Neuroanesthesia and Intensive Care

Anesthesia for cerebral aneurysms: a comparison between interventional neuroradiology and surgery

Yeow-Choy Lai MBBS,
Pirjo H. Manninen MD FRCPS

Purpose: To review the anesthetic management of patients with cerebral aneurysms during treatment in the interventional neuroradiology (INR) suite compared with in the operating room.

Methods: This was a retrospective chart review of 100 consecutive patients treated by endovascular coiling compared with 100 patients treated by surgical clipping of a cerebral aneurysm. Information compared and analyzed included demographics, pre-procedure medical history, neurological status including location and size of aneurysm, anesthetic management, complications and patient outcome. $P < 0.05$ was considered significant.

Results: Patients in the INR group were older (54 ± 15 *vs* 49 ± 12 yr), had a greater incidence of pre-procedure cardiorespiratory problems (55 *vs* 34 patients) and had more aneurysms located in the posterior fossa (68 *vs* 11) ($P < 0.05$). General anesthesia was used in all except seven INR patients who received conscious sedation. There were some differences in the anesthetic agents and techniques. There was less monitoring of INR patients; temperature (33 *vs* 99 patients), intraarterial catheter (22 *vs* 100), central venous catheter (4 *vs* 78), and evoked potential monitoring (0 *vs* 100). There were no differences in the incidence of documented complications or in patient outcome.

Conclusion: There were some differences in the anesthetic management of patients undergoing endovascular treatment of a cerebral aneurysm compared with treatment in the operating room. The patients in the INR suite were sicker and somewhat older and they received less invasive monitoring, but the complication rate and outcome did not differ.

Objectif : *Examiner la ligne de conduite adoptée pour l'anesthésie pendant le traitement d'anévrysmes cérébraux en neuroradiologie interventionnelle (NRI) comparé au traitement en salle d'opération.*

Méthode : *C'est une revue de dossiers rétrospective de 100 patients successifs qui ont reçu une prothèse spiralée, comparés à 100 patients traités par ligature chirurgicale d'un anévrysme cérébral. Les informations comparées et analysées comprennent les données personnelles, l'histoire médicale antérieure à l'intervention, l'état neurologique incluant le site et la taille de l'anévrysme, la démarche anesthésique, les complications et l'évolution du patient. P < 0,05 a été considéré comme significatif*

Résultats : *Les patients du groupe de NRI étaient plus âgés (54 ± 15 vs 49 ± 12 ans), présentaient une plus forte incidence de problèmes cardiorespiratoires antérieurs à l'opération (55 vs 34 patients) et avaient plus souvent des anévrysmes de la fosse postérieure (68 vs 11) (P < 0,05). L'anesthésie générale a été utilisée chez tous, sauf chez sept patients de NRI qui ont reçu une sédation consciente. Différents agents et techniques anesthésiques ont été utilisés. Il y a eu moins de monitorage chez les patients de NRI; température (33 vs 99 patients), cathéter intra-artériel (22 vs 100), cathéter veineux central (4 vs78), et potentiel évoqué (0 vs 100). L'incidence de complications notées ou l'évolution du patient n'ont pas présenté de différences.*

Conclusion : *Certaines différences de gestion anesthésique sont apparues quand on compare le traitement endovasculaire d'un anévrysme cérébral au traitement en salle d'opération. Les patients de NRI étaient plus malades et plus âgés et ont reçu un monitorage moins effractif, ce qui n'a pas affecté le taux de complications ni l'évolution des patients.*

From the Department of Anesthesia, Toronto Western Hospital, University Health Network, University of Toronto, Toronto, Ontario, Canada.

Address correspondence to: Dr. Pirjo H. Manninen, Department of Anesthesia, Toronto Western Hospital, 399 Bathurst Street, Toronto, Ontario, M5T 2S8. Phone: 416-603-5118; Fax: 416-603-6494; E-mail: Pirjo.Manninen@uhn.on.ca

Accepted for publication December 11, 2000.

ENDOVASCULAR therapy is now an established therapeutic alternative to surgical clipping of some cerebral aneurysms.[1–5] Initially, aneurysms that were surgically difficult to access, such as those situated in the posterior fossa, were treated by interventional neuroradiology (INR).[6] As well, patients with high-risk medical conditions may benefit from INR as they need not be subjected to the more invasive technique of surgery.[7] The most common endovascular treatment is by the insertion of Guglielmi detachable coils (GDC).[1] In most institutions, an anesthesiologist is involved in the care of the patient during INR treatment.[2,8–10] The roles of the anesthesiologist in the INR suite are to monitor the patient, to provide appropriate anesthesia to facilitate the procedure, and to manage any complication that may arise. The aim of this study was to review the overall anesthetic management of patients during the treatment of their cerebral aneurysm in the neuroradiology suite and compare this to the management in the operating room for surgical clipping of a cerebral aneurysm.

