Anaesthesia for interventional neuroradiology

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Abstract
The specialty of interventional neuroradiology has expanded enormously over the last few years and in addition to treating intracranial aneurysms, arteriovenous malformations (AVMs) and dural fistulae, there is increasing involvement in the embolization of tumours and the treatment of vasospasm and stroke. An appreciation of the physiological requirements and potential problems relating to each individual procedure permits the close cooperation between anaesthetist and radiologist that is essential in order to provide the optimum working conditions. This attention to detail must extend into the post-procedural period when the patients should be recovered in an environment where close attention to neurological examination and the recognition of potentially subtle changes warranting action must be appreciated.

Keywords Anaesthesia; arteriovenous malformations; cerebral aneurysms; neuroradiology

Learning objectives

After reading this article you should understand:
- the principles of anaesthesia for interventional neuroradiology
- the special requirements for patients undergoing procedures in the radiology suite
- which conditions are amenable to radiological intervention.

General considerations

Standard preoperative assessment should be supplemented with details of the underlying pathology, baseline neurological state (e.g. Glasgow Coma Score and any focal deficit) and the proposed radiological intervention. Patients requiring interventional neuroradiology often come directly from the intensive care unit (ICU) and safe transfer may include the management of external ventricular drains and intracranial pressure (ICP) monitoring devices. In general the principles of anaesthesia for neurosurgery apply, with appropriate control of the ICP and maintenance of cerebral perfusion pressure.

General considerations for anaesthesia

Many of the patients undergoing neuroradiological procedures require neither anaesthesia nor sedation. However, patients that are uncooperative, confused or very young may require general anaesthesia to remain still so that meaningful images may be obtained. Patients requiring interventional procedures usually require general anaesthesia because:

- procedures are of long duration and remaining comfortable and still on narrow angiography tables is difficult
- manipulation of blood pressure and ventilation may be required
- complications may occur rapidly
- image quality is improved if the patient is motionless.

General anaesthetic techniques should be chosen to allow maintenance of appropriate haemodynamic variables during the procedure and to facilitate rapid emergence so post-procedure neurological assessment can be performed as soon as possible. There is little evidence to suggest that either intravenous or inhalational techniques are superior. Neuromuscular blocking drugs are rarely required for angiographic procedures as there is minimal surgical stimulation. However, adequate analgesia is essential especially during extracranial procedures or dural stimulation during embolization of tumours when pain may be intense. Nitrous oxide should be avoided as it may cause expansion of air micro-emboli which may be unwittingly introduced.

Careful securing of the airway is essential as it is often difficult to access the patient for long periods of time. Reinforced tracheal tubes are less prone to kinking and if positioned correctly do not interfere with imaging. Invasive blood pressure monitoring is usually recommended and if not required for post-procedure monitoring can be achieved by sharing the radiologist's arterial line. Intravenous access should take account of inaccessibility by using extension tubing. The administration of intravenous fluids, endovascular catheter flush (> 2 litres during complicated procedures) and the diuretic effect of contrast agents mean a urinary catheter is essential. Patient-warming devices should be used. Vessel thrombosis is a complication of endovascular procedures and the anaesthetist is often required to administer heparin, the dose of which is determined by estimation of the activated clotting time (ACT). In addition, a dose of aspirin and/or clopidogrel may be given during the procedure via a nasogastric tube. Although rare, damage to major vessels is a possibility and provision should be made for major blood loss. Before any procedure appropriate ICU and recovery facilities should be identified for the close monitoring of haemodynamic variables and regular observation of neurological status with especial attention to the development of any focal deficit and severe headache.

Contrast agents and nephropathy

Patients receive significant volumes of contrast agents (150–250 ml) during interventional procedures and some are at risk of acute renal failure (Box 1). All patients should have plasma creatinine levels and glomerular filtration rate checked prior to the procedure. The risk of precipitating acute renal failure can be lessened

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Risk factors for contrast induced nephropathy

- Reduced glomerular filtration rate
- Diabetes mellitus (especially if taking metformin)
- Dehydration
- Hypotension
- Age >75 years
- Co-administration of nephrotoxic drugs (aminoglycosides, non-steroidal anti-inflammatory drugs etc.)

Box 1

by using dilute and smaller volumes of contrast and ensuring hydration during the procedure. There is insufficient evidence to support the prophylactic use of *N*-acetylcysteine. Metformin should be omitted 48 hours before the procedure and afterwards until the glomerular filtration rate is at preoperative levels.

