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Dorsal Internal Carotid Artery Aneurysms with Special Reference to Angiographic Presentation and Surgical Management

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Summary

Aneurysms arising from the dorsal wall of the internal carotid artery are rare. The authors surgically treated twenty dorsal internal carotid artery aneurysms. Pre-operative angiographic findings were reviewed and classified into three types. Eleven aneurysms projecting superiorly on the lateral angiogram were found to be adherent to the base of the frontal lobe by the pterional approach. Five aneurysms which had been superimposed with the internal carotid artery on the lateral angiogram were found adhered to the medial surface of the temporal lobe. Four aneurysms not seen on the angiogram had no adhesion. Two aneurysms, which had not been seen on the initial angiograms, were visualized on the angiograms taken during the period of vasospasm. This type of aneurysms can be the source of a subarachnoid haemorrhage of unknown origin and requires repeated examinations. Premature rupture occured intra-operatively in five cases and postoperative bleeding was encountered in two. Clipping technique is discussed from the viewpoint of preventing intra- and postoperative rupture.

Keywords: Aneurysm; internal carotid artery; clipping; intraoperative rupture.

Introduction

It is generally known that the majority of saccular aneurysms are located at arterial divisions and those unrelated to any arterial junction are extremely rare. We[5] previously described eight aneurysms protruding from the dorsal wall of the internal carotid artery with no relation to arterial divisions. These "dorsal internal carotid artery aneurysms" are usually small and fragile, and therefore special care should be taken to prevent premature rupture. We have operated on twenty such cases. This report presents our further experience, highlighting their angiographic features and intra- and postoperative rupture for a more successful outcome.

Material and Methods

General Data of the Cases

In the past 10 years, 20 cases of dorsal internal carotid artery aneurysms were operated on at Shinshu University Hospital and its affiliated hospitals (Table 1). During the same period there were a total of about 1,600 aneurysms submitted to surgery, so that the incidence of dorsal internal carotid aneurysms is about 1% of all cerebral aneurysms. All the dorsal internal carotid aneurysms were operated on by the pterional approach. The criterion for selecting a patient for inclusion in this series was that the aneurysm must be found to originate on the dorsal surface of the internal carotid artery with no relation to arterial divisions confirmed in the operative field. There were sixteen females and 4 males with the age ranging from 26 to 61 years (average: 45 years). All patients presented with subarachnoid haemorrhage, caused by rupture of the dorsal internal carotid aneurysm in 18 cases and of an associated aneurysm in two (cases 14 and 15). The aneurysm size was from 2 to 6 mm in diameter (average: 4 mm) on the angiogram. Four dorsal internal carotid aneurysms were not seen on the pre-operative angiograms. Six patients had multiple aneurysms.

Angiographic Evaluation

Pre-operative angiograms were reviewed and classified into three types according to the operative findings.

Type 1: Eleven aneurysms projected superiorly in the lateral view and superimposed with the internal carotid artery or projected superiorly in the anteroposterior view (Fig. 1). These aneurysms were found at surgery to be protruding toward the surgeon or slightmedially and to be adherent to the basal surface on the frontal lobe except for one very small aneurysm. An illustrative case is shown in Fig. 2.

Type 2: Five aneurysms were superimposed with the internal carotid artery in the lateral view and projected laterally in the anteroposterior view (Fig. 3). At surgery, these aneurysms were found to be protruding slightly-laterally and adherent to the medial surface of the temporal lobe except one very small aneurysm. An illustrative case is shown in Fig. 4.

