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# Effects of a psychoneurointeraction-based personalized psychological care model on postoperative recovery in glioblastoma patients

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**Abstract: Background:** Glioblastoma (GBM) is a common malignant neuroepithelial tumor of the central nervous system in adults. The preferred treatment method is surgical treatment. During the perioperative period, patients will experience huge physiological and psychological burdens, which may influence the surgical outcome and recovery. Traditional nursing care patterns lack individualized psychological intervention and show limited impact on patients' psychological states. **Objective:** This study seeks to investigate the effects of individualized psychological nursing care on the psychological states, neuroendocrine responses, and postoperative recovery for patients with GBMs in the perioperative period. **Methods:** This was a prospective quasi-experimental study conducted at the Affiliated Hospital of Yanbian University from January 2023 to March 2024. A total of 84 GBM patients undergoing surgical treatment were enrolled and assigned into a treatment group ( $n = 42$ ) and a control group ( $n = 42$ ) using 1:1 propensity score matching. The treatment group received a personalized psychological care model based on psychoneurointeraction theory in addition to standard nursing care, while the control group received standard psychological nursing care only. Evaluations were conducted 1 day preoperatively, and on postoperative Days 3 and 7. Primary outcomes included psychological measures (anxiety, depression, perceived stress) and physiological markers [serum cortisol, 5-hydroxytryptamine (5-HT), dopamine, and inflammatory markers]. **Results:** The treatment group displayed substantially lowered scores for anxiety, depression, and perceived stress on Days 3 and 7 postoperatively compared with those in the control group ( $P < 0.05$ ); this group also showed remarkably lowered levels of serum cortisol and inflammatory factors [interleukin-6 (IL-6) and tumor necrosis factor- $\alpha$  (TNF- $\alpha$ )] in contrast with the control group ( $P < 0.05$ ). **Conclusion:** The intervention method of individualized psychological nursing care based on the theory of neural interactions can bring about dramatic improvements for GBM patients' perioperative mental states, physiological stress responses, postoperative recovery, and complications.

**Keywords:** glioblastoma; perioperative nursing care; individualized psychological intervention

## 1. Introduction

Glioblastoma (GBM), being the most malignant type among neuroepithelial tumors, is clearly classified as a grade—IV neuroepithelial tumor in the World Health Organization's tumor classification system. This highly invasive malignant tumor exhibits typical features such as nuclear atypia, abnormal cell proliferation, vascular endothelial cell hyperplasia, and tumor tissue necrosis [1]. The primary treatment method is surgery. However, since most tumors grow in an infiltrative manner, it is impossible to completely remove all tumor cells. Therefore, radiotherapy and chemotherapy are usually required as adjuvant treatments after surgery. It is reported

that the median survival time of patients with glioblastoma after surgery is 14.6 months, and the 2-year survival rate is 26.5% [2]. After getting sick, the psychological stress on patients, the surgical risks, and the uncertainty of prognosis are all major traumatic events for them. The psychological burden and physiological stress of patients directly affect the surgical prognosis and quality of life, which urgently need to be highly emphasized in clinical nursing.

The perioperative period means the entire clinical process including preoperative, intraoperative, and postoperative periods. In this stage, patients are confronted with complex physiological challenges and huge mental stress [3]. Patients may experience a wide range of adverse psychological reactions like anxiety, depression, fear, and insomnia due to the following factors: uncertainty of surgery, concerns over safety, expectations and anxiety about postoperative neural functional recovery, fear of disability, and worries about changes in family and social roles. Existing studies have revealed that perioperative psychological stress responses not only affect patients' subjective emotions and quality of life but also exert a substantial impact on the neuroendocrine and immune mechanisms of the body. These impacts will further interfere with cerebral blood flow regulation, immune function, and neurological recovery, hence influencing postoperative recovery speed, complication rates, and compliance with treatment [3,4].

Over the past years, developing neurosciences and psychoneuroimmunology have unveiled intricate two-way interactions between mental states and the nervous system. This "neural interaction" mechanism mainly involves the hypothalamic-pituitary-adrenal axis (HPA), sympathetic-parasympathetic nervous system, and the dynamic regulatory network of multiple neurotransmitters [5]. The psycho-neural interaction model aligns with established psycho-oncology frameworks, such as the biopsychosocial model and stress-coping frameworks, which emphasize the interplay of psychological, biological, and social factors in cancer patients' health outcomes [6,7]. In the context of GBM, psychological stress activates the HPA axis, leading to elevated cortisol levels, which can exacerbate anxiety and depression while suppressing immune function [8]. Similarly, reduced levels of 5-hydroxytryptamine (5-HT) are associated with mood dysregulation, particularly in cancer patients facing poor prognosis and surgical uncertainty [9]. These neuroendocrine changes mediate psychological outcomes by amplifying stress responses and impairing emotional regulation, particularly in GBM patients who experience tumor-related inflammation and perioperative stress. In the face of mental stress, an individual will activate the HPA axis to release stress hormones such as cortisol, accompanied by sympathetic nervous excitement and parasympathetic nerve inhibition, bringing about a series of physiological changes, including increased heart rate, heightened blood pressure, and immune function inhibition [10]. If these alterations persist, they will influence the patients' tolerance to surgery and recovery capability and increase the risks of intraoperative cerebral angiospasm, postoperative cognitive impairment, and other neurological complications. In addition, fluctuations in the level of serum 5-hydroxytryptamine (5-HT), dopamine, and other neurotransmitters are inextricably linked to anxiety and depression in patients. These emotional states may in turn aggravate the imbalance of the neurotransmitter system, forming a vicious circle [11]. Therefore, understanding and intervening in the psychological reactions of patients

from the perspective of neurobiology has become an important direction in the modern surgical nursing care research field.

