Chapter 14
Basics of Neurosurgical Techniques and Procedures

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Overview

Neurosurgical procedures are a collaborative effort between surgical, anesthesiology, and nursing teams. Approaches to the cranial vault are generally designed to minimize retraction and manipulation of surrounding neural tissue and to provide the shortest distance possible from the surgeon's hands to the surgical target. Cranial procedures are unique in that the approach vector can take on any number of trajectories. The position of the patient's head is determined by the anatomic location of the lesion and the approach and exposure selected by the neurosurgeon. Similarly, approaches to the spine are dependent on the target of interest and are typically posterior, anterior, lateral, or some combination of the three.

Implications for the Neurosurgical Patient

Cranial Surgery

Cranial procedures are often performed with the patient's head in three-point fixation to minimize movement of the operative field during the procedure. Approaches are fashioned depending upon the goal of the operation and the anatomic area of interest. Lesions on the superficial aspect of the brain are most easily operated upon

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by placing the lesion near the top of the operative field. If the lesion is frontal, the head is secured in the anatomic position. If the lesion is occipital, the head is secured in the prone position. If the lesion is lateral, the head is turned to provide easy access to the lesion. Surgery of deeper structures, such as the cranial nerves and the arteries at the base of the brain require retraction of neural structures to adequately visualize and manipulate the surgical target. Additionally, brain relaxation via CSF drainage catheters is often used to provide adequate operative corridors.

Cautery is primarily used to control bleeding in the surgical field by the induction of thermal damage to incompetent blood vessels. The majority of non-neurosurgical procedures rely on monopolar electrocautery, which creates a current between a handheld electrode and an electrode placed on the patient's skin. This typically creates an arc of electricity between the handheld electrode and the tissue in closest proximity. Because this runs a current through the patient's body, neurosurgeons are hesitant to use monopolar electrocautery in an electrically active organ such as the brain, for fear of inducing cortical arrhythmias and/or seizures. More commonly, bipolar cautery is used for hemostasis in cortical tissue where the current runs between two poles in the forceps-shaped handpiece, precluding the need to run electrical current through the entire body. While bipolar cautery is fairly well tolerated, the use of monopolar cautery should be used with caution in patients harboring an electrically active device such as a pacemaker or implanted automatic defibrillator. Other methods of hemostasis typically involve tamponading the bleeding area with a biologic agent (such as methoxycellulose) soaked in thrombin. These methods tend not to work as well when the patient is hypertensive.

In patients undergoing cerebrovascular procedures, intraoperative angiograms are occasionally performed to confirm obliteration of the vascular anomaly. These are typically accomplished using a transfemoral approach with a catheter coupled with a fluoroscope. Intracranial Doppler ultrasonography is also used to confirm patency of parent vessels especially after aneurysm surgery. Intraoperative optical angiography is another method, albeit fairly new, that is used to evaluate the circulation in the surgical field. Injection of a fluorescing agent systemically can be visualized through digital infrared processing via the surgical microscope.

Spinal Surgery

Spinal procedures are performed with the patient in the supine, prone, or lateral positions. Preoperative communication between the surgeon and the anesthesiologist is important to identify issues related to the perioperative management of the patient. For example, spinal procedures may be associated with significant blood loss. Anterior approaches to the thoracic and lumbar spine may involve a thoracotomy and benefit from the anesthesiologist utilizing a double-lumen endotracheal tube. Transoral approaches to the high cervical spine may require keeping the patient intubated postoperatively because of airway edema. Careful communication between all members of the surgical team is crucial to preventing perioperative and postoperative morbidity.

Stereotactic and Awake Cranial Procedures

Occasionally, patients are kept awake for a portion of or all of a neurosurgical procedure. Procedures such as deep brain stimulation involve the implantation of an electrode in thalamic or subthalamic structures for the treatment of movement disorders. These procedures are often done awake to facilitate the correct placement of these electrodes and to monitor patient progress during the procedure. For these cases, the patient's head is secured in a frame, and for someone to lie with their head secured for an hour or more, especially someone with a movement disorder, this can be difficult. Carefully titrated anesthesia is required to keep the patient comfortable but awake enough so that they can be adequately assessed neurologically. Careful hemodynamic monitoring and control at the time the electrode is placed is necessary as well.

More extensive awake procedures are performed when a lesion, such as a tumor, involves the eloquent cortex of the brain, usually the speech area or the motor cortex. Some centers utilize a fully awake approach for the entire procedure with a scalp block as the only form of anesthesia. Other centers use an anesthetized-awake-sedated technique. In this latter situation, the patient is usually ventilated via an LMA, which is removed after emergence from anesthesia once the brain is exposed (see Chap. 20). The patient then answers questions or performs physical tasks while the surgeons stimulate the cortex to delineate which areas can be safely removed without causing a neurologic deficit. Keeping a patient who is in pins calm and awake while their cerebral cortex is exposed can be a daunting task. Once the lesion is removed, the patient is sedated for the remainder of surgery.

Shunt and Generator Implantation

These cases are fairly noninvasive neurosurgically but can still be very stimulating for patients. Placement of CSF shunts from the cranium to the peritoneum involves prepping out the patient from head to abdomen. The large surface exposure is associated with significant convective heat loss for the patient and makes it difficult for the anesthesia team to maintain the patient's body temperature in a normal physiologic range. ECG leads and other monitoring devices must be kept out of the surgical field and are best placed on the back of the patient. Shunt tubing or lead wires are passed between stab incisions to keep the hardware subcutaneous. This portion of the procedure (tunneling in the subcutaneous tissue) can be very stimulating for the patient.

