Anesthetic Management of Cerebral Aneurysm Clipping Using the Deep Hypothermic Circulatory Arrest Technique : A Case Report

LAWAN TUCHINDA, M.D.*,
SUPUDJANEE LIM-U-TAITIP, B.A.*,
RUNGSAK SIWANUWATN, M.D.**,
ORANUCH KYOKONG, M.D.*,
SURACHAI KHAOROPTHAM, M.D.**,
VICHAI BENCHACHOLAMAS, M.D.***

Abstract

Deep hypothermic circulatory arrest may prove advantageous during surgery of some technically difficult brain lesions. This technique was first applied in one patient with a large intracavernous aneurysm which had failed standard neurosurgical techniques. For this technique to be successful the cooperation of neurosurgeons, cardiovascular surgeons, anesthesiologists, perfusionists and nurses is essential. Techniques aimed at improving the outcome include a short period of circulatory arrest, the depth of hypothermia, barbiturate administration, coagulation management and well-controlled blood glucose levels. The total time of circulatory arrest and the thiopentone dosage were 61 minutes and 1,700 mg respectively. The lowest core temperature was 13.9°C. The positive outcome supports the use of this technique in selected patients with complex intracranial vascular lesions who may not be operable by standard techniques.

Key word : Anesthesia, Cerebral Aneurysm, Cardiopulmonary Bypass, Deep Hypothermia

TUCHINDA L, KYOKONG O, LIM-U-TAITIP S, KHAOROPTHAM S, SIWANUWATN R, BENCHACHOLAMAS V
J Med Assoc Thai 2000; 83: 1544-1549

Some complex neurovascular lesions can not easily be operated on by standard neurosurgical techniques even with the advancement of microneurosurgery. A useful adjunct available to the neurosurgeon in these patients is deep hypothermic circulatory arrest. In 1959, Woodhall et al[1] reported the successful use of this technique in one patient with a huge subcortical tumor cyst. In the 1960's, a number of neurosurgical centers pioneered the technique of profound hypothermia and

* Department of Anesthesiology,
** Division of Neurosurgery, Department of Surgery,
*** Division of Cardiovascular and Thoracic Surgery, Department of Surgery, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand.

circulatory arrest for intracranial aneurysm surgery[2-6]. The advantages of employing deep hypothermic circulatory arrest in the treatment of complex neurovascular lesions are a bloodless surgical field which improves visualization of the vascular anatomy and pathology. The danger of aneurysm rupture during dissection is effectively eliminated. The aneurysm may be manipulated allowing for safer dissection of the neck of the aneurysm and identification of associated vascular and neural structures. For a number of reasons this technique fell into disuse. Multiple coagulation problems associated with bypass discouraged some neurosurgeons. Recently along with improved cardiac surgery techniques and sophisticated technology for cardiopulmonary bypass, many of the complications including postoperative coagulopathy and prolonged anesthesia time have been minimized. These advances encouraged neurosurgeons in a few centers in the 1980's to reexplore the utility of deep hypothermic circulatory arrest for the clipping of giant and complex intracranial aneurysms[7,8]. We used this technique successfully in one patient at King Chulalongkorn Memorial Hospital who failed standard neurosurgical methods. This is the first case reported in Thailand.

CASE REPORT

A 47-year old male patient presented with a one-year history of headache, diplopia, ptosis and left eye squint. He had no other medical problems except for hypertension which was well controlled with propanolol. At admission he was alert. Neurological examination showed left cranial III, IV and VI palsies and decreased pin prick sensation on the left face. Magnetic resonance imaging and angiography showed a large trigeminal artery aneurysm (20 mm) in the cavernous sinus arising from the carotid and basilar arteries.The patient underwent the first unsuccessful operation for clipping of the aneurysm on March 31, 1998, due to the incapacity to identify the aneurysmal neck. A second operation was planned using the deep hypothermic circulatory arrest technique nine days after the first operation.

