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The Role of Nurses in Promoting Nutritional Therapy for Cancer Patients Undergoing Chemotherapy: A Multidisciplinary Approach

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Abstract:

Background: Cancer remains one of the leading causes of mortality globally, with significant efforts focusing on improving treatment and survival outcomes. Although advancements in therapeutic strategies have been made, there remains a considerable gap in treatment effectiveness for certain malignancies. Recent studies highlight the potential of nutritional therapy in cancer care, as diet plays a pivotal role in modulating cancer biology, including growth, metabolism, and immune responses.

Aim: This review aims to explore the role of nurses in promoting nutritional therapy for cancer patients undergoing chemotherapy, focusing on multidisciplinary approaches to enhance the integration of nutritional interventions into conventional cancer treatments.

Methods: A comprehensive review of existing literature was conducted to evaluate dietary strategies such as caloric restriction, ketogenic diets, and intermittent fasting, examining their potential impact on cancer treatment and survival outcomes. The mechanisms through which diet interacts with cancer, including nutrient metabolism, hormone signaling, and microbiota interactions, were also assessed.

Results: Dietary modifications have shown promising results in influencing tumor growth, resistance to chemotherapy, and overall patient health. Specific dietary strategies, such as reducing glucose intake and enhancing the gut microbiome, have been identified as potentially effective therapeutic options. Moreover, these dietary changes can influence metabolic pathways that are crucial for cancer progression, such as

oxidative stress regulation and immune modulation. However, there remains a lack of robust clinical data to fully validate these interventions.

Conclusion: The incorporation of nutritional therapy into cancer treatment offers substantial potential for enhancing patient outcomes, especially in chemotherapy. Nurses play a critical role in promoting these therapies by educating patients and coordinating multidisciplinary care. The growing body of research underscores the need for further clinical trials to establish the most effective dietary strategies for cancer patients.

Keywords: Cancer, nutritional therapy, chemotherapy, oncology nursing, multidisciplinary care, diet-cancer interactions, immune modulation.

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Introduction:

Notable progress in combating cancer has been made over the last century; yet, cancer remains a leading cause of death and a considerable public health challenge. Statistics reveal that one in five individuals receives a cancer diagnosis prior to the age of 75, with fifty percent of these cases culminating in death [1]. Contemporary instruments for cancer prevention, diagnosis, and therapy have profoundly transformed the course of cancer mortality, reversing earlier patterns [2]. Nevertheless, many tumors with poor prognoses continue to exist due to inadequately effective therapy alternatives. Consequently, novel therapeutic approaches or improvements to current treatments are crucial for decreasing cancer-related mortality. Dietary changes provoke extensive physiological responses that may affect cancer risk, progression, and development (**Figure 1**). Current estimates suggest that dietary changes could avert about one-third of the most common malignancies [3–5]. Recent discoveries from preclinical models and initial clinical trials indicate that specific dietary behaviors can significantly impact cancer prevention and therapy. These activities can impede carcinogenesis, slow tumor growth, and improve the effectiveness of many anticancer therapies [5–7]. Notwithstanding these encouraging results, the lack of robust mechanistic data and the difficulties related to extensive clinical studies on nutritional treatments have resulted in the underutilization of dietary interventions in clinical practice, especially in oncology. Ambiguities in patient enrollment criteria and variability in metabolic and tumor characteristics hinder studies, often concealing the advantages of dietary interventions.

Nevertheless, growing research endeavors are focused on elucidating the processes by which dietary changes influence cancer. Advancing understanding guides the formulation of randomized clinical studies designed to assess the impact of nutrition on tumor behavior and treatment results, with the ultimate objective of incorporating customized dietary plans into precision oncology. This review examines advanced nutritional therapies in translational oncology. This analysis reviews the current evidence regarding diet-cancer interactions, clarifies mechanisms including nutrient metabolism, growth signaling, immune modulation, microbiota interactions, and inflammation (**Figure 1**), and evaluates dietary strategies with potential anticancer advantages, such as caloric restriction (CR), the ketogenic diet (KD), and intermittent fasting (IF). This review evaluates current trials regarding the safety and feasibility of dietary treatments and discusses upcoming studies to assess their therapeutic implications. This paper provides complete insights to assist researchers and clinicians in oncology in incorporating nutritional methods into conventional cancer therapy and promoting this developing therapeutic strategy.

Current Evidence for Diet–Cancer Interactions

Diet exerts pervasive effects on health and physiology, serving as a critical mediator of antitumor responses through various mechanisms. Dietary strategies can directly influence cancer metabolism by depriving tumors of their preferred nutrients and modulate processes critical for tumor survival, such as growth signaling, oxidative stress, and immune response. This section examines the key mechanisms through which diet interacts with cancer biology.

