Intramedullary spinal cord tumors in children under the age of 3 years

SHILOMO CONSTANTINI, M.D., M.S.C., JOHN HOUTEN, M.D., DOUGLAS C. MILLER, M.D., PH.D., DIANA FREED, B.A., MEMET M. OZEK, M.D., LUCY B. RORKE, M.D., JEFFREY C. ALLEN, M.D., AND FRED J. EPESTEIN, M.D.

Divisions of Pediatric Neurosurgery, Neuropathology, and Pediatric Neurooncology, and Kaplan Comprehensive Cancer Center, New York University Medical Center, New York, New York; Division of Pediatric Neuropathology, Children’s Hospital of Philadelphia, Philadelphia, Pennsylvania; and Division of Pediatric Neurosurgery, Department of Neurosurgery, Dana Children’s Hospital, Tel Aviv–Sourasky Medical Center, Tel Aviv, Israel

Over a 13-year period extending from 1980 to 1993, 27 children less than 3 years of age underwent operation for removal of an intramedullary spinal cord tumor (IMSCT). The majority (18 of 27) of children had undergone surgery before being referred to New York University (NYU) Medical Center. The most common reasons for radiological investigation were pain (42%), motor regression (36%), gait abnormalities (27%), torticollis (27%), and progressive kyphoscoliosis (24%).

Forty procedures were performed in 27 children. Nine children underwent two operations and two children underwent three procedures. A gross-total resection was achieved in 72% of the procedures. There was no surgical mortality. A comparison of the preoperative and 3-month postoperative functional grades for the first NYU procedure (NYU-1) yielded the following findings: 20 patients’ conditions remained the same, five patients improved, and two patients deteriorated. The functional outcomes of a second operation (NYU-2) were similar.

The majority of the children (24 of 27, 89%) had histologically determined low-grade lesions. There were 12 patients with low-grade astrocytomas (Grades I–III), eight with gangliogliomas, two with ganglioglioneurocytomas, one with a glioneurofibroma, and one child with a mixed astro/oligodendroglioma. Two children had anaplastic astrocytomas (Grades II–III) and one child had a glioblastoma multiforme.

In a median follow-up review of 76 months, two patients died and two patients were lost to follow up. The 3- and 5-year progression-free survival (PFS) rates were 81.7% (standard error of the mean (SEM) 0.083) and 76.2% (SEM 0.094), respectively. Eight of 24 patients suffered a recurrence within a mean time of 45.4 ± 28.9 months. All were treated with surgery (NYU-2). Lesions recurred in three of 12 children with low-grade astrocytomas, two of eight children with gangliogliomas, one child with an anaplastic astrocytoma, one child with a ganglioglioneurocytoma, and one child with a glioblastoma multiforme. At follow-up review, most of these children were doing well. Sixteen are in functional Grades I or II and 18 children attend a normal school system.

The authors conclude that surgery for the removal of IMSCTs in children less than 3 years of age can be performed radically and safely. The postoperative functional performance is determined by the degree of the preoperative deficit. It is, therefore, of utmost importance to diagnose and treat these children as early as possible. Spinal cord tumors should be recognized as potentially excisable lesions on their initial presentation and when they recur. The optimum treatment for malignant lesions is still to be determined.

**KEY WORDS** • congenital tumor • spinal cord neoplasm • central nervous system neoplasm • magnetic resonance imaging • astrocytoma

---

**I**ntramedullary spinal cord tumors (IMSCTs) are relatively rare neoplasms accounting for only 4% to 10% of central nervous system (CNS) tumors and 2% to 4% of CNS glial tumors. In adults intramedullary tumors only comprise approximately 20% of all intraspinal neoplasms, whereas in children at least 35% of pediatric intraspinal tumors are intramedullary.4-10,46,68,72 We estimate that only 10 to 20 new cases of intramedullary tumors in children less than 3 years of age appear in the United States per year.44

Despite consistent, recent reports on aggressive removal of intramedullary tumors, the treatment of these lesions, especially spinal astrocytomas and gangliogliomas, remains unsettled.49 In the past, there has been relatively little impetus to modify the traditional approach of biopsy, dural decompression, and radiation therapy, despite the recognition that after a relatively short remission, serious disability or death ensues.49,41,40 This attitude was, and unfortunately still is, based on the assumption that astrocytomas are infiltrative tumors and thus it is not fea-
Intramedullary tumors in children under 3 years of age

sible to accomplish extensive tumor removal from within the center of the spinal cord without a great likelihood of inflicting additional neurological injury. 1,6,11 This is particularly troubling because most of these neoplasms are low-grade lesions and microscopically similar to tumors arising in the brain, which are surgically curable. 6,38

