Intramedullary Spinal Cord Tumors (IMSCTs): Outcome after surgical resection in 35 cases and review of literature

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ABSTRACT

BACKGROUND

Intramedullary Spinal Cord Tumors (IMSCTs) are rare and they represent only 5% of all spinal tumors. Ependymoma and astrocytoma are two most common IMSCTs. Due to recent advances in micro instruments, imaging and technology, aggressive surgical excision has become a safer possibility with better outcome. Aim of this study is to analyze functional outcome of patients after surgical resection of IMSCTs and review of literature.

METHODOLOGY

Over a period of 4 years, between May 2017 and January 2021, 35 patients were operated for IMSCTs under general anesthesia. Neurophysiological monitoring (NPM) was recently available and used only in last few cases. CUSA was used whenever required in these microsurgical procedures. This retrospective study was carried out after retrieving data from OT registers, inpatient files, OPD records, and statistical analysis was executed using SPSS software (version 18). Functional outcome was assessed by McCormick grading scale and mean follow up period was 2.5 years.

RESULTS

Out of 35 patients, 17 were male and 18 female. Mean age distribution was 27.57(+/-17.68). On admission, 30 patients had motor deficits, 18 had neck or back pain, 10 had sphincter dysfunction, 7 had kyphoscoliosis and 2 patients had normal neurology. MRI with IV contrast of these 35 patients revealed intramedullary lesions at cervical (11), cervicomedullary (4), thoracic (8), cervicothoracic (2), thoracolumbar (3), conus (6) and lumbar (1) regions. 22 patients had gross total and 13 had subtotal resection. Histological examination confirmed 30 glial tumors (ependymoma & astrocytoma), 2 dermoid/ epidermoid, 2 neurenteric cysts and 1 secondary. Postoperative complication was 17% and there was no surgery related 30 days' mortality. Functional outcome was measured by McCormick grade before and after microsurgical resection. Preoperatively 3(8.5%) patients had low grade or independent and 32 (91.4%) had high grade or dependent. Postoperatively and at the time of discharge 14 (40%) of patients had low grade or independent and 21 (60%) were dependent or high grade. On last followed up (4 years) 15 (48.3%) had low grade and 16 (51.6%) had high grade or dependent. In our series, on followed up of 4 years, recurrence rate was 5(14.2%), They were 2 astrocytoma, 1 secondary, and 2 myxopapillary ependymomas. Two patients with myxopapillary ependymoma were operated twice and no radiotherapy was advocated. 8 (22.6%) patients received local radiation and recurrence rate was 17.2%.

CONCLUSION

Safe resection of intramedullary lesion is possible with the aid of modern neurosurgical tools, however, functional outcome relies on preoperative neurological status of the patients, extent of excision and histology of tumor. Risk factors for recurrence of IMSCTS are extent of resection and histological behavior of tumor.

Keywords: Intramedullary spinal cord tumor; surgical resection; outcome

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INTRODUCTION

Only 5% of spinal tumors represent intramedullary spinal cord tumors (IMSCTs) and a majority of them are glial tumors, either ependymoma or astrocytoma [1]. Other rare intramedullary spinal tumors are dermoid/epidermoid, neurenteric cyst, hemangioblastomas, lymphoma, gangliogioma and mets [2].

Surgical resection is the best treatment option for IMSCTs since a majority of them are benign lesions and curable [3].

Cushing is given for the first successful removal of intramedullary ependymoma in 190512, however, Elsburg in 1925 published his first paper describing surgical technique, pathophysiology, classification, diagnosis, and management of spinal cord tumor13.

There was no remarkable progress in spinal cord tumor surgery for 4 decades since Elsburg's work, until Greenwood published a large series of successful removal of intramedullary tumors [4].

Rapid advances in neuroimaging, micro instruments, and microsurgical techniques, aggressive surgical resection of intramedullary tumors has become a safe possibility with acceptable results [5].

MATERIALS AND METHODS

This is a retrospective study of 35 patients who underwent surgical excision for IMSCTs over a period of 4 years between May 20017 and January 2021 in our institute. All the surgical procedures were mostly carried out by single senior neurosurgeon (GRS). After the clinical evaluation and making a provisional diagnosis of spinal pathologies all these patients were subjected for MRI of the spine with Gadolinium IV contrast (fig.1a, b & c).

After having study approval from IRB retrospective data were acquired from inpatient, operation theatre and outpatient records and analyzed applying SPSS software (Version18).