Table 1. *Summary of Twenty Patients of the Dorsal Internal Carotid Artery Aneurysm*

Case no.	Age (yrs) Sex	Preop. grade *	Size of aneurysm (mm) §	Type of aneurysm #	Adhesion to brain	Intraop. rupture	Aneurysm management	Result
1	53, F	II	4	1	frontal	no	clipping	died (rebleeding)
2	44, F	II	4	1	frontal	yes	clipping, wrapping	good
3	46, M	IV	4	2	temporal	yes	clipping, wrapping	died (vasospasm)
4	47, F	II	3	1	frontal	no	clipping	good
5	43, F	III	4	1	frontal	no	clipping	died (vasospasm)
6	38, F	III	6	2	temporal	no	clipping	good
7	45, F	I	6	1	frontal	no	clipping	good
8	50, F	III	3	1	frontal	no	clipping	fair
9	61, F	II	[a]	[a]	no	no	wrapping	good
10	55, F	III	3	1	frontal	no	clipping	good
11	44, M	II	[a]	[a]	no	yes	clipping, wrapping	good
12	58, F	II	6	2	temporal	yes	trapping, bypass	died (brain swelling)
13	34, M	III	5	1	frontal	yes	clipping	died (brain swelling)
14	48, F	I	[b]		no	no	wrapping	good
15	52, F	II	[b]		no	no	clipping	good
16	39, M	II	6	1	frontal	no	clipping	good
17	41, F	II	2	1	no	no	clipping, wrapping	good
18	42, F	III	3	2	temporal	no	clipping, wrapping	good
19	26, F	II	2	2	temporal	no	clipping, wrapping	good
20	42, F	III	3	1	frontal	no	clipping, wrapping	good

* Grading according to the Hunt and Kosnik system (Hunt WE, Kosnik EJ (1974) Timing and peri-operative care in intracranial aneurysm surgery. Clin Neurosurg 21: 79–89

§ The largest diameter of aneurysmal neck or dome as seen on the angiogram.

Type 1: Aneurysms protruding superiorly on the lateral angiograms.
Type 2: Aneurysms superimposed with the internal carotid artery on the lateral angiograms.

[a] Cerebral angiograms showed no dorsal internal carotid artery aneurysms. Surgical treatment was performed because CT scan revealed subarachnoid haemorrhage suggesting rupture of the internal carotid artery aneurysm.

[b] Cerebral angiograms showed no dorsal internal carotid artery aneurysms. The dorsal internal carotid artery aneurysms were incidentally found during the approach to an associated ruptured aneurysm.

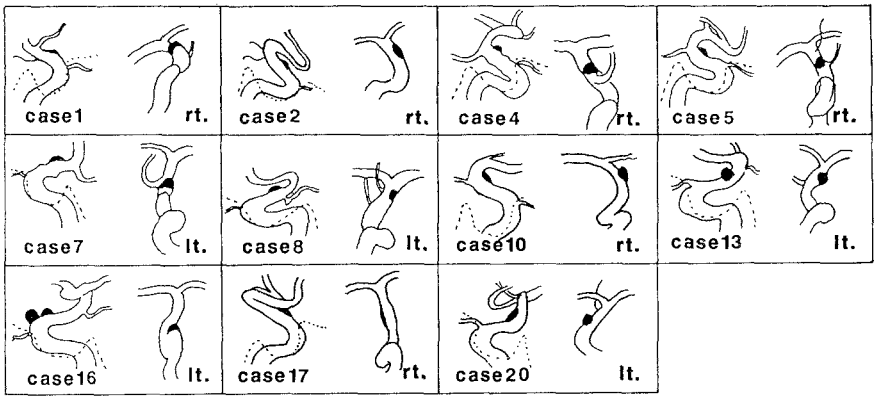

Fig. 1. Tracings of the lateral (left) and antero-posterior (right) angiograms from the eleven cases of the dorsal internal carotid artery aneurysm Type 1 (black areas), which were at surgery adherent to the base of the frontal lobe except case 17

Type 3: Four aneurysms were not seen on the angiograms. They had no adhesion to the brain at surgery. Two (cases 14 and 15) of these four aneurysms were incidentally found during the approach to an associated ruptured aneurysms. The other two (cases 9 and 11) were operated on because the computerized tomographic scan had shown haematoma in the basal cistern, suggesting rupture of an internal carotid artery aneurysm.

In two patients (cases 2 and 19) the aneurysms were not seen in the initial angiograms but later were revealed by angiograms taken during the period of vasospasm (Fig. 5).

