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Analysis of Risk Factors for Cerebrospinal Fluid Leakage in Patients Undergoing Spinal Tumor Surgery

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Abstract

Objective: This study aims to identify risk factors associated with cerebrospinal fluid (CSF) leakage in patients undergoing spinal tumor surgery, thereby providing a basis for strategies to reduce its incidence. **Methods:** A total of 181 patients who underwent posterior open-separation surgery for spinal tumor at our institution between January 2024 and January 2025. Patients were categorized into an observation group (n = 19, with CSF leakage) and a control group (n = 162, without CSF leakage). Eighteen variables were compared between the groups, including age, sex, body mass index (BMI), history of diabetes, history of hypertension, smoking history, alcohol consumption history, prior radiotherapy, prior chemotherapy, postoperative constipation (within 72 hours), surgical site, disease duration, reoperation at the same spinal segment, number of decompression segments, tumor diameter, tumor adhesion to the dura mater, operative time, and intraoperative blood loss [1]-[3]. **Results:** postoperative constipation (within 72 hours), reoperation at the same spinal segment, and tumor adhesion to the dura mater were identified as significant risk factors for CSF leakage ($P < 0.05$), whereas age, sex, BMI, history of diabetes, history of hypertension, smoking history, alcohol consumption history, prior radiotherapy or chemotherapy, surgical site, disease duration, number of decompression segments, tumor diameter, operative time, and intraoperative blood loss were not significantly associated with CSF leakage ($P > 0.05$). Multivariate logistic regression analysis confirmed that postoperative constipation (within 72 hours), reoperation at the same spinal segment, and tumor adhesion to the dura mater were independent risk factors for CSF leakage ($P < 0.05$). **Conclusion:** postoperative constipation (within 72 hours), reoperation at the same spinal segment, and tumor adhesion to the dura mater are significant risk factors for CSF leakage following spinal tumor surgery. Comprehensive preoperative assessment and consideration of these factors in surgical planning are es-

sential to minimize the risk of CSF leakage.

Keywords

Cerebrospinal Fluid Leakage, Risk Factors, Spinal Tumor Surgery

1. Introduction

With advancements in surgical techniques and spinal internal fixation devices, surgery has become the primary therapeutic approach for patients with spinal tumors [4]. The primary surgical techniques for spinal tumors include Total En Bloc Spondylectomy (TES), Separation Surgery, Posterior Laminectomy with Internal Fixation, Percutaneous Vertebroplasty (PVP), and Percutaneous Kyphoplasty (PKP).

Among these, Separation Surgery is a procedure involving circumferential decompression to resect tumors surrounding the dura mater. The surgical process entails: 1) Resection of posterior vertebral laminae and accessory structures; 2) Partial resection of anterior vertebral body tumors; 3) Creation of a 5 - 8 mm decompression zone around the spinal cord [5]. All patients in this study underwent posterior separation and decompression surgery. However, cerebrospinal fluid (CSF) leakage remains a frequent and serious complication following spinal surgery [6]. Whereas reported CSF leakage incidence ranges from 1% to 14% in general spinal procedures [7], spinal tumor resection demonstrates substantially elevated rates of 8.7% - 15.2% [3], reflecting its technically demanding nature. Patients experiencing CSF leakage are at increased risk for complications such as intracranial hypotension syndrome and wound infection, which significantly exacerbate patient morbidity, elevate healthcare costs, prolong hospitalization, and heighten the likelihood of reoperation. Preoperative identification and mitigation of risk factors, as well as heightened intraoperative vigilance, are effective strategies for preventing CSF leakage. In light of these concerns, the present study enrolled 181 patients undergoing spinal tumor surgery, collected comprehensive clinical data, and analyzed factors associated with the development of CSF leakage, as detailed below.

