REVIEW ARTICLE

ANAESTHESIA FOR INTERVENTIONAL NEURORADIOLOGY

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There have been rapid and significant advances in diagnostic and interventional radiology, including interventional neuroradiobgy, in recent years. Many intracranial vascular pathologies are being successfully managed by endovascular interventional neuroradiology techniques. These techniques include procedures like embolization of vascular tumours and arterio-venous malformations, coiling of cerebral aneurysms, etc. The support of anaesthesia team is requested for these therapeutic endovascular neuroradiological procedures. The main aims of the anaesthesiologist during any interventional neuroradiology procedure are provision of a physiologically stable and immobile patient, alteration of arterial blood pressure as necessary, and appropriate and timely management of complications. Provision of anaesthesia in remote locations, such as the radiology suite, has its own inherent risks. In this article the anaesthetic considerations for therapeutic interventional neuroradiology procedures performed in the radiology suite have been reviewed, including the preprocedure preparation, monitoring requirements, suitable anaesthetic techniques, postprocedure management and complications.

Key Words: Anaesthesia; Neuroradiology; Interventional radiolo gy

INTRODUCTION

Over the last two decades, the medical world has seen rapid advances in diagnostic and interventional radiology, including interv entional neuroradiology.[1,2]

Many intracranial vascular pathologies can now be successfully managed by interventional neuroradiology techniques by the endovascular approach, thus either avoiding surgical intervention or making it safer for the patient.[3] These techniques include embolization of vascular tumours and arterio-venous malformations (AVM), coiling of cerebral aneurysms, and balloon occlusion of arteries of some vascular lesions.[4] It has been shown that endovascular intervention with detachable pla tinum coils in patients with ruptured intracranial aneurysms can improve the chances of independent survival compared with neurosurgical intervention to clip the neck of the aneurysm.[3,5]

Keeping in step with this worldwide advancement, many radiologists in Pakistan are now routinely performing these procedures. These advances have provided new and less invasive therapeutic options for the patients, but at the same time, have also led to increased demands on anaesthesia services.

The role of the anaesthesiologists in the interventional neuroradiology suite are to provide appropriate anaesthesia to facilitate the procedure, to ensure patient safety by appropriate monitoring, and to manage any complications that may arise.[6]

An increase in patient volume requ iring this therapeutic modality of modern-day medicine is most likely to occur in the years to come and this would lead to increased challenges for anaesthesiologists.

Comprehensive literature on the anaesthetic management of these patients, the expected complications and their prompt and timely management is scarce and most commonly read anaesthesia books have only included an outline of this aspect of anaesthesia practice.

This article reviews the anaesthetic considerations for therapeutic interventional neuroradiology procedures as an endeavour to act as a guide for those involved in this upcoming and challenging practice. In addition to the review of the available literature, the practice in the author's institute is mentioned at various important points to incorporate the local trends and limitations.

ANAESTHETIC CONSIDERATIONS

The procedures performed in interventional neuroradiology suite are inherently dangerous. In addition, provision of anaesthesia in remote locations such as the radiology suite, has its own inherent risks.

Missant and de Velde reported that anaesthesia procedures performed outside the operating room may increase morbidity and complications due to the difficulty of reaching the patient during an emergency, working in a small area, insufficient monitoring, and lack of cooperation between the working teams.[7] Assigning a designated anaesthesia team in radiology departments may reduce the rate of morbidity in these patients.[8] Jones et al have suggested that experienced neuroanaesthes ia team is preferable in interventional neuroadiology departments.[9]

Pre-anaesthetic Assessment:

All interventional radiological patients requiring anaesthesia must be seen by the anaesthesiologist and a thorough pre-procedure assessment should be done, including relevant history, physical examination and appropriate investigations.[10]

History of concurrent illness like diabetes mellitus, hypertension, ischemic heart disease, renal impairment etc. and their status of optimization should be determined. The control of pre-procedure

essential hypertension is critical for hemodynamic stability in patients with occlusive cerebrovascular disease.[10] Possibility of pregnancy in female patients should be considered and ruled out. Inquiries should be made about any history of reactions to radiological contrast material. Guidelines for pre-anaesthesia fasting should be followed in all patients.[11]

Relevant physical examination should be carried out and an examination of the pre-procedure neurological status is absolutely essential, so that it could be compared with the post-procedure status.[12] Laboratory investigations include routine haematological and biochemical tests according to the institutional policy and the patient's physical condition. Written informed consent must be obtained from the patient or the next of kin before proceeding with the procedure.[13]

