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The cerebral circulation: The centrality of its function, the catastrophe of its failure

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Although the brain may contribute only a modest 2% to the body's total mass, it uses a wildly disproportionate 25% of the body's total glucose utilization, and 15%–20% of its total cardiac output.[1,2] This disproportionality may be striking, but it is wholly in keeping with the power and importance of the myriad functions underwritten by the brain. Many of these functions are indispensable to survival, such as the respiratory and cardiac rhythms controlled by the autonomic centers in the brainstem, the sleep and feeding cycles regulated by the hypothalamus, and the sensory modalities with which we find nutrients and avoid dangers presented by our environment. Many other cerebral functions, while not strictly necessary for survival, are nevertheless numbered among life's preeminent treasures: the capacity to design cities, to compose symphonies, to communicate one's inner life through language to loved ones.

To support these myriad and crucial cerebral functions, every anatomical part of the brain must be constantly perfused with blood. Analogously to the body's other circulatory beds, the cerebral circulation that provides this perfusion delivers the glucose and oxygen needed to drive much of cerebral metabolism on the cellular level[3] and, at its venous end, relieves the brain of metabolic waste. In other respects, the cerebral circulation is unique among circulatory beds. It participates in the protective production of cerebrospinal fluid.[4] It contains, with its Circle of Willis, a built-in buffer against hemodynamic stress.[5] It possesses, through both intracranial and extracranial anastomoses, an extensive collateral circulatory network capable of mitigating damage in the wake of cerebrovascular disease.[6,7]

Cerebrovascular disease may be defined generally as the result of overwhelming the cerebrovascular compensatory mechanisms with pathology. This is, unfortunately, an occurrence of sufficient frequency to constitute a worldwide epidemic: despite contemporary advances in treatment and improvements in understanding, cerebrovascular disease continues its status, with 6.7 million deaths every year, as one of the world's most prolific killers.[8] Moreover, as is unsurprising given the centrality of the many functions it controls, the damage wrought by cerebrovascular disease is often catastrophic even to survivors. In a study of first-ever stroke survivors, In a study of first-ever stroke survivors, it was found that, on a scale from 0-1, health-related quality of life was less than or equal to 0.1 among almost 25% of patients. Among 8% of survivors, health-related quality of life was absent enough to be considered equivalent to death.[9]

In three articles published in this edition of Brain Circulation, several authors have undertaken a thorough review of cerebrovascular disease. The purpose of this review series is, through a contextualized presentation of promising interventional research, to catalyze progress toward a better therapeutic horizon for patients with this pathology. The review will begin, in Part I, with an anatomical overview of the cerebral circulation. The arterial, venous,

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and microcirculations will be discussed. This discussion will then be followed, in Part II, by an introduction to the types of cerebrovascular disease pathogenesis. For the sake of organizing, this complex subject in a manner that renders it approachable, the authors have elected to divide pathogenesis into four categories: occlusive processes intrinsic to the vessel, occlusive processes extrinsic to the vessel, inadequate cerebral blood flow, and hemorrhage. The reader will thus be provided with the structural and functional foundation of Part III of this review, in which anatomy and physiology converge on a discussion of stroke. This discussion will be presented in two layers of organization. The first will divide stroke up into its two major pathologic partitions: Ischemic stroke (transient ischemic attack, because, it is treated clinically as a herald of future ischemic ictus, will be examined under this heading) and hemorrhagic stroke. The second organizational layer will then divide these two stroke sections into four subsections. The subsections will treat the relevant epidemiology, pathophysiology, clinical presentation, and available therapies individually.

As Dr. Louis Caplan once wrote,[10] "No medical task exists that is more complex, more multifaceted, more important, and potentially more rewarding than caring for a stroke patient." Put succinctly, the purpose of the review to follow is to substantiate this claim. There are few diseases that can take from patients so much from the essence of who they are, and of such diseases, none with nearly the ubiquity of cerebrovascular disease. In counterbalance to the catastrophic severity and global reach of cerebrovascular disease, however, research into stroke treatment and prevention possesses a nearly unequalled potential to alleviate suffering.[11-13] This is what accounts for the remarkable energy and spirit of hope with which research in this field is undertaken. Should anything written in this journal in any way further the development of therapies that may ameliorate the toll wrought by stroke and other cerebrovascular disease, then our preeminent aim in writing shall have been fully served.

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