The surgical treatment of metastatic spinal tumors within the intradural extramedullary compartment

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The authors retrospectively reviewed the surgical outcomes in 10 cases of symptomatic intradural extramedullary spinal metastases of nonneurogenic origin because the collective experience in treating this rare manifestation of systemic cancer is limited. Pain and weakness were the presenting complaints in 70% of the patients and sensory changes were found in all cases. Cytological tests on one specimen of cerebrospinal fluid (CSF) from each of seven patients showed malignant cells in two cases. Gadolinium contrast-enhanced biplanar magnetic resonance (MR) imaging was effective in localizing the lesion and showed evidence of leptomeningeal carcinomatosis in two cases; myelography showed leptomeningeal carcinomatosis in one case and erroneously identified the lesion as intramedullary in the other. Eight of 10 cases had antecedent intracranial metastatic foci with the interval from presentation of the intracranial lesion to appearance of the spinal disease ranging from 3 to 51 months. The majority of the spinal lesions occurred in the thoracolumbar area. The most frequent histological type was adenocarcinoma and the most frequent source was the lung. In all cases laminectomies, intradural exploration, and biopsy or subtotal excision aided by microscopy and ultrasonography were performed. Results of surgical decompression were poor with only 30% of the patients showing improvement, at a 20% risk of perioperative mortality and a 60% risk of morbidity. Plans for surgical intervention in patients with intradural extramedullary metastases from a distant nonneurogenic source should be weighed against the high association with intracranial lesions, overall poor prognosis, and modest symptomatic results of decompression. Comprehensive evaluation including multiple specimens of CSF for cytology and contrast-enhanced MR imaging should be undertaken to exclude patients with diffuse leptomeningeal involvement, who should be treated by means other than surgery.

KEY WORDS • spinal metastasis • spinal tumor • leptomeningeal carcinomatosis • intradural spine surgery
low-up care at intervals determined by the nature of their primary tumor, but all patients were seen at least every 6 months.

**Results**

**Clinical Profile**

Among the cases reviewed, there were four men and six women. Their mean age was 51 years (range 35–64 years). Pain (70%) and weakness (70%) were the most common presenting complaints. Sensory changes were found in all patients, and reflex changes were present in four, with sphincter dysfunction in three patients. The mean interval between onset of symptoms and surgical intervention was 3.6 months (range 1 week–12 months).

Eight patients had antecedent or synchronous intracranial metastatic lesions, and the interval between treatment for the intracranial lesion and treatment for the spinal disease averaged 13.7 months (range 3–51 months).

**Preoperative Investigations**

A single CSF specimen was evaluated from each of seven patients. Two of the CSF specimens were positive for malignant cells. Myelography in one patient showed asymmetrical expansion of the distal cord from T-11 to the lower margin of T-12, subarachnoid nodular defects in the area of L-1, and smaller filling defects at the very distal end of the thecal sac. Segmentally thickened lumbar roots were also seen. This case was interpreted as leptomeningeal carcinomatosis. In a second patient, myelography showed a partial block in the flow of contrast material from the midvertebral body of T-2 to the lower aspect of the T-4 vertebral body. This lesion was interpreted to be intramedullary. Each of these tumors was found dorsolateral to the spinal cord at surgery. Of the eight cases evaluated with MR imaging presurgery, seven (87%) showed the tumor as isointense to the spinal cord on T1-weighted sequences, and one tumor (13%) was hyperintense. On T2-weighted images, five lesions were isointense to the cord and three were hyperintense. All lesions enhanced brightly with gadolinium: six homogeneously and two heterogeneously. All lesions studied by MR imaging were localized to the intradural extramedullary space. Two of the studies revealed multifocal leptomeningeal involvement and were interpreted as showing leptomeningeal carcinomatosis. Illustrative cases are shown in Figs. 1 and 2.