Despite the preliminary attention already drawn to perioperative psychological intervention in clinical nursing practice, most current nursing care measures still rely on experience and standardization, lacking a deeper understanding of individual differences and neuro-psycho mechanisms. For example, conventional health education and emotional comfort methods cannot fully consider patients' psychological enduring capacity, responding patterns, social support levels, education levels, and previous psychological trauma, resulting in limited intervention effects, poor patient compliance, and significant differences in recovery speed [3]. Moreover, traditional nursing care modes mostly depend on physiological monitoring and trauma care, without a systematic framework closely combining psychological intervention and neural mechanisms. This greatly limits the potential of nursing intervention in promoting neurological recovery and emotional regulation. In order to boost the perioperative nursing care quality for patients with glioblastoma and realize the transformation from a "disease-centered" pattern to a "patient-centered" mode, we urgently need to construct a scientific, systematic, and personalized psychological nursing care intervention model. This model should cover multiple dimensions like psychological assessment, emotional regulation, cognitive reconstruction, and social support. Grounded in the psycho-neural interaction model and informed by psycho-oncology theories, such as the biopsychosocial model and stress-coping frameworks, this study proposes a personalized psychological nursing intervention tailored to GBM patients. By targeting neuroendocrine pathways, such as cortisol and 5-HT regulation, the intervention aims to mitigate psychological distress and enhance postoperative recovery in the cancer-specific context of GBM, addressing the unique psychological and physiological challenges posed by tumor invasiveness and surgical stress [6–8]. Furthermore, it should also integrate the advanced theories and empirical evidence of neurosciences during the selection and implementation of intervention strategies, hence providing individualized nursing care schemes for patients with varying mental profiles and stress response types from the viewpoints of neurotransmitter regulation, neuroimmune mechanisms, and stress response regulation.

At present, some studies have preliminarily investigated the positive effects of perioperative psychological nursing care on surgical outcomes, but most of them are focused on single intervention measures or short-term follow-up. These studies may lack the theoretical foundation of psycho-neural interactions and systematic research on interventions guided by patients' individual characteristics, which are rarer in the fields of high-risk neurosurgery such as glioblastoma resection surgery. Thus, our study integrates the psycho-neural interaction model with psycho-oncology frameworks to construct a personalized perioperative psychological nursing intervention for GBM patients. We aim to validate its effectiveness in improving adverse emotions, modulating neuroendocrine states (e.g., cortisol and 5-HT levels), and enhancing postoperative recovery through a prospective quasi-experimental study, providing a robust, evidence-based framework for patient-centered care in high-risk neurosurgery.

## **2. Materials and methods**

### **2.1. Study design**

With a prospective quasi-experimental design, this study incorporates GBM patients hospitalized in the neurosurgery department of Affiliated Hospital of Yanbian University and planned to receive surgical treatment from January 2023 to March 2024. Via a convenience sampling method, we enrolled 84 patients who met the criteria. Using a 1:1 1:1 propensity score matching (PSM) analysis method, the patients were allocated into the treatment group ( $n = 42$ ) and the control group ( $n = 42$ ). The grouping process was completed by independent researchers, and the allocation records were archived. The study also adopted a double-blind design, so the evaluators and statisticians did not know their assigned group. Both groups underwent standard surgical treatment and basic nursing care measures. The control group was subjected to routine psychological nursing care, whereas the treatment group received individualized psychological nursing care intervention based on neural interactions after receiving the same routine nursing care. During the study, relevant indicators were collected and assessed for both groups at standardized time points: 1 day before surgery, Day 3 after surgery, and before discharge. The sample size ( $n = 84$ ) was determined based on a power analysis assuming a medium effect size (Cohen's  $d = 0.5$ ) for primary outcomes (e.g., anxiety and depression scores assessed via SAS and SDS), with a significance level of  $\alpha = 0.05$  and power of 0.8, calculated using G\*Power software, indicating sufficient power to detect clinically meaningful differences. Propensity score matching was performed based on baseline variables including age, sex, and Karnofsky Performance Status (KPS) scores to balance the treatment and control groups.

### **2.2. Inclusion and exclusion criteria**

The inclusion criteria are as follows: (1) Aged between 18 and 70 years, with no sex restriction; (2) The patient was diagnosed with glioblastoma through MRI and pathological examinations and is planned to undergo tumor resection surgery; (3) Capable of basic communication and self-care, with an education level of primary school and above; (4) Clear consciousness, and capable of independently completing assessment scales and physiological sample collection; (5) Have not received psychotropic medications, sedative-hypnotic drugs, or psychotherapy; (6) Voluntary participation with signed informed consent.

The exclusion criteria encompass: (1) Concomitant major diseases related to the nervous system (epilepsy, brain tumors, Parkinson's disease, etc.); (2) History of mental disease (major depressive disorder, anxiety disorder, schizophrenia, etc.); (3) Concomitant active infections, autoimmune diseases, or severe internal medicine diseases; (4) In the pregnancy or lactating period; (5) Lack of continuous postoperative care or insufficient family cooperation; (6) Presence of severe communication disorders or aphasia; (7) Currently receiving other psychological interventions.

### **2.3. Collection of baseline data**

Preoperatively, we recorded the patients' general data and disease information,

including age, sex, body mass index (BMI), education level, employment status, marital status, drinking and smoking history, history of chronic underlying diseases (hypertension, diabetes, etc.), Karnofsky Performance Status Scale (KPS) scores, neurological function grading, and history of antidepressant or anti-anxiety medications.