Surgical Procedures

All cases were operated on by the ipsilateral pterional approach. Careful separation of the Sylvian fissure was essential for prevention

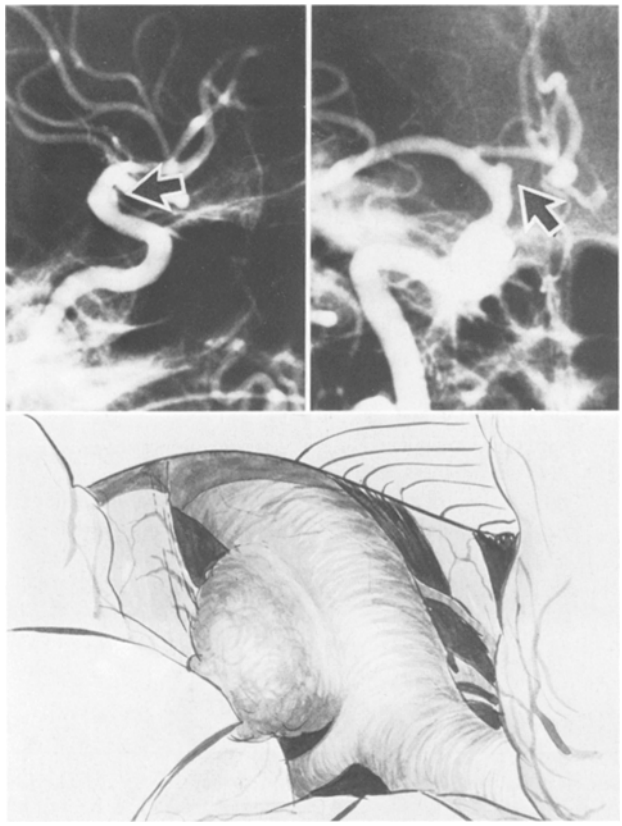

Fig. 2. Case 10 (Type 1). Upper: Right carotid angiograms. Arrows indicate the aneurysm projecting superiorly in the lateral view (left) and antero-posterior (right) views. Lower: Intra-operative illustration as approached right-pterionally showing the aneurysm adherent to the base of the frontal lobe

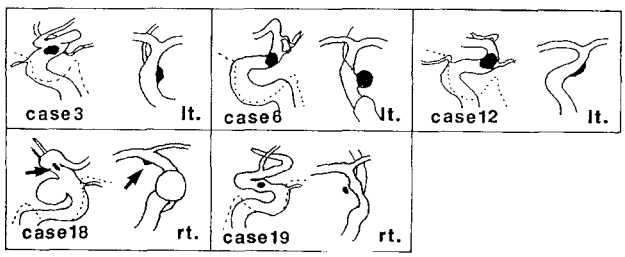

Fig. 3. Tracings of the lateral (left) and antero-posterior (right) angiograms from the five cases of the dorsal internal carotid artery aneurysm Type 2 (black areas), which were at surgery adherent to the medial surface of the temporal lobe. Case 18 has another aneurysm proximal to the small dorsal internal artery aneurysm (arrow)

of premature rupture. Neck clipping of the aneurysm was performed in 17 cases, of which supplementary wrapping with cellulose fabric (Bemsheet^{R}) or muscle was used in seven. Two were managed with wrapping alone because of their small size. One was managed with a bypass (superficial temporal artery-middle cerebral artery) and trapping of the parent artery due to uncontrolable intra-operative bleeding. The clip should best be placed on the neck parallel to the