All surgeries were performed utilizing operating microscope, micro instruments, CUSA, USG and ICG Videography whenever required. Intra operative NPM were used only in last 6 cases.

Preoperative and postoperative functional neurological assessment was carried out using McCormick's grade and it was dichotomized into low grade or independent (1,2,3) and high grade or dependent (4,5) to analyze and interpretate data with ease.

We routinely recommend postoperative MRI with contrast in three months or earlier if necessary (fig.3a, b & c).

Mean followed up period was 2.5 years

Surgical procedures:

After general anesthesia electrodes of NPM are established. Patient is put in prone position and spinal level is confirmed by fluoroscope. Midline skin incision is made at the desired levels of spine. After incising skin and subcutaneous tissues, fascia is incised in the midline, and then subperiosteal dissection of paraspinal muscles is carried out in both sides exposing spinous processes, laminae, interlaminar spaces, and facet joints. I usually prefer laminotomy in children (to prevent kyphosis/scoliosis) and laminectomy in adults (less likely to have spinal deformities). Under the operating microscope midline dural opening is made exposing arachnoid and cord. While opening the dura I always try to keep the arachnoid intact. After hitching dural edges to muscles in both sides, midline opening of arachnoid layer is performed exposing dorsal pial surface of cord. A midline myelotomy is carried out along the median sulcus from rostral to caudal or caudal to rostral end of the tumor(fig.2a). Pial hitches are applied using 4.0 or 5.0 prolene suture and fixed them with inner surface of dura (fig.2b). After debulking the tumor, separation of tumor capsule from cord parenchyma is possible if there is clear cut cleavage between tumor and cord (fig.2c). Separation of capsule can be started from either end of tumor. Majority of ependymomas, hemangioblastomas, and neurenteric cysts have cleavage between lesion and cord parenchyma whereas in astrocytoma and dermoid/epidermoid clearcut cleavage may not be found. Some of the glial tumors (ependymoma and astrocytoma) have cystic cavities in both ends of the tumor, in that scenario separation of tumor from cord parenchyma is more possible. Often use of CUSA is useful to debulk tumor mass. During surgery we have to check SSEP and MEP regularly and if evoked potential goes down during tumor excision we have to stop and change course of procedure to prevent further neurological deficit. After excision of the tumor I do hemostasis using surgicel and I hardly use bipolar coagulation (fig.2d). I do not close pia and arachnoid layers (some neurosurgeons routinely do it for anatomical proximity however I do not find any benefit). Watertight dural closure is mandatory and I often use fibrin glue over outer surface of dura after its closure. Then wound is closed in anatomical layers. This is a classical surgical technique for IMSCTs however this classical technique may not be applicable in some tumors like hemangioblastoma where tumor should be removed in a single piece. Similarly, there is no need of midline myelotomy in conus lesions like myxopapillary ependymomas, dermoid/epidermoid.

Adjuvant Therapy:

All sub totally resected astrocytoma, recurrent astrocytoma and malignant pathologies were subjected for a course of local spinal radiation therapy.

No patient in our series received chemotherapy.

Follow up:

All the patients were followed up in one week, one month, 6 months, and each year in OPD.

Follow up imaging was advised in 3 months and in one year as a routine, but anytime, if there is deteriorated neurology after surgical intervention.

RESULTS

Out of 35 patients who harbored IMSCTs, there were 17 male and 18 female and mean age was 27.57(+/-17.68) (Table1). On admission, 30 patients had motor deficits, 18 had neck pain or back pain, 10 had sphincters dysfunction, 7 had kyphoscoliosis and two had normal neurology (Table.2). MRI with IV contrast of these 35 patients revealed intramedullary lesions at cervical (11), cervicomedullary (4), thoracic (8), cervicothoracic (2), thoracolumbar (3), conus (6) and lumbar (1) regions. Other associated features on MRI were syrinx in 17 (51.4%), polar cyst formation in13 (37.4%) and kyphoscoliosis in 5 (14.2%) (Table.2).

22 patients had gross total and 13 had subtotal resection. Histological examination confirmed 30 glial tumors (ependymoma, astrocytoma), 2 dermoid/epidermoid, 2 neurenteric cyst and 1 secondary (Table.3). 6(17%) patients suffered postoperative complications and common complications were CSF leak (2), wound infection/ dehiscence (3), and chest infection (1) (Table.4). There was no 30 days' surgery related mortality however 4 patients died during followed up period of 4 years due to disease progression (Table.4).