#### **2.4. Nursing care interventions**

The control group experienced routine perioperative nursing care, including preoperative health education, intraoperative monitoring, and postoperative rehabilitation management. Based on routine nursing care, the treatment group was subjected to perioperative psychological intervention. The intervention period spanned from 1 day before surgery to Day 5 after surgery, using a multi-dimensional intervention strategy based on the “psychoneuroimmune axis”. The specific process is as follows:

Preoperative intervention (starting from 1 day prior to surgery)

- (1) Classify the mental states as per Zung’s Self-Rating Anxiety Scale (SAS), Self-Rating Depression Scale (SDS), Perceived Stress Scale (PSS-10), and Social Support Rating Scale (SSRS);
- (2) High-anxiety patients received mindfulness meditation training twice daily (9:00 and 17:00), 20 min each session;
- (3) Depression-stress patients underwent cognitive reconstructing training once daily, 20 min each time, focusing on the automatic identification of adverse thoughts and cognitive re-assessment;
- (4) Composite patients received muscular relaxation training twice daily (10:00 and 16:00), 30 min each session, including systematic training of the face, neck and shoulders, limbs, and abdomen.

Postoperative intervention (from Day 1 to Day 5 after surgery)

- (1) Continue the individualized psychological intervention strategy matched prior to surgery;
- (2) Play soothing classical music for 30 min at 22:00 each night, using audio in the  $\alpha$  wave frequency range, with the volume controlled at 30–40 decibels;
- (3) The principal nurse was responsible for conducting empathic communication support once daily, 15 min each time, to encourage the patients to express their anxious feelings and voluntarily participate in rehabilitation decision-making. Empathic communication involved active listening, validating patients’ emotions (e.g., acknowledging fears about surgery or prognosis), and using open-ended questions (e.g., “Can you share how you’re feeling about the upcoming procedure?”) to foster trust and encourage shared decision-making. Nurses were trained in empathic techniques, such as reflective listening and emotional validation, during a two-day workshop to ensure consistent delivery;
- (4) Instruct the family members to record the patients’ daily sleep quality, emotional fluctuations, and degree of participation in self-care.

To ensure consistency across nurses and patients, all interventions were guided by a standardized manual based on Mindfulness-Based Stress Reduction (MBSR) and Cognitive Behavioral Therapy (CBT) protocols. Nurses underwent a two-day training

program led by certified instructors, covering theoretical and practical components of mindfulness, cognitive restructuring, and progressive muscle relaxation. The training included lectures on psychoneurointeraction principles, hands-on practice of intervention techniques, and a skills assessment to confirm competency. Intervention fidelity was monitored through weekly supervisory sessions conducted by the research team, random audits of 10% of intervention sessions via audio recordings, and the use of standardized adherence checklists, achieving a 95% compliance rate. For example, the mindfulness meditation protocol included a guided breathing exercise where patients were instructed to focus on their breath for 20 min while the nurse provided standardized verbal cues such as, “Notice the sensation of your breath as it flows in and out.” These measures ensured that mindfulness, cognitive restructuring, and other intervention components were delivered consistently across all participants.

## 2.5. Assessment of indicators and collection of data

Psychological state-related parameters encompass SAS and SDS scales, which were completed for assessments 1 day before surgery, as well as on Days 3 and 7 postoperatively, and a score  $\geq 50$  suggested positivity. The sleep quality was determined by the Pittsburgh Sleep Quality Index (PSQI) scale, which was completed preoperatively and on Day 7 after surgery, and a score  $> 7$  indicated poor sleep quality. Perceived stress (via PSS-10) was assessed preoperatively and on Day 3 after surgery. In terms of physiological indicators, blood sampling was conducted before surgery and on Day 3 after surgery for determination of serum cortisol through radioimmunoassay. 5-HT and dopamine were examined using the enzyme-linked immunosorbent assay (ELISA) at the same time point. Inflammatory factors interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- $\alpha$ ) were evaluated through the double antibody sandwich method. Heart rate variability (HRV) parameters [standard deviation of NN intervals (SDNN) and root mean square of successive differences (RMSSD)] were obtained via Holter monitoring before surgery and on Day 2 post-surgery. Saliva samples were collected preoperatively and on Days 1, 3, and 5 in the morning for determination of  $\alpha$ -amylase, with the enzyme rate assay utilized to confirm its activity.

## 2.6. Data analysis methods

All data were subjected to statistical analysis using SPSS 26.0 software. The measurement data were displayed as  $\bar{x} \pm s$  after normality testing, comparisons between groups were conducted using the independent sample *t*-test, and within-group comparisons before and after intervention were performed using paired *t*-tests. Data that did not meet normal distribution were analyzed via non-parametric testing. The enumeration data were represented as frequencies and percentages, with inter-group comparisons achieved through  $\chi^2$  testing. Multivariate analysis of influencing factors was performed with the use of a Logistic regression model. A significance level of  $\alpha = 0.05$  was set, while  $P < 0.05$  denoted statistically significant variances.

To assess the clinical significance of intervention effects, Cohen's *d* was calculated for primary psychological outcomes (SAS, SDS, and PSS-10) using the formula:  $d = (\text{Mean1} - \text{Mean2}) / \text{Pooled SD}$ , with effect sizes interpreted as small (0.2),

medium (0.5), or large (0.8). To examine whether neuroendocrine changes mediated psychological improvements, mediation analyses were conducted using the Baron and Kenny approach, testing the indirect effect of the intervention on SAS and SDS scores through changes in serum cortisol levels on Day 3 post-surgery. The significance of indirect effects was assessed using Sobel tests, with bootstrapping to confirm robustness.

### 3. Results

#### 3.1. Comparison of general data

The results from a comparison of baseline data between the two groups of patients showed that no remarkable differences were found in age, sex, BMI, education background, marital status, drinking and smoking history, history of chronic underlying diseases like hypertension and diabetes, or KPS scores ( $P > 0.05$ ). Therefore, the baseline data from the two groups exhibited comparability. See **Table 1**.

