Solitary fibrous tumor of the meninges

Case report and review of the literature

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The authors present the case of a left frontal solitary fibrous tumor of the meninges. The gross appearance of the tumor was very similar to that of a fibroblastic meningioma. Histological examination showed a mixture of spindle-shaped and round cells arranged in a collagen matrix. Immunohistochemical staining of the tumor demonstrated diffuse positive staining for CD34 and vimentin. The tumor displayed no positive staining for markers of muscle, epithelial, glial, or neurocrest differentiation or for estrogen and progesterone receptors. The MIB-1 labeling index (the percentage of positive staining tumor cell nuclei), a marker of cellular proliferation, was 1.1%. Ultrastructural studies support attributing a mesenchymal, rather than meningothelial, nature to the tumor. A differential diagnosis is discussed and a review of the literature on these rare tumors is presented.

KEY WORDS • solitary fibrous tumor of meninges • meningeal tumor • CD34 • meningioma

THE solitary fibrous tumor is a relatively rare neoplasm that arises most frequently in association with the pleura; an extension into adjacent structures is not uncommon. The origin of these tumors has been a matter of some debate and both a mesothelial and mesenchymal origin have been hypothesized.3,10,11,13,16,19 To our knowledge, only seven cases of this tumor have been reported to arise in the meninges.6

We present the case of a solitary fibrous tumor of the meninges that was located over the left frontal convexity. The clinical and pathological features of this tumor, including light microscopic, immunohistochemical, and ultrastructural features, are delineated and a differential diagnosis is discussed.

Case Report

This 43-year-old man presented with a 2- to 3-month history of decreased short-term memory and poor vision in the left eye. More recently, he began experiencing headaches and what were thought to be seizures. He did not complain of weakness, numbness, bladder or bowel dysfunction.

Examination. A magnetic resonance (MR) study revealed a large mass in the left frontal lobe (Fig. 1 left). The tumor enhanced with homogeneous intensity. A focal area of tumoral cyst formation was also seen and there was moderate edema (Fig. 1 right). The tumor was associated with a subfalcine shift toward the right side with effacement of the left lateral ventricle. Magnetic resonance angiography failed to demonstrate large vessels within the tumor. A physical examination including neurological testing was unremarkable.

Operation. The patient underwent a left frontal craniotomy with biopsy and gross-total resection of the right frontal lobe tumor using a computerized tomography–guided frameless stereotactic technique. Intraoperatively, the tumor was noted to be attached to the inner table of the skull over the left frontal convexity. The tumor approached but did not involve the sagittal sinus.

Postoperative Course. The patient’s postoperative course was uneventful and he was discharged on the 2nd postoperative day.

Pathological Findings. A 7 × 5 × 4–cm mass of firm tan tissue was submitted for pathological examination. On gross inspection, there was no evidence of necrosis or hemorrhage. Histological sections revealed that the tumor was composed of spindle cells with scant eosinophilic cytoplasm and elongated nuclei with rounded ends (Fig. 2 upper). The nucleoli were inconspicuous and chromatin appeared to be evenly distributed throughout the nucleus. In other areas, tumor cells in cross section displayed a more rounded configuration (Fig. 2 lower). Collagen material was deposited between individual cells and, in some areas, was abundant, resulting in areas of relative hypocellularity alternating with more hypercellular regions. Only a rare mitotic figure was observed (1/10 hpf). There was no evidence of necrosis, hemorrhage, or microcystic degeneration. Capillary vessels and ectatic vessels were
scattered and focally prominent throughout the tumor. Focal infiltration of the overlying bone by tumor was also noted.

Paraffin immunohistochemical analysis was performed using several antibodies with an avidin-biotin peroxidase methodology that previously has been described.20 Table 1 provides a summary of the immunohistochemical profile of the tumor. Tumor staining proved negative for markers of epithelial cell epithelial membrane antigen (EMA), cytokeratins AE1 or AE3, and cytokeratin CAM5.2, smooth muscle (smooth-muscle actin and desmin), and glial fibrillary acidic protein (GFAP) differentiation, and for neural crest cell origin (S-100 protein). The tumor showed diffuse positive cytoplasmic staining using both CD34 (an endothelial cell and selective connective tissue cell marker) and vimentin. Immunostaining for both estrogen and progesterone receptors was negative. The MIB-1 labeling index (the percentage of positive-staining tumor nuclei) was determined to be 1.1%.