Recent microsurgical advances and the development of other surgical adjuncts, such as the ultrasonic aspirator, the laser, and intraoperative ultrasonography, have led many to select a more aggressive surgical approach. 2,16,17,19,36,40,49,50,52,57,63,67,69,77 This was first attempted successfully with conus and intramedullary ependymomas. A similar radical surgical approach for other intramedullary gliomas has been used by the senior author (F.J.E.) since 1982 in more than 200 children and 100 adults. 26,27,29-32

We have, therefore, decided to review our overall results, including long-term follow-up review, in treating IMSCTs in children. The focus of the current study is the treatment of IMSCTs in children less than 3 years of age. In view of the early age of presentation, it is reasonable to suggest that many, if not all, of these tumors are congenital in origin. Among patients with malignant brain tumors, infants and very young children have the worst prognosis. 23,24,34 It is unknown whether a similar trend exists for intramedullary tumors. Radiation has a deleterious effect on the immature developing nervous and osseous systems. 8,39,51 Deferring adjuvant treatment and using surgery as the primary tool is, therefore, especially important in this age group.

Clinical Material and Methods

Patient Population

Between 1980 and 1993, 27 children consecutively admitted to a major health center, who had true IMSCTs and were diagnosed at, or before, the age of 3 years were included in this study. Children with tumors originating in the cauda equina or filum terminale were excluded. There were 15 boys and 12 girls, 6 to 36 months of age (mean 20.1 months). During that period, a total of 170 children underwent surgery for IMSCTs at the Division of Pediatric Neurosurgery, New York University (NYU).

Clinical Evaluation

Case records were examined for presurgical symptomatology and evaluation, surgical details, and immediate and late follow-up findings. All patients or their close families were called and interviewed according to a carefully designed questionnaire. In this manner, we were able to verify the details in our records and obtain an up-to-date functional evaluation. The patient's functional status was graded according to a modified McCormick scale 52 (Table 1). The most recently obtained magnetic resonance (MR) images were evaluated by a neuroradiologist. 20 In the majority of the cases (18 of 27), the children had undergone prior surgery before being referred to NYU. Eleven of 18 patients had biopsies and seven had subtotal removals of their tumors. Three patients received chemotherapy before referral. None had received radiotherapy.

Histological Evaluation

All pathological specimens were reevaluated by two senior neuropathologists (D.C.M. and L.B.R.) who first looked at the patients' slides and graded them independently and later reached a consensus. Diffuse fibrillary astrocytomas were graded into three groups using standard criteria. 7,53,58,66 We separated the low-grade fibrillary astrocytomas from pilocytic astrocytomas by using strict criteria for the latter: to be called pilocytic, the tumor had to have some mixture of loose “spongy” and dense “compact” architecture with the appropriate elongated bipolar cells. Rosenthal fibers or microcysts alone were insufficient evidence for a diagnosis of pilocytic astrocytoma. Using these criteria, no pilocytic tumors were identified (see Results). Gangliogliomas were identified by their characteristic perikaryal surface immunoreactivity for synaptophysin. 47,48,54,55 Neurocytomas were separated from clear-cell ependymomas and oligodendrogliomas by the former's neuronal pattern of synaptophysin immunoreactivity. 53

Surgical Approach

The senior author (F.J.E.) attempted gross-total removal (GTR) in all patients. A more conservative approach was used for lesions within the conus medullaris. Gross-total removal is defined as removal of more than 90% of the tumor as evidenced by both the surgical report and postoperative MR imaging. The surgical technique has been described in detail in previous publications. 11-14,28,31,32,75 Ultrasonography was routinely used before and after resection for localization and to assure complete tumor removal. 33 Ultrasonic aspiration was invariably used after 1985 to excavate the tumor from the inside outward until its interface with the white matter was reached. 15,25 Sensory evoked and, recently, motor evoked potentials were used routinely for on-line feedback to the surgeon. 20 All children operated on for the first time underwent an osteoplastic laminotomy with subsequent bone replacement.

