2 Anesthetic Considerations in Endoscopic Skull Base Surgery

This chapter discusses the unique challenges that endoscopic skull base surgery present to the neuroanesthesiologist. The neuroanesthesiology team plays a vital role in ensuring a safe outcome to this delicate surgery. Highly specialized endoscopic techniques and equipment, together with the use of sophisticated intraoperative monitoring, all mandate skillful anesthesia management that is tailored to the needs of minimally invasive, fully endoscopic skull base surgery. The specific neuroanesthetic considerations for fully endoscopic endonasal, supraorbital, and retrosigmoid approaches as well as future challenges are discussed.

Keywords: Anesthesia; Endonasal; Endoscopic; Minimally invasive; Neuroanesthesiologist; Neuroanesthesiology; Neuroanesthetic; Retrosigmoid; Skull base; Supraorbital; Surgery; Surgical.

1. INTRODUCTION

Endoscopic skull base surgery represents a major advance in patient outcome and recovery. It also presents a unique challenge to the neuroanesthesiologist. Highly specialized endoscopic techniques and equipment, together with the use of sophisticated intraoperative monitoring, all mandate skillful anesthetic management that is tailored to the needs of minimally invasive, fully endoscopic skull base surgery. The neuroanesthesiology team plays a vital role in ensuring a safe outcome to this delicate surgery.

2. PREOPERATIVE ASSESSMENT

Patients undergoing skull base surgery commonly present with coexisting manifestations of their operative disease. Perioperative management of patients with endocrine and other neurological disorders has been well covered in the literature; however, patients with pituitary neoplasms present frequently enough for endoscopic skull base surgery to warrant a review of anesthesia management for these patients.

Pituitary adenomas cause a spectrum of presenting symptoms. They are the most common cause of hypopituitarism in patients presenting for pituitary resection. Less common causes of hypopituitarism include Rathke's cleft cysts and childhood craniopharyngiomas. Patients with pituitary hypofunction are usually receiving hormone replacement therapy that must be continued perioperatively. They also typically require "stress" doses of corticosteroids on the day of surgery.

All patients undergoing pituitary surgery are at risk for perioperative antidiuretic hormone (ADH) deficiency, which presents clinically as diabetes insipidus (DI). The production of large volumes of dilute urine can result in dangerously high serum osmolality, and both urine output and serum osmolality should be monitored closely, with replacement of vasopressin/ADH as indicated.

Pituitary hyperfunction may also be present in patients presenting for skull base surgery. Most common are prolactin-secreting adenomas, but of more concern are the adenomas responsible for Cushing's disease and acromegaly. Patients with a pituitary adenoma secreting ACTH (corticotropin) present with classic symptoms of Cushing's disease. Adrenocorticoid excess leads to obesity with centripetal fat accumulation, hypertension, osteopenia, fluid retention, and hyperglycemia. Perioperative testing should include careful monitoring of serum glucose and serum electrolytes, which may be deranged as a result of mineralocorticoid-induced effects. The neuroanesthesiologist should take into account the obesity and possible delayed gastric emptying that may be present, as well as the risk of pathologic fractures during positioning at the time of surgery.

Growth hormone-secreting pituitary adenomas cause acromegaly. Of particular concern to the neuroanesthesiologist is the thickened, enlarged tongue, which may complicate laryngoscopy and endotracheal intubation. In addition, cartilaginous hypertrophy of the arytenoids and tracheal rings may actually narrow the patient's functioning airway, necessitating smaller-caliber

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endotracheal tubes. Both airway abnormalities may also contribute to postoperative airway obstruction, especially if deep extubation is attempted.

3. GENERAL CONSIDERATIONS

Fully endoscopic skull base surgery presents a unique operating room environment for the neuroanesthesiologist. The skull base surgeon uses highly advanced technology to perform the surgery, including complex robotic equipment to fix the endoscopes and other instruments in place, thus freeing both hands for bimanual dexterity. The patient's head is typically fixed in a Mayfield three-pin head clamp in a position that affords good surgical access. However, for the neuroanesthesiologist, this position provides poor access to the patient's face and airway. All hoses, intravenous lines, arterial lines, and the like must be of sufficient length to provide secure "long-distance" anesthesia, and special care must be given to securing the patient's airway. For emergency vascular access, it is a good idea to have the patient's foot exposed and easily accessible.

