Anesthesia and the neurosurgical patient: Part II—Neuroradiologic procedures
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In Part II of a continuing series on neuroanesthesia, the author discusses the many variables in managing anesthesia for neuroradiologic procedures, encompassing pneumoencephalography, angiography, myelography, and computerized axial tomography (CAT scans).

From the discovery of the X-ray to the introduction of computed tomography, the one basic and most important requirement for obtaining a satisfactory and interpretable neuroradiologic study is the immobilization of the patient to be examined. Movement during the study will only increase the complication rate with repetition and will subject the patient to additional and unnecessary radiation exposure.

Nurse anesthetists should be somewhat familiar with neuroradiologic diagnostic tools, the position of patients for the various procedures and the anaphylactic reactions which may occur with the use of iodinated contrast material. Most radiology suites are situated away from the operating rooms, either on a different floor or even in a different wing of the hospital. Because of the isolation of radiology suites, nurse anesthetists must be even more aware of proper functioning anesthesia equipment, availability of adequate suctioning devices, and all possible drugs that might be needed. These are only a few of the ways that we can provide the patient with the best care possible.

Preanesthetic considerations
Before a procedure begins, be sure that ventilation, monitoring and resuscitation equipment is immediately available in the radiology suite. ECG monitoring is essential, especially if controlled ventilation is used. Arrhythmias may be the earliest sign that pressure is developing on the brain stem.

Intravenous sedation may be used in the neuroradiologic procedures. If this is the anesthetic technique being considered, it is extremely important that the anesthetist is able to view the patient at all times to determine that the airway is patent and that respiration remains optimum in order to avoid a rise in the carbon dioxide level which would, in turn, increase the intracranial pressure. The ECG should be monitored in the same manner as in a general anesthetic. A precordial or esophageal stethoscope should be used for monitoring the breath sounds and heart tones.

The choice of whether the procedure should be under local sedation or general anesthesia is dependent on several factors. Will the young child or older adult be able to remain still or will the fear and lack of understanding prevent their immobilization? This is a “foreign” area for many patients and, understandably, apprehension and anxiety run high. Can the semicomatose patient follow commands? Will the patient who has under-
gone previous neuroradiologic procedures consent to a local standby remembering the nausea, vomiting, and headache associated with his or her past examination?

A general anesthetic could be less hazardous to certain poor risk patients whose airway or respiratory patterns may be jeopardized. Another important consideration is the fact that many neuroradiological examinations performed under general anesthesia and controlled ventilation seem to offer definite diagnostic advantages in comparison with similar procedures performed under local anesthesia.\(^2\)

In patients who show signs of increased intracranial pressure, there may be reason to expect that air cannot pass through herniated tonsils to enter the ventricular system; thus, burr holes have to be made prior to the examination for a subsequent ventriculography. In such situations, the trephination and neuroradiologic procedure are usually performed under general anesthesia.\(^2\) The risk of medullary coning during the lumbar puncture can also be controlled under general anesthesia. Thiopental can be of particular value since it may protect the brain against the metabolic effects of cerebral ischemia and reduce intracranial pressure.\(^5\) \(^4\)

Spontaneous ventilation during anesthesia in patients undergoing neuroradiology can be a dangerous situation. Intracranial pressure is often elevated, and the presence of depressed respirations could lead to a fatal complication. Even though it is a controversial issue, the restriction of the use of inhalation agents during these procedures is believed by this writer to be even more mandatory than during an intracranial procedure. During the neuroradiology procedure, the skull remains closed and the possibility of surgical decompression is rare. Controlled ventilation during all types of neuroradiological work has been found to be the method of choice by many.\(^5\) \(^6\)

Pre-diagnostic evaluation of these patients should be accomplished in precisely the same manner as that for patients being prepared for intracranial interventions. One never knows when the local standby anesthetic may be converted to a general anesthetic. These patients are being evaluated for a neurological disease. If a patient is complaining of headaches, nausea and vomiting and if papilledema is present, there is a reasonable certainty that he or she has an increase in intracranial pressure and should be treated accordingly.

Some patients may have been confined to bed rest for an extended period of time due to their neurological condition or as a result of trauma.

The anesthetist must keep in mind the possibility of a decreased blood volume, general debilitated state and the effects the anesthetic drugs may have on this type of patient. It would also be wise to use a non-depolarizing muscle relaxant, avoiding the hyperkalemic response to succinylcholine.