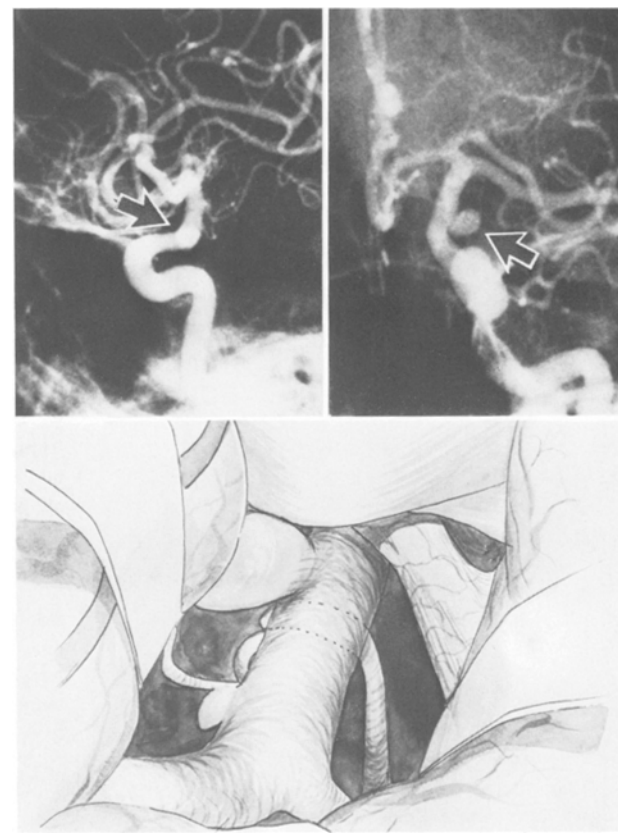

Fig. 4. Case 6 (Type 2). Upper: Left carotid angiograms. Arrows indicate the aneurysms superimposed on the internal carotid artery in the lateral view (left) and projecting laterally in the antero-posterior view (right). Lower: Intra-operative illustration as approached left-pterionally showing the aneurysm adherent to the medial surface of the temporal lobe

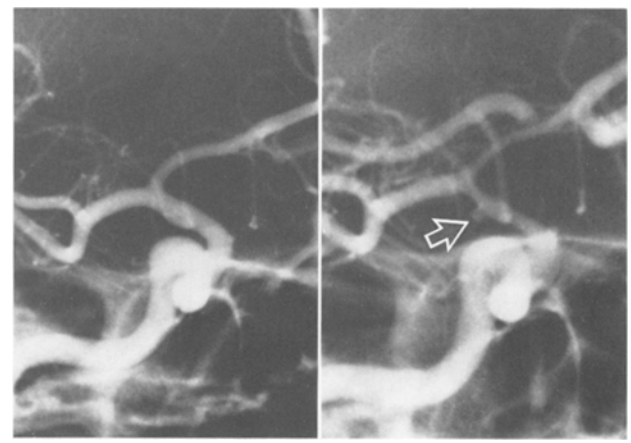

Fig. 5. Case 2. Left: Oblique view of right carotid angiogram on the next day of bleeding. No aneurysm is seen. Right: Right carotid angiogram, oblique view, 13 days later. Note that there is severe spasm and a dorsal internal carotid artery aneurysm (arrow) is now visible

Table 2. *The Relationship Between Clipping Direction and Intra- and Postoperative Rupture of the 17 Cases of the Dorsal Internal Carotid Artery Aneurysm, Except two Wrapped Aneurysms and a Trapped Aneurysm*

Clipping direction to the parent artery		Rupture	
		Intra-operatively	Post-operatively
Parallel	(9 cases)	1	0
Oblique	(5 cases)	2	1
Perpendicular	(3 cases)	1	1

Table 3. *The Relationship Between Proximal Temporary Occlusion of the Internal Carotid Artery and Intra-Operative Rupture Due to Neck Laceration or Slipping of the Clip*

Temporary occlusion	Neck laceration	Slipping
Yes (6 cases)	0	1
No (11 cases)	3	0

parent artery, including the neck and part of the parent artery within the clip blades. However, there were cases where we had to place a clip obliquely or perpendicularly to the parent artery due to a difficult anatomical situation in the field. Table 2 shows the relationship between clipping direction and intra- and postoperative rupture. There is no definite tendency between the two factors and this may be due to the small number of cases, but we considered that parallel clipping to the parent artery would be safer than clipping in the other two directions.