Statistical Analysis

Progression-free survival (PFS) rates were measured from the first NYU operation (NYU-1) to clinical or radiological deterioration. Progression-free and overall survival rates were estimated using the technique of Kaplan

---

**TABLE 1**

Modified McCormick scale for functional evaluation in children with intramedullary tumors*

<table>
<thead>
<tr>
<th>Functional Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I neurologically intact; walks normally; may have minimal dysesthesia</td>
<td></td>
</tr>
<tr>
<td>II mild motor or sensory deficit; maintains functional independence (walking, feeding, &amp; using the bathroom)</td>
<td></td>
</tr>
<tr>
<td>III moderate deficit; limitation of function; independent with external aid</td>
<td></td>
</tr>
<tr>
<td>IV more severe motor or sensory deficit; limited function with dependency</td>
<td></td>
</tr>
<tr>
<td>V paraplegia or quadriplegia (even if there is flickering movement)</td>
<td></td>
</tr>
</tbody>
</table>

and Meier. Standard errors of the Kaplan–Meier estimates were calculated as suggested by Peto and coworkers. Because of the small numbers, no comparison between groups was performed.

Results

Preoperative Clinical Status

The median prodrome time was 5.4 months, with a span of 14 days to 2 years from the beginning of symptomatology. Table 2 provides a summary of the main indicators that alerted parents to their child’s illness. In most cases parents became aware of the problem before there were objective signs of neurological dysfunction. The most common indicators for radiological investigation were pain (42%), motor regression (36%), gait abnormalities (27%), torticollis (27%), and progressive kyphoscoliosis (24%).

On examination, five (19%) of 27 children had intact motor function, seven (26%) had mild deficits (no muscle group weaker than 4+5), 10 (37%) had moderate deficits (no muscle group weaker than 3/5), and five (19%) had severe motor deficits (at least one muscle group weaker than 3/5). Five children (19%) had urinary problems and 15 (56%) had hyper- or dysesthetic areas in dermatomes corresponding to the tumor. Kyphoscoliosis and/or torticollis were noticed in 12 children (44%). Five patients had a functional score of I, 10 patients had II, six patients had III, and six had IV (see Tables 1 and 3).

Radiological Evaluation and Tumor Architecture

Nineteen children were diagnosed by MR imaging and eight by computerized tomography myelography. All 23 living patients still available for follow up are currently being followed with MR imaging. Five of the patients’ tumors were primarily cervical, nine were cervicothoracic, and 13 were thoracic. The average extent of tumor (and cysts where applicable) was 7 ± 3.3 bone levels (range 3–17). In 16 children (59%) there were associated cysts: in five children the location of the cysts was only rostral; in two, only caudal; in two, intratumoral; and in seven children, rostral and caudal. More than 90% of tumors enhanced with administration of gadolinium, albeit inhomogeneously.

<table>
<thead>
<tr>
<th>Indicator Triggering Parental Alert</th>
<th>Percentage of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>pain</td>
<td>42</td>
</tr>
<tr>
<td>motor regression</td>
<td>36</td>
</tr>
<tr>
<td>gait abnormality</td>
<td>27</td>
</tr>
<tr>
<td>torticollis</td>
<td>27</td>
</tr>
<tr>
<td>kyphoscoliosis</td>
<td>24</td>
</tr>
<tr>
<td>delayed milestones</td>
<td>12</td>
</tr>
<tr>
<td>urinary retention</td>
<td>8</td>
</tr>
<tr>
<td>other</td>
<td>4</td>
</tr>
</tbody>
</table>

Surgery and Surgical Morbidity

Forty procedures were performed in 27 children. Nine children underwent two operations and two children underwent three procedures. Children underwent a second operation if the surgeon realized, during the first procedure or on postoperative MR imaging, that a substantial volume of tumor was left behind (three patients), or if the tumor had recurred (eight patients). During the first procedure (NYU-1), 19 GTRs (70%) and eight subtotal removals (30%) were achieved. During the second operation (NYU-2), eight GTRs (73%) and three subtotal removals (27%) were accomplished. Both patients in whom surgery was performed for a third time had GTRs.