Large-bore intravenous and arterial lines are usually indicated in intracranial procedures, and central venous access may be considered if the potential for venous air embolism is high. Armored endotracheal tubes are used to prevent the tube from becoming kinked or obstructed; this is especially important in retrosigmoid approaches, for which repeated jaw clenching may result from cranial nerve stimulation. Of paramount importance during endoscopic skull base surgery is a stationary field; any patient movement carries the risk of intracranial injury by the endoscope or endoscopic instruments and the risk of possible spine injury from the head being fixed in the Mayfield frame.

4. SPECIAL CONSIDERATIONS

4.1. NEUROANESTHESIA FOR THE FULLY ENDOSCOPIC ENDONASAL APPROACH (FIG. 1) The fully endoscopic endonasal approach to the pituitary gland and its surrounding structures involves some intranasal dissection and dilation, turbinate manipulation, or out-fracture and approaching the sella turcica through the posterior nasopharynx. These structures are very vascular, and surgical visualization can be severely compromised by bleeding. Therefore, the neuroanesthesiologist should maintain blood pressure in the low-normal range throughout the whole surgery. This can be quite challenging as endonasal surgery elicits a strong sympathetic response; thus, a combination of deep anesthesia and antihypertensive medications is usually necessary. A balanced narcotic/inhalational anesthetic technique may be supplemented by propofol infusion. Intermittent or continuous infusion of antihypertensive drugs such as labetalol and sodium nitroprusside constitutes the next line of therapy. It is advisable, of course, to perform continuous intra-arterial blood pressure monitoring.

Endoscopic endonasal surgery, unlike the posterior cranial fossa approaches, typically does not require monitoring of cranial nerves or the brain stem. Therefore, the patient may be kept on muscle relaxants, fully sedated, and "deep." Toward the end of the operation and as the surgeon assesses the field for bleeding, the patient may be "lightened," and the blood pressure may be allowed to increase up to 110 to 130 mmHg systolic. It is important that the patient does not become too "light" at this point because periods of intense stimulation may still occur. Before closure, the surgeon will typically request one or more Valsalva maneuvers, to intrathoracic pressures of 30 to 40 cm H_2O; this permits the surgeon to visualize the surgical cavity and to check for cerebrospinal fluid (CSF) leaks. It is wise to

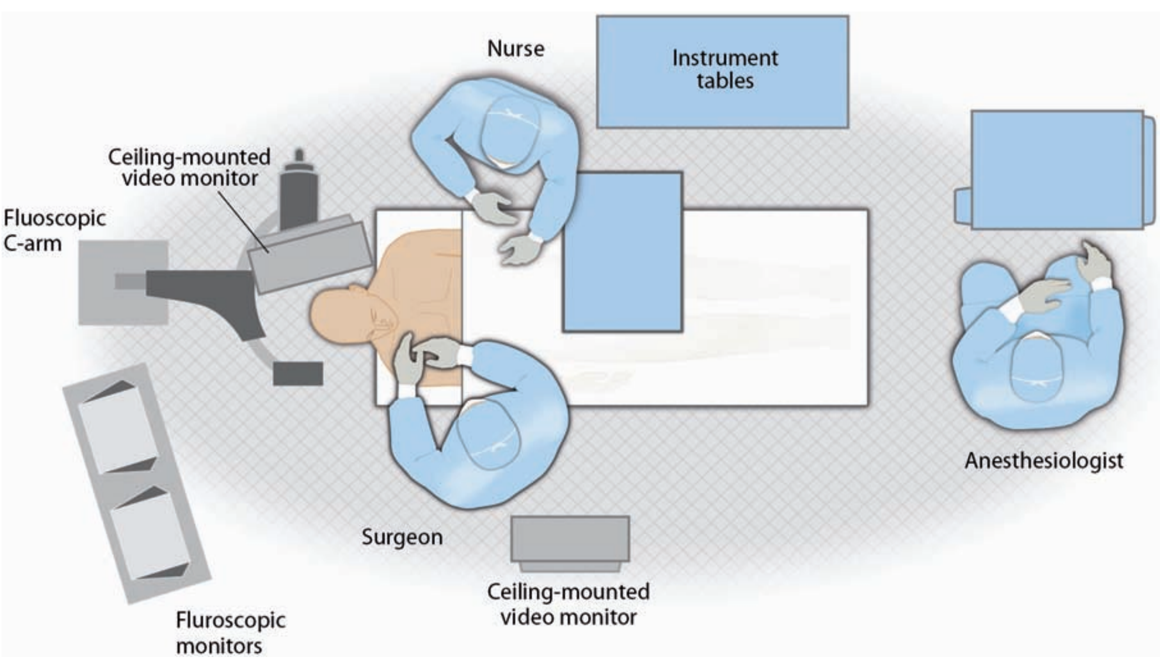

Fig. 1 Operating room setup for the endoscopic endonasal approach.

maintain paralysis for as long as possible, reversing it only after the Mayfield head clamp has been removed.