Temporary occlusion of the parent artery was used in six cases when the aneurysmal neck was markedly thin at the base (Table 3).

Results

Intra-Operative Rupture

Intra-operative rupture occured in five cases (Table 1). In four cases (cases 2, 3, 12, and 13) the cause of rupture was laceration at the neck. In case 12, rupture was encountered during dissection of the Sylvian fissure and had to be managed by a bypass and trapping. In cases 2, 3, and 13, rupture occurred at the time of completely closing the clip blades. However, clip-closing was finally performed by either single or multiple clipping. In case 3, the laceration site was closed using two right-angled clips (Fig. 6), and in case 13 using two bent clips (Fig. 7). In the other case (case 11)) the cause of intra-operative rupture was slipping-off of the clip; reclipping was easily performed.

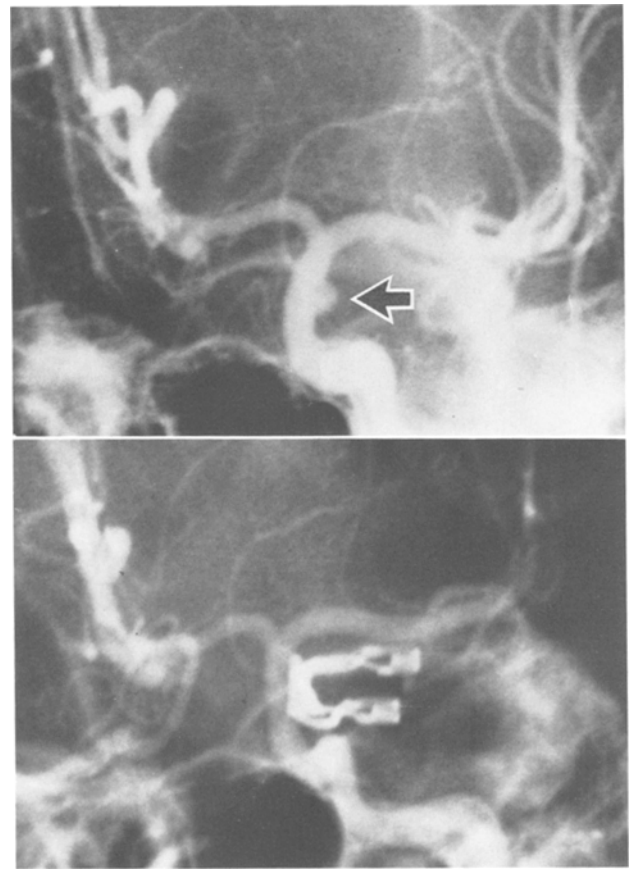

Fig. 6. Case 3. Antero-posterior views of left carotid angiogram. Upper: Pre-operative angiogram showing the internal carotid artery aneurysm (arrow). Lower: Postoperative angiogram showing successful clipping using two right-angled clips after intra-operative rupture

Table 3 shows the relationship between temporary occlusion of the internal carotid artery before clipping and intra-operative rupture. Temporary occlusion seems useful in preventing intra-operative rupture.

Postoperative Rupture

Postoperative rupture occured in two cases (cases 1 and 18). In these cases the neck and the adjacent wall of the parent artery were found at surgery to be very thin. The cause of postoperative rupture is thought to be slipping-off of the clip, incomplete clipping, or new growth of the aneurysm due to insufficient inclusion of adjacent wall of the parent artery within the clip blades. Angiograms of case 18 showed a remarkable growth of the aneurysm only 21 days after operation (Fig. 8).