TABLE I Profile of patients undergoing INR or surgical treatment of cerebral aneurysms.

Patient characteristics	*INR*	*Surgery*
Age (yr)	54 ± 15*	49 ± 12
Weight (kg)	75 ± 26	72 ± 17
Male:Female	32:68	47:53
Cardiovascular illness	55*	34
Respiratory illness	9*	1
WFNS grade I	30	39
grade II	10	9
grade III	8	4
grade IV	8	8
grade V	4	1
unruptured aneurysms	40	39
anterior circulation aneurysms	32	89
posterior circulation aneurysms	68*	11

All figures are expressed as number or mean ± sd
WFNS = World Federation of Neurological Surgeons grade
* = $P < 0.05$

Methods

With approval of the Institutional Review Board, a retrospective chart review was performed of patients treated for cerebral aneurysms by interventional neuroradiology or surgery over a two year period. The first 100 consecutive patients with available medical records who had been treated by INR techniques and 100 patients treated by surgery were selected for analysis. Demographic data, past medical history and the current events prior to treatment, including the neurological status of the patient were documented. Information regarding the aneurysm that was being treated included the location (anterior or posterior circulation) and size. The size of the aneurysm was divided into small (<12 mm diameter), large (12-25 mm) or giant (>25 mm). The World Federation of Neurological Surgeons (WFNS) grading was used to assess the patients' neurological status following a subarachnoid hemorrhage: grade I - Glasgow Coma Scale (GCS) 15 with no motor deficit, grade II - GCS 14 to 13 with no motor deficit, grade III - GCS 14 to 13 with motor deficit, grade IV - GCS 12 to 7 with or without motor deficit, and grade V GCS 6 to 3 with or without motor deficit. If there was no acute bleed, the aneurysm was considered intact. All co-existing medical illnesses were noted such as cardiac disease (hypertension, ischemic heart disease or arrhythmias) or respiratory illness (asthma, obstructive airway disease or pneumonia). The anesthetic records were reviewed for the technique of anesthesia (general anesthesia or neurolept / conscious sedation) including drugs and monitors used, and the duration of the procedure. All complications relevant to anesthesia and the procedure, and the overall outcome of the patients on discharge were also recorded. Statistical analysis was performed with Chi-square and t tests were appropriate; a P value < 0.05 was considered significant.

Results

Demographics and the premorbid illness of all patients in each group are shown in Table I. Patients in the INR group were older and had a higher incidence of cardiovascular and respiratory illness. There were no differences in the WFNS grade or of the size of aneurysms between the groups: small – INR 74, surgery 69; large – INR 17, surgery 18; giant – INR 9, surgery 13. More patients in the INR group had aneurysms located in the posterior circulation (Table I). Seventy procedures were performed on an emergency basis (23 INR, 47 surgery). The timing of the procedure following a subarachnoid hemorrhage was different between the groups: the mean (± SD) interval for the INR group was 9.7 ± 19.2 days and for the surgical group 4.4 ± 5.7 days, ($P = 0.04$). The anesthetic technique for the INR group was general anesthesia with tracheal intubation in all cases except for six patients who received neurolept anesthesia and one patient who had monitored anesthetic care. These seven patients were all of good neurological grade (Grade 1 (2) and intact (5)). One patient started with neuroleptanesthesia that was converted to general anesthesia 165 min into the procedure, because of excessive pain and discomfort. The procedure then proceeded uneventfully and coiling was successful. Twelve patients arrived from the intensive care unit (ICU) with an endotracheal tube in situ (INR 7, surgery 5). The anesthetic data are summarized in Table II. Propofol (n = 67) was used more commonly as an induction agent in INR whereas thiopental (n = 89) was used for surgery. Patients who underwent INR had a shorter duration of procedure and required less opioid and volatile anesthetic agents. Patients who had arrived with an endotracheal tube *in situ* were returned to the ICU for continuous ventilation of their lungs. Thirteen patients (INR 2 *vs* surgery 11, P = 0.02) had delayed awaking and were transferred to ICU for ventilation and tracheal extubation at a latter time. The two INR patients had both suffered an intracranial bleed during the procedure.