Functional outcome was measured by McCormick grade before and after microsurgical resection of IMSCTs. Before surgery 3(8.5%) had low grade or independent and 32(91.4%) had high grade or dependent. After the resection of tumor and at the time of discharge14 (40%) of patients had low grade or independent and 21(60%) were dependent or high grade (P value 0.407) which was not statistically significant, however on last follow up (4th year) 15(48.3%) had low grade and 16(51.6%) had high grade or dependent (P value 0.011) which revealed significant neurological improvement of patients postoperatively (Table.5).

When comparing pre and post operative McCormick neurological grade of patients this study showed that patients who were used intraoperative NPM had no influence on neurological improvement than those patients who had no monitoring (odd ratio-0.18, 95%CI- 0.03 - 1.04, P value 0.056). (Table.6)

Patients who had total tumor resection (odd ratio-0.03, 95%CI – 0.00 - 0.45, P value 0.011) and having glial tumors like astrocytoma (odd ratio – 0.01,95%CI – 0.00 – 0.03, P value 0.007) and ependymoma (odd ratio – 0.06, 95%CI – 0.01 – 0.31, P value 0.001) had shown statistically significant neurological improvement on subsequent followed up. Likewise there was significant functional improvement in patients who had radiation therapy after surgery (odd ratio – 0.01,95%CI – 0.001 – 0.06, P value 0.00). (Table. 6 &7)

On last follow up there was no statistically significant difference in outcome in relation to age and sex, however variables like total excision of tumor (odd ratio – 0.01, 95%CI – 0.001-0.24, P value 0.003), astrocytoma (odd ratio-0.004, 95%CI – 0.05-0.29, P value 0.011) and ependymoma (odd ratio-0.02, 95%CI – 0.001-0.23, P value 0.002) showed statistically significant improvement on functional outcome (Table.7).

8 patients with subtotal resection of tumors and malignant pathologies underwent local spinal radiation under the supervision of oncologist.

Recurrence rate was 5(14.2%) (5) in 4 years.

Safe resection of intramedullary tumor is possible in more than 50% of cases with the aid of modern neurosurgical technologies; however, postoperative functional outcome is mainly dictated by the preoperative neurological status of the patients, extent of resection and histological character of tumors.

Risk factors for recurrence are extent of tumor excision and adverse histological character of tumor.

DISCUSSION

Only 5% of spinal tumors represent intramedullary spinal cord tumors (IMSCTs) and most of them are glial tumors either ependymoma or astrocytoma [1]. Ependymomas are more common in adults whereas astrocytomas in children and adolescents [6]. Other rare IMSCTs are dermoid/ epidermoid, neurenteric cysts, hemangioblastomas, mets, germ cell tumors, CNS lymphomas, and gangliogliomas [2].

Most common presentation of IMSCTs is back or neck pain. Spinal cord and nerve root compression can produce motor weakness, spasticity, sensory deficits, and sphincter dysfunction 1. Centrally located lesion can produce myelopathic symptoms 9,11,30. Long standing IMSCTs in children and adolescents can develop kyphoscoliosis [7].

In our series, 85% patients presented with some degree of focal neurological deficit, 50% had neck or back pain, 28% had bowel and bladder involvement, and 20% children with IMSCTs presented with kyphoscoliosis and these findings are similar to previously published series and is more frequently present in children and adults with long standing pathology [7]. Final diagnostic tool for IMSCTs is MRI with Gadolinium IV contrast. Syrinx is one of the common associated radiological findings in IMSCTs. The ncidence ranged from 25-58% [8] and 48.6% had syrinx on MRI in our series which are mostly related to ependymoma

and astrocytoma. A syrinx was more likely to be found above (49%) than below (11%) the tumor level. In 40%, a syrinx could be identified above and below the tumor level [9]. Polar cyst formation was found in 37.2% of IMSCTs on MRI of spine of our patients and Goy has mentioned 20% cyst formation in his series19. IMSCTs usually involve cervical and thoracic spinal cord and may involve one to multiple segments and rarely the whole spinal cord35. Ependymoma and astrocytoma are usually found in cervical and thoracic spines, these lesions rarely may extend to the brain stem involving cranial nerves [10]. Myxopapillary ependymoma is the tumor of conus medullaris and filum region [11]. Dermoid/epidermoid usually involves conus and queda equina [12] and hemangioblastoma, lymphoma, ganglioglioma, melanoma, mets, may occur anywhere in the spine.