Anesthetic management

Preoperative evaluation was directed towards detection of any diseases potentially complicating the cardiopulmonary bypass technique including cardiovascular, pulmonary and hematologic diseases. The aortic valve function should be carefully evaluated because central cannulation and left ventricular venting through a median sternotomy are required if the aortic valve is insufficient.

Premedication in this patient was diazepam 5 mg orally on the morning of surgery. After placement of monitoring equipment including ECG, pulse oximeter and noninvasive blood pressure monitor, anesthesia was induced with thiopentone 5 mg/kg and fentanyl 3 mcg/kg, intubation was facilitated with pancuronium 0.1 mg/kg. Direct arterial pressure monitoring was placed at the left radial artery before intubation. Labetolol was used if required to aggressively treat any intraoperative hypertension. Anesthesia was maintained with air and oxygen, isoflurane up to 1.5 per cent, fentanyl infusion 1 mcg/kg/hour and pancuronium. Ventilation was adjusted to provide a PaCO2 of 30-35 mm. Hg. After the patient was intubated, a second arterial line was placed at the left dorsalis pedis artery. Central venous cannulation at the right internal jugular vein, nasopharyngeal and rectal temperature probe and a foley catheter were then placed. The head was locked in rigid pin fixation after supplementary fentanyl 1 mcg/kg. EEG electrodes were then placed in a F3-C3, P3-O1, F4-C4 and P4-O2 montage. EEG monitoring was performed using a 4-channel spontaneous EEG (Nicolet-Viking II, Nicolet, Madison, Wisconsin). Median nerve somatosensory evoked potentials (SSEPs) were monitored simultaneously with the EEG. The median nerve SSEPs were recorded from cervical and contralateral somatosensory cortical sites following stimulation of the median nerves at the wrist. The stimulus was a monophasic rectangular pulse of 0.2 ms duration at an intensity of 20 mA at rates of 4.7 Hz. Base line evoked potential and EEG recordings were made after skin incision and stable anesthesia as shown in Fig. 1 and 2 respectively. Surface cooling was initiated by placing the patient on a cooling blanket and infusing cold saline intravenously. Hemodilution to a hematocrit level of 28 per cent to 30 per cent was performed by collecting blood from the arterial line. This blood was reintroduced after the bypass was discontinued in order to replace essential clotting factors. Arterial blood gas and blood glucose were monitored intermittently. Blood glucose was controlled to remain below 200 mg/dl. Mannitol 1 g/kg was given during the opening. Dilantin 500 mg was loaded to prevent intraoperative and postoperative seizures.

