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Analysis of Factors Influencing the Psychological State of Patients After Autologous Liver Transplantation

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEF **Ting Zhang**
AG **Songnian Fu**

Department of Psychological Medicine, The First Affiliated Hospital of Xinjiang Medical University, State Key Laboratory of Pathogenesis, Prevention and Treatment of High Incidence Diseases in Central Asia, Urumqi, Xinjiang, PR China

APPROVED GALLEY PROOF

Corresponding Author: Songnian Fu, Department of Psychosomatic Medicine, The First Affiliated Hospital of Xinjiang Medical University, No. 137 Liyushan South Road, Urumqi, Xinjiang 830054, P.R. China, Phone: +86-15199088337, e-mail: 15199088337@163.com
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Background: The use of ex vivo liver resection and autologous liver transplantation (ELRA) for end-stage hepatic alveolar echinococcosis is gradually increasing, while postoperative psychological disorders in these patients remain underrecognized. We prespecified that longer pre-transplant waiting time, postoperative complications, and higher transfusion volume would be associated with worse anxiety, depression, and sleep disturbance at 1 month after ELRA.

Material/Methods: This single-center retrospective study enrolled 138 patients who underwent ELRA from 2020 to 2025. We collected demographic data, perioperative clinical indexes, and scores at baseline and 1 month postoperatively using the Self-Rating Anxiety Scale (SAS), Self-Rating Depression Scale (SDS), Hamilton Anxiety Rating Scale (HAMA), Hamilton Depression Rating Scale (HAMD), and Pittsburgh Sleep Quality Index (PSQI). Univariate analysis and multivariate linear regression were used to identify independent influencing factors.

Results: Longer pre-transplant waiting time independently predicted worse scores across all psychological and sleep scales (all $P<0.05$). Prolonged anhepatic phase duration was specifically associated with higher PSQI scores ($P<0.05$). Intraoperative transfusion showed marginal but nonsignificant associations, and postoperative complications were significant only in univariate analysis.

Conclusions: Longer pre-transplant waiting time is the core and most consistent risk factor for poor mental health after ELRA, while prolonged anhepatic phase is specifically linked to postoperative sleep disturbance. These findings support the implementation of targeted, stage-specific psychological interventions, especially during the pre-transplant waiting period, to improve mental health and quality of life in patients undergoing ELRA.

Keywords: **Anxiety • Depression • Liver Transplantation**

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Introduction

Overview of Echinococcosis and Liver Transplantation

Echinococcosis, also known as hydatid disease, is a parasitic infection caused by the larvae of the tapeworm *Echinococcus* in humans [1-3]. Once hydatid larvae enter the human body, they can invade various organs, causing particularly severe damage to the liver [4,5]. It represents a significant contemporary global public health issue, with severe endemicity in China's northwestern pastoral and semi-pastoral regions [6]. Most patients require surgical intervention after diagnosis, with radical resection of lesions combined with antiparasitic drug therapy offering the best chance of cure [7]. Liver transplantation is the ultimate treatment option [5]; however, conventional allogeneic liver transplantation (using living donors or organs from brain-dead or cardiac-dead donors) necessitates lifelong immunosuppressive therapy, increasing the risk of recurrence or reinfection [8,9]. Additionally, living liver donors face significant psychological challenges [10,11]. For patients with unresectable end-stage hepatic alveolar echinococcosis, ex vivo liver resection with autologous liver transplantation (ELRA) has emerged as a definitive curative option, representing a major advance over conventional allogeneic liver transplantation. Unlike allogeneic transplantation, ELRA eliminates organ donor dependency and the need for lifelong immunosuppressive therapy, thereby reducing the risk of recurrence, reinfection, and rejection [12]. As the ELRA patient population continues to grow, increasing attention is being directed toward their mental health status and quality of life across various clinical and research fields.

Psychological Status of Liver Transplant Patients

Patients undergoing liver transplantation frequently endure persistent disruptions to physiological function both pre- and postoperatively, which often preclude their return to full-time employment. This results in diminished household income at a time of escalating medical costs, thereby amplifying financial strain and material hardship. Family support is frequently constrained, creating a mismatch between available resources and patient needs that contributes to inadequate objective social support. Additionally, visible post-surgical scarring may foster feelings of diminished self-worth or body image concerns, which can in turn lead to social withdrawal or avoidance of interpersonal interactions. Although the mental health status of patients receiving conventional allogeneic liver transplantation has been extensively investigated, such research findings cannot be directly generalized to patients undergoing ELRA, who are confronted with unique psychological stressors. Patients undergoing ELRA are free from donor shortage, lifelong immunosuppressive therapy, and the psychological pressures associated with the uncertainty regarding transplantation timing. However, they face distinctive new challenges, including a lengthy and technically sophisticated surgery, prolonged rehabilitation period, obvious postoperative scars, and complicated physiological recovery procedures. These unique stressors specific to ELRA can aggravate anxiety, depression, and sleep disturbances, and also trigger patients' concerns about body image, social reintegration, and long-term functional recovery. However, existing studies focus almost exclusively on allogeneic transplantation, leaving a critical gap in our understanding of the psychological trajectories and specific risk factors in patients undergoing ELRA. No large-scale study has yet systematically evaluated mental health outcomes, including anxiety, depression, and sleep quality, in this unique cohort. Studies by Qiao and Li [13], Vogt et al [14], and Liang [15] indicate that liver transplant recipients exhibit low psychological resilience, which correlates closely with postoperative quality of life. Zeng [16] found that recipients with higher social support levels demonstrate greater psychological resilience and better adapt to various physiological and psychological changes. When disease progresses to end-stage organ failure, patients face psychological strain from confronting limited life expectancy, the necessity of organ transplantation, fear of death, internal conflict, and uncertainty about transplant timing. Posttransplant recipients then endure a relatively prolonged recovery period. During this phase, disappointment stemming from overly high surgical expectations and the occurrence of adverse events may contribute to psychological issues. A domestic survey of adult liver transplant patients revealed a median disease cognition score of 33 points [17], which correlated with psychological coherence. International studies report that some pediatric patients may develop cognitive impairments after liver transplantation, primarily associated with underlying diseases, polypharmacy, and prolonged intensive care unit treatment.

