Direct clipping of basilar trunk aneurysms using temporary balloon occlusion

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In the surgical treatment of basilar trunk aneurysms, there is still considerable technical difficulty in gaining both proximal artery control and a sufficient operative field. The authors describe their experience in five patients with basilar trunk aneurysms treated using temporary balloon occlusion and intraoperative digital subtraction angiography. With the patient under general anesthesia, a heparinized angiography catheter was guided into the dominant vertebral artery by means of the Seldinger technique. A silicone balloon catheter was introduced coaxially through the angiography catheter to the basilar artery just proximal to the aneurysm. The balloon was inflated tentatively to evaluate the appropriate inflation volume, then the balloon catheter was withdrawn back into the angiography catheter to prevent thrombus formation. After exposure of the aneurysm, the occlusion balloon was advanced again and inflated temporarily within the basilar artery to prevent premature rupture and to facilitate dissection of the aneurysm. The mean duration of temporary balloon occlusion was 22 minutes. There were no patients with postoperative deficits attributable to the temporary occlusion. The results of aneurysm clip placement were confirmed by intraoperative digital subtraction angiography immediately after clipping. No patient suffered from distal embolism or other complications related to vessel catheterization. From this experience, it is concluded that this intraoperative endovascular technique can contribute to the success of surgery for complex cerebral aneurysms, particularly for basilar trunk aneurysms in which proximal vascular control is difficult.

Key Words • temporary balloon occlusion • aneurysm • basilar trunk • intraoperative digital subtraction angiography

Aneurysms of the posterior circulation, especially those of the basilar trunk, are still the most difficult aneurysms to manage. This is related mainly to the deep location of the aneurysm and the difficulty in gaining proximal vascular control. To resolve this surgical difficulty and to confirm the completeness of the clip application, we have used temporary balloon occlusion and intraoperative digital subtraction angiography during surgery for basilar trunk aneurysms. In this report, we describe our surgical experience with five cases of basilar trunk aneurysms using these intraoperative endovascular techniques.

Clinical Material and Methods

Patient Population

From 1988 to 1992, five patients with basilar trunk aneurysms were surgically treated with the aid of endovascular catheter techniques. The five patients included one woman and four men, ranging in age from 25 to 67 years (mean 41 years). All patients presented with subarachnoid hemorrhage. The aneurysms ranged from 4 to 30 mm in diameter, with an average size of 13 mm. The distance measured from the posterior clinoid process to the aneurysmal neck ranged from 10 to 28 mm, with a mean of 20 mm. Three aneurysms projected laterally and two anteriorly. The clinical aspects of all patients are summarized in Table 1.

Surgical Technique

The patient was placed on a radiolucent operating table. After induction of anesthesia, the patient's head was fixed in the desired position with a standard Mayfield headholder. In the two most recently treated cases, a radiolucent carbon-composite headholder* was used. A No. 5 French heparinized angiography catheter was used.

* Radiolucent skull clamp manufactured by Ohio Medical Instrument Co., Cincinnati, Ohio.
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TABLE 1

Clinical features of five patients with basilar trunk aneurysms

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Presentation (SAH Grade)*</th>
<th>Aneurysm Diameter</th>
<th>Distance From Dorsum Sellae</th>
<th>Surgical Approach</th>
<th>Balloon Occlusion Time</th>
<th>Clip Repositioning Required</th>
<th>Outcome†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39, M</td>
<td>SAH (I)</td>
<td>13 mm</td>
<td>10 mm</td>
<td>subtemporal</td>
<td>15 min</td>
<td>no</td>
<td>good</td>
</tr>
<tr>
<td>2</td>
<td>35, F</td>
<td>SAH (I)</td>
<td>30 mm</td>
<td>20 mm</td>
<td>combined supratentorial &amp; infratentorial</td>
<td>30 + 25 min</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>3</td>
<td>25, M</td>
<td>SAH (II)</td>
<td>4 mm</td>
<td>25 mm</td>
<td>subtemporal transtentorial</td>
<td>28 min</td>
<td>no</td>
<td>good</td>
</tr>
<tr>
<td>4</td>
<td>67, M</td>
<td>SAH (II)</td>
<td>9 mm</td>
<td>15 mm</td>
<td>subtemporal transtentorial</td>
<td>18 min</td>
<td>no</td>
<td>good</td>
</tr>
<tr>
<td>5</td>
<td>40, M</td>
<td>SAH (II)</td>
<td>10 mm</td>
<td>28 mm</td>
<td>transtentorial</td>
<td>20 min</td>
<td>yes</td>
<td>good</td>
</tr>
</tbody>
</table>

* SAH = subarachnoid hemorrhage. The SAH grading is based on the classification of Hunt and Kosnik.† Outcome based on the Glasgow Outcome Scale.