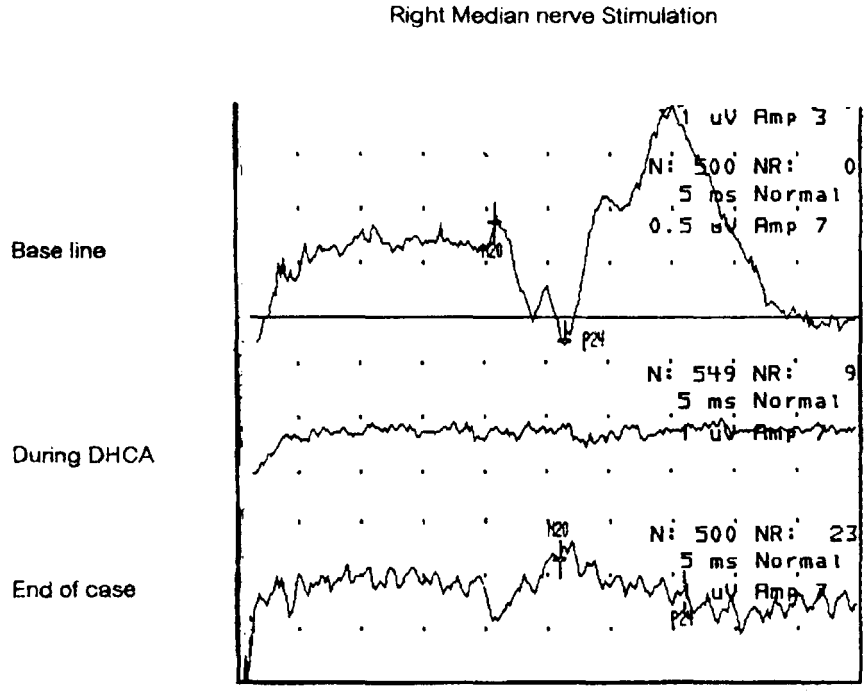

Fig. 1. Median nerve SSEPs during clipping of left trigeminal artery aneurysm using the deep hypothermic circulatory arrest technique. Upper tracing is the base line normal potential recording (N20 P24 wave) after induction. The potential was lost during cooling down and circulatory arrest (middle tracing). The potential gradually returned during rewarming but still delayed at the end of the operation (lower tracing).

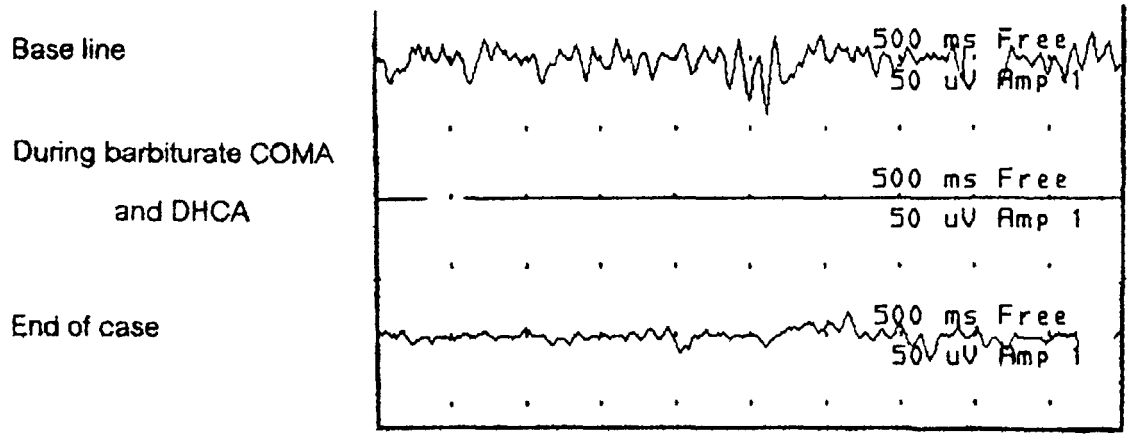

Fig. 2. Electroencephalography (EEG) of this patient during operation. Upper tracing is the base line EEG after induction. The EEG became isoelectric after barbiturate COMA and during DHCA (middle tracing) and returned but still slightly slowed at the end of the operation (lower tracing).

The aneurysm was dissected as much as possible with meticulous hemostasis. The right femoral-femoral cardiopulmonary bypass was begun at a core temperature of 33°C after full heparinization to maintain an activated coagulation time of 450-480 seconds. Perfusion was carried out using a pump flow range from 2.6-3.9 L/min to maintain the mean arterial blood pressure at 40-80 mm.Hg and acceptable blood gas level. Cooling during extracorporeal circulation was facilitated by nicardipine 0.2 mg incrementally and continued until the desired 15°C core temperature was reached. Thiopentone was loaded and infused to induce EEG burst suppression or isoelectric EEG (Fig. 2) for cerebral protection and discontinued when circulation was stopped. Methylprednisolone 1 g was administered. While cooling the patient, SSEPs were delayed and ceased altogether at 23.1°C (Fig. 1). Ventricular fibrillation occurred when the core temperature was 30°C. Circulation was stopped when the core temperature reached 15.3°C which required 27 minutes. The aneurysm was finally dissected and clipped with four clips. The patient's lowest core temperature was 13.9°C. Flow was restored after a circulatory arrest time of 61 minutes and the patient was subsequently rewarmed. Thiopentone was started to maintain EEG burst suppression until the end of the operation using a total dose of 1,700 mg. SSEPs gradually returned at 22°C but were still slightly delayed at the end of the operation (Fig. 1). The heart started fibrillating at an esophageal temperature of 28°C and was defibrillated easily. When the patient's core temperature reached 36°C the cardiopulmonary bypass was weaned and stopped using a low dose of dopamine as an inotropic support. The total cardiopulmonary bypass time was 2 hours 27 minutes. The effect of heparin was reversed with protamine sulfate and the patient's blood and fresh frozen plasma were given. The total operating time was 10 hours 5 minutes.

