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Risk Factors Associated with Postoperative Incision Infection after Surgery for Spinal Metastases and Nursing Interventions

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Abstract

Objective: To investigate factors associated with postoperative incision infection in patients with spinal metastases and provide evidence for reducing the incidence of postoperative wound infection. **Methods:** We retrospectively included 223 patients who underwent surgical resection for spinal metastatic tumors at our hospital during the period from December 1, 2024 to December 31, 2025 as research participants. Patients were divided according to the occurrence of wound infection into an observation group (11 cases) and a control group (212 cases). The two groups were compared and analyzed with respect to 18 indicators, including surgical approach, postoperative drainage duration, surgical site, age, operative time, cerebrospinal fluid leakage, BMI, intraoperative blood loss, hemoglobin, serum albumin, hypertension, sex, peripheral blood inflammatory markers, history of smoking and alcohol consumption, diabetes mellitus, internal fixation, and others, to assess their effects on wound infection. **Conclusion:** Postoperative drainage duration, surgical site, age, and operative time were independent factors influencing postoperative incision infection after surgery for spinal metastases. Among them, postoperative drainage duration, surgical site, and operative time were independent risk factors, whereas age was a protective factor; surgical approach had no independent effect. When formulating a surgical plan for resection of spinal metastases, the above factors should be considered. Intraoperatively, operative time should be controlled; postoperatively, patients should be rigorously assessed and wound drains should be removed in a timely manner to reduce the risk of postoperative incision infection. Targeted nursing measures should also be implemented according to patients' postoperative conditions, thereby improving the quality of clinical nursing and patient prognosis.

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Keywords

Surgery for Spinal Metastases, Incisional Infection, Associated Factors, Nursing Measures

1. Introduction

The spine is the third most common site of metastasis after the lungs and liver and the most common site of bone metastasis [1] [2]. With advances in comprehensive cancer treatment, the average life expectancy of cancer patients has increased, and the incidence of metastatic spinal tumors has also continued to rise [3]. Surgical treatment is one of the main therapeutic options commonly selected for patients with spinal metastatic tumors. Surgery can substantially relieve pain, restore spinal stability, reduce the likelihood of spinal cord compression, and markedly improve patients' quality of life [4] [5]. Therefore, most patients with spinal metastases preferentially undergo surgery to relieve pain symptoms. However, the postoperative incidence of SSI in patients with metastatic spinal tumors is 8 - 10 times the average rate observed after general spinal surgery [6]-[9]. Once infection occurs, it prolongs hospitalization, increases the economic burden, and creates challenges for nursing care. This study retrospectively analyzed the clinical data of patients who underwent resection of spinal metastases, identified factors potentially associated with postoperative incisional infection, and determined the independent risk factors, thereby providing data to support early identification of high-risk patients and optimization of perioperative management, with the aim of reducing the incidence of postoperative incisional infection and informing clinical practice.

2. Materials and Methods

2.1. General Information

A total of 223 patients who underwent resection of spinal metastases in the Department of Bone and Soft Tissue, Sun Yat-sen University Cancer Center, between December 1, 2024 and December 31, 2025 were selected as the study cohort. Observation continued until discharge postoperatively. According to the occurrence of wound infection, they were divided into an observation group (incisional infection; 11 cases) and a control group (no incisional infection; 212 cases). Inclusion criteria: ① all patients underwent resection surgery for spinal metastatic tumors; ② patients met the diagnostic criteria for early postoperative incisional infection of the U.S. Centers for Disease Control and Prevention (centers for disease control and prevention, CDC) [10]: SSI was diagnosed when at least one of the following criteria was fulfilled: 1) the incision showed redness, swelling, heat, and pain, accompanied by fluctuation or abscess formation and purulent discharge; 2) bacterial culture of incisional secretions was positive; 3) bacterial culture of intraoperative irrigation fluid or tissue obtained during debridement was positive;

4) SSI was confirmed by laboratory indicators, including routine blood tests, C-reactive protein (CRP), procalcitonin, as well as imaging examinations or histopathological examination; ③ complete medical records were available; ④ patients were older than 18 years, and both the patients and their families provided informed consent. Exclusion criteria: ① age under 18 years; ② abnormal coagulation function; ③ uncertain wound infection status; ④ presence of other psychiatric disorders or inability to cooperate.

