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Profound Hypothermia and Cardiopulmonary Bypass in the Treatment of Recurrent Giant Angioblastic Meningioma

– Case Report –

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Hypothermia and cardiopulmonary bypass has rarely been used for difficult lesions of the brain such as giant aneurysms and hemangioblastoma of the brainstem. We report a case of huge recurrent angioblastic meningioma operated under the profound hypothermia and cardiopulmonary bypass. We reviewed the complications related to hypothermia and cardiopulmonary bypass for brain lesions.

Key Words : *Hypothermia, Cardiopulmonary bypass, Meningioma*

INTRODUCTION

Meningiomas are usually slow growing, benign tumors. The real pathogenesis of meningiomas is still unknown. Surgical treatment is the usual method for meningiomas ; however, some meningiomas can not be removed totally, due to inaccessible anatomical location and/or invasive characteristics. Typically these cases are meningiomas of the skull base in which a microsurgical cure is deemed impossible and/or surgery would cause unjustifiable neurological morbidity, and thus some disease remains following surgery. The various types of adjuvant therapy can be administered and usually consists of fractionated external beam radiation,(Taylor et al.,1988) or focused radiation, either percutaneous(Duma et al.,1993) or interstitial,(Kumar et al.,1993) all of which have demonstrated efficacy. There remains a relatively small number of patients who are not candidates for focused irradiation and/or who fail conventional radiation therapy and require other adjuvant treatment.

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Although a number of neurosurgical centers pioneered hypothermic cardiac arrest techniques 30 years ago as an aid to intracranial aneurysm surgery(Woodhall et al.,1960 ; Patterson and Ray,1962 ; Michenfelder et al.,1964 ; Gonski and Johnston,1966 ; Uihlein et al., 1966), these techniques fell into disuse by neurosurgeons for a number of reasons : the combination of hypothermia and extracorporeal circulation led to multiple clotting problems and the procedure was very time-consuming. However, there are aneurysms presently considered inoperable that might be approached by utilizing profound hypothermia.

We are reporting here a giant angioblastic meningioma which was resected by profound hypothermia and circulatory arrest.

CASE REPORT

A 44-year-old woman presented with a 3-month history of progressive left-sided weakness. She had a history of first, brain tumor operation for angioblastic meningioma(Fig. 1) 10 years ago and another one for recurrent meningioma 2 years ago. She refused to have any radiation therapy after previous operations. An examination revealed an alert and oriented woman with bilateral cortical visual dysfunction and mild cognitive dysfunctions. There was a bilateral papilledema. The

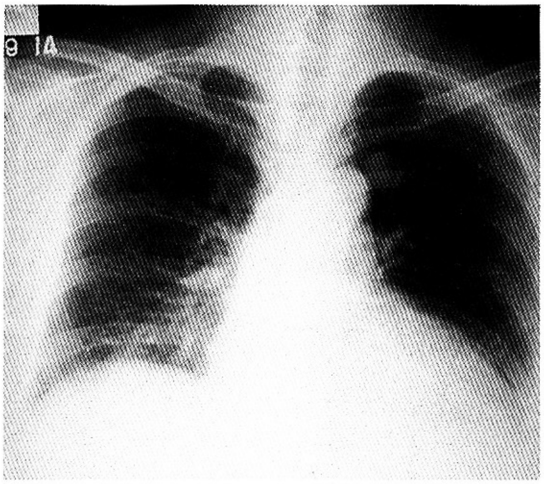

Fig. 1. Chest PA demonstrates well defined hyperattenuation metastatic nodule in left upper lung field.

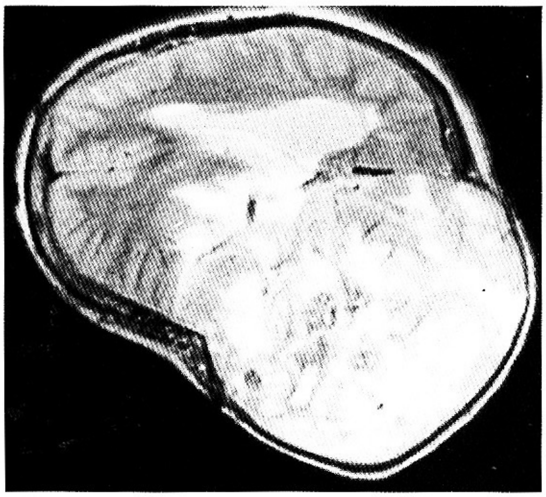

Fig. 2. Axial T2WI(SE, TR/TE ; 2000/110) shows huge heterogenous signal intensity mass, which extends outside the skull vault in right frontoparietooccipital area.

