

Anaesthetic considerations for Interventional Radiology

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Abstract

INTRODUCTION

The minimally invasive procedures for various diseases are on an increasing trend with the advent of the latest sophisticated technology. The interventional radiologists have started performing various procedures that were previously done with conventional open surgical techniques. With the development of this new technique, the management in the periprocedural period remains the concern. These procedures require some unique requirements mandating the need of anaesthesiologist. Thus the anaesthesiologists have a challenging job in the management of such procedures. The anaesthetist must be aware of the procedure and risk of life-threatening complications related to the pathology itself and to the procedure.

1. Drainages
 3. Paracentesis
 4. Thoracocentesis
 5. Percutaneous drainage of abscesses and fluid collections
 6. Placement of chest tubes
1. Venous Access
 3. Placement of PICCs (Peripherally Inserted Central Catheters)
 4. Placement of chest ports
 5. Placement and maintenance of apheresis, dialysis and infusion catheters
 6. Temporary central venous catheters
1. Percutaneous Biopsy
 3. Image-guided soft tissue and bone biopsy
 4. Intraarticular steroid injections
 5. Percutaneous liver and kidney biopsy
 6. Transjugular liver biopsy
1. Gastrointestinal
 3. Placement of gastrostomy and gastrojejunostomy feeding tubes
 4. Placement of caecostomy tubes
 1. Obstructive Uropathy
 3. Nephrostomy, nephroureterostomy and ureteronephrostomy
 4. Ureteral stents
 5. Percutaneous access for stone retrieval
 6. Suprapubic drainage
1. Biliary Intervention
 3. Biliary drainage (native and transplant liver)
 4. Cholecystostomy
 5. Biliary Endoscopic Laser Lithotripsy (BELL) and percutaneous stone retrieval
1. Arteriography
 3. Renal vascular disease - renal artery angioplasty and stenting
 4. Visceral angiography
 1. Vascular Embolization
 3. Varicocele embolization

4. Gastrointestinal bleeding
5. Arteriovenous Malformations - peripheral and pulmonary
6. Haemoptysis - bronchial artery embolization
7. Sclerotherapy of venous and lymphatic malformations
1. Venous Thromboembolic Disease
3. Venous thrombolysis, angioplasty and stenting
4. Permanent and temporary caval filtration
1. Portal Hypertension
3. TIPS
4. Variceal embolization
1. Chronic renal failure and End stage renal disease
3. Dialysis access planning (ultrasound mapping and venography)
4. Percutaneous treatment of malfunctioning or thrombosed dialysis access
1. Neurological procedures:
 3. Closing or occluding procedures- embolization of aneurysms, arterio-venous malformations (AVM) and fistulae of the brain and spine, preoperative embolization of vascular tumours such as meningiomas, temporary or permanent occlusion of arteries intra- or extra-cranially
 4. Opening procedures - treatment of vasospasm or stenosis by angioplasty and stenting, chemical and mechanical thrombolysis in stroke.
1. Cancer Therapy
3. Chemoembolization of liver tumours
4. Radio Frequency Ablation (RFA) of liver tumours, kidney tumors and osteoid osteomas
5. Stenting of malignant strictures: bile duct, esophageal, tracheobronchial and intestinal

ANAESTHETIC TECHNIQUES

The choice of anaesthetic technique performed will depend on several factors ¹. The procedure itself, the anaesthesiologist, patient's health status, and patient preference are all taken into consideration when planning optimal patient care. This can range from Monitored

Anaesthesia Care (MAC) to general anaesthesia or regional / local anaesthesia. The choice of anaesthesia depends on factors related patient condition, procedure related, also the feasibility of anaesthetic techniques. So anaesthesiologist must consider these various factors and type of anaesthesia needs to be individualized.