All patients were monitored with an electrocardiogram, pulse oximeter, non invasive blood pressure and end tidal CO_2. Temperature was monitored in only 33 INR cases with a mean temperature of 36.0 ± 0.8°C compared with 99 surgery cases with a mean of 35.0 ± 1.0°C. Fewer INR patients had invasive arterial or central venous pressure monitoring. An intraarterial catheter was used in 22 patients during INR and in all patients during surgery. However, 11 of these catheters in the INR group had been inserted prior to the patient arriving in the INR suite. The mean blood pressure was analyzed only during the maintenance phase of the procedure as it was difficult to retrospectively identify events such as intubation (Table II). Blood pressure and / or heart rate was pharmacologically (esmolol, labetalol, metoprolol or hydralazine) lowered in 11 patients during INR and 10 patients during surgery. Blood pressure was increased by the administration of a vasoactive agent (ephedrine, phenylephrine, dopamine) in 9 INR patients and 29 surgical patients (P < 0.05). Induced hypotension was not used for any INR treated patient in this series and only for two surgical patients. A central venous catheter was *in situ* in four patients in the INR group. None were inserted in the INR suite. In the surgical group, four were *in situ* and 74 patients received a central venous catheter in the operating room. The most common site for central venous monitoring was the right internal jugular vein. Monitoring of cerebral function by somatosensory evoked potentials (SSEP) was used in the operating but not in the INR suite. Clinically important SSEP changes were documented in seven patients and six of them had a new neurological deficit postoperatively. Heparin use for anticoagulation was documented in 96 INR cases, and reversal with protamine was documented in 26 cases at the end of the procedure. Intravenous heparin was administered without the use of activating clotting times by giving a bolus dose (100 units·kg) followed by hourly additions of 1000 units.

There were no major anesthetic complications documented in either group during the procedure. Post procedure, one patient from each group required unanticipated re-intubation after the procedures due to delayed recovery (surgery) and respiratory distress (INR). All INR group patients were treated with GDC coils. Procedure related complications included vascular perforation in four INR cases. Eight INR procedures failed to secure the aneurysm, of which four proceeded to surgery with fair to good outcomes. Of the four managed conservatively, three subsequently died of complications related to rebleeding. In the surgical group, clipping of the aneurysm was successful in all cases and none required further surgical or interventional management. Intraoperative rupture of the aneurysm was documented in 12 patients. These were controlled by tamponade effect or by use of temporary clipping. There were no significant differences in overall outcome at discharge between the two groups. A good to fair outcome (no major neurological deficits) was recorded for 88 INR and 94 surgical patients; poor outcome (major neurological deficits) in three INR and four surgery patients; eight INR and two surgery patients died.

TABLE II Summary of anesthetic management

Anesthetic management	*INR*	*Surgery*
Elective:Emergency	77:23	53:47
Duration of procedure (min)	226 ± 64*	321 ± 85
General anesthesia	93	100
Sedation / neurolept	6	0
Monitored anesthetic care	1	0
Midazolam (mg)	2.1 ± 1.9 (n = 65)	1.6 ± 0.2 (n = 70)
Lidocaine (mg) at induction	95 ± 19 (n = 19)	96 ± 19 (n = 57)
Mean N_2O ET (%)	59 ± 8 (n = 88)	55 ± 10 (n = 99)
Mean Isoflurane ET (%)	0.55 ± 0.25(n = 86)*	0.62 ± 0.22 (n = 99)
Total fentanyl dose (μg)	219 ± 112*	484 ± 169
Total fluid (litres)	1.4 ± 0.8*	3.1 ± 1.1
Mean arterial pressure (mmHg)	83.5 ± 11	80 ± 9
Patients given blood / colloids	0	12
PET CO_2 (mmHg)	34 ± 4*	31 ± 4

All figures are expressed as number or mean ± sd
* = P < 0.05

Discussion

Traditionally, the treatment of cerebral aneurysms has involved surgical clipping[2,3] but many recent developments in INR have resulted in more patients undergoing endovascular coiling of aneurysms. There is little information in the literature regarding the anesthetic management of patients with cerebral aneurysms during the endovascular treatment. Our intent was to review the overall anesthetic management of patients in the INR suite compared to our traditional management of similar patients in the operating room. We found that there were differences in the patient population, in the anesthetic management in regard to drug and fluids administration, and the monitoring used. There were no differences in the documented complications and patient outcomes.