**Table 1.** Comparison of baseline data between the two groups.

| Item                                                      | Treatment group ( $n = 42$ ) | Control group ( $n = 42$ ) | $t$ value/ $\chi^2$ value | $P$ value |
|-----------------------------------------------------------|------------------------------|----------------------------|---------------------------|-----------|
| Age (years)                                               | $55.3 \pm 10.2$              | $54.9 \pm 9.8$             | 0.22                      | 0.826     |
| Sex (male/female)                                         | 24/18                        | 23/19                      | 0.026                     | 0.871     |
| BMI ( $\text{kg}/\text{m}^2$ )                            | $24.7 \pm 2.9$               | $24.5 \pm 2.7$             | 0.208                     | 0.835     |
| Education level (primary school/secondary school/college) | 10/20/12                     | 11/19/12                   | 0.063                     | 0.97      |
| Marital status (married/unmarried)                        | 30/12                        | 31/11                      | 0.183                     | 0.669     |
| Smoking history (yes/no)                                  | 15/27                        | 14/28                      | 0.051                     | 0.821     |
| Drinking history (yes/no)                                 | 10/32                        | 11/31                      | 0.215                     | 0.643     |
| Hypertension (yes/no)                                     | 19/23                        | 21/21                      | 0.209                     | 0.647     |
| Diabetes (yes/no)                                         | 8/34                         | 7/35                       | 0.091                     | 0.763     |
| KPS scores (0–100)                                        | $90.2 \pm 7.1$               | $89.8 \pm 7.3$             | 0.153                     | 0.878     |

#### 3.2. Mental state changes post-intervention

Assessments were made on the mental states of patients in the treatment group and the control group before surgery, on Day 3, and on Day 7 after surgery. On Days 3 and 7 after surgery, the treatment group displayed notably lowered scores of SAS, SDS, and PSS-10 compared with those of the control group ( $P < 0.05$ ). On Day 3 postoperatively, the scores of SAS, SDS, and PSS-10 decreased by 12.5, 11.2, and 8.3 points, respectively, compared with preoperative levels, while the control group showed reductions of 3.2, 4.5, and 2.1 points. The intervention demonstrated large effect sizes for anxiety reduction (Cohen's  $d = 0.99$  on Day 3, 1.31 on Day 7), depression reduction (Cohen's  $d = 0.71$  on Day 3, 0.94 on Day 7), and stress reduction (Cohen's  $d = 0.89$  on Day 3, 0.84 on Day 7), indicating clinically significant improvements. Refer to **Table 2**.

**Table 2.** Changes in mental states before and after surgery in the two groups.

| Time point                 | Treatment group ( <i>n</i> = 42) | Control group ( <i>n</i> = 42) | <i>P</i> value | Cohen's <i>d</i> |
|----------------------------|----------------------------------|--------------------------------|----------------|------------------|
| <b>Before surgery</b>      |                                  |                                |                |                  |
| SAS (anxiety score)        | 53.6 ± 10.2                      | 54.2 ± 10.5                    | 0.813          |                  |
| SDS (depression score)     | 50.1 ± 11.1                      | 51.0 ± 11.5                    | 0.724          |                  |
| PSS-10 (stress score)      | 27.4 ± 6.9                       | 27.1 ± 7.0                     | 0.926          |                  |
| <b>Day 3 after surgery</b> |                                  |                                |                |                  |
| SAS (anxiety score)        | 41.1 ± 9.8                       | 51.0 ± 10.1                    | 0.001          | 0.99             |
| SDS (depression score)     | 38.9 ± 10.4                      | 46.5 ± 11.0                    | 0.004          | 0.71             |
| PSS-10 (stress score)      | 19.1 ± 6.2                       | 24.9 ± 6.8                     | 0.002          | 0.89             |
| <b>Day 7 after surgery</b> |                                  |                                |                |                  |
| SAS (anxiety score)        | 37.3 ± 9.2                       | 49.7 ± 9.8                     | 0.001          | 1.31             |
| SDS (depression score)     | 35.6 ± 9.5                       | 45.1 ± 10.7                    | 0.004          | 0.94             |
| PSS-10 (stress score)      | 18.3 ± 5.7                       | 23.4 ± 6.4                     | 0.002          | 0.84             |

### 3.3. Changes in neuroendocrine parameters

In terms of alterations in neuroendocrine parameters following surgery, the intervention group presented with significant improvements in several physiological indicators. The treatment group exhibited remarkably lowered levels of serum cortisol on Day 3 after surgery in contrast with before-surgery levels, as well as significant reductions compared with the control group. This finding confirmed that psychological intervention might effectively reduce postoperative physiological stress responses. Furthermore, the level of 5-HT was markedly heightened on Day 3 after surgery in the treatment group, demonstrating the positive impact of psychological intervention on the neuroregulatory function, despite no substantial differences in dopamine levels between the two groups. The levels of IL-6 and TNF- $\alpha$  were evidently lowered in the treatment group in contrast with before-surgery levels and compared with those in the control group. As for HRV, SDNN and RMSSD were dramatically elevated on Day 2 following surgery in the treatment group, which reflected the promoting effect of psychological intervention on automatic nervous system recovery. Additionally, the salivary  $\alpha$ -amylase activity was abated on Days 1, 3, and 5 after surgery in the intervention group compared with before surgery, which indicated the positive influence of the intervention on reducing physiological stress. Mediation analyses revealed that reductions in serum cortisol levels on Day 3 partially mediated the intervention's effect on anxiety (indirect effect:  $\beta = 0.15$ ,  $p = 0.03$ , Sobel test  $z = 2.14$ ,  $p = 0.03$ , 95% CI: 0.02–0.28) and depression (indirect effect:  $\beta = 0.12$ ,  $p = 0.04$ , Sobel test  $z = 1.98$ ,  $p = 0.048$ , 95% CI: 0.01–0.24), with bootstrapping confirming the significance of indirect effects. All in all, during the postoperative recovery process, the treatment group demonstrated prominent advantages in alleviating stress, improving inflammatory responses, and boosting automatic nervous system recovery. This observation suggested that individualized psychological nursing care intervention had a significant boosting effect on patients' physiological recovery following surgery. See **Table 3**.

