Anaesthesia for neurosurgery

Oliver Hambidge

Robert John

Abstract

Neuroanaesthesia is an expanding speciality that requires a good understanding of neurophysiology as well as the pathophysiology of raised intracranial pressure. Neuroanaesthetists need to ensure neurosurgical patients maintain an adequate cerebral perfusion pressure intraoperatively, while providing optimum operating conditions. To achieve this, a balanced anaesthetic technique preventing hypertensive surges and optimizing cerebral venous drainage by careful patient positioning is important. Knowledge of the therapeutic options available to the anaesthetist for decreasing ICP intraoperatively is essential. As neurosurgery evolves, it provides neuroanaesthetists with new challenges including awake craniotomies, stereotactic neurosurgery and intraoperative MRI.

Keywords Anaesthesia; awake craniotomy; intraoperative MRI; monitoring; neurosurgery; postoperative analgesia

Royal College of Anaesthetists CPD Matrix: 1A02, 3F01

Learning objectives

After reading this article, you should understand:

- the principles of anaesthesia for neurosurgery
- the preoperative and perioperative requirements regarding monitoring and positioning of the patient
- the postoperative management of pain in neurosurgical patients
- the special requirements for pregnant patients and those undergoing awake craniotomy and intraoperative MRI

General principles

Preoperative assessment

A thorough preoperative assessment of the neurosurgical patient is vital, and extends beyond the patient's past medical history and previous surgery. The anaesthetic technique and intraoperative positioning of the neurosurgical patient is influenced by the site, size and vascularity of the intracranial lesion. As such, preoperative CT scans and MRI scans are invaluable. Preoperative imaging can also inform the anaesthetist of any evidence of midline shift or hydrocephalus.

Supratentorial lesions commonly present with neurological deficits, seizures, or symptoms consistent with raised intracranial pressure (ICP). Meningiomas account for around 15% of central nervous system tumours, and are more likely to cause significant blood loss owing to their increased vascularity. These patients can have large tumours, yet may remain relatively asymptomatic. In contrast, lesions in the posterior fossa commonly present with lower cranial nerve symptoms, and poor bulbar function. These patients may also have cardiorespiratory dysfunction, which should be explored at the preoperative visit.

A full preoperative neurological examination should be carried out and documented, so a postoperative comparison can be made. Neurological deficits following surgery may occur due to oedema or intraoperative injury. Evidence of hearing difficulties, receptive or expressive dysphasia should also be documented, as communication problems will make the postoperative assessment more challenging.

Routine medications should be continued preoperatively, especially anticonvulsants and corticosteroids. Neuroanaesthetists need to be alert to the pharmacokinetic and pharmacodynamic interactions between anticonvulsants and drugs used in neuroanaesthesia. The most significant is the induction and inhibition of the cytochrome p450 isoenzymes.

Hypertension is common in the neurosurgical population, often as a consequence of the neurosurgical pathology (acromegaly, raised ICP) or it's treatment (corticosteroid therapy). As perioperative hypertension can contribute to intracranial bleeding after a craniotomy, a well-controlled preoperative blood pressure is important. Some units discontinue angiotensin converting enzyme (ACE) inhibitors and angiotensin II antagonists, so as to avoid perioperative hypotension. Patients receiving diuretic therapy may have disordered electrolytes, and those receiving preoperative dexamethasone may be hyperglycaemic.

Sedative premedication is rarely required and should be avoided in patients with raised ICP. Many patients will, however, be very anxious and require reassurance prior to surgery.

Induction

Induction of anaesthesia is normally performed using an intravenous agent such as propofol or thiopental. Short-acting opioids such as fentanyl or alfentanil are used to attenuate the hypertensive response to laryngoscopy and intubation. Further boluses can also obtund the haemodynamic response to Mayfield pins insertion. Muscle relaxation is established with non-depolarizing drugs such as rocuronium or atracurium. These have minimal effects on intracerebral haemodynamics. It is important to allow sufficient time to ensure complete paralysis before attempting intubation, as coughing can raise ICP. If a rapid sequence is required, suxamethonium should be used, as the importance of securing a definitive airway promptly, outweighs any transient rise in ICP seen with this agent.

To prevent kinking, reinforced endotracheal tubes are commonly used for tracheal intubation. Adhesive tape should be used to secure the airway as using ties can obstruct cerebral venous drainage and result in a rise in ICP. If bulbar function is

***Oliver Hambidge** Bsc(hons) BM(hons) FANZCA is a Consultant Anaesthetist and Clinical Fellow at the National Hospital for Neurology and Neurosurgery, London, UK. Conflict of interests: none declared.*

***Robert John** MBBS BSc (Hons) FRCA is a Consultant Neuroanaesthetist at the National Hospital for Neurology and Neurosurgery, London, UK. Conflict of interests: none declared.*

compromised, a nasogastric tube should be inserted. The eyes need to be protected with a waterproof dressing and padded to prevent any perioperative pressure damage.

