Fenestrated clips for unusual aneurysms of the carotid artery

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Twenty-four different kinds of fenestrated clips are introduced for the obliteration of unusual aneurysms. The clips were used for eight aneurysms of the internal carotid artery and 10 aneurysms of the vertebral artery. All but one of the aneurysms were successfully obliterated. Recommendations are made concerning the actual use of the clips.

KEY WORDS: subarachnoid hemorrhage, fusiform aneurysm, giant aneurysm, aneurysm clip, carotid artery, vertebral artery

Some aneurysms with peculiar shapes or in unusual locations cannot be obliterated by ordinary clipping methods. For such difficult cases, several special methods have been devised, such as those involving copper wire insertion, stereotaxic thrombosis, detachable balloons, and remote tourniquets.1,2,4,6-10,12

We believe that the improvement of the shape of aneurysm clips will enable successful clipping of most types of difficult aneurysms. We have previously described a clipping method for fusiform vertebral aneurysms using fenestrated clips.15,16 In this paper we report the obliteration of unusual aneurysms of the internal carotid artery by means of special clips.

Description of Clips Used

In the past 3 years we have operated on 450 aneurysms at the Shinshu University Hospital and its five affiliated hospitals. Thirty-six cases (8%) were unusual lesions, having a wide neck, large dome, anomalous shape, or peculiar protrusions. For those cases we used various special kinds of Sugita clip, including L- or J-shaped clips, those with ultralong blades, and fenestrated clips. Fenestrated clips were used in 18 aneurysms. There are 24 different kinds of fenestrated Sugita clip: 1) straight, oblique-angled, right-angled, and bayonet-shaped clips; 2) clips with blade lengths of 5, 6, 7.5, 9, 10, and 12 mm; and 3) clips with fenestrations 3.5, 4, 5, and 6 mm in diameter. Fenestrated clips have maximum opening widths at the blade tips ranging from 7 to 14 mm. The straight clip has the widest opening distance, followed by the oblique-angled clip, and the right-angled clip has the narrowest opening.

Illustrative Cases

Case 1

This 72-year-old woman had a minor subarachnoid hemorrhage (SAH) 2 weeks before surgery. On admission, no neurological symptoms were present except for a slight headache. The carotid angiogram showed a large aneurysm of the left internal carotid artery proximal to the origin of the anterior choroidal artery; the left posterior communicating artery was not seen (Fig. 1A and B). A left frontotemporal craniotomy was carried out under normotensive general anesthesia. A large fusiform aneurysm was found protruding ventromedially from the carotid artery. Vasa vasorum, which usually suggest the side of the original parent artery, were seen spread on the dorsal surface of the aneurysm wall. Adequate space for insertion of the clip was obtained by upward retraction of the left optic nerve after unroofing the left optic canal. First, the proximal half of the dome was clipped with an oblique-angled clip with a fenestration 5 mm in diameter and straight blades 10 mm long. Then, a second fenestrated clip of the same shape with blades 7.5 mm long was applied to the distal residual half of the aneurysm so as to partially overlap the first clip. The anterior choroidal and all perforating arteries around the aneurysm were successfully clipped.
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FIG. 1. Case 1. Left carotid angiograms, preoperative anteroposterior view (A), preoperative lateral view (B), postoperative anteroposterior view (C), and postoperative lateral view (D). Lower: Schematic drawings of the operative views. Arrow = posterior communicating artery, which appears as a degenerated fibrous string.

preserved with this clipping method and the newly reconstructed carotid artery seemed to have ample diameter. After clipping, the posterior communicating artery was clearly identified as a degenerated fibrous string (Fig. 1 lower). The postoperative angiogram showed good patency of the carotid artery, and the patient returned home without neurological deficits (Fig. 1C and D).

Case 2

This 74-year-old woman had a mild SAH. Right carotid angiography revealed a large aneurysm at the junction of the internal carotid and posterior communicating arteries. The posterior communicating artery seemed to originate from the aneurysm dome, and the right posterior cerebral artery was predominately supplied from this posterior communicating artery (Fig. 2A and B). The patient's condition was graded as Hunt and Kosnik Grade II.

At surgery 22 hours after SAH, a relatively generous right frontotemporal craniotomy was made under halothane anesthesia with normotension. A large aneurysm without a neck was encountered at the right carotid artery. The carotid wall had been stretched to become fusiform. Vasa vasorum were seen distributed on the dorsal side of the carotid artery. The aneurysm protruded ventrally from the carotid artery. The posterior communicating artery was found by retracting the right optic nerve medially. The posterior communicating artery appeared to originate not from the carotid artery but from the aneurysm dome.