MONITORED ANESTHESIA CARE

MAC is the most often technique used by the nonanesthesiologist as well by anesthesiologist for various interventional procedures. The MAC has its limitation in certain procedures where patient needs to lie in motionless position, prolonged procedure or when procedure is painful. Sedation causing hypnotics (propofol, midazolam) and opioids (alfentanil, remifentanil) is commonly used as intermittent boluses, continuous infusion, target controlled intravenous sedation or patient controlled sedation. Conscious sedation is an accepted method of pain control during interventional procedures ². Sedation is often used in interventional procedures to minimize discomfort, improve the patient's experience, and reduce the risk of procedural complications by assuring immobility and compliance of the patient, however, adds a new dimension to the procedure by compromising the patients' normal protective mechanisms and carries the potential of cardiac, respiratory, and cognitive complications ³. Ketamine-induced sedation may be a safe and effective alternative to general anesthesia for some interventional radiologic procedures in pediatric patients ⁴.

GENERAL ANESTHESIA

General anesthesia can involve either inhalational or intravenous techniques, or a combination of both. The technique used will depend on local facilities and equipment and the interventional procedure being performed. General anaesthesia would be preferred for long procedures, requiring total immobility.

REGIONAL ANESTHETIC TECHNIQUES

Local/regional anaesthesia proposed for some cases. A regional anesthetic technique may be very useful for many interventional radiologic procedures. Peripherally sited lesions may be done under a peripheral nerve block. Spinal anesthesia is a choice for lower body and leg procedures and is frequently used for abdominal aortic stenting procedures. A continuous epidural catheter may provide anesthesia and analgesia for a segmental block for a truncal procedure. Epidural infusions can be continued into the post procedural period, allowing excellent analgesia for several days and

may be “topped up” for a repeat procedure if required.

A survey by Haslam et al shows clear differences in the use of sedation for vascular and visceral interventional procedures. Many, often complex, procedures are performed at the awake/alert level of sedation in Europe, whereas deeper levels of sedation are used in the United States⁵. In another survey⁶ from interventional radiologists to evaluate current practice in analgesia and sedation in adults showed diagnostic angiography was performed with local anesthesia in 94% to 99%; for PTA, local thrombolysis or stent placement, light sedation was added in 0.1%. Premedication was given in 43% of diagnostic angiographies and in 68% of therapeutic procedures. Radiologists consulted an anesthesiologist before administration of intravenous sedation, always in 54% of cases, occasionally in 19% and never in 27%. General anesthesia with artificial ventilation was applied in 56% of TIPS, in 70% of aortic stent grafting and in 82% of neuroradiological interventions. Intravenous sedation was applied given in 53% of percutaneous biliary drainage, in 42% of bile duct dilatation or stenting, in 40% of percutaneous nephrostomy and in 72% of ureteral balloon dilatation. Patient monitoring during an interventional procedure was always carried out by an anesthesiologist in 52% of cases. 21% of radiologists never visited the patient before a therapeutic procedure, and 36% never did so after completion of a procedure.

91 patients were studied to evaluate the safety and effectiveness of a systematic protocol for sedation and analgesia in interventional radiology². Fentanyl citrate and midazolam hydrochloride were administered in one to five steps (A, B, C, D, E) until the patient was drowsy and tranquil at the effective loading dose (ELD). Doses per step were as follows: A, fentanyl 1 mg per kilogram of body weight; B, midazolam 0.010–0.035 mg/kg; C, repeat dose in A; D, repeat half the dose in B; and E, midazolam 1–2-mg boluses (maximum, 0.15 mg/kg). This authors concluded that stepwise “ABCDE protocol” allows safe and effective sedation of patients. It is easy to use and may be useful in training radiology residents, staff, and nurses in the techniques of sedation and analgesia. Supplemental oxygen should be used routinely.

PREMEDICATION

Premedication should be cautiously used in such patients as some of the procedures are done on day care procedures or some patient are very sick making them unsuitable for elective surgical procedures. Certain preoperative

medications are best avoided to allow accurate assessment of the patient's immediate preoperative neurological condition and clinical grade. On the other hand, an anxious patient may become hypertensive, increasing the chance of bleeding.

Most patients with sub arachnoid haemorrhage are on oral or intravenous nimodipine to minimise cerebral vasospasm and consequent cerebral ischaemia⁷. This should be continued as it lessens the incidence of traumatic vessel spasm during catheter passage in neck as well as in the intracranial arteries⁸.

