Advances in the Treatment of Patients with Benign Brain Tumors*

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Introduction. Since the Stoneburner Lecturer for this year, Dr. Thomas Langfitt, is Professor and Chairman at the hospital of the University of Pennsylvania, it would only be proper to recall at least one of the important lessons taught by Dr. Francis Grant, Dr. Langfitt's predecessor at the University of Pennsylvania. One of Dr. Grant's most remembered dictums was that when a benign brain tumor is encountered, the best surgical team the clinic can assemble should be put to work on it (1). This is a valuable concept in the treatment of benign brain tumors. It is of paramount importance to protect the brain, to preserve neurological function, to restore neurological function which has been lost, and to remove the tumor completely if possible. Ample statistics reveal a 20% recurrence rate in operated benign central nervous system tumors, a rate largely related to incomplete removal at the first operation (2).

What are the recent advances which will ensure a better fate for the brain tumor patient? First is the diagnosis of the degree, if any, of increased intracranial pressure (ICP) before surgery; second is the meticulous management of anesthesia at surgery; and third is the use of the operating microscope with the associated microneurosurgical instrumentation to provide magnification surgery.

Intracranial Pressure. The recognition of increased intracranial pressure is important not only in benign brain tumors but all brain tumors which manifest increased intracranial pressure by headache, altered states of consciousness, and the finding of papilledema. All brain tumor patients treated at MCV have ICP monitoring for three-to-five days before surgery, during surgery, and for at least three days following surgery with a subarachnoid screw (3). Figure 1 is a recording of intracranial pressure demonstrating increased intracranial pressure as the patient is being monitored before and during steroid treatment prior to surgery.

If the baseline ICP is elevated above 40 mm Hg (normal less than 11 mm Hg), there will usually be plateau waves—a transient marked increase in ICP up to 60 Hg. With the rise in ICP or at the time of a plateau wave, there may be a decrease in the level of consciousness, hypoventilation, and an increase in Pa_{CO_2}. The patient may then be aroused by severe headaches, or by an examiner, and may then hyperventilate, lowering the Pa_{CO_2}, relieving the headache, and returning intracranial pressure to the baseline.

We have found, upon establishing the baseline ICP, that there is usually no rapid reduction of ICP in the first 24 hours of steroid therapy even though clinical improvement is seen during the same period. We have often observed a decrease in the number of plateau or Lundberg waves occurring in the first 24–36 hours of steroid treatment. Early clinical improvement in the patient's condition, not associated with a lowering of mean ICP, may reflect a direct effect of steroids on the brain or improvement in cerebral blood flow as brain edema is reduced. Because ICP is usually reduced only after at least 24–36 hours of steroids, all of our patients are prepared for brain tumor surgery with three-to-five

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days of steroids. During this long period of time, in which steroids may be necessary to reduce ICP, effect membrane stabilization and capillary integrity, they also may have a beneficial effect on other subcellular organelles such as lysosomes, which appear better preserved when the patient has been well prepared with steroids. Without steroids, under stress of trauma, breakdown of lysosomes results in formation of lipofuscin bodies and the release not only of acid phosphatases, but of other hydrolytic enzymes as well (4). Experimental evidence also reveals a decrease in the severity of the traumatized brain when treated with steroids (5); thus, we use ICP monitoring and long-term steroid administration prior to surgery to reduce ICP and to protect the brain from any trauma that may occur during surgery.

Anesthesia. The next important aspect of the management of patients with benign brain tumors is induction of anesthesia. This is a most critical time for the patient. Even preoperative sedation can cause hypoventilation, blood gas changes, and alterations in intracranial pressure between the time the patient leaves the floor and the time he arrives in the operating room. All brain tumor patients undergoing surgery have intracranial pressure subarachnoid monitoring not only preoperatively but during the induction of anesthesia as well. Likewise, an arterial line from the patient's radial artery is connected to a 4 channel Grass recorder, and end-expiratory CO_2 is measured on a capnograph. By this technique we have been able to confirm that there are many times during the induction of anesthesia when a change in ICP may occur (6). A rise in ICP may be hazardous for the patient if increased intracranial pressure is present at the induction of anesthesia. It is best to have knowledge of the intracranial pressure prior to the induction of anesthesia as hyperventilation or intravenous mannitol may be needed to reduce intracranial pressure. For instance, while halothane is not a dangerous anesthetic, increasing its concentration quickly increases intracranial pressure. Figure 2 shows the reduction of ICP when intravenous pentothal is administered. This is in agreement with Shapiro's recent report showing that thiopental sodium, or pentobarbital, will reduce intracranial pressure (7). Ethane is an agent useful in lowering intracranial pressure unless increased to a concentration of 4% or more. Intracranial pressure monitoring reveals a balanced barbiturate anesthetic to be a valuable anesthetic technique in brain tumor surgery.