Positioning

Patient positioning is largely determined by the location of the patient's intracranial lesion, so as to optimize surgical access. Most neurosurgical procedures can be performed with the patient in the supine position with the head rotated and fixed in Mayfield pins. A sandbag is commonly placed under the ipsilateral shoulder. A 15° reverse Trendelenburg tilt with appropriate head rotation can improve cerebral venous drainage, lower ICP and improve operating conditions. Excessive head rotation may, however, cause stretching of the brachial plexus and jugular veins.

The prone position may be used for access to midline structures in the posterior fossa. Placing the head in a Mayfield 3 point fixator reduces the chance of injury to the face and eyes and helps prevent facial and orbital oedema. The patient should be placed in a specially designed mattress supporting the chest and pelvis that allows for free abdominal movements and facilitates effective ventilation. Bony prominences should be padded in all prone patients.

The park bench position is a variation of the lateral position and allows surgical access to the cerebellopontine angle. The patient is placed on their side with anterior and posterior supports. The lower leg is flexed and the upper leg is straight with a pillow between the knees. The lower arm is flexed while the upper arm remains extended and taped along the body. The axilla needs to be well padded so as to prevent brachial plexus injuries.

The sitting position is achieved by placing the patient on a conventional operating table and sitting them up at the waist with their legs outstretched and slightly flexed. The advantages of this position include excellent access to midline posterior structures and good venous drainage, but there is an increased risk of air embolism.

Maintenance of anaesthesia

Propofol versus volatiles

There are no consensus recommendations regarding the type of maintenance anaesthesia for neurosurgical procedures. Total intravenous anaesthesia (TIVA) is, however, becoming a popular anaesthetic technique for neurosurgery and there are some indications of its superiority over volatiles presented in a recent meta-analysis.[1] Compared to volatiles, propofol has been found to be associated with a faster time to obey commands in the post anaesthetic care unit (PACU), as well as a reduced risk of postoperative nausea and vomiting. Other well-established benefits include suppression of the inflammatory response, less interference with motor evoked potentials (MEPs), anti-tumour properties and the preservation of cerebral flow-metabolism coupling and vascular reactivity to changes in CO_2. While the quality (and quantity) of studies seeking to establish any medium-to long-term outcome difference between propofol and volatile maintenance in elective neuroanaesthesia remains low, volatiles remain an acceptable alternative for maintenance of anaesthesia in the elective neurosurgical patient.

Remifentanil

Remifentanil is a potent mu receptor agonist that is able to achieve anaesthesia and profound analgesia. It is ultra-short acting on account of its unique structure (2 ester links) allowing metabolism by non-specific plasma and tissue esterases; having a context 'in-sensitive' half time of 3 minutes following a 3 hours infusion. It is a potent respiratory depressant, which avoids the need to repeatedly administer muscle relaxants intraoperatively. The use of remifentanil also facilitates a smooth, haemodynamically stable extubation allowing rapid neurological assessment. It can be used in conjunction with propofol or volatile agents for maintenance of anaesthesia.

N_2O

Nitrous oxide should be avoided in neuroanaesthesia as it causes cerebral vasodilation with a resulting increase in cerebral blood flow (CBF) and ICP. It also has a high blood:gas partition coefficient (0.47) so will worsen any pneumocephalus. It is also associated with an increased risk of postoperative nausea and vomiting (PONV).

Dexamethasone

Dexamethasone (4–8 mg on induction) has dual benefits in neuroanaesthesia. It reduces the risk of PONV, as well as reducing cerebral oedema associated with tumours. It is important to note however that even in non-diabetics this may result in an appreciable increase in plasma glucose levels up to 12 hours postoperatively. While this has not been demonstrated to increase the risk of wound infection it is prudent to exercise caution in brittle diabetics.

Intravenous fluids

The water flux across an intact blood brain barrier is determined by plasma osmolality. A 0.9% saline solution is a hyperosmolar crystalloid and is the maintenance fluid of choice in the neurosurgical patient, although large volume infusions can cause a hyperchloraemic metabolic acidosis. Normovolaemia should be maintained and overhydration should be avoided. Glucose containing solutions such as 5% dextrose and 4% dextrose in 0.18% saline should not be used, as their hypotonicity can raise ICP and may worsen cerebral oedema. The intraoperative management of raised ICP is summarized in Box 1.

Routine and specialized monitoring is essential during neurosurgery (Box 2). Mild intraoperative hypothermia in elective neurosurgical patients has not been shown to confer any benefit, therefore normothermia should be targeted using air and fluid warming devices. Hyperthermia should be avoided.

All patients should be given an appropriate prophylactic antibacterial agent. This may need to be repeated during long procedures. Neurosurgical patients should all receive mechanical deep vein thrombosis (DVT) prophylaxis intraoperatively (TEDS and intermittent calf compression devices).

Emergence

To ensure early neurological assessment, emergence from neurosurgery must be relatively rapid. Patients are usually extubated at a deep plane of anaesthesia to prevent coughing.