Fig. 1. Case 1. This 39-year-old man suffered a minor subarachnoid hemorrhage 1 month before aneurysm clipping. Left: Preoperative angiogram demonstrating a broad-based basilar trunk aneurysm located close to the superior cerebellar artery. Since the aneurysm arose relatively high, it was approached via the standard subtemporal route. Center: Intraoperative angiogram showing a temporary occlusion balloon (arrow) advanced to and inflated at a site just proximal to the aneurysm. Right: Postoperative angiogram demonstrating that the aneurysm was dissected and successfully clipped. The patient was neurologically intact postoperatively.

introduced coaxially through the femoral sheath to the dominant vertebral artery under fluoroscopic control. For one patient who underwent surgery in the lateral park-bench position (Case 2), transfemoral catheterization was carried out prior to patient placement. Preoperative digital subtraction angiography (Figs. 1 to 5 left) was performed routinely to confirm that the aneurysm was not being obscured by the headholder or skull-fixation pins. A silicone balloon (0.7 to 1.5 mm in uninflated diameter) attached to a No. 1.5 French polyethylene catheter was then advanced through the angiography catheter to the basilar artery about 1 cm proximal to the aneurysm. The balloon was inflated tentatively to assess the appropriate inflation volume to occlude the parent artery, then the balloon catheter was withdrawn back into the angiography catheter to prevent thrombus formation. The angiography catheter was situated within the vertebral artery throughout the surgery and both the femoral sheath and the angiography catheter were flushed continually with heparinized saline (10 U/ml) at a rate of 0.5 ml/min. The femoral sheath was used as the arterial line for systemic blood pressure monitoring. The groin was covered with a sterile drape for the subsequent intraoperative catheterization procedures, and the craniotomy was begun.

Various surgical approaches were used depending upon the location of the aneurysm, its projection and size: the standard subtemporal approach (Case 1), the subtemporal transtentorial approach (Cases 3 and 4), the transtentorial approach (Case 5), and the combined supratentorial and infratentorial approach (Case 2). The operation was temporarily interrupted just before the final stage of aneurysm dissection. The operating microscope was displaced, and a C-arm fluoroscope, covered with a sterile drape, was positioned around the patient’s head. The balloon catheter was advanced to the target location under fluoroscopic guidance. After we had confirmed that the tip of the balloon catheter was in the appropriate position for proximal vascular control, the C-arm was removed and the operating mi-
F
case 2. This 35-year-old woman experienced the sudden onset of severe headache, and a computerized tomography scan showed a mild subarachnoid hemorrhage. Left: Preoperative angiogram demonstrating a giant basilar trunk aneurysm. For surgery, the combined supratentorial and infratentorial approach was used. A balloon catheter was introduced into the right vertebral artery and proximal control of the left vertebral artery was obtained intracranially. Center: After the aneurysm was temporarily trapped by the balloon and temporary clips, two ultralong No. 92 Sugita clips were applied in tandem fashion to the aneurysm. However, since this aneurysm was of the giant fusiform type, it was impossible to obliterate the aneurysm completely. Right: The final intraoperative digital subtraction angiogram showing a small residual portion of the aneurysm. The postoperative course was uneventful.

