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Current Status and Intervention of Cancer-Induced Fatigue in Patients with Lung Cancer Undergoing Chemotherapy

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Abstract: This paper summarized the key issues in the study of cancer-induced fatigue in patients with lung cancer undergoing chemotherapy, and pointed out the main progress in the incidence, evaluation tools, related mechanisms and intervention measures of cancer-induced fatigue in patients with lung cancer undergoing chemotherapy. The intervention strategies for different types of fatigue in patients with lung cancer were discussed. On this basis, the research prospects of cancer-induced fatigue in patients with lung cancer were prospectively discussed.

1. Introduction

Guidelines for diagnosis and Treatment of Primary Lung Cancer (2022 Edition) [1] Lung cancer is the fastest growing malignant tumor in China in the past 30 years. Lung cancer has become the first cause of cancer death in the third retrospective investigation of causes of death in the 21st century [2].Chemotherapy is an effective method in the treatment of advanced, perioperative and non-small cell lung cancer. Cluster symptoms such as anxiety, fatigue, vomiting and difficulty breathing may occur during or after treatment [1].Symptoms such as pain and vomiting associated with cancer chemotherapy can now be effectively controlled, but there is no gold standard of treatment for fatigue symptoms. Survivors identified fatigue as an important issue that healthcare providers were not adequately addressing [3]. Cancer-related fatigue (CRF) is the pervasive, persistent, subjective fatigue that cannot be relieved by sleep or rest during and after aggressive Cancer treatment for a significant proportion of Cancer survivors [4]. Fatigue has a greater negative impact on functioning and health-related quality of life than symptoms such as pain or depression due to illness [5]. Persistent fatigue has a number of negative effects and can reduce employment [6]In addition, it may reduce survival rates. Previous studies on cancer-induced fatigue mainly focused on breast, colon and prostate cancer, while there were no relevant studies on CRF in lung cancer and other cancers. This article aims to review the incidence, assessment tools, pathogenesis, and treatment methods of cancer related fatigue in lung cancer patients undergoing chemotherapy through the guidelines for cancer related fatigue (Table 1) and related literature, with a view to providing reference for the intervention of cancer related fatigue in lung cancer patients undergoing chemotherapy.

Table 1: Guide features.

Guide developers; Geographical position	citations	Update time;	Development method	Adaptive age	Applicable stage	Type of evidence used
American Oncology Society (ASCO), United States, Canada	Bower et al.	April 2014	ADAPTE method	adult	Post-treatment	NCCN and ONS categories
National Comprehensive Cancer Network (NCCN), USA	NCCN	Second edition, February 2022	Expert consensus supported by evidence	Adults and minors	Post-treatment	NCCN Evidence categories and consensus
Cancer Care Society (ONS), USA	Mitchell et al.	Third edition, August 2014	System search	adult	During and after treatment	ONS Evidence category
Canadian Society for Psychosocial Oncology (CAPO), Canada Canadian Society for Psychosocial Oncology (CAPO), Canada	Howell et al. Howell et al.	Second edition, April 2015 June 2013	System retrieval and ADAPTE System search	adult adult	During and after treatment During and after treatment	GRADE rating GRADE rating
Cancer Rehabilitation and Palliative Care Committee, Chinese Anti-Cancer Society, China	CRPC	January 2022	Systematic retrieval and clinical study	adult	During and after treatment	--
Chinese Oncology Society, China	The Oncology Society of Chinese Medical Association supports the rehabilitation therapy group	2021 edition	Systematic search and expert clinical experience	Adults and minors	During and after treatment	GRADE rating
European Society of Oncology (ESMO)	A. Abi et al.	March 2020	--	adult	During and after treatment	--

1.1. Incidence of Cancer-Induced Fatigue in Lung Cancer Patients Undergoing Chemotherapy

Have research [7]Different levels of CRF have been shown to occur in 25% to 99% of cancer patients, and 30% to 60% of patients will experience moderate to severe fatigue during treatment, or even cause treatment interruption. Yuan Jing et al. [8] in 173 elderly patients with non-small cell lung cancer treated with chemotherapy, 71 (41%) had non-moderate to severe fatigue and 102 (59%) had severe fatigue. Song Yan et al. [9]A total of 106 patients with lung cancer undergoing chemotherapy were investigated. The incidence of total fatigue was 100%, including 100% physical fatigue, 100% emotional fatigue and 95.3% cognitive fatigue. Leak Bryant [10] the incidence of cancer-related fatigue in lung cancer patients treated with chemotherapy was more than 80%.