2.2. Methods

Surgical procedures for spinal metastases: All patients completed the relevant preoperative examinations, and individualized surgical plans were formulated by the surgical team led by the attending professor according to the site and extent of tumor metastasis. Prophylactic antibiotics were administered preoperatively; if the operative time exceeded 3 h, additional antibiotics were given. Patients were placed in the supine or prone position intraoperatively. A posterior midline longitudinal incision was made, and the skin, subcutaneous tissue, and fascia were incised sequentially. Before closure of the surgical incision, the operative field was irrigated with hydrogen peroxide. After irrigation, one or two silicone drainage tubes were placed. The incision was closed layer by layer with absorbable sutures, and the incision length was recorded. Systemic antibiotics were continued until removal of the drainage tubes. Postoperatively, routine symptomatic and supportive treatments were provided, including anti-inflammatory therapy, analgesia, and wound dressing changes. The characteristics of the drainage fluid were closely monitored; if the drainage fluid became turbid or body temperature exceeded 38.5˚C, bacterial culture of the drainage fluid or blood culture was performed.

2.3. Observational Indicators

The status of early surgical incision infection after spinal metastatic tumor resection and related influencing factors were analyzed, including 18 indicators: surgical approach, Surgical site, postoperative drainage duration, age, operative time, postoperative cerebrospinal fluid leakage, BMI, intraoperative blood loss, hemoglobin, serum albumin, history of hypertension, sex, peripheral blood neutrophil indices, leukocyte indices, history of alcohol consumption, smoking history, history of diabetes mellitus, and whether internal fixation was implanted.

2.4. Statistical Analysis

Data were analyzed using SPSS 27. For conventional categorical variables, the χ^2 (chi-square) test was employed to compare distribution differences between the infection group (11 cases) and the control group (212 cases). Given the small sample size in the infection group and the presence of zero frequencies or theoretical frequencies < 5 for certain categorical variables (smoking, alcohol consumption, diabetes, internal fixation implantation), the Fisher exact probability method was used as an alternative to the χ^2 test; a P-value < 0.05 was considered statistically significant. Categorical variables with a P-value < 0.05 from univariate analysis were combined with continuous variables in binary logistic regression to identify independent influencing factors after adjustment for confounding factors, with an alpha level of $\alpha = 0.05$ and a P-value < 0.05 indicating statistical significance.

3. Results

3.1. Incidence of Surgical Site Infection Following Resection of Spinal Metastases

A total of 223 cases were included, of which 11 developed postoperative incision infections and 212 did not; the overall incidence of postoperative incision infection was 4.93% (see Table 1).

Table 1. General characteristics of the study participants and incidence of postoperative infection.

Project	Numerical
Total number of included cases	223 cases
Number of cases of postoperative incision infection	11 cases
Number of postoperative non-infection cases	212 cases
Overall incidence of postoperative incision infection	4.93%

3.2. Analysis of Clinically Relevant Indicators

All patient data were statistically analyzed. Univariate testing showed that surgical approach, postoperative drainage duration, surgical site, age, and operative duration were associated with postoperative incisional infection; cerebrospinal fluid leakage, BMI, intraoperative blood loss, hemoglobin, albumin, hypertension, sex, peripheral blood inflammatory markers, smoking and alcohol history, diabetes mellitus, and internal fixation showed no statistically significant associations. For some variables (smoking, alcohol consumption, diabetes mellitus, and internal fixation), P = 1.000, likely because there were only 11 infection cases in this cohort and the distribution of cases across groups was imbalanced (see Table 2).

Table 2. Univariate analysis of factors associated with postoperative incision infection in spinal metastases.

Influencing factors	P-value	Statistical significance
Surgical approach	<0.001	P < 0.05, indicating statistical significance.
Duration of postoperative drainage	<0.001	P < 0.05, indicating statistical significance.
Surgical site	0.001	P < 0.05, indicating statistical significance.
Age	0.008	P < 0.05, indicating statistical significance
Operative duration	0.016	P < 0.05, indicating statistical significance.
Cerebrospinal fluid leak	0.101	P > 0.05, indicating no statistical significance.

Continued

BMI	0.108	P > 0.05, indicating no statistically significant difference.
Intraoperative blood loss	0.109	P > 0.05, indicating no statistical significance.
Hemoglobin	0.119	P > 0.05, not statistically significant.
Serum albumin	0.139	P > 0.05, indicating no statistical significance.
History of hypertension	0.145	P > 0.05, not statistically significant.
Gender	0.218	P > 0.05, indicating no statistical significance.
Neutrophils	0.946	P > 0.05, not statistically significant.
Leukocytes	0.950	P > 0.05, indicating no statistically significant difference.
History of alcohol consumption	1.000	P > 0.05, indicating no difference in distribution between groups.
History of diabetes mellitus	1.000	P > 0.05, indicating no difference in distribution between groups.
Smoking history	1.000	P > 0.05, indicating no difference in distribution between the groups.
Internal fixation implantation	1.000	P > 0.05, with no difference in distribution between groups.

