

Article

Effects of perioperative “Internet+” rehabilitation nursing combined with early nutritional support on postoperative recovery and nutritional status of patients with esophageal cancer

Qianqian Zhu¹, Weisu Wang², Yunyun Chen^{1,*}

¹ Department of Cardiothoracic Surgery 1, The Affiliated Huai'an No.1 People's Hospital of Nanjing Medical University, Huai'an 223300, Jiangsu Province, China

² Department of General Surgery, Huaiyin District Sanshu Hospital, Huai'an 223300, Jiangsu Province, China

* Corresponding author: Yunyun Chen, sarah3808@163.com

CITATION

Zhu Q, Wang W, Chen Y. Effects of perioperative “Internet+” rehabilitation nursing combined with early nutritional support on postoperative recovery and nutritional status of patients with esophageal cancer. *Psycho-Oncologie*. 2026; 20(1): 4581. <https://doi.org/10.18282/po4581>

ARTICLE INFO

Received: 12 June 2025

Revised: 9 January 2026

Accepted: 15 January 2026

Available online: 30 January 2026

COPYRIGHT



Copyright © 2026 by author(s). *Psycho-Oncologie* is published by PiscoMed Publishing Pte Ltd. This work is licensed under the Creative Commons Attribution (CC BY) license. <https://creativecommons.org/licenses/by/4.0/>

Abstract: Objective: To evaluate the effects of perioperative “Internet+” rehabilitation nursing combined with early nutritional support on postoperative recovery, nutritional status, and secondary psychological outcomes in patients with esophageal cancer. **Methods:** A total of 135 patients who underwent radical resection of esophageal cancer from January 2022 to December 2023 were selected and assigned to a control group (CG, $n = 67$) or an observation group (OG, $n = 68$). The CG received routine nursing plus total intravenous parenteral nutrition, while the OG received “Internet+” rehabilitation nursing combined with early enteral nutrition. Postoperative intestinal function recovery time, length of hospital stay, psychological status (SAS/SDS), quality of life (QLQ-C30), nutritional indicators, immune function, complication rates, and nursing satisfaction were compared between groups. **Results:** Compared with the CG, the OG demonstrated shorter time to first anal exhaust, first defecation, and hospital stay ($P < 0.01$). Post-intervention SAS and SDS scores were lower in the OG ($P < 0.05$), while physical, role, cognitive, emotional, and social functioning scores were higher ($P < 0.05$). Nutritional markers (TRF, ALB, TP) and immune indices (IgA, IgG, IgM) were significantly higher in the OG ($P < 0.05$). The OG also showed a lower complication rate and higher nursing satisfaction (both $P < 0.05$). **Conclusion:** Perioperative “Internet+” rehabilitation nursing combined with early nutritional support may accelerate postoperative recovery, enhance nutritional and immune function, improve psychological adaptation, and reduce complication rates in esophageal cancer patients. These findings support the clinical value of integrating digital rehabilitation models and structured nutritional pathways into perioperative care.

Keywords: distress management; esophageal cancer; “Internet+” rehabilitation nursing; early enteral nutrition; immune function; complication; postoperative recovery; psychological adaptation; quality of life (QoL)

1. Introduction

Esophageal cancer belongs to one of the most common gastrointestinal malignancies worldwide, with an estimated 604,000 new cases as well as 544,000 deaths worldwide in 2020 [1]. Esophageal cancer is mostly squamous cell carcinoma, and the main clinical manifestations are progressive eating obstruction, dysphagia, swallowing obstruction, and vomiting after eating, etc. [2]. If treatment is delayed, sternum pain and discomfort and other severe symptoms may occur with the aggravation of the disease until the advanced stage [3]. Esophageal cancer continues to be a major public health issue for oncology prevention and control in China, given the country's large demographic skill set and the increasingly serious phenomenon of

an ageing population. With the development of medical technology, the current treatment mode of esophageal cancer mainly consists of surgery, radiotherapy, and chemotherapy [4]. Among them, radical resection of esophageal cancer has a wider operation scope, more severe operation trauma and more intense body stress response [5]. Therefore, it is very important to do scientific and comprehensive nursing intervention in perioperative period to reduce postoperative complications, promote the smooth recovery of patients, as well as improve the quality of life [6]. In addition to physical burden, esophageal cancer surgery also leads to significant psychological strain, including anxiety, depressive symptoms, anticipatory fear of postoperative outcomes, and perceived loss of bodily control. Hospitalization, dysphagia, and uncertainty surrounding recovery can trigger threat appraisal responses, causing emotional distress that negatively influences immune response, treatment engagement, and rehabilitation outcomes [7]. Evidence in psycho-oncology shows that unmanaged perioperative distress can delay recovery and impair quality of life, making psychological support an important component of comprehensive care.

The “Internet+” model refers to the application process of a whole set of information technology on the basis of the Internet in multiple sectors of society, economy as well as life [8]. In recent years, a number of national policies have advocated guiding and promoting the cooperation between the “Internet+” model and the medical field [9]. “Internet+” nursing model has been actively used in postoperative care of different cancers with remarkable results [10], but at present, there are no relevant reports about the application of perioperative “Internet+” rehabilitation nursing in esophageal cancer patients. From a psychological perspective, Internet-based care may also provide continuous communication, emotional reassurance, and guidance that reduces uncertainty, enhances perceived control, and improves patients’ sense of safety during hospitalization. Digital contact and immediate access to information can buffer negative emotions, reduce isolation, and strengthen coping responses, which aligns with psycho-oncology findings on the importance of continuity in psychosocial support [11]. However, existing studies have largely examined digital nursing interventions or nutritional support in isolation, with limited evidence on their combined application during the perioperative period of esophageal cancer surgery, particularly with regard to both physical recovery and psychological adaptation.

A study by the Chinese Anti-Cancer Society showed that the incidence of malnutrition in esophageal cancer ranks first [12]. This is due to the fact that most EC patients have symptoms of insufficient intake, malnutrition, water and electrolyte disorders before surgery due to different degrees of dysphagia. Moreover, the surgical trauma of esophageal cancer patients is relatively large, patients need to fast for a long period after surgery, and a series of postoperative stress reactions caused by high catabolic, which further aggravated the malnutrition of patients [13]. In addition, surgery caused certain damage to the lower esophageal sphincter and esophageal hiatus structure, resulting in gastrointestinal dysfunction of patients, which seriously affected the postoperative recovery of patients [14]. Therefore, it is necessary to take an active and effective way to supplement nutrition in the early stage after esophageal cancer surgery to facilitate the recovery of gastrointestinal function and improve the immune capacity of the body [15]. Early nutritional stability may also indirectly

relieve psychological distress by reducing somatic discomfort, improving energy levels, and restoring a sense of physical control, which contributes to better emotional adaptation during hospitalization [16].

In response to these gaps, the present study aimed to evaluate the effects of perioperative “Internet+” rehabilitation nursing combined with early nutritional support on postoperative recovery outcomes in patients undergoing esophageal cancer surgery. The primary objective was to assess postoperative rehabilitation, nutritional status, immune function, and complication rates, while the secondary objective was to explore changes in psychological distress and quality of life during the perioperative period. This will provide esophageal cancer patients with more clinic-able care strategies and further improve the efficiency and effectiveness of care. By integrating clinical recovery indicators with secondary psychological outcomes, this study provides evidence to support a biopsychosocial approach to perioperative nursing care, offering practical implications for clinicians and nursing practitioners and informing future research on integrated rehabilitation models in esophageal cancer management [17].