At the time of intubation, there is usually a brief increase in intracranial pressure associated with a small change in arterial blood pressure (Fig. 2). A short period of straining on the endotracheal tube will likewise produce a rise in ICP, and prolonged straining or "bucking" must not be allowed.

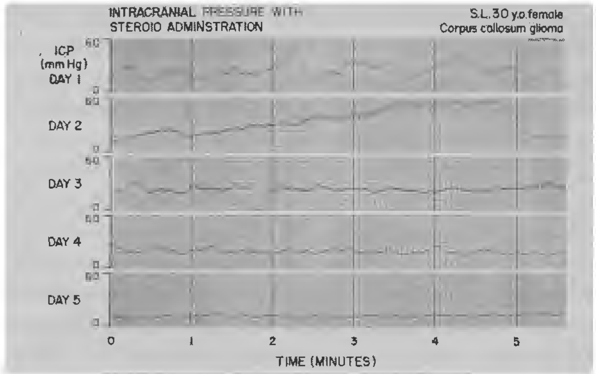

Fig. 1—Intracranial pressure recording in mm Hg during 5 days of steroid (Decadron® 4 mg lm q6h) treatment. On day 1 and 2 baseline ICP runs between 30–40 mm Hg with plateau waves up to 60 mm Hg. Plateau waves disappear on day 3 but baseline ICP is only in normal range on the fifth day of treatment.

After the induction of anesthesia, the surgeon must carefully position the patient's head for his surgical advantage without turning the head so severely that a major blood vessel to or from the head is occluded; this is often overlooked in preparing the patient for surgery. Care must be taken not to obstruct venous drainage from the head as this will certainly increase ICP.

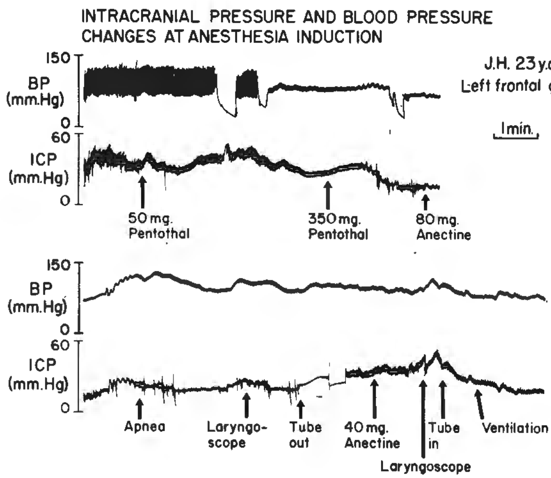

Fig. 2—(Top Tracing) Pentothal lowering ICP within 1 minute of administration; 50 mg pentothal produced a slight decrease in ICP while 350 mg produced a marked decrease in ICP. (Bottom Tracing) Rise in ICP to almost 60 mm Hg during intubation.

Following the induction, both the surgeon and the anesthesiologist must also focus on ventilation of the patient. Figure 3 is the ICP recording of an operation on the posterior fossa where spontaneous respiration is generally used since it is a safeguard against undue trauma or traction of the brainstem. Spontaneous respiration produced a prompt rise in intracranial pressure and the patient was then placed on a respirator to control ventilation and reduce ICP. In order to operate on an adult patient, intracranial pressure is maintained in a safe range with ventilation controlled at the rate of 12 respirations/min and a tidal volume of 900 cc with each respiration. Unfortunately, when the surgeon is operating he may, nevertheless, reach a point where he is about to open the dura only to find it very tight. If the surgeon demands that the anesthetist hyperventilate the patient, an over reaction by the anesthetist of rapid hand ventilation may result in exchange of a small tidal volume too rapidly for sufficient venous return and intracranial pressure may not be lowered but may actually be increased. The induction of anesthesia must be attended by the neurosurgeon as well as the anesthetist. This is one of the most important aspects of the operation, errors in management of the anesthetic resulting in intracranial pressure changes could lead to a tragic result from the operation.