Smooth emergence from anesthesia is particularly important because violent “bucking” while intubated and coughing after extubation may cause bleeding in the surgical bed or dislodgement of the fat graft. This may predispose the patient to further complications, such as postoperative infection and persistent CSF leak. One approach to ensure a smooth emergence from anesthesia is to establish adequate spontaneous ventilation while the patient is still intubated under deep inhalational anesthesia. After good gastric and pharyngeal suctioning, an oral airway is placed, and the endotracheal tube cuff is slowly deflated (known as “taming the trachea”). If breathing remains regular—a sign that the patient is still deep—the patient is extubated, and supplemental oxygen is administered. The patient can thus emerge from anesthesia without the need for endotracheal stimulation. The oral airway is kept in to prevent airway obstruction until the patient is more awake.

4.2. NEUROANESTHESIA FOR THE FULLY ENDOSCOPIC SUPRAORBITAL APPROACH (FIG. 2) The fully endoscopic supraorbital approach is used to access and resect different tumors of the anterior and middle cranial base, such as meningiomas, craniopharyngiomas, supra- or parasellar extensions of pituitary tumors, esthesioneuroblastomas, and others. Conventional open craniotomies entail creating large bicoronal scalp flaps and retracting one or both frontal lobes to gain access to the anterior or middle cranial base. In contrast, the fully endoscopic approach uses a small incision, which is hidden in the hair of the eyebrow, and a 1.5-cm keyhole craniotomy to accesses these same areas. The patient may be positioned semisitting facing the surgeon or supine with the neck extended and the surgeon operating from a location cephalad to the patient’s head. The latter approach allows the brain to “retract” away from the skull base and helps the surgeon to drain CSF from the surrounding cisterns, thus assisting the neuroanesthesiologist in maintaining a lax brain and eliminating the need for any brain retraction.

The neuroanesthetic management for the supraorbital approach to the skull base is similar to that used in surgical clipping of brain aneurysms. The area of the skull base near the optic chiasm is crossed by major vascular structures, and there is the potential for rapid blood loss if these vessels are injured. As in aneurysm surgery, it may be necessary to induce hypotension for short periods of time in case the surgeon needs to identify and control the source of hemorrhage. The patient must have good venous access, and blood must be readily available should rapid transfusion be necessary.

Intraoperative cranial nerve or brainstem monitoring is not usually performed with the supraorbital approach, so muscle relaxation is generally permissible. This approach to the skull base does not disrupt major sensory nerves, so surgical stimulation remains low throughout the procedure (with the exception of the Valsalva maneuver, used occasionally to help the surgeon drain CSF from the operative field and further improve the exposure). After adequate brain relaxation is achieved, a balanced anesthetic using shorter-acting agents provides for quicker emergence as postoperative pain is minimal with this surgery and patients may remain asleep for a long time if longer-acting agents are used.

A smooth emergence from anesthesia is vital. The skin over the eyebrow is fairly loose, and violent bucking and coughing can cause a CSF collection to form subcutaneously around the eye. It may help to maintain gentle pressure over the surgical site during extubation to avoid this complication. Unlike the endonasal and retrosigmoid approaches, the supraorbital approach requires loading and maintaining phenytoin for about 6 months.