INTRAVENOUS ACCESS

In the radiology suite, the accessibility to the patient may be limited due to presence of various radiological equipments like fluoroscopy machine, ultrasound machine. Moreover in certain procedures the patient arms needs to be on the side of the patient side, this limits the access of intravenous port for administering various drugs.

In adults at least two intravenous cannulae should be available for the procedure. It is advisable to have extension tubings with three way taps for easier access. It is important to remember that the effects of the administered drugs may be delayed due to the extension tubings.

MONITORING

The type of monitoring primarily depends on the patient medical status and procedure to be performed. Apart from routine monitoring like electrocardiogram, pulse oximetry, non invasive blood pressure, capnography, certain special haemodynamic monitoring (arterial catheter, central venous pressure) and haemostatic monitoring may be necessary for certain procedures⁷. Neuroradiological procedures may require neurophysiological monitoring, transcranial doppler. Monitoring of temperature and diuresis may be useful for long procedures. Urine output is measured and frequently assessed because in addition to large volumes of fluid used to flush the catheters by the neuroradiologists, the contrast medium produces an osmotic load and often leads to a vigorous diuresis⁹. Due to the ambient temperature of neuroradiology suite and the duration of the procedure during endovascular repair, it sometimes becomes necessary to use active warming devices to prevent hypothermia in these patients. Bladder catheters assist in fluid management and patient comfort. A significant volume of heparinized flush solution and radiographic contrast may be used by an interventional team.

NEURO RADIOLOGICAL PROCEDURES

The anaesthetist has a crucial role in facilitating neuroradiological procedures, and this requires an understanding of specific neuroradiological procedures, their potential complications, and their management. There are several anaesthetic concerns that are particularly important for such procedures ¹⁰ , including

1. Evaluation of general condition and neurological status of the patients and impact of CNS injury on various other systemic functions (cardiovascular, respiratory etc)
2. Maintaining immobility during procedures to facilitate imaging,
3. Rapid recovery from anesthesia at the end of procedures to facilitate neurologic examination and monitoring or to provide for intermittent evaluation of neurologic function during procedures,
4. Managing anticoagulation,
5. Treating and managing sudden, unexpected, procedure-specific complications during procedures (eg, hemorrhage or vascular occlusion) which may involve manipulating systemic or regional blood pressures,
6. Guiding the medical management of critical care patients during transport to and from the radiology suites,

TECHNIQUE OF ANAESTHESIA FOR INTERVENTIONAL NEURORADIOLOGICAL PROCEDURES

Conscious sedation, neurolept anaesthesia and general anaesthesia have all been described ^{8,11,12,13,14,15} . The goal of motionless patients with improved images and minimal risk of aneurysmal rupture can be safely achieved with general anaesthesia with muscle relaxation and endotracheal intubation. The other advantages of this technique include airway control in supine position, and thereby improved control of elevated ICP and management of intraoperative neurological emergencies. Endovascular treatment is generally not very painful and hence achieving analgesia is not very difficult. There is an element of pain (frequently described as burning), though, associated with the injection of contrast material into the cerebral arteries and headache associated with distension and traction of cerebral arteries.

Pain may also result from stretching the arteries in the skull base against their pial covering when distal access is attempted.

Figure 1

Table 1 : Interventional neuroradiologic procedures and primary anesthetic considerations .

Procedure	Possible anesthetic considerations
Therapeutic embolization of vascular malformation	
Intracranial AVMs	Deliberate hypotension, postprocedure NPPB
Dural AVM	Existence of venous hypertension, deliberate hypercapnia
Extracranial AVMs	Deliberate hypercapnia
Carotid cavernous fistula	Deliberate hypercapnia, post-procedure NPPB
Cerebral aneurysms	Aneurysmal rupture, blood pressure control
Ethanol sclerotherapy of AVMs or venous malformations	Brain swelling airway swelling, hypoxemia, hypoglycemia, intoxication from ethanol, cardiorespiratory arrest
Balloon Angioplasty and stenting of occlusive cerebrovascular disease	Cerebral ischemia, deliberate hypertension, concomitant coronary artery disease, bradycardia, hypotension
Balloon angioplasty of cerebral vasospasm secondary to aneurysmal SAH	Cerebral ischemia, BP control
Therapeutic carotid occlusion for giant aneurysms and skull base tumors	Cerebral ischemia, BP control
Thrombolysis of acute thromboembolic stroke	Post-procedure haemorrhage, concomitant CAD, BP control
Intra-arterial chemotherapy of head and neck tumors	Airway swelling, intracranial hypertension
Embolization for epistaxis	Airway control