Prespecified Study Hypotheses

The primary hypothesis of this study was that longer pre-transplant waiting time is independently associated with higher Self-Rating Anxiety Scale (SAS), Self-Rating Depression Scale (SDS), Hamilton Anxiety Rating Scale (HAMA), Hamilton Depression Rating Scale (HAMD), and Pittsburgh Sleep Quality Index (PSQI) scores at 1 month.

Secondary hypotheses were as follows: (1) postoperative complications are associated with worse psychological outcomes, (2) higher intraoperative red blood cell transfusion is associated with higher anxiety/depression, and (3) longer anhepatic phase duration is associated with higher PSQI scores.

Research Objectives

With the maturation of ELRA techniques and improvements in long-term patient survival, there has been a growing emphasis

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on postoperative quality of life and psychological recovery. Patients undergoing ELRA encounter substantial psychological stressors, including major surgical trauma, extended convalescence, financial strain, and alterations in body image, which may contribute to anxiety, depressive symptoms, and sleep disturbances. However, most current literature centers on allogeneic liver transplantation, leaving a critical gap in the systematic investigation of psychological outcomes in the distinct autologous transplant population. The determinants of psychological well-being in this cohort remain poorly understood. Accordingly, the present study was designed to evaluate postoperative anxiety, depression, and sleep disturbances in patients after ELRA and to analyze their associations with demographic, surgical, and clinical variables. Through this analysis, we aimed to identify key factors associated with postoperative psychological status and provide evidence to inform the development of targeted psychological and sleep-related intervention strategies for patients undergoing ELRA.

Material and Methods

Study Design

This is a single-center retrospective observational study conducted at the department of hepatobiliary surgery of a tertiary hospital. All enrolled patients underwent ELRA for end-stage hepatic alveolar echinococcosis between 2020 and 2025. Demographic data and complete perioperative clinical data were extracted from electronic medical records.

Ethics Approval and Informed Consent

This study was approved by the Ethics Committee of The First Affiliated Hospital of Xinjiang Medical University (No. K202505-02; May 15. 2025). A waiver of informed consent was approved for deceased patients and retrospective chart review. All data were anonymized.

Study Population

Inclusion Criteria

Patients aged 18 to 70 years who received primary ELRA surgery were included in the study. This age group was selected because patients generally have stable physical and mental status, as well as complete cognitive and expression abilities, which are conducive to the smooth implementation of scale assessments and data collection. Further inclusion criteria were as follows. Patients had no previous history of mental illness and no long-term use of psychotropic drugs before the operation, with clear consciousness and normal verbal communication ability. Patients with a history of mental disorders were excluded to avoid interference with the objective evaluation of postoperative mental changes. In addition, patients were required to have completed both the preoperative baseline and postoperative 1-month standardized psychological scale assessments in full.

Exclusion Criteria

Patients were excluded if they had previously received or were concurrently undergoing transplantation of other organs. Patients who died intraoperatively or within 1 month after surgery were also excluded because they could not complete the required 1-month postoperative psychological assessments and therefore could not be included in the statistical analysis of psychological outcomes. Patients with severe postoperative critical illness, disturbance of consciousness, or other conditions that prevented completion of the scale investigation were excluded. Finally, questionnaires were excluded if more than 10% of responses were missing or if the response pattern suggested invalid completion, such as more than 80% of responses being identical.

Measurement of Patients' Psychological State

All psychological and sleep quality assessments were performed at 2 fixed time points: preoperative baseline (within 7 days before surgery) and 1 month after surgery. All psychological assessments were conducted using a standardized institutional protocol, which included unified assessment instructions and blinded assessors, to ensure consistency across all patients. We performed a retrospective analysis of these consistently collected clinical data.

Self-Rating Anxiety Scale (SAS)

The SAS was developed by William W. K. Zung in 1971. It consists of 20 items rated on a 4-point scale, with responses indicating the frequency of each symptom: 1, no or very little of the time; 2, some of the time; 3, a good part of the time; and 4, most or all of the time.

Self-Rating Depression Scale (SDS)

The SDS was developed by William W. K. Zung in 1965. It consists of 20 items rated on a 4-point scale and assesses depressive symptoms, including affective, somatic, psychomotor, and psychological symptoms.

Hamilton Depression Rating Scale (HAMD)

The HAMD was developed by Hamilton in 1960 and is one of the most widely used clinical instruments for assessing depressive states. It is available in 17-, 21-, and 24-item versions.

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This study used the 24-item version. The scale demonstrates good clinical reliability and is administered by trained assessors through conversation and observation. Assessors evaluate patients before and after treatment to determine the severity of depressive symptoms and assess therapeutic efficacy.

