Intradural Extramedullary Spinal Cord Tumours: A Retrospective Study of Surgical Outcomes.

Md. Kamrul Ahsan[1], Md. Abdul Awwal[2], Shahidul Islam Khan[3], Md. Hamidul Haque[4], Naznin Zaman[5]

[1]Associate Professor, [2]Assistant Professor, [3]Medical Officer, Department, Of Orthopaedic Surgery, [4]Resident, Orthopaedis, DMCH, [5]Junior Consultant, Department of Anesthesiology, Sarkari Kormosari Hospital, Dhaka, Bangladesh.

Abstract:

Background: Intradural extramedullary spinal cord tumours (IESCT) accounts for approximately two thirds of all intraspinal neoplasm and are of important clinical consideration and surgery is the essence in cases with neurological deterioration. **Objective:** To share our experience on the outcome of surgical excision of intradural extramedullary spinal cord tumours. **Methods:** Results of 60 patients surgically treated intradural extramedullary spinal tumours between October 2003 and October 2015 at Bangabandhu Sheikh Mujib Medical University and in our private settings, Dhaka, were analyzed retrospectively. There were 32 males, 28 females with an average age of 52.4 years (13-70 years) and followed up for at least a year. The preoperative symptom with duration, tumours location and intradural space occupancy and the histopathological diagnosis were analyzed. Pain was evaluated by the visual analogue scale (VAS) and the neurologic function was assessed by Nurick`s grade. **Results:** The tumours were located as, thoracic 32 (53.33%), lumbar 16 (26.67%), cervical 04 (6.67%), and junctional 08 (13.33%), CervicoThoracic-01, Thoracolumbar-07). The histopathological diagnosis included schwannoma 35 (58.33%), meningiomas 14 (23.33%), neurofibroma 4 (6.67%), arachnoid cyst and myxopapillary ependymoma 03 (05.00%) each and paraganglioma 01 (01.67%). The VAS score was reduced in all cases from 8.0 ± 1.2 to 1.2 ± 0.8 ($p < 0.003$) and the Nurick's grade was improved in all cases from 3.0 ± 1.3 to 1.0 ± 0.0 ($p < 0.005$). The preoperative neurological deficit improved within 8 postoperative weeks in most cases and within 1 postoperative year in all cases. Complications included cerebrospinal fluid leakage, parasthesia, dependant bedsore 02 (3.33%) each and recurrence 03 (05.00%). and further neurological deterioration 1 (01.67%) case. **Conclusion:** Intradural extramedullary tumors detected by MRI are mostly benign and good clinical results can be obtained when treated surgically. Aggressive surgical excision potentially minimizes neurologic morbidity and improved outcome.

Keywords: Intradural Extramedullary Spinal Tumour, Spinal Cord Tumour, Surgical treatment of Spinal Tumour.

[BSMMU J 2016 ; 9 (1) : 11-19]

Introduction:

Primary tumors of the spinal cord are 10-15 times less common than primary intracranial tumors and overall represent 2-4% of all primary tumors of the central nervous system (CNS)[1]. The annual incidence of primary spinal neoplasms has been estimated at 2.5 per 100,000 per year[2] . These neoplasms can be divided into extradural and intradural tumors on the basis of their relation to the thecal sac that surrounds the spinal cord and cauda equina. Intradural tumors, account for almost 30% of tumors and are important consideration in the differential diagnosis of patients with back pain, radicular pain, sensorimotor deficits, or sphincter dysfunction. Concomitant intradural and extradural components, though rare; are associated with roughly 10% of SCNs.[3]

Intradural extramedullary spinal cord tumours (IESCT) constitute approximately two thirds of all intraspinal neoplasms[4,5]; most commonly- schwannomas and meningiomas, whereas myxopapillary ependymoma is less

Corresponding Author: Dr. Md. Kamrul Ahsan, Associate Professor of Spinal surgery, Department of Orthopaedic Surgery, BSMMU
Mobile No-+88-01711809908. E mail: kahsansps@yahoo.com.

frequent[6]. Relatively few published reports have sufficient sample sizes to adequately analyze surgical outcomes, demographics, symptoms and data of tumour types and locations[7,8,9].