2. Data and methods

2.1. General data

One hundred and thirty-five patients who underwent radical resection of esophageal cancer from January 2022 to December 2023 were selected and divided into control group (CG, 67 cases) and observation group (OG, 68 cases) according to random number table method. No difference was discovered in general data between two groups ($P > 0.05$, **Table 1**). Inclusion criteria: (1) Patients met the diagnostic criteria for esophageal cancer; (2) Esophageal cancer was confirmed by imaging and pathological examination in our hospital; (3) Patients signed the informed consent forms. Exclusion criteria: (1) Combined with other malignant tumor diseases, or organ dysfunction such as heart, liver and lung; (2) Combined with mental disorders or inability to communicate normally; (3) Withdrawing from the study or transferring to another school; (4) Poor compliance and non-cooperation. In addition, although patients with severe psychiatric conditions were excluded, psychological responses during hospitalization and surgery were therefore monitored as part of routine perioperative assessment, and psychological indicators were defined as secondary outcomes. Accordingly, psychological measures were predefined as secondary outcomes to observe perioperative emotional responses [18]. This study was conducted with approval from the institutional ethics committee, and written informed consent was obtained from all participants prior to enrollment.

Table 1. General data between two groups (mean $\pm$ SD) or n (%).

Items	Control group ($n = 67$)	Experimental group ($n = 68$)	χ^2/t	P
Gender (male/female)	37/30	38/30	0.005	0.938
Age (years)	61.25 $\pm$ 6.13	61.32 $\pm$ 6.16	0.066	0.947
Course of disease (years)	1.11 $\pm$ 0.42	1.12 $\pm$ 0.45	0.133	0.894
Tumor site			0.005	0.938

Table 2. (Continued).

Items	Control group (<i>n</i> = 67)	Experimental group (<i>n</i> = 68)	χ^2/t	<i>P</i>
Upper esophagus	37	38		
Middle and lower esophagus	30	30		
TNM stage				
Stage I	12	10	0.016	0.991
Stage II	30	32		
Stage III	25	26		

2.2. Nursing methods

The CG received routine nursing, including (1) Preoperative diet education: After admission, patients were informed of the hospitalization treatment process in detail, and perioperative dietary characteristics and precautions were informed according to the principle of rapid recovery, so as to ensure perioperative nutrition supply without increasing the burden of gastrointestinal tract. (2) Psychological counseling: Nurses fully informed patients and their families of the diagnosis and treatment process, eliminated the fear of patients and their families, and strengthened psychological construction. (3) General condition assessment: Nurses formulated corresponding treatment plan for the patient's underlying disease, and actively prepare for surgery to minimize its influence in the perioperative period of the patient. (4) Postoperative observation: Nurses observed patients' vital signs, incision conditions, pain conditions and other general postoperative conditions. (5) Postoperative rehabilitation guidance: nurses provided short-term targeted rehabilitation guidance during the postoperative hospital, including the exercise of the affected limb function, the overcoming of fear, and the treatment of pain.

Based on the CG, the OG adopted "Internet+" rehabilitation nursing.

(1) The rehabilitation intervention team was composed of one attending physician of the oncology department, one head nurse, one psychological consultant, and four responsible nurses. The head nurse was responsible for the overall coordination of nursing work, the attending physician was responsible for the diagnosis and treatment of patients and the decision of the program, and the responsible nurse and psychological consultant were responsible for the data collection and program implementation. A psychological consultant participated in the intervention team to assist with patient communication and support during the perioperative period [19].

The nursing department conducted unified training for team members, which mainly included the pathogenesis of esophageal cancer, knowledge related to surgery, network application, rehabilitation nursing, and another knowledge. All team members were required to master the training content. A rehabilitation group working group was established to provide feedback, summary and analysis of the intervention effects of patients on a weekly basis, so as to timely propose improvement countermeasures to existing nursing problems.

(2) Implementation of "Internet+" rehabilitation nursing. (a) During the preparation period, general information of patients was collected, including education level, disease cognition, psychological state, living situation, WeChat /QQ number, etc., personal files were established for patients, and patients were guided to join

WeChat groups, and medical staff was added to WeChat and public accounts were followed. Baseline psychological status was recorded to characterize perioperative emotional responses and to support secondary outcome analysis [20]. The intervention team consulted relevant literature and combined clinical data and clinical nursing problems of patients. The network continuous rehabilitation nursing support mode intervention measures were developed in the form of conference discussion. (b) Preoperative guidance. The intervention team made online courses (electronic versions) with text, pictures and videos on the relevant knowledge of esophageal cancer rehabilitation nursing support, and the responsible nurse pushed the relevant contents to the WeChat group or WeChat public account, and instructed the patients to read the rehabilitation guidance contents carefully. The online course mainly includes preoperative emotional sleep, pain and fatigue nursing guidance, and postoperative patient emotional sleep, pain and fatigue, and side effect symptoms nursing guidance. The online educational content included guidance on sleep, pain, fatigue, and emotional well-being during the perioperative period [21]. (c) Preoperative communication. Responsible nurses organize and organize patient communication meetings with the help of WeChat group, which is fixed twice a week. Patients who have recovered well are invited to share their experiences. Encourage patients to actively feedback the recovery situation after the operation, and give some incentives to support patients with good recovery [22].

2.3. Nutrition support methods

The CG was given total intravenous parenteral nutrition support on the first day after surgery: fatty milk amino acid glucose (11%) injection (Manufacturer: Liaoning Haisco Pharmaceutical Co., LTD., Specifications: 1440 mL, including Fat Milk injection (20%) 255 mL; Compound amino acid injection 300 mL; Glucose injection (11%) 885 mL), the daily total energy intake was set at 30 kcal/(kg·d) (1 kcal = 4.184 kJ), and the drip rate was < 3.7 mL/(kg·h) [23]. After no anastomotic fluid or obstruction was found by angiography on the 8th day after surgery, liquid diet was given, semi-liquid diet was given after the 10th day, and ordinary diet was given on the 14th day [24].

The OG was given early enteral nutrition support. (1) Preoperative: Naso-intestinal tube was inserted into the patient. First, the patient was placed in a semi-decubitus or semi-seated position, and the insertion length of the spiral Naso-intestinal tube (the distance from sternal xiphoidal to nasal tip to earlobe, plus 10–15 cm) was measured, and marked. Secondly, 20 mL normal saline was injected into the Naso-intestinal cavity to activate the lubricant on the surface of the guide wire after the guide wire was inserted into the Naso-intestinal cavity. Then, after dipping a little normal saline into the head of the Naso-intestinal tube, the tube was slowly inserted through one side of the nasal cavity and inserted into the throat, and the patient was asked to swallow to facilitate the smooth entry of the Naso-intestinal tube into the esophagus. When the Naso-intestinal tube was inserted to the marked length, the gastric fluid was drawn out with an empty needle and 10 ml normal saline was injected. Then the guide wire was withdrawn, the nasal tube was fixed under the set, and the tube was kept in a natural bending state. Due to the special spiral memory performance of the

production material of the spiral Naso-intestinal tube, the head will return to the spiral shape after the withdrawal of the guide wire, and under the action of stomach peristalsis, the Naso-intestinal tube will enter the duodenum and jejunum by itself, and the specific position of the Naso-intestinal tube could be adjusted during the operation. (2) Postoperative: At 8 h after surgery, the patient was placed in a semi-recumbent position and injected with enteral nutrition emulsion [TP, Fresenius Kabi Deutschland GmbH (Germany)] through Naso-intestinal tube with a nutrient pump, the dose was generally 500 mL (500 Kcal). Before injection, 250 mL of normal saline was injected through the Naso-intestinal tube, the drip rate was 40 drops/min. TP could be injected at a constant rate after the patient had no discomfort, the drip rate was 20 mL/h, and then increased by 20 mL/h day by day, and the maximum drip rate was not more than 125 mL/h. The dose was increased to 1000 mL 48 h after surgery, depending on the patient's condition, and to 1500 ~ 2000 mL 72 h after surgery. After 7 days of operation, the Naso-enteric tube could be removed by angiography, liquid diet was given, semi-liquid diet was given after the 10th day, and ordinary diet was given on the 14th day [25].