Hamilton Anxiety Rating Scale (HAMA)

The HAMA was developed by Hamilton in 1959 and is one of the most commonly used instruments in psychiatric practice. It consists of 14 items, and the total score effectively reflects the severity of anxiety symptoms. The scale can be used to evaluate the severity of anxiety symptoms in patients with anxiety and depressive disorders and to assess the efficacy of various treatments.

Pittsburgh Sleep Quality Index (PSQI)

The PSQI was developed by Buysse and colleagues in 1989. It is widely used to evaluate sleep quality in patients with sleep disorders as well as in the general population. The PSQI assesses participants' subjective sleep quality and related sleep characteristics over the preceding month and is therefore suitable for evaluating changes in sleep quality over time.

The missing data processing principle was as follows. Questionnaires with a missing rate higher than 10% were directly excluded. Valid questionnaires with a missing rate of less than 10% were processed using multiple imputation by chained equations (MICE) to ensure data integrity. Five imputed datasets were generated, and the final regression models were fitted to each dataset. The results were then pooled according to Rubin's rules to account for uncertainty due to imputation. No listwise deletion was performed.

There was a high correlation among the five psychological scales included in this study. Considering that this study was exploratory clinical research aiming to generate research hypotheses, no additional alpha correction was performed for multiple comparisons. This limitation will be acknowledged in the Discussion section.

Measurement of Influencing Factors

Demographic data included age, sex, marital status, education level, and occupation. Such factors may affect patients' postoperative mental state by regulating social support level, coping style, and family economic pressure.

The following perioperative surgical variables were collected: time from initial symptom presentation to clinical consultation, pre-transplant waiting time, operation duration, anhepatic phase duration, intraoperative fluid balance, intraoperative blood loss, transfusion requirements (including total volume and any allogeneic exposure), use of surgical implants, remnant liver volume, and extrahepatic invasion. Extrahepatic invasion was defined as the presence of echinococcal lesions outside the liver, such as involvement of the diaphragm, lung, or adjacent organs, and was assessed based on preoperative imaging findings (computed tomography and magnetic resonance imaging) and confirmed by intraoperative exploration when applicable. Patients were classified into 2 groups: (1) with or without extrahepatic invasion, and (2) postoperative complication status. These surgical metrics serve as proxies for procedure complexity and postoperative physiological recovery, both of which are strongly associated with postoperative psychological outcomes.

Statistical Analysis

Data analysis was performed using SPSS 26.0 statistical software. The normality of continuous variables, including psychological scale scores, was assessed using the Shapiro-Wilk test. Normally distributed data are presented as mean ± standard deviation, and non-normally distributed data are presented as median (interquartile range). Independent *t* tests, 1-way ANOVA, and multiple linear regression were used for normally distributed data. Quantitative data are expressed as mean ± standard deviation, with intergroup comparisons conducted using independent-samples *t* tests or 1-way ANOVA. Qualitative data are presented as counts and percentages (%), with intergroup comparisons done using chi-square tests.

Variables with $P < 0.05$ in univariate analysis were included in multiple linear regression. We used this model to identify independent risk factors for psychological status after autologous liver transplantation. The significance level was set at $\alpha = 0.05$. Categorical variables such as sex, postoperative complications, and implant status were converted into dummy variables, with the lowest category as the reference group. Missing data of psychological scales (less than 10% missing proportion) were processed via multiple imputation by chained equations. Five imputed datasets were generated, and final analysis results were pooled in accordance with Rubin's rules; no listwise deletion was applied in this study, and cases with missing values were excluded from the model. We also carried out complete model diagnostics. Multicollinearity was tested using the variance inflation factor, and a factor less than 5 meant no significant collinearity. Outlier detection and residual analysis were used to confirm model goodness of fit. This analysis helped determine key independent factors and provided a scientific basis for intervention strategies.

Variable Dictionary

To ensure consistency and clarity, all perioperative variables were defined and used consistently throughout the manuscript,

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tables, and figures. The standardized variable definitions are as follows: (1) Pre-transplant waiting time (days): the interval from initial diagnosis to surgery; (2) Anhepatic phase duration (min): the duration of the anhepatic stage during surgery; (3) Operation duration (min): the total time from skin incision to closure; (4) Intraoperative blood loss (mL): the estimated total blood loss during the operation; (5) Urine output during anhepatic phase (mL): the urine volume recorded during the anhepatic stage; (6) Intraoperative red blood cell transfusion volume (U): the total volume of red blood cells transfused during the operation; (7) Postoperative complications: the presence or absence of postoperative adverse events; and (8) Extrahepatic invasion: the presence of echinococcal lesions outside the liver, assessed based on preoperative imaging and intraoperative exploration and classified as "present" or "absent." All variables were used with consistent definitions, units, and labels throughout all analyses.

Results

Baseline Data and Psychological Scale Analysis

The final analysis included 138 patients who completed both the baseline preoperative assessment and the 1-month postoperative psychological scale evaluations. All patients who died intraoperatively or during the 1-month follow-up period were excluded, as they could not provide valid outcome data. **Table 1** shows that this study enrolled 138 patients with hepatic echinococcosis from 2020 to 2025, including 64 men (46.38%) and 74 women (53.62%). Among them, 21 patients were aged 18 to 25 years, 47 patients were aged 25 to 35 years, and 70 patients were aged 36 years or older. Perioperative variables, including pre-transplant waiting time, operation duration, anhepatic phase duration, intraoperative blood loss, transfusion volume, urine output during the anhepatic phase, postoperative complications, and extrahepatic invasion, are summarized in **Table 2**.