Diagnosis of a primary spinal cord tumor requires a high index of suspicion based upon clinical signs and symptoms as well as spine-directed MRI[1] . Other radiographic examinations, such as CT and myelogram, are useful if MRI is contraindicated[3]. .Histological examination of the tumour after biopsy or surgical resection is able to establish the histogenesis of intradural tumors in almost all cases. The primary objective of this study was to examine surgical outcomes following intradural extramedullary tumour excision in a large retrospective cohort of patients. Secondary goals included examination of clinical data pertaining to demographics, clinical symptoms, tumour location, type and the prognostic factors.

Methods:

Sixty cases of intradural extramedullary spinal tumors were treated surgically between October 2003 and October 2015 at Bangabandhu Sheikh Mujib Medical University (BSMMU) and in our private settings, Dhaka, and were analyzed retrospectively. These 32 males and 28 females with an average age of 52.4 years (13-70 years) were followed up for at least 1 year. Pain was evaluated by the visual analogue scale (VAS)[10] and the pre and postoperative neurological function, ambulatory ability was graded according to the Nurick's grading system (Table-1)[11]. Locations of the tumors, the percentage of tumor occupying the intradural space (TOIDS%) was determined by the preoperative Magnetic Resonance Imaging (MRI) analysis on both the sagittal and axial images [Figure-2(a),(b),(c), 3(a),(b),(c), 4(a),(b),(c)]. The percentage was investigated to find out any statistically significant association with the preoperative symptoms and the final surgical outcome. The TOIDS% was calculated on the axial image showing the maximum size as follows[12] [Figure-1]: [(the transverse diameter of the tumor mass + the longitudinal diameter of the tumor mass) / (the transverse diameter of the intradural space + the longitudinal diameter of the intradural space)] × 100. The preoperative symptom duration, postoperative clinical results and the histo-pathological diagnosis were also analyzed. On last follow up, the MRI was checked to evaluate whether or not the tumor had recurred. The SPSS ver. 11.5 (SPSS Inc., Chicago, IL, USA) was used and statistical analysis was done by Wilcoxon signed rank test, partial correlation test, Spearman correlation test, Mann Whitney test and ANOVA. $p<0.05$ was considered to be significant and <0.005 as highly significant. Surgical Technique:[13,14] The patient was placed prone under general anesthesia. A laminectomy was performed regardless of the location or type of tumor through the posterior approach alone. A longitudinal incision was made in the dura mater and the tumor was detached from the dura mater and removed. During excision of tumour we used microscope or magnifying Loupe. Additional Posterior interbody fusion with instrumentation was performed in 3 cases where the tumor were so large as to cause posterior instability.

During the removal of a cervical tumor ventral to the spinal cord, the paired denticulate ligaments on one side were incised to allow lateral retraction of the spinal cord. The spinal cord or the cauda equina was protected with a cottonoid and the tumor was removed with a freer and a hook. During the excision, the nerve fibers over the surface of a tumor were carefully separated and those penetrating the tumor mass were either excised with the tumor if the distal ends were not identified or they were preserved through an intralesional tumor excision if the distal ends were observable. A total of 54 (90.00%) marginal and 6 (10.00%) intralesional excisions biopsies were performed. Closure of the dura mater was performed with 4-0 silk or prolene 6-0. Negative pressure drainage was performed in all the cases. The drain was removed on the 2nd postoperative day and gait training was started on the 3rd postoperative day. A thoracolumbosacral orthosis was worn for 2 postoperative months by the patients who underwent posterior spinal fusion with instrumentation.

Results:

The histopathological diagnosis included 35(58.33%) schwannoma, 14(23.33%) meningiomas, 04(6.67%) neurofibroma, 03(5.00%) arachnoid cyst and myxopapillary ependymoma each and 01(01.67%) paraganglioma. The plain radiographs taken at the time of admission revealed no abnormalities in 54 cases, increased interpedicular distance, calcifications and mild kyphoscoliosis in 02(03.33%) cases, Scalloping and erosions of vertebral bodies in 04(06.67%) cases. MRI showed IESCT in 60 cases, moreover, at the last follow-up it showed recurrence of schwannoma in 02(3.33%) and myxopapillary ependymoma in 01(1.67%) patient. As observed on the Sagittal plane images, 32 (53.33%) cases in the thoracic region, 16 (26.67%) cases in the lumbar region, 04 (6.67%) cases in the cervical region and 08(13.33%) cases in junctional area (CT-01, TL-07) [Table-II]. With regard to the relative location, 48(80.00%) were dorso-lateral and 12 (20.00%) were ventral to the spinal cord or the cauda equina. The mean percentage of tumor occupying the intradural space was 83.0% (82.9±9.4%).

