Electron Microscopy of Human Cerebral Aneurysms*

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Although aneurysms occurring on the arteries of the circle of Willis have been recognized since 1761, the mechanism of their production remains obscure. Apart from the rare occurrence of aneurysms in the newborn, less than 5 per cent were found in individuals under the age of 20 years in large collected, post-mortem series. Riggs and Rupp were unable to find one aneurysm in a series of 102 brains of infants and children. In an extensive post-mortem series Baker and Iannone documented degenerative arterial changes in the cerebral arteries of 21 per cent of all individuals dying before the age of 30, but they failed to find any degenerative changes on superior cerebellar arteries. The study of McDonald and Korb showed that less than 0.2 per cent of 1,125 intracranial aneurysms were found on superior cerebellar arteries. While Forbus had emphasized the role of congenital defects of the arterial media in the production of intracranial aneurysms, Glynn subsequently demonstrated the occurrence of such defects of the media at 80 per cent of all cerebral arterial forks. He therefore suggested that so common a defect alone would be unlikely to explain the far rarer occurrence of aneurysms in less than 1 per cent of the population.

Stehbens has focused attention on dilatations of the arteries of the circle of Willis. He emphasized the basic dissimilarity between these lesions and the medial defects of Forbus, since he never observed dilatations at lateral angles of arterial bifurcations where defects of Forbus are prevalent.

Stehbens concluded that the prevalence of medial fibrosis described by Carmichael and seen so commonly in his own series near the entrance to the sacs does not favor a congenital origin for intracranial aneurysms. In order to obtain further information about the nature of what appeared to be a degenerative process, the necks of aneurysmal sacs, as well as the parent vessel and aneurysmal wall, were studied by phase-contrast and electron microscopy, techniques which permit cytological alterations to be examined in greater detail.

Methods and Material

Grossly normal arteries obtained within a few hours of death from the circle of Willis of 2 infants were used as controls for both light and electron-microscopic study. Four aneurysms from the anterior circle of Willis together with the necks of the sacs and a portion of the parent artery were obtained post mortem. A fifth aneurysm was made available as a surgical biopsy (by kindness of Mr. Valentine Logue). The age of the patients from whom these aneurysms were obtained ranged from 27 to 69 years.

All material, whether control or aneurysm, was cut into small pieces with a razor blade, then fixed rapidly in 1 per cent osmium oxide (in Palade-buffered Ringer’s solution) or 0.6 per cent potassium permanganate (in buffered Ringer’s solution). Usually the tissue was split to provide several specimens fixed by each method. Fixation continued for 4 hours at 4°C and then the tissue was dehydrated in 70 per cent alcohol overnight. It was dehydrated further in absolute alcohol or in absolute alcohol containing 1 per cent phosphotungstic acid as a stain.

All specimens were embedded in Araldite. Sections were cut on a Porter-Blum microtome; 0.5 μ serial sections were cut for phase-contrast examination at varying intervals. Ultrathin (silver or gold interference) sections were used for electron-microscopic examination in a Siemens Elmiskop I. The sections were mounted on carbon-coated copper grids and photographed at magnifications between 2,000 and 80,000X. Micrographs were made on contrast plates and enlarged photographically as desired.

Received for publication June 1, 1964.

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Results

Controls. Electron microscopy of the control vessels yielded structural details consistent for the most part with the published descriptions of coronary arteries of rabbits, femoral arteries of mice, pial vessels of the cat and monkey, and human cerebellar arteries. As was noted with the histological controls, endothelial cells were often disjoined and a continuous layer frequently could not be seen, although remaining individual cells appeared normal. The cells contained a few fine filaments and moderate endoplasmic reticulum. The plasma membrane showed terminal bars at points of apposition.

The elastic lamina, which lay immediately external to the endothelium (Fig. 1) measured 2–3 μ in thickness, was thrown into a series of irregular folds and was penetrated at regular intervals by 1–2 μ fenestrations (Fig. 2). The staining properties of the internal elastic lamina depended on the method of preparation. When the specimen was fixed in osmium oxide and stained in the block with phosphotungstic acid, the elastic lamina was composed of a homogeneous pale center with a dense surface layer (on both internal and external surfaces—Fig. 1). With permanganate fixation alone, the elastic lamina appeared as a structure of moderate and of uniform electron density (Fig. 3). When the permanganate preparation was stained in the block with phosphotungstic acid, an unusually intense stain resulted (Fig. 4). The internal (luminal) surface of the lamina was covered with 600–900 Å bars, which appeared to merge with the homogeneous central part. This homogeneous portion sometimes contained narrow channels on the luminal side (Fig. 1). The whole gave an impression of a

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Fig. 1. Control artery, showing folding of the elastica. e = endothelial cell, el = elastica, f = fenestration, mus = muscle cell. Osmium oxide, phosphotungstic acid, ×8,800.

Fig. 2. Control artery showing fenestration at higher magnification. Large arrow points toward lumen, small arrow indicates filament of collagen. el = elastica, ef = elastic fibril. Osmium oxide, phosphotungstic acid, ×25,300.

Fig. 3. Control artery, showing appearance with fixation of potassium permanganate without stain. el = elastica, mus = muscle cell. ×18,600.