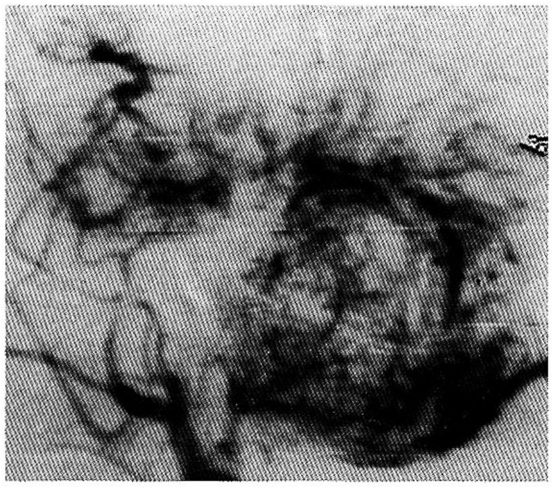

Fig. 3. External carotid angiogram shows prominent hypervascular tumor feeding vessels, mainly on occipital branch.

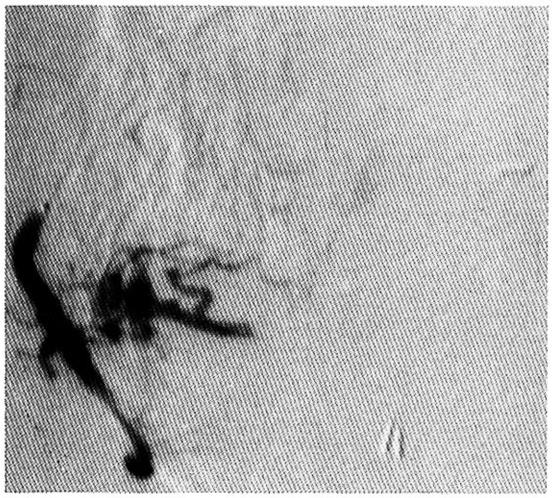

Fig. 4. Postembolization lateral angiogram, demonstrating disappeared tumor feeding vessels of occipital branch., and slowing of the flow.

patient exhibited a right side 4/5 hemiparesis affecting both upper and lower extremities. Right-sided hyperreflexia was evident without extensor plantar response. There was a huge palpable mass(width and length : 10cm×12cm) in the right parieto-occipital region. Roentgenogram of the chest showed multiple nodules in the both lung field(Fig. 2). Magnetic resonance imaging defined a huge right parieto-occipital convexity lesion with neuroimaging features consistent with a meningioma(Fig. 3). The patient underwent preoperative angiography and selective tumor embolization. Anteroposterior and lateral angiograms revealed a vascular tumor blush with supply from both the external and internal carotid artery, vertebral artery. A Tracker 10 microcatheter(Target Therapeutics Inc., Freemont, CA) was selectively navigated into the right occipital artery ipsilateral to the mass. Selective tumor embolization was performed with polyvinyl alcohol particles(150-250, 250-355, 355-500um) (ITC CONTOUR emboli) (Fig. 4). After appropriate consultation with the relatives of this patient, decisions were made to remove the huge brain mass using hypothermia with extracorporeal circulation.