2. Cancer Fatigue Assessment Scale for Lung Cancer Patients Undergoing Chemotherapy

2.1. Unidimensional Scale

2.1.1. Brief Fatigue Inventory (BFI)

The scale was developed by Mendoza et al. [11] Designed to assess fatigue over the past 24 hours. BFI consists of 9 items, and each item is rated from 0 to 10. The fatigue score is the total score divided by 9. The higher the score is, the heavier the fatigue degree is. A score of 0 indicates no fatigue, 1 to 3 is mild fatigue, 4 to 6 is moderate fatigue, 7 to 9 is severe fatigue, and 10 is the most severe fatigue imaginable. The scale is simple and easy to understand, and can distinguish the severity of fatigue, but limited by the measurement dimensions, it cannot measure aspects such as quality of life. The Taiwan version of the FATIGUE Unidimensional Scale (BFI-T) has been validated in 439 Taiwanese patients diagnosed with multiple cancers with a reliability and validity of 0.82 to 0.97, indicating that it is reliable, effective, and sensitive in measuring the severity and interference of cancer-related fatigue [12].

2.1.2. Facit-Fatigue Scale for Functional Assessment of Chronic Disease Treatment

The scale was developed by Yellen et al. [13] the design, developed and validated primarily in cancer patients with fatigue and anemia, was designed to assess fatigue over the past 7 days. Including 13 fatigue items, using a score scale of 0 to 4, 0 means "not at all", 4 means "very", with an overall score of 0 to 52, the lower the score indicates more fatigue and better quality of life. Fatigue component showed strong internal consistency with reliability and validity ranging from 0.93 to 0.95.Is a useful measure of quality of life after cancer treatment and can also be used by itself as a very brief but reliable and effective measure of fatigue.

2.1.3. Visual Analogue Scale (VAS)

The scale was developed by Lee et al. [14] the reliability and validity of this method was 0.94 ~ 0.96, which was sensitive and comparable. Draw a 10 cm horizontal line on the paper, one end of the horizontal line is 0, indicating no pain; the other end is 10, indicating severe pain; the middle part represents different levels of pain. Ask the patient to mark the level of pain on the line according to how he feels. The mean value of mild pain was 2.57±1.04.The mean of moderate pain was 5.18±1.41.The mean value of severe pain was 8.41±1.35.

2.2. Multidimensional Scale

2.2.1. Multidi-Mensional Fatigue Inventory (MFI-20)

The scale is developed by the University of Amsterdam Medical Sements in the Netherlands [15]Designed in 1995, the method was designed to assess fatigue occurring in the past 24 hours with a reliability and validity of 0.53 to 0.93.The MFI-20 consists of 20 items divided into five dimensions: general fatigue, physical fatigue, reduced activity, reduced motivation and psychological fatigue. Likert 5-level scoring method was adopted, with 1-5 points indicating from "completely consistent" to "completely inconsistent", and MFI-20⩾12 points was diagnosed as fatigue.

2.2.2. The Revised Piper Fatigue Scale (PFS-R)

The scale was developed by Piper et al. [16] after a large sample cross-sectional survey, the internal consistency of the scale was 0.97, and it was modified to consist of 22 items, which were divided into 4 dimensions: 6 behavioral (severity) dimensions, 5 emotional dimensions, 5 sensory dimensions, and 6 cognitive (emotion) dimensions. The numerical scoring method was adopted with 0 to 10 points, with 0 indicating no fatigue at present, 1 to 3 indicating mild fatigue, 4 to 6 indicating moderate fatigue, and 7 to 10 indicating severe fatigue. The score of the scale is divided by the number of items filled in. The higher the score is, the more serious the fatigue you feel now.