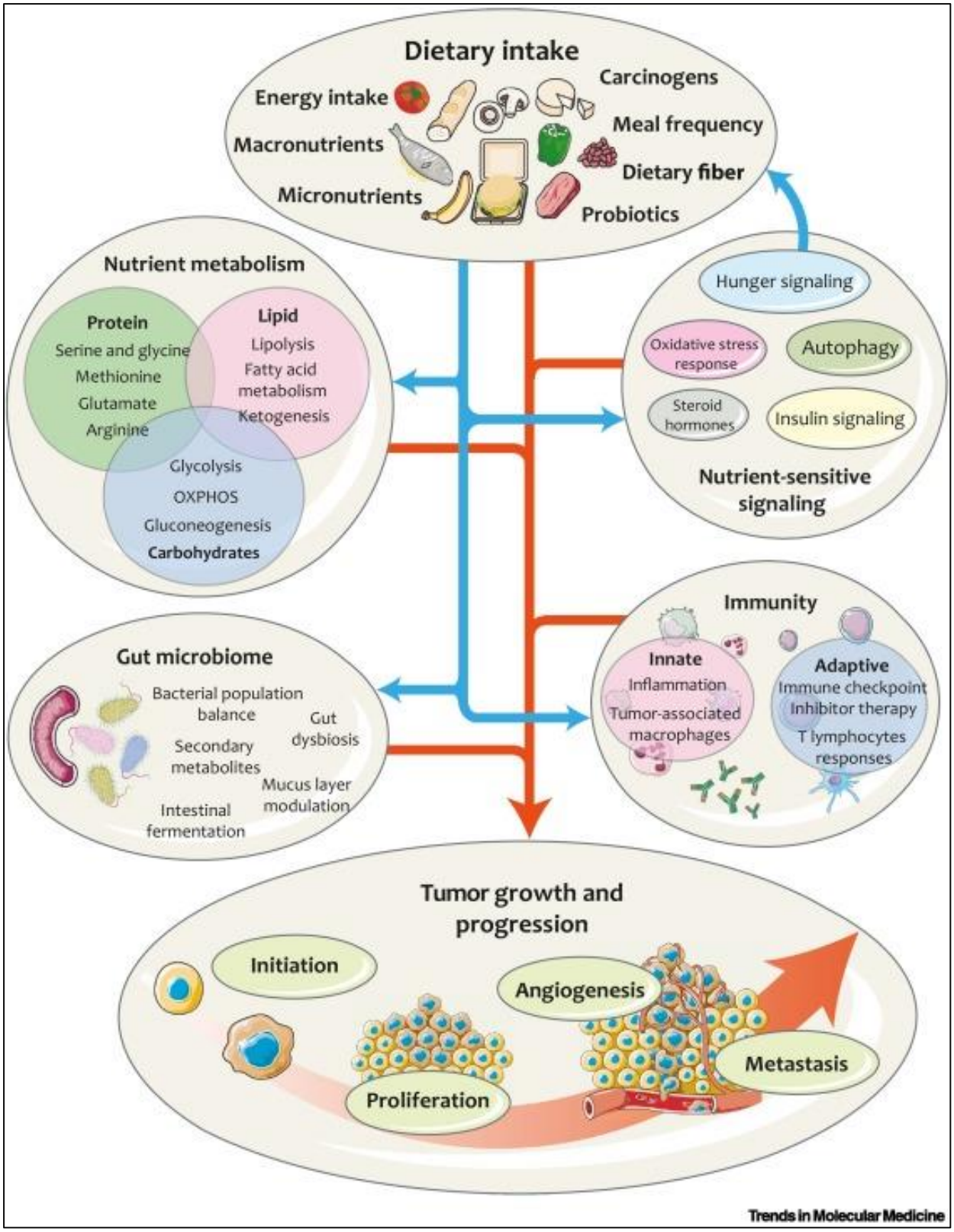

Figure 1: Multiple axes of diet–cancer interactions.

Nutrient Metabolism

Metabolic reprogramming is a recognized characteristic of cancer, initially observed by Otto Warburg in the early 20th century [8–10]. This adaptability enables tumors to maximize energy and nutrient resources to facilitate growth and spread. Cancer cells, owing to their genetic diversity and tissue-

specific metabolic characteristics, rely on certain nutrients, making them susceptible to targeted nutritional therapies. Under standard physiological conditions, cells produce ATP by linking glycolysis with oxidative phosphorylation. Cancer cells primarily depend on aerobic glycolysis, converting glucose into lactate regardless of oxygen presence. This system, while less efficient in ATP synthesis, facilitates rapid glucose consumption and generates metabolic byproducts such lactate, which enhance tumor growth and progression [11]. This reliance on glucose underscores its vital function in cancer advancement and its promise as a therapeutic target [12]. Fructose, a monosaccharide, is associated with cancer proliferation. Research indicates its correlation with the epithelial-to-mesenchymal transition (EMT) in human lung malignancies and EMT-driven colon cancer models in murine subjects [13]. Furthermore, fructose stimulates transketolase in pancreatic cancer cells, promoting cell proliferation through the pentose phosphate pathway [14]. These data indicate a substantial association between elevated consumption of simple carbs and tumor advancement, facilitated by metabolic reprogramming [15].