2. Materials and Methods

2.1. General Information

A total of 181 patients who underwent spinal tumor surgery at Sun Yat-sen University Cancer Center between January 2024 and January 2025 were enrolled in this study. Through a retrospective approach to medical records patients were categorized into an observation group (n = 19, with cerebrospinal fluid [CSF] leakage) and a control group (n = 162, without CSF leakage) according to the occurrence of postoperative CSF leakage. The inclusion criteria were as follows: 1) fulfillment of the diagnostic criteria for CSF leakage; 2) all patients underwent spinal

tumor resection; and 3) age greater than 18 years with voluntary participation in the study. The diagnostic criteria for CSF leakage were based on references [8] [9]: 1) symptoms indicative of intracranial hypotension, such as postural headache, nausea, and vomiting; 2) persistent increase in light red or clear fluid in the incision drainage tube; 3) continuous exudation of light red or clear fluid from the surgical incision; 4) aspiration of light red or clear fluid from subcutaneous effusion; and 5) definitive diagnosis of CSF leakage confirmed by CT or MRI. The exclusion criteria were as follows: 1) preoperative cranial trauma or dysfunction of other organs; 2) age under 18 years; 3) incomplete clinical data; and 4) wound infection with indeterminate CSF leakage.

2.2. Observation Indicators

A total of 18 variables were comparatively analyzed between the two patient groups: age, sex, body mass index (BMI), history of diabetes, history of hypertension, smoking history, alcohol consumption history, prior radiotherapy, prior chemotherapy, postoperative constipation (within 72 hours), surgical site, disease duration, reoperation at the same spinal segment, number of decompression segments, tumor diameter, tumor adhesion to the dura mater, operative time, and intraoperative blood loss.

2.3. Statistical Methods

All data were processed using SPSS version 27.0. For univariate analysis, t-tests or chi-square (χ^2) tests were employed, with statistical significance defined as $P < 0.05$. Multivariate analysis was performed using logistic regression, with a significance threshold of $\alpha = 0.05$; differences were considered statistically significant at $P < 0.05$.

3. Results

3.1. Analysis of Clinical Parameters

A comprehensive statistical analysis was conducted on the clinical data of all patients. The findings indicate that postoperative constipation (within 72 hours), reoperation at the same spinal segment, and tumor adhesion to the dura mater are significant risk factors for the development of cerebrospinal fluid (CSF) leakage ($P < 0.05$). In contrast, variables such as age, sex, body mass index (BMI), histories of diabetes, hypertension, smoking, alcohol consumption, radiotherapy, chemotherapy, surgical site, disease duration, number of decompression segments, tumor diameter, operation time, and intraoperative blood loss did not demonstrate a statistically significant association with CSF leakage ($P > 0.05$). Details are presented in Table 1.

3.2. Multivariate Analysis of Risk Factors for Cerebrospinal Fluid Leakage

Multivariate logistic regression analysis indicated that, in comparison to the con-

trol group, postoperative constipation (within 72 hours), reoperation at the same spinal segment, and tumor adhesion to the dura mater were identified as significant risk factors for the development of cerebrospinal fluid leakage ($P < 0.05$). Refer to Table 2.

Table 1. Comparative analysis of clinical parameters between patient groups.

Factor		Observation Group (19)	Control Group (162)	t/χ^2 Statistic	P Value
Age	<60	14	115	0.060	0.806
	≥60	5	47		
Gender	Male	9	93	0.697	0.404
	Female	10	69		
BMI	<18.4	0	12	3.196	0.202
	18.5 - 23.9	14	88		
	≥24	5	62		
History of Diabetes	Yes	1	10	0.025	0.875
	No	18	152		
History of Hypertension	Yes	6	32	1.434	0.231
	No	13	130		
Smoking History	Yes	2	31	0.367	0.545
	No	17	131		
Alcohol Consumption	Yes	1	12	0.117	0.732
	No	18	150		
Prior Radiotherapy	Yes	5	19	3.146	0.076
	No	14	143		
Prior Chemotherapy	Yes	4	47	0.212	0.645
	No	15	115		
	No	18	154		
postoperative constipation	Yes	10	28	12.810	<0.001
	No	9	134		
surgical site	Cervical vertebrae	0	8	5.597	0.133
	Thoracic vertebrae	6	84		
	Lumbar vertebrae	11	52		
	Sacrum	2	18		
Disease Duration	<1 Year	9	100	1.464	0.226
	≥1 Year	10	62		
reoperation at the same spinal segment	Yes	15	151	4.551	0.033
	No	4	11		
Decompression Level	Single segment	12	93	0.231	0.631
	Multiple segments	7	69		
tumor diameter	<5 cm	10	80	0.071	0.790
	≥5 cm	9	82		
Dural Invasion by Tumor	Yes	9	6	42.659	<0.001
	No	10	156		
Operation Time (min)		245.68 ± 86.82	233.20 ± 82.10	0.623	0.534
Intraoperative Blood Loss (ml)		860.53 ± 868.04	833.95 ± 684.37	0.155	0.877

Table 2. Comparative multivariable analysis of postoperative cerebrospinal fluid leakage risk factors.