Note: The small number of infection cases resulted in zero cell counts for some variables, leading to P = 1 in Fisher's exact test/chi-square test. This is an objective result of the data, with no data-entry errors. Invalid variables that lacked clinical significance or showed no statistically significant single-factor association were excluded. All included variables underwent preliminary screening through single-factor analysis (P < 0.05) and demonstrated a clear pathophysiological correlation with postoperative wound infection of the spine. The total number of infections in this cohort was only 11 (4.93%). Because the number of infected cases was too small, the distribution of some exposure factors was highly unbalanced between the infected and non-infected groups, and statistical tests were unable to detect differences. This is a common phenomenon in small-sample clinical studies.

3.3. Multivariable Logistic Regression Analysis

Five indicators with a univariate analysis P < 0.05 were included in the multivariate logistic regression. After adjusting for confounding factors, four independent risk factors for postoperative wound infection were identified, with the following effect sizes: ① Postoperative drainage duration: a modifiable independent risk factor; each additional day of drainage tube placement increased the risk of wound infection by 11.5% (OR = 1.115, 95% CI: 1.042 - 1.193, P < 0.05); ② Surgical duration: a modifiable independent risk factor; each additional hour of surgery increased the risk by 15.1% (OR = 1.151, 95% CI: 1.065 - 1.245, P < 0.05); ③ Surgical site: an independent risk factor; infections were 28.4% higher in complex sites such as thoracic or sacral spine compared to single-segment lumbar spine surgeries (OR = 1.284, 95% CI: 1.053 - 1.564, P < 0.05); ④ Age: an independent associated factor; each additional year of age reduced the risk of wound infection by 7.0% (OR = 0.930, 95% CI: 0.874 - 0.990, P < 0.05). These findings should be interpreted with caution (see Table 3).

Table 3. Multivariable logistic regression analysis of factors associated with postoperative incisional infection in patients with spinal metastases.

Influencing factors	Regression coefficient β	OR value	95% CI	P-value
Surgical approach	−0.519	0.595	0.351 - 1.007	>0.05
Postoperative drainage duration	0.109	1.115	1.042 - 1.193	<0.05
Surgical site	0.250	1.284	1.053 - 1.564	<0.05
Age	−0.073	0.930	0.874 - 0.990	<0.05
Surgical duration	0.141	1.151	1.065 - 1.243	<0.05

Note: After screening through univariate testing and considering both clinical significance and the stability requirements of small-sample regression, independent factors influencing postoperative wound infection were analyzed after adjusting for confounding variables. The significance level was set at $\alpha = 0.05$, with $P < 0.05$ indicating statistical significance.

4. Discussion

The incidence of surgical site infection among patients undergoing surgery for spinal metastases in this cohort was 4.93%, which is comparable to domestic epidemiological data from spinal surgery. Postoperative surgical site infection therefore remains a key complication requiring focused prevention and control in perioperative nursing care. Multivariate analysis identified four independent influencing factors, which are discussed below in conjunction with clinical nursing considerations.

1) Operative duration and postoperative drainage time increase the risk of infection

This study showed that operative duration (OR = 1.151) and postoperative drainage duration (OR = 1.115) were independent risk factors. Longer operative time increases paravertebral soft-tissue injury and prolongs wound exposure in the operative field, thereby increasing the risk of colonization by exogenous bacteria. Long-term placement of postoperative drainage tubes can create retrograde bacterial pathways outside the body, significantly increasing the risk of deep wound infections. Early removal of the drainage tube postoperatively can reduce the risk of SSI and shorten hospital stay [11]. Nursing countermeasures include strictly implementing intraoperative time-control mechanisms, strengthening operating room management and rigorously enforcing handwashing protocols, thoroughly disinfecting the skin in the operative field, protecting the incision, ensuring gentle intraoperative manipulation, handling tissues carefully, avoiding mass ligation and residual dead space, and achieving meticulous hemostasis to reduce wound oozing and hematoma formation; drainage tubes are generally exteriorized through puncture sites in the sacrospinalis muscles on both sides of the incision, and strict aseptic technique should be followed when evacuating accumulated blood after negative-pressure drainage to prevent retrograde wound infection via the drainage tube [12], thereby reducing the risk of intraoperative contamination at the source. At the same time, aseptic principles should be strictly observed, personnel movement during surgery should be minimized, air contamination in the operative field should be avoided, and all instruments and dressings should be managed under strict sterile conditions to prevent iatrogenic infection. After surgery, the volume and characteristics of drainage fluid should be assessed daily, extubation criteria should be strictly followed to prevent residual fluid accumulation caused by premature tube removal, and prolonged indwelling drainage should also be avoided to reduce the risk of retrograde infection. Drainage tubes should be properly secured to prevent kinking, compression, dislodgement, or displacement; in high-risk patients, double fixation should be used to prevent tube dislodgement due to changes in body position and to strictly control catheter-related infection.

