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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 urteteronephrostomy
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. ArteriovenousMalformations - 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 invidualized.

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 States [5] . In an another survey [6] 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 radiology [2] . 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 ischaemia [7] . This should be continued as it lessens the incidence of traumatic vessel spasm during catheter passage in neck as well as in the intracranial arteries [8] .

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 oximetery, non invasive blood pressure, capnography , certain special haemodynamic monitoring (arterial catheter, central venous pressure) and haemostatic monitoring may be necessary for certain procedures [7] . 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 diuresis [9] . 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 controla
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, bradycadia, 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 endartectomy patients [19] . 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 moreuncommon than ‘‘silent'‘ hyperemic states; and with use of more sensitive MRI, ischemic events are found more common than suspected previously [22] .

OTHER INTERVENTIONAL RADIOLOGICAL PROCEDURES

The specific anaesthetic techniques has not been recomended 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 used [24] . 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 common [25] . 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 model [26] . 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 pharmaceuticals [29] . The approach to the liver is through the venous sysytem. 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 TIPS [29] .

THORACIC PROCEDURES

Image-guided catheter drainage of infected pleural collections is a safe and effective method [30] . Ultrasound or CT guidance is usually necessary in the fibropurulent stage of empyema thoracis because multiple loculations develop [31] . 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. Anesthesia is obtained with 1% to 2% lidocaine injected locally.Conscious sedation is achieved using intravenous midazolam and fentanyl [33] . 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 anesthesia [34] . 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 anesthesia, 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 satisfaction [35] . PCNL has been performed under the lidocaine infiltration and sedation with benzodiazepine [36] .

SPECIAL CONCERNS DURING INTERVENTIONAL RADIOILOGICAL 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 quarterly [33] .

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 pterional craniotomy sometimes can result in impaired tempomandicular joint mobility [10] .

Management of a suspected difficult airway is an 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 mange 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 anesthesic 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 anaphlactic reactions. Moreover, performing interventional radiology with a permanent anesthesia team in the radiology department may prove to be invaluable.

CORRESPONDENCE TO

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References

1. Neilson GA, Pamela H, Lennox MB. Sedation and anaesthesia for interventional oncology. Seminars in Roentgenology 2007;42:150-163.
2. Mueller PR, Biswal S, Halpern EF, Kaufman JA, Lee MJ. Interventonal radilogic procedures: patient anxiety, perception of pain, understanding of procedure, and satisfaction with medication - a prospective study. Radiology 2000:215:684-688.

