The authors present a rare case of clear cell ependymoma that developed in the cauda equina. A 54-year-old man was admitted to hospital with intermittent lower back pain. A neurological examination conducted on admission revealed no sensory or motor disturbance. Deep tendon reflexes in both lower extremities were normal. Magnetic resonance images demonstrated a 1.0 cm-sized intradural mass at the filum terminale. Gross total resection was performed via total laminectomy of L1 and L2. The tumor was confirmed to be clear cell ependymoma by histopathologic examination. His symptom was relieved after surgery.

**KEY WORDS**: Clear cell ependymoma, Cauda equina.

**INTRODUCTION**

Clear cells are not uncommon in ependymomas, and resemble oligodendroglial cells with round cell bodies and nuclei with a perinuclear halo. Clear cell ependymomas are listed as a pathological entity in the World Health Organization's (WHO) classification of tumors of the central nervous system. Clear cell ependymoma is a subtype of ependymoma, as advocated by Kawano in 1989, and was added to the WHO Classification of Tumors of the Central Nervous System revised in 1993. Clear cell ependymomas are usually encountered in the cerebral and cerebellar hemispheres, and rarely in the spinal cord; intradural and extramedullary locations are also rare.

Generally, magnetic resonance (MR) images visualize clear cell ependymomas as mildly hyperintense as compared with the normal spinal cord on T1-weighted images and as homogeneously hyperintense on T2-weighted images. In addition, tumors show uniform, marked enhancement and were well demarcated (Fig. 1).

In the present case, light microscopy showed that the tumor cells possessed clear cytoplasm and round nuclei with a perinuclear halo. Immunohistochemical stainings for glial fibrillary acidic protein (GFAP) and vimentin were positive in cytoplasm. A search of the English literature failed to unearth any previous report of cell ependymoma of the cauda equina.

**CASE REPORT**

A 54-year-old man presented with intermittent lower back pain. A neurological examination revealed no reduction in sensation or motor function, and no bowel or bladder function difficulty. Lumbar MR imaging demonstrated a 1.0 cm-sized intradural mass at the L1-L2 level. The tumor had isointensity on T1-weighted images and high signal intensity on T2-weighted images. In addition, it demonstrated homogeneous contrast enhancement and was well demarcated (Fig. 1).

Total laminectomy of L1 and L2 was performed. After opening the dura, a round, encapsulated mass was noted. The tumor was a pale pink, rubbery, well circumscribed, and attached to the cauda equina. Accordingly, the cauda equina was sectioned, and the tumor was totally excised. The resected tumor was soft and had a volume of approximately 1.0 mL. The tissue sections were stained with hematoxylin and eosin (H & E). Frozen smear findings revealed no evidence of clear cells and suggested a glial tumor. A light microscopic examination revealed that tumor cells had long glial processes, and microphotographs showed characteristic perivascular pseudorosettes, in which tumor cells were arranged radially around blood vessels (Fig. 2A). A high magnification examination revealed that tumor cells had round nuclei with a perinuclear halo; a characteristic of oligodendroglia (Fig. 2B). Relatively, few mitotic figures and no evidence of anaplasia...
were observed. Immunohistochemically, tumor cells were positive for glial fibrillary acidic protein (GFAP) (Fig. 3) or vimentin, but negative for cytokeratin (AE1/AE3). Immunohistochemical staining revealed only rare tumor cell positivity for Ki-67, and equivocal positivity to negativity for S-100 protein. These results were compatible with the characteristics of clear cell ependymoma.

Neither radiotherapy nor chemotherapy was performed postoperatively. Cranial and whole spinal MR image examinations revealed no other tumors. The patient demonstrated a favorable outcome, and there was no evidence of recurrence during a 6-month follow-up (Fig. 4).

DISCUSSION

Ependymoma arises from the ependymal cells which line theventricles and central canal of the spinal cord. About 40 percent of spinal canal ependymomas arise within thecauda equina, and most occur in its proximal intradural region. Cauda equina ependymoma has been classified as an intramedullary lesion due to the neuroectodermal origin of the cauda equina. However, it should also be considered an extramedullary tumor from an anatomic and surgical perspective.

The new classification of tumors of the nervous system issued by the WHO (1999) characterizes ependymal tumors as: 1, four subtypes of ependymomas (cellular, papillary, clear cell, and tanyctic); 2, anaplastic ependymoma; 3, myxopapillary ependymoma; or 4, subependymoma. Clear cell ependymomas are predominantly composed of clear cells and usually develop in the brain. Clear cell ependymoma of the spinal cord has been reported on several occasions, but no report has been previously issued on clear cell ependymoma of the cauda equina, although Robles et al. reported malignant transformation of intradural extramedullary ependymoma. However, all ependymomas pursued a benign course.