The proximal carotid artery was clipped with a
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Fig. 2. Case 2. Upper: Right carotid angiograms, preoperative lateral view (A), preoperative anteroposterior view (B), and postoperative anteroposterior view (C). Lower: Schematic drawings of the operative views. Open arrows = posterior communicating artery; solid arrows = anterior choroidal artery.

temporary Sugita clip with weak pressure. First, a straight clip with a fenestration 5 mm in diameter and blades 6 mm long was applied to the proximal side of the dome perpendicular to the carotid artery. The intention was to partially obliterate the dome and construct the wall of the posterior communicating artery, which was assumed from the preoperative angiogram to originate from the anteroventral portion of the dome. The temporary clip was removed in less than 1 minute. An oblique-angled clip with a fenestration of 5 mm and blade 10 mm long was then applied from the side of the distal carotid bifurcation to the residual dome parallel to the carotid artery so as to form a new parent artery. The anterior choroidal artery originating from the distal side of the aneurysm wall and three perforators from the carotid bifurcation were preserved through the fenestrated portion of the second clip. Finally, a third clip, curved and without fenestration, was placed distally on the small residual portion under the right carotid bifurcation, sparing the anterior choroidal and three perforating arteries. The reconstruction occurred without any bleeding (Fig. 2 lower).

In the postoperative angiogram the patency of the carotid, posterior communicating, and anterior choroidal arteries was confirmed (Fig. 2C). Postoperatively, the patient developed hydrocephalus which disappeared after a shunt operation. She returned home able to walk 8 weeks later.

Case 3

This 62-year-old woman had a severe SAH 3 weeks before the operation. Angiography revealed an aneurysm arising from the left carotid artery (Fig. 3A and
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B). The operative approach was made in the usual manner, and a relatively large aneurysm with a wide neck was found protruding ventrolaterally from the left carotid artery. The posterior communicating artery arose from the proximal side of the neck. A straight clip with blades 18 mm long was applied to the dome of the neck, sparing the posterior communicating artery. Although it was applied on the dome side, it slipped to the side of the neck, obliterating the small anterior choroidal and two fine perforating arteries behind the aneurysm. An oblique-angled clip with a fenestration of 5 mm and blades 10 mm long was placed on the dome side of the neck with its blades parallel to the first clip. After confirmation that the second clip was correctly applied, the first clip was withdrawn through the fenestrated part of the second. Then, the same type of fenestrated clip as the second was applied shallowly to the dome side of the residual neck (Fig. 3 lower). Although transient right hemiparesis lasting for a few weeks appeared postoperatively, the patient later returned to full activity (Fig. 3C and D).

Case 4

This 58-year-old woman had a severe SAH 16 days before the operation. Slight hemiparesis of the right side continued up to the time of operation. On angiography, a large aneurysm with a wide neck was found extending ventrolaterally from the left carotid artery (Fig. 4A and B). At surgery, a small artery,
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believed to be the anterior choroidal artery, was encountered coursing away from the dome. The artery was sacrificed because its origin from the dome was too far from the neck to be spared. A straight clip with 18-mm blades was applied as parallel as possible to the parent artery to avoid postoperative stenosis of the artery. The clip apparently obliterated the aneurysm only partially because pulsatile motion of the clip blade was seen; however, when a second clip of the same shape was added on the dome side, the pulsation stopped. Unfortunately, the 18-mm clips, the longest available at that time, were not long enough, and left a small residual neck ventromedially behind the proximal carotid artery. A third straight clip with a fenestration of 6 mm and blades 6 mm long was used for closing the residual neck (Fig. 4 lower). The postoperative carotid angiogram revealed complete obliteration of the aneurysm and patency of the parent artery (Fig. 4C and D). Although the right hemiparesis became transiently worse for a few weeks, the patient returned to her normal life 4 months later.

Results

We have used fenestrated clips for eight carotid artery aneurysms and 10 aneurysms of the posterior circulation, without intraoperative bleeding. The postoperative results were excellent in 17 cases (94%), and one patient died. Obliteration of the parent artery occurred in two cases. In one case, where both a fusiform vertebral artery aneurysm and the distal portion of the artery were obliterated, the postoperative course was uneventful because of good contralateral vertebral circulation. The other patient, who had a carotid artery aneurysm, died due to obliteration of the carotid artery at the site of the clipping. The obliteration was believed to be due to tearing off the atheroma by repeated clipping of the neck with an angled fenestrated clip.