Various complications associated with interventional neuroradiological procedures includes CNS complications like haemorrhagic (Aneurysm perforation, Intracranial vessel injury, dissection), occlusive (Thromboembolic complications, Displacement of coil into parent vessel, coil fracture, Vasospasm) and Non-CNS complications (contrast reactions, contrast nephropathy, haemorrhage at the puncture site, groin haematoma, retroperitoneal haematoma).

SUPERSELECTIVE ANAESTHESIA FUNCTIONAL EXAMINATION AND WADA TEST

The Wada test consists of behavioural testing after the injection of an anaesthetic agent, such as sodium amobarbital or sodium methohexital, into the internal carotid arteries. The test is conducted with the patient awake, to determine the dominant side for vital cognitive functions, namely speech and memory. Typical uses of the test include the lateralization of language abilities before surgery. In surgery for a non-life-threatening condition, for example, epilepsy, this is an important consideration. Superselective anaesthesia functional examination (SAFE) is an extension of the Wada test. It is carried out before therapeutic embolization, to exclude inadvertent placement of the tip of the catheter proximal to the origin of normal vessels supplying important regions in the brain or spinal cord ^{17,18} . The patient should be awake before performing the test. Sodium amytal is injected into the vascular territory planned

for occlusion and repeated neurological examination is made to exclude any functional involvement.

POSTOPERATIVE MANAGEMENT AFTER NEURORADIOLOGICAL PROCEDURES

Endovascular surgery patients pass the immediate postoperative period in a monitored setting to watch for signs of hemodynamic instability or neurologic deterioration. Control of blood pressure may be necessary during transport and postoperative recovery (eg, induced hypertension) if indicated. In particular, patients undergoing treatment of extracranial carotid disease are prone to post-procedural hemodynamic instability, similar to postcarotid endarterectomy patients¹⁹. Abrupt restoration of normal systemic pressure to a chronically hypotensive (ischemic) vascular bed may overwhelm autoregulatory capacity and result in hemorrhage or swelling (normal perfusion pressure breakthrough [NPPB])^{20,21}. The pathophysiology for NPPB is unclear but probably it is not simply a hemodynamic effect. The loss of neurovascular unit integrity probably is related to the pathways involved in postreperfusion hemorrhage in the setting of acute stroke (described previously). In addition, cerebral hyperemia probably is exacerbated if uncontrolled increases in systemic arterial blood pressure occur in the postoperative period. In the absence of collateral perfusion pressure inadequacy, fastidious attention to preventing hypertension is warranted. Complicated cases may go first to CT or some other kind of tomographic imaging; critical care management may need to be extended during transport and imaging. Symptomatic hyperaemic complications are more uncommon than “silent” hyperemic states; and with use of more sensitive MRI, ischemic events are found more common than suspected previously²².

OTHER INTERVENTIONAL RADIOLOGICAL PROCEDURES

The specific anaesthetic techniques has not been recommended for these interventional radiological procedures but needs to be individualized as mentioned earlier.

CATHETERS PLACEMENT

Percutaneous implantation of large-lumen, tunneled, central venous catheters (hickman catheter) can be achieved with a high technical success rate and a low complication rate under combined sonographic and fluoroscopic guidance.²³ These procedures have been performed by interventional radiologist under local anaesthesia.

LOWER LIMB ARTERIOGRAPHY

Arteriography is a relatively painless experience for most patients when modern radiologic techniques are used²⁴. The use of benzodiazepine or opiates should be used very cautiously as such patients have associated cardiorespiratory compromise.

OBSTETRIC PROCEDURES

The adjunctive use of interventional radiology procedures to minimize and control bleeding at the time of cesarean delivery has become increasingly common²⁵. In patients with clinical circumstances where postpartum hemorrhage and hysterectomy were likely, Cesarean delivery is performed in the interventional radiology suite after selective uterine artery balloon placement and/or embolotherapy, which successfully minimized blood loss during delivery.

