Immediate Anesthesia Management Of Complications During Embolization Of Cerebral Vascular Lesions

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Abstract

Interventional neuroradiology (INR) can provide treatments for central nervous system (CNS) diseases, especially for intracranial vascular lesions by endovascular access in order to deliver therapeutic agents, including both drugs and devices. The procedures can be lengthy and uncomfortable and patients require sedation or anesthesia in addition to continuous monitoring of the cardiorespiratory and neurologic systems. The anesthetic management, the occurrence and the treatment of complications are reviewed in 101 patients who underwent a total of 121 INR procedures. Under general endotracheal anesthesia a superselective microcatheter was introduced into the cerebral circulation via the femoral artery. The coaxial catheter was advanced into the lesion with fluroscopic guidance and used to deliver embolic materials into the lesion. Charts were reviewed for information regarding the anesthetic management, monitoring technique, intraoperative complications and the anesthetic intervention. There were documented 22 episodes of anesthetic or radiological technique-related complications. Anesthesia was involved in 7 cases and 15 complications were directly related to the INR.

INTRODUCTION

Interventional neuroradiology (INR) can provide treatments for central nervous system (CNS) diseases by radiological techniques and new therapeutic options were described during the last decades ([1]). These procedures include embolization of arteriovenous malformations (AVMs), intracranial aneurysms, vascular tumors, balloon occlusion of arteries supplying aneurysms and arteriovenous fistula ([2]). The goal of this treatment is to prevent the blood flow into the aneurysm sack by filling the aneurysm with coils, using the principles of electrothrombosis and electrolysis ([3]) or in case of AVMs, the obliteration of the nidus of the AVMs by occlusion feeder vessels ([4]). The method involves the placement of a catheter into the femoral artery and floating it just proximal to the aneurysm or to the feeding artery of the AVMs.

Because of a recent advancement in the field of INR, more anesthesiologists are involved in care of patients undergoing INR procedure. Anesthesiologists have several important concerns when providing care to patients who undergo INR procedures, including maintenance of patient immobility and physiologic stability, manipulating systemic or regional blood flow, managing anticoagulation, treating and managing sudden unexpected complications during the procedure, guiding the medical management of critical care patients during the transport to and from the radiology suites and rapid recovery from the anesthesia and sedation during or immediately after the procedure to facilitate neurologic examination and monitoring ([5]).

The purpose of this study is to review retrospectively the intraoperative management of patients undergoing INR procedures and the occurrence and treatment of any complications encountered.

PATIENTS AND METHODS

Between 2001 and 2003, 101 patients at our institution underwent 121 INR procedures for the treatment of aneurysm or AVM's (table 1). The clinical records were reviewed and the data collected from the charts included the anesthetic management and monitoring, the neuroradiological techniques and details of intraoperative complications that occurred either as a result of the anesthesia or the procedure. No patient was excluded.

Figure 1

Table 1: Patient Data

Lesion	No Patients	No Procedure
AVM	21	35
Aneurysm	80	86
Total	101	121

AVM= Arteriovenous malformation.

Eighty patients underwent 86 INR procedures for the treatment of aneurysm (5 patients had more than one procedure), 51 male and 35 female. Neurological assessment was performed using the Hunt and Hess classification in the radiology suite (table 2). Thirty-four patients had ruptured aneurysms. Four patients have been transported intubated either from the ICU or another hospital. Seventy-four patients submitted to elective and 12 patients to emergency endovascular treatment. The mean age (year ±SD) of the patients was 51 ± 13 years (range from 18 to 77 years).

Figure 2

Table 2: Hunt and Hess Classification of patients with aneurysm

Hunt Hess Classification	No patients With aneurysm
0	52
1	17
2	5
3	6
4	2
5	4
Total	86

Twenty-one patients underwent 35 elective INR procedures for the treatment of AVM's (9 patients had more than one procedure), 24 male and 31 female. Five patients were suffered of subarachnoid or intracranial bleeding due to rupture of the lesion. All the procedures were elective. The mean age (year ±SD) of the patients was 42 ± 14 year (a range from 25 to 76 years).

The premedication was the same for all patients, benzodiazepines orally.

In the radiology suite, the monitoring was ECG, SpO_2 placed on the great toe of the leg at the side of the femoral introducer sheath, $EtCO_2$, NIBP and Invasive Blood Pressure via the femoral artery introducer sheath. Monitoring of CVP was placed only in patients who needed vasoactive drug infusion or monitoring of cardiac filling pressures. The bladder catheter was required for most of the procedures because it assists in fluid management, as a significant volume of heparinized flush solution and radiographic contrast is often used. All the patients underwent angiography before the INR procedure. Under local anesthesia, the transfemoral catheterization was performed and a 7.5 Fr sheath was inserted into the femoral artery using the Seldinger technique. A coaxial catheter 7.0 Fr was advanced through the introducer sheath into the carotid artery under fluoroscopic guidance and the cerebral vessels were revealed.

