POLAROGRAPHIC STUDY OF CORTICAL BLOOD FLOW IN MAN*

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Knowledge of human cerebral hemodynamics in normal and diseased states has been advanced considerably by the application of the nitrous-oxide technique for measuring cerebral blood flow and metabolism. This method provides an average measurement for the entire brain; the extent of localized circulatory and metabolic changes cannot be assessed. Moreover, the technique does not permit continuous recording of rapid changes in circulation or in metabolism.

In a search for a method whereby rapid adjustments of the cerebral circulation might be analyzed, the polarographic measurement of cerebral oxygen tension proved to be of value in the study of localized changes in blood flow and metabolism in such conditions as experimental cerebral concussion, contusion, laceration, brain-stem injury, ischemia, infarction and respiratory anoxia. The polarographic method was also found to be of value in assessing local cerebral blood flow and metabolism in states of hypothermia, both in animals and in man.

The historical background of the polarographic method and a critical assessment of its validity as an index of local blood flow and metabolism have been discussed in earlier communications. The technique was first applied to physiological studies by Davies and Brink in 1942 although it had been in use for many years in physical chemistry. The principle of electropolarography is that the oxygen tension of an unknown solution may be measured by recording the current flow between a platinum electrode acting as a cathode and a second nonpolarizable electrode. The local cerebral oxygen tension appears to depend on three factors: local blood flow, local metabolism of oxygen and the concentration of oxygen in the general circulation. If local tissue metabolism and the concentration in the general circulation remain constant, changes in local oxygen tension reflect alterations in local blood flow. It has been shown experimentally that cerebral metabolism and the concentration of oxygen in the general circulation remain remarkably constant under light anesthesia.

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We wish to report observations in man relating to cortical blood flow and oxygen metabolism determined by the polarographic method during the course of neurosurgical procedures. The method has been used in order to provide information relating to possible changes in blood flow and metabolism in cerebral contusion, cerebral laceration and cerebral compression from subdural hematomata. This information was correlated with the electroencephalogram as an indication of neuronal activity and with measurements of blood flow as indicated by temperature electrodes. In addition, observations were made on patients with cerebrovascular disease in whom subdural hematoma was suspected and on patients with vascular malformations requiring occlusion of the carotid artery in the neck. For purposes of comparison, observations have been made in a case of juvenile dementia without signs of cerebrovascular disease.

MATERIALS AND METHODS

Thirteen cases were studied in this series; they are listed according to diagnosis in Table 1. In all instances the diagnosis was confirmed either by arteriogram, operation or necropsy. Polarographic measurements in 7 of these cases are illustrated and clinical summaries are included. The clinical and polarographic data obtained in Case 10 have been published in detail in another communication. Measurements of cortical oxygen tension were made during the course of neurosurgical treatment, and in other cases the cortical oxygen tension was recorded after exploratory burr-holes had been made for diagnostic purposes (Cases 6, 7, 8, 13). These measurements were not found to be harmful and in some instances they were recorded under local anesthesia (Fig. 2). In the other cases, light anesthesia was maintained with endotracheal nitrous oxide and oxygen, occasionally supplemented with ether. Continuous charts of blood pressure were made by the anesthetist. The effects of changes in the oxygen content of the inspired air on the cortical oxygen tension were recorded while changes in the composition of the gas mixture were made by the anesthetist. In all cases except 2, electroencephalographic records were made during or a few hours prior to neurosurgery.

The oxygen tension of several small areas of brain was recorded concurrently with other parameters by modifications of the polarographic method described in earlier studies. The anode (silver-silver chloride) is a silver wire insulated with Teflon, except for its last 1 cm., which is freshly chloridized prior to use. At operation the anode is inserted through a stab-wound situated on the edge of the craniotomy flap or the site of the burr-hole. The cathodes, or active electrodes, are several in number. Each is made from a 1-cm. length of platinum wire, 0.02 in. in diameter, soldered to an 8-cm. length of silver wire. The composite wire is insulated with Teflon except for the exposed tip of the platinum. The exposed portion is 3 mm. in length, tapered to a point and polished. The silver shaft of the electrode, being malleable, aids in placing the electrode in any desired area of cortex. The anode and several cathodes are soldered onto the adjustable rods of a