CIRCULATORY DYNAMICS OF THE CANINE SPINAL CORD

TEMPORAL PHASES OF BLOOD FLOW MEASURED BY FLUORESCINE AND SERIOROENTGENOGRAPHIC METHODS

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In the course of studies of experimental angiography in dogs, it became evident that the spinal cord is especially vulnerable to injury by roentgen contrast agents, and that this injury is modified strikingly by the position of the animal during an injection.\(^{13,16}\) It was readily apparent that the peculiar features of the blood supply and the caudal anatomical situation of the animal cord are important factors in the production of the injury. The postural effect, with the cord being protected when an animal is prone and rendered most vulnerable with the animal supine, could be explained in theory by differential gravitational flow of a medium heavier than blood.\(^{7,13,16}\)

An alternate possibility arises that the unusual susceptibility of the spinal cord to this injury, and the modifying effect of position could be explained by intrinsic features of the circulation of the spinal cord. For example, it is conceivable that the circulation time of the spinal cord is inherently slower than that of the brain, rendering the exposure time to the contrast substance critically long. Consistent with this hypothesis is the observation that the spinal cord is relatively resistant to circulatory stasis such as that produced by aortic occlusion.\(^{1,11}\) Another possibility is that the modifying effect of posture is related to an alteration of speed of blood flow. With the animal supine, a slowing of the circulation of the cord by venous stasis or by arterial constriction is possible theoretically.\(^3\) The importance of prolonged application time to the production of contrast medium injury of the brain has been emphasized repeatedly by Broman \textit{et al.}\(^4,5\) To resolve the problems raised above, information is needed concerning the circulation time of the spinal cord and, in particular, the time of exposure of the circulation and parenchyma of the spinal cord to an injected mass of contrast substance in its first circulation.

These few basic facts about spinal cord circulation are unknown. From a consideration of the anatomic arrangement of the blood supply of the

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cord, with its variable and numerous arterial and venous radicles, it is evident that the quantitative technics used in the measurement of cerebral blood flow are not applicable to this structure. However, the pattern of both the extrinsic and intrinsic vessels of the cord\textsuperscript{1,6,9,13,15,16} renders it as readily approachable as the brain by technics designed to study temporal phases of the circulation, and perhaps even better adapted for the study of features of segmental or regional blood flow. The present report describes experiments designed to obtain this fundamental information, and the results of these studies.

**EXPERIMENTAL**

The principal method for the study of the vascular dynamics of the spinal cord consisted of a modification of the fluorescein technic used by Minard\textsuperscript{14} to study the cerebral circulation time.

Adult dogs of varied breeds were used for these studies. With an animal under Nembutal anesthesia a laminectomy was performed, exposing from 3 to 5 cm. of lumbar cord. The dura mater was incised and reflected laterally, care being taken to avoid perforating the arachnoid membrane. In each animal the vascular network of the dorsal surface of the cord was carefully studied under a Zeiss technoscope at magnifications ranging from 10X to 60X. Animals demonstrating circulatory abnormalities such as the sludging phenomenon,\textsuperscript{10} traumatic subarachnoid hemorrhage, or a loss of the subarachnoid space consequent to perforation were not used in critical observations. For further observations a magnification of 16X was generally used. A polyethylene catheter was inserted into the femoral artery and passed retrograde into the abdominal aorta until the tip reached to approximately the level of the umbilicus. For the indicator substance a 0.5 per cent Na fluorescein solution in physiological saline was used. This substance was injected manually in doses of 1 cc. per kg. at a rate of approximately 5 cc. per sec., this dose and injection time being based upon previously reported studies of contrast medium injuries.\textsuperscript{15,16} The fluorescence of the dye was activated by exposure to a long wave (3660A) ultraviolet lamp (Ultraviolet Products, Inc.) in a dark room. Care was taken during these tests to reduce the exposure to ultraviolet light to a minimum time and to keep the field of observation protected from light and moistened with physiological saline during interval periods. The circulatory events were timed by being directly recorded upon a Sanborn polyviso recorder through a remote control switch activated by the observer. During these studies continuous blood pressure tracings obtained from a catheter in the contralateral femoral artery were also recorded on this instrument. Animals exhibiting hypotension were eliminated from these studies of the normal circulatory dynamics. Parallel studies of the canine cerebral circulation were made through a 1.8 cm. trephine opening, under conditions similar to those of the spinal cord studies. For these observations a catheter was anchored in the external carotid artery in a retrograde direction, and the vessel was ligated distally. Na fluorescein in 0.5 per cent solution was again used as the indicator substance, with the test dose generally being 1 cc. per kg. administered at approximately 5 cc. per sec. In a few animals, doses of 0.2 to 0.4 cc. per kg. were also used.

The following variables of blood flow were recorded in each animal studied: