Effects of the Sitting Position on Blood Flow in the Internal Carotid Artery of Man During General Anesthesia*

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Placing a patient in a sitting position during an operation on the cervical spine or the posterior fossa offers at least two technical advantages to the neurosurgeon: it is easier to maintain a given position, and there is less bleeding. However, two well-recognized potential hazards are associated with this surgical position, namely, air embolism and inadequate cerebral blood flow.

When a patient is in the sitting position, venous pressure at the cervical level can fall below atmospheric pressure during inspiration; thus, an opening in a vein could allow a fatal amount of air to enter the heart.3-5 Although clinical experience with patients who have undergone surgery in the sitting position has shown that cerebral perfusion is usually sufficient to preserve normal cerebral function, the degree to which cerebral flow is depressed during these procedures has not been previously measured. Since anesthesia accompanied by hypocarbia is known to cause a marked reduction in cerebral blood flow,14 any further decrease resulting from the sitting position could lower cerebral blood flow to a dangerous level.

The following experiments were designed to determine the effects of the sitting position on blood flow and pressure in an internal carotid artery in anesthetized patients. In addition, the effects of general anesthesia combined with hyperventilation on internal carotid arterial flow and pressure were evaluated.

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Method

Continuous blood-flow measurements were made in nine male patients who were undergoing surgical exposure of the carotid vessels so that an anti-tumor drug† could be infused directly into the internal carotid artery. In each patient, craniotomy and subtotal resection of a supratentorial brain tumor had been performed 10 to 20 days before the study. The histologic diagnosis was glioblastoma multiforme in seven patients and astrocytoma in two. Pre-anesthetic medication consisted of 0.6 mg atropine sulfate and 100 mg sodium secobarbital. The patients were initially anesthetized with 10.0 cm³ of a 2.0% solution of sodium thiopental administered intravenously. They were then given 40.0 mg succinylcholine chloride and 3.0 mg decamethonium bromide intravenously and intubated. Anesthesia was continued using a 50-50 mixture of nitrous oxide and oxygen, with sufficient Halothane (0.1-0.5%) to prevent coughing or gross movements. The patients were manually hyperventilated, and the level of anesthesia was maintained as constant as possible throughout the study. These anesthetic techniques are identical with those ordinarily employed at Duke University Medical Center for neurosurgical procedures done in the sitting position.

A neck dissection was performed, and the common carotid artery and proximal portions of the internal and external carotid arteries were exposed. To monitor arterial pressure, a 16-gauge Rochester catheter was inserted into the common carotid artery and connected to a pressure transducer.§ The probe of a Kolin-Kado type electromagnetic

† S-112 (a-chloroethylthioacetamide), given in a dosage of 0.08 mg/kg body weight.

§ Model P23dB, Statham Instruments, Los Angeles, California.
flowmeter (EMF)** was placed about the common carotid artery approximately 4 cm proximal to its bifurcation. A Crutchfield clamp was used to occlude the external carotid artery throughout the experimental study so that blood in the common carotid artery was distributed only to the internal carotid system. A second Crutchfield clamp was placed around the internal carotid artery and left open. This clamp was used briefly to occlude the internal carotid artery in order to establish the zero flow reference for the EMF. The EMF probe leads and the arterial catheter were brought out through the incision, which was temporarily closed with silk sutures. Continuous measurements of blood flow and arterial pressure were obtained as described in previous reports.\(^2\)\(^,\)\(^12\)

The EMF was calibrated following the surgical procedure by passing known quantities of normal saline solution through the probes in a given period of time. The calibration factor for the probes (the flow per unit EMF signal) remained within a SD ± 6.8% during the period of study. Right atrial level was used as zero reference for the arterial pressure. Mean values for both pressure and flow were obtained by electrical integration. Brachial arterial samples were drawn for measurement of \(pCO_2\), \(pO_2\), and \(pH^*\) during the control state and at the end of a 10-minute control period. In addition, cardiac output was obtained during each period using the indicator dilution technique: Indocyanine green dye was injected into the median basilic vein and sampled from the brachial artery. All data were recorded on a direct-writing oscillograph.*

With the patient in a horizontal position, continuous measurements of blood flow and arterial pressure were obtained during a 5-minute control period. At the end of this time, the operating table was adjusted so that the patient was in a sitting position with the head supported by a Craig chair attachment and the cervical spine in moderate flexion and perpendicular to the floor. The legs were extended at the knees and the thighs were flexed at the hips. Each leg had been previously wrapped securely to mid-thigh level with Ace bandages. Positioning the patient required approximately 2 minutes; the position was then maintained for 10 minutes while recordings of blood flow and arterial pressure were made.

With the patients still in the sitting position, five of them were stimulated by pinching the skin of the neck for 2 to 3 minutes to simulate the effects of surgical dissection. Both blood pressure and flow in the internal carotid artery were recorded during this period. The patients were then returned to a horizontal position and the procedure concluded.

To obtain control data of internal carotid flow and arterial pressure, these measurements were recorded approximately 3 hours after anesthesia was discontinued in four of these nine patients. In addition, similar measurements were obtained in six other patients who were not placed in the sitting position. Arterial \(pCO_2\), \(pO_2\), and \(pH\) were determined in both the awake state and during general anesthesia.

Although continuous measurements of both phasic and mean arterial pressures and flow were obtained, only mean values will be presented. The data given for the control period and for the awake study represent the average for measurements made each minute during a 5-minute period. During the period of sitting, data recorded at 2, 4, 5, 8, and 9 minutes were analyzed and an index of cerebral vascular resistance (CVR) was obtained from

\[
\text{CVR} = \frac{P}{Q} \cdot \frac{1}{1}
\]

where \(P\) (mm Hg) is the mean arterial pressure and \(Q\) (cm\(^3\)/min) is the simultaneous mean flow of the internal carotid artery. Standard statistical techniques were used to evaluate the data.\(^11\)

** Results**

The data obtained on 10 patients illustrating the effects of general anesthesia combined with hyperventilation are listed in Table 1. The mean value for internal carotid flow in these subjects while awake was 201 cm\(^3\)/min, SD ± 38. During anesthesia, flow decreased significantly (\(p<0.01\)) by an average of 34% (range: 4 to 50%) to a mean

** Model K-2000 Statham Instruments, Los Angeles, California.