Anaesthesia for neurosurgery

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Abstract
Neuroanaesthesia provides a unique set of challenges, in which anaesthetists’ knowledge and techniques may directly influence patient outcome. As neurosurgery evolves it has provided neuroanaesthetists with an ever-changing speciality especially in minimally invasive and functional techniques.

Keywords Anaesthesia; Awake craniotomy; monitoring; neurosurgery; postoperative analgesia

General principles
Preoperative assessment
Preoperative assessment of the neurosurgical patient should address some specific issues in addition to questions about past medical history and previous surgery. The operation to be performed, the site and extent of the lesion can significantly impact on anaesthetic technique, intraoperative positioning and post operative complications.

Supratentorial lesions tend to present with seizures, neurological deficits or raised intracranial pressure (ICP). Meningiomas in particular may be vascular and are more likely to cause significant blood loss. These patients may have large tumours but remain relatively asymptomatic. Posterior fossa lesions often present with lower cranial nerve symptoms and signs, poor bulbar function, cardiorespiratory complications and reduced level of consciousness.

Neurological deficits should be carefully assessed and documented, as there may be postoperative deterioration secondary to oedema or intraoperative damage. Any communication difficulties, receptive or expressive dysphasia and hearing problems should also be documented, as this will influence accurate post operative assessment.

Routine medications should be continued preoperatively especially anti-convulsants and corticosteroids. Sedative premedication is rarely required although many patients will be extremely anxious and require reassurance prior to surgery.

Induction
Induction of anaesthesia is normally performed using an intravenous agent such as propofol or thiopental. In addition, a short-acting opioid such as fentanyl or alfentanil is used to attenuate the hypertensive response to intubation. A muscle relaxant such as vecuronium or atracurium is used and it is essential that adequate time be allowed for the agent to work before attempting intubation, which may cause coughing and raised ICP. If a rapid sequence induction is required, suxamethonium must be used as the prompt securing of the airway outweighs any transient rise in ICP seen with this agent.

Following induction of anaesthesia a reinforced tracheal tube should be secured with adhesive tape; ties can predispose to obstruction of cerebral venous drainage resulting in a rise in ICP. A nasogastric tube should be inserted if bulbar function is compromised. The eyes should be protected with a waterproof dressing and padded to prevent pressure damage perioperatively.

Positioning
Positioning the patient is dictated by the surgical approach. Most procedures are performed with the patient in the supine position usually with the head rotated and fixed in Mayfield pins with a sandbag under the ipsilateral shoulder. For all patients a reverse Trendelenburg tilt of 15° and avoiding excessive rotation of the head improves cerebral venous drainage, lowers ICP and improves operating conditions. Before the patient is draped, all connections in the breathing circuit should be checked and made secure. Access to intravenous cannulae and arterial line should be unimpeded.

The prone position may be used for access to the posterior fossa. Placing the head in pins reduces the chance of injury to the face and eyes and helps prevent facial and orbital oedema. The patient should be placed on a specially designed mattress to allow abdominal movements and therefore ensuring optimal ventilation.

The lateral (park-bench) position allows access to the cerebello-pontine 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 is taped along the line of the body.

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**

Despite the theoretical benefits of intravenous agents the majority of neuroanaesthetists use a balanced anaesthetic technique using controlled ventilation, opioids and a volatile agent. Routine and specialized monitoring is essential (Box 1). The actual technique used for maintenance of anaesthesia is less important than careful attention to detail.

Sevoflurane is the volatile anaesthetic agent of choice as it allows maintenance of cerebral autoregulation at doses of up to 1.5MAC (minimum alveolar concentration) and reduces cerebral oxygen requirements. A low blood-gas partition coefficient also allows swift emergence from anaesthesia. Propofol has many theoretical advantages by reducing cerebral blood volume (CBV) and while preserving autoregulation and vascular reactivity, but no consistent clinical benefit has been demonstrated by its sole use. Nitrous oxide is no longer used in neuroanaesthesia as it causes a significant increase in CBV and raised ICP. Other mechanisms for lowering ICP intraoperatively are shown in Box 2.

Remifentanil is an ultra-short-acting opioid agent which allows rapid emergence from anaesthesia and has become widely used in neuroanaesthesia. It can be titrated to provide cardiovascular stability during periods of surgical stimulation. It also suppresses respiration avoiding the need for repeated doses of non-depolarizing muscle relaxants.

Corticosteroids such as dexamethasone 8 mg are usually given with the dual benefit of reducing cerebral oedema and preventing postoperative nausea and vomiting. However, even in the non-diabetic population this dose can raise the blood glucose concentration. Although there is good evidence that good glycaemic control improves outcome in critically ill neurologically impaired patients, there are no data for elective neurosurgical patients.

