Circulatory Arrest with Profound Hypothermia During the Surgical Treatment of Large Internal Carotid Artery Aneurysm

—Case Report—

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Abstract

A 43-year-old male presented with a cerebral aneurysm manifesting as right facial paresthesia, without neurological deficit. Angiography revealed a large aneurysm (22 mm) of the left internal carotid artery. Intravascular treatment using placement of a detachable coil was attempted, but the coil did not stay in the aneurysmal cavity and the procedure was abandoned. The patient did not tolerate the transient balloon occlusion test of the left internal carotid artery. Therefore, the aneurysm was clipped through an open craniotomy with profound hypothermia (20°C) with cardiac arrest (24 minutes). The aneurysmal dome was collapsed, allowing easy dissection of the posterior communicating artery. The closed chest method was used during the extracorporeal cardiopulmonary bypass. Postoperative angiography revealed complete neck clipping with preservation of carotid blood flow. The patient recovered well and resumed his employment. Circulatory arrest with hypothermia provides several benefits for the surgical treatment of large and giant aneurysms.

Key words: cerebral aneurysm, hypothermia, cardiac standstill, cardiopulmonary bypass

Introduction

Advances in cardiac surgery using profound hypothermia and cardiac arrest have here enabled very stable and effective cardiac surgery. The body temperature can be reduced safely and the cardiac arrest can be prolonged for as long as 1 hour. Such methods can also be applied to neurosurgery and have become nearly routine in neurosurgery in North America.2,4,7-11,15 However, this technique is seldom used in Japan because of problems associated with obtaining hypothermia, lack of information regarding blood coagulation systems, and unsatisfactory mortality and morbidity.15 Cardiac arrest has the advantages of causing collapse of the dome of the aneurysm and providing a better view around the neck, enabling neck clipping with more ease in elective cases.

We describe a case of a large aneurysm of the internal carotid artery which was clipped during cardiac arrest and hypothermia.

Case Report

A 43-year-old male developed right facial paresthesia. A cerebral aneurysm was found at a local hospital. He was referred to our hospital. Neurological examination found no deficit on admission. Angiography revealed a large aneurysm on the left internal carotid artery (Figs. 1 and 2). Magnetic resonance imaging showed partial thrombus inside the aneurysm but no calcification around the aneurysmal neck or the left internal carotid artery (Fig. 3). The distal aneurysmal sac had an irregular shape suggesting adhesion to the temporal and cranial basal dura. The maximum diameter of the
aneurysm was 22 mm.

Intravascular treatment was initially chosen. Placement of an interlocking detachable coil (Target, Inc., Fremont, Calif., U.S.A.) was attempted, but part of the coil protruded from the large neck of the aneurysm. The coil was removed and the intravascular procedure was abandoned. All further treatment options, surgical clipping of the aneurysm, trapping of the aneurysm, or proximal occlusion of the internal carotid artery by either surgery or endovascular treatment, were expected to require either permanent or transient occlusion of the internal carotid artery. The balloon occlusion test was performed. The balloon was inflated and the internal carotid artery was occluded. The patient immediately became unconscious, with dysphasia and right hemiparesis. The balloon was deflated and internal carotid arterial blood flow was restored, when the symptoms disappeared immediately. The regional cerebral blood flow, examined during balloon occlusion, showed a
marked decrease. Therefore, brain protection was thought to be mandatory during surgery, and bypass and hypothermia were considered.

Surgical intervention with bypass was chosen. Before surgery 400 ml of autologous blood was collected for extracorporeal circulation. The patient was placed in the supine position, and the chest was exposed for possible counter shock or open cardiac manipulation for ventricular fibrillation. The neck on the left was linearly incised to expose the external and internal carotid arteries. The left radial artery was dissected and a radial arterial graft was removed. A left frontal craniotomy was made. The dura was opened widely and the Sylvian fissure was opened. The M2 portion of the middle cerebral artery was exposed, and the radial arterial graft was anastomosed between the external carotid artery and the M2 portion in end-to-side fashion. After dissecting the internal carotid artery and aneurysm, the cardiac surgeon placed one catheter into the right femoral artery and two catheters into the femoral veins. The tip of one of these two catheters was directed up to the right atrium. Extracorporeal circulatory assistance was then started to reduce the body temperature, which was measured at the bladder. Circulation was maintained at 3 l/min/m². Heparin was administered during extracorporeal circulatory assistance, to maintain the active clotting time at between 360 and 480 seconds. As hypothermia progressed, the blood pressure dropped and aneurysmal dissection was carried out. Finally body temperature reached 20°C, and cardiac arrest was attained. The posterior communicating artery adhering to the dome was easily dissected because of the collapse of the aneurysmal dome due to circulatory arrest. Four clips were applied to the neck during cardiac arrest, which lasted for 24 minutes. Gradually the body temperature was raised and the ventricular fibrillation was reversed by counter-shock. The heart started to beat normally. The body temperature returned to the normal level. Extracorporeal circulatory assistance was ceased and heparin was reversed. The total time for extracorporeal assistance was 104 minutes. Intraoperative angiography confirmed complete neck clipping and patency of the radial graft. The craniotomy was closed.