2.2.3. Cancer Fatigue Scale (CFS)

Cancer Fatigue Scale (CFS) : This scale contains 15 items in 3 dimensions, including 7 items in physical fatigue dimension (1, 2, 3, 6, 9, 12, 15), 4 items in emotional fatigue dimension (5, 8, 11, 14), and 4 items in cognitive fatigue dimension (4, 7, 10, 13).The score of each dimension is as follows: score of physical fatigue = (item 1+2+3+6+9+12+15) -7, score of emotional fatigue =20-(item 5+8+11+14), score of cognitive fatigue = (item 4+7+10+13) -4. Total score of fatigue is the sum of scores of the three dimensions (0 ~ 60 points). The higher the score is, the more serious the fatigue is. Zhang Fengling et al. [17] The Cronbach α coefficients of internal consistency of dimensions and total amount of CRF were 0.63 ~ 0.86, and the retest reliability was 0.55 ~ 0.77, indicating good reliability and validity.

3. The Pathogenesis of Cancer-Induced Fatigue in Lung Cancer Patients Undergoing Chemotherapy

According to research [18-20], the biological mechanisms of cancer-related fatigue include anemia, cytokine imbalance, hypothalamic pituitary adrenal (HPA) axis imbalance, pentahydroxytryptophan (5-HT) neurotransmitter imbalance, and reduced energy metabolism. However, the most concerned and supported mechanism is the dynamic regulation of cytokines, with the emphasis on proinflammatory cytokines (Figure 1).

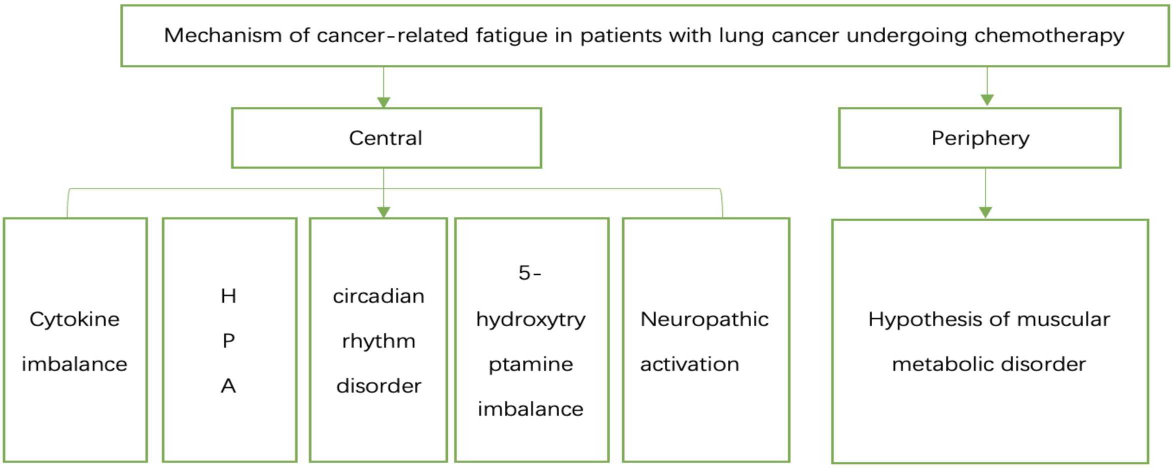

Figure 1: Mechanism of cancer-related fatigue in patients with lung cancer undergoing chemotherapy.

3.1. Pro-Inflammatory Cytokines

Basic studies of neuroimmune signaling suggest that inflammatory processes may be involved in cancer-related fatigue. The brain monitors peripheral innate immune responses in several parallel ways, the first of which involves afferent nerves: locally produced cytokines activate primary afferent nerves, such as the vagus nerves of the abdomen and viscera [21] A. The second pathway involves the blood-brain barrier's cytokine transporters: these saturated transport systems allow overflow of pro-inflammatory cytokines from systemic circulation to enter the brain [22]. There is good evidence for the role of inflammation in CRF [23]. This study suggests that cancer and its treatment can activate peripheral pro-inflammatory cytokine networks that produce CRF symptoms through cytokine signaling in the central nervous system [24-25]. Neuroinflammation is considered to be a possible mechanism of persistent CRF after chemotherapy. In cancer treatment, cytokines may be produced in response to tissue damage caused by chemotherapy[26-27]. Inflammatory responses may persist long after treatment is complete as the host attempts to deal with ongoing changes in pathogenesis and homeostasis.