**Monitoring in neuroanaesthesia**

**Routine**
- Continuous electrocardiography
- Pulse oximetry
- End-tidal capnography
- Invasive blood pressure
- Temperature
- Urine output

**Specialized**
- Central venous pressure (for medical reasons, if large blood loss is expected e.g. meningioma surgery or in sitting position risking air embolism)
- Somatosensory/motor evoked potentials (brainstem/spinal surgery)
- Facial nerve monitoring (acoustic neuroma surgery)
- Electroencephalography monitoring (epilepsy surgery)

**Box 1**

**Intraoperative management of raised intracranial pressure**

- Check patient position and maintain reverse Trendelenburg position
- Avoid excessive head rotation
- Tape tracheal tubes rather than tie
- Ensure CO₂ 4.5–5 kPa
- Control blood pressure
- Deepen anaesthesia using bolus doses of propofol or thiopental
- Consider dexamethasone 8–12 mg for tumours if not previously given
- Mannitol 0.5 mg/kg is rarely used intraoperatively, but can be used as a stalling strategy prior to surgery

**Box 2**

All patients should be given an appropriate prophylactic antibacterial agent. This may need to be repeated during long procedures. Thromboembolic events should be prevented by the use of graduated compression stockings and pneumatic calf compression.

**Emergence**

Emergence from anaesthesia must be relatively rapid to allow early neurological assessment. Extubation of the trachea is usually performed at a deep plane of anaesthesia in order to prevent coughing. Hypertension on emergence can be treated with labetolol or hydralazine. Ventilation on the intensive care unit should only be considered if the patient was severely obtunded preoperatively, there has been massive blood loss or if acute intraoperative brain swelling requires monitoring of ICP postoperatively.

**Postoperative management**

Patients undergoing craniotomy experience moderate to severe postoperative pain. All patients should receive regular paracetamol, which reduces opioid requirements. Appropriate doses of opioid analgesia are also needed. Morphine sulphate is the most commonly used agent and can be given in oral and intravenous forms. Non-steroidal anti-inflammatory drugs are controversial, as they offer good postoperative analgesia but are a risk factor in the development of postoperative haematoma formation. Much of the postoperative pain arises from the pericranial muscle and soft tissue so local anaesthetic infiltration of the scalp should be used perioperatively.

Postoperative nausea and vomiting are common especially following posterior fossa surgery and should be avoided if possible, as there is an ICP rise associated with vomiting. Prophylactic anti-emetics should be given perioperatively and prescribed postoperatively.

Mechanical methods for preventing thromboembolic events should be continued in the immediate postoperative period until the patient is mobilizing or low-molecular-weight heparin can be safely prescribed.
Special circumstances

Pregnancy
Neurosurgical intervention during pregnancy is required infrequently, but provision may need to be made for Caesarean section at the time of the neurosurgery. This should be carefully planned with the obstetric team. Incidental primary cerebral tumours may present earlier due to pregnancy-induced oedema and meningiomas may grow faster during pregnancy if they contain oestrogen or progesterone receptors. Subarachnoid haemorrhage is a leading indirect cause of maternal death, as there is an increased risk of rupture during pregnancy, probably due to an increased maternal circulating volume and cardiac output. Pregnancy-induced hypertension may also increase the risk of aneurysm rupture, as well as causing intracranial haemorrhage. Patients with severe pre-eclampsia may present to the neurosurgical team for intracranial pressure monitoring or rarely, decompressive craniectomy.

Awake craniotomy
Awake craniotomy is gaining popularity. It is routinely used for epilepsy surgery and increasing used for removal of lesions adjacent to eloquent brain tissue. Continuous neurological assessment allows maximal resection with minimal postoperative neurological dysfunction. Functional neurosurgery for movement disorders such as Parkinson’s disease, dystonias and Tourette’s syndrome may also require the patient to be awake.

A multidisciplinary approach involving the theatre team, speech therapists, occupational therapists and the patient is essential for awake surgery to be successful. Anaesthetic techniques include the use of remifentanil and propofol infusions providing titratable sedation and rapid recovery. Large volumes of local anaesthetic to the scalp are required which carries the potential risk of local anaesthetic toxicity. Airway compromise is a risk and anaesthetic management must include a plan for securing the airway rapidly if necessary.

Stereotactic neurosurgery
Developments in stereotactic neurosurgery have allowed access to smaller lesions and those in areas that were previously considered impossible to reach. Imaging produces a three dimensional picture to accurately define intracranial lesions and structures referenced to an extracranial system. Traditionally stereotactic surgery has required an external frame, but frameless stereotactic techniques are now used. Indications for stereotactic surgery include biopsy and resection of tumour, aspiration of haematoma or cysts and functional neurosurgery such as implantation of electrodes for deep brain stimulation in movement disorders. Surgery involving frames may make access to the airway difficult if this is positioned prior to surgery.

Surgery in intraoperative MRI (iMRI)
A recent development has been operating in specially designed MRI suites. During surgery the patient undergoes MRI scanning until the resection is complete. These procedures are often long and particular attention should be paid to positioning to prevent pressure areas, temperature control and fluid management. During scanning the anaesthetist does not have access to the patient as they may be monitored from a separate room.

FURTHER READING