Postoperative 1-month baseline data for SAS, SDS, PSQI, HAMA, and HAMD scales among liver echinococcosis patients were analyzed for differences. Results showed no significant differences across scales for age, sex, ethnicity, marital status, education level, occupation, or extrahepatic invasion classification ($P > 0.05$). SAS, SDS, PSQI, HAMA, and HAMD scores were significantly correlated with complications, number of complications ($P < 0.05$). Univariate analysis showed that postoperative complications and the number of complications were significantly correlated with patients' postoperative mental state and sleep quality scores ($P < 0.05$). Patients with postoperative complications tended to have higher anxiety, depression and sleep disturbance scores.

Univariate Linear Regression Analysis of SAS, SDS, PSQI, HAMA, and HAMD Scores With Surgical-Related Indicators

Table 3 shows that pre-transplant waiting time, intraoperative red blood cell transfusion volume, and operation duration were significantly associated with SAS scores ($P < 0.05$). **Table 4** shows that pre-transplant waiting time and intraoperative red blood cell transfusion volume were significantly associated with SDS scores ($P < 0.05$). **Table 5** shows that pre-transplant waiting time, anhepatic phase duration, and intraoperative implants were significantly associated with PSQI scores ($P < 0.05$). **Table 6** shows that pre-transplant waiting time and intraoperative red blood cell transfusion volume were significantly associated with HAMA scores ($P < 0.05$). **Table 7** shows that pre-transplant waiting time and intraoperative red blood cell transfusion volume were significantly associated with HAMD scores ($P < 0.05$).

Multivariate Linear Regression Analysis of Variables Associated With SAS, SDS, PSQI, HAMA, and HAMD

Multivariate linear regression was used to identify independent factors associated with each psychological scale score, and the results are presented in **Table 8**. Pre-transplant waiting time was independently associated with all postoperative anxiety, depression, and sleep quality scores, while prolonged anhepatic phase duration was independently associated specifically with postoperative sleep quality disturbance. Intraoperative red blood cell transfusion volume and postoperative complications were not retained as independent predictors in the final models, indicating that their associations with psychological outcomes were significant only in the univariate analyses and were no longer significant after adjustment for other factors.

Correlation Analysis Among Psychological Scales

Correlation analysis among the SAS, SDS, PSQI, HAMA, and HAMD scores showed significant positive correlations between SAS and SDS ($r = 0.896$), PSQI ($r = 0.316$), HAMA ($r = 0.759$), and HAMD ($r = 0.766$) (all $P < 0.05$). SDS was significantly and positively correlated with PSQI ($r = 0.294$), HAMA ($r = 0.784$), and HAMD ($r = 0.817$) (all $P < 0.05$). PSQI was significantly and positively correlated with HAMA ($r = 0.194$) and HAMD ($r = 0.192$) (both $P < 0.05$). HAMA and HAMD were also significantly and positively correlated ($r = 0.901$, $P < 0.05$). The detailed correlation results are presented in **Table 9** and **Figure 1**.

Discussion

Interpretation of Core Findings

Demographic factors, including age, sex, ethnicity, marital status, educational attainment, occupation, and the presence of

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Table 1. Baseline data and psychological scale analysis for autologous liver transplantation.

Variable	SAS	SDS	PSQI	HAMA	HAMD
Age					
≤25 (n=21)	41.33±15.47	41.62±15.55	12.33±5.57	11.48±7.74	11.48±8.14
25-35 (n=47)	42.70±16.06	43.98±14.51	11.85±4.72	10.11±6.26	9.85±7.21
≥36 (n=70)	45.40±16.54	45.17±14.51	11.93±4.85	12.04±6.73	12.11±7.16
F	0.689	0.484	0.074	1.171	1.354
P	0.504	0.618	0.929	0.313	0.262
Sex					
Male (n=64)	43.33±15.45	42.53±14.16	11.83±5.27	10.70±6.35	10.75±7.39
Female (n=74)	44.32±16.89	45.69±14.93	12.08±4.57	11.81±7.07	11.68±7.33
t	0.359	1.269	0.304	0.962	0.737
P	0.720	0.207	0.762	0.338	0.462
Ethnicity					
Han Chinese (n=23)	46.04±16.56	46.43±15.71	11.22±4.77	12.83±8.22	12.61±8.28
Tibetan (n=74)	44.38±15.36	43.76±14.16	12.04±4.97	10.81±6.56	10.95±7.31
Kazakh (n=26)	42.96±17.89	44.00±15.16	12.19±4.72	11.77±5.98	10.65±7.24
Other (n=15)	39.53±17.34	43.53±15.38	12.33±5.37	10.53±6.67	11.67±6.62
F	0.543	0.21	0.228	0.624	0.372
P	0.654	0.889	0.877	0.601	0.773
Marital Status					
Married (n=100)	45.02±16.17	45.29±14.20	12.14±4.79	11.55±6.71	11.32±7.29
Unmarried (n=38)	40.82±16.06	41.42±15.50	11.50±5.18	10.63±6.87	11.05±7.60
t	1.367	1.394	0.686	0.713	0.191
P	0.174	0.166	0.494	0.477	0.849
Educational attainment					
Illiterate (n=35)	43.09±14.92	42.40±13.95	11.97±4.15	10.29±6.39	10.14±6.82
Elementary, Middle, and High School (n=84)	44.87±16.64	45.40±14.80	11.93±5.12	11.99±6.80	12.08±7.62
Vocational school, junior college, undergraduate (n=19)	40.84±16.82	42.37±15.19	12.11±5.29	10.11±7.06	9.58±6.83
F	0.531	0.697	0.011	1.133	1.439
P	0.591	0.501	0.991	0.325	0.241

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Table 1 continued. Baseline data and psychological scale analysis for autologous liver transplantation.