The mean duration of symptoms was 14.76 months (range, 2 to 60 months) and the mean postoperative follow-up period was 36.8 months (range, 12 to 96 months). Among various symptoms, the most common symptoms were lower limb pain (local or radicular) and numbness, which were observed in 54(90.00%) cases, sensory disturbance of the lower limbs in 40(66.67%) cases, motor weakness in 30(50.00%) cases and sphincter disturbance was observed in 28(46.67%) cases. Remarkable relationships were found between the symptoms and locations of a tumor. Tumors in the cervical spine were associated with pain in the neck and motor weakness in the distal upper limbs. Thoracic tumors were related to severe pain in the thoracic spine due to compression of the spinal cord by the tumor. Paresis of both lower limbs was also more related to thoracic tumors than to the lumbar ones. The chief complaints of the patients with conus medullaris and cauda equina tumors included bladder and bowel dysfunction and saddle anesthesia. In particular, pain in the lesions of the conus medullaris tended to precede a sphincter disturbance occurring in the late stage. The symptoms tended to increase during walking rather than during bed rest and sitting. All the cases symptoms improved postoperatively. The VAS score decreased in all the cases from an average of 7.67, 8.0 ±1.2 (range, 5 to 10) preoperatively to 1.2 ± 0.8 (range, 0 to 3) at the last follow-up ($p < 0.005$). The preoperative Nurick's grade was 1 in 01(1.67%) case, 2 in 10(16.67%) cases, 3 in 14(23.33%) cases, 4 in 28(46.67%) cases and 5 in 07(11.67%) cases. During the follow-up period, Nurick's grade 1 was 53(88.33%) cases, 2 in 05(8.33%) cases, 3 in 01(01.67%) case and 5 in 01(01.67%) cases. The preoperative Nurick's grade improved from 3.0 ±1.3 (range, 1 to 5) to 1.0 ± 0.0 (range, 1 to 5) at the last follow-up ($p < 0.005$) (Table-III). The preoperative symptoms measured by the VAS and the Nurick's grading system were highly associated with the percentage of the tumor occupying the intradural space. However, no statistically significant association or difference was found between the preoperative symptoms and the duration of symptoms and the location of a tumor. A remarkable improvement in symptoms i.e. 88.33% was obtained after surgery. Few complications including CSF leakage 02 (3.33%), paresthesia 02 (03.33%), bedsore 02 (03.33%) and even further neurological deterioration 01 (01.67%) also developed after surgery. Recurrence of tumor also developed in 03(05.00%) cases (Table-IV).

Table-I

Nurick's functional grading

Grade	Description
1	Normal walk, possible clinical spinal irritation
2	Slight difficulty in walking with normal domestic and working life
3	Functional disability limiting normal work and domestic activities
4	Significant weakness making walking impossible without help
5	Bedridden or wheelchair bound

Table-II

Demographic data of Intradural Extramedullary Spinal Tumors (n=60)

Tumor Type		Total	Sex		Age			Location			
		No	Male	Female	<40yrs	40-60yrs	>60yrs	Cervical	Dorsal	Lumbar	Junctional
Intra-dural Extra-Medul-lary (IDEM)	Schwannoma	35 (58.33%)	18 (30.00 %)	17 (28.33 %)	13 (21.67%)	15 (25.00%)	07 (11.67%)	02 (3.33%)	16 (26.67%)	13 (21.67%)	04 (6.67%)
	Meningiomas	14 (23.33%)	05 (8.33%)	09 (15.00 %)	04 (6.67%)	06 (10.00%)	04 (6.67%)	00 (0.00%)	13 (21.67%)	00 (0.00%)	01 (1.67%)
	Neurofibroma	04 (6.67%)	03 (5.00 %)	01 (1.67%)	01 (1.67%)	03 (5.00%)	00 (0.00%)	02 (3.33%)	01 (1.67%)	01 (1.67%)	00 (0.00%)
	ArachnoidCyst	03 (5.00 %)	03 (5.00%)	00 (0.00%)	02 (3.33%)	01 (1.67%)	00 (0.00%)	00 (0.00%)	01 (1.67%)	00 (0.00%)	02 (3.33%)
	Myxopapillary Ependymoma	03 (5.00 %)	02 (3.33%)	01 (1.67%)	02 (3.33%)	01 (1.67%)	00 (0.00%)	00 (0.00%)	01 (1.67%)	01 (1.67%)	01 (1.67%)
	Paraganglioma	01 (1.67%)	01 (1.67%)	00 (0.00%)	01 (1.67%)	00 (0.00%)	00 (0.00%)	00 (0.00%)	00 (0.00%)	01 (1.67%)	00 (0.00%)
Total		60	32 (53.33%	28 (46.67%)	23 (38.33%)	26 (43.33%)	11 (18.33%)	04 (6.67%)	32 (53.33%)	16 (26.67%)	08 (13.33%)