Under general anesthesia with intravenous anesthetic agents (propofol or pentothal), opioid (fentanyl or remifentanyl), lidocaine and neuromuscular relaxants (cis-atracurium or rocuronium bromide), the endotracheal tube was placed to secure the airway. Ventilation was maintained to achieve normocapnia ($PaCO_2$: 30-35 mmHg) or mild hyperventilation with FiO_2: 0.4 and N_2O/O_2: 60/40. The maintenance of anesthesia included either continuous infusion of propofol and/or remifentanyl or bolus fentanyl plus continuous infusion of muscle relaxants. Volatile agents were used only for patients without clinical symptoms of increased intracranial pressure (ICP). Although, the mean arterial pressure (MAP) ranged from 60-80 mmHg during the whole procedure, the minimum allowable pressure during the period of the placement of coils or other supplements was 55-60 mmHg, for short periods of induced hypotension. Patients with history of hypertension lowered the MAP at least up to 75 mmHg. Vasodilators (nitroglycerin), b-blocker (esmolol) and a-blocker were used to control blood pressure intraoperatively.

A superselective microcatheter 1.5-2.8 Fr was introduced into the cerebral circulation through the coaxial catheter and advanced into the lesion with fluoroscopic guidance, too. The superselective catheter was used to deliver embolic materials into the lesion.

RESULTS

Information was available from 121 charts: 101 patients

underwent a total of 121 separate procedures (14 patients had more than one procedure) (Table 1).

There were documented 22 episodes of anesthetic or radiological technique-related complications (Table 3). Anesthesia was involved in 7 of these and 15 complications were directly related to the interventional procedure.

Figure 3

Table 3: Incidence of complications during embolization of aneurysms and AVM's

Complications	No of pts with aneurysm	No of pts with AVM
vasospasm	6	-
Bleeding due to rupture	8	-
Neurologic deficit	1	-
Bradycardia-hypotension	4	2
Respiratory failure	1	-
Total	**20**	**2**

After the end of the procedure, 15 patients were transported intubated to the ICU and 106 patients to the ward, after short time staying in the recovery room: fourteen of these patients after embolization of aneurysm and one after embolization of AVM.

Eight patients suffered from aneurysm rupture and the goal was to increase coagulability. Bleeding occurred during coiling. Hemorrhage was manifest as extravasation of contrast medium, with a sudden rise of systolic blood pressure. Protamine was administrated rapidly to reverse heparin. The blood pressure was decreased as low as possible using esmolol (b-blocker), clonidine (a-agonist), nitroglycerin (vasodilators) and nifedipine (calcium antagonist). Thiopental 100-150mg bolus administrated for cerebral protection and seizure prevention activity from acute subarachnoidal bleeding. In addition the brain edema treated by decreasing CBF following the elevation of the head, the bolus infusion of mannitol and furosemide and the hyperventilation ($PaCO_2$: 20-25 mmHg). All patients pupils were dilated. The emergency ventricular drainage was performed only in seven cases. Before the transportation in the ICU the pupil dilation had been reversed in all patients.

Six patients suffered from vasospasm. Immediately intraarterial papaverine was administrated from the edge of the superselective catheter. The goal was to increase the systemic blood pressure to drive adequate flow via collaterals to the area of ischemia as a temporary measure. The MAP was raised 30-40% above the baseline to increase collateral flow and prevent ischemia. The controlled hypertension accompliced by vasoconstriction (hydrochloride etilefrine), the depth of anesthesia was minimized and the patients were simultaneously hypoventilated to increase $PaCO_2$ and as a consequence, to increase cerebral blood flow.

Six patients suffered from mild hemodynamic disorders, such as bradycardia and hypotension. All the patients were faced with the appropriate pharmaceutical treatment, atropine and vasoconstriction drugs (hydrochloride etilefrine).

One patient suffered from respiratory failure after the end of the embolization of aneurysm. The patient's past history was clear for respiratory disease. The angiography of pulmonary artery was negative and no suspicious for pulmonary emboli existed. After many unsuccessfully attempts for recovery, the patient was transported intubated to the ICU.

One patient presented with neurological deficit of left eye reflex after recovery.