3.1.1. Inflammation and Fatigue during Lung Cancer Treatment

Radiation and chemotherapy are the two most common cancer treatments, and both have been associated with increased fatigue and elevated markers of certain inflammation [28] A. Zhang Danping et al. [29]The study showed that the reduction of CD3+ and CD4+, inflammatory markers associated with fatigue, was significantly greater in the experimental group than in the control group.Wang et al. [30]The study evaluated 62 patients who received chemotherapy for locally advanced non-small cell lung cancer and showed that fatigue symptoms continued to be severe with the accumulation of chemotherapy doses, peaking at week 8 with significantly increased serum concentrations of interleukin (IL) -6, IL-10, and tumor necrosis factor soluble receptor 1 (STNF-R1) (all $P < 0.05$).Chou et al.[31]A longitudinal repeated-measure design was used to assess subjective symptoms (fatigue, sleep disturbance, pain, depression, and confusion) in patients undergoing chemotherapy for lung cancer. Trends in serum biomarker tartrate-resistant acid phosphate 5A (TRACP5a) were positively correlated with trends in fatigue symptoms, but not with trends in IL-6 and IL-8.Therefore, TRACP5a may be a potential biomarker for assessing fatigue symptoms in lung cancer patients undergoing chemotherapy. These researchers studied and documented trends in inflammatory markers associated with fatigue in lung cancer patients undergoing chemotherapy. Some results suggest that inflammation contributes to fatigue in lung cancer patients during chemotherapy, especially after treatment. However, some studies have found that inflammatory markers are not positively correlated with fatigue in lung cancer patients undergoing chemotherapy, so this issue remains controversial. Future studies should increase the sample size and extend the follow-up time to resolve this controversy.

3.1.2. Inflammation and Fatigue in Lung Cancer Survivors

On average, cancer-related fatigue increased during lung cancer treatment and resolved within a year of completion of treatment [32]. However, these averages mask large individual differences in fatigue severity and process. There is growing evidence that some survivors still experience fatigue a year or years after successful treatment. Liu et al. [33] A total of 217 non-small cell lung cancer (NSCLC) survivors and 200 controls were recruited. Compared with the control group, NSCLC survivors had increased fatigue scores, fatigue severity, depression scores, depression rates, and depression severity (all $P < 0.001$), and had higher levels of inflammatory factors (TNF-α, IL-1β, and IL-17) (all $P < 0.01$). This suggests that serum TNF-α, IL-1β, IL-6, and IL-17 are partly associated with increased risk of anxiety and depression in NSCLC survivors. At present, most studies on inflammation-related fatigue in cancer survivors are in patients with breast cancer and ischemic stroke, while few studies on lung cancer survivors.

3.2. Thalamic-Pituitary-Adrenal (HPA) Axis Disorders

In the direct or indirect development of CRF, maladjustment of the HPA axis is associated with inflammatory response and activation of the immune system [34]One of the functions of the HPA axis is to regulate the release of cortisol during stress [35]. Cortisol suppresses the production of cytokines, protects the body from overactivation by the immune system, and can minimize tissue damage caused by inflammation. Changes in cortisol levels have also been linked to circadian disruption and sleep deprivation, as seen during chemotherapy in lung cancer patients [36] related to CRF.

3.3. Reduced Energy Metabolism

Disruption of energy metabolism (adenosine triphosphate (ATP) production) due to cachexia or damage to the sarcoplasmic reticulum and cartilage after chemotherapy or radiation may cause long-term side effects in all tissues, especially skeletal muscle [34-35]. This in turn increases the risk of peripheral fatigue.

4. Intervention of Chemotherapy Patients with Lung Cancer

4.1. Drug Therapy

Both drug and non-drug therapies are indicated for the treatment of cancer-induced fatigue in patients with lung cancer undergoing chemotherapy, although drug therapy has been used to treat CRF (Figure 2), Mustian et al. [37]. Human studies have shown that exercise and psychological and educational interventions can effectively reduce CRF during and after cancer treatment and are significantly superior to existing drug options. Clinicians should use exercise or psychological intervention as the first line of treatment for CRF.