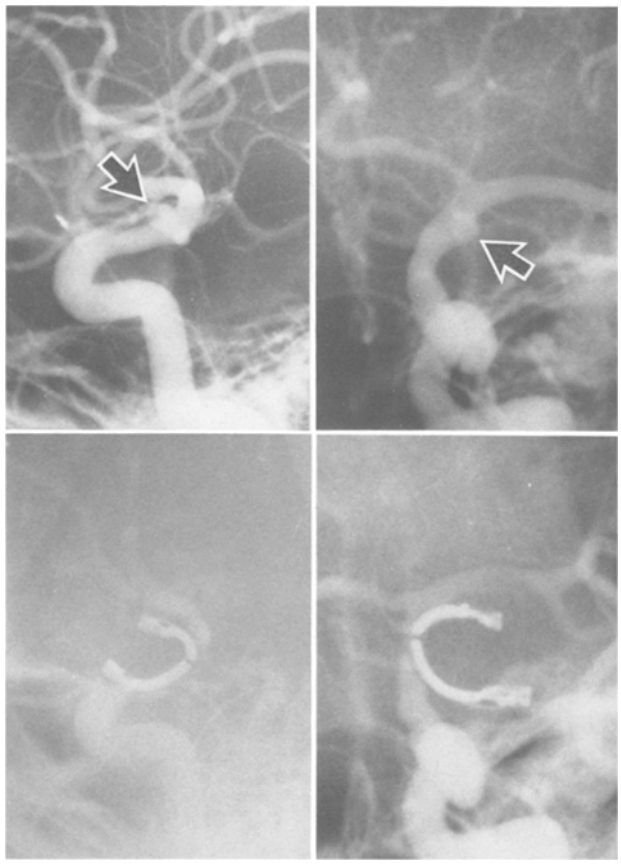

Fig. 7. Left carotid angiograms of case 13. Upper: Pre-operative angiograms (lateral and antero-posterior views) showing the internal carotid artery aneurysm projecting superiorly (arrow). Lower: Post-operative angiograms (lateral and antero-posterior views) showing clipping using two bent-clips and stenosis of the parent artery

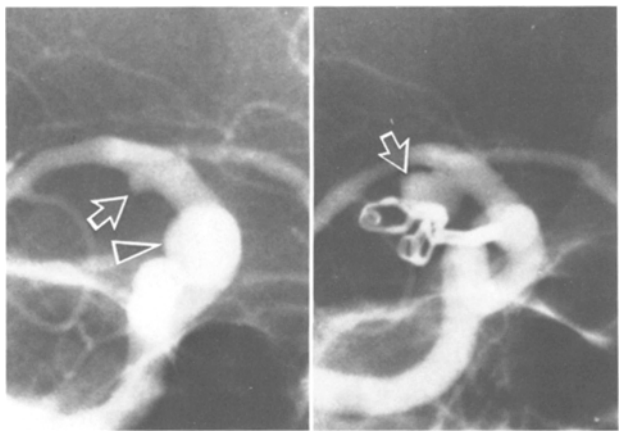

Fig. 8. Case 18. Oblique views of right carotid angiogram. Left: Pre-operative angiogram showing a small aneurysm arising from the dorsal wall of the internal carotid artery (arrow) and another aneurysm proxymal to it (arrow head). Right: angiogram taken 21 days after clipping of both aneurysms showing a remarkable growth of the dorsal internal carotid artery aneurysm (arrow); the proxymal aneurysm is incompletely clipped

Operative Results

Fourteen patients were discharged from hospital without neurological deficits. One patient suffered long-term morbidity due to cerebral infarction resulting from vasospasm. Five patients died. Two (cases 3 and 5) of them were lost due to cerebral infarction resulting from vasospasm. Two (cases 12 and 13) died due to brain swelling after prolonged temporary occlusion of the internal carotid artery. One patient (case 1) was lost due to postoperative rupture of the aneurysm.

Discussion

Saccular aneurysms without any relation to arterial bifurcations were thought to be extremely rare. Yaşargil[8] reported three cases of an unusual type of aneurysm arising from the dorsal or medial wall of the distal internal carotid artery. In 1986 we[5] described eight aneurysms protruding from the dorsal wall of the internal carotid artery and pointed out that special care should be taken in surgical management. We had also stressed their high risk of premature rupture due to their unusual shape and position, adhesion to the brain tissue, and fragile neck. These aneurysms we called dorsal internal carotid artery aneurysms. Recently they are sometimes called "blood blister like aneurysms" for the point of view of their hemispheric shape and small size[1]. The "dorsal internal carotid artery aneurysms" include not only blister like aneurysms but usual saccular aneurysms. The importance of recognizing "dorsal internal carotid artery aneurysms" refers to the difficulty of clipping not only because of their shape but also of their location.