2.4. Observation indicators

(1) The postoperative intestinal function recovery time (first anal exhaust, first defecation) as well as length of hospital stay were observed in two groups.

(2) Psychological status: Self-rating Anxiety Scale (SDS) together with Self-rating Depression Scale (SAS) was implemented to evaluate the psychological status of patients [26]. Among them, SAS score ≥ 50 points indicated anxiety, and SDS score ≥ 53 points indicated depression. The higher the score, the more severe the anxiety and depression was. In this study, SAS and SDS were defined as secondary psychological outcomes to observe perioperative emotional responses rather than to diagnose psychiatric disorders [27].

(3) Quality of life: EORTC QLQ-C30 was used to evaluate the quality of life of patients [28]. The scale covered 5 dimensions of physical function, role function, cognitive function, emotional function as well as social function, with a total of 100 points for each item. The higher the score, the better quality of life of patients was. The emotional and social functioning domains were additionally analyzed as indirect indicators of psychological adaptation.

(4) 4 mL of fasting venous blood was extracted from two groups, centrifugation at a rotating speed of 3000 r/min for 10 min, serum was separated, and serum transferrin (TRF), albumin (ALB) and total protein (TP) levels were detected by automatic biochemical analyzer.

(5) 4 mL of fasting venous blood was extracted from two groups, centrifugation at a rotating speed of 3000 r/min for 10 min, serum was separated, and serum levels of immunoglobulin G (IgG), immunoglobulin A (IgA) as well as immunoglobulin M (IgM) were detected by Immunospectrophotometry.

(6) The incidence of complications including pulmonary infection, incision infection, and anastomotic fistula was recorded in two groups.

(7) The nursing satisfaction questionnaire was prepared by ourselves to assess the nursing satisfaction of patients in two groups. The total score of the questionnaire was

100 points, and the score of 80-100 was very satisfied, 60-79 was satisfied, and less than 60 was dissatisfied. Total satisfaction rate = (very satisfaction rate + satisfaction rate).

2.5. Statistical analysis

SPSS 24.0 statistical software was adopted for data analysis. Measurement data were expressed as ($\bar{x} \pm s$), and t-test was adopted for comparison. Count data were expressed as ($n, \%$), and χ^2 test was used for comparison. $P < 0.05$ meant statistical significance. Clinical outcomes served as primary endpoints, while SAS/SDS and emotional QLQ-C30 domains were analyzed as secondary exploratory psychological indicators [29].

3. Results

3.1. Postoperative intestinal function recovery time and length of hospital stay in two groups

In comparison with the CG, the first time of anal exhaust (75.68 ± 4.25 vs. 67.00 ± 4.19), first time of defecation (6.43 ± 0.44 vs. 5.00 ± 0.30) as well as length of hospital stay (15.19 ± 1.43 vs. 12.83 ± 0.82) in the OG presented shorter ($P < 0.01$, Figure 1).

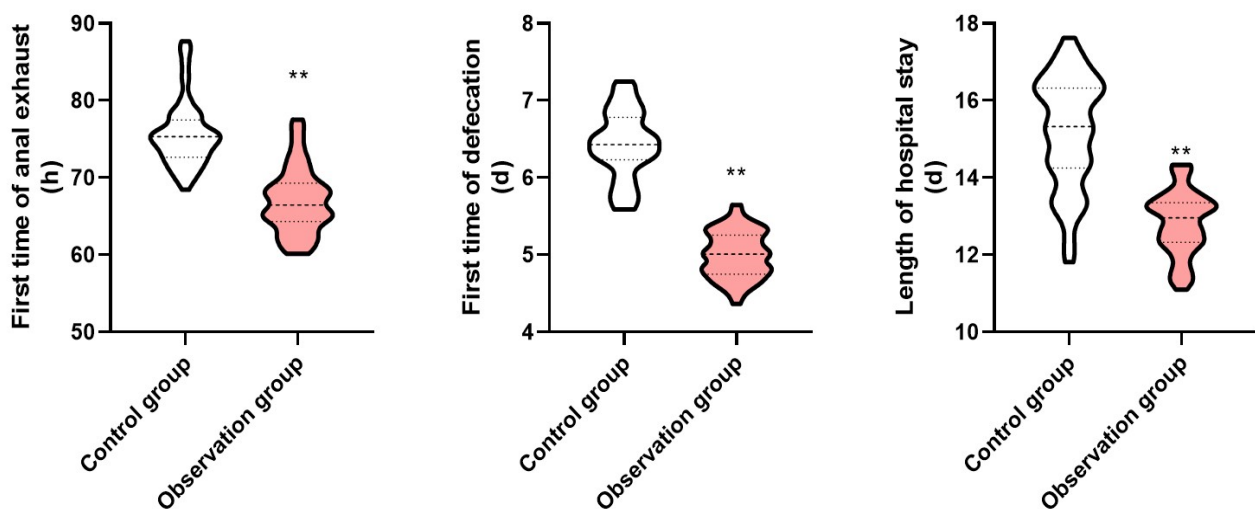


Figure 1. Postoperative intestinal function recovery time and length of hospital stay in two groups.

** $P < 0.01$.

3.2. Psychological status in two groups

Relative to before intervention, SAS and SDS scores in two groups were lower after intervention, whereas both SAS (44.56 ± 4.52 vs. 51.35 ± 5.14) and SDS (47.62 ± 4.72 vs. 53.26 ± 5.32) scores in the OG group were significantly lower than those in the CG group ($P < 0.05$, Figure 2).