ENDOSCOPIC RETROGRADE CHOLANGIO-PANCREATOGRAPHY (ERCP)

The cooperation of the patient is essential for performing ERCP. This is sometimes difficult in paediatrics necessitating general anaesthesia. Sometimes prone position is required and thus endotracheal intubation is preferred.

Children with more complex medical problems, anticipated airway difficulties, morbid obesity or behavioural problems can undergo their procedure in the operating room. In addition, the anaesthetic technique depends on the procedure, the patient and the skill of the endoscopist as well as the limitations and capabilities of the endoscopy suite (for example, total intravenous anaesthesia techniques in the absence of appropriate scavenging).

Both diagnostic and interventional EUS are likely to grow over the next decade as equipment and expertise becomes more widely available, and as techniques are developed and refined. There are already reports of EUS guided targeted delivery of immunotherapy into unresectable pancreatic tumors, plus EUS guided radiofrequency ablation of pancreatic tissue in a porcine model²⁶. In addition, EUS guided delivery of high intensity focused ultrasound and radiation therapies are being evaluated^{27,28}.

TRANSJUGULAR INTRAHEPATIC PORTOSYSTEMIC SHUNT (TIPS) PROCEDURE

A TIPS procedure is done in Interventional Radiology under general anesthesia as the procedure can be uncomfortable. Pain control and sedation in patients with severe liver failure

are difficult due to the inability of the liver to metabolize pharmaceuticals²⁹. The approach to the liver is through the venous system. Because the catheter and guidewire systems traverse the heart, cardiac arrhythmias may be expected during TIPS implantation. It requires respiratory motion control during passage into the portal vein necessitating the use of general anaesthesia. The complication of GI haemorrhage necessitates airway management. The use of local anaesthetic infiltration at the tract site and use of sedation has been used during TIPS²⁹.

THORACIC PROCEDURES

Image-guided catheter drainage of infected pleural collections is a safe and effective method³⁰. Ultrasound or CT guidance is usually necessary in the fibropurulent stage of empyema thoracis because multiple loculations develop³¹. Percutaneous drainage of empyema and lung parenchymal abscesses under interventional radiology are described.³²

PERCUTANEOUS CHOLECYSTOSTOMY

Percutaneous cholecystostomy under fluoroscopic and sonographic guidance is easy to perform, with low complication and high success rates. Anaesthesia is obtained with 1% to 2% lidocaine injected locally. Conscious sedation is achieved using intravenous midazolam and fentanyl³³. It is the procedure of choice in patients with acute cholecystitis unfit for emergency surgery.

PERCUTANEOUS GASTROSTOMY AND JEJUNOSTOMY

Although surgeons and gastroenterologists have traditionally provided enteral access services, interventional radiologists can safely, effectively, and successfully perform these procedures as well. Percutaneous enteral access procedures can be performed safely and comfortably with local anaesthesia³⁴. In cooperative patients, conscious sedation is often unnecessary. In high-risk patients with cardiopulmonary disease, this procedure offers a significant advantage over endoscopic and surgical gastrostomy, which usually require conscious sedation and general anaesthesia, respectively.

PERCUTANEOUS ABSCESS DRAINAGE

Image guided drainage of deep-seated abscess have been attempted. After localization of abscess under imaging, the needle is guided by imaging the abscess is drained.

PERCUTANEOUS NEPHROLITHOTOMY

Intrathecal low-dose bupivacaine and fentanyl offers a

reliable neuraxial block for patients subjected to percutaneous nephrolithotomy, with stable haemodynamics, good post-operative analgesia and acceptable patient and endoscopist satisfaction³⁵. PCNL has been performed under the lidocaine infiltration and sedation with benzodiazepine³⁶.

SPECIAL CONCERNS DURING INTERVENTIONAL RADIOLOGICAL PROCEDURES

RADIOLOGY SUITE PREPARATION AND RADIATION SAFETY

Ideally the radiology suite should be equipped for anaesthesia care exactly as a standard operating theatre. Unfortunately, many radiology suites were not built with procedures under general anaesthesia in mind and therefore conditions can be suboptimal.