Central stimulants

Modafinil and methylphenidate, the central nervous system stimulants, have been recommended for the treatment of cancer-related fatigue despite a limited evidence base [38].But Anna et al.[39] One hundred and sixty patients with advanced NSCLC who did not receive chemotherapy or radiation and who had a fitness status of 0 to 2 were randomly assigned to daily modafinil or placebo. Results showed an improvement in the FACit-fatigue score from baseline to day 28.But there was no difference compared with placebo. It follows that modafil has no effect on fatigue associated with lung cancer and should not be prescribed outside the clinical trial setting. In addition, Gong et al. [40] A study of methylphenidate in the treatment of cancer-induced fatigue in cancer patients found that the effect of methylphenidate on CRF increased over time. But more patients in the methylphenidate group reported dizziness, anxiety, anorexia and nausea. These questions suggest that methylphenidate should not be used routinely in patients with lung cancer, but may be used selectively in certain patients.

4.1.1. Antidepressants

Lung cancer chemotherapy patients will produce anxiety depression and other adverse emotions. At present, the main antidepressant drugs used to treat cancer - induced fatigue are bupropion [41]. It can inhibit neuronal reuptake of serotonin, norepinephrine and dopamine to produce antidepressant effects, but its inhibitory effect is weak, and it is an atypical antidepressant drug. Bupropion has been clinically reported to help alleviate cancer fatigue [42]. There are limited studies on the application of antidepressants in the treatment of CRF, and antidepressants have great side effects, including insomnia, palpitation, gastrointestinal symptoms and so on.

4.1.2. Hematopoietic Growth Factor

Currently, erythropoietin is primarily used to treat cancer-induced fatigue in anemia, meaning that if erythropoietin is associated with anemia (either early or during cancer treatment), it can effectively improve CRF by increasing hemoglobin levels [43]. However, due to the safety of tumor growth and the increased risk of cardiovascular events, current clinical guidelines recommend the use of gonadotropin as a treatment for anemia in selected patients only.

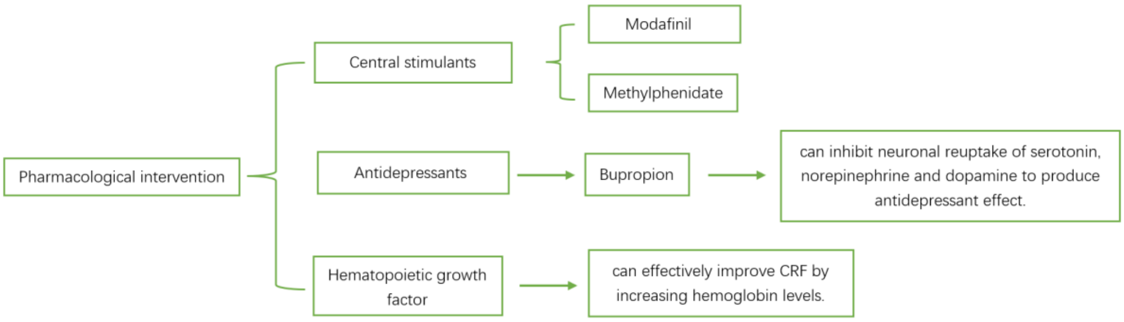

Figure 2: Drug intervention.

4.2. Non-Drug Therapy

Non-pharmacological approaches to managing CRF are more widely accepted in the cancer treatment phase, and there are many options for non-pharmacological approaches.