**Pneumoencephalography**

This procedure is performed with less frequency since the introduction in 1973 of the computed tomography of the head by Hounsfield. Areas where pneumoencephalography is still thought to be of great diagnostic value are for small suprasellar mass lesions and those lesions located in the cerebellopontine angle. Some indications for pneumoencephalography include congenital intracranial anomalies, hydrocephalus, cerebral atrophy, low pressure hydrocephalus, acoustic neuromas, brain stem mass, sellar and suprasellar masses, intraventricular masses, para-sagittal masses and cerebral hemispheric masses.

**Complications.** Nausea, vomiting and headaches are common complications of pneumoencephalography. Maintaining an adequate blood pressure for the patient undergoing a pneumoencephalogram can help alleviate some of the nausea and vomiting. The headaches can be controlled with bed rest and analgesics. Respiratory depression can be pronounced by the patient's disease state, anesthetic drugs, and positioning during the procedure. The above have all been reported in the unanesthetized patient.\(^8\)

Air embolism and herniation of the brain stem, with abrupt respiratory and cardiac embarrassment that may be followed by cardiac arrest, are very serious complications. If the patient is known to have an increase in intracranial pressure, a pneumoencephalogram should not be performed. Wolfson and Heterick suggest that when such signs occur after lumbar puncture, but before injection of air, herniation of the brain stem should be diagnosed.\(^9\) If air has just been injected, embolism should be considered.

The entry sites for air embolism could possibly be through a dural sinus or intravascular placement of the lumbar needle. Another factor which increases the incidence of air embolism is a functioning ventriculatrial shunt. Do not waste any time while appropriate measures are being taken to diagnose the problem. Immediately place the patient in a left lateral Trendelenburg position for air embolism or reinjection of cerebral spinal fluid (CSF) or saline for brain stem herniation.\(^9\)

The use of nitrous oxide (\(\text{N}_2\text{O}\)) during air encephalography has been and is still questioned by
many. Air-containing cavities within the body may increase in volume and/or pressure during nitrous oxide anesthesia. This phenomenon is related to the 34-fold difference in blood solubility between N$_2$O and nitrogen, which results in a more rapid transfer of N$_2$O molecules from blood into air-containing cavities than the removal of nitrogen molecules from the air space. A maximum increase of gas volume of 3.4-fold would occur if the venous blood was in equilibrium with a 70% concentration of N$_2$O.\textsuperscript{10} 

Anesthesia may be best administered if N$_2$O is eliminated. After a smooth induction with thiopental or thiamylal intubation with a non-depolarizing muscle relaxant, anesthesia maintenance may consist of either small incremental doses of thiopental or fentanyl, a short acting narcotic. Although controlled ventilation was cited earlier in this article as being the preferred method of respiration, it could also be stated that by lowering the P$_{CO_2}$, you can possibly counteract the increase in intracranial pressure caused by the contrast medium.

**Angiography**

Angiography in neuroradiodiagnostic practice may be used to delineate the cerebral or spinal cord vasculature. In recent years, selective catheterization of the individual carotid or vertebral artery via femoral artery puncture (or rarely via axillary artery puncture) has gradually replaced the direct percutaneous puncture of carotid, vertebral, subclavian or brachial arteries.\textsuperscript{9}

**Complications.** Complications of the arterial puncture or catheterization may include spasms, hematoma or embolization of arteriosclerotic plaques, or thrombosis of the injected vessel.

The dye most commonly used for this procedure is Conray\textsuperscript{(r)} (meglumine iothalamate). It may cause pain or a burning sensation, but these effects seem to occur to a lesser extent with this particular dye than with others. Most serious contrast-induced complications include arterial spasm and anaphylactic reactions. Spasm may be very detrimental to a patient with a recent or existing leaking cerebral aneurysm. Many times, spasm is already present and it can become intensified. Even though it is known that anaphylactic reactions occur less after arterial injection than after an intravenous injection, hypotension, bradycardia, arrhythmia and pulmonary edema may still be encountered.\textsuperscript{9}

If hypotension is severe enough to necessitate treatment, the drug of choice would be ephedrine since it is predominantly beta-acting. This reaction can occur because a vasoconstriction of the vessels may decrease the blood flow to the area of a spinal cord tumor or injury, possibly causing an ischemic insult resulting in further nerve damage. Hypotension and bradycardia occurring during dye injection may be vagal and should respond to atropine. Angiography may be performed under a local standby or general anesthetic.

There are several things to consider to determine which type of anesthesia is best for the patient. Special advantages of general anesthesia for cerebral angiography are patient comfort, immobility and the enhanced quality of the angiogram from hyperventilation. Hypocarbia produces vasoconstriction of the cerebral vessels, thus improving clarity. And, with a slower cerebral circulation, the dye concentration will be greater. Hyperventilation may improve angiographic quality in patients with brain tumors by provoking an intracerebral steal.\textsuperscript{8} Hyperventilation should be avoided if a suspected ruptured intracranial aneurysm is the case. These patients usually have a related spasm from their condition and the impaired cerebral circulation may be intensified by hypocarbic-induced cerebral vasoconstriction.

