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Clinical Study

Microsurgical treatment and functional outcomes of multi-segment intramedullary spinal cord tumors

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ABSTRACT

We aimed to prospectively analyze correlations between clinical features and histological classification of multi-segment intramedullary spinal cord tumors (MSICTs), and the extent of microsurgical resection and functional outcomes. Fifty-six patients with MSICTs underwent microsurgery for tumor removal using a posterior approach. The tumor was exposed through a dorsal myelotomy. Pre-operative and post-operative nervous function was scored using the Improved Japanese Orthopaedic Association (IJOA) grading system. Correlation analyses were performed between functional outcome (IJOA score) and histological features, age, tumor location, and the longitudinal extent of spinal cord involvement. The most frequently involved levels were the medullo cervical and the cervicothoracic regions (51.8%, 29/56) followed by the conus terminalis (26.8%, 15/56) and the thoracic region (14.3%, 8/56). Ependymoma was the most frequent MSICT type, seen in 22 of 56 patients (39%), followed by low grade astrocytoma (17 patients, 30%) and glioblastoma multiforme (3 patients, 5%). Gross total tumor removal was achieved in 33 cases (58%), subtotal resection in 4 (7%), and partial resection in 16 (28%). The histological classification of the tumor was the most important factor influencing the extent of surgical removal (χ^2 = 22.17, p = 0.00). The overall difference between pre-operative and post-operative neurological state was not significant (χ^2 = 5.44, p = 0.61). Thus, MSICTs were most commonly seen in the medullo cervical and cervicothoracic regions, with ependymoma and low grade astrocytoma the most common tumour types. We stress the importance of early microsurgical treatment for MSICTs while the patients do not have severe dysfunction.

1. Introduction

The incidence of spinal tumors is less than that of intracranial tumors, with an overall incidence of about one spinal tumor for every four intracranial lesions. The incidence of multi-segment intramedullary spinal cord tumors (MSICTs) is much less (about 1 MSICT for every 10 spinal tumors).[1,2] Although usually not life threatening, MSICTs cause permanent disability in patients, and consequently also place large burdens on their families and on society. In the past, total removal of MSICTs was rarely attempted because of the difficulty of the operative procedure, and the worsening post-operative neurological status.[2,3] With the advance of modern microsurgical techniques, it is now possible to completely resect MSICTs without worsening the post-operative neurological status. For this reason, total removal has now become the gold standard for the treatment of MSICTs where possible. In this article, we prospectively analyzed 56 patients presenting with MSICTs who received microsurgery at this hospital from January 2002 to October 2007.

2. Materials and methods

This was a prospective, descriptive study using clinical records. Ethics approval from the Research Ethics Board of Peking University Third Hospital was obtained to conduct this study.

2.1. Patients

A consecutive series of 56 patients diagnosed with MSICTs extending for 3 or more spinal segments were referred to our institution and underwent microsurgical treatment.[2,3] Basic demographic data, clinical and radiological presentation, and intraoperative observations were evaluated. Pre-operative neuroimaging, including MRI, was performed in all cases. Spinal angiography was performed if the MRI suggested a possible vascular lesion.

2.2. Surgical technique

All 56 patients underwent their first operation at our institution. The operation followed the usual procedures for intramedullary spinal cord tumors. Laminectomy was performed over the

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region of the tumor on the basis of pre-operative neuro-diagnostic testing. Only medial facet joint exposure was required in most cases, and an effort was made to preserve the facet joint capsule in all cases. After midline dural incision, the operating microscope was brought into the field and a midline myelotomy was performed and pia traction obtained using sutures to the dura. The resection was then modified based on the tumor dissection plane, and infiltration as determined by pre-operative MRI and the appearance under intra-operative microscopy. Intra-operative neurophysiological monitoring was regularly used. The pia mater was not normally reattached at the end of the resection. For spinal ependymomas (Fig. 2), midline myelotomy was carried out to expose the proximal and distal ends of the tumor mass. Spinal ependymomas originate from the central canal, grow concentrically, and demonstrate a clear plane to normal cord tissue. Ultrasonic aspiration was used to resect the tumor to its interface with the normal cord white matter. This dissection plane between the tumor mass and normal cord tissue was relatively easy to preserve in most cases.

In spinal astrocytic tumors, in contrast, tumor extension is typically eccentric without any defined plane to normal cord tissue. Due to this intramedullary eccentric mass, the posterior median sulcus is often shifted to the opposite side. Midline myelotomy was used cautiously to identify the posterior median sulcus. The malignant astrocytic tumors in this series, including anaplastic astrocytomas (Fig. 3) and glioblastomas, mostly invaded through the pia mater or arachnoid. After the extramedullary tumor was removed, the opening of the spinal cord was extended in the midline. The tumor was dissected along the cleavage plane with the spinal cord as much as possible. In areas of obvious infiltration, the tumor was removed layer by layer starting from the innermost layers until white matter was identified. In cases where malignant astrocytoma was suspected at frozen biopsy, partial removal was performed and complete resection was not attempted. Radiotherapy was then performed.