Electron microscopic examination of the tumor (previously described17) showed a mixture of round and spindle cells frequently separated by a collagenous matrix (Fig. 3 upper). The nuclei were generally elongated with evenly distributed chromatin. Prominent nucleoli were not observed. Occasional primitive cell junctions were seen between adjacent cells. The cytoplasm contained a few microfilaments, rough endoplasmic reticulin, occasional mitochondria, and lipid droplets (Fig. 3 lower). A scant amount of glycogen was also noted. Evidence of smooth-muscle or meningothelial cell differentiation was not seen.

Discussion

To our knowledge, there has only been one previous report involving so-called solitary fibrous tumor of the meninges.6 That study included seven cases, five women and two men ranging in age from 47 to 73 years. The tumors were located in the tentorium region in two cases, cerebellopontine angle in two cases, spinal dura in two cases, and parasagittal region in one case. There was no evidence of metastatic disease in any of the four patients who had at least 1 year of follow-up review; however, one patient had a local recurrence of a subtotally resected neoplasm 5 years later. Similar to our case, the tumors in that study exhibited diffusely positive staining for both vimentin and CD34 and showed negative staining for S-100 protein, desmin, and EMA. Two of four tumors displayed a positive reaction for estrogen receptors by immunostaining and five of five tumors showed a positive reaction for progesterone receptors. Ultrastructural study of two tumors was reported in that study and showed evidence of fibroblastic differentiation.

Most cases of solitary fibrous tumor have been reported to arise in the pleura. In this particular location, distinguishing this tumor from the desmoplastic mesothelioma has been problematic. Initially characterized as a hematopoietic progenitor cell antigen,1,8 CD34 was subsequently found to stain endothelial cells and is useful in the detection of some vascular neoplasms and certain connective tissue cells found in the skin.15,21 In 1993, Weiss and Nikoloff23 noted CD34-positive staining in a small number of solitary fibrous tumors of the pleura. A subsequent larger study10 demonstrated positive staining using CD34 in 15 (78.9%) of 19 such tumors. The expression of CD34 in solitary fibrous tumors, although helpful from a diagnostic standpoint, does not appear to be a lineage-specific antibody.

Although it appears that solitary fibrous tumors that are located in the meninges may recur,4 experience with these
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particular neoplasms is limited. In cases arising in the pleura, the vast majority of solitary fibrous tumors behave in a benign fashion. Those tumors that are associated with a poor outcome in this location often are large and cause difficulties because of their size. No single histological feature appears to be associated with prognosis. In their report of 223 fibrous tumors of the pleura, England, et al., classified histologically 82 (36.8%) as malignant tumors based on the presence of one or more features: high cellularity, high number of mitotic figures (≥4/10 hpf), and nuclear pleomorphism. Fifty-five percent of patients with histologically malignant tumors died of tumor. Resectability appeared to be the single most important factor in predicting clinical outcome. Worrisome histological features, including nuclear pleomorphism and high mitotic rate, do not necessarily seem to be predictive of aggressive behavior if the tumor is circumscribed and amenable to complete excision.

The histopathological differential diagnosis of solitary fibrous tumor centers around other spindle cell neoplasms that arise in the meninges. The most notable differential diagnostic consideration is meningioma, particularly the fibroblastic variant. Indeed, the radiographic as well as the gross appearance of the lesion in our case was indistinguishable from that of a meningioma. Histologically, a fibroblastic meningioma may mimic the solitary fibrous tumor: they are both characterized by spindle cells associated with collagen deposition. Fibroblastic meningiomas often lack many of the histological features, such as a whorled arrangement of cell, nuclear pseudoinclusions, and prominent psammoma bodies, that are characteristic of many other forms of meningioma and that would allow for easy distinction from the solitary fibrous tumor. Reliable distinction of these two lesions can be made using immunohistochemical analysis. Immunohistochemically, meningiomas, similar to solitary fibrous tumors, will show positive staining for EMA and demonstrate occasional focal positivity with cytokeratins and S-100 protein. Although the number of studies that focus on CD34 reactivity in meningiomas is somewhat limited, it appears that most meningiomas do not stain or are only focally positive for CD34, unlike the solitary fibrous tumor, which shows diffuse positive staining. In addition, ultrastructural features that suggest a meningioma, such as interdigitating cytoplasmic membranes, are not a prominent feature of this tumor.

