CAROTID-INTERNAL JUGULAR ANASTOMOSIS
IN THE RHESUS MONKEY

ANGIOGRAPHIC AND GASOMETRIC STUDIES*

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An arteriovenous anastomosis between the carotid artery and the external jugular vein was performed by Gluck\(^3\) in 1896. In 1902, Carrel and Morel\(^2\) anastomosed the carotid artery to the external jugular vein in the dog. Later, in 1907, Watts\(^6\) made pathological studies of the external jugular vein through which carotid arterial blood had traversed. Carrel suggested that such an anastomosis may "increase the circulation of the brain by directing a strong current of red blood through the internal jugular vein in dogs, the peripheral end of this vein being anastomosed through a central end of the common carotid artery." He quoted Jaboulay,\(^4\) who in 1902 had expressed the opinion "that an arteriovenous anastomosis might have a good result in case of insufficient circulation, as in softening of the brain." Carrel did not believe that such a lesion could be successfully treated but stated that "it is not absolutely improbable that the slow and progressive disease of cerebro-sclerosis might be benefited by an operation modifying the circulation."

Carrel noted that when arterial blood was shunted into a vein, the vein wall rapidly thickened. The degree of thickening depended upon the amount of increase in the blood pressure. If the vein was required to support the normal arterial pressure, extensive thickening resulted with eventual complete obliteration of the lumen. Carrel found after the production of a shunt that "no clinical troubles occur in the dog; a dog operated on five months ago is living in good health." It is doubtful that arterial blood ever reached the brain in these animals even though the shunt may have been functioning. If the external jugular were used for such an anastomosis most of the blood would be shunted into the veins of the neck rather than into the cranial cavity.

Beck, McKhann, and Belnap\(^1\) have reported upon common carotid-internal jugular anastomosis in the neck with ligation of the distal end of the internal jugular vein, as a means of revascularization of the human brain. A side-to-side anastomosis of the common carotid and internal jugular has been done and in later operations the external carotid and the internal jugular have been anastomosed. After the anastomosis an increase in the blood flow through the head was noted by utilizing a technique of tracing

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radioactive material injected into the circulation and gasometric studies of oxygen in the sagittal sinus before and after a shunt.

In order to evaluate critically carotid and internal jugular shunts, experiments have been performed on rhesus monkeys. Two fundamental factors have been studied and are discussed in this paper. (1) The direction of the flow of blood after the shunt. (2) The oxygen content of the blood in the sagittal sinus before and following the shunting procedure, studied by gasometric methods.

MATERIAL AND METHODS

The use of the dog as an experimental animal in this type of research is unsatisfactory since the internal jugular in this animal is small or absent and the external

![Angiogram of rhesus monkey after carotid-internal jugular shunt (5 cc. of 35 per cent diodrast injected). The diodrast goes up one jugular to the lateral sinus on the same side, thence to the opposite lateral sinus and down the other jugular in the neck. Note also that there are many other neck communications.](image1)

![Angiogram of a shunted rhesus (5 cc. diodrast). Note that the internal jugular has extensive neck communications, although some of the diodrast reaches the intracranial space and enters the lateral sinus in the head.](image2)

jugular has extensive extracranial tributaries. The rhesus monkey, on the other hand, is suitable since the internal jugular vein and its communication with intracranial venous pathways is similar to that in the human (Figs. 1–5).

Thirty-eight animals were experimented upon. Intravenous Nembutal (1 gr./5 lbs. body weight) was used for anesthesia in all experiments.

In 11 animals angiograms were obtained after the shunt. Five cc. of 35 per cent solution of diodrast was used for visualization of the shunted pathways. Angiograms were obtained under varying conditions, including ligation of other veins on the neck such as the opposite jugular, external jugular and other neck tributaries; obstruction of both carotid arteries and ligation of the opposite lateral sinus. The pressure of the diodrast injection was measured in some experiments.

In 17 monkeys gasometric studies of oxygen content were made by the Van Slyke technique. Artificial respiration with intratracheal oxygen was used with 16