Cancer cells demonstrate elevated requirements for amino acids to facilitate protein synthesis and proliferation. Numerous malignancies rely on external sources of non-essential amino acids, rendering these nutrients conditionally essential. The "Hoffman effect" refers to the incapacity of cancer cells to produce methionine from homocysteine, requiring external methionine for growth [16,17]. Likewise, some malignancies are deficient in enzymes essential for arginine production, such as argininosuccinate synthetase, especially in high-grade neuroendocrine carcinomas [18]. Restricting dietary amino acids such as serine and glycine has demonstrated suppression of tumor growth and prolonged survival in preclinical models of intestinal cancer and lymphoma [19]. Moreover, the targeting of glutamate transporters has been successful in inhibiting growth in multiple malignancies, such as gastric and triple-negative breast tumors [20–22]. Lipids are essential for cellular architecture, energy reserves, and signaling mechanisms. Changes in lipid metabolism are widespread in cancer cells, frequently marked by increased lipid receptors and transporters. CD36, a fatty acid receptor, is associated with unfavorable prognosis in several malignancies, facilitating metastasis in oral squamous cell carcinoma and ovarian cancer [26–28]. Palmitic acid has been associated with long-term metastasis via CD36-dependent pathways that involve Schwann cell activation [26,29]. Cancer cells increase the expression of LDL receptors and fatty acid-binding proteins to utilize lipid resources, which enhances treatment resistance and spreading capability [30,31]. These findings jointly highlight the complex link between dietary nutrients and cancer biology, emphasizing the possibility of nutritional therapies to inhibit tumor growth and enhance clinical outcomes.

Hormone Signaling and Oxidative Stress

Dietary interventions can elicit physiological adjustments that mitigate tumor genesis and development, so extending their influence beyond mere cellular nutrition. Particular food patterns induce systemic changes in growth signaling pathways, fostering either proliferative or conservative metabolic states to enhance energy and nutrition use. Hormones responsive to nutritional availability, including leptin, insulin, insulin-like growth factor 1 (IGF-1), and steroid hormones, play a crucial role in facilitating the anticancer effects of dietary interventions. Increased concentrations of circulating glucose and amino acids amplify growth factor signaling through insulin and IGF-1, triggering downstream pathways such as PI3K/AKT/mTOR and Ras/MAPK, which are crucial for cell survival and proliferation regulation. These pathways are often overexpressed in cancer [32,33]. Moreover, nutritional treatments affect the tumor-suppressor protein p53 by regulating aldolase A and its downstream effector, DNA-dependent protein kinase [33,34]. Steroid hormones, such as estrogens and androgens, associate cancer prevalence with metabolic problems. Adipose tissue is essential for the conversion of androgens to estrogens in men and postmenopausal women, a process mediated by aromatase synthesized in adipocytes. Estrogen signaling facilitates tumor growth by augmenting proliferative pathways and stimulating angiogenesis, thereby demonstrating a molecular link between fat and cancer [35]. Dietary interventions also influence the control of oxidative stress signals. The AKT protein suppresses FOXO transcription factors, which initiate oxidative stress resistance mechanisms that include enzymes such as heme oxygenase 1 (HO1), superoxide dismutase (SOD), and catalase [36,37]. Increased blood glucose levels inhibit AMPK activation via protein kinase. A signal that diminishes the production of early growth response protein 1, an essential component

for stress tolerance [38]. β-hydroxybutyrate (βOHB), a product of ketogenesis, inhibits histone deacetylases, resulting in enhanced acetylation of oxidative stress-resistance proteins such as FOXO3A and MT2 [39]. βOHB has exhibited direct tumor-suppressive effects by activating Hopx in colorectal cancer mice [40].