Some well-defined MSICTs (including hemangioblastoma (Fig. 1) and schwannoma) may partially invade the spinal cord and extrude through the pia mater. In these cases, the draining veins were carefully displaced from the field before the feeding arteries were clipped and then obstructed with bipolar coagulation. Tumors were partially dissected and not totally removed where necessary. In patients with hemangioblastomas the tumor cyst was not removed. In order to prevent the contents of teratomas from seeding the subarachnoid space, well-defined intramedullary cystic teratomas were shielded with cotton slips before being cut open. The cyst walls of tumors that adhered tightly to the spinal cord were cauterized with micro-power bipolar coagulation, rather than separated and removed by force. Lipomas between the spinal cord and nerve root were debulked and decompressed partially; total resection was not attempted.

The extent of tumor removal was graded using four classes according to intraoperative observations and post-operative MRI. Cases with no residual enhancement on post-operative MRI were classified as class 1. Subtotal resection of about 80 to 90 percent was defined as class 2. Partial resection of about 60% to 80% of the tumor was defined as class 3. All other procedures, including decompression and biopsy, were classified as class 4.

The Improved Japanese Orthopaedic Association (IJOA) grading system was used to evaluate pre-operative and post-operative nervous function. IJOA is based on the JOA grading system, with the addition of scoring stool function as normal, slight dysfunction, severe dysfunction, or incontinent. Functional outcome was defined as post-operative IJOA score minus pre-operative IJOA score. The clinical outcomes were independently analyzed by an observer who was blind to other features.

The first post-operative follow-up MRI was done at two weeks post-operative and the second at 6 months. MRI was then repeated annually in order to detect disease progression in cases without symptomatic change. If patients experienced symptomatic change, then MRI was performed immediately. Disease progression was defined as recurrence in cases of complete removal, and regrowth in cases of incomplete removal.

2.3. Post-operative management

Post-operatively all patients received routine administration of methylprednisolone with a flushing dose (about 500–1000 mg/d according to body weight) for three days, and vitamin B1 and B12 for at least two months. A neck collar or waistline brace was used to fix position and prevent vertebral deformation. All patients received rehabilitation training at local physical therapy centers.

The condition of patients was evaluated according to the functional status and graded as improved, unchanged, or worsened.

2.4. Statistical analysis

To compare the two groups, the data was analyzed by cross table studies with the *p*-values generated using either the chi-squared test or Wilcoxon Signed Rank test. Data analysis was performed using a computer-based statistical program, Statistical Package for the Social Sciences v. 11.0 for Windows (SPSS, Chicago, IL, USA). Data were expressed as the mean ± standard error (s.e.). *P* values of less than 0.05 were considered significant.

3. Results

3.1. Clinical factors

Of the 56 patients, 34 were male (61%) and 22 were female (39%). Children less than age 10 years represented 6 cases, ages 10–19 years 6 cases, ages 20–29 years 13 cases, ages 30–39 years 13 cases, ages 40–49 years 8 cases, and ages 50 years or older 10 cases (mean age, 32.6 ± 15.6 years, Table 1).

The most common initial symptom was pain (52%, 29/56), followed by sensory disturbance (23%, 13/56), motor weakness (14%, 8/56), gait deterioration (9%, 5/56) and sphincter dysfunction (2%, 1/56) (Table 1). Age and initial presentation have prognostic significance (χ^2 = 15.4, p = 0.02). Adolescent patients tended to present with subtle changes in gait or more frequent falls. Older patients mostly presented with sensory disturbance and weakness.

The most commonly involved location was the medullo cervical and the cervicothoracic segments (51.8%, 29/56), followed by the conus terminalis (26.8%, 15/56), the thoracic region (14.3%, 8/56), and the lumbosacral region (7.1%, 4/56). Three spinal segments were involved in 20 (35.7%) cases, four in 16 (28.6%) cases, five in 10 (17.8%) cases, and more than five in 10 (17.9%) cases.

The most frequent MSICTs were ependymomas (39.3%, 22/56), followed by astrocytomas (30.3%, 17/56, grade I-II in 14 cases, grade III in 3 cases), cystic teratomas (10.7%, 6/56), glioblastomas (5.4%, 3/56), lipomas (5.4%, 3/56), hemangioblastomas (5.4%, 3/56), and schwannomas (3.5%, 2/56). The ependymomas and astrocytomas mostly involved the cervical spinal cord and the teratomas mostly involved the medullary conus. The location of MSICTs did not predict histology (χ^2 = 7.51, p = 0.28).

3.2. Surgical outcomes

Gross total tumor removal was achieved in 33 cases (58.9%), subtotal resection in 4 (7.1%), and partial resection in 16 (28.6%). Owing to the absence of a clear dissection plane in three patients (5.4%), only a decompression or biopsy was performed (one glioblastoma, one ependymoma, and one teratoma). The histological