CIRCUMVENTION OF ANOXIA DURING ARREST OF CEREBRAL CIRCULATION FOR INTRACRANIAL SURGERY

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Comparison of Shunts and of Local and Systemic Hypothermia. Effect of Hypothermia on Cerebral Metabolic Rate and Cerebral Tolerance to Anoxia. Vascular lesions of the brain could be treated more adequately if the blood supply to the affected area were occluded or at least diminished. This necessitates supplying the brain distal to the lesion with arterial blood or protecting it from anoxia. In searching for a method to facilitate the neurosurgical approach to these lesions of the brain, we first tried in dogs various kinds of polyethylene shunts and perfusion pumps to deliver arterial blood to the brain distal to points of occlusion of its trunk arteries. The disadvantages proved so great that we moved to a study in dogs of hypothermia, which we now consider the method of choice.

Since Bigelow2-4 first suggested the use of hypothermia for cardiac surgery there has been an ever increasing interest in this field. Bigelow, Lewis and Taufic17 and Swan et al.20 have demonstrated conclusively the protection it affords both the heart and the brain during circulatory arrest.

POLYETHYLENE SHUNTS AND PERFUSION PUMPS

Polyethylene shunts varying from 0.5 to 2.0 mm. in diameter were used. In order to test them easily, the superficial femoral artery was occluded by a bulldog clamp and the artery was cannulated above and below the point of occlusion with this polyethylene tubing. The occurrence of thrombosis in all preparations was the prime factor in the failure of these shunts. The time interval before thrombosis occurred usually varied between 5 and 10 min.; only an occasional shunt lasted longer. Unless a flow meter is available for continuous observation of blood flow, the occurrence and site of thrombosis in the shunt are not detectable and represent a great danger and inconvenience. It was proposed to use these shunts for lesions of the middle cerebral artery. The external carotid artery was cannulated with polyethylene tubing and the shunt was then carried externally around the head and inserted into one of the branches of the middle cerebral artery. We found, however, that it was impossible to cannulate the cerebral vessels with a mere tip of polyethylene, and so mounted a #22 needle, which had been especially ground on its outside diameter, on the end of the polyethylene shunt. The needle on this end even though siliconed acts as a nidus for thrombosis. These small shunts deliver only a small amount of blood, and they are very difficult to maintain in place.

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It was decided to increase the pressure of the blood in order to increase the rate of circulation. A simple perfusion pump was built to do this. It consisted of two 500 cc. bottles arranged in such a way that the arterial blood could flow into one bottle (from a cannula in the carotid) while arterial blood previously collected could be forced into the cerebral artery by oxygen pressure delivered to the bottle that was perfusing the blood (Fig. 2). The cannula receiving the blood from the animal had a double barrel, so that citrate could be mixed with the blood as it entered the pump.

By this method we were able to perfuse the area of brain that had its blood supply isolated, but it was very difficult to insert a cannula in the small branches of the middle cerebral artery and even harder to maintain it in place, for the slightest movement resulted in tearing of the small branch out of its bed. We, therefore, concluded that the above methods present three disadvantages, in that:

1) The use of anticoagulants is contraindicated during neurosurgical procedures.
2) The preparation of the extracorporeal circulation becomes an operation in itself before a lengthy neurosurgical operation is embarked upon.
3) The large blood vessels of the brain do not have sufficient collateral circulation to allow them to be sacrificed for cannulation. Therefore, it is necessary to cannulate a small cerebral artery. This reduces the quantity of blood that can be perfused through the isolated portion of the brain. These small vessels are very delicate and it is difficult to maintain the cannula in place. For the above reasons we have given up these approaches for the simpler and more feasible one of hypothermia.

HYPOTHERMIA

Prior to a discussion of the advantages of hypothermia, it is essential to be aware of its dangers and disadvantages. The primary dangers of hypothermia are ventricular fibrillation and cardiac failure. As a part of this investigation, studies of the cardiac output, mean femoral and pulmonary arterial pressures, and mean right and left auricular pressures were done, from which calculations of the total pulmonary and peripheral resistance and the right and left ventricular stroke works were made. The electrocardiogram was recorded at sampling intervals. These findings will be reported separately. It is sufficient to state here that ventricular fibrillation did not occur in this series of dogs at temperatures above 25°C. (excluding local hypothermia). Below 25°C. there were 3 dogs out of 15 that died from fibrillation. Our findings agree with those of Clark et al. The latter said:

"...the minimum temperature at which the mammalian heart can beat against what may be called an average resistance varies between 23° and 26°C. As the heart is gradually cooled, when the critical temperature is reached, it suddenly dilates, the output diminishes rapidly, and unless the arterial resistance is relaxed and the blood warmed quickly, the heart ceases to beat, often going into fibrillary