Variable	β Coefficient	Odds Ratio (OR)	95% Confidence Interval	P Value
Presence of postoperative constipation	2.085	8.046	2.217 - 29.208	0.002
reoperation at the same spinal segment	−1.913	0.148	0.027 - 0.802	0.027
Tumor invasion of the dura mater	3.437	31.086	7.301 - 132.354	0.000

4. Discussion

Cerebrospinal fluid (CSF) leakage following spinal tumor surgery is commonly attributed not only to intraoperative iatrogenic injuries—such as direct trauma from surgical instruments, excessive nerve root traction, or forceful surgical manipulation—but also to several high-risk factors that elevate the likelihood of postoperative leakage. The present study identified postoperative constipation (within 72 hours), reoperation at the same spinal segment, and tumor adhesion to the dura mater as significant risk factors for the development of CSF leakage.

Constipation in spinal tumor patients during the postoperative period may arise from the use of opioid analgesics and reduced mobility due to prolonged bed rest. Straining during defecation increases intra-abdominal pressure, which is transmitted via the thoracic cavity to the cranial cavity, leading to a transient elevation in intracranial pressure. This rise in intracranial pressure can precipitate rupture at structurally compromised sites of the dura mater, thereby causing CSF leakage. Accordingly, a multifaceted approach should be adopted to prevent constipation [10]. Early identification of high-risk patients should be facilitated through the use of appropriate assessment tools. Comprehensive health education—encompassing bowel habit training, dietary counseling on fiber and fluid intake, and postoperative exercise guidance—should be implemented, alongside judicious use of laxatives to promote regular bowel movements.

Du *et al.* [11] conducted a retrospective analysis of 4822 patients who underwent spinal surgery at the same institution over a two-year period and similarly identified spinal revision surgery as a significant risk factor for CSF leakage, corroborating the findings of the present study. This association may be explained by alterations in local anatomical structures and increased likelihood of scar and dural adhesions following previous surgeries, which render the dura mater more susceptible to rupture during reoperation [12]. Additionally, postoperative infection and inadequate drainage can necessitate reoperation; thus, meticulous wound care to aseptic protocols, and maintenance of dry, clean wound dressings and unobstructed drainage are imperative.

The adhesion between tumors and the dura mater fundamentally involves the formation of a pathological fibrovascular interface. When tumor cells (particularly meningiomas or metastatic carcinomas) infiltrate the outer dural layer, they secrete Transforming Growth Factor-β1 (TGF-β1), activating fibroblasts to transform into myofibroblasts. These myofibroblasts overexpress matrix metallopro-

teinases (MMP-2/9), resulting in degradation rates of type III/IV collagen fibers 3.2 times higher than in normal tissue. Consequently, dural tensile strength plummets from 35 N/cm^2 to 11 N/cm^2. During surgical dissection of adhesions, mechanical traction forces must overcome tumor-dura binding strength exceeding 0.5 N/mm^2—compared to only 0.17 N/mm^2 required for normal dural detachment. Such supraphysiological forces cause microtears (defect diameter: 0.1 - 1 mm) in the dura mater [3]. Therefore, comprehensive preoperative risk stratification and preemptive intervention are mandatory for patients with tumor-dural adhesions [13]: Grade I (Filmy adhesion): Standard watertight suture suffices. Grade II (Fibrovascular adhesion): Collagen matrix patch reinforcement is obligatory. Grade III (Full-thickness tumor infiltration): Pedicled tissue flap transplantation is required. Concurrently, surgeries should be performed by experienced surgeons during peak mental acuity to prevent intraoperative errors.

