Occlusion of the Blood Supply to the Brain of the Goat

Protective Effect of Deep Hypothermia*

MAURICE C. SMITH, M.D., AND JOHN E. ADAMS, M.D.
With the Technical Assistance of TILLIE B. LEAKE, A.B., and BETTY HALLIDAY, A.B.
Division of Neurological Surgery and Cardiovascular Research Institute, University of California
School of Medicine, San Francisco, California

Because the brain of the goat receives its entire blood supply from the carotid arteries with no contribution from the vertebral arteries, this animal is unusually suited for studies involving complete circulatory arrest to the brain. Our initial objective was to determine, if possible, the relation of the temperature of the brain to the length of time its blood supply could be occluded safely. As the work progressed, it became apparent that conclusions concerning the blood supply of different portions of the brain could be drawn from the rate of their cooling and warming. This information can be used to demonstrate the pathways for the development of collateral blood flow during progressive occlusions of the arterial inflow to the brain.

Blood destined for the head and upper extremities leaves the aorta via the single common brachiocephalic artery. This vessel, after giving off both subclavian arteries, bifurcates into two external carotid arteries. As they proceed through the goat's long neck, each external carotid artery enters its respective rete; these retia lie close together in the posterior pituitary fossa and are connected by numerous vessels which cross the midline and form a continuous plexiform vascular bed. From the rete of each side arises an intracranial internal carotid artery, which immediately gives off its posterior communicating branch. These two vessels unite to form the basilar artery. The caliber of the basilar artery diminishes as it progresses caudally (Fig. 1), and it has been demonstrated by injections of latex and neoprene that, under normal circumstances, blood flows caudally in the basilar artery.

The vertebral plexus supplies the vertebrae and muscles of the neck. From this plexus arise small perforating branches which


Note continuation of basilar artery into anterior spinal artery.

Received for publication July 19, 1962.

This work was supported by the National Institutes of Health, Grant B-1678, Bethesda, Maryland, and the Rose Shurtleff Fund, University of California.
Occlusion of Blood Supply to Brain of the Goat

unite with the anterior spinal artery. The vertebral plexus is supplied by the two vertebral arteries (branches of the subclavian arteries) and the two occipital arteries (branches of the external carotid arteries proximal to the origin of the mandibular artery), as shown in Fig. 2. This occipital-vertebral anastomosis accounts for the ability of the goat to tolerate ligation of both external carotid arteries caudad to the origin of the occipital arteries, whereas simultaneous ligation of both vertebral and carotid arteries results in unconsciousness.8

Ligation of both carotid arteries cephalad to the point of origin of the occipital and mandibular branches cannot be tolerated either, as shown in the following experiment. The left external carotid artery was ligated cephalad to the point of origin of the occipital and mandibular branches. Electrocorticograms demonstrated bilateral decreased voltages for 2 min., but after 3 min. the tracings became normal. The animal made a complete recovery. One day later, the opposite carotid artery was ligated at the same point. The electrocorticogram became isoelectric within 20 sec. and the animal did not regain consciousness or breathe spontaneously. Since the carotid arteries were ligated cephalad to the occipital branches, blood could not return to the carotid from the vertebral plexus, and retrograde flow in the anterior spinal artery was not sufficient to maintain viability of the brain stem.

Previous work from this laboratory has shown that the brain can be cooled selectively by a carotid-to-carotid extracorporeal cooling shunt.1 Our first experiments were designed, therefore, to study the effect of deep cerebral hypothermia in animals whose carotid arteries had been ligated above the mandibular branches.

Method

Angora wethers weighing 25 to 40 kg. and aged 2 to 4 years were used. The animals were fasted for 3 to 4 days before the experiment and were premedicated with 0.6 mg. of atropine intramuscularly 1 hour before induction of anesthesia with Sodium Pentothal (thiopental sodium) 500 mg. and Anectine (succinyl choline) 100 mg. Anesthesia was

Fig. 2. Vertebral plexus of the goat. Note major vertebral-occipital arterial anastomosis as well as numerous carotid contributions to vertebral plexus.