

Histological verification of microaneurysms as a cause of cerebral haemorrhage in surgical specimens

SUSUMU WAKAI, MASAKATSU NAGAI

From the Department of Neurosurgery, Dokkyo University School of Medicine, Mibu, Japan

SUMMARY Surgical specimens taken from 14 patients with lobar intracerebral haemorrhage or cerebellar haemorrhage without vascular abnormalities on angiograms were examined histologically. In seven of the 14 patients, arteriovenous malformation or amyloid angiopathy were found by ordinary pathological examinations. Among the remaining seven patients, definite microaneurysms were verified in five and possible ones in two patients by using the technique of serial sectioning of the solid nodular tissues removed from the presumed bleeding site, where an arterial connection between the tissues and the surrounding brain was noted. Four of these seven patients had no history of hypertension and showed normal blood pressure before and after surgery. To verify microaneurysms in surgical specimens, it seems important to search the presumed bleeding site properly by a meticulous microsurgical technique and to section the tissues serially for the histological examination.

Since Charcot and Bouchard found microaneurysms in necropsy specimens to be the cause of intracerebral haemorrhage (ICH),¹ most such haemorrhages in patients with hypertension but without angiographically demonstrable aetiology have been attributed to the rupture of microaneurysms.²⁻⁴ In 1971, Fisher observed two major types of vascular abnormalities in the necropsy brain from hypertensive patients with a history of cerebral haemorrhage or lacunar infarcts or both; these were aneurysmal and nonaneurysmal, so-called bleeding globe (ruptured artery).^{5,6} Though lobar ICH and cerebellar haemorrhage (CH) are known to have a variety of causes, such as cerebrovascular malformations, brain tumours and amyloid angiopathy,⁷⁻¹⁴ those with negative angiograms and negative pathology have also been attributed to the rupture of a microaneurysm or a small artery.^{10,12} To our knowledge, however, no histological verification has yet been obtained in surgical specimens, presumably as a result of improper operative techniques and incomplete pathological examination. We here describe microaneurysms in surgical specimens taken from the patients with lobar ICH or CH by using the technique of serial sectioning

of the solid nodular tissue removed from the presumed bleeding site, where an arterial connection between that tissue and the surrounding brain was noted under a surgical microscope.¹³

Materials and methods

During the period from January 1986 to June 1987, we operated on 20 patients with lobar ICH and six with CH. The cases with lobar ICH and those with CH caused by the rupture of a saccular aneurysm or trauma were not included. Fourteen of the 21 patients who received angiography before surgery had no angiographical evidence of the cause of the bleeding. The haematoma and its wall were thoroughly investigated under a surgical microscope by using the operative technique described elsewhere.¹³ The removed solid tissues or the abnormal vascular nodules were sent for pathological examination. All the tissues, covered with blood clot, had vascular connections with the surrounding brain. Five arteriovenous malformations and two examples of amyloid angiopathies were found in ordinary histological sections.

The specimens taken from the remaining seven patients were fixed in 10% formalin for 24 to 48 hours and the paraffin embedded tissues were sectioned serially at a thickness of 2.5 μ m. Every other section was examined using haematoxylin and eosin, Azan-Mallory and elastica van Gieson stains. Histological findings were not classified as miliary aneurysm and bleeding globe (ruptured artery) as described by Fisher,^{5,6} because once a microaneurysm has ruptured it may only be recognised pathologically as a bleeding globe (ruptured artery).^{5,6} Therefore we combine these two categories and simply call them microaneurysm. The tissues in which a

Address for reprint requests: Susumu Wakai, MD, Department of Neurosurgery, Dokkyo University School of Medicine, Mibu-machi, Tochigi, 321-02, Japan.

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Table 1 Summary of the clinical findings in seven cases of cerebral haemorrhage with verified microaneurysms

Case	Age/Sex (yr)	Onset	Symptoms and signs	Site of haematoma	HT	Operation
1*	73/M	Sudden	Hemianopsia	Lt temporal	(+)	Day 32
2	44/F	Sudden	Headache, hemianopsia	Rt temporal-parietal	(+)	Day 1
3	64/M	Sudden	Drowsy, hemiparesis	Rt fronto-temporal	(-)	Day 1
4	44/M	Sudden	Drowsy, hemiparesis	Lt parieto-occipital	(-)	Day 5
5	59/M	Sudden	Stupor	Lt cerebellum	(+)	Day 1
6	73/F	Sudden	Stupor, aphasia	Lt temporal	(-)	Day 3
7†	79/F	Gradual	Hemiparesis	Rt parietal	(-)	Day 10

*A dural AVM was found on angiograms in the left temporal region near ICH. Thus, an evacuation surgery was undertaken at chronic stage in considering the possibility of ruptured dural AVM having formed an ICH.