Ionizing radiation

Patients may be exposed to significant doses of ionizing radiation during neuroradiological procedures (Table 1). Female patients between 15 and 55 years should have a negative pregnancy test before undergoing any procedure. Standard precautions should be taken by all staff and patients to limit the exposure to ionizing radiation.

Imaging technology

Imaging technology has evolved dramatically in the last 10 years allowing greater endovascular access to the brain. In order to improve 'positioning' the 'road map' is used. Initially a mask picture is taken (essentially a plain X-ray). Fluoroscopy screening is then performed and all stable structures common to both images are subtracted digitally from the mask image. Simultaneously angiography is performed and as the contrast is not on the mask image it is not subtracted leaving an image of the vessel (the roadmap). Subsequently, any items introduced onto the roadmap (e.g. stents, coils) are clearly visible.

Specific procedures

Endovascular treatment of cerebral aneurysms

The incidence of cerebral aneurysms in the general population is 1.5–8% with 20% of patients having multiple aneurysms. Patients may present with symptoms of sub-arachnoid haemorrhage (SAH), cranial nerve palsies or asymptomatically as a result of a screening programme. Endovascular coiling can be safely undertaken within hours of aneurysm rupture (Figure 1). The size and configuration of the aneurysm is the key factor to the success of coiling techniques.

Radiation doses with radiological procedures

• Chest radiograph (CXR)	0.02 mSv	1 CXR equivalent
• Abdomen radiograph	0.06 mSv	3 CXR
• Computed tomography of head	2 mSv	100 CXR
• Cerebral angiogram	5 mSv	250 CXR
• Interventional cerebral angiogram	7–10 mSv	300–500 CXR

Table 1

Aneurysmal disease can be classified into three categories: (i) small, <12 mm in diameter; ii) large, 12–24 mm; and iii) giant >24 mm. Complete thrombosis can be achieved in approximately 70% of aneurysms with a neck diameter <4 mm. The International Subarachnoid Aneurysm Trial (ISAT) has shown that patients with Grade 1 and 2 SAH with small aneurysms in the anterior circulation have a better clinical outcome after endovascular coiling than surgical clipping. There is no difference in death related to rebleeding in the two groups. Endovascular coiling is also the preferred treatment for posterior circulation aneurysms. Surgical clipping may still be required for aneurysms with difficult angiographic anatomy such as wide necks, difficult vascular access or if endovascular treatment fails. There is increasing evidence that stent-assisted coil embolization (SAC) may improve long-term durability of the endovascular approach. Currently this is only a suitable technique for unruptured aneurysms and SAC is not recommended in the setting of acutely ruptured aneurysms.

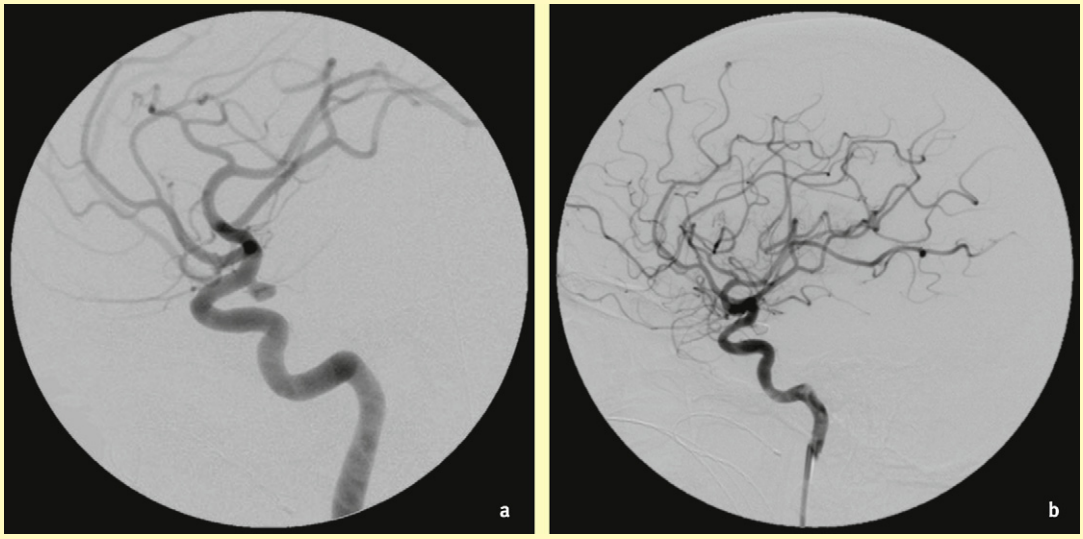
Patients with unruptured aneurysms should be given aspirin pre-procedure. All patients should receive heparin on the radiologist's request to achieve an ACT of two to three times their baseline value, usually 70 IU/kg. Any episodes of haemodynamic instability should be reported to the radiologist as this may indicate aneurysm rupture. If confirmed, the blood pressure should be lowered immediately either by deepening anaesthesia or with short-acting anti-hypertensive agents while the radiologist packs the aneurysm. In these circumstances a computed tomography (CT) scan may be required and an external ventricular drain inserted if the intra-ventricular blood load is high. Rarely, the heparin will need to be reversed with protamine. Intra-arterial thrombosis may also occur and can be treated with intra-arterial tissue plasminogen activator (achieving recanalization rates of 40–50%) and/or anti-platelet agents such as abciximab (a glycoprotein IIb/IIIa receptor inhibitor) which prevents platelet recruitment and clot stabilization and is given as an intra-arterial bolus followed by an intravenous infusion. Once the aneurysm is protected the blood pressure should be raised to normal/supra-normal levels until the end of the procedure when neurological assessment is possible.