In our series, more than 70% of IMSCTs are present in cervical and thoracic region and 30% in thoracolumbar regions and these findings are similar with other series of IMSCTs [13]. In Kane's series, common levels were cervical (33%) followed by thoracic (26%) and lumbar (24%). In Antonino's series of 202 cases, 30% were cervical, 29% dorsal, 25% cervico dorsal and 15% conus30. Sandalcioglu described 55% cervicothoracic, 32% thoracic and 13% medullary conus in his series of IMSCTs 32.

In the past, due to high morbidity and mortality following IMSCTs surgery, many neurosurgeons were worried about an aggressive approach thus it was limited to biopy, aspiration of cysts, decompressive laminectomy, and radiotherapy as the main strategy of management18,30. In 1954, Greenwood revolutionized the management of IMSCTs after publishing his large series of IMSCTs who benefited from aggressive surgery20. These days due to advanced neuroimaging, micro instruments, and state of art technology surgery has taken the main strategy of treatment for IMSCTs 9,10,23,32.

Constantini published a series of 164 with IMSCTs, in which gross total excision was achieved in 76.8% and subtotal resection in 20% [14]. In our series gross total excision was carried out in 62.8% and subtotal excision in 37.2% and these results are comparable with Constantini's series. Similarly, in Cristante's series of 69 cases 55% were radically resected, 17.4% had gross total resection and 27.5% partially resected10. In his study of 78 cases, Sandalcioglu reveals complete removal in 65(83.3%), subtotal in 9 (11.5%) and biopsy in 4(5.2%) [15].

In this retrospective study ependymomas were the most common intramedullary tumor followed by astrocytoma and other less common intramedullary pathologies were myxopapillary ependymoma, dermoid/epidermoid, mets, and neurenteric cysts and these observations were similar to published series [16]. There were 41.4% ependymomas, 31% astrocytoma, 13.8% dermoid/epidermoid, 6.8% neurenteric cysts, 3.5% germinoma, and 3.5% secondary in our case series. Out of 12 ependymomas, 2 were myxopapillary, but no subependymoma and anaplastic ependymoma were found in our series.We had 2(6%) myxopapillary ependymoma in our series this finding is similar to Tobin's series of 618 cases where myxopapillary ependymoma were 42 (6.8%) [17]. All intramedullary astrocytoma in our series were WHO grade I and II and out of them there were 2 pilocytic astrocytoma. Our intramedullary met was adenocarcinoma which spread from the breast Ca that was operated 5 years back. Contrary to previously published series [18], there were no intramedullary lymphoma, ganglioglioma, and melanoma in our series, probably due to the small sample size.

17.2% (6) suffered postoperative complications in our series which included CSF leak (2), wound infection/dehiscence (3), and chest infection (1) and these complications are similar to complications experienced by previous neurosurgeons [18]. In Cooper's series of 51 cases 14 died after mean survival of 10 months [19]. There was no 30 days surgery related mortality however 4 patients died in 1st, 2nd and 5th year due to disease progression.

Functional outcome was measured by McCormick grade before and after microsurgical resection of IMSCTs. Before surgery 3(8.5%) had low grade or independent and 32(91.4%) had high grade or dependent. After the resection of tumor and at the time of discharge14 (40%) of patients had low grade or independent and 21(60%) were dependent or high grade (P value 0.407) which was not statistically significant, however on last follow up (4th year) 15(48.3%) patients had low grade and 16(51.6%) had high grade or dependent (P value 0.011) which confirmed significant neurological improvement on subsequent followed up. In Christante's series of 69, 17.1% improved, 55.5% unchanged and 31.5% become worse10. Similarly in Sandalcioglu's case series of 78 IMSCTs, 65.4% improved or unchanged, 34.6% worsened 32. Functional neurological recovery experienced by our patients after IMSCTS surgery looked similar to previous studies.

When comparing pre and post operative McCormick neurological grade of patients this study showed that patients who were used intraoperative NPM had no influence on neurological improvement than those patients who had no monitoring (odd ratio-0.18, 95%CI- 0.03 - 1.04, P value 0.056). Our result is just opposite of previous studies36 where patients who had under gone surgery with intraoperative NPM had better neurological outcome than patients who had no NPM. We could use NPM only in last 6 patients after it's availability and this small sample size might be a factor for this equivocal result.