Table-III

Clinical Improvement (n=60)

		Pr eoperative	Last follow up	P -Value
VAS		8.0 ± 1.2 (range, 7 to 10)	1.2 ± 0.8 (range, 0 to 3)	0.003
Nurick`s Grad e	1	01 (01.67 %)	53 (88.33 %)	
	2	10 (16.6 7%)	05 (8.3 3%)	
	3	14 (23.33 %)	01 (01.67 %)	
	4	28 (46.67 %)	00 (00 .00 %)	
	5	07 (11.67 %)	01 (01.6 7%)	
Nurick`s Grade	Mean	3.0 ± 1.3	1.0 ± 0.0	0.005

Table-IV

Complication of Surgery.

Complications	No	Percentage
CSF leakage	02	03.33
Bed Sore	02	03.33
Paresthesia	02	03.33
Recurrence	03	05.00
Neurological deterioration	01	01.67
Total	10	16.66

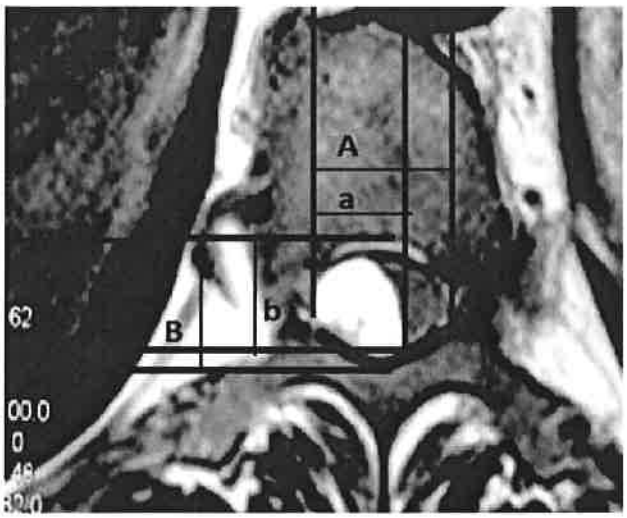

Fig-1: *This picture shows how to calculate the percentage of tumor occupying the intradural space on an axial MRI film. It is as follows: {(a + b) / (A + B)} × 100. A: transverse diameter of the intradural space, B: longitudinal diameter of the intradural space, a: transverse diameter of the tumor mass, b: longitudinal diameter of the space, a: transverse diameter of the tumor mass, b: longitudinal diameter of the tumor mass.*

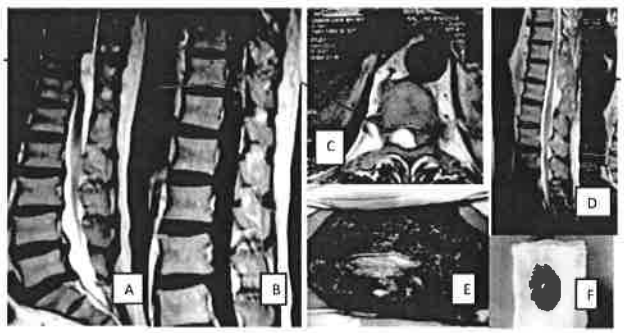

Fig-2: *Schwannoma: (A) The T2 weighted image shows irregular and higher signal intensity than that of the CSF. (B) The contrast-enhanced MR often shows an irregular margin and ring-shape enhancement. (C) Axial view. (D)Post Operative follow up MRI (E) and (F) Per operative picture and excised tumour.*

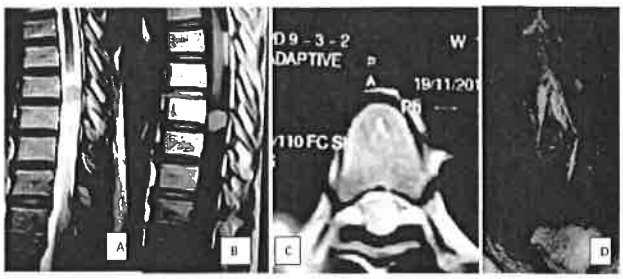

Fig-3: *Meningioma at D9/10 (A) the T2 weighted images show slightly lower intense than that of the cord and this is a homogenous lesion. (B) Contrast-enhanced MR shows high homogenous signal intensity of tumor. (C) Axial T2 weighted images. (D) Per operative picture.*