2) The surgical site is an independent risk factor for infection

Complex surgical sites involve multiple paravertebral anatomical layers and extensive dissection, with marked disruption of local blood supply and severe tissue edema, thereby facilitating microbial proliferation. Before surgery, aseptic management should be strictly implemented; patients should be instructed to complete whole-body cleansing; preoperative skin preparation should be standardized; damage to the skin barrier should be avoided; and the nutritional status of elderly high-risk patients with prolonged bed rest, pressure-related skin compromise, or malnutrition should be optimized. After surgery, specialized and meticulous care should be provided for complex operative incisions associated with multisegment surgery for spinal metastases, which are characterized by long incisions, deep wound beds, severe tissue injury, high incision tension, and poor blood supply at the wound edges. First, graded dressing-change management should be implemented. Second, targeted wound management should be provided. Third, dedicated positional protection should be applied, with patients instructed to turn using a log-roll technique to avoid traction on or compression of the surgical incision during repositioning, prevent wound dehiscence and bleeding or exudation, reduce local tissue injury, and create favorable conditions for incision healing. Fourth, refined dressing management should be implemented to keep dressings clean, dry, and secure; if exudate saturation, contamination, or loosening occurs, the physician should be notified immediately for replacement to prevent bacterial growth and colonization.

3) The association between age and postoperative infection requires cautious interpretation

Multivariate regression analysis of this study revealed a negative correlation between age and surgical site infection after spinal surgery (OR = 0.930, 95% CI: 0.874 - 0.990, $P < 0.05$), which contradicts the conclusion of most literature that advanced age elevates the risk of postoperative infection. As a retrospective observational study with a small sample size, this finding cannot be attributed to superior perioperative interventions for elderly patients and is mainly affected by selection bias and unadjusted confounding factors. First, strict preoperative screening was implemented for patients with spinal metastatic tumors in our center, and the baseline infection risk of enrolled elderly patients was lower than that of the general population and younger patients complicated with severe immunosuppression. Second, confounding factors such as greater surgical trauma, higher tumor invasiveness, and myelosuppression induced by neoadjuvant chemotherapy in younger patients were not fully incorporated into the regression model, creating an apparent protective illusion of age. Third, only 11 infectious events were recorded in this cohort; insufficient sample size led to unstable effect estimation. The upper limit of the confidence interval for age was close to 1, indicating an extremely weak association effect and a risk of false-positive results due to the small sample.

Individualized perioperative management can be adopted clinically to reduce infection susceptibility in elderly patients. Nevertheless, advanced age itself should not be regarded as an anti-infective protective factor, and this correlation needs to be further verified by large-sample prospective cohort studies [13].

4) The surgical approach has no independent effect

Univariate analysis showed a statistically significant difference according to surgical approach; however, after adjustment for confounders, surgical approach had no independent effect. This may reflect the increasing adoption of minimally invasive spinal surgery, which has narrowed differences among approaches in aseptic technique and tissue injury, while standardized nursing care may offset approach-related differences in infection risk. Recent multicenter, large-scale studies have also confirmed that operative duration, drainage indwelling time, and complex surgical segments are the core independent risk factors for postoperative surgical site infection (SSI) in spinal metastatic tumors, consistent with the findings of this study.

5) Other indicators and research limitations

For variables such as smoking, alcohol consumption, diabetes mellitus, and internal fixation, $P = 1.000$. Because this study included only 11 infection cases, the small sample size and multiple zero-frequency cells within groups limited the ability to detect associations. Variables such as BMI and cerebrospinal fluid leakage had univariate P-values between 0.05 and 0.1 and were not identified as final independent influencing factors. This was a single-center retrospective study with limited generalizability; future studies should expand the sample size for further investigation.

6) Implications for holistic nursing care

A postoperative infection prevention and control strategy was developed around strict control of operative duration, refined drainage management, specialized care for incisions in complex surgical fields, and individualized care for older patients. Stratified nursing interventions were implemented for high-risk patients, with whole-process risk management as the core approach. By accurately identifying high-risk factors for postoperative incision infection after surgery for spinal metastases, and through standardized specialized nursing, individualized stratified interventions, and rigorous refinement of key procedural steps, this strategy effectively shortens operative time, standardizes drainage management, optimizes care for complex incisions, and implements dedicated care for older patients. It thereby comprehensively reduces the incidence of adverse events such as postoperative incisional erythema and swelling, exudation, suppuration, and deep tissue infection, improves surgical prognosis and the quality of patient recovery, and safeguards medical safety.

5. Limitations and Future Directions

This study has several limitations. It was a retrospective, single-center study, and the number of cases included in the infection group was relatively small, which may affect the accuracy of the findings. Although relevant factors associated with incision infection were collected, the study was also limited by interindividual differences. In addition, given the limited number of cases, the associated factors should be further validated through better-designed prospective, multicenter studies with larger sample sizes.

Declaration

All relevant materials in this document are strictly confidential; no patient information will be retrieved, and we consistently prioritize the protection of each patient's privacy.

Conflicts of Interest

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

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