†This patient suffered a left cerebellar haemorrhage six months after this haemorrhagic episode.

HT = hypertension

parent artery was not verified histologically were classified as possible microaneurysm.

A summary of the clinical pictures of these seven patients is given in the table. Four patients had no history of hypertension and had normal blood pressure before and after surgery. No patients had a bleeding tendency or any findings suggesting cerebral arteritis on angiograms.

Results

Microaneurysms were found in five cases (Case 1–5, figs 1 and 2 a–d). The specimens taken from three different sites of the haematoma wall in Case 2 contained four microaneurysms (fig 1, c–i), one of which is not shown in the figure. One of those aneurysms had lipohyalinosis in its wall (fig 1, g–i).⁵⁶ In these five cases, the relationship between the parent artery and its orifice to the microaneurysm was clearly demonstrated. At the orifice, the elastic lamina appeared degenerated and disappeared gradually toward the body of the microaneurysm (fig 1 and 2, a–d).

In the remaining two cases, the parent artery was not found but only degenerated elastic lamina were scattered within the wall of the possible microaneurysm enveloping masses of red blood cells (fig 2, e & f). The parent artery might have been lost during the histological processing. The contiguity of the masses

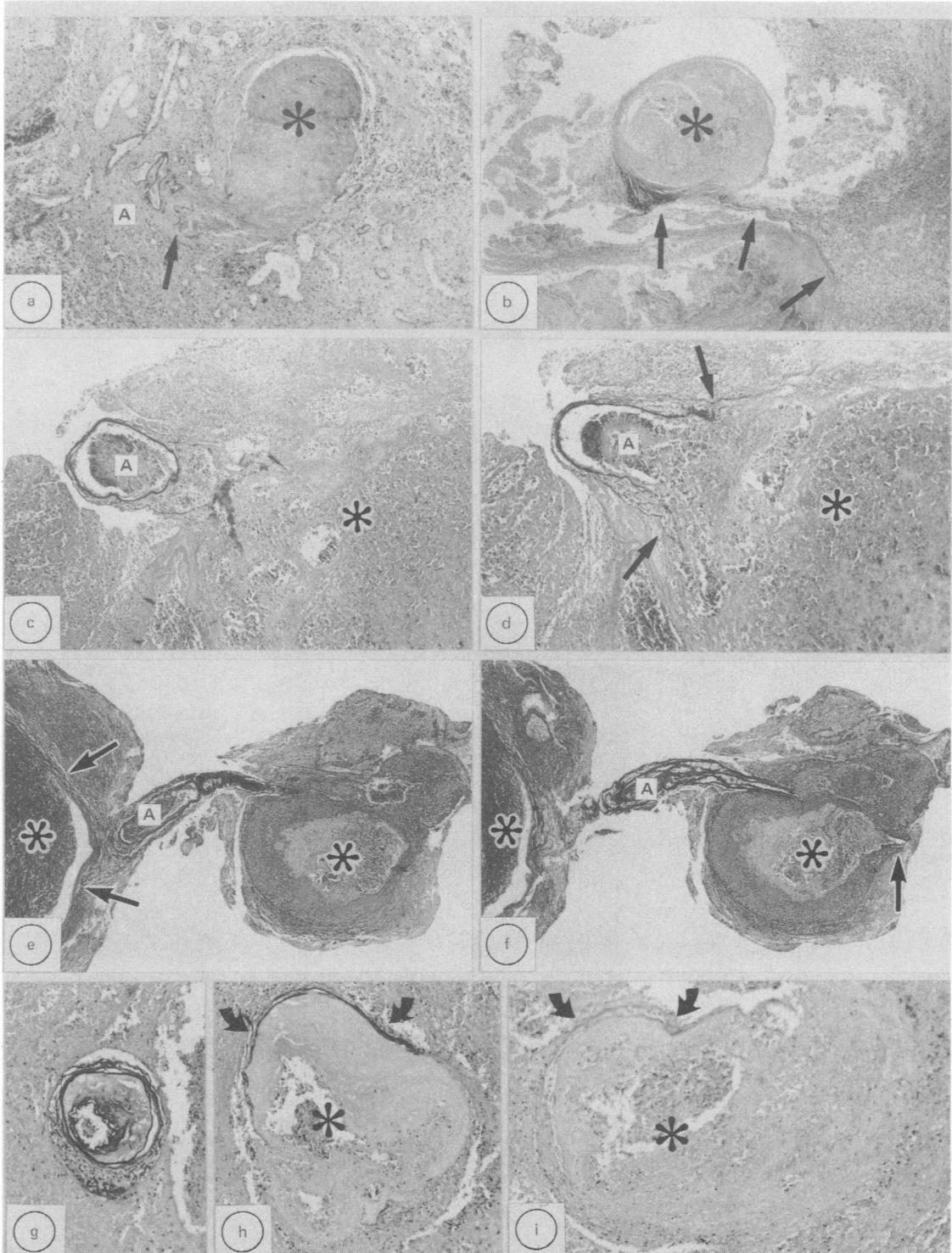
of red blood cells within the microaneurysm and the surrounding haematoma was observed in some of the serial sections in all the cases (figs 1 and 2).