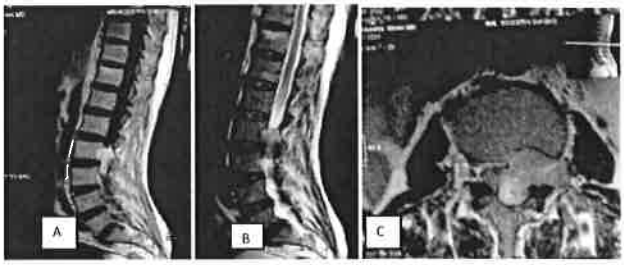

Fig-4: *Ependymoma at L2-S1 (A),(B) The T1 weighted image shows signal intensity that is similar to the spinal cord. (B) The T2 weighted image shows higher signal intensity than that of the spinal cord. (C) Axial section shows a well defined margin and regular intensity lesion and vertebral scalloping effect*

Discussion:

The incidence of IESCT is 0.3 out of 100,000, with no gender preferences. More than 50% of these are found in the thoracic spine, and 22% and 18% in the cervical and lumbosacral spine respectively.[15] Histopathological diagnoses include schwannoma in 23-48%, meningiomas in 9.6-35%, neurofibroma in 4-23%, and metastatic tumors in 6.4-25%.[15,16] The demographics in this series are similar to those in previous studies.[4,10] We found that schwannomas affected male patients, meningiomas are women predominant (15.00%), who tend to be older than patients with schwannomas or ependymomas. Patients with myxopapillary ependymomas were younger than patients with schwannomas[17]

As a historical note, Sir Victor Horsley (1857-1916) in 1887, performed successful resection of an IESCT in the thoracic region 44 years before the invention of myelography.[18] Thereafter remarkable improvements in

the diagnosis and surgical treatment has occurred but the basic surgical principles have not been changed.[19,20] Many IESCTs are treated primarily with an aggressive surgical excision because they are benign and can be separated easily from the spinal cord due to the development of microsurgical and neuroanesthesia techniques[21-24]. In this study, most of the 56 IESCTs were surrounded by a capsule with a well-defined margin and could be easily dissected. During the procedure, posterior lumbar interbody fusion and instrumentation were also performed in 02 cases where the tumours were so large to cause posterior instability. We also experienced no difficulties in removing cervical and thoracic tumors ventral to the spinal cord and so we thought extreme lateral or anterior approaches were not necessary. For the removal of a cervical tumour, we cut the paired denticulate ligaments superior and inferior to the tumour to promote mobility of the spinal cord[25]. Klekamp and Samii[26] reported favorable surgical outcome when the interval from the diagnosis to surgery was short.

Schwannomas are nerve sheath tumors that arise from the dorsal nerve root (DNR), considered benign tumors, presents usually in the 4th-6th decades. Although mostly solitary, rare (2.5%) malignant variety (i.e., malignant schwannoma), carries poor prognosis.[27] Reported frequencies among IESCT vary from 43-67% (58.33% in this series)[4,10,18,28]. These tend to produce localized pain, rediculopathy and cauda equina syndrome. There is an increased incidence in patients with neurofibromatosis type II (NF2). In this study, schwannomas were the only group of tumours without predominant location of occurrence. Surgery is usually curative and no adjuvant therapy is recommended. Stereotactic radio surgery is an option for poor surgical candidates[29]. Most authors have emphasized that the preservation of nerve roots compromises achieving complete tumour removal[30,31]. yet according to Kim[32] only 23% of the complete excisions with functionally important nerve roots resulted in the development of neurological symptoms (not severe ones) because the nerve roots involved in the tumours had already become dysfunctional. In this study, nerve fibers were found traveling distally through the tumour mass in 3 out of 35 schwannomas, so intralesional excision was performed. The nerve fibers with no identified distal ends were removed with the tumour mass by marginal resection in 5 cases. No deterioration of the neurological function was observed on the neurological examination that was performed immediately after surgery. Because the Nurick's grade improved to 1 in all the cases at the last follow-up, the nerve fibers with no identified distal end were deemed dysfunctional. Based on the observation of only 3 tumour recurrence on MRI, we believed that the preservation of nerve roots during tumour resection did not affect the recurrence of tumour.