These aneurysms have a high risk of premature rupture. The most important point in the surgical treatment of these aneurysms is therefore how to avoid premature rupture. Dissection of the Sylvian fissure and exposure of the aneurysm should be performed more carefully than in usual aneurysms. These aneurysms are frequently adhered to the frontal (Type 1) or temporal lobe (Type 2). Our angiographic classification suggests the site of adhesion and therefore should be helpful in preventing premature rupture when retracting brain and dissecting such aneurysms. Careful and minimal retraction of the brain to which the aneurysm is adhered is necessary. Wide opening of the Sylvian fissure is important to obtain the necessary exposure of the aneurysm complex when either frontal or temporal lobe cannot be retracted because of the adhesion. The clip is best placed on the neck parallel

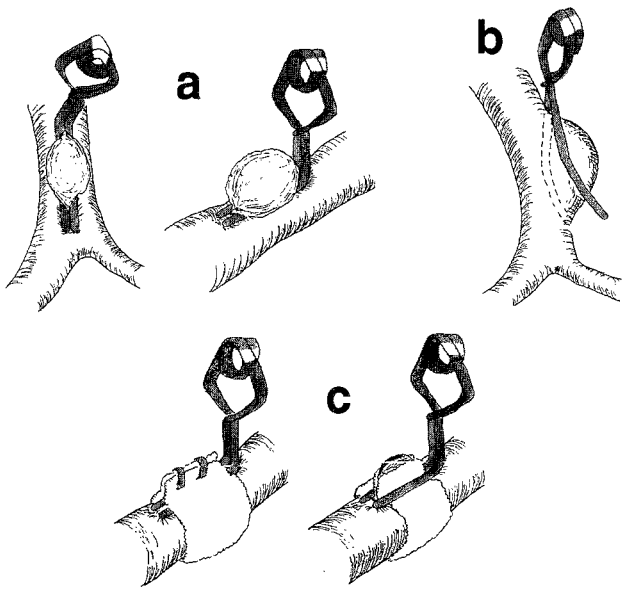

Fig. 9. Clipping method for the dorsal internal carotid artery aneurysm. (a) Clip is best placed parallel to the parent artery including a portion of the parent artery within the clip blades. (b) The side-bent clip is useful in clipping of the aneurysms located slight-medially or laterally. (c) Putting cellulose fabric and Weck's clips around the clip blades to the parent artery or clipping after wrapping the aneurysm including the parent artery may be effective in preventing slipping-off of the clip and neck laceration, and in re-inforcing a vulnerable wall

to the parent artery, including the neck and part of the parent artery within the clip blades (Fig. 9 a). Neck laceration of the aneurysms occured most frequently just at the time of complete closure of clip blades because of the vulnerability of the neck and adjacent wall of the parent artery. By the parallel clipping to the parent artery, it is easier to include its thin-walled aneurysmal protrusion within the clip blades than by clipping perpendicularly. When clipping the aneurysm located slightly-laterally or medially, a side bent clip is useful (Fig. 9 b). It is important to select an appropriate clip suitable for the physiological curve of the parent artery thus avoiding mechanical stress to the neck and thin parent artery. Temporary occlusion of the parent artery just at the time of clipping is useful in preventing intra- and postoperative rupture of aneurysms. This technique decreases the arterial pressure and facilitates complete clipping. Care should be taken about the position of the clip head, because the clip may slip and cause rupture of the aneurysms when brain retraction is released on closing. The clip head should be placed on the cranial base without pressure on it. Embedding the clip in the brain tissue is often advisable by tearing a small area of the pia to accomodate the clip head.