The patient woke up 7 hours later and could be extubated 38 hours postoperatively. There were no difficulties with intraoperative or postoperative bleeding. Neurological examination was normal except for the presence of left third, fourth and sixth cranial nerve palsies. The postoperative angiogram showed residual aneurysm. The patient underwent a third operation successfully under mild hypothermia and barbiturate protection with conventional clipping of the aneurysm and went home nine days after his third operation.

DISCUSSION

Deep hypothermic circulatory arrest is the ultimate aid in clipping a complicated intracranial aneurysm. Many neurosurgical centers have reported improved outcome when utilizing this technique in treating giant intracranial aneurysms[3,5,7,8]. Techniques aimed at reducing morbidity were short duration of circulatory arrest, depth of hypothermia, barbiturate protection, coagulation management and well controlled blood glucose levels.

The duration of complete arrest can be safely increased by reduction in body temperature[9,10]. Clinical and experimental experience in cardiac surgery have demonstrated that circulatory arrest under deep hypothermia (18°C) for 30-45 minutes produces virtually no discernible neurological damage. There is a slight increase in neurological consequences as the 60-minute limit is approached. The range duration of complete arrest in most series was 7-53 minutes[8,11]. The circulatory arrest time in this patient was 61 minutes due to the problematic vascular structure.

Hypothermia is a method applied to decrease the oxygen consumption of the brain. Oxygen consumption declines to 50 per cent of normal at 30°C, 25 per cent of normal at 25°C, 15 per cent of normal at 20°C and 10 per cent of normal at a temperature as low as 15°C. The cardiopulmonary bypass time can be reduced if the patient's core temperature decreases as much as possible during the initial dissection. We administered surface cooling and infusion of cold intravenous fluid. Also the cooling and rewarming time can be reduced by means of a vasodilator. In the case presented we used nicardipine, a short acting calcium channel blocker. In this patient, the core temperature was lowered to 15°C before circulatory arrest because the neurosurgeon expected a long arrest time might be required to dissect and clip the aneurysm due to the complicated vascular structure.

Barbiturate administration has been used in conjunction with hypothermia during circulatory arrest. Brain oxygen consumption can be reduced by as much as 50 per cent when barbiturate was given to the isoelectric EEG. Barbiturates clearly have the capacity to modify or prevent focal cerebral ischemia[12-14] and are most effective when the agent is administered before a period of temporary ischemia. The role of barbiturates is less well established in the setting of temporary global

ischemia[15]. However Slogott[16] and Nusmeier [17] demonstrated an improved outcome in patients during procedures employing circulatory arrest. The thiopentone dose in this patient to maintain EEG burst suppression was 32 mg/kg. Propofol and etomidate which are new anesthetic agents have less pronounced brain protective effects than barbiturates[18,19].

In the case of intracranial operation absolute hemostasis must be employed. Cardiopulmonary bypass and circulatory arrest affect coagulation in several ways. Use of heparin, hypothermia, hemodilution and a heart-lung machine all affect normal hemostasis. Meticulous heparin administration and reversal must be achieved by measuring the activated clotting time. Combined use of the patient's autologous whole blood and of supplementary banked blood products can be helpful in hemostasis.

Thorough control of blood glucose level is another important factor because hyperglycemia can worsen neurological damage. Usually hyperglycemia tends to occur due to the stress of surgery and hypothermia itself also causes reduction of glucose utilization. Serial blood glucose measurements intraoperatively and insulin infusion for controlling blood glucose levels are therefore necessary.