Meningiomas (25-46% of all primary intraspinal neoplasm) are dural-based tumors that arise from arachnoid cap cells and consequently can be found in any location where dura is present but only 7.5-12.5% from spinal dura[33]. Overall, 15% are in the cervical spine, 81% in the thoracic spine (92.82% in this series), and 4% in the lumbar spine[34-37]. In men, spinal cord meningiomas are equally distributed between the cervical and thoracic cord. Most are slow-growing low-grade tumors (WHO grade 1). Genetic predisposition (NF2) and prior exposure to ionizing radiation are the only definite risk factors. Common presenting symptoms include back pain (70%), motor dysfunction (60%), sensory disturbance (40%), and incontinence (40%)[33,36,37]. In this study, 13 of 14 meningiomas were found in the thoracic vertebra and 09 were female. By imaging, these appear solid, well circumscribed with an attachment to the dura[38]. When treatment is indicated, surgery is the primary modality and can be curative with complete resection (5- and 10-year recurrence rates 3% and 6%, respectively)[36,37] With regard to the treatment of the dural attachment of a meningiomas, there are three common procedures: 1) some portion of the dura mater is resected with the tumor to remove any residual tumor cells and then duraplasty is performed, 2) some of the internal dura mater is peeled off and the rest of it is sutured, or 3) the dural attachment is cauterized[39]. In this study, the closures were performed without additional procedures because all the tumors were easily separated from the dura mater and no recurrence was observed at the last follow-up. In this series, patients with meningiomas were older than other tumour types and they were more common in females (64.28%), presumably due to female hormonal influence[33]. Consistent with previous report, we found these to be more aggressive in younger patients[4].

Myxopapillary ependymoma constitute 4.76% of IESCT in this study and men and women ratio 2: 1, another series reported twice as many men as women.17 In this series mean age of the ependymoma group was lower than the mean age of patients with meningioma or schwannoma. Symptomatically, ependymomas tended to produce cauda equina syndrome, localized pain and radiculopathy.

With regard to the factors that influence the prognosis, the longer the preoperative duration of symptoms was, the severer the neurological deficits were, 5 the more proximal the location of a tumor was18 and the more ventral the tumor was to the spinal cord, the worse the surgical outcome was[9]. In this study, the degree of preoperative neurological symptoms was not associated with the duration of symptoms, the location of a tumor or the relative location of a tumor to the spinal cord. Neurological symptoms improved postoperatively in most of the cases, but partial improvements and deterioration were also observed in some cases. The preoperative Nurick's grade was 1 in 01 case, 2 in 10 cases, 3 in 14 cases, 4 in 28 cases and 5 in 7 cases. During the postoperative follow-up period, Nurick's grade 1 was 53 (88.33%) cases, 2 in 5 (8.33%) cases, 3 in 01 (01.67%) case , 4 in 00 (00%) case and 5 in 01 (01.67%) cases. The VAS score was reduced in all cases from 7.67 to1.14 8.0 ± 1.2 to 1.2 ± 0.8 ($p = 0.003$) and the Nurick's grade was improved in all cases from 3.5 to 1.16 3.0 ± 1.3 to 1.0 ± 0.0 ($p = 0.005$) (Table III). The preoperative neurological deficits improved within 8 postoperative weeks in most cases and within 1 year in all cases.

However, the preoperative neurological symptoms measured by the VAS and the Nurick's grading system were significantly related with the percentage of tumor occupying the intradural space. However, considering that the tumors of Nurick grade 4 and over were all observed in the thoracic region, this above mentioned correlation may be a consequence of statistical error due to the small patient population of our study. In addition, we thought that surgical intervention should be recommended for all IESCT tumors regardless of the prognostic factors because the Nurick's grade improved to 1 postoperatively for almost all the cases in our study regardless of the prognostic factors.

According to el-Mahdy18 the postoperative recurrence rate of IESCT was 16% and Asazuma30 reported 46% of recurrence masses were IESCT tumors which recur more than other intraspinal tumors. They also reported that the ventral location of a tumor, extradural invasion, neurogenic tumors and ependymomas were the risk factors for recurrence. According to the study on the treatment of ependymomas by Klekamp and Samii, 26 the recurrence rate was 29.5% at 5 years after complete resection, and this rate was higher than that of other tumors. We believed incomplete removal of the dura mater, which is the origin of the tumor, caused the high rate of recurrence of meningioma. In this study, the recurrence rate was found to be 5.00%. However, it is our understanding that our obtained recurrence rate is not reliable because the mean follow-up period (36.8 months) was too short and various pathological diagnoses were included.