Other differential diagnostic considerations include meningeal sarcoma, meningeal myofibroblastoma, meningeal fibroma, and schwannoma. The solitary fibrous tumor lacks the histological features that generally correlate with sarcoma, including parenchymal infiltration, nuclear pleomorphism, increased mitoses, and necrosis. A meningeal myofibroblastoma is a rarely reported lesion of

### TABLE 1

<table>
<thead>
<tr>
<th>Stain</th>
<th>Source</th>
<th>Dilution</th>
<th>Results</th>
</tr>
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<tr>
<td>vimentin</td>
<td>Dako Corp., Carpinteria, CA</td>
<td>1:300</td>
<td>+</td>
</tr>
<tr>
<td>CD34</td>
<td>Becton-Dickenson, Mt. View, CA</td>
<td>1:3</td>
<td>+</td>
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<tr>
<td>EMA</td>
<td>Dako Corp.</td>
<td>1:160</td>
<td>–</td>
</tr>
<tr>
<td>S-100 protein</td>
<td>Dako Corp.</td>
<td>1:1000</td>
<td>–</td>
</tr>
<tr>
<td>GFAP</td>
<td>Dako Corp.</td>
<td>1:600</td>
<td>–</td>
</tr>
<tr>
<td>cytokeratins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE1/AE3</td>
<td>Boehringer-Mannheim Corp.,</td>
<td>1:200</td>
<td>–</td>
</tr>
<tr>
<td>CAM5.2</td>
<td>Indianapolis, IN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>desmin</td>
<td>Becton-Dickenson</td>
<td>1:10</td>
<td>–</td>
</tr>
<tr>
<td>smooth muscle</td>
<td>Enzo, New York, NY</td>
<td>1:1</td>
<td>–</td>
</tr>
<tr>
<td>actin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>estrogen receptor</td>
<td>Ventana, Tucson, AZ</td>
<td>undiluted</td>
<td>–</td>
</tr>
<tr>
<td>progesterone receptor</td>
<td>Ventana</td>
<td>undiluted</td>
<td>–</td>
</tr>
<tr>
<td>MIB-1</td>
<td>Amac Inc., Westbrook, ME</td>
<td>1:10</td>
<td>1.1%</td>
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* + = positive; – = negative.

Fig. 3. Electron micrographs. **Upper:** Spindle cells with evenly distributed chromatin and lack of prominent nucleoli are separated by collagen bundles. Original magnification × 1700. **Lower:** Higher magnification demonstrates rough endoplasmic reticulin and occasional mitochondria within the cytoplasm. Original magnification × 5400.
myofibroblast origin that is also described as arising in the meninges.\textsuperscript{5,17} This tumor can generally be distinguished from the solitary fibrous tumor by the presence of myofibroblastic differentiation in the form of positive immunostaining with actin, desmin, or myosin as well as ultrastructural evidence of actinlike myofilaments within the cytoplasm of the tumor cells. In addition, amianthoid fibers, which represent collections of collagen fibrils, are somewhat characteristic of myofibroblastosomas, but are distinctly absent in the solitary fibrous tumor. Rare cases of so-called fibroma of the meninges have also been described; however, one reported case showed a marked immunoreactivity for S-100 protein.\textsuperscript{18} The exact relationship of this lesion to the solitary fibrous tumor remains unclear in the literature. Finally, the lack of S-100 protein–positive immunostaining in the tumor in our case effectively excludes a schwannoma from the differential diagnosis. In addition, the solitary fibrous tumor typically lacks the biphasic histological pattern that typifies most schwannomas.

The ultrastructural features of this case of solitary fibrous tumor of the meninges would suggest a fibroblastic origin for this neoplasm. This is also supported by extensive ultrastructural studies and immunohistochemical studies of this tumor in the pleura. Hanau and Miettinen\textsuperscript{12} have suggested that the solitary fibrous tumor is essentially a neoplasm composed of fibroblast or primitive mesenchymal cells with features of multidirectional differentiation, as evidenced by rarely observed focal positive immunoreactivity in response to markers of neural and muscle differentiation (neither of which was observed in our case).

Whether distinguishing the solitary fibrous tumor of the meninges from ordinary meningiomas is of clinical significance awaits further study. It appears that the two lesions are derived from a different cell of origin and that they represent different entities. Studies of solitary fibrous tumors arising in the pleura would indicate that most behave in a benign fashion. The low MIB-1 index (1.1%) in our case and in most of the cases reported by Carneiro, et al.\textsuperscript{6} (mean MIB-1 labeling index 4%) further support the notion that this tumor is generally a slow-growing neoplasm.

References


15. Nickoloff BJ: The human progenitor cell antigen (CD34) is localized on endothelial cells, dermal dendritic cells, and perifollicular cells in formalin-fixed normal skin, and on proliferating endothelial cells and stromal spindle-shaped cells in Kaposis’s sarcoma. \textit{Arch Dermatol} 127:523–529, 1991


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