There was no direct operative mortality. One patient with a ganglioglioneurocytoma died 1 month after surgery for GTR of his tumor due to an infection that developed during chemotherapy. A second child with an intramedullary ganglioglioneurocytoma died more than 5 years after he was diagnosed and 4 months after his third NYU operation because of tumor progression.

In a comparison of pre- and postoperative functional grades for the first NYU procedure (NYU-1) made 3 months after surgery, clinical status was unchanged in 20 patients, improved in five, and deteriorated in two children. In a separate comparison of patients who first underwent operation at NYU (NYU-1/original) and those who first underwent operation elsewhere (NYU-1/reoperation), the changes in functional scores were similar. However, patients in the NYU/original group came to surgery in a better condition (average functional score 2.2 ± 1.4)
Intramedullary tumors in children under 3 years of age

### Table 4: Comparison of histopathological findings and recurrence rates in 27 children less than 3 years of age with intramedullary tumors*

<table>
<thead>
<tr>
<th>Pathological Findings</th>
<th>Total No. of Patients</th>
<th>Tumor Recurrence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>low-grade astrocytoma</td>
<td>12 (11)</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>mixed astro/oligodendroglioma</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>anaplastic astrocytoma</td>
<td>2 (1)</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>glioblastoma multiforme</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>ganglioglioma</td>
<td>8</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>gliomegocytoma</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ganglioglioneurocytoma</td>
<td>2</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>total</td>
<td>27 (24)†</td>
<td>8</td>
<td>33</td>
</tr>
</tbody>
</table>

* Numbers in parentheses indicate number of patients available for follow-up evaluation.
† Because two children were lost to follow up and one child with ganglioglioneurocytoma died shortly after surgery, only 24 cases are used for the overall recurrence calculation.

Pathological Findings

Table 4 contains a summary of tumor histopathology in this series. The majority of the children had low-grade lesions (24 patients, 89%). Twelve children had low-grade fibrillary astrocytomas, one had a mixed astro/oligodendroglioma, eight had gangliogliomas (previously reported by Miller, et al.,55 and Lang, et al.56), one had a glioneurofibroma (previously reported by Vazquez, et al.57), and two children had ganglioglioneurocytoma (previously reported by Miller, et al., and Lang, et al.). There were no cases of pilocytic astrocytoma in this series. It is noteworthy that in several cases a peripheral rim of gliosis closely mimicked what has been called pilocytic astrocytoma, in that the tissue had numerous Rosenthal fibers among a moderately dense proliferation of bipolar astrocytes. Biopsies of this gliosis alone were easily labeled as pilocytic astrocytoma. With the comparatively large resection specimens available from these patients, however, this gliotic rim was easily distinguished from the deeper tumor, which was ganglioglioma or low-grade fibrillary astrocytoma. Also important is that many of the gangliogliomas were originally diagnosed as astrocytomas both by outside pathologists and pathologists at NYU prior to the use of synaptophysin immunostaining.

Among the minority of children with high-grade tumors, two had anaplastic astrocytomas and one had a glioblastoma multiforme. There were no ependymomas in the children in this series.

Postoperative Adjuvant Therapy

Seven patients received additional therapy after surgery. In two cases this decision was based on determination of a high-grade tumor by histology, whereas in the other five cases treatment was based on non-NYU institutional preferences. Four patients received chemotherapy, one patient radiation therapy, and two received both. Treatment was initiated in children with anaplastic tumors or tumor recurrence before a second operation was considered and performed. One child died from infection during chemotherapy.

Follow-Up Review

Two patients were lost to follow-up review (one patient with an anaplastic astrocytoma and one with a low-grade astrocytoma). One patient with a ganglioglioneurocytoma died approximately 1 month postoperatively from infection that developed during chemotherapy. Twenty-four children were available for long-term follow up (median 76 months, range 20–143 months).

Tumor recurred in eight of 24 patients within a mean time of 45.4 ± 28.9 months. All of these patients were retreated with surgery (NYU-2). One child died during chemotherapy after his first operation for removal of a ganglioglioneurocytoma and before any recurrence. An additional patient died after a third operation for removal of a recurrent ganglioglioma. Death in this instance was caused by tumor progression. Recurrence was noted in three of 12 cases of low-grade astrocytomas, two of eight cases of gangliogliomas, one case of anaplastic astrocytoma, one of two cases of ganglioglioneurocytoma, and in one case of glioblastoma (Table 4). The patient with the recurring anaplastic astrocytoma who underwent surgery for the first time in 1983, and again in 1989 for a recurrent tumor, is presently free of disease without any adjuvant treatment.