3. Shabanie A . Conscious sedation for Interventional Procedures: A Practical Guide. Sedation. Techniques in vascular and Interventional Radiology 2006;9:84-88.
4. Mason KP, Michna E, Dinardo JA, Zurakowski D, Karlan VE, Connor L, Burrows PE. Evaluation of a protocol for ketamine induced sedation as an alternative to general anesthesia for interventional radiologic procedures in pediatric patients. Radiology 2002;225:457-465.
5. Haslam PJ, Yap B, Mueller PR, Lee MJ. Anesthesia practice and clinical trends in interventional Radiology: a European survey. Cardiovascular and Interventional radiology 2000;23:256-261.
6. Trotteur G, Stockx L, Dondelinger RF. Sedation, analgesia and anesthesia for interventional radiological procedures in adults. Part I. Survey of interventional radiological practice in Belgium. JBR-BTR 2000;83:111-15.
7. Lakhani S, Guha A, Nahser HC. Anaesthesia for endovascular management of cerebral aneurysms. Eur J Anaesthesiol 2006;23:902-913.
8. Young WL, Pile-Spellman J. Anaesthetic considerationsfor interventional neuroradiology. Anesthesiology 1994; 80:427-456.
9. Jaeger K, Ruschulte H, Herzog T et al. Anaesthesiological and critical care aspects regarding the treatment of patients with arteriovenous malformations in interventional neuroradiology. Minim Invas Neurosur 2000; 43: 102-105.
10. Young WL. Anesthesia for endovascular neurosurgery and interventional neuroradiology. Anesthesiology Clin 2007;25:391412.
11. Qureshi AI, Suri MFK, Khan J et al. Endovascular treatment of intracranial aneurysms by using gugleilmi detachablecoils in awake patients: safety and feasibility. J Neurosurg 2001; 94: 880-885.
12. Manninen PH, Gignac EM, Gelb AW, Lownie SP. Anesthesia for interventional neuroradiology. J Clin Anaesth 1995;7: 448-452.
13. Manninen PH, Chan ASH, Papworth D. Conscious sedation for interventional neuroradiology: a comparison of midazolam and propofol infusion. Can J Anaesth 1997; 44: 26-30.
14. Luginbuhl M, Remonda L. Interventional neuroradiology. Recent developments and anaesthesiologic aspects. Minerva Anesthesiol 1999; 65: 445-454.
15. Wang LP, Wolff J. Anesthetic management of severe chronic cardiopulmonary failure during endovascular embolisation of a PICA aneurysm. J Neurosurg Anesth 2000; 12: 120-123.
16. Varma MK, Jayakrishnan V, Manickam B, Kessell G. Anaesthetic considerations for interventional neuroradiology. Br J Anaesth 2007;99:75-85.
17. Barnwell SL. Interventional neuroradiology. West J Med 1993;158: 162-70.
18. Rauch RA, Vinuela F, Dion J, et al. Preembolization functional evaluation in brain arteriovenous malformations: the ability of superselective Amytal test to predict neurologic dysfunction before embolisation. Am J Neuroradiol 1992; 13: 309-314.
19. Qureshi AI, Luft AR, Sharma M, et al. Frequency and determinants of postprocedural hemodynamicinstability after carotid angioplasty and stenting. Stroke 1999;30:2086-93.
20. Meyers PM, Higashida RT, Phatouros CC, et al. Cerebral hyperperfusion syndrome after percutaneous transluminal stenting of the craniocervical arteries. Neurosurgery 2000;47:335-43.
21. Young WL, Kader A, Ornstein E, et al. Cerebral hyperemia after arteriovenous malformation resection is related to "breakthrough" complications but not to feeding artery pressure.Columbia university AVM study project. Neurosurgery 1996;38:1085-93.
22. Cronqvist M, Wirestam R, Ramgren B, et al. Endovascular treatment of intracerebral arteriovenous malformations: procedural safety, complications, and results evaluated by MRimaging, including diffusion and perfusion imaging. AJNR Am J Neuroradiol 2006;27:162-76.
23. Gebauer B, Teichgraber UMK, Werk M, Beck A, Wagner HJ. Sonographically guided venous puncture and fluoroscopically guided placement of tunneled, large-bore central venous catheters for bone marrow transplantation-high success rates and low complication rates. Supportive Care in Cancer 2008;16:897-904.
24. Kennedy PT, Kelly IMG, Loan WC, Boyd CS. Conscious sedation and analgesia for routine aortofemoral arteriography: a prospective evaluation. Radiology 2000;216:660-664.
25. O'Rourke Nollag, McElrath T, Baum R, Camann W, Tuomala R, Stuebe A, Kodali BS. Cesarean delivery in the interventional radiology suite: a novel approach to obstetric hemostasis. Anesth Analg 2007;104:1193-4.
26. Phillips-Hughes J. invasive and interventional uses of endocscopic ultrasound. The British journal of Radiology 2007;80:1-2.
27. Fusaroli P, Caletti G. Endoscopic ultrasonography.Endoscopy 2005;37:1-7.
28. Tamerisa R, Irisawa A, Bhutani MS. Endoscopic ultrasoundin the diagnosis, staging and management of gastrointestinaland adjacent malignancies. Med Clin N Am 2005;89:139-158.
29. Pulido-Duque JM, Reyes R, Gorriz E, Cabrera J, Rostagno R, Castaneda-Zuniga WR, Maynar M. Intraparenchymal anesthesia infiltration during transjugular intrhepatic portosystemic shunting. Radiology 1992;185:903-904.
30. Akhan O, Ozkan O, Akinci D, Hassan A, Ozmen M. Image guided catheter drainage of infected pleural effusuions. Diagn Interv Radiol 2007;13:204-209.
31. Jutley RS, Waller DA. Empyema Thoracis. Surgery 2005;23:398-400.
32. Norman JT, Donaldson JS. Interventional Procedures in the Pediatric Chest: Biopsy and Drainage. Seminars in Interventional Radiology 2002;19:39-50.
33. Byrne MF, Suhocki P, Mitchell RM, Pappas TN, Stifler HL, Jowell PS, Brancch MS. Baillie J. Acute cholecystitis: experience of 45 patients at a US referral center. J Am Coll Surg 2003;197:206-211.
34. Pearce CB, Duncan HD. Enteral feeding. Nasogastric, nasojejunal, percutaneous endoscopic gastrostomy, or jejunostomy: its indications and limitations. Postgrad Med J 2002;78:198-204.
35. Atallah MM, Shorrab AA, Abdel YM, Demian AD. Low dose bupicaine spinal anaesthesia for percutaneous nephrolithotomy: the suitability and impact of adding intrathecal fentanyl. Acta Anaesthesiol Scand 2006;50:798-803.
36. Aravabtinos E, Karatzas A, Gravas S, Tzortzis V. Feasibility of percutaneous nephrolithotomy under assisted local anaesthesia: A prospective study on selected patients with upper urinary tract obstruction. European Urology 2007;51:224-228.
37. Caro JJ, Trindade E, McGregor M. The risks of death and ofsevere nonfatal reactions with high- vs low-osmolality contrast media: a meta-analysis. Am J Roentgenol 1991; 156: 825-32.
38. Caro JJ, Trindade E, McGregor M. The cost-effectiveness of replacing high-osmolality with low-osmolality contrast media. Am J Roentgenol 1992; 159: 869-874.

39. Hirshfeld JW, Jr. Low-osmolality contrast agents-who needs them? N Eng J Med 1992; 326: 482-4.
40. International Subarachnoid Aneurysm Trial (ISAT) CollaborativeGroup. International subarachnoid aneurysm trial of neurosurgicalclipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised trial. Lancet 2002;360: 1267-74.

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