Discussion

In recent years, it has been reported that cerebrovascular malformations, brain tumours or amyloid angiopathy could be found histologically within surgical specimens in some ICH cases with negative angiograms.^{7,14,15} To date, however, microaneurysms have not been verified in surgical specimens as a cause of lobar ICH or CH. In the current study, we found microaneurysms in five cases and possible ones in the remaining two cases in the periphery of the haematoma.

All the specimens were examined by using the serial sectioning technique. To verify vascular abnormalities such as microaneurysms pathologically, two factors seem to be important: (1) to detect the bleeding site, where solid tissues, covered with blood clot, have a vascular connection with the surrounding brain, properly by a meticulous microsurgical technique¹³ and (2) to section the removed tissues serially for the histological examination. Careless evacuation of the haematoma causes the tissue, which might contain the bleeding source, to be lost. On the other hand, even if

Fig 1 Photomicrographs of the surgical specimens. (a–b): Case 1. (a) A small artery (A) has its connection with a microaneurysm (asterisk), the wall of which has been sectioned obliquely. The haematoma capsule contains a number of newly formed, thin walled vessels. An attenuated degenerated elastic lamina is also seen (arrow). *Elastica van Gieson*. X34. (b) The section 20 µm further. The microaneurysm (asterisk) is now cross-sectioned. The aneurysm has a collagenous layer in its wall. Arrows indicate degenerated elastic lamina. *Elastica van Gieson*. X23 (c–i): Case 2 (c–f): Serial sections of one of the three specimens. Ten µm apart between c and d, and between e and f respectively. Fifty µm apart between d and e. (c & d): The artery (A) gradually opens its orifice to the microaneurysm (asterisk). Its wall contains a layer of collagenous material. Thin degenerated elastic laminae (arrows) are noted around the orifice in d. *Elastica van Gieson*. X54. (e & f): The artery (A) appears on the opposite side of the same microaneurysm (asterisk) shown in (c) and (d). A small microaneurysm (asterisk) is attached to the same artery (A). Its wall is enveloped in concentric rings of fibrin material without a collagen layer. Arrows in (e) indicate a part of the aneurysmal wall enveloped by collagen bundles. A part of the artery is also seen on the right of the picture in (f) (arrow). *Elastica van Gieson*. X23. (g–i): Serial sections of another specimen. The artery with lipohyalinosis shown in (g) is transposed gradually to the microaneurysm (asterisk in h), which finally ruptured (asterisk in i) producing a large haematoma. Arrows indicate degenerated elastic lamina. *Elastica van Gieson*. X88.