Variable	SAS	SDS	PSQI	HAMA	HAMD
Occupation					
Farmer (n=73)	44.51±16.84	44.71±15.43	11.84±4.60	11.74±6.89	11.73±7.82
Herder (n=25)	45.60±15.63	45.08±13.13	10.96±5.30	11.12±5.97	10.64±6.08
Public institutions, civil servants (n=11)	39.27±16.83	44.73±11.93	14.00±5.27	11.64±6.41	11.55±7.23
Other (n=29)	42.48±15.11	42.07±15.11	12.34±5.11	10.21±7.32	10.45±7.40
F	0.494	0.266	1.050	0.367	0.276
P	0.687	0.850	0.373	0.777	0.842
Complications					
Present (n=53)	60.28±10.23	60.75±6.01	14.08±4.88	17.68±4.91	18.49±4.99
None (n=85)	33.62±9.30	33.92±6.79	10.67±4.45	7.32±4.19	6.73±4.34
t	-15.758	-23.581	-4.19	-13.223	-14.608
P	0.01	0.01	0.01	0.01	0.01
Number of complications					
≤2 types (n=115)	41.03±15.79	41.10±13.83	11.30±4.84	10.13±6.52	10.10±7.25
2-4 species (n=13)	58.15±6.78[a]	60.15±4.69[a]	15.17±3.10[a]	16.15±4.14[a]	15.92±3.97[a]
≥4 species (n=10)	57.90±12.33[a]	59.50±7.00[a]	15.70±4.30[a]	18.40±4.84[a]	18.40±5.44[a,b]
F	12.342	20.27	7.126	12.411	9.932
P	0.01	0.01	0.01	0.01	0.01
Extrahepatic invasion					
No (n=53)	44.23±15.36	43.92±13.65	12.10±5.15	12.00±7.16	11.68±7.10
Yes (n=85)	43.64±16.77	44.41±15.26	11.88±4.75	10.86±6.48	10.98±7.52
t	0.208	-0.190	0.247	0.967	0.545
P	0.836	0.850	0.805	0.335	0.587

Continuous variables are presented as mean±SD. Categorical variables are presented as n (%). One-way ANOVA was used for group comparisons, and post hoc multiple comparisons were performed using Bonferroni correction.* $P<0.05$, ** $P<0.01$; [a] compared with the <2 types group; [b] compared with the 2-4 types group.

Table 2. Descriptive statistics of perioperative variables.

Variable	Mean±SD / median (IQR)	Range	Missing data, n (%)
Pre-transplant waiting time (days)	45.2±12.6	12-98	0 (0.0)
Anhepatic phase duration (min)	210.5±45.3	120-360	0 (0.0)
Operation duration (min)	420.8±85.6	280-620	0 (0.0)
Intraoperative blood loss (mL)	1850.3±620.5	500-3800	3 (2.2)
Urine output during anhepatic phase (mL)	220.6±85.2	50-520	2 (1.4)
Intraoperative red blood cell transfusion volume (U)	6.8±3.2	2-16	0 (0.0)

Table 3. Univariate linear regression analysis of SAS scores with surgical-related indicators.

Variable	Unstandardized coefficient		Standardized coefficient	*t*	*P*	95% CI
	B	Standard error	Beta			
Time since onset (months)	0.019	0.039	0.041	0.483	0.631	-0.057 to 0.094
Pre-transplant waiting time (days)	0.374	0.071	0.411	5.262	**<0.001**	0.234 to 0.515
Anhepatic phase duration (min)	0.008	0.011	0.064	0.742	0.460	-0.014 to 0.030
Intraoperative fluid administration (ml)	0.001	0.001	-0.017	-0.196	0.845	-0.001 to 0.001
Intraoperative blood loss (ml)	0.001	0.001	0.113	1.322	0.189	-0.001 to 0.003
Intraoperative red blood cell transfusion volume (U)	0.689	0.243	0.237	2.834	**0.005**	0.212 to 1.166
Remaining liver volume (%)	-0.001	0.002	-0.046	-0.541	0.589	-0.005 to 0.003
Implant (implantation)	-0.181	3.122	-0.005	-0.058	0.954	-6.301 to 5.939
Total intraoperative urine output (mL)	-0.001	0.001	-0.149	-1.299	0.196	-0.003 to 0.001
Urine output during anhepatic phase (mL)	-0.001	0.002	-0.076	-0.683	0.496	-0.004 to 0.002
Surgery duration (h)	1.02	0.457	0.199	2.233	**0.027**	0.125 to 1.916

Table 4. Univariate linear regression analysis of SDS scores and surgery-related indicators.