The postoperative course was uneventful except for a small hemorrhage in the frontal lobe which disappeared rapidly during the following week. Postoperatively, the platelet count was $191 \times 10^9/l$ and there was no bleeding tendency. Postoperative angiography disclosed complete clipping of the aneurysm and patency of the radial graft (Figs. 4 and 5). The patient's neurological status was normal on discharge. He resumed his employment.

Discussion

Endosaccular occlusion of aneurysms with a neck larger than 4 mm is difficult as in our case. If occlusion of the internal carotid artery cannot be tolerated, as shown by the balloon occlusion test, the surgical approach is indicated but large and giant aneurysms are difficult to treat. The suction decompression method or profound hypothermia with cardiac standstill was recently introduced for large

Fig. 4 Postoperative left internal carotid arteriograms, anteroposterior (left) and lateral views (right), showing complete clipping of the aneurysmal neck.

Fig. 5 Selective external carotid arteriogram showing good patency of the bypass.
and giant aneurysms.\textsuperscript{1)} However, the suction decompression method cause zero flow in perforating arteries or critical small arteries such as the anterior choroidal artery and infarction in the perfusion area may occur without effective brain protection.

Profound hypothermia and hypotension followed by cardiac arrest provides four major advantages. Cardiac arrest reduces the cerebral blood volume, resulting in easier brain retraction, a wider operative field, and easier operative manipulation in narrow and deep spaces. Aneurysmal tension is minimized so the dissection of tiny branches such as perforating arteries, posterior communicating arteries, and anterior choroidal arteries becomes very easy, and even the important perforating arteries hidden behind a large aneurysm can be easily found and dissected from the aneurysm. The aneurysm loses tension so the aneurysmal neck can be easily observed, and endarterectomy of the neck is easier for a thrombosed or arteriosclerotic aneurysm, so the clipping is more secure. Finally, brain protection is achieved, which cannot be obtained by the suction decompression method or standard temporary occlusion of the parent artery if the balloon occlusion test is positive. Therefore, profound hypothermia with cardiac arrest is a very effective adjunctive procedure for the treatment of large or giant aneurysms in either a narrow operative field or surrounded by small important branches in patients who cannot tolerate temporary or permanent occlusion of the parent artery. We found that 24 minutes of hypothermia and cardiac arrest was needed for clipping of the aneurysm. Thus the limit of 1 hour appears to be long enough to dissect and clip an aneurysm in elective cases. This procedure has also been recommended for aneurysms of the upper basilar artery, internal carotid artery aneurysm, and hemangioblastoma.\textsuperscript{2,3,12,13}

In our case, we also performed a radial arterial bypass, because if neck clipping could not be completed within 1 hour of cardiac arrest, the alternative procedure would have been trapping of the internal carotid artery that could not be tolerated without bypass. The bypass was established prior to the trapping, because the serial procedure of dissecting the radial artery and the carotid artery followed by anastomosis of the bypass takes more than 1 hour and so permanent ischemic insult would not be avoided. The bypass is unnecessary if the clipping is expected to be easy before and during surgery. However, in this case, the clipping appeared to be difficult before surgery and so the bypass was positioned first. Also, we were not certain whether the clips would slip out from the neck when the body temperature rose, the heart started to beat and the blood pressure rose to the usual level. Slipping of the clip would require trapping with bypass. Fortunately in this case, the clipping was successful even after the temperature rose and the heart beat again normally, and the bypass became unnecessary. There was some anticipation of hyperperfusion syndrome and closure of the bypass was considered after clipping was completed. After surgery the blood pressure was carefully controlled and hypertension was avoided.

Our patient was young and had no history of cardiac problems, so the closed chest method was used, but open chest methods avoid the left ventricular overload, myocardial infarction, and limitation of maximal flow.\textsuperscript{3)} For reversal of ventricular fibrillation, the chest surface is exposed and kept sterile. Ventricular fibrillation was reversed with the defibrillator and did not require emergency thoracotomy.

The aneurysm in this case could have been clipped with standard temporary occlusion with bypass. This is the standard procedure if the surgeon is experienced and confident enough to clip the aneurysm without deficit. However, this case does show the additional and important benefits of profound hypothermia with cardiac arrest as an adjunctive procedure in aneurysmal surgery.

\textbf{References}


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