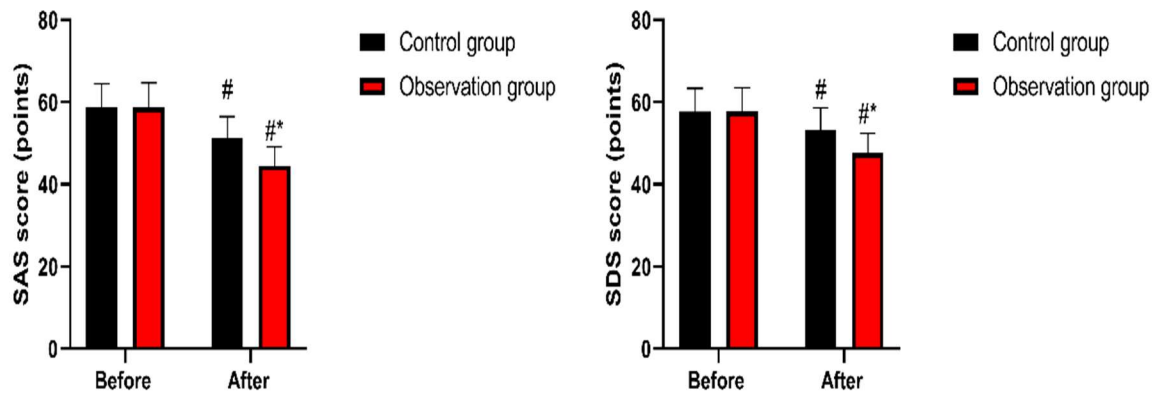


Figure 2. Psychological status before and after the intervention in two groups.

[#] $P < 0.05$, in contrast to before intervention. ^{*} $P < 0.05$, in contrast to CG.

3.3. Quality of life in two groups

Relative to before intervention, the scores of physical functions, role function, cognitive function, emotional function as well as social function were elevated in two groups after intervention, and those in OG presented higher than those in CG ($P < 0.05$, Figure 3).

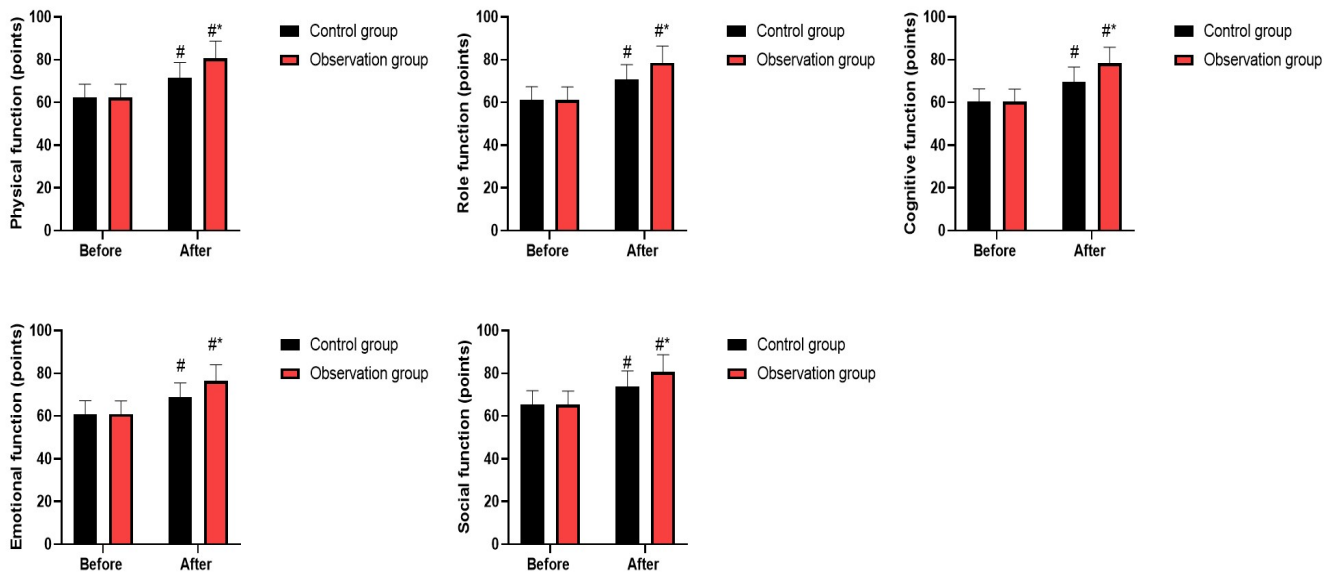


Figure 3. Quality of life before and after the intervention in two groups. [#] $P < 0.05$, in contrast to before surgery.

^{*} $P < 0.05$, in contrast to CG.

3.4. Nutritional status in two groups

Compared with before surgery, serum TRF, ALB and TP levels in two groups were lower 7 days after surgery, while those in OG presented higher than those in CG ($P < 0.05$, Figure 4).

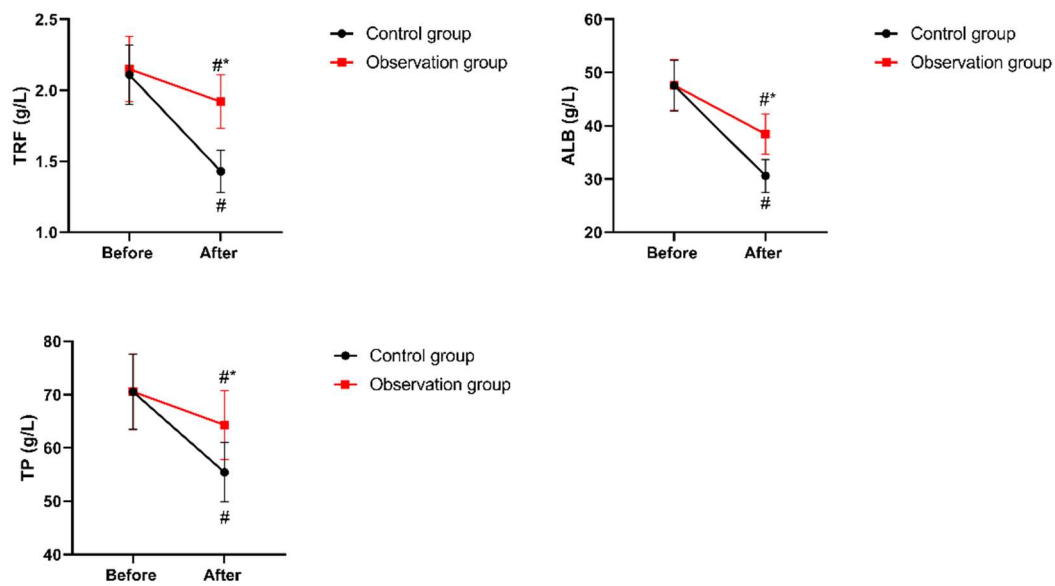


Figure 4. Nutritional status before and after the intervention in two groups.

$P < 0.05$, in contrast to before surgery. * $P < 0.05$, in contrast to CG.

3.5. Immune function in two groups

Compared with before surgery, serum IgA, IgG and IgM levels in two groups were lower 7 days after surgery, while those in OG presented higher than those in CG ($P < 0.05$, Figure 5).