Todd *et al.*[7] described that wrapping of an aneurysm reduced the incidence of rebleeding, particularly during the first 6 months when the risk of rebleeding is high. The best wrapping material is thought to be gauze so far[2, 6, 7]. When an aneurysm cannot be clipped due to its small size, or a portion of an aneurysm remains outside the clip, wrapping with cellulose fabric (Bemsheet^R) has offered a certain degree of protection from rebleeding in our practice. Putting cellulose fabric and Weck's clips (or ligatures) around the clip blades to the parent artery or clipping after wrapping the aneurysm and the parent artery with cellulose fabric may be effective in preventing slipping-off of the clip and neck laceration, and in reinforcing a vulnerable wall (Fig. 9 c).

In case on intra-operative rupture, an advisable technical option is placing two clips parallel to the parent artery so as to catch the adjacent parent arterial wall with the lacerated aneurysmal neck (Fig. 10).

The dorsal internal carotid artery aneurysm is usually small and angiographic investigation should be performed with great care. Even after careful angiographic investigation, there is still a group of patients (Type 3) in whom the cause of subarachnoid haemorrhage cannot be found. The mechanisms by which an aneurysm fails to fill with contrast material at angiography include vasospasm, increased intracranial pressure, narrowing of the neck, alterations in blood flow, spontaneous thrombosis, and its small size[3]. Four aneurysms in our series were not found on repeated angiograms pre-operatively. The most possible explanation for failure in demonstrating our dorsal aneu-

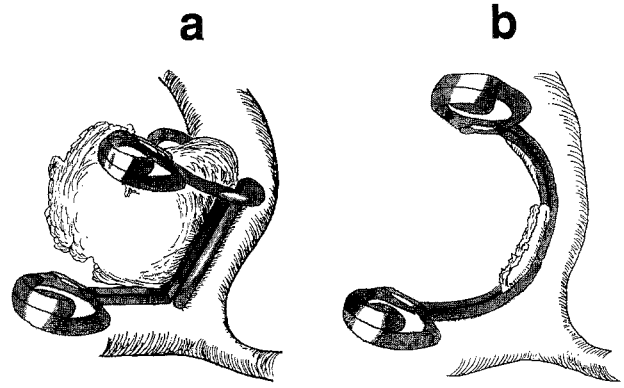

Fig. 10. Clipping method in the cases with intra-operative rupture. The laceration site closed using two right-angled (a) or bent clips (b)

rysms is their small size. Vasospasm may be the cause of insufficient filling of an aneurysm. Contrary to expectation, we have had two dorsal aneurysms that were not visualised on the initial angiograms when no vasospasm was present, but were seen on angiograms taken during the period of vasospasm. Forster *et al.*[3] also described such an aneurysm of the anterior communicating artery. This experience leads us to stress the importance of repeated examination even in the presence of vasospasm, and we should bear in mind this type of aneurysm when seeing subarachnoid haemorrhage of unknown origin in the basal cistern.

We have treated two patients who showed regrowth of the aneurysm or development of new aneurysms at the site of initial clipping. Studies on the regrowth of aneurysms after clipping are relatively rare. Lin *et al.*[4] have presented 19 patients whose aneurysms showed regrowth at intervals ranging from 3 to 24 years after clipping of the neck. The regrowth arose proximal to the clip from a tiny portion of the aneurysm neck which remained outside the clip after the initial surgery. Ebina *et al.*[2] described two patients who had a new aneurysm at the site of the initial clipping. Histological examination of the recurrent aneurysm showed that the arterial wall had been damaged by the clip edge, which resulted in thinning and disruption of both the muslce layer and internal elastic lamina. They suggested that local fragility of the arterial wall adjacent to the aneurysm seems to have been the cause of the formation of a new aneurysm and so reinforcement of the thin-walled parent artery is important. Because the parent arterial wall adjacent to the dorsal internal carotid artery aneurysms is especially thin and the aneurysm is dome shaped, the risk of its regrowth is high. Some of the aneurysms under discussion could be dissecting in nature. We emphasize the importance of complete clipping and reinforcement of the thin arterial wall as necessary.

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