The need to have an image intensifier around the head end of the fluoroscopy table makes airway access difficult for the anaesthetist.

It is imperative that various equipment and monitors used by radiologists and by anaesthetists are arranged in a convenient manner, which does not cause hindrance to other members of the team. As the radiology suite may not be a familiar environment to work in, it is necessary for all staff members working there to have a fundamental knowledge of radiation safety. Medical personnel are exposed to direct radiation from the X-ray tube or scattered radiation. Optimal protection for personnel includes lead aprons providing at least 0.5 mm lead equivalent thickness. Supplemental shielding devices like thyroid collars, glass lead screens should also be available. All staff should wear dosimeter badges which should be checked monthly or quarterly³³.

DIFFICULT AIRWAY MANAGEMENT IN THE RADIOLOGY SUITE

For cases managed with an unsecured airway, routine evaluation of the potential ease of laryngoscopy in an emergent situation should take into account that direct access to the airway may be limited by table or room logistics. Recent periorbital craniotomy sometimes can result in impaired temporomandibular joint mobility¹⁰.

Management of a suspected difficult airway is a challenge for interventional radiology suite. This is because of the limitation of the availability of the airway gadgets and airway management may be difficult even for an experienced anesthesiologist. It is prudent to manage the

airway in OR or an area having access to airway gadgets for difficult airway and than shift the patient to the interventional radiology suit. The unrecognized difficult airway is problematic in a remote location. Therefore, it is important to have LMA stocked in all extramural anesthesia carts.

BLOOD LOSS MANAGEMENT OUTSIDE OF THE OPERATING ROOM

Transfusion requirements are rare in extramural locations, yet pre-procedural anaemia, accidental perforation of vascular structures or medical transfusion requirements such as sickle cell disease or prematurity may require transfusion therapy. The blood bank should be approachable and assistant for arranging the blood urgently should be available especially in at risk cases of bleeding.

CONTRAST REACTIONS

The most commonly used contrast for INR nowadays is iohexol (non-ionic) with an osmolality of 672 mOsm/kg. Although fatal reactions occur at the same frequency ionic agents (1:10 000 exposures), non-ionic agents have a lower incidence of mild and moderate reactions^{37,38,39,40}. Reactions can be caused by hypertonicity, direct cardiac depression, or idiosyncratic anaphylactoid reactions.

SAFE ADMINISTRATION OF SEDATION AND ANALGESIA

The safe administration of sedation and analgesia requires knowledge of the drugs available and an appreciation of the potential complications associated with their use. Principles to ensure safe and effective use of these agents are as follows:

1. Sedative drugs should be easily titrated to the desired clinical effect and should have a predictable onset and duration of action, with a rapid recovery.
2. Intravenous administration is preferred to oral, as it allows a more reliable rate of onset, and more predictable absorption.
3. Every drug should be titrated in small increments.
4. Sufficient time should be given, to allow the drug effect to be evaluated before giving further doses, or administering another drug.
5. Combinations of drugs should be used cautiously, and careful patient assessment should be noted.
6. Remember, repeated dosing may be required during a prolonged procedure to maintain a consistent, adequate level of sedation or analgesia.
7. Supplemental oxygen should be administered, via facemask, to all patients receiving anything more than minimal sedation or analgesia.

The provision of safe, effective sedation and analgesia requires an understanding of the individual patient, the procedure being undertaken, and a working knowledge of drugs and techniques available to provide both analgesia and sedation.

The radiology suite must have adequate facilities to provide pre- and post-sedation care and staff that are familiar with delivering, monitoring, recognizing, and dealing with complications arising from sedation. A close working relationship between the radiology and anesthesiology departments is vital, to ensure timely patient referral, assessment, and adequate facilities and for efficient use of staff.

CONCLUSION

In conclusion, the type of anesthetic administration employed in interventional radiological procedures is determined by the physical conditions of the operation room together with the experience of the radiology-anesthesia team. When anesthetizing these patients, proper monitorization must be utilized and conditions for possible urgent intervention and intensive care observed because of the probability of complications such as hemorrhage, vascular occlusion, or anaphylactic reactions. Moreover, performing interventional radiology with a permanent anesthesia team in the radiology department may prove to be invaluable.

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