Operative Procedure :

Under general anesthesia, the patient was placed on the operating tables in the semi-Fowler position. The available blood volume was drained into the pump reservoir, markedly reducing brain bulk and collapsing the vascular tumor. Surface cooling by water blankets was utilized and body temperatures was reduced to 34 ℃. The following variables were continuously monitored throughout the surgical procedures : nasopharyngeal and esophageal temperatures ; venous pressure, obtained by threading a 15-guage catheter through a right internval jugular vein into the superior vena cava; arterial pressure obtained by way of a needle placed in the right radial artery, and the electrocardiogram visualized on an oscilloscope. After skin preparation, median sternotomy was made. After the heparinization, aortic cannulation and single venous cannulation were used. Aprotinin 2×10^6 units were mixed in priming solution. Cardiopulmonary bypass with core cooling started at 10:40 am. Hemodilution was achieved to hematocrit 25%. Profound hypothermia at 15.6℃ was used and the pump flow rate was reduced to 1.0 L/min/m^2 BSA for minimizing bleeding. Craniotomy was started at 10:30 am and the area of tumor exposed fully at 11:00 am. The brain was of pale color with appropriate normal differences between large cortical arteries and veins. The brain was very cold to palpation as expected, soft and malleable. The tumor was removed near totally without remarkable bleeding. But superior sagittal and transverse sinuses were torn during the dissection of tumor and bleeding was uncontrollable with surgicel, avitene, and gelfoam. In addition to this, there was diffuse bleeding from the tumor bed after removal of tumor mass. Blood pressure was controlled by the transfusion and volume replacement. Protamine sulfate (10 mg/1000 units of initial heparin dose) was given immediately after decannulation, normalizing the activated clotting time. Bleeding from the epidural space and sinuses was copious despite the dural tenting sutures. The bleeding was not under control with the administration of the clotting factors. After operation the patient had a complicated course. She died on the day following operation.

DISCUSSION

Cardiac surgeons introduced profound hypothermia to protect the brain during longer periods of ischemia in open-heart surgery employing a caridopulmonary bypass pump and heat exchanger. Core-temperatures were reduced to 10-15℃ and periods of total circulatory arrest amounting to 45 min. have been accomplished safely(Drew,1961 ; Uihlein et al.,1962). Experimentally at 28℃, cerebral metatolism is reduced below 50 percent(Lougheed and Kahn,1955) and the effects of hypoxia have been avoided in patients during intervals of 5 to 10 min. of occlusion of the carotid and/or vertebral artery. Conventional hypothermia introduced by Botterell et al.(1958) has become widely used in the protection of the brain during craniotomy in some aneurysm cases. Woodhall et al.(1960) explored the use of deep hypothermia during craniotomy for ruptured aneurysm. Patterson and Ray(1962) described their laboratoy work and the use of closed-chest perfusion with 2 deaths in 7 clinical cases. Uihlen(1962) reported on 36 cases with 8 deaths. Drake et al.(1964) used deep hypothermia in 10 cases of difficult aneurysms but the results were not rewarding, even though exsanguination and circulatory arrest facilitated superb exposure of the aneurysm and its connections and accurate placement of a ligature or clip. The case mortality was 50 percent. Craniotomy under deep hypothermia is a considerable undertaking involving two teams and a maze of equipment and technical help. The average operating time was 8 hours with a mean cooling phase of 58 min. and average rewarming period of 75 min. The final core temperatures ranged from 9.6 to 16.8℃. with an average rewarming period of 10 min.(2 min. to 18 min.)(Drake et al.,1964)

Intracranial operations can be performed under hypothermia and cardiac arrest in a dry surgical field which obviates the difficulties that can arise from premature rupture of the aneurysm and facilitates the identification of the vasculature for accurate placement of clips or ligatures. While the repair of an aneurysm may be accomplished without loss of blood at these low temperatures there may be annoying bleeding from poorly defined points in the operative field in the period of rewarming. Attempts to stop the bleeding during this time are not rewarding and may provoke more bleeding (Patterson and Ray,1962). There is some evidence that extremely low temperatures may cause damage to the brain, perhaps as a result of sludging due to changes in the plasma and increased viscosity of the blood. But on the other hand there is the possibility that at the low temperatures attained, a degree of protection is provided for the brain even against occlusion of fairly large arteries that does not exist in the presence of higher temperatures(Rosomoff,1959).

Bjork and Hulquist(1960) have commented on the dangers of emboli of fibrin and platelets as a cause of dementia following deep hypothermia. The closed-chest method is favored by some groups(Michenfelder et al., 1964)(Patterson and Ray,1962). Although atrial cannulation was simplified, poor venous return resulted in inadequate perfusion and severe deep thrombophlebitis. In comparing the closed-chest technique with the Drew method, several differences are to be noted. The major advantages of the closed-chest technique are as follows : 1) simplification of the technique reduces the operative hazards ; 2) significantly less blood is lost which makes this technique safer and more available than the Drew method ; and 3) the postoperative complications of thoracotomy are avoided. The associated complications of clamping a major cardiac vessel, such as thromboembolism, loss of control of cardiac rhythm, and post-arrest hypertension, are obviated by the open method.