4.3. NEUROANESTHESIA FOR THE FULLY ENDOSCOPIC RETROSIGMOID APPROACH (FIG. 3) The fully endoscopic retrosigmoid approach is used to access tumors and the cranial nerves of the posterior cranial fossa. The approach

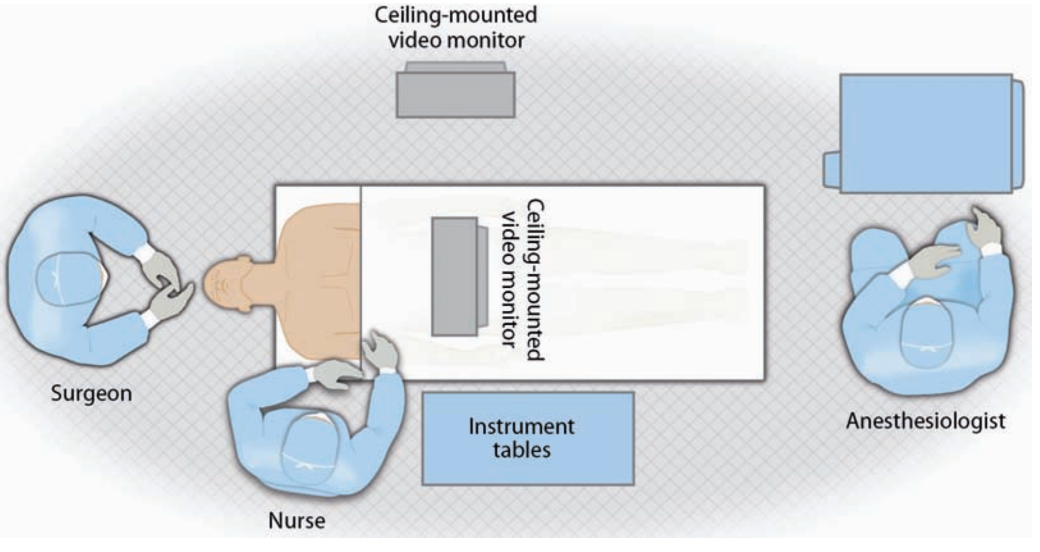

Fig. 2 Operating room setup for the endoscopic supraorbital approach.

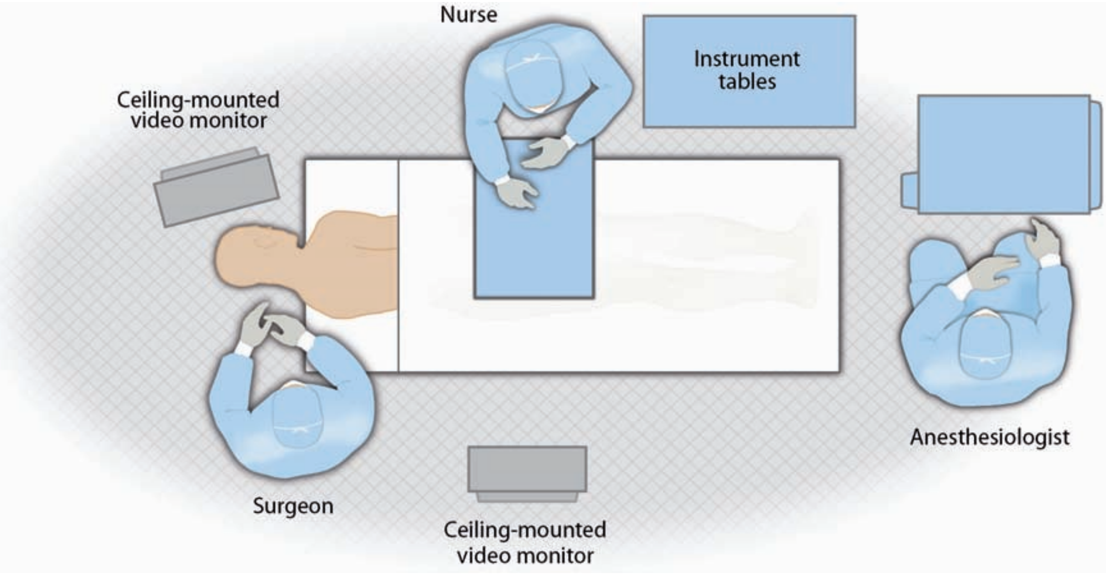

Fig. 3 Operating room setup for the endoscopic retrosigmoid approach.

is mainly used for resection of cerebellopontine angle tumors, such as vestibular (acoustic) schwannomas and meningiomas. It is also used for microvascular decompression of cranial nerve V (trigeminal) for trigeminal neuralgia or, less commonly, cranial nerve VII (facial) for hemifacial spasm or cranial nerve IX (glossopharyngeal) for glossopharyngeal neuralgia.