The indications for endovascular therapy are evolving.[1,7,10,11] The initial use of INR for aneurysms was in situations where surgical treatment was difficult such as in the posterior fossa. The less invasive approach of INR may be a good alternative for elderly and patients with severe cardiorespiratory or systemic diseases.[7,11] The management of our patients reflected these trends in that more patients with posterior fossa aneurysms and with cardiorespiratory disease were treated by INR. Early treatment of a ruptured aneurysm is the usual practice to decrease the incidence of rebleeding.[12,13] In our study, INR patients had their procedures performed at a later date from their subarachnoid bleed than the surgical group. Since our hospital is a referral centre for INR, there could have been delays in the referral and transfer process. Another possible reason is that these patients had more medical problems which required stabilization before the procedure. In this retrospective review, we were unable to determine the definitive reason for the selection and the time of treatment for all patients that were treated by INR.

The technique of anesthesia used for INR procedures varies amongst institutions and is often influenced by the preferences of the neuroradiologist. Both neurolept / conscious sedation and general anesthesia have been described.[8–11,14] During conscious sedation, the awake patient serves as an effective overall monitor of neurological status. Conscious sedation may also be more suitable for patients with systemic medical problems.[11] Reasons for the use of general anesthesia during INR procedures include the length of time that the patient may have to lie still, as well as the repeated requests for absolute stillness (breath holding) for some of the radiological techniques such as road mapping. The definite reason for neurolept anesthesia in seven of our patients was not documented but, overall, it has been the preference of our neuroradiologists to have all patients under general anesthesia for treatment of cerebral aneurysms.

The principles of safe neuroanesthesia should be applied to all patients with a cerebral aneurysm whether it is in the operating room or the INR suite.[12,13] In our study, some of the anesthetic agents and techniques used in the INR were different from those used in the operating room. The different choices of induction agent can be explained by the set up; in the INR suite thiopental is not kept as a pre-mixed solution, contrary to the operating room, and propofol is readily available. The total quantity of agents used reflects the differences in the duration of the procedures and the degree of "painful" stimulation. The optimal or the intended level of blood pressure during these procedures is difficult to assess from a retrospective review. We only analyzed the level of blood pressure during the maintenance phase and there was no difference. However, more patients required pharmacological agents to increase their blood pressure during surgery, implying that there were probably more episodes of hypotension in the operating room. The end-tidal CO_2 was lower in the surgical patients. Mild to moderate hyperventilation is commonly used during a craniotomy to help decrease brain bulk to allow for surgical exposure. This would not be required during INR procedures. The ability to assess the neurological status of patients immediately at the end of the procedure is desirable. In our review, delayed awakening occurred more frequently in the surgical group, which may reflect the greater complexity of the procedure and anesthetic during surgery. The overall outcome at discharge did not differ, but the purpose of our review was not to assess completeness of the coiling or clipping of the aneurysm.

Monitoring standards for anesthesia in remote locations, such as the INR suite, should be no different from those in the operating room.[15,16] All patients were monitored with an electrocardiogram, pulse oximetry, non invasive blood pressure, and capnography. However, there was a difference in other monitoring modalities in our study. There was a lack of monitoring of the patient's temperature in the INR suite. The reason for this can only be speculated on. The capacity to monitor temperature was always available, but not as conveniently located as in the operating room. This deficiency has now been rectified in our institution. More patients in the INR group had premorbid cardiorespiratory illness and yet, few had invasive monitoring. Routine invasive arterial monitoring for blood pressure was not used in the INR. Most of the patients who had an intraarterial catheter and all central venous catheters arrived with these lines *in situ* from the ICU. There were no major problems documented with blood pressure or fluid management in the INR. Induced hypotension was not used for any of these INR procedures. Central venous lines are useful for monitoring volume status and venous air embolism. Marked fluid shifts, blood loss and an air embolism are less likely to occur during INR treatment. The need for a central venous pressure monitoring is therefore less indicated in INR. The lack of invasive monitoring in our study population during INR did not appear to affect the management, the incidence of complications nor the outcome of our patients. SSEP are used as a neurophysiologic monitor during aneurysm surgery.[17,18] In our surgical group, according to our routine practice, all patients were monitored with appropriate SSEP modalities. SSEP monitoring is feasible, though more complex in the INR suite.[19,20] In our centre, it was not used in the INR suite due to space and logistical constraints.