**Tumor Location and Type**

The tumor locations indicated by preoperative imaging were confirmed at surgery in all patients. In relation to the spinal cord, six lesions were dorsal or dorsolateral, one was lateral, and three were ventral or ventrolateral. Of the 16 spinal segments involved, the majority were located in the lower thoracic and lumbar spine (Table 1). Adenocarcinoma was the most common histological type (40%), and the lung was the most common site of origin (40%) (Table 1).

**Surgical Outcome**

Because no detailed prospective grading system was used uniformly, an outcome was recorded as “improved” if alleviation of pain, stronger extremities, or better sphincter control was seen the day after surgery. By these criteria, four of the patients improved, two were worse postsurgery, and four were unchanged. Minor complications in three patients included transient urinary retention, ileus, and hyponatremia. These conditions were treated and resolved prior to the patients’ discharge. There were three major complications: one patient suffered a myocardial infarction, one a respiratory arrest, and one a central cord syndrome (in this patient, the only one with neurological decline postsurgery, the tumor was ventral to the spinal cord). Two patients died within 30 days of surgery, one from respiratory arrest and another from intracranial
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**TABLE 1**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Spinal Level</th>
<th>Histopathology</th>
<th>Site of Origin</th>
<th>Postop Outcome</th>
<th>Follow-Up Period†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35, M</td>
<td>L-2</td>
<td>alveolar soft-part sarcoma</td>
<td>muscle</td>
<td>improved</td>
<td>13 mos</td>
</tr>
<tr>
<td>2</td>
<td>37, M</td>
<td>C-4</td>
<td>squamous cell carcinoma</td>
<td>nasopharynx</td>
<td>improved</td>
<td>11 mos</td>
</tr>
<tr>
<td>3</td>
<td>39, F</td>
<td>L-1</td>
<td>adenoid cystic carcinoma</td>
<td>lacrimal gland</td>
<td>unchanged</td>
<td>died at 3 mos</td>
</tr>
<tr>
<td>4</td>
<td>44, F</td>
<td>T-7</td>
<td>poorly differentiated adenocarcinoma</td>
<td>primary unknown</td>
<td>improved</td>
<td>63 mos</td>
</tr>
<tr>
<td>5</td>
<td>50, F</td>
<td>C2–7</td>
<td>poorly differentiated adenocarcinoma</td>
<td>lung</td>
<td>worse</td>
<td>died at 2 mos</td>
</tr>
<tr>
<td>6</td>
<td>54, F</td>
<td>T3–4</td>
<td>small cell carcinoma</td>
<td>lung</td>
<td>worse</td>
<td>died at 5 mos</td>
</tr>
<tr>
<td>7</td>
<td>61, M</td>
<td>L3–4</td>
<td>adenocarcinoma</td>
<td>lung</td>
<td>improved</td>
<td>died at 6 mos</td>
</tr>
<tr>
<td>8</td>
<td>62, M</td>
<td>L1–2</td>
<td>T-cell lymphoma</td>
<td>lymphoreticular system</td>
<td>unchanged</td>
<td>3 mos</td>
</tr>
<tr>
<td>9</td>
<td>64, F</td>
<td>L1–2</td>
<td>small cell carcinoma</td>
<td>lung</td>
<td>unchanged</td>
<td>died at 8 days</td>
</tr>
<tr>
<td>10</td>
<td>64, F</td>
<td>T7–8</td>
<td>adenocarcinoma</td>
<td>ovary</td>
<td>unchanged</td>
<td>died at 22 days</td>
</tr>
</tbody>
</table>

* Measured the day after surgery.
† Duration of follow-up period postsurgery.

Intradural extramedullary spinal metastasis for which she declined further therapy. Overall morbidity, both minor and major, was thus 60%, and the mortality rate was 20%. At last follow-up review, four patients were alive at 3, 11, 13, and 63 months postsurgery. Late deaths included one patient who died of pneumonia 3 months postsurgery, and three patients who died 2, 5, and 6 months postsurgery, respectively, from progression of leptomeningeal carcinomatosis.