4.2.1. Exercise Intervention

Overall, there is still some uncertainty about the beneficial effects of good exercise habits in reducing CRF, but there is evidence that exercise does not increase the risk of CRF [44]. Exercise capacity and health-related quality of life are common in patients with non-small cell lung cancer (NSCLC) after pneumonectomy. Exercise training has been shown to improve exercise capacity and quality of life for people with a range of chronic diseases, including chronic obstructive pulmonary disease and heart failure, as well as prostate and breast cancer. Chen Fang et al. [45] showed that muscle training combined with aerobic exercise has a definite effect on CRF patients after chemotherapy for lung cancer, and can significantly reduce CRF symptoms. Its mechanism may be closely related to inhibiting the secretion and release of ACTH, promoting the secretion and release of Cor, and regulating the dysfunction of HPA axis. Ke Jianfan et al. [46] Studies have shown that eight weeks of aerobic exercise combined with resistance exercise reduced cancer-induced fatigue in patients undergoing chemotherapy for non-small cell lung cancer. The results of Yin Zhongmei et al [47] showed that lung rehabilitation exercise for lung cancer patients lasting 2 months can significantly improve lung function, relieve cancer-related fatigue and improve the quality of life of lung cancer patients undergoing chemotherapy. A randomized controlled trial conducted by Liu Yiying et al. [48] showed that graded walking exercise program could reduce CRF of lung cancer patients undergoing chemotherapy, effectively improve the walking distance of 6 min walking test (6MWT) after intervention, and initially achieved results after 8 weeks of intervention. These findings suggest that sustained exercise over a long period of time may have beneficial effects on cancer-induced fatigue in patients with lung cancer undergoing chemotherapy. (Table 2)

Table 2: Effect of exercise intervention on cancer-related fatigue.

article	Type of cancer	movement technique	Results of exercise intervention	Motion frequency	experience group	control group
RCT	Lung cancer patients undergoing chemotherapy	Combine muscle training with cardio	After 12 weeks of intervention, the level of serum ACTH in the two groups decreased significantly, and the level of Cor increased significantly ($P<0.05$ or $P<0.01$); Piper fatigue score decreased significantly compared with the previous score, and the decrease range was ≥ 50%	The training time was (20-30) min/time, once a day before going to bed, (3-5) times/week, and the intervention lasted for 12 weeks.	Aerobic exercise on the basis of single use group	Give muscle training treatment
RCT	NSCLC	Aerobic exercise+resistance exercise	Eight weeks later, the total score and scores of each dimension of cancer-related fatigue in the intervention group were lower than those in the control group, and the quality of life score was higher than that in the control group ($P<0.05$)	The total training time is 30-50 minutes, Aerobic exercise and resistance exercise were started 1 day before chemotherapy, 3-5 times/week, a total of 8 weeks of training.	Routine care	Intervention measures of aerobic+resistance exercise on the basis of routine nursing
RCT	NSCLC	respiratory training+Upper and lower limb movement+ resistance exercise	The above fatigue scores in the observation group were lower than those in the control group, and the difference between the groups was statistically significant ($P<0.05$).	There are 20~30 movements in one group, 2~3 groups each time, twice a day. Lower limb exercise 30 min each time, 5 times a week	Routine exercise rehabilitation intervention	Pulmonary rehabilitation exercise training
RCT	Lung cancer patients undergoing chemotherapy	Graded walking exercise program	The CFS score of intervention group was lower than that of control group ($P<0.01$); The 6MWT walking distance in the intervention group was greater than that in the control group ($P<0.05$ and $P<0.01$)	Mild: 1~2 weeks: 3 days a week, at least 20~30 min/d; 3-4 weeks: 4 days a week, at least 30 min/d; 5-6 weeks: 5 days a week, at least 30-40 min/d; 7-8 weeks: 7 days a week, at least 40 min/d Moderate: 1~2 weeks: 3 days a week, at least 20~30 min/d; 3-4 weeks: 4 days a week, at least 30 min/d; 5-6 weeks: 5 days a week, at least 30-40 min/d; 7-8 weeks: 6 days a week, at least 40 min/d Severity: 1~2 weeks: 3 days a week, at least 20 min/d;3-4 weeks: 4 days a week, at least 30 min/d,5-6 weeks: 5 days a week, at least 30-40 min/d; 7-8 weeks: 6 days a week, at least 40 min/d	A graded walking exercise program was used to guide walking for 8 weeks.	The control group was guided by routine chemotherapy