Intraoperative electrophysiologic monitoring during cerebral aneurysm surgery include EEG and SSEPs. EEG recording is a sensitive index of generalized cortical activity and a precise measure of the cerebroprotective barbiturate dose. The SSEPs are a more specific response of the intact sensory pathway. Together, they can be monitored to achieve optimum doses of barbiturates and minimal retraction of neural structures before hypothermic arrest. During rewarming the recovery of both the SSEPs and EEG activity can be interpreted as a reassuring measure of central nervous system recovery. In this patient, SSEPs were lost at 23°C core temperature and returned at 22°C but were still slightly prolonged until the end of the operation. However his neurological examination was normal except for left third, fourth and sixth cranial nerve palsies.

SUMMARY

Deep hypothermic circulatory arrest can be applied safely to facilitate surgical repair of complex intracranial aneurysms that would be inoperable by standard techniques. Anesthetic management to improve the outcome for the patient included facilitated cooling, use of barbiturate coma, coagulation management and good control of blood glucose levels.

(Received for publication on March 3, 1999)

REFERENCES

1. Woodhall B, Sealy WC, Hall KD, Floyd WL. Craniotomy under conditions of quinidine-protected cardioplegia and profound hypothermia. Ann Surg 1960; 152: 37-44.
2. Uihlein A, Terry HR, Payne WS, Kirklin JW. Operations on intracranial aneurysms with induced hypothermia below 15°C and total circulatory arrest. J Neurosurg 1962; 19: 237-9.
3. Patterson RH, Ray BS. Profound hypothermia for intracranial surgery: Laboratory and clinical experient with extracorporeal circulation by peripheral cannulation. Ann Surg 1962; 156: 377-93.
4. MacCarty CS, Michenfelder JD, Uihlein A. Treatment of intracranial vascular disorders with the aid of profound hypothermia and total circulatory arrest; Three years' experience. J Neurosurg 1964; 21: 372-7.
5. Drake CG, Bar HWK, Coles JC, Gergely NF. The use of extracorporeal circulation and profound hypothermia in the treatment of ruptured intracranial aneurysm. J Neurosurg 1964; 21: 575-81.
6. Housepian EM, Bowman FO, Gissen AJ. Elective circulatory arrest in intracranial surgery. J Neurosurg 1967; 26: 594-7.
7. Baumgartner WA, Silverberg GD, Ream AK, Jamieson SW, Tarabek J, Reitz BA. Reappraisal of cardiopulmonary bypass with deep hypothermia and circulatory arrest for complex neurosurgical operations. Surgery 1983; 94: 242-9.
8. Spetzler RF, Hadley MN, Rigamonti D, et al. Aneurysms of the basilar artery treated with circulatory arrest, hypothermia, and barbiturate cerebral protection. J Neurosurg 1988; 68: 668-79.