Variable	Unstandardized coefficient		Standardized coefficient	*t*	*P*	95% CI
	B	Standard error	Beta			
Time since onset (months)	0.026	0.035	0.063	0.742	0.459	-0.042 to 0.094
Pre-transplant waiting time (days)	0.305	0.065	0.371	4.664	**<0.001**	0.176 to 0.434
Anhepatic phase duration (min)	0.010	0.010	0.082	0.952	0.343	-0.010 to 0.030
Intraoperative fluid administration (ml)	-0.001	0.001	-0.091	-1.047	0.297	-0.000 to 0.000
Intraoperative blood loss (ml)	0.001	0.001	0.012	0.111	0.912	-0.002 to 0.002
Intraoperative red blood cell transfusion volume (U)	0.627	0.279	0.238	2.248	**0.026**	0.080 to 1.174
Remaining liver volume (%)	-0.001	0.002	-0.037	-0.428	0.669	-0.004 to 0.003
Implant (implantation)	1.121	1.962	0.049	0.571	0.569	-2.724 to 4.966
Total intraoperative urine output (mL)	1.471	2.838	0.045	0.518	0.605	-4.091 to 7.033
Urine output during anhepatic phase (mL)	-0.002	0.001	-0.135	-1.545	0.125	-0.004 to 0.001
Surgery duration (h)	0.575	0.405	0.124	1.420	0.158	-0.219 to 1.369

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Table 5. Univariate linear regression analysis of PSQI scores and surgery-related indicators.

Variable	Unstandardized coefficient		Standardized coefficient	*t*	*P*	95% CI
	B	Standard error	Beta			
Time since onset (months)	-0.005	0.011	-0.039	-0.476	0.635	-0.027 to 0.016
Pre-transplant waiting time (days)	0.080	0.023	0.291	3.535	**0.001**	0.035 to 0.125
Anhepatic phase duration (min)	0.018	0.004	0.464	4.515	**<0.001**	0.010-to 0.026
Intraoperative fluid administration (ml)	0.001	0.001	-0.148	-1.876	0.063	-0.001 to 0.001
Intraoperative blood loss (ml)	-0.001	0.001	-0.046	-0.445	0.657	-0.001 to 0.001
Intraoperative red blood cell transfusion volume (U)	0.162	0.091	0.186	1.801	0.074	-0.014 to 0.338
Remaining liver volume (%)	-0.001	0.001	-0.115	-1.506	0.135	-0.002 to 0.000
Implant (implantation)	-1.926	0.754	-0.251	-2.553	**0.012**	-3.404 to -0.447
Total intraoperative urine output (mL)	0.631	0.862	0.058	0.731	0.466	-1.058 to 2.319
Urine output during anhepatic phase (mL)	-0.001	0.001	-0.132	-1.243	0.216	-0.001 to 0.001
Surgery duration (h)	0.001	0.001	0.108	1.056	0.293	-0.001 to 0.001

Table 6. Univariate linear regression analysis of HAMA scores and surgery-related indicators.

Variable	Unstandardized coefficient		Standardized coefficient	*t*	*P*	95% CI
	B	Standard error	Beta			
Time since onset (months)	-0.007	0.017	-0.040	-0.445	0.657	-0.040 to 0.025
Pre-transplant waiting time (days)	0.132	0.031	0.348	4.327	**<0.001**	0.072 to 0.192
Anhepatic phase duration (min)	-0.002	0.006	-0.037	-0.330	0.742	-0.014 to 0.010
Intraoperative fluid administration (ml)	0.001	0.001	-0.081	-0.940	0.349	-0.000 to 0.001
Intraoperative blood loss (ml)	-0.001	0.001	-0.118	-1.053	0.294	-0.001 to 0.001
Intraoperative red blood cell transfusion volume (U)	0.395	0.138	0.323	2.866	**0.005**	0.125 to 0.665
Remaining liver volume (%)	-0.001	0.001	-0.069	-0.831	0.408	-0.002 to 0.001
Implant (implantation)	1.087	1.156	0.101	0.941	0.349	-1.178 to 3.352
Total intraoperative urine output (mL)	1.129	1.306	0.074	0.865	0.389	-1.431 to 3.690
Urine output during anhepatic phase (mL)	-0.001	0.001	-0.102	-0.881	0.381	-0.001 to 0.001
Surgery duration (h)	-0.001	0.001	-0.189	-1.699	0.092	-0.003 to 0.001

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Table 7. Univariate linear regression analysis of HAMD scores and surgery-related indicators.

Variable	Unstandardized coefficient		Standardized coefficient	*t*	*P*	95% CI
	B	Standard error	Beta			
Time since onset (months)	-0.018	0.019	-0.090	-0.983	0.327	-0.055 to 0.018
Pre-transplant waiting time (days)	0.161	0.033	0.390	4.942	**<0.001**	0.097 to 0.225
Anhepatic phase duration (min)	0.001	0.007	0.017	0.149	0.882	-0.012 to 0.014
Intraoperative fluid administration (ml)	-0.001	0.001	-0.118	-1.338	0.183	-0.000 to 0.000
Intraoperative blood loss (ml)	-0.001	0.001	-0.148	-1.283	0.202	-0.002 to 0.000
Intraoperative red blood cell transfusion volume (U)	0.478	0.153	0.360	3.117	**0.002**	0.177 to 0.778
Remaining liver volume (%)	0.001	0.001	-0.048	-0.558	0.578	-0.002 to 0.001
Implant (implantation)	0.291	1.286	0.025	0.226	0.821	-2.229 to 2.811
Total intraoperative urine output (mL)	1.511	1.453	0.092	1.039	0.301	-1.338 to 4.359
Urine output during anhepatic phase (mL)	0.001	0.001	-0.029	-0.242	0.809	-0.001 to 0.001
Surgery duration (h)	-0.001	0.001	-0.163	-1.431	0.155	-0.003 to 0.001

