right internal carotid artery (RICA) is occluded and the right parietal (RMCA) and occipital (RPCA) lobes are supplied from the basilar system, which, in turn, is normally fed by a dominant left vertebral artery (LVA), the occipital lobe (RPCA) ischemia lies in the normal territory of the VA, and the parietal (MCA) lobe ischemia lies in a territory

collateral to that of the VA, namely, that of the RICA.

If we then proceed to the level of the arteries in the neck, we find that the left subclavian artery is partially occluded, that the blood flow in the LVA can be reversed by reflex hyperemia or exercise of the left arm, and that, with this maneuver, the ischemia of the right parietal (RMCA) and occipital (RPCA) lobes can be increased. So in the final analysis, although brain perfusion is the bottom line, the localization of regional brain ischemia, the knowledge of precisely how the blood arrives there and how the system responds to stress are important pieces of information that are useful in making effective clinical decisions.

The benefits of this approach and perspective are significant. With a clear idea of what the problem is, the appropriate instrumentation for each facet can be fashioned and the expectations from the measurement of brain blood flow can be reduced and become more realistic. The terminology is made more precise and clinically useful. Brain hemodynamics have been appreciated. The impact of carotid or vertebral artery surgery on brain perfusion remote from the normal territory of the artery has been observed. The hemodynamic significance of dynamic arterial obstructions, that is, constrictions, entrapments and kinks, has been documented. Furthermore, parallel systems for diagnosis and investigation that can be related to regional brain perfusion, a reference more valid than the angiogram, have been developed. And finally, considerable thought has been given not only to surgical and medical therapeutic approaches but also to the design of the organizational structure necessary to implement the approach.

Despite the awesome nature of sophisticated instrumentation, we should not lose sight of the fact that the perspective and approach are dictated not by the instrumentation contrived by humans but by the basic physiological and anatomical situation with which we must contend, which can be simply and concisely summarized: "The cephalic arteries, whether they be carotid or vertebral, communicate with one another in various ways, so that should one of

them become obstructed or compressed, nonetheless, through one of these arteries, even only one, carotid or vertebral, the blood immediately supplies the parts in need. This we have demonstrated by injecting dark substances in only one branch and observing that the whole brain becomes colored" (1).

REFERENCE

1. Willis, T. (1720): *Opera Omnia*, edited by J. Venetius, Johannes Malactinus, Venice. Quoted by C. Loeb and J. S. Meyer (1965): *Strokes Due to Vertebral Basilar Disease*. Charles C Thomas, Springfield, Illinois.