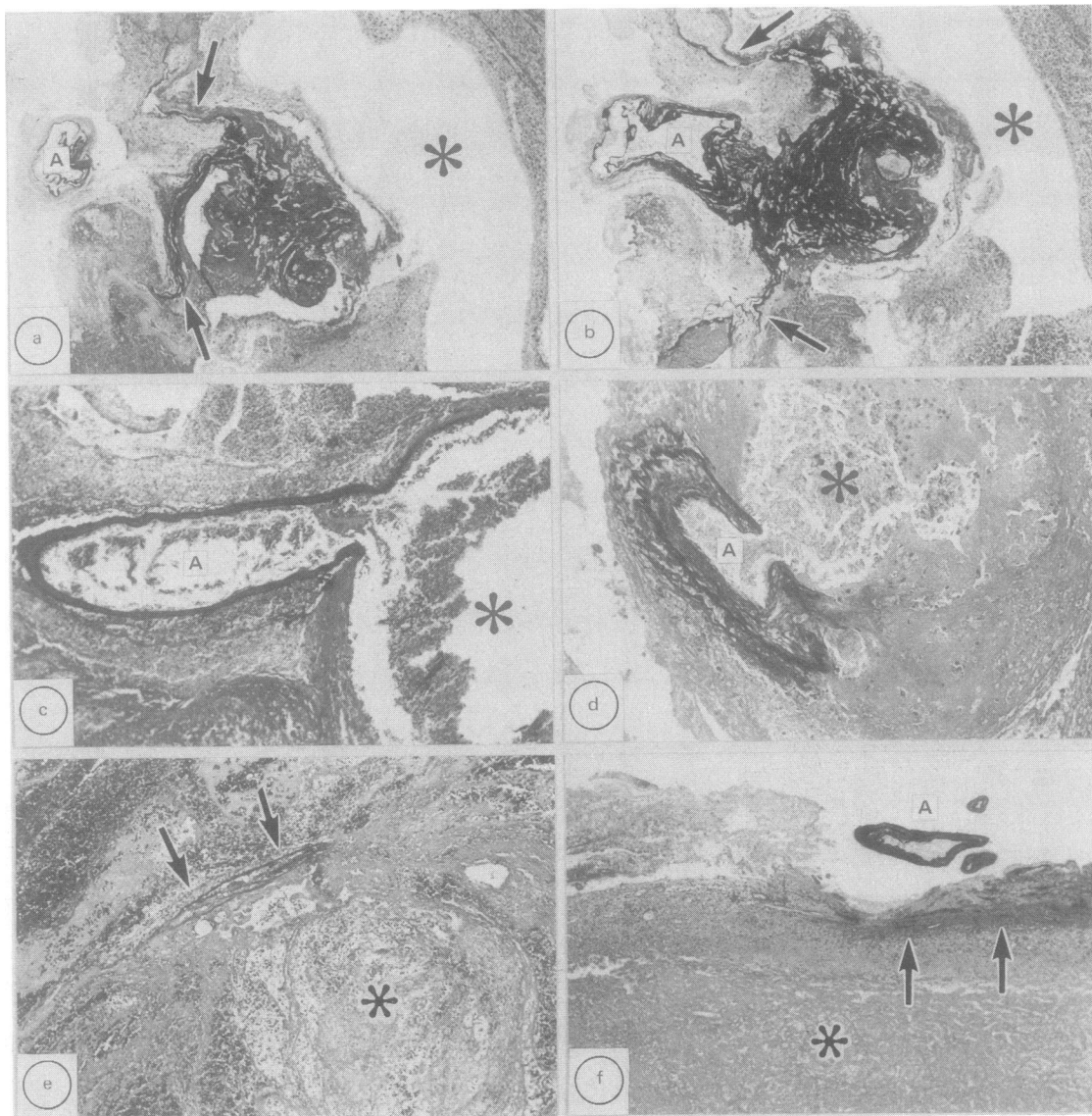


Fig 2 (a & b): Case 3. The parent artery (A) is separated from the microaneurysm (asterisk) in (a). The section 10 μm further showing the continuity between the parent artery (A) and the microaneurysm (asterisk) in (b). Arrows indicate the attenuation of the degenerated elastic lamina. The haematoma is seen on the right of the fig. No collagenous material is seen in the wall of the microaneurysm. *Elastica van Gieson*. X33. (c): Case 4. An obliquely sectioned parent artery (A) and the microaneurysm (asterisk) are noted. Its wall is enveloped only by concentric rings of fibrin material. *Elastica van Gieson*. X53. (d): Case 5. A small artery (A) has the orifice to the microaneurysm (asterisk). No collagenous material is contained in the wall of the microaneurysm. *Elastica van Gieson*. X115. (e) Case 6. Only degenerated elastic laminae (arrows) are noted within the wall of the possible microaneurysm (asterisk). The parent artery has not been verified in the specimen. *Elastica van Gieson*. X53. (f): Degenerated elastic laminae (arrows) are scattered within the wall of a relatively large possible microaneurysm (asterisk). The parent artery has not been found though a small artery is seen around the microaneurysm (A), *Elastica van Gieson*. X30.

the proper tissue is obtained, arbitrary sectioning of the specimen may fail to reveal microaneurysms or other vascular abnormalities within it.

