Influence of Multiple Vessel Impairment on Carotid Blood Flow in the Monkey*

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One important factor when considering a patient for carotid endarterectomy is the percentage of constriction as determined by arteriography. Mann, et al.,\(^6\) reported in 1938 that it is necessary to reduce the diameter of the lumen of an artery by 70% or the cross-sectional area by 90% before a 50% reduction in blood flow occurs. Tindall, et al.,\(^9\) demonstrated that a 90.5% reduction in the cross-sectional area of the human common carotid was necessary before a significant reduction of flow or blood pressure occurred.

In our experience, patients have shown transient ischemic attacks with less than 70% reduction in diameter of the internal carotid artery. These attacks could have been caused by emboli arising from the atheromatous plaque as has been suggested by De Bakey.\(^2\) Another factor that may have influenced the onset of the attacks was the presence of lesions in more than one neck vessel. Gurdjian and Thomas\(^5\) have stressed the importance of multiple vessel disease in patients with cerebral ischemia. We noted lesions in more than one neck vessel in some patients who had less than 70% occlusion of the appropriate vessel. To compare the effect of a carotid constriction when the collateral arteries are open with that when they are compromised, we performed the following experiment.

Method

Ten large stump-tail macaque monkeys were used for this study. The animals were tranquilized with Sernylan\(^\dagger\) and then given intravenous sodium pentobarbital. A tracheostomy was performed and breathing was controlled with a Bird respirator. The femoral artery was cannulated, and constant blood pressure recordings were made using a Statham strain gauge. Through a midline incision, both carotid and both vertebral arteries were clearly exposed (Fig. 1). A Medic-on flow probe was placed around the left carotid artery, and the carotid flow and blood pressure measurements were recorded using a Honeywell Visicorder. After obtaining the flow base line, the left carotid was occluded in measured increments with a modified Crutchfield clamp. In each animal several recordings of the flow rate with gradual occlusion of the artery were made (Fig. 2 left).

In the next phase of the study, the opposite carotid and both vertebral arteries were occluded with nontraumatic clamps. The remaining artery was then occluded by the same increments while its blood flow was

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FIG. 1. Operative exposure used in this experiment. Both carotid and both vertebral arteries are available for study.
measured (Fig. 2 right). The carotid blood flow rates with the collateral vessels occluded were compared to the flow rates when the collateral vessels were patent. More than 90 observations were made on the 10 monkeys, and the results were averaged and plotted (Fig. 3). Further studies were obtained with the collateral arteries partially occluded instead of completely occluded. Thus, comparison was made between the effect of a carotid constriction when the collateral arteries were open and when they were totally or partially occluded.

**Results**

The average flow rate in the common carotid artery before constriction was 38 ml per min. The flow in the left carotid artery increased as the opposite carotid and each vertebral artery were occluded in succession. The average increase was to a level of 160% of the value with the collaterals open.

![Graph](image-url)  
*Fig. 3. Carotid artery blood flow during gradual occlusion with the collateral arteries patent and with the collateral arteries occluded. Note that at approximately 87% constriction of the artery there is a 50% reduction in blood flow with the collaterals patent and a 62% reduction with the collaterals impaired.*