extrahepatic invasion, were not significantly associated with postoperative psychological status. However, univariate analysis showed that postoperative complications were significantly associated with patients' negative emotional states. Patients who experienced postoperative complications tended to have higher levels of anxiety and depression, which may reflect greater psychological distress related to postoperative recovery and concerns about their rehabilitation and prognosis. These findings suggest that postoperative complications may be associated with poorer psychological outcomes, although causal relationships cannot be established based on the present analysis. However, after eliminating the interference of multiple confounding factors, postoperative complications failed to become independent influencing factors, indicating that their impact on mental state was mostly mediated by other surgical stress factors, such as a longer surgical duration and more complex recovery trajectory. Other relevant factors included pre-transplant waiting time, intraoperative red blood cell transfusion volume, and anhepatic phase duration, which were associated with postoperative depression, anxiety, and sleep disorders ($P<0.05$).

Sleep disturbances are common in both living and deceased donor liver transplant recipients, consistent with findings by Zhu et al [18] and Biyyala et al [19]. Prolonged pre-transplant waiting time induces physiological stress, heightening susceptibility to anxiety and depression while increasing psychological burden, consistent with the conclusions of studies by Annema et al [20] and Ünay et al [21]. The occurrence of postoperative complications signifies an impeded recovery process, intensifies patients' concerns about their future health status, and exacerbates uncertainty and fear regarding disease prognosis, thereby triggering psychological issues. Research indicates that longer anhepatic phase duration correlates with a higher likelihood of early liver dysfunction [22]; patients also express greater apprehension about potential recurrence postoperatively [23]. In summary, due to the greater surgical complexity and more intricate postoperative management of autologous liver transplantation, postoperative complications exert a more pronounced impact on patients' psychological state. In allogeneic liver transplantation, the primary focus is on issues such as immune rejection. In contrast, autologous liver transplantation carries comparable perioperative challenges while introducing unique procedure-specific risks, such as technically demanding surgical steps and ischemia-reperfusion injury. These factors collectively contribute to a higher rate of postoperative complications, which in turn exert a more pronounced psychological burden on affected patients. Our findings therefore indicate that psychological care strategies for autologous liver transplant recipients should prioritize the postoperative recovery period, with proactive delivery of targeted psychological support and counseling.

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Table 8. Multivariate linear regression analysis of variables associated with SAS, SDS, PSQI, HAMA, and HAMD.

Variable	Unstandardized coefficient		Standardized coefficient	*t*	*P*	95% CI
	B	Standard error	Beta			
SAS						
Pre-transplant waiting time (days)	0.34	0.072	0.376	4.721	0.01	0.199 to 0.482
Intraoperative red blood cell transfusion volume (U)	0.454	0.231	0.156	1.961	0.052	0.000 to 0.907
SDS						
Pre-transplant waiting time (days)	0.278	0.067	0.34	4.179	0.01	0.148 to 0.409
Intraoperative red blood cell transfusion volume (U)	0.358	0.214	0.136	1.672	0.097	-0.062 to 0.777
PSQI						
Pre-transplant waiting time (days)	0.063	0.021	0.23	3.049	0.01	0.022 to 0.103
Anhepatic phase duration (min)	0.017	0.003	0.431	5.702	0.01	0.011 to 0.023
Implant	0.438	0.824	0.04	0.532	0.596	-1.176 to 2.053
HAMA						
Pre-transplant waiting time (days)	0.118	0.031	0.313	3.821	0.01	0.058 to 0.179
Intraoperative red blood cell transfusion volume (U)	0.186	0.1	0.153	1.865	0.064	-0.009 to 0.381
HAMD						
Pre-transplant waiting time (days)	0.149	0.033	0.361	4.47	0.01	0.084 to 0.214
Intraoperative red blood cell transfusion volume (U)	0.167	0.107	0.126	1.566	0.120	-0.042 to 0.377

Table 9. Correlation analysis among psychological scales (*r*).

	SAS	SDS	PSQI	HAMA	HAMD
SAS	1				
SDS	0.896**	1			
PSQI	0.316**	0.294**	1		
HAMA	0.759**	0.784**	0.194*	1	
HAMD	0.766**	0.817**	0.192*	0.901**	1

* $P<0.05$; ** $P<0.01$.