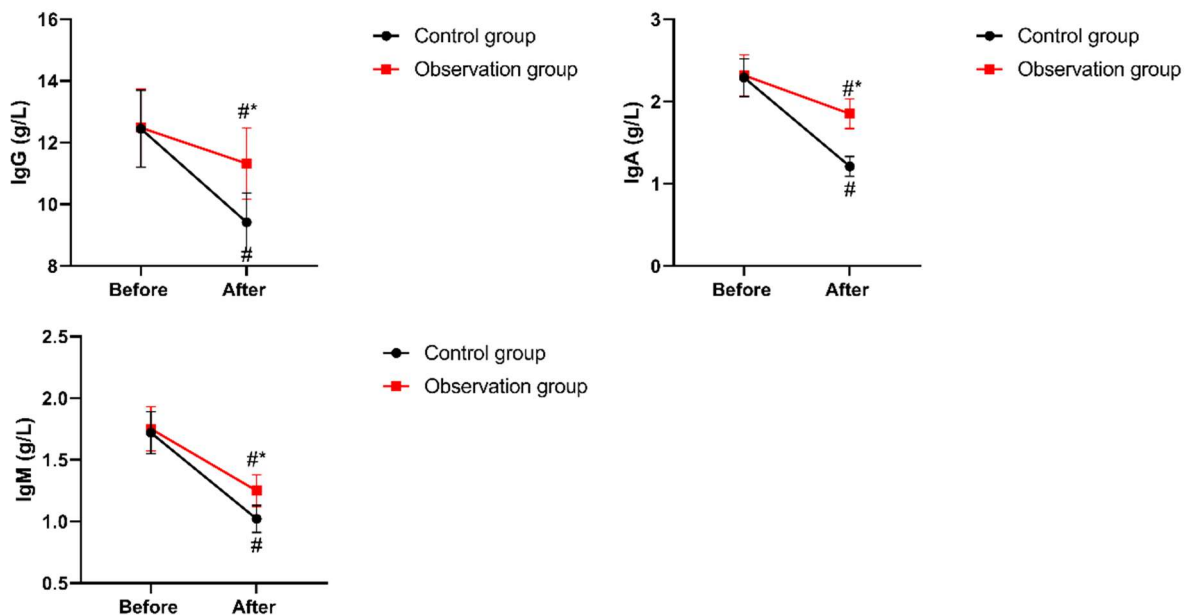


Figure 5. Immune function before and after the intervention in two groups.

$P < 0.05$, in contrast to before surgery. * $P < 0.05$, in contrast to CG.

3.6. Incidence of complications in two groups

The total complication rate in the OG (2.94%) was significantly lower than that in the CG (14.92%) ($P = 0.014$, Table 2).

Table 2. Incidence of complications in two groups, *n* (%).

Groups	<i>N</i>	Pulmonary infection	Incision infection	Anastomotic fistula	Total incidence rate
Control group	67	3	4	3	10 (14.92%)
Observation group	68	1	1	0	2 (2.94%)
χ^2					5.985
<i>P</i>					0.014

3.7. Nursing satisfaction in two groups

Nursing satisfaction was significantly higher in the OG (97.05%) compared with the CG (83.58%) ($P < 0.05$, **Table 3**).

Table 3. Nursing satisfaction in two groups, *n* (%).

Groups	<i>N</i>	Very satisfied	Satisfied	Dissatisfied	Total satisfaction rate
Control group	67	34	22	11	56 (83.58%)
Observation group	68	36	30	2	66 (97.05%)
χ^2					7.043
<i>P</i>					0.008

4. Discussion

Esophageal cancer surgery is associated with substantial physiological stress and functional disruption, making perioperative nursing care and nutritional support critical determinants of postoperative recovery and patient well-being [30]. Due to the high level of trauma caused by surgery, effective nursing care and nutritional support should be implemented during the perioperative period may be able to ameliorate the patient's adverse trauma. Because major surgical intervention can simultaneously trigger both physical stress responses and psychological distress responses such as anxiety and loss of control, multidisciplinary perioperative care is recommended in modern psychosocial oncology practice [29].

With the development of information age and the transformation of nursing mode, the nursing mode based on "Internet+" has been widely applied to patients with chronic diseases like diabetes, hypertension as well as stroke, and the application effect is good [23,31,32]. Researches have shown that "Internet+" nursing support can significantly promote the self-management ability of patients with chronic diseases, enhance the rehabilitation effect and clinical prognosis of patients [23]. Perioperative "Internet+" rehabilitation nursing mode is a convenient and continuous rehabilitation nursing mode. With the rehabilitation of patients as the center, this model implements a series of nursing measures such as psychological nursing, rehabilitation guidance, life and diet guidance for patients through many network tools such as public accounts, online videos, and communication groups, enhancing nurse-patient communication, supporting self-management, and alleviating negative emotional responses [33]. This aligns with findings that remote communication, continuous instruction, and accessible clarification of postoperative concerns can buffer uncertainty, reduce anxiety, and sustain emotional stability during hospitalization, which are recognized psychological needs among surgical cancer patients [34].

Total parenteral nutrition is commonly used in clinical practice to provide perioperative nutritional support for surgical or critically ill patients [35]. However, both peripheral and central venous routes are associated with potential complications, including phlebitis, catheter-related infections, pneumothorax, and metabolic disturbances, and prolonged use may adversely affect liver function and bile metabolism [36–38]. In contrast, early enteral nutrition delivers nutrients directly through the gastrointestinal tract, which is more consistent with physiological processes and is associated with lower cost and easier administration [39,40]. Meta-analytic evidence has demonstrated that early enteral nutrition reduces complications and length of intensive care stay compared with parenteral nutrition [41]. In patients with esophageal cancer, studies have shown that early enteral nutrition is associated with shorter hospital stay and reduced medical costs, with comparable or favorable nutritional outcomes relative to total parenteral nutrition [42,43]. Therefore, early enteral nutrition represents a more appropriate nutritional strategy in perioperative nursing care for esophageal cancer. From a psychological perspective, improved nutritional stability may also alleviate somatic discomfort and fatigue, which are known contributors to emotional distress during postoperative recovery [44].

In our study, the results suggested that in comparison with the CG, the first time of anal exhaust, first time of defecation as well as length of hospital stay in the OG presented shorter, suggesting that perioperative “Internet+” rehabilitation nursing in combination with early enteral nutrition support could restore gastrointestinal function of patients with esophageal cancer. The reason is that early enteral nutrition intervention helps to maintain the integrity of intestinal mucosal structure along with barrier function, and stimulates the normal physiological function of the intestine while providing nutrients [45]. When the intestinal neuroendocrine axis is stimulated, the intestinal secretion of 5-hydroxyserotonin, a smooth muscle contraction stimulator and strong vasoconstrictor, is promoted, and then the intestinal peristalsis function is regulated, and the early intestinal peristalsis and intestinal function are restored [46]. This is consistent with the findings of Shao et al. that postoperative gastrointestinal surgery patients who received early enteral nutrition recovered gastrointestinal function faster [47]. These physiological improvements may also reduce postoperative uncertainty and enhance patients perceived control, factors associated with reduced anxiety and more adaptive recovery behavior in perioperative oncology settings [48].

Our study also indicated that after intervention, SAS and SDS scores in OG presented lower than those in CG, while the scores of physical functions, role function, cognitive function, emotional function as well as social function in OG presented higher than those in CG. These domains of functioning do not operate independently, but rather they are interconnected and influence each other. Somatic dysfunction generally coexists with anxiety and depressive symptoms, and physical limitations can reduce self-efficacy, which can cause social isolation and increase psychological burden. Cognitive functioning is also one of the risk factors for negative mood, which may affect the ability to function in daily life thus causing the patient to experience problems such as excessive worrying and lack of concentration. Anxiety and depression are forms of emotional dysfunction, and improvement in this functioning directly affects the improvement of negative emotions. Social support systems are a key influence on mental health, and social dysfunction can exacerbate negative

emotions by straining interpersonal relationships and making it more difficult for individuals to cope with life's challenges. Therefore, all of the above results suggest that perioperative "Internet+" rehabilitation nursing in combination with early enteral nutrition support could relieve the negative emotions as well as promote the quality of life of patients with esophageal cancer. Consistently, Yao et al. have indicated that nursing intervention based on "Internet Plus" continuous mode can lessen negative emotions as well as promote the quality of life of severe adrenal tumor patients [49]. These findings align with the biopsychosocial recovery framework, where reductions in emotional distress coexist with functional improvement, suggesting that psychosocial stability may act as a supportive mechanism rather than a standalone outcome [50].