Patients who had total tumor resection (odd ratio-0.03,

95%CI – 0.00 - 0.45, P value 0.011) and having glial tumors like astrocytoma (odd ratio – 0.01,95%CI – 0.00 – 0.03, P value 0.007) and ependymoma (odd ratio – 0.06, 95%CI – 0.01 – 0.31, P value 0.001) had shown statistically significant neurological improvement on subsequent followed up. Likewise there was significant functional improvement in patients who had radiation therapy after surgery (odd ratio – 0.01,95%CI – 0.001 – 0.06, P value 0.00).

On last follow up there was no statistically significant difference in outcome in relation to age and sex, however variables like total excision of tumor (odd ratio – 0.01, 95%CI – 0.001-0.24, P value 0.003), tumors histologically diagnosed as ependymoma (odd ratio- 0.02, 95%CI – 0.001-0.023, P value 0.002) and astrocytoma (odd ratio-0.004, 95%CI -0.05-0.29, P value 0.011) showed statistically significant improvement in functional outcome on subsequent followed ups. Previous studies have also shown that gross total resection of glial tumors had better outcome as in ours [18]. Radiotherapy after subtotal excision or biopsy of IMSCTs may produce better functional outcome and may reduce disease progression and recurrence rate for some duration. As mentioned in literature, radiotherapy should be recommended in those patients who have malignant pathologies, sub totally resected tumor and recurrence [20]. In our series 8 (22.8%) patients were advised for local spine radiation who had malignant tumor and recurrence of tumor. There is little role of chemotherapy in intramedullary tumors, but anaplastic ependymoma, germinoma, lymphoma, and malignant astrocytoma in children and perhaps in adult may benefit from a course of chemotherapy [21].

In our series, on followed up of 4 years, recurrence rate was 5(14.2%), They were 2 astrocytoma, 1secondaries, and 2 myxopapillary ependymomas. Two patients with myxopapillary ependymoma were operated twice and no radiotherapy was advocated. Previous experiences have shown that recurrence rate depends on extent of excision and histological character of tumors [22]. Astrocytoma and secondaries tend to reoccur earlier than other tumors.

CONCLUSION

Safe resection of intramedullary tumor is possible in more than 50% of cases with the aid of modern neurosurgical technologies; however, postoperative functional outcome is mainly dictated by the preoperative neurological status of the patients, extent of resection and histological character of tumors.

Intraoperative NPM did not influence the post operative functional outcome of patients.

Risk factors for recurrence are extent of resection and histological characters of tumors.

DISCLOSURE

The authors report no conflict of interest.

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Table1: Overall Demographic features in 35 patients operated for IMSCTs

Variable	Freq.(Percent)	P value
Numbers of IMSCT	35	
Age		
Median age		
age <18	10(28.57%)	
18-28	11(31.43%)	
29-38	4 (11.43%)	
39-48	5(14.29%)	
49-58	3(8.57%)	
59+	2(5.71%)	
Age category 18		**0.271**
age<18	10 (28.57%)	
age>=18	25 (71.43%)	
Age category 40		**0.487**
age<40	25 (71.43%)	
age>=40	10 (28.57%)	
Mean age Distribution	27.57 + / - 17.68	
Sex		**0.507**
Sex, Male	17 (48.57%)	
Sex, Female	18 (51.43%)	
Sex ratio (Male/ Female)	0.944	

Table 2: Clinical and Radiological Characteristics of 35 patients who under gone surgery for IMSCTS

Neck pain/Back pain		
No	3(8.57%)	
yes	32(91.43%)	
Kyphosis		
No	32(91.43%)	
yes	3(8.57%)	
Scoliosis		
No	32(91.43%)	
yes	3(8.57%	
Malignancies		
No	34(97.14%)	
yes	1(2.86%)	
Spinal level		
Cervical	11(31.43%)	
Cervicomedullary	4(11.43%)	
Thoracic	8(22.86%)	
Conus	6(17.14%)	
Thoracolumbar	4(11.43%)	
Cervicothoracic	2(5.71%)	
Syrinx		
No	18(51.43%)	
Yes	17(48.57%)	
Cyst formation		
No	22(62.86%)	
yes	13(37.14%)	

Table 3: Intraoperative NPM, surgical treatment of 35 patients and histological characters of IMST Tumors