Similar to other approaches used in endoscopic skull base surgery, after induction of anesthesia, the patient's head is placed in a Mayfield clamp. Precautions related to the remoteness of the surgical field and the need for complete stillness should be taken by the neuroanesthesiologist as previously described. The lateral oblique (park-bench) position, with the patient facing away from the surgeon, is preferred for this approach. This position, however, makes it more difficult for the neuroanesthesiologist to gain access to the patient's face; therefore, strict measures must be taken to protect the airway.

Intravenous access and intra-arterial blood pressure monitoring must be established, and dehydrating measures with mannitol and hyperventilation must be initiated. Effective brain relaxation obviates the need for brain retraction, thus reducing unnecessary trauma to the brain tissue. Relaxation is typically achieved with 1 g/kg mannitol, hyperventilation to an arterial pCO_2 of 25 to 30 mmHg, and infusion of propofol.

After anesthesia is induced, intraoperative monitoring devices are connected to the patient. For most posterior fossa surgeries, cranial nerve electromyograms (EMGs) and brainstem auditory and somatosensory evoked potentials are monitored. The EMGs assess the integrity of the facial nerve (VII) and motor function of the trigeminal nerve (V). Brainstem auditory-evoked responses assess the function of the acoustic nerve (VIII). Brainstem somatosensory-evoked responses asses the function of the upper and lower extremities; therefore, after the patient is put in the appropriate position for surgery, neuromuscular blockade must be allowed to wear off, and the patient should remain unparalyzed throughout the procedure. This presents a particular challenge to the neuroanesthesiologist as inadvertent patient movement during surgery can be very dangerous. Furthermore, the use of an armored endotracheal tube, or at least an oral airway, is advisable to prevent the patient from biting and occluding the tube during facial or trigeminal nerve stimulation.

In addition to the contraindication of neuromuscular blockade, use of intraoperative cranial nerve and brainstem monitoring dictates that only moderate doses of inhalational anesthetic be used; higher doses are damaging to motor potentials and to evoked cortical responses. Fortunately, endoscopic retrosigmoid surgery is, for the most part, minimally stimulating to the patient. After the surgeon infiltrates the scalp and periosteum with local anesthetic, the only stimulation comes from the Mayfield pins and the endotracheal tube. At certain times during the procedure, however, stimulation may increase dramatically. Common sources of intense stimulation are the Valsalva maneuver and direct trigeminal nerve irritation.

The anesthetic technique must accomplish the necessary depth of anesthesia to avoid patient movement during periods of intense stimulation while permitting sensitive cranial nerve monitoring. This is particularly challenging for the neuroanesthesiologist. However, an effective approach to solve the dilemma (anesthesia light enough to monitor, deep enough to prevent movement) is to combine elements of total intravenous anesthesia with inhalational techniques. On a baseline of low-to-moderate levels of inhalational agent, infusion of propofol and a short-acting opioid such as remifentanil can provide a stable level of anesthesia and still permit good neurophysiologic monitoring. To have a reasonable margin of safety against movement during cranial nerve stimulation, it may be necessary to increase the intravenous agents to fairly high doses, doses that may cause hypotension during quieter periods.

In this situation, during periods of little stimulation, infusion of vasopressors such as phenylephrine may be necessary.

After closure, emergence from anesthesia following this approach may sometimes be prolonged. This is due to the lingering effects of intravenous anesthetics and the absence of postoperative pain. This delay can frustrate the surgeon's postoperative neurologic assessment. Again, tailored anesthetic management can help by reinstating short-acting neuromuscular blockade during surgical closure and cranioplasty (cranial nerve and brainstem monitoring is no longer needed). The patient may be safely lightened while immobilized in the Mayfield head clamp. The patient's position also permits the use of bispectral index (BIS) monitoring, a useful technological tool that is used to assess anesthetic depth and speed of emergence. The patient is then ready for extubation and neurological assessment fairly soon after the Mayfield head clamp is removed.

5. FUTURE CHALLENGES

As endoscopic skull base surgery progresses, new and novel approaches will be used to access deeper areas at the base of the skull. Just as these operations will be custom tailored to a particular patient's pathology, neuroanesthetic management will have to be customized for the surgical approach. Specialized neurologic monitoring equipment and three-dimensional imaging will provide further challenges to the neuroanesthesiologist. With special care and a tailored approach analogous to that of skull base surgeons, neuroanesthesiologists can continue to make major contributions to fully endoscopic skull base surgery.

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