Pre-medication

If the patient is alert and very anxious, an anxiolytic can be prescribed.[12] On the other hand, in cases of altered consciousness, sedative premedication should be avoided. The patient might already be on calcium channel blockers like nimodipine as a brain protection agent or for reducing the incidence of vasospasm during passage of endovascular catheter.[14] Anticonvulsants, corticosteroids, antibiotics etc. might be used as premedication depending upon the patient's status and requirements. In patients with subarachnoid haemorrhage, obesity or gastroesophageal reflux, H_2 receptor antagonists such as ranitidine and metoclopramide are used to decrease the risk of aspiration.[15]

Pre-procedure Preparation

Ideally the interventional radiology suite should be equipped for anaesthetic care similar to a standard operating room.[6] The anaesthesiologist must check the medication trolley and equipment and ensure that all essential medications are available and all equipment is in perfect working conditions.[2,9]

Of particular importance is to ensure continuous supply of oxygen and working suction. Emergency resuscitation drugs, anaesthetic drugs and intravenous fluids should be available on the drug trolley.[2,6,9] Emergency trolley for cardiopulmonary resuscitation, materials for access to airway and difficult airway equipment should be immediately available. The anaesthesia circuits must have extension tubing. All standard monitoring equipment should be available and in perfect working conditions.[2] Provision must be available for invasive monitoring of arterial and venous pressures.[5,9]

The arrangement of the equipment should be such that the imaging devices can rotate freely around the head.[16] The anaesthesia personnel should wear lead aprons and thyroid shields and ideally movable lead-glass shields should also be placed for the anaesthesiologist to stand behind.[6]

MONITORING

Monitoring of the patient under anaesthesia in a remote location should be of the same standard as that in the operating room (OR).[17]

Adequate monitoring may reduce the complications associated with interventional radiological procedures.[18] This should include an electrocardiogram (ECG), pulse oximetry, non-invasive blood pressure (NIBP) and capnography. There should also be a provision for temperature monitoring.[17] Indications for direct arterial line monitoring include induced hypotension, induced hypertension, intracranial or spinal cord procedures, haemodynamically unstable patients and systemic heparinization with frequent monitoring of activated clotting time (ACT).[16] In the author's institute invasive arterial monitoring for blood pressure is routinely used for these cases and provision has been made in the radiology suite to enable this monitoring. As opposed to surgical management of intracranial vascular lesions, marked fluid shifts, blood loss and air embolism are less likely to occur during interventional neuroradiology treatment[17], therefore CVP lines should only be inserted if these patients have serious co-morbidities or are haemodynamically unstable requiring vasoactive drug infusions.[16]

Neurological monitoring, including electroencephalogram, somatosensory and motor-evoked potentials , transcranial doppler ultrasound etc might be indicated to help in determining central nervous system integrity during the procedure.[6] The use of such monitoring largely depends upon financial resources and availability. All patients undergoing major endovascular neuroradiological procedures should be catheterized to monitor their urine output.[16]

All monitoring lines should be of sufficient length to prevent stretching and disconnection.

ANAESTHETIC TECHNIQUES

Intravenous Sedation or General Anaesthesia

The anaesthetic objectives in endovascular interventional neurovascular procedures are the same as those in traditional neurosurgery.[16] The management of intracranial pressure dynamics, blood pressure, intravascular volume and $PaCo_2$ control are even more important in these cases as the cranium is not opened.[16] The technique of anaesthesia used for interventional neuroradiology procedures is influenced by the preference of both the anaesthesiologist and the neuroradiologist. Both, sedation and general anaesthesia have been described.[4,19]

The anaesthetic technique employed must be based on the experience of the anaesthesiologist and the requirements and goals of the anaesthetic management. A technique that allows for rapid

haemodynamic control and prompt emergence is desirable.[20,21]

Many of the procedures performed in interventional neuroradiology suites requiring anaesthesia care can be performed under sedation and monitored anaesthesia care.[4] When carefully performed with the use of appropriate sedative agents, this technique allows rapid neurological assessments during the procedure, which is often desirable.[19] During sedation the patient can serve as an effective monitor of his own neurological status.[17]

Neuroradiologists who prefer to embolize under general anaesthesia rely on the knowledge of neuroanatomy and vascular architecture to ascertain the likelihood of neurologic damage after deposition of the embolizing material.[22] General anaesthesia allows for improved visualization of structures, provision of temporary apnoea and absence of patient movement[22], permitting optimal image acquisition and treatment delivery.[8]

Procedures like embolization of AVM or coiling of aneurysms can take a long time and require complete patient stillness. It would be very difficult for the patient to be still for long periods on a radiology table and in a cold environment, especially if his blood pressure is being manipulated and his sedation is being lightened intermittently for neurological assessment. Should a complication occur during a procedure, such as aneurysm rupture, it could be very difficult for the radiologist to control the situation by delivering and detaching a coil unless the patient remains absolutely immobile.[8] Thus sedation might not be able to achieve the required conditions or adequate cooperation of the patient.[17] In such situations general anaesthesia is a better choice, and neuroradiologists are increasingly requesting general anaesthesia for interventional procedures.[21,23] This is also the case at the author's hospital where all therapeutic endovascular neuroradiology procedures are performed under general anaesthesia.