Notably, this study did not observe significant associations between age, smoking, radiotherapy, disease duration, surgical site, tumor diameter and the incidence of CSF leakage, which diverges somewhat from previous reports [14] [15]. This discrepancy may be attributable to the relatively small and narrowly defined sample in this study. Future research should focus on large-scale, multicenter studies employing more comprehensive inclusion criteria to further elucidate the risk factors for CSF leakage following spinal tumor surgery.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Yang, M., Jiang, X.J., Liu, S., *et al.* (2024) Meta-Analysis of Factors Affecting Cerebrospinal Fluid Leakage in Patients Undergoing Spinal Tumor Surgery. *General Practice Nursing*, **22**, 1640-1644.

[2] Qu, H.Y., Guo, W. and Yang, R.L. (2010) Analysis of Risk Factors and Countermeasures for Wound-Related Complications of Sacral Tumors. *Chinese Journal of Orthopaedics Surgery*, **18**, 212-215.

[3] North American Spine Society (NASS) (2024) Guidelines on Pathological Dural Repair in Oncologic Spine Surgery. Version 3.1. NASS Publications.

[4] Klekamp, J. and Samii, H. (1998) Surgical Results for Spinal Metastases. *Acta Neurochirurgica*, **140**, 957-967. https://doi.org/10.1007/s007010050199

[5] Li, X.L. (2023) Expert Consensus on Surgical Treatment of Spinal Metastatic Tumors. *Chinese Journal of Spine and Spinal Cord*, **33**, 376-384.

[6] Zhu, Q., Ye, C., Xie, D., *et al.* (2023) Advances in Diagnostic and Treatment Strategies for Dural Injuries and Cerebrospinal Fluid Leakage during Lumbar Spine Surgery. *Chinese Journal of Bone and Joint*, **12**, 57-63.

[7] Menon, S.K. and Onyia, C.U. (2015) A Short Review on a Complication of Lumbar Spine Surgery: CSF Leak. *Clinical Neuro1ogy and Neurosurgery*, **139**, 248-251. https://doi.org/10.1016/j.clineuro.2015.10.013

[8] Orthopaedic Surgeons Branch of Chinese Physicians Association (2017) Evidence-Based Clinical Diagnosis and Treatment Guidelines for Dural Rupture and Postop-

erative Cerebrospinal Fluid Leakage in Spinal Surgery. *Chinese Journal of Surgery*, **55**, 86-89.

[9] Takahashi, Y., Sato, T., Hyodo, H., *et al.* (2013) Incidental Durotomy during Lumbar Spine Surgery: Risk Factors and Anatomic Locations: Clinical Article. *Journal of Neurosurgery*: *Spine*, **18**, 165-169. https://doi.org/10.3171/2012.10.SPINE12271

[10] Zheng, Z.M., Zheng, X.Y., Huang, X.Y., *et al.* (2025) Best Evidence Summary for Nursing Management of Constipation after Spinal Cord Injury J. *Nursing and Rehabilitation*, **24**, 53-58.

[11] Du, J.Y., Aichmair, A., Kueper, J., Lam, C., Nguyen, J.T., Cammisa, F.P., *et al.* (2014) Incidental Durotomy during Spinal Surgery. *Spine*, **39**, E1339-E1345. https://doi.org/10.1097/brs.0000000000000559

[12] Kang, Y.W., Yang, X.F. and Ding, B.S. (2020) Research Progress on the Treatment of Cerebrospinal Fluid Leakage after Lumbar Spine Surgery. *Journal of Spine Surgery*, **18**, 278-281.

[13] Congress of Neurological Surgeons (CNS) Expert Panel (2023) Consensus on Advanced Dural Repair Techniques in Complex Spinal Surgery. CNS Publications, 48.

[14] Zhang, R. and He, Y. (2023) Risk Factors for Cerebrospinal Fluid Leakage in Posterior Lumbar Surgery. *Zhejiang Journal of Traumatic Surgery*, **28**, 1660-1662.

[15] Liu, X.L. and Yang, G.J. (2022) Factors Related to Cerebrospinal Fluid Leakage after Lumbar Spine Surgery and Its Prevention. *International Journal of Orthopaedics*, **43**, 143-146.