**Table 3.** Comparison of physiological indicator changes between the two groups.

| Indicator                 | Time point          | Treatment group ( <i>n</i> = 42) | Control group ( <i>n</i> = 42) | <i>P</i> value |
|---------------------------|---------------------|----------------------------------|--------------------------------|----------------|
| Serum cortisol (μg/dL)    | Before surgery      | 16.4 ± 5.1                       | 15.9 ± 4.8                     | 0.615          |
|                           | Day 3 after surgery | 10.2 ± 3.5                       | 13.1 ± 4.2                     | 0.005          |
| 5-HT (ng/mL)              | Before surgery      | 156.3 ± 22.4                     | 157.2 ± 21.9                   | 0.912          |
|                           | Day 3 after surgery | 188.5 ± 20.1                     | 171.2 ± 19.5                   | 0.043          |
| Dopamine (ng/mL)          | Before surgery      | 68.3 ± 15.6                      | 67.8 ± 16.1                    | 0.845          |
|                           | Day 3 after surgery | 72.1 ± 14.2                      | 70.0 ± 15.8                    | 0.18           |
| IL-6 (pg/mL)              | Before surgery      | 8.1 ± 2.3                        | 7.9 ± 2.1                      | 0.642          |
|                           | Day 3 after surgery | 5.2 ± 1.9                        | 6.5 ± 2.3                      | 0.02           |
| TNF-α (pg/mL)             | Before surgery      | 7.5 ± 2.4                        | 7.4 ± 2.2                      | 0.788          |
|                           | Day 3 after surgery | 5.1 ± 1.8                        | 6.3 ± 2.0                      | 0.038          |
| SDNN (ms)                 | Before surgery      | 45.3 ± 6.7                       | 44.8 ± 6.2                     | 0.812          |
|                           | Day 2 after surgery | 50.1 ± 7.3                       | 47.3 ± 7.6                     | 0.029          |
| RMSSD (ms)                | Before surgery      | 38.1 ± 6.2                       | 37.5 ± 5.9                     | 0.704          |
|                           | Day 2 after surgery | 42.3 ± 7.0                       | 39.1 ± 6.4                     | 0.035          |
| Salivary α-amylase (U/mL) | Before surgery      | 112.5 ± 25.4                     | 110.3 ± 27.1                   | 0.731          |
|                           | Day 1 after surgery | 95.2 ± 21.3                      | 107.3 ± 25.9                   | 0.085          |
|                           | Day 3 after surgery | 88.7 ± 19.2                      | 106.5 ± 23.3                   | 0.043          |
|                           | Day 5 after surgery | 85.3 ± 18.7                      | 104.9 ± 22.1                   | 0.027          |

## 4. Discussion

This study explored the application of individualized psychological nursing intervention based on the psycho-neural interaction model, integrated with established psycho-oncology frameworks, in the psychological and physiological recovery of glioblastoma (GBM) patients during the perioperative period. By aligning with the biopsychosocial model and stress-coping frameworks, our intervention leverages the interplay of psychological, biological, and social factors to address the unique challenges faced by GBM patients, such as tumor-related inflammation and prognostic uncertainty [6,7]. This study explored the application of individualized psychological nursing care intervention based on neural interactions in the psychological and physiological recovery of GBM patients during the perioperative period. The study results revealed that individualized psychological intervention could significantly alleviate patients' anxiety and depression and modulate the neuroendocrine and immune systems, hence promoting postoperative recovery. This observation provided a new theoretical basis for nursing care in the perioperative period and offered more precise nursing regimens for clinical practice.

In the perioperative period, particularly the early period of postoperation, patients usually experience adverse emotions such as anxiety, depression, and stress. These emotions not only influence their mental health but also obstruct physiological recovery [12,13]. In the context of GBM, these psychological burdens are exacerbated by the tumor's invasiveness, poor prognosis, and surgical uncertainties, which amplify stress responses through neuroendocrine pathways [6]. Our study findings demonstrated that the treatment group had substantially lower scores of anxiety,

depression, and perceived stress on Days 3 and 7 postoperatively compared with the control group, which indicated that individualized psychological nursing care intervention could evidently ameliorate adverse feelings in the early period of postoperation. This effect may be associated with the impact of psychological nursing care intervention on the nervous system. Adverse emotions tend to activate the HPA axis and cause increases in the secretion of stress hormones like cortisol. Consistently high levels of cortisol will aggravate psychological discomfort and lead to immune dysfunction and inflammatory responses, hence impeding wound healing and increasing postoperative complications [14]. Specifically, in GBM patients, tumor-related neuroinflammation and surgical stress may further dysregulate the HPA axis, intensifying cortisol-driven psychological distress [8]. Individualized psychological interventions, such as mindfulness and cognitive restructuring, likely mitigate these effects by reducing HPA axis overactivation, thereby alleviating anxiety and depression and supporting recovery in the cancer-specific context of GBM. Thus, individualized psychological intervention can deal with anxiety, depression, stress, and other adverse feelings in the early postoperative period and effectively ameliorate postoperative physiological stress responses, providing a favorable circumstance for patients' recovery.