Some authors were able to remove vascualr tumor, hemangioblastomas of the brain stem, successfully. (Silverberg et al.,1981)(Patterson and Fraser,1975) With the patient in a semisitting position under hypothermia and circulatory arrest, the tumor, initially very vascular and friable, became a pale, shrunken mass that separated without too much difficulty from the medulla. We were able to remove the huge angioblastic meningioma extending both supra and infratentorial region with profound hypothermia and cardiopulmonary bypass procedures. Unfortunately the outcome was not good because sinuses(superior and transverse) were damaged during surgery.

Of particular concern to the neurosurgeon was the danger of bleeding. The bleeding following hypothermic procedures appeared during the rewarming and in the early postoperative period. Although troublesome, bleeding during the period of heparinization came under control after administration of Polybrene and there were no postoperative clots on the surface. The bleeding tendency seen in patients following extracorporeal circulation can be due to a number of defects in the clotting scheme(Muller et al.,1975 ; Moriau et al.,1977 ; Choi et al.,1988 ; Park et al.,1989). In any individual case, it is usually believed to be due to one or several of the following disorders : 1) thrombocytopenia and abnormal platelet function ; 2) inadequate correction of heparinization ; and 3) inhibition(mainly dilutional) of coagulation Factors I,II,V,VII,X, and XIII. The addition of deep hypothermia further inhibits clotting by delaying all the enzyme-mediated steps in the coagulation cascade.

Biological abnormalities in clotting occur in 68% to 100% of cases during and after use of extracorporeal circulation(Moriau et al.,1977). For the cardiac surgeon, however, only 2% to 3% of these patients exhibit clinically significant bleeding. Drake et al.(1964) reported that several catastrophic bleeding episodes occurred during surgery with hypothermic cardiac arrest, causing him to abandon the procedure. Silverberg et al. have therefore, adopted a "shotgun" approach to replacing clotting factors since more sophisticated clotting studies are not reliably available in time to affect replacement therapy during surgery(Silverberg et al.,1981). In addition, laboratory evidence of adequate replacement is sometimes associated with bleeding, which can be corrected by further factor administration. Infusion of fresh frozen plasma and the patient's own warm blood helps correct the clotting factor deficit which, with the exception of Factor V, is primarily dilutional(Moriau et al., 1977). Fibrinolysis may be accentuated with hypothermia(Morgan et al.,1973), although the reason for this is not clear. In order to minimize clotting deficits, the depth and duration of hypothermia and bypass should be the least that affords adequate protection during definitive surgery. Therefore, as much of the exposure and preliminary dissection as can be safely done should be completed before cardiopulmonary bypass begins. Severe hemodilution(hematocrit approximately 10%) may be beneficial in preventing the hemorrhagic diathesis that frequently accompanied profound hypothermia procedures in neurosurgery in the past. Severe hemodilution appears to lessen the activation of the fibrinolytic system and a sizable part of the patient's own blood components(including platelets) are given back after rewarming, having escaped the trauma of perfusion and hypothermia. Severe hemodilution may help prevent the previously recognized,often disastrous hemorrhagic problems encountered in the craniotomy wound(Morgan et al.,1973). In regard to craniotomy, Nofzinger and Murphey reported that the bleeding tendency could be minimized by performing craniotomy electively 1 week before approaching the aneurysm itself. The use of dissecting microscope, the timing of the operation, the use of steroids and most important, experience, have been essential. Based on our limited experience, cardiopulmonary bypass and profound hypothermia might be one of the useful tools for huge vascular tumors inoperable by conventinal operative methods.

It has yet to be determined what dangers or advantages attend greater cooling of the brain. The establishment of individual contraindications to profound hypothermia and circulatory arrest will come with cautious trial and experience. Thus far, the patients have been relatively young and free of advanced cardiovascular, renal and hepatic disease.

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