9. Reitz BA, Ream AK. Use of hypothermia in cardiovascular surgery. In: Ream AK. Fogdall RP. Editors. Acute Cardiovascular Management: Anesthesia and Intensive Care. JB Lippincott 1982: 830-48.
10. Rittenhouse EA, Mohri H, Dillard DH. Deep hypothermia in cardiovascular surgery. Ann Thorac Surg 1974; 17: 63-98.
11. Solomon RA, Smith CR, Raps EC, Young WL, Stone G, Fink ME. Deep hypothermic circulatory for the management of complex anterior and posterior circulation aneurysm. Neurosurgery 1991; 29: 732-8.
12. Shapiro HM. Barbiturates in brain ischemia. Br J Anaesthiol 1985; 57: 82-95.
13. Lavine SD, Masri L, Levy ML, Giannotta SL. Temporary occlusion of the middle cerebral artery in intracranial aneurysm surgery: time limitation and advantage of brain protection. J Neurosurg 1997; 87: 817-24.
14. Selman WR, Spetzler RF, Roski RA, Roessmann U, Crumrine R, Macko R. Barbiturate coma in focal cerebral ischemia. Relationship of protection to timing of therapy. J Neurosurg 1982; 56: 685-90.
15. Steen PA, Milde JU, Michenfelder JD. No barbiturate protection in a dog model of complete cerebral ischemia. Ann Neurol 1979; 5: 343-9.
16. Sloogoff S, Girgis KZ, Keats AS. Etiologic factors in neuropsychiatric complications associated with cardiopulmonary bypass. Anesth Analg 1982; 61: 903-11.
17. Nussmeier NA, Arlund C, Slogoff S. Neuropsychiatric complications after cardiopulmonary bypass: cerebral protection by a barbiturate. Anesthesiology 1986; 64: 165-70.
18. Kochs E, Hoffmann WE, Werner C, Thomas C, Albrecht RF, Schulte ED. The effects of propofol on brain electrical activity, neurologic outcome and neuronal damage following incomplete ischemia in rats. Anesthesiology 1992; 76: 245-52.
19. Watson JC, Drummond JC, Patel PM, Sano T, Akrawi W, Hoi SU. An assessment of the cerebral protective effect of etomidate in a model of incomplete forebrain ischemia in the rat. Neurosurg 1992; 30: 540-4.

การดมยาสลบสำหรับการผ่าตัด Cerebral Aneurysm Clipping โดยใช้เทคนิค Deep Hypothermic Circulatory Arrest : รายงานผู้ป่วย

ลาวัลย์ ตู้จินดา, พ.บ., อรนุช เกี่ยวข้อง, พ.บ.*, สุพจนีย์ ลิ้มอุทัยทิพย์, ค.บ.*, สุรชัย เคารพธรรม, พ.บ.**, รุ่งศักดิ์ ศิวานุวัฒน์, พ.บ.*, วิชัย เบญจชลมาศ, พ.บ.****

เทคนิค deep hypothermic circulatory arrest อาจมีประโยชน์สำหรับการผ่าตัดรอยโรคในสมองที่ยากต่อการผ่าตัดด้วยวิธีการปกติ เทคนิคนี้นำมาใช้ได้เป็นผลสำเร็จครั้งแรกที่โรงพยาบาลจุฬาลงกรณ์ในการผ่าตัด intracavernous aneurysm ขนาดใหญ่ด้วยความร่วมมือจากประสาทศัลยแพทย์ ศัลยแพทย์ทรวงอกและหัวใจ วิสัญญีแพทย์ perfusionists และพยาบาล วิธีการต่าง ๆ ที่จะช่วยเสริมให้การผ่าตัดได้ผลดีได้แก่ ระยะเวลาในการทำ circulatory arrest ที่สั้น ระดับอุณหภูมิร่างกาย การให้ barbiturate การดูแลการแข็งตัวของโลหิต และการควบคุมระดับน้ำตาลในเลือดให้ปกติ ผลการผ่าตัดที่ได้ผลดีสนับสนุนการใช้เทคนิคนี้ในการผ่าตัดแก้ไขความผิดปกติของเส้นเลือดในสมองที่ไม่สามารถผ่าตัดด้วยวิธีการปกติ

คำสำคัญ : การให้ยาระงับความรู้สึก, เส้นเลือดโป่งพองในสมอง, ปอด–หัวใจเทียม, อุณหภูมิร่างกายต่ำอย่างมาก

ลาวัลย์ ตู้จินดา, อรนุช เกี่ยวข้อง, สุพจนีย์ ลิ้มอุทัยทิพย์, สุรชัย เคารพธรรม, รุ่งศักดิ์ ศิวานุวัฒน์, วิชัย เบญจชลมาศ จดหมายเหตุทางแพทย์ ฯ 2543; 83: 1544–1549

* ภาควิชาวิสัญญีวิทยา,

** หน่วยศัลยกรรมประสาท, ภาควิชาศัลยศาสตร์,

*** หน่วยศัลยศาสตร์ทรวงอกและหัวใจ, ภาควิชาศัลยศาสตร์, คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย, กรุงเทพ ฯ 10330