case 3. This 25-year-old man was admitted to our clinic 12 hours after a sudden onset of severe headache. Left: Preoperative angiogram revealing a small basilar trunk aneurysm (arrow) projecting anteriorly and located 25 mm below the posterior clinoid process. It was also apparent that the aneurysm arose from the proximal side of the fenestration of the basilar artery. Center: Surgery was performed on the 4th day after symptom onset using a right subtemporal transtentorial approach. The aneurysm was found to be located with a surrounding clot in the narrow space between the fifth and eighth cranial nerves. The balloon (arrow) was introduced into the basilar artery about 1 cm proximal to the aneurysm and was inflated. Right: The aneurysm was dissected and successfully clipped while preserving the fenestration of the basilar artery and the small branch adherent to the aneurysm. The patient made a favorable postoperative recovery except for transient right abducens paresis, which resolved within 3 months.

croscope was replaced. The balloon was then inflated for temporary vascular occlusion (Figs. 1 to 5 center). This maneuver could be performed without fluoroscopic control because the appropriate inflation volume had been verified beforehand. In order to provide cerebral protection during temporary occlusion, 500 ml of a solution of 20% mannitol, with 500 mg phenytoin and 500 mg vitamin E, was administered. In all cases, we confirmed the results of the clipping with intraoperative digital subtraction angiography; if the results were unsatisfactory, the clip placement was corrected.
Results

Temporary Balloon Occlusion

Temporary balloon occlusion was achieved in all cases. The time required for the preoperative vessel catheterization and intraoperative balloon manipulation ranged between 60 and 120 minutes. The duration of temporary occlusion ranged from 15 to 30 minutes, with a mean of 22 minutes. Intraoperative somatosensory evoked potential (SEP) monitoring was performed in all cases; however, significant changes in the SEPs were not observed during occlusion in any case. Also, no patient demonstrated postoperative sequelae attributable to the ischemia caused by temporary balloon occlusion. The duration of intravascular placement of the heparinized catheter was about 6 to 8 hours, and no patient suffered an embolic or other complication related to vessel catheterization.

Intraoperative Digital Subtraction Angiography

Intraoperative digital subtraction angiography was performed after the initial attempt at aneurysm clipping. In three of the five cases, successful obliteration of the aneurysm was demonstrated (Figs. 1, 3, and 4 right). In the two remaining patients (Cases 2 and 5), clip repositioning was required. In one patient with a giant aneurysm (Case 2), complete aneurysmal neck occlusion was found to be impossible so clipping of the aneurysmal body was necessary (Fig. 2 right). In Case 5, intraoperative digital subtraction angiography demonstrated occlusion of the basilar artery distal to the aneurysm. Accordingly, the clip was repositioned slightly distal to the aneurysmal neck; however, a second angiogram still showed basilar artery occlusion. Eventually, it was recognized that the balloon catheter placed within the basilar artery obscured angiographic visualization of the artery (false-positive finding). The final angiogram, obtained following removal of the balloon catheter, showed excellent patency of the vertebrobasilar arterial system and satisfactory clipping of the aneurysm (Fig. 5 right).

Outcome

Two patients suffered transient neurological deficits postoperatively: abducens nerve paresis in Case 3 and hemiparesis in Case 4. These deficits were considered to be the direct result of retraction of neural structures, and both resolved 1 to 3 months thereafter. The outcome at 3 months after surgery, evaluated according to the Glasgow Outcome Scale, was good in all cases.

Discussion

Drake recommended a subtemporal transtentorial approach for basilar trunk aneurysms above the middle third of the clivus and a suboccipital approach for those below that level. However, there are considerable surgical difficulties in such standard operative approaches, as those invariably require direct retraction of the cranial nerves and/or the brain stem due to the limited operative field. The transoral transclival approach, which offers a direct angle of visualization, has been mostly abandoned due to the high risk of postoperative meningitis. Recently, a variety of modified approaches that lessen the degree of retraction of the neural structures have been reported, including the transpetrosal approach, the retrolabyrinthine transsigmoid approach, and the combined supratentorial and infratentorial approach. In the case of basilar trunk aneurysms, however, such modern approaches even
with extensive bone removal would still provide only a narrow access to the prepontine cistern. When a temporary clip is applied to the basilar artery, the clip itself potentially obstructs the operative field. Temporary balloon occlusion can minimize such an obstruction of the surgical field.