It may be questioned whether these microaneurysms found in surgical specimens were the actual cause of the bleeding. There was contiguity of the masses of red blood cells and the surrounding haematoma in all cases. Furthermore, only solid tissue covered by blood clot with an arterial connection in the surrounding brain was found in the periphery of the haematoma in all but one (Case 2) of the seven cases. In two cases (Cases 6 and 7, possible microaneurysm) was the parent artery not revealed histologically, though it was seen during surgery under the microscope. Accordingly, in these six cases, it is reasonable to conclude that a vascular abnormality was the cause of the bleeding. In Case 2, in which specimens were examined from three sites in the haematoma, there was no other solid clot having an arterial connection. Thus, one of them is assumed to be the cause of the bleeding and the other two to be secondary. On the other hand, all of the microaneurysms found histologically might have ruptured simultaneously.⁶

In the series of lobar ICH and CH reported by Hinton *et al*, the aetiology of the haemorrhage was found only in 33.3% of the cases which underwent surgery. They stated that in no cases were Charcot-Bouchard microaneurysms identified.⁷ In many series, the cases in which no bleeding source was discovered were diagnosed as hypertensive or unknown in origin.^{10 12 15} In our series, microaneurysms (including two cases with possible microaneurysms) were found in seven of the 14 patients with negative angiograms. Among the remaining half of the patients, an AVM was verified in five and amyloid angiopathy in two. As a whole, the discovery rate of the possible bleeding source was 100%. It is 85% even if the two cases with possible microaneurysm are excluded. This rate is quite high in comparison with that of other series,^{7 10 12 15} though the total number of patients was small in our series. The appropriate microsurgical and histological techniques described here might yield a higher discovery rate of a microaneurysm as a cause of lobar ICH or CH.

Furthermore, if we could characterise the CT findings before surgery in cases in which microaneurysms were identified later, the indications for surgery in lobar ICH and CH might be obtained.

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References

- 1 Charcot J-M, Bouchard C. Nouvelle recherches sur la pathogenie de l'hémorrhagie cérébrale. *Arch Physiol Normale Pathol* 1868;1:110-127.
- 2 Cole FM, Yates PO. The occurrence and significance of intracranial micro-aneurysms. *J Pathol Bacteriol* 1967;93:393-410.
- 3 Ooneda G, Yoshida Y, Suzuki K, Shinkai H. Plasmatic arterionecrosis and its thrombotic occlusion. *Thromb Res* 1976;8(Suppl 2):357-64.
- 4 Russell RWR. Observations on intracranial aneurysms. *Brain* 1963;86:425-42.
- 5 Fisher CM. Pathological observations in hypertensive cerebral hemorrhage. *J Neuropathol Exp Neurol* 1971;30:536-50.
- 6 Fisher CM. Cerebral miliary aneurysms in hypertension. *Am J Pathol* 1972;66:313-30.
- 7 Hinton DR, Dolan E, Sima AAF. The value of histopathological examination of surgically removed blood clot in determining the etiology of spontaneous intracerebral hemorrhage. *Stroke* 1984;15:517-20.
- 8 Ishii N, Nishihara Y, Horie A. Amyloid angiopathy and lobar cerebral haemorrhage. *J Neurol Neurosurg Psychiatry* 1984;47:1203-10.
- 9 Jellinger K. Pathology and aetiology of ICH. In: Pia HW, Langmaid C, Zierski J, eds. *Spontaneous Intracerebral Haematomas: Advances in Diagnosis and Treatment*. Berlin: Springer, 1980:13-19.
- 10 Kase CS, Williams JP, Wyatt DA, Mohr JP. Lobar intracerebral hematomas: clinical and CT analysis of 22 cases. *Neurology* 1982;32:1146-50.
- 11 McCormick WF, Rosenfield DB. Massive brain hemorrhage: a review of 144 cases and an examination of their causes. *Stroke* 1973;4:946-54.
- 12 Ropper AH, Davis KR. Lobar cerebral hemorrhage: acute clinical syndromes in 26 cases. *Ann Neurol* 1980;8:141-7.
- 13 Wakai S, Ueda Y, Inoh S, Nagai M. Angiographically occult angiomias: A report of thirteen cases with analysis of the cases documented in the literature. *Neurosurgery* 1985;17:549-56.
- 14 Wakai S, Yamakawa K, Manaka S, Takakura K. Spontaneous intracranial hemorrhage caused by brain tumor: Its incidence and clinical significance. *Neurosurgery* 1982;10:437-44.
- 15 Tanaka Y, Furuse M, Iwasa H, Masuzawa T, Saito K, Sato F, Mizuno Y. Lobar intracerebral hemorrhage: etiology and a long-term follow-up study of 32 patients. *Stroke* 1986;17:51-7.