**Discussion**

Review of the Literature

Metastasis to the intradural extramedullary space of the spinal column is a rare but ominous complication of systemic cancer. Since 1950, 49 patients (excluding those in the M. D. Anderson Cancer Center series) with such tumors have been reported, with histological confirmation by surgery. The average age of 54 years at diagnosis (range 23–74 years) is similar to that found in both the present study (mean age 51 years) and in the only other published series of significant size reported by Perrin and colleagues in 1982. Women outnumbered men in both series by 6:4, and the female/male ratio is 1.3:1 when all 59 cases now on record are considered. Overall, the most common histopathological finding is adenocarcinoma (Table 2) and the most frequent site of origin is the breast (Fig. 3). This is consistent with the known propensity of breast cancer to spread to the central nervous system (CNS) and to disseminate within it along CSF pathways. The cumulative geography of intradural extramedullary metastasis shows a bimodal distribution, with the most frequently involved spinal segments clustered at the cervicomedullar junction and in the upper lumbar and midlumbar segments (Fig. 4). In comparison, tumors in all but one of Perrin’s patients were located between T-10 and L-3; the tumors in our series were more widely scattered.

**Mechanisms of Tumor Spread**

Mechanisms proposed for the spread of tumor cells in the spinal subarachnoid space include direct extension from the extradural space, exfoliation of tumor cells from exophytic parenchymal brain lesions, and perineural lymphatic spread. Hematogenous dissemination from tumor emboli is generally suggested as the most important and common mechanism. If this were the determining factor for intradural extramedullary metastasis, however, the long expanse of thoracic spinal cord would be expected to account for half or more of such tumors. Instead, the more diminutive conus medullaris and cauda equina harbor a disproportionate number of these metastases (Fig. 4). This distribution supports the idea that seeding of tumor cells into the subarachnoid space is followed by gravitational or bulk-flow spread to the dependent part of the thecal sac. The high prevalence of concomitant intracerebral metastasis (80% in this series) and the known association of posterior fossa metastasis with subsequent spinal subarachnoid tumor attest to the possible role of the CSF pathways in the pathogenesis of intradural extramedullary metastases. Any theory of intradural extramedullary metastasis must also account for the circumferential pattern of axial deposition relative to the spinal cord. The majority (60%) of tumors arise in the dorsolateral quadrant, a feature that loosely suggests an association with the sensory spinal roots but does not exclude any of the above hypotheses.

It is also possible that the prevalence of involvement at inferior spinal regions relates to the vascular supply to the spinal cord. The artery of Adamkiewicz, the largest of the radiculomedullary arteries, typically enters the spinal cord between T-7 and L-4 and is located between T-9 and L-2 in 90% of patients. The cervicothoracic junction, a region in which the arterial supply for the rostral cord enters the spinal canal, also appears to be overrepresented as a site of tumor involvement. Regional blood flow characteristics and differences in nutrient environment may be peculiarly conducive to tumor cell implantation in these areas. One may speculate that the diffuse, matlike involvement of the leptomeninges seen in some patients and the focal or multifocal involvement found in others may reflect the different avenues by which the tumor cells arrived.

**Leptomeningeal Carcinomatosis**

Patients with cancer are suspected of having leptomeningeal carcinomatosis when neurological signs and symptoms reflect neoplastic lesions involving two or
The patients reported by Perrin, and 45.) reported in references 2, 3, 7, 9–13, 16, 17, 19, 24–28, 32–37, 42, and 45.)

...intradural extramedullary metastases. (Included are patients lesions in the subarachnoid space. Watanabe, approximately one-third of the cases show distinct mass subsets of spinal leptomeningeal carcinomatosis and that...Schu...that seen in classic leptomeningeal carcinomatosis with its more limited involvement of the leptomeninges than...leptomeningeal carcinomatosis. More recently, MR imaging in patients with leptomeningeal carcinomatosis has shown diffuse leptomeningeal thickening, focal subarachnoid nodules, and thickening of nerve roots or spinal cord; some images have shown extension of a parenchymal brain lesion into the subarachnoid space.1,22,41,44,46 Six of the patients reported by Perrin, et al.,39 and eight of those reported here had a metachronous or synchronous intracranial tumor and, thus, met the clinical criteria for leptomeningeal carcinomatosis. Of these eight patients, leptomeningeal carcinomatosis was diagnosed by cytological studies in two cases, myelography in one, and MR imaging in two. Apparently discrete intradural extramedullary metastatic tumors may in many instances represent a local accumulation of more widespread leptomeningeal carcinomatosis.