Recently, portable angiography equipment has been developed and intraoperative digital subtraction angiography has been successfully used in the treatment of complex cerebrovascular lesions in several institutes. In 1990, Shucart, et al., reported a balloon occlusion method for difficult aneurysm surgery; we had independently developed and used a similar method for surgery of arteriovenous malformation in 1985. More recently, Bailes, et al., also reported using the temporary balloon occlusion technique for surgery of basilar tip aneurysms. Thus far, we have used this intraoperative endovascular technique mostly for internal carotid artery (ICA) aneurysms in which proximal vascular control is difficult. The conventional method for exposing the cervical ICA may provide sufficient proximal control for proximal ICA aneurysms. For most cases of basilar tip aneurysms, proximal control can also be obtained by incising and retracting the tentorial edge. From our experience, it is considered that temporary balloon occlusion can be most usefully employed for basilar trunk aneurysms.

It is our policy to use temporary clips for ruptured aneurysms to prevent the possibility of intraoperative rupture and to facilitate the complete treatment of the aneurysm. All five patients in this series had ruptured basilar trunk aneurysms. In operations on these cases, preparation for proximal artery control was essential. From our experience with these patients, the advantages of temporary balloon occlusion can be summarized as follows: 1) proximal control has already been obtained before craniotomy, which results in less effort to gain access to the basilar artery proximal to the aneurysm; 2) this technique minimizes obstruction of the surgical field as would be caused by the conventional use of temporary clips; and 3) use of intraoperative digital subtraction angiography facilitates the evaluation of clip placement.

The most serious complication of this technique is embolism. To prevent this complication, in all cases we kept the balloon catheter within the heparinized angiography catheter during surgery, proceeded with the operation until the point where balloon occlusion was required, and then advanced the balloon catheter to the target point. In all cases, a heparinized angiography catheter was left in the vertebral artery throughout the surgery. Systemic heparinization was not used, but the catheter was flushed continually with heparinized saline. Embolic complications did not arise even though the catheter was kept in place for 6 to 8 hours.
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our experience with such cases, it seems that the heparinized catheter\(^1\) can allow a prolonged intravascular placement without incurring embolic complications.

Bailes, et al.,\(^2\) reported the complication of vessel rupture during intraoperative catheterization of the basilar artery, and “although the massive hemorrhage was eventually controlled, the patient subsequently died.” In our series we have not encountered such a disastrous complication. Temporary balloon occlusion is a relatively simple procedure among the various endovascular techniques; however, it should be performed by an expert neuroradiologist to minimize complications.

We generally initiate vascular occlusion before dissection of the aneurysm itself. In the present series, we treated all aneurysms without intraoperative aneurysm rupture. The duration of the balloon occlusion was relatively long (average 22 minutes), but there were no cases of ischemic symptoms caused by the temporary occlusion. The administration of brain protective agents, including mannitol, vitamin E, and phenytoin,\(^25\) might have brought about such good results. Since there were no changes in the SEP’s during occlusion, these findings indicate that there was sufficient retrograde collateral flow through the posterior communicating artery in all cases. As Little, et al.,\(^10\) reported, however, monitoring of the SEP’s and/or brain-stem auditory evoked potentials (BAEP’s) during surgery for basilar artery aneurysms occasionally fails to identify ischemic events. Although there have been many reports of SEP and BAEP monitoring during aneurysm surgery, none has clarified the permissible occlusion time for the basilar artery.\(^13\)–\(^17\)

Drake and Peerless’\(^19\) recommended intermittent temporary occlusion and reperfusion to avoid ischemic periods of longer than 3 to 4 minutes; however, they described a case of prolonged basilar artery occlusion for up to 30 minutes without apparent neurological deficits. From our experience with this series of patients, it is suggested that the brain stem could tolerate temporary occlusion of the basilar artery for about 20 to 30 minutes under normotension in combination with administration of cerebral protective agents. However, it need hardly be said that the tolerance of cerebral ischemia is likely to be quite variable among individual patients depending upon the development of collateral circulation, and that the occlusion time should be reduced to as short a period as possible.

In conclusion, from this preliminary experience with five patients, it is emphasized that intraoperative digital subtraction angiography and temporary balloon occlusion can be used safely as new adjunctive procedures for surgery of complex posterior circulation aneurysms.

References

22. Solomon RA, Stein BM: Surgical approaches to aneurysms

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