Anesthesia for Interventional Neuroradiology: Part III: Anesthetic goals and techniques

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Abstract

ANESTHETIC GOALS AND TECHNIQUES

The goals of anesthetic management for INR procedures are:

1. To safely render a patient immobile, painless and comfortable.
2. To provide the neuroradiologist with optimum hemodynamic and intracerebral conditions for successful performance of the procedure.
3. To allow for perioperative evaluation of neurologic function
4. To assist in treating complications

The two basic techniques are general anesthesia and monitored intravenous sedation. There are advantages and problems associated with each technique, and different centers employ various approaches successfully.

The choice of anesthetic technique is dictated not only by the physiologic status of the patient, and the duration and type of interventional procedure, but also by the particular experience of each interventional neuroradiology team.

INTRAVENOUS SEDATION

The demands placed on the anesthesiologist by an interventional neuroradiology (INR) procedure are much greater than those of simple diagnostic angiography.(57) The anesthesiologist must keep the patient immobile and calm, sometimes for many hours, and manage hemodynamics, cerebral perfusion, and coagulation; yet, on demand, the patient may need to be responsive enough for a neurologic examination. In selected procedures with cooperative patients, managed anesthesia care with intravenous sedation (MAC) can provide excellent conditions for performance of endovascular interventional procedures. Its main advantage is the ease with which an awake neurologic examination can be carried out during the procedure. There are also significant disadvantages associated with this approach:

Advantages of Intravenous sedation:

1. Easier to perform neurologic testing repeatedly
2. No hemodynamic changes associated with intubation or emergence

Potential disadvantages:

1. Poor control of the airway, with potential for:
   - Hypoxemia
   - Hypercapnia
   - Stertorous breathing and movement

2. Side effects of IV sedatives
   - Dysphoria
   - Prolonged somnolence
   - Extrapyramidal symptoms

3. Poor tolerance of induced hypotension in awake patient.

4. Nausea and vomiting

5. Vagal reactions

6. Delays and complications if neurologic emergency occurs
   - Need to intubate acutely
   - Hemodynamic changes at wrong time

7. No protection from aspiration

8. May need to interrupt the procedure and induce general anesthesia if the patient is unable to tolerate sedation.

INDICATIONS FOR MAC

There are specific procedures during which the patient must be fully awake, with minimal or no sedation:

1.- Test occlusions of major cerebral vessels:(58)

When a major vascular supply to the brain must be permanently or temporarily interrupted, a test occlusion of the vessel is performed to asses the adequacy of collateral flow and the consequences of occlusion. The patient must be awake because an ongoing neurologic evaluation is of primary importance to asses neurologic integrity during the period of occlusion.

2.- Performance of the Wada-Rasmussen test:(59)

Amobarbital, a short acting barbiturate, is directly injected into the carotid circulation while the patient undergoes electrophysiologic and neurobehavioral exams in this test used to determine cerebral dominance, cognitive, and language function, and to locate seizure foci prior to surgical ablation. Usually, no premedication or sedation is given during this procedure because it interferes with interpretation of the test.

RELATIVE INDICATIONS FOR MAC

These procedures are usually performed under MAC in our institution:

1.- Simple procedures:

When they are of short duration, the patient is amenable and absolute immobility is not crucial (e.i., diagnostic angiography)

2.- Intra-arterial chemotherapy of brain tumors with cis-platinum:

This procedure is essentially the same as a diagnostic angiogram, except that a catheter is placed in a branch of the carotid or vertebral system to infuse chemotherapy in direct proximity to an intracranial tumor. The procedure typically lasts two to three hours, but absolute immobility is not crucial.

3.- Preoperative embolization of intracranial and extracranial tumors or, arterio-venous malformations which are perfused by the external carotid circulation.

These procedures are usually of short duration, do not often require hemodynamic management, and although sometimes painful, are usually well tolerated with MAC. However, in patients with large extracerebral to intracerebral vascular anastomosis, embolic material can pass into the brain from the extracerebral circulation. In these cases, as discussed before,Young et al advocate increasing cerebral blood flow, by increasing the PaCO2, to establish a pressure gradient that opposes intracerebral embolization. Hypercapnia is produced by adding CO2 to the circuit, or by decreasing the minute ventilation. Control of ventilation for production of hypercapnia is accomplished best with general anesthesia

4.- Embolization of intracranial arterio-venous malformations (AVM's):

This is a challenging procedure for both neuroradiologist and anesthesiologist. It had previously been performed under MAC to evaluate the patient's neurologic status during the procedure. However, in our institution, general anesthesia has superseded MAC for these cases because our team feels that the advantages of general anesthesia outweigh those of MAC. Superselective flow-guided catheterization of the feeding vessels of the AVM, can place the tip of the embolizing catheter in the nidus of the AVM. Using liquid adhesive with the catheter in this position, the deposition of embolic material can be precisely controlled, such that the possibility of compromising normal neural tissue is decreased.