Ependymomas show mildly hyperintensity versus the normal cord on T1-weighted images and homogenously hyperintensity on T2-weighted images, homogenous and heterogenous contrast enhancement, and sharply defined rostral and caudal margins. In clear cell ependymoma, this enhancement pattern is uniform and homogeneous. The early recognition of clear cell ependymoma is critical for optimal management, and an MR image examination should be performed as soon as possible to check for a tumor of the cauda equina.

Our microscopic examination of the excised tumor showed characteristic perivascular pseudorosettes, in which tumor cells are arranged radially around blood vessels. High magnification revealed tumor cells with an oligodendroglialike appearance, that is, round nuclei with a perinuclear clear halo. The diagnostic electron microscopic hallmarks of clear cell ependymoma include perivascular junctions, surface microvilli, and cilia, and microrosette formation. Its differential diagnosis includes central neurocytoma and glioneurocytoma in...
addition to oligodendroglialoma. Immuno histochemical staining for glial fibrillary acidic protein (GFAP) is positive for tumor cells, which confirms a glial origin. Immunohistochemical stain is also positive for epithelial membrane antigen (EMA) and vimentin, but negative for cytokeratin (AE1/AE3) and synaptophysin. Some authors have reported that clear cell ependymoma tumor cells are positive for S-100, GFAP, and vimentin, but negative for synaptophysin and EMA. The Ki-67 labeling index of tumor cells has been previously reported to be 19%. It is important to realize cytokeratin AE1/AE3 stains glial tumors strongly, and that occasionally it also strongly stains mesenchymal neoplasms that express GFAP (such as schwannomas). In our case, immunostaining was equivocal to negative for S-100 protein, which is compatible with a diagnosis of clear cell ependymoma. S-100 is normally present in cells derived from the neural crest (Schwann cells, melanocytes, and glial cells), chondrocytes, adipocytes, myoepithelial cells, macrophages, Langherans cells, dendritic cells, and keratinocytes, and it may also be present in some breast epithelial cells. Furthermore, several members of the S-100 protein family are useful markers of epidermal differentiation and certain tumors, for example, S-100 is expressed in melanomas, in 50% of malignant peripheral nerve sheath tumors, and in clear cell sarcomas. In our case, tumor cells were positive for GFAP and vimentin, but negative for EMA, synaptophysin, and S-100 protein, and their Ki-67 labeling index was less than 1%. Furthermore, the presences of a macroscopic cleavage plane, true ependymal rosettes, perivascular pseudorosettes, perilinuclear lucency, and GFAP positivity are essential for the diagnosis of clear cell ependymoma.

Min et al. reported that the biologic behaviors of clear cell ependymomas and other ependymomas are similar, and that a proliferative index must be used to determine malignancy. In our case, Ki-67 was expressed only rarely at low levels in tumor cells, which suggested that the tumor was benign.

Microsurgery is the treatment of choice for ependymoma of the cauda equina. Radical excision using microsurgical techniques enables curative surgery to be undertaken, and this should be the goal of initial surgery. Furthermore, the extent of tumor resection is the most important prognostic factor of long-term survival in patients with a nonmalignant form of ependymoma, regardless of location. Thus, gross total resection (GTR) is optimal. The surgical results of cauda equina tumors depend on both histologic findings and tumor size, because large lesions are generally more difficult to remove without causing further neurological damage. Currently, adjuvant therapy is not used after the complete surgical resection of spinal ependymoma. Radiation is used in patients with a residual tumor postoperatively and in those that experience early recurrence, after considering medical condition and neurological status, and can achieve excellent local control and survival. However, radiotherapy of the neuroaxis is reserved when dissemination has been diagnosed before surgery or as a rescue therapy after conventional radiotherapy in cases of late spreading. Chemotherapy has also been recommended in those with a recurrent or intradural extramedullary ependymoma and in those refractory to surgical treatment.

Some authors have reported late recurrence at more than 40 years postoperatively despite radical total resection and postoperative radiotherapy. Accordingly, long-term follow-up is also recommended.

CONCLUSION

The authors report a rare case of clear cell ependymoma that developed at the cauda equina. Although clear cell ependymoma of the cauda equina is extremely rare, the possibility of occurrence should be considered. A histological diagnosis is crucial when considering postoperative adjuvant therapy for ependymoma of the cauda equina, and long-term follow up is recommended.

References
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