Good intravenous access is important before starting both general anaesthesia and Monitered Anaesthesia Care (MAC) with sedation, and for major cases two intravenous (IV) cannulae should be placed, one atleast 18 G or greater.[6] Long extension tubings with 3way connectors are mandatory for easy access to the IV line for bolus injections. It is very important for the anaesthesiologist to be well prepared and organized as access to the patient and especially the IV sites might be difficult during the procedure. Therefore IV tubings and extensions should be appropriately checked and well labeled before the patient is placed in the final position and handed over to the radiologists. Similarly any vasoactive drugs planned or expected to be used for blood pressure manipulation should be available at hand as moving around the bulky and fixed fluoroscopy machine can be awkward.

During the procedure, radiologists use heparin through the femoral catheter and may also request the anaesthesiologists to administer heparin.[16] The anaesthesiologist should document the time and dose of heparin. In the unfortunate event of aneurysm or vessel rupture during the procedure, the radiologist will urgently request for the antagonism of heparin with protamine sulphate (1mg/100units of heparin).

GENERAL ANAESTHESIA

Indications and rationale for general anaesthesia for interventional neuroradiology procedures include a better airway control, facilitation of induced hypotension or hypertension, need for a motionless patient, assistance in control of raised intracranial pressure (ICP) and enhancing cerebral protection.[20]

Anaesthesia should be induced after careful preoxygenation. Both, thiopentone and propofol have been used but as quick emergence is desired, propofol is the preferred choice in most cases.[21] A short to intermediate acting analgesic agent like Fentanyl, 1-2 mcg/kg, is a suitable agent and is usually required only at the induction of anaesthesia. Using Fentanyl at induction is helpful in the prevention of exacerbated haemodynamic response to laryngoscopy and intubation, which is especially important for patients who might have a raised ICP.[24]

Amongst the muscle relaxants, atracurium is preferred, the reason again being the need to prevent delays in emergence.[21] Endotracheal intubation and intermittent positive pressure ventilation is usually employed. Laryngeal mask airway without neuromuscular blockade can be used as an alternative.[23] The anaesthesia team may facilitate the neuroradiologist in many ways by manipulating systemic blood pressure and controlling end tidal $PaCo_2$.[21-23]

Induced Hypotension

Electively induced hypotension is required to slow blood flow in an AVM feeding artery before the injection of glue for embolization of an AVM.[22] Sodium nitroprusside (SNP) and nitroglycerine have been described for these procedures.[6,22] It is the author's practice to use nitroglycerine infusion titrated to achieve the desired effect. One has to be cautious while using drugs like SNP and GTN as it is easy to overshoot the dose and render the patients severely hypotensive.[6] Beta adrenergic blockers like Esmolol, would be a better choice as adrenergic blockers have the advantage of not affecting cerebral blood flow directly.[24] Esmolol can be given as a 0.5-1 mg/kg bolus followed by an infusion of 0.1-0.5 mg/kg/min.[25] Unfortunately, Esmolol is not locally available at present.

Blood Pressure Augmentation

In some cases of interventional neuroradiology procedures, inadvertent vascular occlusion and cerebral ischemia may occur. In these situations systemic blood pressure should be increased to drive

adequate flow through collaterals to the area of ischemia as a quick but temporary measure to control the situation.[26] Phenylephrine could be used as a 1 µ/kg bolus. Then a titrated infusion can be started to keep the blood pressure 30 – 40 % above baseline.[22] The ECG should be watched for signs of myocardial ischemia. If phenylephrine could not be used either due to a slow heart rate or unavailability, Dopamine infusion could be used.[6] Deliberate hypertension is not guaranteed to succeed as adequate collateral pathways might be absent.[26]

SEDATION AND MONITORED ANAESTHESIA CARE (MAC)

The patient should first be made as comfortable as possible. The aims of IV sedation are to alleviate pain and discomfort, reduce anxiety, and ensure that the patient remains still, but at the same time be able to rapidly reduce sedation when neurologic testing is required.[4] It is suggested that carefully titrated sedation is a suitable technique for therapeutic endovascular neuroradiology procedures as it allows for intraprocedure neurological examination and assessment[17], thus allowing any new neurological deficit during the procedure to be quickly diagnosed. The selection of sedation regime must be based on the procedure being conducted, the experience of the anaesthesiologist and availability of drugs.[21]