With regard to the postoperative complications, cerebrospinal fluid (CSF) leakage was observed in 2 patients and parasthesia in another 2 patients and bedsore in two patients. The former was resolved with the placement of a temporary lumbar drain. The latter, although improved slightly after ≥6 postoperative months, was still present. 1 case of myxopapillary ependymoma and 2 cases of schwannoma recur and 1 case of schwannoma detoriate neurologically.

Conclusion:

Early recognition of the symptoms and signs of intradural spinal tumours facilitates early diagnostic evaluation and treatment. Intradural extramedullary tumors, which are detected by MRI and tend to be histopathologically benign, can be separated completely from the spinal cord without difficulty by surgery. In addition, good treatment outcomes and prognoses can be expected after surgical removal of IESCTs. Therefore, aggressive surgical approaches for the treatment of intradural extramedullary tumours by orthopedic spine surgeons are recommended

References:

01. Chamberlain MC, Tredway TL. Adult Primary Intradural Spinal Cord Tumors: A Review. Curr Neurol Neurosci Rep. 2011:11:320-28.

02. Jha AN, Kumar P, Niranjan A. Intraspinal Tumours. In: Ramani PS, editor. Textbook of Spinal Surgery. New Delhi, India. Jaypee Brothers: 2005; vol 1:268-78.

03. Traul DE, Shaffrey ME, Schiff D. Part I: Spinal-cord neoplasms—intradural neoplasms. Lancet Oncol 2007; 8: 35-45.

04. Hufana V, Tan JSH, Tan KK. Microsurgical treatment for spinal tumours. Singapore med J. 2005; 46:18-24.

05. Albanese V, Platania N. Spinal intradural extramedullary tumors: personal experience. J Neurosurg Sci. 2002; 46(1):18-24.

06. S Stawicki, J Guarnaschelli. Intradural Extramedullary Spinal Cord Tumors: A Retrospective Study of Tumor Types, Locations, and Surgical Outcomes. The Internet Journal of Neurosurgery. 2006 Volume 4 Number 2

07. Peker S, Cerci A, Ozgen S, Isik N, Kalelioglu M, Pamir MN. Spinal meningiomas: evaluation of 41 patients. J Neurosurg Sci. 2005; 49: 7-11.

08. Prevedello DM, Koerbel A, Tatsui CE, et al. Prognostic factors in the treatment of the intradural extramedullary tumors: a study of 44 cases. Arq Neuropsiquiatr. 2003; 61(2A):241-47.

09. Slinko EI, Al-Qashqish II. Intradural ventral and ventrolateral tumors of the spinal cord: surgical treatment and results. Neurosurg Focus. 2004; 17(1):ECP2.

10. Guyatt GH, Townsend M, Berman LB, Keller JL. A comparison of Likert and visual analogue scales for measuring change in function. J Chronic Dis. 1987; 40:1129-33.

11. Nurick S. The natural history and the results of surgical treatment of the spinal cord disorder associated with cervical spondylosis. Brain. 1972; 95(1):101-8.

12. Cohen-Gadol AA, Zikel OM, Koch CA, Scheithauer BW, Karauss WE. Spinal Meningiomas in patients younger than 50 years of age: a 20 year experience. J Neurosurg. 2003;98:258-66.

13. Song KW, Shin S-II, Lee JY, Kim GL, Hyun YS, Park DY. Surgical Results of Intradural Extramedullary Tumors. Clinics in Orthopedic Surgery 2009; 1(2):78-80.

14. Ahn DK, Park HS, Choi DJ, Kim KS, Kim TW, Park SY. Surgery for Spinal Intradural Extramedullary Tumours. Clinics in Orthopedic Surgery 2009; 1(3):165-72.

15. Nittner K. Spinal meningiomas, neurinomas, and neurofibroma-hourglass tumors. In: Vinken PJ, Bruyn GW, editors. Handbook of clinical neurology. Vol.20. Amsterdam: North-Holland Publishing Co; 1976. 177-322.