Magnification Surgery. One of the reasons for emphasizing control of intracranial pressure and the induction of anesthesia is that it is important, in the technique of operating on a brain tumor using an operating microscope, to have as much exposure as possible often beneath the brain or deep within the brain without retracting the brain. Careful attention to the small metabolic parameters discussed above afford a much better opportunity to operate on the brain under relaxed conditions. Brain retractors should be used to protect the brain, not to retract the brain, and the tumor must be removed from the brain, not the brain from the tumor. The operating microscope has changed our approach not only to intracranial vascular surgery, where it is absolutely necessary, but also to benign brain tumor surgery as well. Presently the only type of tumors not requiring use of a microscope are malignant gliomas of the cerebral hemispheres.

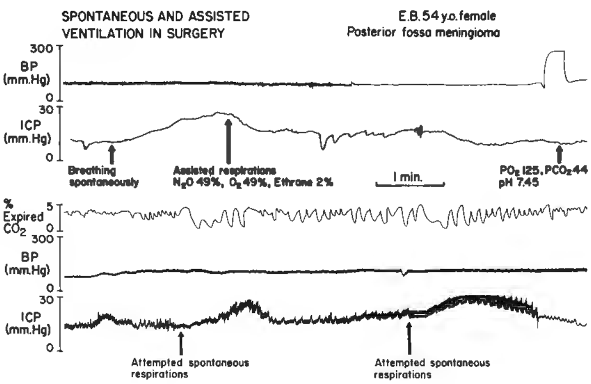

Fig. 3—Intracranial pressure recording during posterior fossa surgery demonstrating repeated elevation of ICP whenever the patient is allowed to breath spontaneously. This elevation of ICP is corrected by assisting respiration (Top Tracing).

Fig. 4—Ceiling-mounted operating microscope in the neurosurgical operating room at the Medical College of Virginia. Focusing is accomplished by foot control pedal not shown in figure.

At MCV a ceiling-mounted microscope allows the surgeon and one assistant or resident to see and become involved in the operation (Fig. 4). The best place to install a ceiling-mounted microscope is in the center of the operating room. Many surgeons prefer the floor-mounted movable microscope, finding it easier to move the microscope to the patient than to move the patient to the fixed microscope. The limitations of the microscope earlier in our experience included the fact that it made resident teaching difficult and did not allow the scrub nurse or the anesthesiologist the opportunity to view the surgery. A video tape camera can be attached to the operating microscope allowing both the scrub nurse and the anesthesiologist to view the surgery and also the televising of the surgery to any location in the hospital, providing greater flexibility of the microscope as a teaching instrument.

The important lessons in developing excellent microsurgery techniques are learned in the microneurosurgical laboratory. An extended period of time must be spent in the laboratory learning how to handle and drape the microscope as well as to learn microneurosurgical instrumentation and techniques. The MCV division of Neurosurgery has such a laboratory. One should borrow neither the ophthalmologists' nor the otolaryngologists' microscope for an occasional neurosurgical operation nor purchase a set of a famous neurosurgeon's instruments and expect to immediately perform magnification neurosurgery.

With the proper use of the microscope, it is possible to approach any area in or near the brain to safely remove tumors while preserving vital structure. For instance, the microscope has been the primary reason for the renewed interest in the transsphenoidal approach to pituitary surgery. The small secreting tumors of the pituitary causing acromegaly can now be removed while preserving the pituitary gland (8).

Summary. Reliable ICP measurement allows an exact quantitation and management of intracranial pressure. This precise assessment of ICP is a valuable adjunct in the management of anesthesia for brain tumor patients. The proper combination of ICP and anesthesia management enables the surgeon to use the operating microscope to approach previously inaccessible areas of the brain and to perform meticulous surgery with a better prognosis for the brain tumor patient.

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