Meningioma and Intracranial Hemangiopericytoma
A Comparative Electron Microscopic Study

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Summary. Electron microscopic study of 2 intracranial hemangiopericytomas and 7 meningiomas revealed fundamental morphologic differences between the 2 neoplasms. The most significant finding in hemangiopericytoma was the presence of ultrastructural features suggesting leiomyoblastic differentiation. These included characteristic fusiform intracytoplasmic and submembranous dense bodies, abundant cytoplasmic filaments, elongated cells with blunt-ended nuclei and juxtanuclear polarization of organelles. This observation is considered highly significant as an indicator of the pericytic nature of this tumor. In addition, hemangiopericytoma cells sometimes were arranged in spirals around pools of basement membrane-like material, perhaps a manifestation of the biologic capability of the cells to synthesize such material. Meningioma cells displayed as their main feature an ability to produce surface membrane specializations including interdigitations, desmosomes, zonulae adhaerentes and gap junctions. Sometimes the last 3 elements were linearly juxtaposed forming junctional complexes similar to those seen in certain epithelia. It is suggested that the characteristic whorls of meningioma are the result of cell interconnections arising from the specialized junctional attachments. Thus the distinctive morphology of the 2 neoplasms appears to derive from basic biologic properties of their elements.

Key words: Hemangiopericytoma (intracranial) — Meningioma — Ultrastructure — Leiomyoblastic differentiation — Intercellular junctions.

Although meningioma generally is recognized as arising from arachnoidal cells (Rubinstein), the histogenesis of intracranial hemangiopericytoma has been controversial. The latter was first described, judging from the illustrations and descriptions, by Bailey et al. (1928) as a variety of angioblastic meningioma and subsequently classified by Cushing and Eisenhardt (1938) as type IV variant 1 angioblastic meningioma. An alternate classification of this neoplasm had to await the description of tumors originating from pericytes by Stout and Murray (1942). The first intracranial hemangiopericytomas described as such were reported by Begg and Garret (1954), Peace (1954), and Fisher et al. (1958). Nevertheless a good deal of controversy persisted and Russell and Rubinstein (1971) expressed disagreement with attempts to separate these tumors from the general category of meningiomas. “Little seems to be gained by creating a separate group . . . out of an already well described variant of meningioma” (Rubinstein, 1972). Further controversy was seemingly added by the tissue culture studies of Muller and Mealey (1971), who reportedly observed meningiomatous whorls in explants of a hemangiopericytoma. Reflecting the general uncertainty, Kernohan and Uihlein, as well as Kruse withheld any definite conclusions as to the histogenetic derivation of this tumor. Published electron microscopic studies either failed to elucidate its histogenesis (Ramsey), or suggested a pericytic origin (Popoff et al.). The two hemangiopericytomas included in this study were reported previously as exhibiting leiomyoblastic differentiation, an observation that was considered compatible with a pericytic origin (Peña).

Materials and Methods

Seven meningiomas and two intracranial hemangiopericytomas were studied. Specimens were obtained at surgery, processed for light microscopy in the usual manner and examined with hematoxylin and eosin, reticulin and trichrome stains. For electron microscopy, tissue samples were fixed in glutaraldehyde, postfixed in osmium tetroxide and embedded in Epon. One micron thick sections were stained with toluidine blue. Ultrathin sections were stained with uranyl acetate and lead citrate.
Observations

Light Microscopy

Hemangiopericytomas. The main feature was the presence of numerous vascular channels surrounded by sheets of tumor cells. Individual neoplastic cells were elongated and had ovoid nuclei with finely granular chromatin (Fig. 1A). Vascular endothelium was visible as a single row of cells separated from the tumor cells by a layer of reticulin fibers. Mitoses were frequent. Examination of 1 μ sections of Epon-embedded material disclosed occasional well defined rosette-like structures. They were composed of 8 – 10 tumor cells with elongated nuclei arranged in a radiating fashion around a centrally located droplet of amorphous material. Individual nuclei remained at some distance from the center, but slender cytoplasmic processes could be seen reaching it (Fig. 1B). Neither lumen nor vessels were present. These structures were not visible in H.-E. stains.

Meningiomas. These included examples of meningothelial (2), fibroblastic (1), and transitional (3) types. In addition, a highly vascular meningioma (type IV variant 2 of Cushing and Eisenhardt) was also examined. All had characteristic histologic features and contained typical whorls. The vascular meningioma exhibited a large number of thin walled blood vessels lined by an endothelium and surrounded by tumor cells.

Electron Microscopy

Hemangiopericytomas. Neoplastic cells were round or elongated with few pseudopodal extensions. Nuclei were ovoid, blunt-ended and had fine chromatin. Nucleoli were inconspicuous. Cytoplasmic organelles frequently were at the end of nuclear poles. Some cells had large numbers of intracytoplasmic filaments, approximately 6–8 nm thick, arranged in bundles or whorls. Sometimes these filaments coalesced into characteristic fusiform dense bodies that measured on the average 650 x 200 nm. Furthermore, dense bodies of similar size and composition were located on the inner surface of the plasma membrane. Occasionally, filaments streaming from them could be traced into an intracytoplasmic fusiform dense body. Glycogen was abundant. Rough endoplasmic reticulum (RER) was sometimes well developed and contained a medium dense amorphous material. Cell membranes were relatively straight or formed long sweeping curves. Intercellular junctions were of the zonula adhaerens type and measured 100–150 nm in length. These were characterized by condensation of apposing cell membranes without tonofilaments, and an intercellular gap of 15 – 20 nm without intercellular dense laminae.

Sometimes cytoplasmic extensions of up to 8 tumor cells were wrapped around pools of basement membrane-like material, in a characteristic spiral fashion (Fig. 3).

Meningiomas. Their ultrastructure has been extensively studied and only certain pertinent features will be presented. All cases, regardless of type, had similar features. The main characteristics were pronounced interdigitation of cell membranes, frequent desmosomal attachments and abundant intracytoplasmic filaments. One meningothelial and one transitional meningioma displayed junctional complexes that included a desmosome, a zonula adhaerens and a gap junction (nexus) occurring in linear juxtaposition (Fig. 6). The desmosome was characterized by an intercellular gap of 25 nm, an intercellular laminar density and prominent tonofilaments. The zonula adhaerens was formed by densifications of apposing cell membranes and a narrower intercellular space (15 nm), but no tonofilaments or intercellular laminae. The gap junction (nexus) was characterized by a very close approximation of the outer leaflets of the plasma membranes of two apposing tumor cells leaving an intercellular gap of 2–3 nm (Fig. 8).

Interdigitation of cell membranes was frequent in all tumors, but more pronounced in the meningothelial type. Intracytoplasmic filaments, 6–8 nm thick, were present in variable numbers. Golgi complex, RER and mitochondria had a conventional appearance. Nuclei were medium sized and contained inconspicuous nucleoli. The interstitial space contained collagen and fibrillar or amorphous material which was occasional-