Electrophysiologic Monitoring

Monitoring of cranial nerves or the cortex is done in certain cases where the intended surgical approach puts certain nervous structures at risk. Cranial nerve monitoring often involves the use of electromyographic needles placed into the various targets of the nerves and requires a working neuromuscular junction. Neuromuscular blockade, therefore, is contraindicated in this regard. Cortical EEG monitoring electrodes are used in somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs) monitoring. Various inhalational and intravenous agents such as propofol can drastically affect the EEG. Again, preoperative communication with the surgical and electrophysiologic monitoring team is important in identifying these pitfalls.

Concerns and Risks

Placing the patient in "pins" or three-point fixation is quite stimulating, and adequate analgesia should be in place before the patient's cranium is secure by the surgeon. Preemptive strategies that have been employed to prevent hypertension or patient movement during pin placement include intravenous administration of short-acting anesthetics (e.g., propofol bolus), short-acting narcotic (e.g., alfentanil), or local block (either scalp block or local application of anesthetic at pin sites). Occasionally, the pins can cause a skull fracture or rest on the patient's face. This should be avoided. Once the head is secured, the neck is often flexed or extended to provide optimum access to the surgical target. This can cause the endotracheal tube to move proximally or distally, and care should be taken to ensure that the patient remains adequately ventilated after the head is secured. Additionally, severe flexion can cause cerebral venous outflow obstruction, which can be problematic for both the surgeon and the anesthesiologist. Likewise, severe flexion or extension may rarely result in critical impairment of arterial blood flow to the brain or direct cervical neurologic injury with potentially devastating consequences for the patient. Adequate space between the patient's chin and chest should be ensured prior to proceeding with the operation. For prone cranial procedures, the patient's head is typically placed in fixation when they are supine prior to rolling them into the prone position. This roll provides an opportunity for disaster, as carefully placed tubes and lines can be inadvertently pulled during positioning. When the patient is placed in the prone position for cranial procedures, adequate padding of pressure points must also be performed to prevent the formation of pressure sores and nerve injury.

In order for the surgeon to expose a large enough working surgical corridor to lesions deep in the brain, brain relaxation is important. This can be achieved with intravascular osmolytes (e.g., mannitol and hypertonic saline) and temporary hyperventilation. The systemic side effects of these two methods must be kept in mind while trying to maintain adequate brain relaxation. CSF drainage catheters, placed either intracranially or intrathecally via a lumbar approach, are occasionally used to control intracranial pressures or assist in brain relaxation. Careful communication between anesthesiologist and surgeon regarding the level of placement of these drainage tubes (i.e., "pop-off" level) and how much fluid should be drained is of tantamount importance. Excessive drainage can cause subdural hematomas and in severe cases, herniation syndrome. When brain relaxation does not provide enough visualization, for instance during surgery of deeper structures at the base of the skull, metal retractors blades are used to gently retract neural tissue. Excessive retraction can cause occult bleeding beneath the retractor or bleed or place tension on cranial nerves that provide autonomic tone to the vascular tree. During intracranial surgery, changes in the patient's vital signs can be very abrupt and should be communicated to the surgeon.

Blood pressure management can be critical, especially during cerebrovascular procedures (aneurysms, carotids, and AVMs). During active bleeding, blood pressures should be kept low. When temporary occlusion of arteries is in place to control bleeding, it is helpful to keep blood pressure up to maintain adequate cerebral perfusion via collaterals to the areas of brain at risk for ischemia. Occasionally, during surgery of the brain stem or during surgery where there are rapid changes in intracranial pressure (decompression during trauma surgery or hydrocephalus surgery), changes in blood pressure and heart rate can be noted secondary to traction or disturbance of the baroreceptor areas in the brainstem. These are often transient in nature but can be severe enough to temporarily require vasoactive pharmacological support. Effective communication of the anesthesiologist with the surgeon can often facilitate surgical amelioration of the inciting factor (e.g., retraction, stimulation, and manipulation) that is causing the hemodynamic instability.

Spinal procedures often have the patient's arms in non-anatomic positions and care should be taken to ensure that there is not excessive traction on the brachial plexus. In situations where the patient is prone, care should be taken not to have the arms in an extended position. They should be flexed at the shoulder and elbow to prevent nerve and joint injury. Spinal procedures also often involve the use of a fluoroscopic unit (C-arm) to guide hardware placement. When the unit is moved in or out of the surgical field, the technician or surgeon can inadvertently place the unit on the patient's body. In addition, this movement may inadvertently result in premature removal of an intravascular catheter or disconnection of a physiologic monitoring. Vigilance is key to prevent complications from excessive pressure and traction from the fluoroscopy unit. Significant blood loss is associated with invasive spinal procedures and should be monitored carefully to optimize perioperative management. For posterior spinal operations, retraction of the paraspinal musculature is used to gain adequate exposure to the bony and neural elements of the spine. Prolonged retraction and prone positioning has been known to occasionally result in rhabdomyolysis or postoperative visual loss.

Key Points

- Positioning the patient for either a cranial or spinal operation requires careful communication with the surgical and nursing teams to minimize perioperative morbidity.
- Preoperative planning with the surgical team regarding the planned use of CSF drainage, the use of neuromuscular blockade, or if the patient will remain awake during the procedure is critical.
- Blood pressure management during cerebrovascular procedures is critical during periods of active hemorrhage and temporary ligation.
- Abrupt changes in vitals can occur with rapid changes in intracranial pressure or manipulation of the brain stem and lower cranial nerves.

Suggested Reading

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