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Analysis of Perioperative Outcomes Following Surgery for Pathological Intra Medullary Spinal Cord Tumors

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ABSTRACT

Intramedullary spinal cord tumors (IMSCTs) are rare neoplasms presenting considerable technical challenges in treatment. This study presents cases of IMSCTs, focusing on clinical presentation, histological characteristics, preoperative outcomes and long-term survival in surgically managed patients. A retrospective analysis identified patients who underwent surgery for primary IMSCTs at an Indian tertiary care center. Data on baseline neurological status, demographics, functional deficits, neuraxial location, operative details and tumor histology were collected. Preoperative outcomes included csomplications postoperative, discharge disposition, length of stay, readmission and reparation. The study comprised 45 patients (mean age 33.8±18.57 years, 57% male). Ependymomas, astrocytomas and hemangioblastomas were the most common tumors. Ependymomas and hemangioblastomas were more frequent in the cervical cord, while astrocytomas were evenly distributed between cervical and thoracic cords. Clinical presentation, functional status and short-term postoperative outcomes were generally consistent across tumor types, although thoracic cord tumors had worse American Spinal Injury Association (ASIA) grades than cervical tumors. Patients with high-grade ependymomas and astrocytomas had worse long-term survival compared to those with low-grade lesions ($p<0.05$). Neuraxial location, extent of resection and postoperative survival varied significantly among different tumor pathologies. However, preoperative outcomes did not differ significantly, indicating that operative nuances, rather than pathology, may primarily influence short-term clinical outcomes, while long-term survival is more impacted by tumor pathology.

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Key Words
Astrocytoma, ependymoma, intramedullary, oncology, spine tumor

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INTRODUCTION

Intramedullary spinal cord tumors (IMSCTs) are uncommon neoplasms, estimated to represent 2-8% of all central nervous system tumors[1–4]. Among IMSCTs, gliomas, primarily ependymomas and astrocytomas, account for about 80% of cases, with hemangioblastomas comprising the majority of the remaining 20%. Intraparenchymal spinal cord metastases are exceedingly rare, constituting less than 2% of all IMSCTs[5]. The typical clinical manifestation of IMSCT includes nonspecific back pain[6], although progressive compression of the adjacent cord parenchyma can lead to weakness, numbness, bladder and bowel dysfunction, as well as motor and sensory deficits. Diagnosis is often delayed due to the nonspecific nature of symptoms, primarily arising from mass effect[7]. Due to the rarity of IMSCTs, most studies conducted at single institutions are small in scale[6,8]. Even those utilizing multi center databases are only moderately sized and lack detailed surgical information[9]. Furthermore, given the infrequency of IMSCTs, few spine surgeons possess extensive experience in their management[5]. In this study, we present a series of patients treated for IMSCTs at an Indian tertiary care center. Our focus is on elucidating the clinical characteristics, surgical approaches and short-term outcomes of these patients. Additionally, we analyze survival rates both among and within different tumor categories based on the World Health Organization (WHO) tumor classification system.

MATERIALS AND METHODS

Medical records of all patients who underwent surgical treatment for IMSCTs at an Indian tertiary care center were retrospectively reviewed. Inclusion criteria comprised patients whose surgery aimed at resecting or biopsying a primary IMSCT and had medical records containing the specified variables. Exclusion criteria involved patients treated for metastatic IMSCT, those lacking histological confirmation of IMSCT, or those undergoing surgery primarily for diagnostic purposes with pathology indicating a nonneoplastic condition like neuroinflammatory disease. The variables collected included patient demographics, clinical presentation, tumor histology, surgical procedures, 1 month outcomes and 3 month neurological deficits. Tumor-specific data covered primary histology, WHO tumor grade (if applicable) and neuraxial location categorized as cervical, cervicothoracic, thoracic, or thoracolumbar/conus. Demographic variables encompassed age and sex. Baseline neurological status was assessed using the American Spinal Injury Association (ASIA) Impairment Scale. Additional data on back pain, bowel dysfunction, numbness, reticular pain, urinary incontinence, weakness. Operative characteristics included whether it was a revision (vs index) procedure, the use of laminectomy versus laminoplasty, type of resection and incision length. Gross-total resection (GTR) was defined as complete removal of visible tumor intra operatively, while subtotal resection (STR) indicated the presence of visible residual tumor. Analyzed outcomes encompassed length of stay (LOS), discharge disposition, 1 month readmission, 1 month reparation, 1 month complications and 3 months neurological deficits. Complications included cerebrovascular accident, death, deep vein thrombosis, delirium, dural leak, ileus, pneumonia, pulmonary embolus, urinary tract infection, wound infection and wound dehiscence. Statistical analysis was performed using Epi Info 6. Continuous variables were presented as mean±standard deviation, while categorical and ordinal data were expressed as counts and proportions. long-term survival across tumor categories and histological subtypes was compared using statistical tests.

