Development of Intracranial Aneurysms as Revealed by Electron Microscopy

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There are many theories concerning the etiology of intracranial aneurysms. As to arterial aneurysms, much attention has been paid to a defective media in the wall of a vessel and their possible congenital or postnatal origin.3,6,12,30 Most of the defects of the media seem to be congenital, but some may have developed subsequently. The replacement of the defect by collagen does not seem to be a sufficient reason for the development of an arterial aneurysm, since numerous medial defects have been observed with no formation of aneurysm. Factors favoring fragmentation and disappearance of the elastic lamellae seem to be of great importance in the development of saccular aneurysms, but the changes caused by sclerosis also may play a primary part in the development of fusiform aneurysms, especially in older persons.

With reference to true arteriovenous aneurysms, much work has been done to clarify their pathogenesis. With the exception of the carotid-sinus cavernous aneurysms, most of the arteriovenous aneurysms are congenital in origin. The group has to be distinguished from other vascular malformations, such as angioma capillare et venosum calcificans (Sturge-Weber disease), telangiectases, cavernous angiomas (without brain parenchyma between the vessels), pure venous racemose angiomas, and pure arterial racemose angiomas. The existence of the last ones has been doubted.2,20,33,25 This opinion is contrary to reports by Hyland and Douglas,40 and by Asenjo and Uiberall,1 who had observed such angiomas. The true arteriovenous aneurysm is characterized by the presence of both one or several feeding arteries and one or several draining veins, between which a direct connection exists either by means of one large vascular branch, several branches or a tangle of tortuous dilated veins, which take the place of the capillary bed. It is not always easy to demonstrate microscopically the connection between the arteries and the veins. Bergstrand et al.2 emphasized that the vessels in the angioma may be so malformed that a pathological examination cannot determine finally whether they are arteries or veins, and that it may be difficult to find a histological difference between aneurysma arteriovenosum and angioma venosum. The difference may be purely physiological, since it is a question of whether there are large shunts, i.e., the vessels drain arterial blood, or if they drain venous blood which has passed through a normal capillary network.

Olivecrona and Ladenheim19 assumed that an arteriovenous aneurysm arises as a result of incomplete development at the fetal stage at which the differentiation of the primordial system into arteries, veins and capillaries occurs and richly anastomosing plexuses are formed (Streeter’s Stadium III). Zülch21 emphasized that it is Streeter’s Stadium V in which arteriovenous aneurysms originate.

Padget,21 in studying vascular development in man, found that crossing vessels may be separated only by a double layer of endothelial cells and suggested that a fistula is formed at the crossing point, this being the origin of a racemose angioma.

Hamby8 has described a typical arteriovenous aneurysm located in the right parieto-occipital lobe. Four different vascular types were found. Vessels of the first type were twisted spirally and located next to the plexus, and ran parallel to the axis of the aneurysm. Another type, empty of blood and
with a straighter course, but with a few sharp coils, was found in the same layer. There also was a blood-filled strongly convoluted type. The fourth type was more elongated. The diameter of the vessels varied from 0.15 to 0.7 mm. All four types of vessels provided drainage to the superficial cerebral or the deep cerebral venous system, through large, thin-walled vessels with a diameter from 1 to 5 mm. Traumatic hemorrhages were seen in the center of the dissection surrounding the vessels of the third type.

Microscopically the arteriovenous aneurysm appears as a confused mass of vessels and varies somewhat in type depending on whether the section has been made in the neighborhood of the feeding artery, more centrally in the specimens or near the draining veins. Sorgo found three types of vessels, i.e., thick vessels with endothelium and hyalin, nuclei-filled connective-tissue layers without elastin; vessels with intima, media and adventitia and a split-up elastica separating the endothelium from the muscular layer; and lacunar blood-filled vessels with thin endothelial walls. Pluvinage emphasized that the walls with a layer of media sometimes may be hypertrophic and sometimes very thin in the same vessel.

In the evaluation of the different factors in the development of intracranial arterial and arteriovenous aneurysms the numerous reports on the occurrence of these two types of aneurysm in one and the same patient are of great interest. 

Material

The whole material studied consisted of 15 patients, of whom 7 had arterial and 3 arteriovenous aneurysms and 5 yielded tissue of origin. Two of the patients with arteriovenous aneurysm also had arterial aneurysms. The cases of arterial aneurysms were as follows:

Two patients, aged 36 and 52 years, the former with a bean-sized and the latter with a cherry-sized aneurysm of the anterior communicating artery; 1 patient 37 years old with two pea-sized aneurysms, one situated on the anterior communicating artery and the other on the left middle cerebral artery; 2 patients 45 and 60 years of age with a bean-sized aneurysm of the right middle cerebral artery; 1 patient aged 49 years with a bean-sized aneurysm of the internal carotid artery; and 1 patient aged 31 years with a cherry-sized aneurysm of the right superior cerebellar artery.

In the group of arteriovenous aneurysms a girl aged 10 had an egg-sized aneurysm in the frontal lobe which was supplied mainly by branches from the right pericallosal artery. One 44-year-old patient had a large arteriovenous aneurysm in the occipital lobe, supplied mainly by the right middle cerebral artery and the right posterior cerebral artery. A bean-sized arterial vascular aneurysm on the right middle cerebral artery was observed in the angiogram. A patient aged 45 had an egg-sized arteriovenous aneurysm of the frontotemporal region, supplied mainly by the right middle cerebral artery. The patient also had a vascular arterial aneurysm on both of the middle cerebral arteries.

There had been bleedings from the aneurysm in all cases. No extensive hypertension was observed. Because of the subarachnoid hemorrhage the patients with an arterial aneurysm were in a poor condition already on admission and were semicomatose when operated on with a fatal result. All the arteriovenous aneurysms were removed completely and the arterial aneurysms in the same patients were also repaired with full recovery of the patients.

Methods

Specimens of the arterial aneurysms for light and electron microscopic studies were taken 4 to 10 hours post mortem. The control specimens were taken from a site symmetrical to the site of the aneurysm.

Specimens of the arteriovenous aneurysms for light and electron microscopy were taken during the operation. The control material in this group consisted of 5 other patients who had undergone craniotomy, resection of some normal brain tissue having to be carried out incidental to different neurosurgical procedures.

Different parts of the aneurysms were fixed in osmic acid, stained with phosphtungstic acid and embedded in methacrylate and araldite. Some specimens were treated by adding uranyl nitrate in the final change of methacrylate. Ultra-thin sections were cut on a Porter-Blum microtome.