Discussion

Direct surgery for aneurysms of large size or in awkward locations is technically extremely dif-
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Fenestrated clips for unusual aneurysms therefore, other methods such as detachable balloon and injection techniques have been devised. However, the results of these procedures are not always satisfactory. Shrinking the aneurysm neck with the bipolar coagulator is impracticable for large aneurysms because their necks are usually too thick. Clipping after having collapsed the aneurysm by puncture under temporary trapping is one of the best methods of treatment. Permanent trapping combined with extra- and intracranial bypass surgery are currently used for the majority of giant aneurysms.

We have tried to develop a method for clipping difficult aneurysms by introducing special clips modified from the clips of Drake, Heifetz, and Sundt and Nofzinger. The use of fenestrated clips of various shapes is one of the new methods, although not all large aneurysms can be obliterated with them. It is also possible that the lesions described above might have been obliterated with other methods without using fenestrated clips. However, we believe that the operation would have been more complicated and troublesome if they had not been used.

In the application of angled fenestrated clips to large aneurysms, we emphasize the following six points: 1) The blade of the angled fenestrated clip must be placed as parallel as possible to the parent artery in cases with a wide-necked lesion. 2) As the wall of the neck of a large aneurysm is generally very thick, the blade should not be placed close to the parent artery but to the side of the dome in order to avoid stenosis. The postoperative angiograms of our cases showed a relatively wide gap between the blade and the contrast medium; the outer diameter of the reconstructed parent artery with the clip must therefore be larger than the original parent artery in order to preserve an adequate internal diameter. When a transient trapping procedure is used, special attention must be paid to the caliber of the parent artery to be reconstructed, because collapse of the parent artery makes it difficult to estimate the exact normal diameter, although application of the clip becomes easier. 3) The most appropriate clip among the 24 kinds of fenestrated clips should be selected before application. Trial application is best avoided. When selection from the 24 clips seems difficult, two or three different clips are brought into the operating field close to the aneurysm for selection before actual application. 4) Multiclipping is often necessary in large and wide-necked aneurysms when the blade is too short or the pressure of the clip is not sufficiently great. When pulsation of the clip is observed in spite of adequate depth of the blade tip, double clipping is indicated, in the tandem or piggyback fashion as described previously by Drake and Sundt and Piepgras. In this way, the pressure is doubled. Another important indication for the multicipping method is that the necessary length of blade for a wide neck can be made up intraparatively by using a number of clips when one clip is not long enough. 5) Replacement or recfipping of the angled fenestrated clip on the same region of the neck is better avoided, because dissection of the atheroma is likely to occur due to the greater blade pressure of angled clips than the usual straight clips. 6) The fenestrated clips cannot be applied to an aneurysm protruding laterally from the carotid artery because there is not enough space for clip insertion, although such an aneurysm located in the middle cerebral artery can be clipped.

The basic principle for clipping a large aneurysm with a wide neck is that the clip blade must never be applied close to the parent artery but should be placed to the side of the dome and parallel to the parent artery. Angled clips are very useful in such cases, and the application technique is simple. Occasionally, when a large aneurysm with no neck is located at the bifurcation and must be obliterated while preserving both the branching arteries (such as in Case 2), clips other than fenestrated ones rarely fulfill the purpose.

Reconstruction of the parent artery wall from a fusiform aneurysm may entail some risk of subsequent bleeding from the wall, although we have not experienced such bleeding.

Temporary clipping may be necessary more frequently in the application of fenestrated clips to large aneurysms than when using ordinary clips for the usual berry aneurysm, because complete obliteration of the wide neck is often impossible with one fenestrated clip, and thus there is a danger of premature rupture. Fortunately, we experienced no rupture in our series using the fenestrated clip. In Case 2, we applied one weak-pressure clip to the proximal carotid artery and avoided trapping. This was done so that another temporary clip could easily be applied to the distal side of the carotid artery if premature bleeding had accidentally occurred, whereas temporary clipping of the proximal side would become difficult after the application of a fenestrated clip on the aneurysm because the spring portion of the fenestrated clip obstructs the insertion of a temporary clip. Although in our practice we seldom use temporary clipping or trapping (we have used these techniques in less than 10% of cases), temporary trapping should be applied as little and as briefly as possible, because vessels that develop aneurysms are mostly sclerotic with atheroma and, therefore, should be touched as little as possible. Temporary trapping is usually possible when premature bleeding occurs if space for trapping has been prepared beforehand. We have experienced intraoperative bleeding in less than 3% of our 450 aneurysm operations.

References