One child currently has active disease. He first underwent operation for radical removal of a glioblastoma, received chemotherapy, and suffered a recurrence 23 months later. He recently underwent operation for the second time for a subtotal removal of a thoracic tumor and is currently receiving radiation therapy.

The 3- and 5-year PFS rates were 81.7% (SEM 0.083) and 76.2% (SEM 0.094), respectively (Fig. 1). The median time to progression was 94 ± 6.8 months. There was no significant difference in 5-year PFS rates between gangliogliomas (70%) and low-grade gliomas (91%).

Functional Status of Patients

To summarize the functional status of 23 patients who were available for follow-up review, 21 children are currently clinically stable and display no MR changes (no change in enhancement pattern or cord diameter). One child has had radiological evidence of tumor recurrence but this has remained stable over a period of 15 months. Sixteen children are in functional Grades I or II (Table 1); however, four children are paraplegic or quadriplegic (Grade V) and an additional three patients have moderate...
deficits (Grades III and IV). Six children have impaired sphincter functions at follow up. Three of these six children (all had surgery at the conus level) are completely incontinent with respect to urine and stool. The remaining three have partial urinary incontinence. Due to their young age, it is difficult to assess whether this deficit will be transient. Three children required shunting procedures and six required an orthopedic operation. Eighteen attend classes in a normal school system.

Discussion

There is no comparable series in the literature that focuses on children less than 3 years of age who have undergone surgery for IMSCTs. Therefore, the database that can be used to compare our results to others consists of general pediatric series. When doing so, one should be cautious to look specifically at the surgical results associated with intramedullary astrocytomas as opposed to ependymomas and/or other lesions that have a confined capsule or pseudocapsule. No ependymomas were present in our series. This series has an inherent referral bias and, therefore, may not correctly reflect the true incidence of low- versus high-grade malignancy of IMSCTs in this age group.

Several questions are of major concern in determining the optimal current treatment of childhood intramedullary tumors. First, is it feasible to perform radical tumor removal from within the spinal cord with an acceptable level of short-term morbidity? Second, are our surgical achievements stable over a long-term follow-up period? Third, is it safe to defer adjuvant therapy, regardless of the degree of operative tumor resection? Fourth, what is the optimum treatment for recurrent disease? Fifth, should we modify our approach and use adjuvant therapy in accordance with histological findings? Finally, is the natural history of IMSCTs in infants different from that of the older population? The first two questions can be directly answered from the data provided in this paper, whereas the rest may be only partially answered at this stage.

Surgical Morbidity

Gross-total removal of intramedullary tumors in this series was achieved in the majority of cases and was associated with a reasonable rate of short-term morbidity. Two of the three children who had worsening of functional ability postoperatively came to surgery with established profound deficits. For such patients surgery is unlikely (but possible) to improve neurological function substantially, although it may prevent further long-term deterioration. It is, therefore, of utmost importance to diagnose and treat these children as early as possible, before neurological deficits develop. Such early diagnosis requires a high degree of clinical suspicion and a low threshold for performing MR imaging in children.

Long-Term Follow-Up Period

The majority of children in this series (89%) had histologically determined low-grade tumors. This number is in accordance with other pediatric series in which 64% to 90% of astrocytic tumors were low grade. These lesions, however, may recur despite what seems to be radical removal. Over an average follow-up time of more than 6 years, recurrence (and PFS) rates were similar for low-grade astrocytomas (27%) and gangliogliomas (25%). Tumor recurred in the two patients available for follow up who had high-grade gliomas. One child had undergone his first operation 11 years previously and a second resection 6 years later. Because there is currently no evidence of active disease, no adjuvant therapy has been given.
Intramedullary tumors in children under 3 years of age

When intramedullary tumors do recur they can be treated again surgically without significant additional operative risk. Surgical palliation with a long-term survival rate is achievable in recurrence of both low- and high-grade tumors. The fact that tumor recurrence emerged on an average of a little less than 4 years in children diagnosed and treated before the age of 3 years implies that Collin’s law does not apply for these lesions. Intramedullary tumors in this age group did not change their histological characteristics. In nine children with low-grade tumors and a need for a second operation, histological findings remained generally the same.