RESULTS AND DISCUSSIONS

Initially, 63 patients were identified during the retrospective review. However, 18 patients were excluded due to various reasons such as vascular malformations (n = 5), benign masses (n = 4), lesions without definitive pathological diagnoses (n = 4), metastatic tumors (n = 2) and incomplete hospital records for intramedullary spinal cord tumors (IMSCTs) (n = 3). Therefore, the final analysis included 45 patients, with a mean age of 35.2±19.5 years (refer to Table 1). Notably, there were no significant differences in sex distribution or median follow-up duration among different tumor histologies, however, there was a significant difference in mean age. Specifically, patients diagnosed with astrocytomas were notably younger compared to those with ependymomas or hemangioblastomas. The most prevalent tumors observed were ependymomas, astrocytomas and hemangioblastomas (see Table 2). Additionally, other lesions included neuronal and mixed neuronal-glial tumors, as well as intramedullary cysts such as dermoid, endodermal, or epidermoid cysts. While most ependymomas were low-grade tumors, two cases were identified as anaplastic. Similarly, astrocytomas were predominantly low grade.

Regarding anatomical distribution, the cervical cord was most commonly affected, followed by the cervicothoracic and thoracic cord regions (refer to Table 1). Notably, astrocytomas were less frequently isolated to the cervical cord compared to ependymomas or hemangioblastomas, however, they exhibited a higher tendency to span the cervicothoracic region, although this difference was not statistically significant. Lesions in the thoracolumbar cord/conus were relatively rare overall. The clinical presentation of patients showed similarities across different types of IMSCTs

Table 1: Demographic, location, and symptoms of 45 cases with primary IMSCTs

Variable	Study Cohort	Ependymoma	Astrocytoma	Hemangioblastoma	p-value			
					Across Groups	E vs A	E vs H	A vs H
No.of cases	45	21	14	5	-	-	-	-
Age in years	35.2±19.5	43.2±13.7	26.8±22.4	38.6±15.5	<0.01	<0.02	0.34	<0.01
Male gender	26 (57.78)	14 (31.11)	9 (20.00)	3 (6.67)	0.59	0.87	0.29	0.38
Location of Tumor								
Cervical	20 (44.44)	11 (24.44)	5 (11.11)	3 (6.67)	0.03	0.02	0.45	0.03
Cervicothoracic	7 (15.56)	2 (4.44)	3 (6.67)	0 (0)				
Thoracic	15 (33.33)	7 (15.56)	5 (11.11)	2 (4.44)				
Thoracolumbar/Conus	3 (6.67)	1 (2.22)	1 (2.22)	0 (0)				
Neurological complaints								
Weakness	24 (53.33)	12 (26.67)	7 (15.56)	3 (6.67)	0.72	0.43	0.95	0.58
Urinary incontinence	9 (20.00)	4 (8.89)	3 (6.67)	0 (0.00)	0.14	0.78	0.1	0.06
Bowel dysfunction	4 (8.89)	1 (2.22)	2 (4.44)	1 (2.22)	0.06	0.01	0.68	0.34
Numbness/sensory changes	28 (62.22)	15 (33.33)	8 (17.78)	0 (0.00)	0.02	<0.01	0.93	0.06
Back pain	18 (40.00)	9 (20.00)	6 (13.33)	1 (2.22)	0.86	0.61	0.76	0.93
Reticular pain	9 (20.00)	6 (13.33)	2 (4.44)	0 (0.00)	0.07	0.04	0.24	0.72
ASIA grade								
A	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0.02	0.02	0.62	0.40
B	0 (0.00)	1 (2.22)	0 (0.00)	0 (0.00)				
C	1 (2.22)	2 (4.44)	2 (4.44)	0 (0.00)				
D	5 (11.11)	18 (40.00)	9 (20.00)	4 (8.89)				
E	1 (2.22)	1 (2.22)	2 (4.44)	1 (2.22)				

Table 2: Histology of tumours

Histology	n	percentage
Ependymoma	21	46.67
WHO grade I, Myxopapillary	1	2.22
WHO grade I, Tanycytic	0	0.00
WHO grade I, Subependymoma	1	2.22
WHO grade II	18	40.00
WHO grade III	1	2.22
Astrocytoma	14	31.11
WHO grade I	6	13.33
WHO grade II	4	8.89
WHO grade III	2	4.44
WHO grade IV	2	4.44
Hemangioblastoma	5	11.11
Miscellaneous	5	11.11
Neuronal and mixed neuronal-glial tumor	1	2.22
Dermoid Cyst	1	2.22
Glioma (unspecified)	1	2.22
Endodermal cyst	1	2.22
Epidermoid cyst	1	2.22

Table 3: Neurological symptoms stratified by tumours location

Tumor Location	Cervical	Cervicothoracic	Thoracic	Thoracolumbar/Conus	p-Value
No.of cases	20	7	15	3	-
Symptoms					
Weakness	13 (65.00)	4 (57.14)	8 (53.33)	1 (33.33)	0.54
Urinary incontinence	2 (10.00)	2 (28.57)	4 (26.67)	1 (33.33)	<0.05
Bowel dysfunction	0 (0.00)	1 (14.29)	2 (13.33)	0 (0.00)	<0.05
Numbness/sensory changes	14 (70.00)	4 (57.14)	10 (66.67)	2 (66.67)	0.25
Back pain	9 (45.00)	3 (42.86)	5 (33.33)	2 (66.67)	0.61
Reticular pain	3 (15.00)	1 (14.29)	4 (26.67)	1 (33.33)	<0.05

(refer to Table 1). However, the neurological presentation varied depending on the tumor's location (refer to Table 3).