Less well-defined angiograms have also been demonstrated in spontaneously breathing adults in whom arterial P$_{CO_2}$ is greater than 45 mmHg.\textsuperscript{5} A similar effect may occur with the use of potent inhalation agents which cause cerebral dilatation. It is our choice then to use a balanced anesthesia technique with a non-depolarizing muscle relaxant and mechanical ventilation. General anesthesia may also have two disadvantages. The state of consciousness cannot be used for neurological evaluation and the intracranial pressure may be increased.

Local standby anesthesia requires the supplementation of a narcotic, usually fentanyl and the use of a hypnotic, such as diazepam (Valium\textsuperscript{(r)}). Circulatory and respiratory monitoring is essential. If a narcotic is used, it should be in small increments to avoid respiratory depression. It may be contra-indicated in the patient who demonstrates signs or symptoms of a mass lesion because of the respiratory depression. It is interesting to note that nearly all the neurological complications including severe shock, loss of consciousness, hemiplegias, or paresis were observed during or after angiographics performed under local anesthesia.\textsuperscript{11}

**Myelography**

The discomfort usually associated with this
procedure occurs during the lumbar puncture and at the removal of the contrast medium.

Anesthesia is required for the adult who is unable to fully cooperate and for children. The problems encountered here are the maintenance of patient airway and stability of the cardiovascular system from the multiple position changes.

**Computerized axial tomography**

**CAT scanning.** The newer scanners have the ability to scan in approximately 3-4 seconds. With the speed of these tests, the anesthetist is not needed as much as with the older models. Our services are usually needed now only if the patient is uncooperative, in a trauma situation or if the patient is a child under the age of 8-10 years. A scan may be done with or without a contrast material. The intravenous administration of water soluble iodinated contrast material has proven very helpful in enhancing intracranial vascular lesions, neoplasms, infarcts and abscesses.

Another use for the CAT scan is in the area of stereotactic procedures. The majority of the time spent during these procedures is devoted to positioning the patient. Because of the importance of correct positioning and the need for the patient to be still, it is preferable to use sedation. The time needed for these procedures is usually several hours and because the patient is required to be absolutely still, comfort is of great importance. The patient should therefore be kept warm and sedated.

Just as in setting up any other type of case, the anesthetist should always check for the proper functioning of the machine, workable suction and the availability of drugs needed if the patient should have a reaction to the contrast material. Equipment should always be in an area that is easily accessible. Since the anesthetist is not permitted to remain in the room after the anesthetic is administered and while the scanner is in operation, it is important to maintain a constant view of the ECG monitor and watch the respiratory pattern. Most scan rooms have intercom systems which the anesthetists can use to speak to the patient if need be to give verbal commands or support.

**Radiation hazards**

Since we cannot administer our anesthetic from the next room, there are several things anesthetists can do to help lessen the exposure we receive during some procedures. Frequently, we must remain in the x-ray room during filming, especially when an angiogram is being done. The two most important safety factors to consider are the wearing of a lead apron and the distance from the radiation source. Radiation dosage is related inversely to the square of the distance from the source. Consequently, with the protection of the lead apron and by standing at least two feet or more from the table, the measured doses of radiation are small. As Lin and Kricheff explain:

"Thus, an individual standing immediately adjacent to a table during fluoroscopy would typically receive 30 mR per hour at eye level and 100 mR per hour at table top level, measured without a lead apron attenuation. Were this individual to move 2 feet from the side of the table, the eye dose would be reduced to 5 mR per hour and table top dose would be reduced to 15 mR per hour. At 6 feet from the table side, the dose would be less than 1 mR per hour. These measured doses are also decreased when measured at the head and/or foot of the table with the patient in place, for there is considerable attenuation of scattered radiation by the body of the patient. When one takes into account distance from fluoroscopy unit to the head of the table, the attenuation by the patient and the reduction factor by the apron, one calculates exceedingly low exposure levels."

**Conclusion**

Most radiology suites are situated away from the operating rooms, either on a different floor or even a different wing of the hospital. Because of the location of these suites, anesthetists must be even more aware of proper functioning anesthesia equipment, the availability of adequate suctioning devices, and all possible drugs needed.

The speed with which certain neuroradiologic procedures are now done, given increased technology, has somewhat lessened the need for anesthesia. The patient's condition, the patient's ability to co-operate, and the test being performed also help to ultimately determine the type of anesthesia needed.

**REFERENCES**


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