Intraoperative use of NPM		**0.056**
No	29 (82.86%)	
Yes	6 (17.14%)	
Surgery subtotal excision		0.011
No	22 (62.86%)	
Yes	13 (37.14%)	
Histology		
Adenocarcinoma	1(2.86 %)	
Astrocytoma	13(37.14 %)	0.007
Ependymomas	13(37.14 %)	
Epidermoid	**2(5.71%)**	
Myxopapillary ependymomas	4(11.43%)	
Neurenteric cyst	2(5.71%)	

Glial tumor		0.086
No	5 (14.29%)	
Yes	30 (85.71%)	

Table. 4: Postoperative complications and mortality of 35 patients operated for IMSCTS

Post operative complications	
CSF leak from wound	2(5.71%)
Chest infection	1(2.86%)
Wound dehiscence	3(8.57%)
None	29(82.86%)
Mortality (in 4 years' duration)	4 (11.43%)

Table 5: Pre-operative and post -operative Neurological status of 35 patients under gone surgery for IMSCTS using McCormick grade (Normal activities - grade1,2,3 & Disabled – grade 4, 5)

Preoperative neurology status (McCormick grade)		
Disabled (dependent)	32 (91.43%)	
Normal activities (independent)	3 (8.57%)	
Postoperative neurology status (McCormick grade)		**0.407**
Disabled (dependent)	21 (60%)	
Normal activities (independent)	14 (40%)	
Neurology on last follow up (McCormick grade)		**0.011**
Disabled (dependent)	16 (51.61%)	
Normal activities (independent)	15 (48.39%)	

Table 6: Level of significance compared with Post operative functional neurology assessed by McCormick Grade.

McCormick grade postcat	Odds Ratio	Std. Err.	z	P>z	[95% Conf. Interval]	
Intraoperative use NPM	0.1837117	0.1629814	-1.91	0.056	0.0322839	1.045412
agecat40	1.585112	1.049527	0.7	0.487	0.4329788	5.80301
agecat18	0.3977348	0.3332021	-1.1	0.271	0.0770017	2.05441
Sex	0.6625976	0.4107119	-0.66	0.507	0.1966217	2.232894
Glial_tumor	12.35713	18.09341	1.72	0.086	0.7007805	217.8981
Surgery_subtotal_excision	0.0326341	0.0437253	-2.55	0.011	0.0023614	0.4509906
Radiotherapy	0.0105795	0.0097291	-4.95	0.000	0.0017445	0.0641573
Histology_Astrocytoma	0.0136441	0.0217629	-2.69	0.007	0.0005987	0.3109227
Histology_Ependymomas	0.0612481	0.0509007	-3.36	0.001	0.0120142	0.3122411

Table. 7: Level of significance compared with neurology (Mc-Cormick Grade) in last last follow up

McCormick grade	Odds Ratio	Std. Err.	z	P>z	[95% Conf. Interval]	
agecat40	1.41087	1.464362	0.33	0.74	0.1845	10.7885
agecat18	0.3360403	0.4057549	-0.9	0.366	0.0315	3.582468
Sex	0.1408193	0.171003	-1.61	0.106	0.013	1.521644
Glial_tumor	7.736009	14.91358	1.06	0.289	0.1768	338.4345
Surgery_subtotal_excision	0.015926	0.0223695	-2.95	0.003	0.001	0.24986

Radiotherapy	0.1049027	0.2191616	-1.08	0.28	0.0017	6.296625
Histology_Astrocytoma	0.0049097	0.0103012	-2.53	0.011	8E-05	0.2999057
Histology_Ependymomas	0.0207173	0.0257059	-3.12	0.002	0.0018	0.2357755
Histology_Ependymomas	0.0612481	0.0509007	-3.36	0.001	0.0120142	0.3122411