16. Cheng MK. Spinal cord tumors in the People's Republic of China: a statistical review. Neurosurgery. 1982; 10(1):22-24.

17. Wippold FJ, Smirniotopoulos JG, Moran CJ, Suojanen JN, Vollmer DG. MR imaging of myxopapillary ependymoma: findings and value to determine extent of tumor and its relation to intraspinal structures. AJR AM J Roentgenol. 1995;165:1263-67.

18. el-Mahdy W, Kane PJ, Powell MP, Crockard HA. Spinal intradural tumours: Part I Extramedullary. Br J Neurosurg.1999; 13(6):550-57.

19. Tredway TL, Santiago P, Hrubes MR, Song JK, Christie SD, Fessler RG. Minimally invasive resection of intradural extramedullary spinal neoplasms. Neurosurgery 2006; 58(1Suppl):ONS52-8

20. Spinal Cord Tumours -Management of Intradural Intramedullary Neoplasm-Medscape References. emedicine.medscape.com/article/249306-overview july10, 2013.

21. Cohen AR, Wisoff JH, Allen JC, Epstein F. Malignant astrocytoma of the spinal cord. J Neurosurg. 1989; 70(1):50-54.

22. Cooper PR, Epstein F. Radical resection of intramedullary spinal cord tumors in adults: recent experience in 29 patients. J Neurosurg.1985; 63(4):492-99.

23. Cristante L, Herrmann HD. Surgical management of intramedullary spinal cord tumors: functional outcome and sources of morbidity. Neurosurgery 1994; 35(1):69-74.

24. Samii M, Klekamp J. Surgical results of 100 intramedullary tumors in relation to accompanying syringomyelia. Neurosurgery 1994; 35(5):865-73.

25. Rezai AR, Woo HH, Lee M, Cohen H, Zagzag D, Epstein FJ. Disseminated ependymomas of the central nervous system. J Neurosurg. 1996; 85(4):618-24.

26. Klekamp J, Samii M. Surgical results for spinal meningiomas. Surg Neurol. 1999; 52(6):552-62.

27. Fromme K, Miltner FO, Klawki P, Friedrich M. Spinal cord monitoring during intraspinal extramedullary tumor operations (perineal nerve evoked response). Neurosurg Rev.1990; 13:195-99.

28. Garrido P, Laher-Mooncey S, Murphree NL, Jonker N, Levy LF, Makarawo S. Neoplasms involving the spinal cord in Zimbabweans: an analysis of 262 cases. Cent Afr J Med.1994; 40:201-04.

29. Gerszten PC, Burton SA, Ozhasoglu C, et al. Radio surgery for benign intradural spinal tumors. Neurosurgery 2008; 62:887–95. Discussion 895-96.

30. Asazuma T, Toyama Y, Watanabe M, Suzuki N, Fujimura Y, Hirabayashi K. Clinical features associated with recurrence of tumours of the spinal cord and cauda equina. Spinal Cord 2003; 41(2):85-89.

31. Parsa AT, Lee J, Parney IF, Weinstein P, McCormick PC, Ames C. Spinal cord and intradural extra-parenchymal spinal tumors: current best care practices and strategies. J Neurooncol. 2004; 69(1-3):291-318.

32. Kim P, Ebersold MJ, Onofrio BM, Quast LM. Surgery of spinal nerve schwannoma: risk of neurological deficit after resection of involved root. J Neurosurg. 1989; 71(6):810-4.

33. Solero CL, Fornari M, Giombini S, et al. Spinal meningiomas: review of 174 operated cases. Neurosurgery 1989; 25(2):153-60.

34. Gelabert-Gonzalez M, Garcia-Allut A, Martinez-Rumbo R. Spinal meningiomas. Neurocirugia (Astur). 2006; 17(2):125-131.

35. Gelabert-Gonzalez M. Primary spinal cord tumors. An analysis of a series of 168 patients. Rev Neurol. 2007; 44:269-74.

36. Gezen F, Kahraman S, Canakci Z, Beduk A. Review of 36 cases of spinal cord meningioma. Spine (Phila Pa 1976). 2000; 25:727-31.

36. Peker S, Cerci A, Ozgen S, et al. Spinal meningiomas: evaluation of 41 patients. J Neurosurg Sci. 2005; 49: 7–11.

37. Abul-Kasim K, Thurnher MM, McKeever P, Sundgren PC. Intradural spinal tumors: Current classification and MRI features. Neuroradiology 2008; 50:301-14.