Endovascular treatment of vasospasm

Management of vasospasm secondary to SAH includes medical treatment ('triple H therapy': hypertension, hypervolaemia, haemodilution) pharmacological treatment (nimodipine) and increasingly mechanical treatment using angioplasty. Angioplasty is most effective when performed within 2 hours of symptomatic ischaemia and is radiologically effective in 98–100% of patients with clinical improvement in 70–80%. Intra-arterial infusions of nimodipine or nicardipine may be given during the procedure by the radiologist and have been reported to improve perfusion with no increase in major peri-procedural morbidity.

Treatment of arteriovenous malformations (AVM)

5–10% of AVMs may present following an SAH but the majority present with seizures, headache or focal neurological signs. The diagnosis is normally made following either CT angiography (CTA) or magnetic resonance imaging (MRI) scanning. Interventional therapy includes the injection of occlusive agents such as detachable coils, scelerosing agents and quick-acting glues to embolize the vessels supplying the AVM. Glues are injected into the nidus of the AVM, which is though to be more effective than



Terminal carotid aneurysm coiled to exclusion.

Figure 1

proximal occlusion of the arterial feeder vessels. Embolization with nonadhesive polymers, such as Onyx, has increased the possibilities for endovascular treatment of AVM. Complications include passage of the glue into the systemic circulation and embolization of a vessel supplying normal brain tissue. This procedure usually occurs under general anaesthesia to allow haemodynamic control and minimal movement. Emergence from anaesthesia should be smooth to prevent coughing and hypertension should be avoided to prevent cerebral oedema. Like most radiological procedures there is minimal postoperative pain but the patient may need to remain supine for a period of time. Severe postprocedure headache may be a warning sign of intracranial haemorrhage and if persistent warrants further CT scanning.

Radiological management of carotid disease

Interventional techniques for the management of carotid occlusive disease were thought to be promising but a recent large systematic review has shown that carotid artery stenting (CAS) is not as safe as carotid endarterectomy in the immediate postoperative period. However, there is a trend to overall reduction in risk over the past few years suggesting that in carefully selected patients with experienced operators this may be a useful technique. High risk factors are anatomical (re-stenosis after carotid endarterectomy, bilateral disease, neck immobility) and medical (severe ischaemic heart disease, obstructive pulmonary disease, congestive cardiac failure, age >75 years). Anaesthetic management is similar to patients undergoing other neuroradiological procedures, although the procedure is often performed awake to allow assessment of cerebral perfusion by continuous neurological examination. Anti-platelet therapy should be continued preoperatively. Bradycardia or asystole is common during angioplasty due to carotid body stimulation. Pre-empting this response is difficult but atropine or glycopyrrolate may be useful. Post-procedure hypertension should be avoided to prevent cerebral reperfusion injury and patients should be managed in an ITU/HDU setting for at least 24 hours after the procedure.

Thrombotic treatment of acute ischaemic stroke

There is increasing interest in treating acute stroke with radiological techniques. Depending on the clinical situation, direct intracranial arterial recombinant tissue plasminogen activator (tPA) can be given 6–24 hours from the onset of neurological symptoms following failed intravenous therapy. Reperfusion using mechanical devices to remove clot is a promising new technique for patients unresponsive to thrombolysis.

Embolization of intracranial tumours

These procedures are increasingly performed to decrease blood supply to vascular tumours and hopefully facilitate surgical excision. Although usually uneventful from a technical and anaesthetic standpoint there may be significant postoperative tumour swelling. A short preoperative course of dexamethasone may be required and severe post-procedural pain may occur if dural vessels are embolized. ◆

FURTHER READING

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