Surgical intervention may be helpful in such cases of focal leptomeningeal carcinomatosis, which might reflect a more limited involvement of the leptomeninges than that seen in classic leptomeningeal carcinomatosis with its multiple untreated sites of tumor involvement. Schu...et al.,39 have suggested that there are recognizable subsets of spinal leptomeningeal carcinomatosis and that approximately one-third of the cases show distinct mass lesions in the subarachnoid space. Watanabe, et al.,44 have suggested dividing leptomeningeal carcinomatosis into pure, dural, spinal, and hydrocephalic categories based on MR findings. They reported different prognoses for the four groups, but their sample size was inadequate to support such a conclusion. Patients with untreated leptomeningeal carcinomatosis survive only 4 to 8 weeks from the time of diagnosis.30,43 More recent treatment protocols using tumor-specific intrathecal or intraventricular chemotherapy have improved survival by a matter of months, but long-term remission is exceedingly rare.45 Although it is unproven that differences in the extent or type of leptomeningeal involvement predict different prognoses, the poor clinical outcomes of patients in this series argue against the validity of the concept of focal leptomeningeal carcinomatosis. Their short survival times indicate that these patients have true leptomeningeal carcinomatosis with the rapid progression to death that this diagnosis predicts or that a focal form of leptomeningeal carcinomatosis is converted into a diffuse form by cells shed into the CSF during tumor removal.

Predicting the Extent of Leptomeningeal Involvement

Cerebrospinal Fluid Cytology. Although the demonstration of neoplastic cells in the CSF has been the standard proof of leptomeningeal involvement, patients with positive CSF cytology show variable infiltration of the leptomeninges at autopsy.14,43 Rarely, false-positive readings can be caused by the presence of atypical lymphoid cells in patients with superimposed undiagnosed infection.14 False-negative rates of between 27% and 90% have been reported.14,43 The reason for such wide variability is unclear, but the sensitivity of the test clearly can be improved with multiple sampling or by cisternal taps.4,38 It is plausible that regional differences in tumor burden within the subarachnoid space, in cellular cohesiveness, and in the mechanism of spread may influence the chance of detecting neoplastic cells in the CSF of individual patients. The sensitivity of CSF examination in those with diffuse carcinomatosis might therefore be different from its sensitivity in those with more focal lesions. Recent studies correlating concentrations of tumor marker proteins with tumor burden may help to categorize further patients with leptomeningeal carcinomatosis.34 Unfortunately, positive CSF cytology alone does not distinguish between types of leptomeningeal carcinomatosis or predict the extent or location of subarachnoid tumor.

Radiological Imaging. Recent advances in imaging technology have made the diagnosis of intradural extramedullary tumors easier and more certain. Before the advent of MR imaging, myelography was used extensive-ly to evaluate metastatic lesions of the spine, and the “capping sign” was used as a marker for extramedullary...
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Conclusions

Surgical treatment of metastatic cancer involving the intradural extramedullary compartment is associated with high morbidity and mortality. The success rate is modest. A vigorous search for intracranial disease is warranted in light of the high incidence of associated cerebral involvement and the poor prognosis when such lesions are present. Surgery is not advised for patients with diffuse leptomeningeal involvement. A thorough search for evidence of multifocal involvement of the CNS, including contrast-enhanced MR imaging of the entire craniospinal axis and multiple lumbar punctures, may identify those patients who will be more successfully treated medically. Surgical intervention is currently appropriate only in cases of diagnostic uncertainty or in patients with indolent primary tumors amenable to adjuvant therapeutic control. The indications will widen in future only if a group of patients with metastases truly focal to the intradural extramedullary space can be identified and shown to have a better prognosis with surgery than with other modes of treatment.

References