Regarding physiological reactions, the study demonstrated that individualized psychological nursing care intervention notably improved the levels of cortisol, 5-HT, and inflammatory factors for patients in the treatment group. Cortisol is a stress hormone secreted by the adrenal glands, and it's usually elevated when the patient experiences psychological or physiological stress [15]. In GBM patients, elevated cortisol levels are particularly detrimental due to the tumor's impact on brain function and the heightened stress of surgery, which can exacerbate immunosuppression and neuroinflammation [8]. Excessively high cortisol levels after surgery may contribute to immunosuppression and increase postoperative complications [16,17]. This research found that the treatment group showed notably lowered serum cortisol levels on Day 3 after surgery versus before surgery, as well as compared with those in the control group. This finding confirmed that individualized psychological nursing care intervention effectively abated postoperative physiological stress responses by modulating the neuroendocrine system. In addition, the levels of 5-HT were dramatically increased on Day 3 after surgery in the treatment group. Serotonin, namely 5-HT, is a primary neurotransmitter in the brain, widely involved in emotional regulation, anxiety amelioration, and pain management [18]. In the GBM context, 5-HT dysregulation is often linked to mood disturbances due to tumor-induced neurological changes and prognostic uncertainty [9]. The observed increase in 5-HT levels likely reflects the intervention's role in enhancing prefrontal cortex-mediated emotional regulation, thereby reducing anxiety and depression and supporting postoperative pain management. 5-HT increases may be inextricably correlated with the function of psychological intervention in improving emotional states and ameliorating anxiety and depression, while providing physiological support for postoperative pain management [19]. Therefore, the regulation of 5-HT levels by psychological nursing care intervention may be a significant foundation for improving emotional states and physiological recovery. Our study also found that the levels of IL-6 and TNF- $\alpha$  were evidently lower on Day 3 after surgery in the treatment group

compared with before-surgery levels and those in the control group. Inflammatory responses play a significant part in stress responses. Long-term inflammatory responses are associated with poor postoperative recovery and the occurrence of complications [20]. In GBM, tumor-related neuroinflammation amplifies these responses, making the reduction of IL-6 and TNF- $\alpha$  particularly critical for mitigating postoperative complications. By reducing inflammatory factors, individualized psychological nursing care intervention can help facilitate wound healing and lower the incidence of postoperative complications.

Apart from improvements in emotional regulation and physiological indicators, the treatment group also displayed substantial increases in HRV indicators like SDNN and RMSSD on Day 2 after surgery. HRV serves as a critical indicator for automatic nervous system functions and reflects the balance between sympathetic nerves and parasympathetic nerves. Heightened HRV levels are usually linked to lowered stress levels and superior autonomic nervous function [21]. Studies have revealed that increased HRV levels denote the recovery of the nervous system and bear a close relation to patients' mental states [22]. In GBM patients, HRV improvements are particularly significant, as tumor-induced neurological disruptions and surgical stress can impair autonomic balance, exacerbating psychological and physiological stress. Therefore, the HRV improvements observed in the treatment group on Day 2 after surgery further indicated that individualized psychological nursing care could assist in the recovery of the automatic nervous system. Moreover, the activity of salivary  $\alpha$ -amylase (a physiological stress biomarker) decreased substantially on Days 1, 3, and 5 after surgery compared with before surgery, which further demonstrated the positive effect of psychological intervention on alleviating physiological stress. Salivary  $\alpha$ -amylase activity tends to be closely linked to the activities of sympathetic nerves, and its increase often reflects that the body is in a relatively high stress state [23]. Individualized psychological nursing care can help ameliorate postoperative physiological stress responses by lowering salivary  $\alpha$ -amylase activity, hence boosting postoperative recovery.

During the intervention process, mindfulness training, progressive muscle relaxation (PMR), cognitive restructuring, and other intervention methods play a significant role. Among them, mindfulness training can help patients strengthen their emotional regulation capability, reduce the occurrence of anxiety and depression, and ameliorate the excessive activation of the nervous system by influencing the self-regulating function of the cerebral cortex [24,25]. PMR can relax the sympathetic nervous system, lower cortisol levels, abate stress responses, and thus improve the immune function [26,27]. Cognitive restructuring assists patients in adjusting unreasonable cognitive patterns, enhancing coping strategies, improving their mental resilience, and hence promoting postoperative recovery [28]. These interventions align with the stress-coping framework, which posits that effective coping strategies mitigate stress by enhancing cognitive appraisal and emotional regulation, particularly in high-stress cancer contexts like GBM [7]. By targeting neuroendocrine pathways, such as cortisol and 5-HT regulation, these methods address the unique psychological and physiological challenges of GBM patients, supporting the psycho-neural interaction model's application in psycho-oncology. The above mechanisms all demonstrate that individualized psychological nursing care intervention can improve

patients' mental states and further boost postoperative recovery through modulation of neuroimmune responses. Our findings provided strong evidence-based support for the use of psychological interventions to modulate neural interaction mechanisms in perioperative nursing care.

The clinical significance of this study lies in promoting a shift in nursing practice from a disease-centered approach to a patient-centered model, offering a more evidence-based and comprehensive care strategy. Traditional nursing care models focus primarily on the treatment of the disease itself, usually overlooking the critical role of patients' emotional and psychological states in the recovery process [29]. With the increasing adoption of the biopsychosocial model in medicine, a growing body of research has supported that mental health and emotional status have a direct impact on the recovery of patients [30,31]. Our study builds on the biopsychosocial model by integrating the psycho-neural interaction model, demonstrating that personalized psychological interventions can address the complex interplay of psychological, neuroendocrine, and immune factors in GBM patients. This approach is particularly critical for GBM patients, who face heightened psychological distress due to the tumor's aggressive nature and poor prognosis, which exacerbate neuroendocrine dysregulation and impair recovery. Building on this concept, the present study proposed a model of individualized psychological nursing care intervention and demonstrated its effectiveness in clinical practice. For GBM patients, perioperative psychological intervention is of great importance. We found that the patients were generally confronted with preoperative and postoperative anxiety and depression issues, which affected their mental health and might lead to poor postoperative recovery and heightened incidence of complications. As evidenced by our study findings, patients' emotional states were obviously improved through individualized psychological intervention, which also contributed to better postoperative recovery. The nursing care model proposed by our study has distinct personalized characteristics. The content of nursing care intervention is based on patients' specific needs and mental states so as to achieve the optimal therapeutic effect. This individualized method can better satisfy the diverse needs of patients, enhance their compliance with treatment and nursing satisfaction, and promote the development of the patient-oriented nursing concept. Via this individualized nursing care strategy, patients can obtain emotional support and achieve satisfactory physiological recovery effects. For example, one patient noted, "The nurse really listened when I shared my fears about losing independence, which made me feel understood and more confident in my recovery plan." Another patient expressed, "Talking openly with the nurse about my worries helped me feel less alone before surgery." In resource-limited settings, nurses can implement this model by using brief SAS, SDS, and PSS-10 scales, which take 5–10 min to administer with minimal training, and delivering low-cost mindfulness meditation and progressive muscle relaxation sessions (15–30 min daily), requiring only a two-day training program and no specialized equipment, allowing integration into busy clinical workflows. To enhance patient-centered care, nurses can integrate brief, validated tools like the PSS-10 (3–5 min) and SAS (5–7 min) into preoperative assessments during routine patient intake, such as within history-taking or admission evaluations, using paper-based or digital formats. These assessments, requiring only a 2-h training module added to standard oncology nursing education, can be completed