At follow up, approximately two-thirds of the children in our series are functioning well. Approximately one third, however, have moderate-to-severe deficits.2 Our focus, in the future, should be concentrated on two aspects of improvement. The first is earlier diagnosis and treatment. The second is improving our intraoperative technical ability to minimize white matter injury during the procedure.

Role of Adjuvant Therapy

There is no clear evidence that radiation or chemotherapy will improve the outcome of low-grade astrocytomas of the CNS.35,37,56 Newly designed chemotherapeutic protocols have recently been shown to produce objective responses with low-grade gliomas.49 In the future, such protocols may play an important role in the treatment of astrocytomas. There is abundant evidence that radiation has deleterious effects on the immature developing nervous and osseous systems.1,8,24,30,51 Low-grade tumors in children possess very little potential to transform into high-grade tumors if not irradiated.22 In addition, irradiation may induce a second malignant tumor at a rate of up to 20% in a 30-year follow-up period.22 Children with benign tumors who are diagnosed before the age of 3 years and treated with radical surgery may have long-term PFS rates without need for oncological adjuvant treatment. In our opinion, therefore, spinal cord low-grade tumors should be recognized at presentation and recurrence as a surgical disease.

In this study we did not directly compare our results to other alternative treatments. Strategies of more limited resections combined with radiation therapy have been suggested by several groups for treating IMSCTs.59 Our data show that GTR does not add to surgical morbidity rates compared to subtotal resections. Given the young age of these patients and the increasing accuracy of MR imaging in identifying tumor recurrence, we believe that it would be safer to follow these children carefully after GTRs than to prescribe adjuvant treatment immediately after surgery.

High-Grade Tumors

The optimum treatment for high-grade astrocytomas of the spinal cord is still to be determined.9,46 Data obtained from the three children with high-grade tumors in our series were insufficient to make any conclusive remarks on the biological behavior, or response to treatment, of these lesions. The one child with an anaplastic astrocytoma who is doing well 11 years after his first tumor resection demonstrates that having a high-grade lesion does not necessarily mean recurrence and death within a short time span. Radiation and chemotherapy should probably be reserved for possible adjuvant use if there is a recurrence. At that time, they might be used after a first or second radical surgical resection. Unfortunately, glioblastomas invariably progress despite aggressive chemotherapy and radiotherapy.7,46

The Issue of Congenital Tumors

Congenital tumors are a distinct clinicopathological entity in the CNS. There are a number of observations that clearly are relevant to understanding the biology of this group of neoplasms and that have important implications for therapy. The survival rate of infants and very young children with brain tumors is significantly worse than that of older children, both overall and for specific tumor types.3,23,34 With IMSCTs young age was not associated with a worse prognosis.

Despite the image conveyed by the term “gross” total tumor excision, it would be naive to assume that residual tumor fragments were not commonly left in situ. We hypothesize that these remaining fragments may remain dormant or involute in a similar way to what has been noted to occur in astrocytomas of the cerebellum.58 However, whether this is a reality or “wishful thinking” will only be known after a long-term follow-up period and retrospective analysis.

Conclusions

Gross-total IMSCT resection in young children can be achieved in the majority of cases with a reasonable rate of short-term morbidity. Early diagnosis and treatment improve the surgical morbidity rate. The morbidity rate of a second operation is similar to that of the first procedure. Most of these tumors are low-grade astrocytomas and gangliogliomas. Children with low-grade tumors who are treated with extensive tumor removal may have long-term PFS rates without a need for additional treatment. Low-grade tumors of the spinal cord should, therefore, be recognized at presentation and recurrence as a surgical disease.

References


J. Neurosurg. / Volume 85 / December, 1996

1041
Intramedullary tumors in children under 3 years of age


75. Zide BM: How to reduce the morbidity of wound closure following extensive and complicated laminectomy and tethered cord surgery. Pediatr Neurosurg 18:157–166, 1992

Manuscript received May 2, 1995. Accepted in final form June 17, 1996. Address reprint requests to: Shlomo Constantini, M.D., M.Sc., Division of Pediatric Neurosurgery, Department of Neurosurgery, Dana Children’s Hospital, Tel Aviv–Sourasky Medical Center, 6, Weizmann Street, Tel Aviv 64239, Israel.