A multimodal method using Midazolam 1 mg bolus, repeated if required, Fentanyl 1-2 mcg/kg, followed by a Propofol infusion of 10 – 25 mcg/kg /min is a well documented technique.[22] When properly titrated, this technique is useful for intraprocedure neurologic assessment. When using opioids as an adjunct to IV sedation, one must be vigilant about airway patency and respiratory depression.[8] In the sedated patient, shivering can interfere with image quality.[16] Patients, especially children, should be covered with warm blankets. During the provision of sedation, anaesthesia team should be ready for the potential risk of respiratory arrest or other cardiorespiratory complications.[27]

POST-PROCEDURE MANAGEMENT

Awakening period after AVM embolization and coiling of aneurysms is very critical. Rapid and smooth emergence without haemodynamic stress, cough, or strain to prevent increases in intracranial pressure is very important.[23] Any unnecessary straining or a sudden increase of blood pressure may cause intracranial haemorrhage.[21] An experienced anaesthesia team regularly assigned in the radiology suite may be more efficient in preventing these adverse events.[27] At the conclusion of the procedure, patients should recover from anaesthesia and sedation in a well equipped post anaesthesia care unit (PACU) with trained staff and appropriate monitoring and resuscitation equipment at hand.[21,28] Many of the patients undergoing endovascular neuroradiological procedures require intensive care and are transported directly to intensive care unit (ICU), special care unit or main operating room PACU. The transfer to these units should be supervised by the anaesthesiologist and the patient's peripheral oxygen saturation, blood pressure and ECG should be monitored during transfer.[21]

Post procedure blood pressure control is important, i.e. modest hypotension in the case of AVM embolization or relative hypertension in the patient with occlusive disease or cerebrovascular vasospasm.[26] After the treatment of AVM, the blood pressure should be kept about 10% below the patient's normal blood pressure, as restoring normal systemic pressure abruptly to a chronically hypotensive vascular bed may disturb autoregulation and result in haemorrhage or swelling.[22] Close observation of the neurological status of the patient is essential and coordination with neurologist and neurosurgeon is important. The anaesthesiologist must be quickly available in case airway compromise is suspected. Anticoagulation with heparin is required during and up to 24 hours after interventional radiological procedures to prevent thromboembolism.[21] The usual dose is a 3000 – 5000 unit bolus and 1000 u/hour to maintain ACT at around 2.5 times the baseline.

COMPLICATIONS

The two most serious complications of interventional neuroradiology procedures are intracranial haemorrhage and thromboembolic stroke.[22] Their incidence during coiling of cerebral aneurysms is 2.4 and 3.5% respectively[23] and during AVM embolization it is 1-8 %.[29]

The anaesthesiologist should be aware of the risks and hazards of the different procedures and there should be effective communication and close collaboration with the neuroradiologist from the beginning so that appropriate management of any potentially fatal haemorrhagic or ischemic complications could be quickly initiated.[20,30]

If a neurological catastrophe occurs, the anaesthesiologist's primary responsibility is to keep the airway secured, ensure adequate gas exchange and support systemic circulation.[8,23]

If haemorrhage has occurred, heparin should be rapidly reversed with protamine 1mg for each 100 unit heparin used during the procedure.[16] The ACT can guide about further protamine requirement. Blood pressure should be kept low during the haemorrhage. Once the bleeding has been controlled, blood pressure is required to be kept normal to high.[22]

The decision whether the patient should be taken for surgery is made in collaboration with the neurosurgeon. In case of vascular occlusion, deliberate hypertension should be induced to increase distal perfusion while the radiologist may try for direct thrombolysis if practical.[6] Another complication that might occur is reaction to the

contrast material.[21] The incidence is less with currently used nonionic agents. Pretreatment with steroids and antihistamines should be employed for patients with a history of such reactions.[31]

Patients who have had complications frequently require postoperative intensive care support. At the author's hospital patients are transferred to the main operating room PACU for recovery and those requiring post procedure ventilation are admitted to the ICU.

CONCLUSION

Endovascular treatment of intracranial vascular pathologies is now widely used and has important implications for anaesthesiologists. Significant issues regarding the anaesthesiologist's involvement in these cases include the decision to use general anaesthesia or sedation, specific factors associated with anaesthesia in the interventional radiology suite, provision of a physiologically stable and immobile patient, altering arterial blood pressure as necessary, and emergency care of catastrophic complications.

Good relationships between a hospital's departments of radiology and anaesthesia are key to providing the best environment for good working practices. The limitation of resources should be born in mind and anaesthesia management planned accordingly. Adequate monitoring may reduce the complications associated with interventional radiological procedures.

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