4.2.2. Psychological/Educational Intervention

Studies have shown that [49] Psychological intervention is second only to exercise intervention in non-drug therapies for reducing CRF in patients. Cognitive behavioral therapy, a symptom commonly associated with cancer-related fatigue, was the most effective of the psychological interventions in reducing CRF [50]. Mindfulness-based intervention (MBI) measures mainly deal with anxiety caused by cancer and related treatment, He Li et al. [51]The scores of behavioral fatigue, emotional fatigue, somatic sensory fatigue and cognitive fatigue in the experimental group were significantly lower than those in the control group after nursing intervention based on MBI for patients with lung cancer chemotherapy. Similarly, educational intervention is also of promotion significance for cancer-induced fatigue in lung cancer patients undergoing chemotherapy. At present, quite a number of lung cancer survivors have a wrong understanding of CRF, and educational intervention is a reasonable and effective way to solve the problem. Wu Yiyan [52] et al. used the method of family members' collaborative health education to intervene in patients with lung cancer undergoing chemotherapy. The results showed that the intervention method had a positive impact on patients' psychological resilience (optimism, self-improvement, emotion, behavior) and self-efficacy. This shows that increasing family members' collaborative intervention on the basis of simple education intervention will reduce the cancer related fatigue of lung cancer patients. This discovery should be paid attention to clinically. (Table 3).

Table 3: Effect of psychological/educational intervention on cancer-related fatigue.

article	Type of cancer	Psychological/educational intervention methods	Results of psychological/educational intervention	experience group	control group
RCT	Lung cancer patients undergoing chemotherapy	Cognitive intervention: through communication, we can find the patients' bad beliefs, correct wrong cognition and improve psychological discomfort; Behavior intervention: carry out breathing training, relax training, and develop a medium intensity exercise program	The score of PFS scale in the observation group was lower than that in the control group, and the difference was statistically significant ($P<0.05$)	Applying cognitive behavioral intervention	Nursing measures for routine chemotherapy
RCT	Lung cancer patients	Mindfulness breathing care; Mindfulness meditation intervention; Walking meditation intervention; Mindfulness yoga and introspection intervention. The intervention was conducted once a week for 50-60 minutes.	The scores of behavioral fatigue dimension, emotional fatigue dimension, physical perception fatigue dimension and cognitive fatigue dimension in the control group after nursing were significantly higher than those in the observation group ($P<0.05$)	Nursing intervention of applying cognitive behavior to accept mindfulness decompression	Give routine care
RCT	Lung cancer patients	Establish a synchronous health education group; The evaluation of family members takes the form of face-to-face interview; Rehabilitation guidance for rehabilitation exercise,; Strengthen family support for patients; Pain intervention	Compared with the conventional group after intervention, the cognitive, emotional, behavioral, somatic scores and the total RPFS scores of the study group after intervention were significantly lower ($P<0.05$)	Give routine health education	On the basis of routine intervention, carry out coordinated health education for family members

5. Summary

CRF is a common distress problem for lung cancer patients. During active lung cancer treatment and survival, a significant proportion of cancer patients survive, and fatigue may persist for several years. Due to the multifactorial nature of cancer-related fatigue, many randomized controlled trials have examined a variety of interventions, including physical activity, psycho-social, psycho-somatic, and medical therapy. While there is no gold standard treatment for fatigue, some of these approaches have shown beneficial effects and can be recommended to patients. Different intervention measures should be taken according to different types of patients. Central stimulants, antidepressants and hematopoietic growth factors may have a certain effect on the improvement of CRF in specific patients, but due to limitations and safety considerations. Pharmacological interventions should not be routinely used to reduce fatigue in patients undergoing chemotherapy for lung cancer. Exercise intervention should be taken for cancer survivors with physical fatigue, and psychological education can be used to alleviate the mental fatigue of cancer survivors.

However, the effect of dietary intervention on cancer-induced fatigue in lung cancer patients undergoing chemotherapy was not reported in the current study. Some studies have proved that fatigue caused by cancer and other related symptoms is related to the diversity and functional disruption of intestinal flora. Therefore, individual dietary interventions (such as the use of prebiotics, probiotics) can be used to adjust the intestinal flora of patients. Future research may focus on dietary intervention for lung cancer patients undergoing chemotherapy to increase the diversity of intestinal flora, improve the intestinal flora of patients, and promote the recovery of central nervous system function, thus alleviating cancer-induced fatigue in lung cancer patients induced by chemotherapy.

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