Placement of the catheter in this position requires a motionless patient, and hemodynamic management by the anesthesiologist.

The hemodynamic and respiratory management is designed to help the radiologist "float" the superselective catheter into position and to decrease the possibility of neurologic damage. We feel that controlled hypotension or induced hypertension with PaCO2-related adjustments of cerebral blood flow and cerebral vascular tone are best managed with the patient under general anesthesia. The complications associated with MAC, such as nausea and vomiting during the critical part of the procedure, are thus avoided. Our colleagues in neuroradiology also feel that awake neurologic assessment is no longer of prime importance because they are able to control the deposition of embolic material more exactly with the conditions provided by general anesthesia.(60) However, if the lesion cannot be reached

with a superselective catheter, or embolization with particulate material must be carried out from a more distal location, the procedure is more safely carried out with MAC.

This allows for performance of a superselective anesthesia functional examination (SAFE),(61) (62) which helps to decide whether the catheter is positioned in a hazardous position, proximal to a vessel irrigating expressive regions of the brain, or if the area can be embolized without neurologic sequelae. At TMH, SAFE is performed with minimal or no sedation. A neurophysiologic exam with EEG is performed as a baseline, followed by sodium amytal injection via the superselective catheter into the vessel. After injection the neurophysiologic exam is repeated to evaluate the area of irrigation.

Thus, the choice of anesthesia, general or MAC, depends not only on the procedure and the patient, but also on the vascular anatomy, the type of embolization material and catheter system used by the neuroradiologist.

TECHNIQUES FOR MAC

There are many “recipes” for sedation.(63) (64) (65) The following are two approaches used at our institution:

1) Neuroleptic analgesia:

This technique offers analgesia, amnesia, and cardiovascular stability. In addition, it decreases cerebral blood flow, and cerebral metabolic rate. It usually renders a quiet cooperative patient, with good airway control, and little nausea. However, excessive sedation with airway obstruction, dysphoria, and extrapyramidal movements can occur. An infusion is prepared and used as follows:

NEUROLEPTIC INFUSION SOLUTION

10 ml of fentanyl + 10 ml of droperidol mixed with D5W to make 250 ml

(10 micrograms/ml droperidol + 2 micrograms fentanyl/ml)

Suggested use:

a.- Start with 50 ml bolus, then proceed with insertion of arterial line and bladder catheters

b.- Infuse at 25ml/Hr, titrating to patient needs

2) Propofol infusion:

Propofol should be combined with fentanyl and/or midazolam for adequate amnesia. If used by itself, propofol can cause patients to wake up and move unexpectedly as the infusion is titrated down. Patients can also develop sudden airway obstruction, (usually at a critical point in the procedure !) and one may need to insert an airway, which will usually cause the patient to move or cough.

SUGGESTED USE

a.- Begin with fentanyl, 2 - 3 micrograms/Kg IV, then add midazolam 2 - 3 mg IV, and droperidol 1.25 mg IV

b.- Insert arterial line under local anesthesia

c.- Propofol, 40 - 60 mg IV bolus can be given for bladder catheterization, and femoral arterial puncture.

d.- Propofol drip: Starting at 20 micrograms/Kg/min, titrating until patient sedated.

GENERAL ANESTHESIA

There are many advantages to this technique. With newer induction and inhalation agents, general anesthesia can be rapidly induced with minimum hemodynamic changes, the depth readily controlled, and a smooth and rapid emergence obtained.(66) (67) Under general anesthesia, PaCO2 can be regulated, and management of induced hypotension is facilitated. Respiratory immobility is essential with certain imaging techniques; when apnea is requested by the neuroradiologist it can be induced at will with general anesthesia. When a neurologic emergency such as thrombosis or hemorrhage occurs, no time is lost in securing the airway and the anesthesiologist can immediately begin to control hemodynamics.