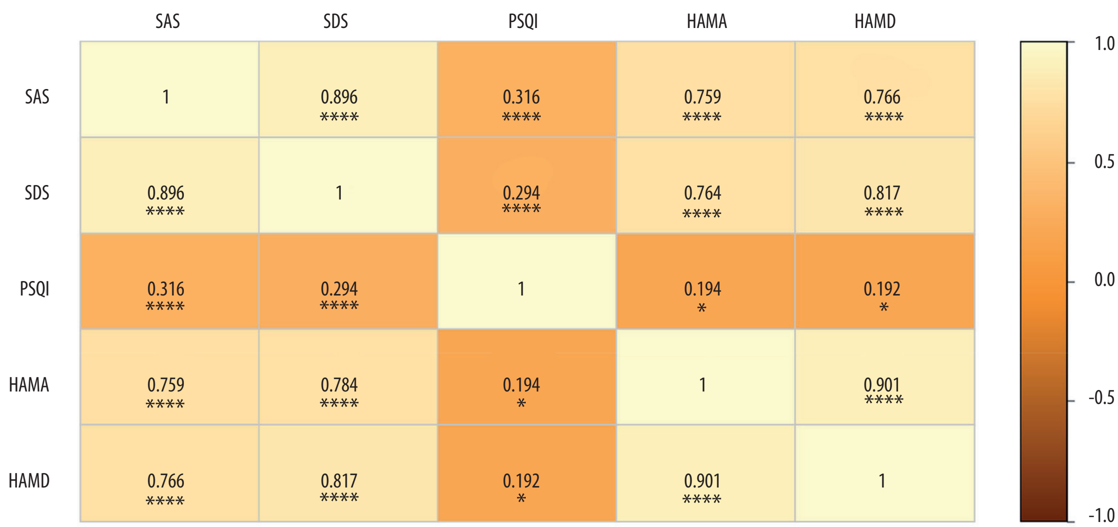

Figure 1. Correlation heatmap among psychological scales (*r*).

Clinical Implications

Healthcare teams should prioritize preoperative psychological assessment for liver transplant candidates. For eligible patients, timely surgical scheduling following the completion of preoperative evaluations may help optimize surgical outcomes and reduce postoperative complications. High-risk individuals should undergo targeted, tailored psychological screening, with personalized intervention strategies developed based on their needs. For example, structured psychological counseling groups can be implemented to provide emotional support and adaptive coping skills training. Additionally, enhanced communication with patients and their families—including comprehensive, evidence-based disease education—can improve disease understanding and alleviate anxiety and uncertainty. Patients should also be encouraged to proactively engage with social support networks and adopt positive coping strategies, such as participation in peer recovery groups or relaxation techniques.

Research Implications

This study provides empirical evidence to inform further investigations into the mechanisms underlying psychological rehabilitation after autologous liver transplantation. Future multi-center, large-scale studies are warranted to integrate neurobiological markers, such as peripheral neurotransmitter and hormone concentrations, and functional brain imaging modalities, enabling a deeper exploration of the bidirectional interactions between psychological well-being and postoperative physiological recovery. As an example, such studies could investigate how perioperative psychological stress impacts neuroendocrine regulation, and whether targeted psychological interventions can restore neuroendocrine function to enhance overall recovery outcomes.

Study Limitations

This study has several limitations that should be considered when interpreting the findings. First, the single-center, retrospective design and modest sample size may have introduced selection bias and limited the external validity of the results. The limited geographic and institutional scope of the cohort may not fully reflect the broader population of autologous liver transplant recipients. Future multicenter, large-scale studies are therefore needed to validate these findings and improve their generalizability and clinical applicability.

Second, data collection relied primarily on questionnaire-based assessments and lacked objective physiological measurements, such as neurotransmitter levels and immune function indicators. Although psychological changes may be associated with physiological alterations, the absence of objective biological measures limited our ability to comprehensively explore the underlying mechanisms of postoperative psychological changes. Integrating physiological and biological assessments in future studies may provide deeper insight into the biological basis of psychological states and provide a stronger foundation for the development of targeted interventions.

Third, the follow-up period was limited to 1 month after surgery, which was insufficient to evaluate long-term psychological trajectories. Psychological states in autologous liver transplant recipients may continue to change during postoperative recovery. Longer-term follow-up is therefore needed to characterize the evolution of psychological status over time and to better inform sustained psychological support and intervention.

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Regarding the multivariate linear regression analyses, six predictor variables were included in the final models, with 138 patients, corresponding to an events-per-variable (EPV) ratio of 23. This exceeds the commonly cited EPV threshold of 10 to 20 and suggests that the number of observations was reasonable relative to the number of predictors included in the models, thereby reducing concerns regarding model overfitting. Nevertheless, EPV is a general rule of thumb rather than a definitive indicator of model adequacy, and the regression findings should therefore be interpreted in the context of the overall sample size and model characteristics.

Finally, the study included five highly correlated psychological scales (SAS, SDS, HAMA, HAMD, and PSQI) without formal adjustment for multiple comparisons, such as the Bonferroni correction. Given the exploratory and hypothesis-generating nature of the study, we chose not to apply an additional alpha correction. However, conducting multiple statistical comparisons increases the risk of type I error and false-positive findings. Therefore, the observed associations, particularly those identified in exploratory analyses, should be interpreted with caution and require confirmation in future studies.

Conclusions

In conclusion, excessive preoperative waiting time is the core independent risk factor for poor postoperative mental health status of patients after ELRA surgery, which can significantly increase the risk of postoperative anxiety, depression, and various negative emotions. Prolonged anhepatic phase is a specific independent influencing factor leading to postoperative sleep quality decline.

Clinically, medical staff should focus on optimizing the preoperative diagnosis and treatment process to shorten unnecessary preoperative waiting time and provide targeted psychological and sleep interventions for patients with a prolonged anhepatic phase during the perioperative period, thereby improving postoperative mental health and overall rehabilitation. In the future, multicenter studies incorporating multidimensional indicators could be conducted to further optimize psychological intervention strategies and promote the comprehensive physical and psychological recovery of patients undergoing autologous liver transplantation.

Department and Institution Where the Work Was Done

The work was conducted at the Department of Psychological Medicine, The First Affiliated Hospital of Xinjiang Medical University, State Key Laboratory of Pathogenesis, Prevention and Treatment of High Incidence Diseases in Central Asia,, Urumqi, Xinjiang, PR China.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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