There are certain limitations to this study. Being retrospective in design, data are limited to what was recorded in the medical records of the patient. Some complications and problems may not have been documented. It was not the intent of this study to examine the reasons for the best treatment choice of the patient with a cerebral aneurysm. A prospective, randomized trial would be needed in this regard.

In conclusion, the anesthetic management of patients with cerebral aneurysms differed in the INR suite compared with the operating room during surgical treatment. For the anesthesiologist one needs to be aware that the patient presenting for INR treatment may have more premorbid cardiorespiratory illnesses and may be older. In our study the INR patients received less invasive monitoring, but the complication rate and outcome did not differ. Further studies and developments in INR technology will help to guide in the anesthetic management of patients undergoing endovascular treatment of their cerebral aneurysm.

References

1 *Viñuela F, Duckwiler G, Mawad M.* Guglielmi detachable coil embolization of acute intracranial aneurysm: perioperative anatomical and clinical outcome in 403 patients. J Neurosurg 1997; 86: 475–82.

2 *Luessenhop AJ.* Interventional neuroradiology: a neurosurgeon's perspective. AJNR 1990; 11: 625–9.

3 *Leber KA, Klein GE, Trummer M, Eder HG.* Intracranial aneurysms: a review of endovascular and surgical treatment in 248 patients. Minim Invas Neurosurg 1998; 41: 81–5.

4 *Brilstra EH, Rinkel GJE, van der Graaf Y, van Rooij WJJ, Algra A.* Treatment of intracranial aneurysms by embolization with coils. A systematic review. Stroke 1999; 30: 470–6.

5 *Nakstad PH.* Review article. Interventional neuroradiology. Acta Radiologica 1999; 40: 344–59.

6 *Guglielmi G, Viñuela F, Duckwiler G, et al.* Endovascular treatment of posterior circulation aneurysms by electrothrombosis using electrically detachable coils. J Neurosurg 1992; 77: 515–24.

7 *Murayama Y, Viñuela F, Duckwiler GR, Gobin YP, Guglielmi G.* Embolization of incidental cerebral aneurysms by using the Guglielmi detachable coil system. J Neurosurg 1999; 90: 207–14.

8 *Young WL, Pile-Spellman J.* Anesthetic considerations for interventional neuroradiology. Anesthesiology 1994; 8: 427–56.

9 *Manninen PH, Gignac EM, Gelb AW, Lownie SP.* Anesthesia for interventional neuroradiology. J Clin Anesth 1995; 7: 448–52.

10 *Luginbühl M, Remonda L.* Interventional neuroradiology. Recent developments and anaesthesiologic aspects. Minerva Anestesiol 1999; 65: 445–54.

11 *Wang LP, Wolff J.* Anesthetic management of severe chronic cardiopulmonary failure during endovascular embolization of a PICA aneurysm. J Neurosurg Anesthesiol 2000; 12: 120–3.

12 *Dangor AA, Lam AM.* Anesthesia for cerebral aneurysm surgery. Neurosurg Clin N Am 1998; 9: 647–59.

13 *Zander JF.* Subarachnoid haemorrhage. Cur Opin Anaesthesiol 1999; 12: 503–9.

14 *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.

15 *Manninen PH.* Anaesthesia outside the operating room. Can J Anaesth 1991; 38: R126–9.

16 American Society of Anesthesiologists. Guidelines for nonoperating room anesthetizing locations. Approved by House of Delegates October 1994. *In*: Park Ridge, IL: American Society of Anesthesiologists 2000 Directory of Members, 2000: 491.

17 *Schramm J, Koht A, Schmidt G, Pechstein U, Taniguchi M, Fahlbusch R.*. Surgical and electrophysiological observations during clipping of 134 aneurysms with evoked potential monitoring. Neurosurgery 1990; 26: 61–70.

18 *Manninen PH, Lam AM, Nantau WE.* Monitoring of somatosensory evoked potentials during temporary arterial occlusion in cerebral aneurysm surgery. J Neurosurg Anesthesiol 1990; 2: 97–104.

19 *Hacke W, Zeumer H, Berg-Dammer E.* Monitoring of hemispheric or brainstem functions with neurophysiologic methods during interventional neuroradiology. AJNR 1983; 4: 382–4.

20 *Hacke W.* Neuromonitoring during interventional neuroradiology. Central Nervous System Trauma 1985; 2: 123–36.