The main disadvantage of general anesthesia is that awake neurologic assessments cannot be readily performed, but as discussed above, we feel this is only of prime importance in selected cases. Other disadvantages are that endotracheal intubation can cause hypertension, while extubation can lead to straining, airway obstruction, and coughing. However, with careful anesthetic management, these disadvantages can be minimized.

TECHNIQUE

We do not give sedatives or narcotics if intraoperative neurophysiologic assessment with somatosensory- evoked potentials (SSEP), or electroencephalography (EEG) is contemplated until baseline studies are obtained and the anesthetic plan has been discussed with the neurophysiologist.

We obtain peripheral intravenous access with a single 16 or

18 gauge IV catheter and a multiple port extension, preferably on the arm nearest to the anesthetist. This is usually adequate, unless the neuroradiologist feels that there is a high probability of serious complications. In such a case, two peripheral IV's or a central line and a peripheral IV are inserted. Particular attention must be given to fluid balance since large amounts of irrigating solutions and contrast media are often used by the neuroradiologist. A urinary catheter is always inserted, either after induction of anesthesia or under sedation. Glucose- containing solutions are avoided because of their deleterious effect on brain ischemia. (68) In diabetics, we strictly control blood sugar levels perioperatively, with intravenous insulin, to maintain blood sugar levels between 150 and 200 mg percent.

After non-invasive monitoring is established, we induce anesthesia with propofol, 2 - 2.5 mg/kg, or etomidate, 0.2 - 0.6 mg/kg and administer esmolol, 0.5 to 1 mg/kg, or lidocaine 1 mg/kg, prior to intubation to avoid the sympathetic response to intubation. If a radial arterial line is indicated, it is usually inserted after induction, prior to intubation. A control activated clotting time (ACT) is obtained after insertion of the arterial line. We do not use eye lubricant in case a fundoscopic exam is necessary during the procedure. Central venous lines or pulmonary artery catheters are inserted via the subclavian route at this time if indicated.

For airway management, we prefer a low profile RAE endotracheal tube, or a regular endotracheal tube with the extraoral end cut short. Cutting the tube short keeps the extraoral end from being pushed in or kinked by the image intensifier, which moves close to the patient's face. We have recently used a laryngeal mask airway (LMA) for airway management. This device allows for control of the airway with minimal stimulation, hypertension, or cough, and a smooth emergence under light general anesthesia.(69) (70) In our experience, however, the head movement that sometimes occurs when using an LMA with spontaneous ventilation has impaired radiographic imaging; and the PaC02 levels have been higher than ideal. Muscle relaxants and controlled ventilation can be used with an LMA, and thus avoid these problems, but only as long as airway pressures are not greater than 20 cm H20.(71) More experience is needed in order to recommend routine use of LMA's in this setting.

For maintenance of anesthesia we use a continuous infusion of propofol plus low inspired concentrations of isoflurane or desflurane. Inhalation anesthetics allow rapid changes of anesthetic depth and blood pressure, but increase ICP with concentrations higher than 1 MAC and normocapnia.(72) We do not advocate the routine use of nitrous oxide for these cases since nitrous oxide increases cerebral blood flow from 60 to 100 percent; and can increase ICP to a variable degree.(73) Nitrous oxide could also theoretically enlarge air bubbles that may be accidentally introduced into the arterial circulation by the radiologist.(74) Minimal amounts of intravenous narcotics should be used because these procedures are not painful, and excessive doses of narcotics will only delay emergence. The intraoperative management of PaCO2, controlled hypotension, and induced hypertension will be discussed in more detail later. The blood pressure should be controlled during emergence and after the procedure.

After assessing the reversibility of the muscle relaxant, we extubate the patient while still under deep anesthesia, reverse the muscle relaxants, and wake the patient breathing oxygen via face mask. If an LMA was used, the patient is allowed to wake up with the device in place, to be removed once the patient responds to commands. This awake extubation with an LMA is remarkably well tolerated, with little cough, straining, or hypertension.

Postoperatively, the mean arterial pressure (MAP) should be kept 10 - 20 percent lower than the patient's basal levels. Acute elevations of blood pressure can be treated with esmolol, 1mg/kg; propofol, in bolus doses of 30 - 50 mg IV; vasodilators; or small doses of narcotics, depending on etiology.

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