in 10–15 min and guide tailored interventions, such as increasing mindfulness sessions for high PSS-10 scores or empathic communication for high SAS scores, optimizing emotional support and treatment outcomes in busy clinical workflows. Although our follow-up was short, sustained psychological support, such as ongoing mindfulness and empathic communication, may enhance [policy://x.com/SeilerA2019PsychoOncol](https://doi.org/10.1186/s12954-019-0219-0) enhance resilience, potentially improving long-term survival, quality of life, and treatment adherence in GBM patients by fostering adaptive coping and emotional regulation, as supported by psycho-oncology frameworks [32].

Although this research has made significant achievements, it still contains some limitations. This study adopts a single-center design with a small sample size, which may influence the generalizability of the results. The sample size ( $n = 84$ ) was determined based on a power analysis assuming a medium effect size (Cohen's  $d = 0.5$ ) for primary outcomes (e.g., anxiety and depression scores), with a significance level of  $\alpha = 0.05$  and power of 0.8, indicating sufficient power to detect clinically meaningful differences. However, the relatively small sample size may limit the robustness of findings, particularly for detecting smaller effect sizes or subgroup differences. Additionally, the use of convenience sampling in a single-center setting may introduce selection bias, as the sample may not fully represent the broader GBM patient population in terms of demographic or clinical characteristics. The quasi-experimental design, while controlled for key confounders through randomization, may still be subject to unmeasured confounding factors. In future studies, multi-center, large-sample randomized controlled trials are recommended to enhance generalizability and reduce bias. Moreover, stratifying participants by baseline anxiety and depression severity could better account for psychological heterogeneity and refine intervention effects. Moreover, this study involves a relatively short follow-up period and fails to assess the impact of the intervention on patients' long-term recovery. In the future, the follow-up duration may be elongated to confirm the long-term effects of psychological nursing care interventions, particularly on the quality of life, neurological function recovery, and complication incidence. Furthermore, future studies could explore the neural mechanisms underlying these interventions using neuroimaging techniques, such as functional magnetic resonance imaging (fMRI), to elucidate how psychological interventions modulate brain activity in GBM patients, aligning with the psycho-neural interaction model and psycho-oncology frameworks.

## 5. Conclusion

In summary, our study, based on neural interactions, has for the first time introduced the method of individualized psychological nursing care intervention. By integrating the psycho-neural interaction model with psycho-oncology frameworks, such as the biopsychosocial model and stress-coping frameworks, this approach effectively improves the preoperative and postoperative mental states of GBM patients, regulates neuroendocrine and immune responses, and facilitates postoperative recovery in the cancer-specific context. Our findings have revealed this individualized pattern provides a new nursing model for patients with malignant tumors and shows significant clinical application value. Despite the aforementioned limitations, this model can offer new ways of thinking for future studies and clinical nursing practice.

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**Ethical approval:** This study has been approved by the Medical Ethics Review Committee of the School of Medicine, Yanbian University. Ethical approval number: (202504301).

**Informed consent statement:** Informed consent was obtained from all subjects involved in the study.

**Availability of data and materials:** The datasets used during the current study are available from the corresponding author upon reasonable request.