Additionally, this study showed that serum TRF, ALB, and TP levels, as well as IgA, IgG, and IgM concentrations, were significantly higher in the observation group than in the control group after intervention, indicating improved nutritional and immune status. TRF, ALB, and TP are established indicators of protein-energy balance, and reductions in these markers are commonly associated with impaired immune function and increased susceptibility to infection. Immunoglobulins IgA, IgG, and IgM directly reflect humoral immune competence, and their synthesis is particularly sensitive to nutritional adequacy, especially protein availability. Taken together, the combined assessment of nutritional and immunological markers provides a comprehensive evaluation of postoperative recovery status [51]. These findings suggest that perioperative "Internet+" rehabilitation nursing combined with early enteral nutrition contributes to maintaining nutritional homeostasis and immune function following esophageal cancer surgery. Enteral nutrition delivers nutrients directly to the gastrointestinal tract, facilitating efficient absorption and protein synthesis, thereby supporting immune competence [52]. Moreover, psychoneuroimmunology research indicates that psychological distress can modulate inflammatory signaling and immune efficiency, suggesting that improvements in nutritional and immune status may coexist with enhanced emotional stability during postoperative recovery [53,54].

It is well established that immune function undergoes complex alterations during the perioperative period in patients undergoing cancer surgery, which can influence postoperative recovery and the occurrence of complications [55]. Improved immune competence supports the clearance of residual tumor cells and maintenance of inflammatory balance, thereby reducing the risk of postoperative infection. In a prospective study of patients undergoing esophageal cancer surgery in Sweden, pneumonia and anastomotic insufficiency were identified as the most common postoperative complications [56]. Consistent with these findings, the present study observed a significantly lower incidence of complications, including pulmonary infection, incision infection, and anastomotic fistula, in the observation group. Previous randomized controlled studies in gastrointestinal cancer have also demonstrated that immunonutrition can improve intestinal barrier integrity and reduce postoperative complications [57]. Notably, the reduced complication rate observed in the observation group may reflect not only physiological benefits of optimized nutritional and immune support, but also the stabilizing effects of continuous nursing guidance and emotional reassurance, as effective communication and psychological

support are known to attenuate maladaptive stress responses during postoperative recovery [58]. In addition, higher nursing satisfaction in the observation group further supports the acceptability and perceived effectiveness of the integrated “Internet+” rehabilitation nursing model, consistent with prior reports [59,60].

This study has several limitations that should be acknowledged. First, as a single-center study with a relatively limited sample size, the findings may be influenced by institutional practices and patient characteristics, which may restrict the generalizability of the results to other clinical settings. Second, individual differences in baseline health status, immune function, and recovery capacity may have contributed to variability in treatment response. Third, this study primarily assessed short-term postoperative outcomes, and the absence of long-term follow-up limits conclusions regarding the durability of clinical and psychological benefits. In addition, psychological outcomes assessed using the SAS and SDS were exploratory and secondary in nature. Future studies should incorporate larger, multicenter designs, extended follow-up periods, and validated psychosocial instruments, such as the Distress Thermometer or Fear of Cancer Recurrence scales, to more comprehensively evaluate long-term psychological adaptation and strengthen comparability within psycho-oncology research [61].

5. Conclusion

This study addressed the research question of whether perioperative “Internet+” rehabilitation nursing combined with early nutritional support can improve postoperative recovery outcomes in patients undergoing esophageal cancer surgery. The findings demonstrate that this integrated care model effectively shortens hospital stay, accelerates gastrointestinal functional recovery, improves nutritional and immune status, and reduces postoperative complications. These benefits are primarily attributable to early enteral nutrition, which helps maintain intestinal mucosal integrity, supports physiological immune defense, and promotes faster physical recovery. In addition, although psychological outcomes were defined as secondary, the intervention was associated with reduced perioperative anxiety and depressive symptoms, as reflected by lower SAS and SDS scores. This suggests that continuous communication, emotional reassurance, and clear postoperative guidance delivered through the “Internet+” nursing model may provide a stabilizing psychological effect during recovery. Consistent with biopsychosocial principles emphasized in psycho-oncology, emotional stability appears to function as a supportive factor that facilitates engagement in rehabilitation and complements physical recovery rather than acting as an isolated outcome. From a practical perspective, these findings have important implications for clinical practice, research, and health policy. For practitioners, the results support the adoption of integrated digital nursing models that combine nutritional management with continuous psychosocial support to enhance postoperative recovery and patient satisfaction. For researchers, the study highlights the value of incorporating psychological indicators as secondary outcomes in perioperative care research to better understand the interaction between emotional adaptation and physical recovery. For policymakers, the demonstrated efficiency of the “Internet+” rehabilitation approach suggests a scalable strategy for optimizing

perioperative care delivery, potentially reducing hospital burden and improving care quality in oncology settings. Nevertheless, given the single-center design and short-term follow-up, future multicenter studies with larger sample sizes and extended follow-up periods are warranted. Incorporating broader psychosocial assessments, such as distress thermometer screening or fear-of-recurrence measures, may further clarify the long-term role of psychological adaptation in recovery trajectories among patients with esophageal cancer.

Author contributions: Conceptualization, QZ and YC; methodology, QZ; software, WW; validation, QZ, WW and YC; formal analysis, QZ; investigation, WW; resources, WW; data curation, QZ; writing—original draft preparation, QZ; writing—review and editing, YC; visualization, YC; supervision, YC; project administration, YC; funding acquisition, YC. All authors have read and agreed to the published version of the manuscript.

Funding: None.

Ethical approval: This study was approved by the Ethical Committee of The Affiliated Huai'an No.1 People's Hospital of Nanjing Medical University (approval number KY-2024-074-01). The ethics review process evaluated the scientific rationale, study design, patient safety, and data confidentiality. All participants were fully informed about the study objectives, procedures, potential risks, and benefits prior to enrollment, and written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki and relevant institutional guidelines.