DISCUSSION

The anesthesiologists are increasingly asked to provide their services in an interventional radiology facility. In this rapidly evolving field, it is important that anesthesiologists understand the nature of the various treatment modalities and requirements for anesthesia and sedation. Interventional neuroradiology (INR), as the specific therapeutic tool, has changed especially during last decade including angioplasty, intravascular adhesive- and stent related technologies and even simple superselective vascular catheterization. Luessenhop and Spence described embolization of brain arteriovenous malformations (AVMs) in 1959 ($_6$) and Guglielmi detachable coiling procedure was introduced in 1991, as an alternative method for the treatment of selected patients with aneurysms ($_7$). Advances in the neurointerventional field have developed in three areas: 1) materials advances, as manufacturing technologies, material engineering sciences and polymer chemistry, 2) imaging chain advances, in order to allow the interventional neuroradiologists to confidently see the therapy being performed and 3) increased interdisciplinary cooperation, as involving progress in microneurosurgical techniques and neuro-intensive care management. Success in the

interdisciplinary cooperation depends on interdisciplinary support between neurointerventionalists, vascular neurosurgeons, stroke neurologists, intensive care specialists and anesthesiologists ([8]).

Interventional neuroradiology can provide an alternative therapeutic approach for cerebral aneurysm, arterionenous malformations, vascular tumors in the form of pre-operative embolization or as a single therapy. However, embolization of aneurysms or AVMs may result in acute cerebral hemorrhage or ischemic events that may acutely impair neurologic and cardiorespiratory function ([9]). The direct surgical excision in the case of AVMs, or the placement of a clip across the neck of an intracranial aneurysm is the most definitive treatment, though it is not always easy without additional neurological deficits. Especially neurological deficits are presented in patients with large or deep-seated AVMs or with some aneurysms, because of their size, location, configuration and sophisticated adjunctive techniques such as vascular bypass or hypothermic cardiac arrest ([10]).

The complications may occur either as a result of the pathophysiology of vessels or because of directly injury by the vascular manipulation. More often in the treatment of intracranial aneurysm, the manipulation of the sac may cause thromboembolism and acute subarachnoid bleeding due to spontaneous aneurysmal rupture or direct injury ([8]). Luessenhop et al and Luessenhop and Presper published early in 1965 and later in 1975 that the complications during embolization of AVMs potentially occurred from thrombus at the catheter tip, arterial spasm, aberrant embolization, venous embolization or the most important when an emboli lodged in a normal vessel before the malformation. In 1984, Vinuela et al reported that edema and bleeding occasionally complicate the same procedures. Later in 1989, Vinuela also predicted that complications would less frequently occur as embolization technology advanced ([6]).

The neurological complications are common and similar either to the INR or the open neurological procedures. As an invasive procedure, all the complications are anesthetic emergencies and the immediate assessment minimizes the early morbidity and mortality.

The anesthetic management of patients during INR procedures primarily involves providing conscious sedation and analgesia to alleviate pain or discomfort, anxiolysis and patient immobility, but at the same time anesthesiologists have to be prepared for rapid decrease in the level of sedation when neurologic testing is required ([2]). General anesthesia is used to obtain a motionless patient to improve not only the quality of the images but also the control of the airway with potential hypo-hypercapnia, tolerance of induced hypotension, prompt confront of complications.

Careful management of coagulation is required to prevent thromboembolic complications during and after the procedures, though algorithms for anticoagulation remain controversial. Whether heparinization should be used for every case of intracranial catheterization is not clear. Although anticoagulation increases the risk of intracranial hemorrhage, Young et al report that heparinization should be performed routinely during any superselective catheterization ([2]). In our practice, heparin is used and activated clotting time (ACT) is checked. ACT is monitored at least every hour.

Preoperative knowledge of the pathophysiological characteristics of neurosurgical disorders is essential for the formulation of an anesthetic plan intra- and postoperatively. In our study, the role of the anesthesiologist was to provide not only general anesthesia but also to acutely treat patients who suddenly deteriorated from a procedure-related complication. Due to the nature of these lesions, patients may have a sudden increase in intracranial pressure and become comatose. Therefore is needed to stabilize blood pressure and control the intracranial pressure. Some patients require urgent surgery for treatment the intracerebral hemorrhage.

The interventional neuroradiology is a rapidly expanding field in the treatment of central nervous system diseases and poses many new and interesting challenges for the anesthesiologist. As the frontiers of INR expand, care of these patients will demand more of the anesthesiologist's participation in years coming. An interventional neuroradiology team should include an interested and expert anesthesiologist who is thoroughly familiar with INR procedures, techniques of controlled hypotension, deliberate hypertension and treatment of cerebrovascular complications. Complications during INR can be rapid and life threatening and require rapid and effective communication between the anesthesiologist and the neurosurgeon for satisfying prompt therapy.

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