**Conflict of interest:** The authors declare no conflict of interest.

## References

1. Xu Z, Rui YN, Hagan JP, et al. Intracranial aneurysms: Pathology, genetics, and molecular mechanisms. *NeuroMolecular Medicine*. 2019; 21(4): 325-343. doi: 10.1007/s12017-019-08537-7
2. Robba C, Busl KM, Claassen J, et al. Contemporary management of aneurysmal subarachnoid haemorrhage. An update for the intensivist. *Intensive Care Medicine*. 2024; 50(5): 646-664. doi: 10.1007/s00134-024-07387-7
3. Xie A, Duff J, Munday J. Perioperative nursing shortages: An integrative review of their impact, causal factors, and mitigation strategies. *Journal of Nursing Management*. 2024; 2024(1). doi: 10.1155/2024/2983251
4. Hiller JG, Perry NJ, Poulogiannis G, et al. Perioperative events influence cancer recurrence risk after surgery. *Nature Reviews Clinical Oncology*. 2017; 15(4): 205-218. doi: 10.1038/nrclinonc.2017.194
5. Lee KS, Zhang JJY, Nguyen V, et al. The evolution of intracranial aneurysm treatment techniques and future directions. *Neurosurgical Review*. 2021; 45(1): 1-25. doi: 10.1007/s10143-021-01543-z
6. Engel GL. The need for a new medical model: A challenge for biomedicine. *Science*. 1977; 196(4286): 129-136. doi: 10.1126/science.847460
7. Folkman S, Lazarus RS, Gruen RJ, et al. Appraisal, coping, health status, and psychological symptoms. *Journal of Personality and Social Psychology*. 1986; 50(3): 571-579. doi: 10.1037/0022-3514.50.3.571
8. Chrousos GP. Stressors, stress, and neuroendocrine integration of the adaptive response: The 1997 Hans Selye Memorial Lecture. *Annals of the New York Academy of Sciences*. 1998; 851: 311-335. doi: 10.1111/j.1749-6632.1998.tb09006.x
9. Young SN, Leyton M. The role of serotonin in human mood and social interaction. Insight from altered tryptophan levels. *Pharmacology, Biochemistry, And Behavior*. 2002; 71(4): 857-865. doi: 10.1016/S0091-3057(01)00670-0
10. Kalisch R, Russo SJ, Müller MB. Neurobiology and systems biology of stress resilience. *Physiological Reviews*. 2024; 104(3): 1205-1263. doi: 10.1152/physrev.00042.2023
11. Yan Q. Neuroimmune imbalances and yin-yang dynamics in stress, anxiety, and depression. *Methods in Molecular Biology*. 2018; 1781: 77-85.
12. Zhu RY, Chen H, Gao YJ, et al. Effects of psychological nursing care on anxiety and depression in perioperative patients with lung cancer: A systematic review and meta-analysis. *Medicine*. 2022; 101(29): e29914. doi: 10.1097/md.00000000000029914
13. Zhao L, Ma L, Chen X, et al. Psychological nursing intervention improve the mental health status of young patients with lung cancer surgery during the perioperative period. *Medicine*. 2021; 100(31): e26736. doi: 10.1097/md.00000000000026736
14. Teixeira AL, Scholl JN, Bauer ME. Psychoneuroimmunology of mood disorders. *Methods in Molecular Biology*. 2025; 2868: 49-72.
15. Lee JH, Meyer EJ, Nenke MA, et al. Cortisol, stress, and disease—Bidirectional associations; Role for corticosteroid-binding

- globulin?. *The Journal of Clinical Endocrinology & Metabolism*. 2024; 109(9): 2161-2172. doi: 10.1210/clinem/dgae412
16. Knezevic E, Nenic K, Milanovic V, et al. The role of cortisol in chronic stress, neurodegenerative diseases, and psychological disorders. *Cells*. 2023; 12(23): 2726. doi: 10.3390/cells12232726
  17. Zefferino R, Di Gioia S, Conese M. Molecular links between endocrine, nervous and immune system during chronic stress. *Brain and Behavior*. 2020; 11(2). doi: 10.1002/brb3.1960
  18. Sharp T, Barnes NM. Central 5-HT receptors and their function; present and future. *Neuropharmacology*. 2020; 177: 108155. doi: 10.1016/j.neuropharm.2020.108155
  19. Smith ALW, Harmer CJ, Cowen PJ, et al. The Serotonin 1A (5-HT1A) receptor as a pharmacological target in depression. *CNS Drugs*. 2023; 37(7): 571-585. doi: 10.1007/s40263-023-01014-7
  20. Glaser R, Kiecolt-Glaser JK. Stress-induced immune dysfunction: implications for health. *Nature Reviews Immunology*. 2005; 5(3): 243-251. doi: 10.1038/nri1571
  21. Arakaki X, Arechavala RJ, Choy EH, et al. The connection between heart rate variability (HRV), neurological health, and cognition: A literature review. *Frontiers in Neuroscience*. 2023; 17. doi: 10.3389/fnins.2023.1055445
  22. Immanuel S, Teferra MN, Baumert M, et al. Heart rate variability for evaluating psychological stress changes in healthy adults: A scoping review. *Neuropsychobiology*. 2023; 82(4): 187-202. doi: 10.1159/000530376
  23. Engeland CG, Bosch JA, Rohleder N. Salivary biomarkers in psychoneuroimmunology. *Current Opinion in Behavioral Sciences*. 2019; 28: 58-65. doi: 10.1016/j.cobeha.2019.01.007
  24. Goldberg SB, Anders C, Stuart-Maver SL, et al. Meditation, mindfulness, and acceptance methods in psychotherapy: A systematic review. *Psychotherapy Research*. 2023; 33(7): 873-885. doi: 10.1080/10503307.2023.2209694
  25. Prakash RS, Shankar A, Tripathi V, et al. Mindfulness meditation and network neuroscience: Review, synthesis, and future directions. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*. 2025; 10(4): 350-358. doi: 10.1016/j.bpsc.2024.11.005
  26. Ruano A, García-Torres F, Gálvez-Lara M, et al. Psychological and non-pharmacologic treatments for pain in cancer patients: A systematic review and meta-analysis. *Journal of Pain and Symptom Management*. 2022; 63(5): e505-e520. doi: 10.1016/j.jpainsymman.2021.12.021
  27. Raad G, Tanios J, Azoury J, et al. Neurophysiology of cognitive behavioural therapy, deep breathing and progressive muscle relaxation used in conjunction with ART treatments: A narrative review. *Human Reproduction Update*. 2020; 27(2): 324-338. doi: 10.1093/humupd/dmaa048
  28. Wenzel A. Basic strategies of cognitive behavioral therapy. *Psychiatric Clinics of North America*. 2017; 40(4): 597-609. doi: 10.1016/j.psc.2017.07.001
  29. Younas A, Quennell S. Usefulness of nursing theory-guided practice: an integrative review. *Scandinavian Journal of Caring Sciences*. 2019; 33(3): 540-555. doi: 10.1111/scs.12670
  30. Jacob KS. Perspectives about mental health, illness, and recovery. *Current Opinion in Psychiatry*. 2017; 30(5): 334-338. doi: 10.1097/ycp.0000000000000346
  31. Higgins A, McBennett P. The petals of recovery in a mental health context. *British Journal of Nursing*. 2007; 16(14): 852-856. doi: 10.12968/bjon.2007.16.14.24322
  32. Seiler A, Jenewein J. Resilience in Cancer Patients. *Frontiers in Psychiatry*. 2019; 10. doi: 10.3389/fpsy.2019.00208