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

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

References

1. Morgan E, Soerjomataram I, Rumgay H, et al. The global landscape of esophageal squamous cell carcinoma and esophageal adenocarcinoma incidence and mortality in 2020 and projections to 2040: new estimates from GLOBOCAN 2020. *Gastroenterology*. 2022; 163(3): 649–658.e2. doi: 10.1053/j.gastro.2022.05.054
2. Waters JK, Reznik SI. Update on Management of Squamous Cell Esophageal Cancer. *Current Oncology Reports*. 2022; 24(3): 375–85.
3. Huang FL, Yu SJ. Esophageal cancer: Risk factors, genetic association, and treatment. *Asian Journal of Surgery*. 2018; 41(3): 210–215. doi: 10.1016/j.asjsur.2016.10.005
4. Borggreve AS, Kingma BF, Domrachev SA, et al. Surgical treatment of esophageal cancer in the era of multimodality management. *Annals of the New York Academy of Sciences*. 2018; 1434(1): 192–209. doi: 10.1111/nyas.13677
5. Mocanu A, Bârla R, Hoara P. Current endoscopic methods of radical therapy in early esophageal cancer. *Journal of Medicine and Life*. 2015; 8.
6. Jia Y, Xing J, Li Y, et al. A systematic review and meta-analysis of nursing effect of fast-track recovery surgery on patients undergoing total endoscopic resection of esophageal cancer: Fast-track recovery surgery vs. nursing care as usual. *Journal of Gastrointestinal Oncology*. 2023; 14(2): 572–584. doi: 10.21037/jgo-23-101
7. Housman B, Flores R, Lee DS. Narrative review of anxiety and depression in patients with esophageal cancer: underappreciated and undertreated. *Journal of Thoracic Disease*. 2021; 13(5): 3160–3170. doi: 10.21037/jtd-20-3529
8. Kovačić Petrović Z, Peraica T, Kozarić-Kovačić D, et al. Internet use and internet-based addictive behaviours during

- coronavirus pandemic. *Current Opinion in Psychiatry*. 2022; 35(5): 324–331. doi: 10.1097/ycp.0000000000000804
9. Banerjee A. Internet use and autism spectrum disorders. *Journal of Autism and Developmental Disorders*. 2023; 53(8): 3307–3308. doi: 10.1007/s10803-023-05904-z
10. Gomez EG, Clark PM. The internet in oncology nursing. *Seminars in Oncology Nursing*. 2001; 17(1): 7–17. doi: 10.1053/sonu.2001.20414
11. Caminiti C, Annunziata MA, Di Giulio P, et al. Psychosocial impact of virtual cancer care through technology: A systematic review and meta-analysis of randomized controlled trials. *Cancers*. 2023; 15(7): 2090. doi: 10.3390/cancers15072090
12. Song C, Cao J, Zhang F, et al. Nutritional risk assessment by scored patient-generated subjective global assessment associated with demographic characteristics in 23,904 common malignant tumors patients. *Nutrition and Cancer*. 2019; 71(1): 50–60. doi: 10.1080/01635581.2019.1566478
13. Chiang HC, Lin MY, Lin FC, et al. Transferrin and prealbumin identify esophageal cancer patients with malnutrition and poor prognosis in patients with normal albuminemia: A cohort study. *Nutrition and Cancer*. 2022; 74(10): 3546–3555. doi: 10.1080/01635581.2022.2079687
14. Steenhagen E. Preoperative nutritional optimization of esophageal cancer patients. *Journal of Thoracic Disease*. 2019; 11(S5): S645–S653. doi: 10.21037/jtd.2018.11.33
15. Miller KR, Bozeman MC. Nutrition therapy issues in esophageal cancer. *Current Gastroenterology Reports*. 2012; 14(4): 356–366. doi: 10.1007/s11894-012-0272-6
16. Meng Y, Gao R, Yang H, et al. Health-related quality of life and related factors among esophageal cancer survivors after esophagectomy in the 6-month postoperative period: A multicenter cross-sectional study in north China. *Asia-Pacific Journal of Oncology Nursing*. 2025; 12: 100655. doi: 10.1016/j.apjon.2025.100655
17. Wada S, Sadahiro R, Matsuoka Y, et al. The association between postoperative recovery and psychosocial factors in cancer patients. *Journal of Surgery*. 2020; 8(1): 9. doi: 10.11648/j.js.20200801.13
18. Shebl MA, Toraih E, Shebl M, et al. Preoperative anxiety and its impact on surgical outcomes: A systematic review and meta-analysis. *Journal of Clinical and Translational Science*. 2025; 9(1): 1–27. doi: 10.1017/cts.2025.6
19. Dimitriadou I, Kaperda A, Toska A, et al. Surgical fear, anxiety, and satisfaction with nursing care: a cross-sectional study of hospitalized surgical patients. *Nursing Reports*. 2025; 15(10): 365. doi: 10.3390/nursrep15100365
20. Bello CM, Eisler P, Heidegger T. Perioperative anxiety: Current status and future perspectives. *Journal of Clinical Medicine*. 2025; 14(5): 1422. doi: 10.3390/jcm14051422
21. Chen X, Chen Y, Zhou L, et al. The role of self-esteem as moderator of the relationship between experienced stigma and anxiety and depression among tuberculosis patients. *Scientific Reports*. 2023; 13(1): 6889. doi: 10.1038/s41598-023-34129-4
22. Castellano-Santana PR, Cabrera-López F, Martín-Alonso MD, et al. The impact of social support on postoperative recovery in retinal detachment surgery. *Medicina*. 2025; 61(2): 273. doi: 10.3390/medicina61020273
23. Chen Y, Qiu C, Chen J, et al. Effect of the internet combined with exercise-based individualized nursing intervention in patients with gestational diabetes mellitus. *Diabetology & Metabolic Syndrome*. 2021; 13(1): 125. doi: 10.1186/s13098-021-00738-0
24. Bergerot CD, Bergerot PG, Philip EJ, et al. Enhancing cancer supportive care: integrating psychosocial support, nutrition, and physical activity using telehealth solutions. *JCO Global Oncology*. 2024; 10: e2400333. doi: 10.1200/GO-24-00333
25. Wang X, Chen J, Feng M, et al. Demand and influencing factors of “Internet + Traditional Chinese Medicine” home nursing service for older adult patients with chronic diseases: A mixed research perspective. *Frontiers in Public Health*. 2023; 11: 1271082. doi: 10.3389/fpubh.2023.1271082
26. Yue T, Li Q, Wang R, et al. Comparison of hospital anxiety and depression scale (HADS) and zung self-rating anxiety/depression scale (SAS/SDS) in evaluating anxiety and depression in patients with psoriatic arthritis. *Dermatology*. 2019; 236(2): 170–178. doi: 10.1159/000498848
27. Abraham J, Holzer KJ, Pedamallu L, et al. Peri-operative mental health interventions for surgical oncology patients: a narrative synthesis and meta-analysis. *Anaesthesia*. 2025; 80(S2): 54–64. doi: 10.1111/anae.16471
28. Nolte S, Waldmann A, Liegl G, et al. Updated EORTC QLQ-C30 general population norm data for Germany. *European Journal of Cancer*. 2020; 137: 161–170. doi: 10.1016/j.ejca.2020.06.002
29. Grimmett C, Heneka N, Chambers S. Psychological interventions prior to cancer surgery: a review of reviews. *Current Anesthesiology Reports*. 2022; 12(1): 78–87. doi: 10.1007/s40140-021-00505-x
30. Siersema PD. Esophageal cancer. *Gastroenterology Clinics of North America*. 2008; 37(4): 943–964. doi:

- 10.1016/j.gtc.2008.09.012
31. Wu Y, Zhao P, Li W, et al. The effect of remote health intervention based on internet or mobile communication network on hypertension patients. *Medicine*. 2019; 98(9): e14707. doi: 10.1097/md.00000000000014707
32. Chen S, Huang J, Yao L, et al. Internet + continuing nursing (ICN) program promotes motor function rehabilitation of patients with ischemic stroke. *The Neurologist*. 2021; 27(2): 56–60. doi: 10.1097/nrl.0000000000000364
33. Yan W, Liu L, Huang W, et al. Study on the application of the Internet + nursing service in family rehabilitation of common bone and joint diseases in the elderly. *European Review for Medical & Pharmacological Sciences*, 2022, 26(18).
34. Ahmed A, Nasur M, Mohamed E, et al. Preoperative anxiety and information desire among patients undergoing elective surgery in northern sudan: multicenter cross-sectional study. *JMIR Perioperative Medicine*. 2025; 8: e75736–e75736. doi: 10.2196/75736
35. Wang P, Sun H, Maitiabula G, et al. Total parenteral nutrition impairs glucose metabolism by modifying the gut microbiome. *Nature Metabolism*. 2023; 5(2): 331–348. doi: 10.1038/s42255-023-00744-8
36. Berlanda D. Parenteral Nutrition Overview. *Nutrients*. 2022; 14(21): 4480. doi: 10.3390/nu14214480
37. Boullata JI, Mirtallo JM, Sacks GS, et al. Parenteral nutrition compatibility and stability: A comprehensive review. *Journal of Parenteral and Enteral Nutrition*. 2022; 46(2): 273–299. doi: 10.1002/jpen.2306
38. Ridley EJ. Parenteral nutrition in critical illness: total, supplemental or never? *Current Opinion in Clinical Nutrition & Metabolic Care*. 2020; 24(2): 176–182. doi: 10.1097/mco.0000000000000719
39. Reintam Blaser A, Starkopf J, et al. Early enteral nutrition in critically ill patients: ESICM clinical practice guidelines. *Intensive Care Medicine*. 2017; 43(3): 380–398. doi: 10.1007/s00134-016-4665-0
40. Bukowski JS, Dembiński Ł, Dziekiewicz M, et al. Early enteral nutrition in paediatric acute pancreatitis—A Review of Published Studies. *Nutrients*. 2022; 14(16): 3441. doi: 10.3390/nu14163441
41. Elke G, van Zanten ARH, Lemieux M, et al. Enteral versus parenteral nutrition in critically ill patients: An updated systematic review and meta-analysis of randomized controlled trials. *Critical Care*. 2016; 20(1). doi: 10.1186/s13054-016-1298-1
42. Han H, Pan M, Tao Y, et al. Early enteral nutrition is associated with faster post-esophagectomy recovery in chinese esophageal cancer patients: A retrospective cohort study. *Nutrition and Cancer*. 2018; 70(2): 221–228. doi: 10.1080/01635581.2018.1412477
43. Hamai Y, Hihara J, Emi M, et al. Prospective randomized trial of early postoperative enteral and total parenteral nutrition for treating esophageal cancer. *Anticancer Research*. 2021; 41(12): 6237–6246. doi: 10.21873/anticancer.15444
44. Zhang P, Mo L, Li X, et al. Psychological intervention and its immune effect in cancer patients. *Medicine*. 2019; 98(38): e17228. doi: 10.1097/md.00000000000017228
45. Moon SJ, Ko RE, Park CM, et al. The effectiveness of early enteral nutrition on clinical outcomes in critically ill sepsis patients: A systematic review. *Nutrients*. 2023; 15(14): 3201. doi: 10.3390/nu15143201
46. Ma BQ, Chen SY, Jiang ZB, et al. Effect of postoperative early enteral nutrition on clinical outcomes and immune function of cholangiocarcinoma patients with malignant obstructive jaundice. *World Journal of Gastroenterology*. 2020; 26(46): 7405–7415. doi: 10.3748/wjg.v26.i46.7405
47. Shao YR, Ke X, Luo LH, et al. Application of early enteral nutrition nursing based on enhanced recovery after surgery theory in patients with digestive surgery. *World Journal of Gastrointestinal Surgery*. 2023; 15(9): 1910–1918. doi: 10.4240/wjgs.v15.i9.1910
48. Mavros M N, Athanasiou S, Gkegkes I D, et al. Do psychological variables affect early surgical recovery? *PloS One*, 2011, 6(5): e20306. doi: 10.1371/journal.pone.0020306
49. Yao J, He W, Chen H, et al. Nursing effect of continuous nursing intervention based on “Internet Plus” on patients with severe adrenal tumor. *Medicine*. 2023; 102(10): e33187. doi: 10.1097/md.00000000000033187
50. Novy DM, Aigner CJ. The biopsychosocial model in cancer pain. *Current Opinion in Supportive & Palliative Care*. 2014; 8(2): 117–123. doi: 10.1097/spc.0000000000000046
51. Methods in Medicine C M. Retracted: Effects of Chinese Herbal formula on immune function and nutritional status of breast cancer patients. *Computational and Mathematical Methods in Medicine* 2023; 1–6. doi: 10.1155/2022/5900024
52. Qi SY, Wang WT, Chen CY, et al. Early enteral and parenteral nutrition on immune functions of neurocritically ill patients. *Journal of Biological Regulators and Homeostatic Agents*. 2016; 30(1): 227–232.
53. Reiche EMV, Nunes SOV, Morimoto HK. Stress, depression, the immune system, and cancer. *The Lancet Oncology*. 2004;

- 5(10): 617–625. doi: 10.1016/s1470-2045(04)01597-9
54. Liu Y, Tian S, Ning B, et al. Stress and cancer: The mechanisms of immune dysregulation and management. *Frontiers in Immunology*. 2022; 13. doi: 10.3389/fimmu.2022.1032294
55. Zhao Y, Wang C. Effect of ω -3 polyunsaturated fatty acid-supplemented parenteral nutrition on inflammatory and immune function in postoperative patients with gastrointestinal malignancy. *Medicine*. 2018; 97(16): e0472. doi: 10.1097/MD.00000000000010472
56. L Lagergren P, Johar A, Schandl A. Postoperative complications and health-related quality of life after oesophageal cancer surgery: a national, population-based cohort study. *Acta Oncologica*. 2024; 63: 41290. doi: 10.2340/1651-226X.2024.41290
57. Ma M, Zheng Z, Zeng Z, et al. Perioperative enteral immunonutrition support for the immune function and intestinal mucosal barrier in gastric cancer patients undergoing gastrectomy: A prospective randomized controlled study. *Nutrients*. 2023; 15(21): 4566. doi: 10.3390/nu15214566
58. Lanini I, Amass T, Calabrisotto CS, et al. The influence of psychological interventions on surgical outcomes: A systematic review. *Journal of Anesthesia, Analgesia and Critical Care*. 2022; 2(1). doi: 10.1186/s44158-022-00057-4
59. Hsieh HL, Kao CW, Cheng SM, et al. A web-based integrated management program for improving medication adherence and quality of life, and reducing readmission in patients with atrial fibrillation: randomized controlled trial. *Journal of Medical Internet Research*. 2021; 23(9): e30107. doi: 10.2196/30107
60. Shahidi S, Zargar F, Khajelangi HA, et al. The effect of internet-delivered mindfulness stress reduction combined with acceptance and commitment therapy on health anxiety and quality of life of caregiver of patients infected by covid-19: A randomized clinical trial. *International Journal of Community Based Nursing and Midwifery*. 2023; 11(2): 110–121.
61. Riba MB, Donovan KA, Ahmed K, et al. NCCN guidelines insights: Distress management, version 2.2023. *Journal of the National Comprehensive Cancer Network*. 2023; 21(5): 450–457. doi: 10.6004/jnccn.2023.0026