Figure.1

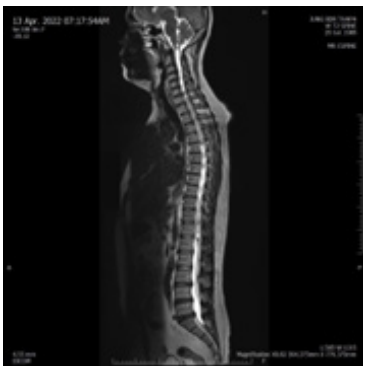


fig.1a

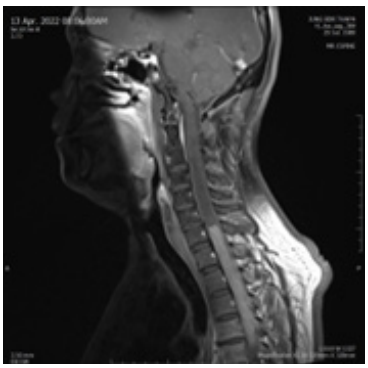


fig.1b

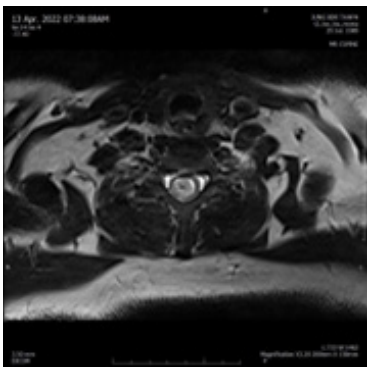


fig.1c

figure1: preoperative MRI (plain & contrast): fig.1a &b. T2 weighted with sagittal & axial section showing hypo to isointense intramedullary mass at C6 to D5 level along with cervical and dorsal syrinx; fig.1c. T1 weighed image, sagittal section with Gadolinium contrast revealed homogenous enhancement of mass, suggestive of ependymoma.

Figure.2

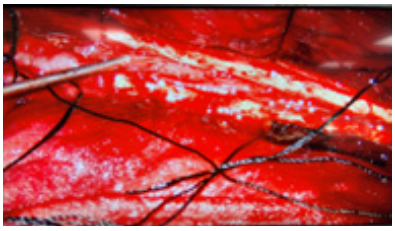


fig.2a

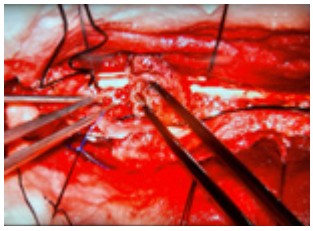


fig.2b

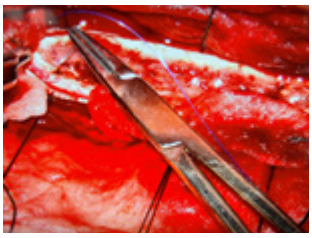


fig.2c

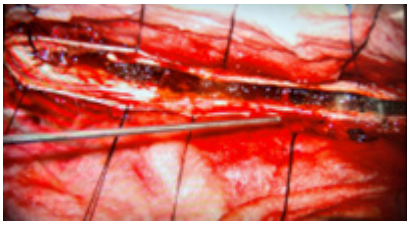
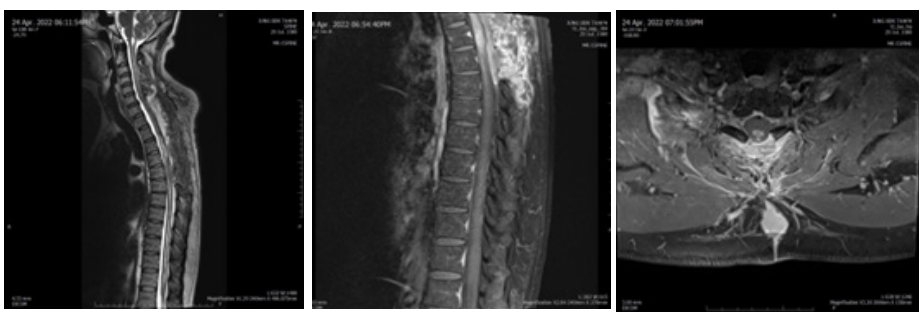


fig.2d

Figure.2: Intraoperative pictures of intramedullary tumor resection at thoracic region: fig.2a. midline myelotomy & exposure of tumor; fig.2b.applying pial hitches to widened operating space more; intramedullary mass was solid, fleshy and moderately vascular; fig.2c.showing distinct cleavage between tumor and cord parenchyma and debulking of tumor from upper pole; fig.2d. hemostatic agent surgical was applied after gross total resection of tumor.

Figure.3



Postoperative MRI of same patient: Fig.3a.b&c. plain and contrast MRI with sagittal &axial images showed myelomalacia at C6 to D5 level with some extradural collection, soft tissues edema and there is no evidence of residual mass. Sizes of both rostral & caudal syrinx have decreased.