Approximately 30% of patients underwent revision surgeries for residual or recurrent tumor removal, with a notably higher proportion of astrocytoma patients undergoing revision surgery compared to those with ependymomas or hemangioblastomas. There were no significant differences in the proportion of patients undergoing laminoplasties versus laminectomies. Generally, surgeries for hemangioblastomas were less extensive than those for ependymomas or astrocytomas. Moreover, there were significant differences in the extent of resection among tumor groups, with lower rates of gross total resection (GTR) observed in astrocytomas compared to hemangioblastomas and ependymomas. Within 30 days post-surgery, around 30% of patients experienced one or more complications. The rates of complications were similar among patients with ependymomas, astrocytomas and hemangioblastomas. Specifically, complications included cerebrovascular accidents (1%), deep vein thrombosis (2.5%), delirium (1%), dural leaks (3.5%), ileus (1%), pneumonia (1%), pulmonary embolus (1.5%) and urinary tract infections (4%). Additionally, death within 30 days post-surgery occurred in 1% of patients, all of whom had ependymomas. Common reasons for readmission included wound infection (19% of readmitted patients), wound dehiscence (12%), cerebrospinal fluid leaks (11%), weakness (9%), urinary tract infections (5%), seroma (2%) and pulmonary embolus (3%). Notably,

there were no significant differences in length of stay (LOS) or discharge disposition among the tumor cohorts. Overall survival was notably worse in patients diagnosed with astrocytomas compared to those with ependymomas and hemangioblastomas..

Treating IMSCTs surgically presents considerable technical challenges and many surgeons encounter few cases of these tumors[10,11]. In this study, we report on 45 cases of IMSCTs, with a focus on their clinical presentation, histological characteristics, surgical treatment and short-term outcomes among surgically managed patients. Our histological findings align with prior reports from single-institution series and multi center cohort studies, indicating that ependymomas constitute 60-80% of IMSCTs[12–14], astrocytomas make up 30-40%[15] and hemangioblastomas account for 2-8%[16,17]. Unlike brain gliomas[18], spinal cord gliomas are mostly low grade. Surgically treated ependymomas were predominantly low grade, consistent with previous estimations indicating that grade II ependymomas represent 55-75% of all IMSCTs. These tumors are often amenable to complete or partial resection, leading to a 15-year overall survival rate exceeding 80% for grade II lesions. Grade III lesions, however, tend to invade surrounding tissue more extensively, making complete resection less feasible and resulting in poorer survival rates[19,20].

Our approach to managing IMSCTs is tailored to each patient's clinical presentation. Patients with localized pain typically undergo conservative management with regular imaging surveillance, as surgery may lead to new or worsening somatosensory deficits. Those with persistent symptoms, new neurological deficits, or tumor progression on imaging are considered for surgical resection. For patients presenting with neurological deficits, early surgery is recommended, as a poorer baseline neurological status is associated with worse postoperative outcomes. In our study, approximately half of the tumors were located in the cervical cord and one-third in the thoracic cord, consistent with the known disproportionate elongation of the vertebral column relative to the spinal cord with age. Previous studies also observed a higher frequency of IMSCTs in the cervical region, followed by the thoracic and cervicothoracic regions[8,21]. The disproportionate burden in these regions may be influenced by the higher gray matter content in the cervical cord[1]. However, myxopapillary ependymomas tend to favor the filum terminale and conus medullaris[22].

The surgical technique and extent of resection depend on the tumor's pathology[23,24]. Ependymomas and hemangioblastomas often have a well-defined plane during surgery and can be removed either completely or partially. We generally prefer complete resection to minimize the risk of local recurrence associated with tumor cell spillage during debulking, although this approach carries a higher risk of complications[22]. Around one-third of patients experienced at least one complication within 30 days of surgery, irrespective of tumor pathology, suggesting that pathology may not be the primary determinant of short-term outcomes. Although neurological status often remained stable at the 90-day follow-up, improvements were noted in urinary incontinence for ependymomas and sensory changes for hemangioblastomas. However, functional independence was frequently reduced in the immediate postoperative period. This study has several limitations, including its retrospective nature and single-institution design, which may introduce institutional and geographical biases. Future studies should confirm resection extent with expert neuroradiologists and investigate predictors of long-term neurological function using prospective multi center cohorts to address these limitations and validate our findings.

CONCLUSION

We observed a higher incidence of astrocytomas among younger patients, while ependymomas were more prevalent in older patients. Interestingly, clinical presentation and short-term postoperative outcomes within 30 days appeared to be mostly unaffected by the underlying tumor pathology, suggesting that surgical nuances rather than tumor type might exert a stronger influence on the clinical trajectory. However, tumor pathology did significantly impact postoperative survival, with astrocytoma patients exhibiting poorer prognoses compared to ependymoma and hemangioblastomas patients.

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