The Gut Microbiome and Its Derived Metabolites

The gut microbiome, a diverse assembly of intestinal microorganisms, is crucial in facilitating the relationship between nutritional consumption and general health. The microbiome serves as the principal interface for orally consumed nutrients and pharmaceuticals, significantly affecting energy balance, intestinal development, mucosal barrier integrity, and immune responses. Dysbiosis in the gut microbiota is significantly associated with metabolic syndrome, neurological illnesses, cardiovascular diseases, and various malignancies [41–44]. The carcinogenic effects of the gut microbiota are frequently associated with its involvement in gastrointestinal inflammation and adjacent tissues. Specific bacterial strains are linked to persistent inflammation, a precursor to malignancies of the stomach, gallbladder, and bile duct [45–47]. Moreover, several strains function as genotoxic agents, modifying genomic stability and growth signaling in intestinal cells [47]. Antibiotic-induced dysbiosis, characterized by a partial reduction of gut microbiota, has been associated with heightened risks of colon, stomach, and lung malignancies, highlighting the complex interplay between microbial ecology and health outcomes.

The microbiome has a crucial role in diet-related disorders by influencing metabolism via the production of metabolic hormones. This interaction affects insulin and glucose metabolism, appetite control, and adipose tissue behavior, collectively determining the metabolic phenotype, including obesity and related metabolic diseases [147]. The microbiota metabolizes food components, generating short-chain fatty acids (SCFAs) such as butyrate, acetate, and propionate, which promote apoptosis in cancer cells, activate tumor-suppressor genes, and improve glucose metabolic regulation. Interactions between dietary fiber and microbiota have been demonstrated to alter the intestinal mucus layer independently of short-chain fatty acids, resulting in tumor-suppressive profiles through the reduction of chronic inflammation [42,149]. Nonetheless, the consumption of soluble fiber in dysbiotic mice has been linked to hepatic disorders, including cirrhosis and hepatocellular carcinoma (HCC), influenced by fermentation metabolites and bile acids [150–152].

Starvation-induced modifications in gut microbiota can facilitate liver carcinogenesis, while specific gut microorganisms worsen nutritional metabolic dysfunctions associated with starvation, hence increasing cancer. Microbial degradation of tryptophan can restrict its availability in the kynurenine pathway, diminishing NAD+ synthesis and thus elevating cancer risk—a risk that can be alleviated through NAD+ precursor supplementation in tryptophan-deficient populations [154]. Treatments utilizing nicotinamide riboside, a NAD+ enhancer, have demonstrated potential in averting non-alcoholic steatohepatitis (NASH)-induced hepatocellular carcinoma (HCC) and pancreatic cancer in preclinical animals [58,155]. Elevated levels of the microbiota-derived metabolite indole-3-acetic acid (3-IAA) are linked to enhanced chemotherapy responses in pancreatic ductal adenocarcinoma (PDAC), with dietary modifications increasing 3-IAA production and chemotherapy effectiveness in murine models [156]. In recent years, gut microbiota has become a significant factor in tumor immunosurveillance and the modification of immunotherapy effectiveness [51–53]. While fecal microbial transplantation has been the principal method to illustrate these effects, dietary methods present a feasible means to augment anticancer immunity. Microbiome-mediated acetate synthesis has been recognized as a mechanism responsible for the anticancer effects of caloric restriction (CR), unlike other energy-restricted approaches such as intermittent fasting [54]. Microbiome-derived inosine supplementation improves the effectiveness of anti-PD-L1 and anti-CTLA-4 treatments by enhancing T-cell functioning [55]. Likewise, prebiotics like mucin and inulin have demonstrated potential in regulating tumor proliferation via microbiome-mediated improvements in antitumor immunity [56]. Considering the microbiome's significant impact on health and disease, along with its individual diversity, delineating dysbiosis and pinpointing pathogenic

microorganisms linked to certain disorders or therapy results will be essential for enhancing precision nutrition.

The Immune System and Tumor Immunosurveillance

A crucial factor in tumor growth and treatment effectiveness is the complex interaction between cancer cells and the immune system. Immunosurveillance is essential for malignancy prevention; however, when cancers adopt evasion tactics or immune dysregulation undermines this surveillance, the probability of tumor development and therapy resistance markedly escalates. Nutrition is vital in regulating immunological responses by supplying the energy and metabolic substrates necessary for optimum immune function. Historical evidence, including the correlation between hunger and compromised immune defense during famine in developing nations, highlights this connection.

The predominant immune cells are located in the gut-associated lymphoid tissue, serving as a primary defense against ingested pathogens and food antigens. Certain food elements can provoke significant immune responses. Overnutrition has been associated with the induction of persistent low-grade inflammation via the interleukin-17 (IL-17) pathway, mostly through adipocytes, resulting in immunological dysfunction and promoting carcinogenesis [57, 58]. Moreover, specific micronutrients and metabolites play crucial roles in immunological modulation. Arginine metabolism regulates macrophage polarization (M1/M2) and nitric oxide production, whereas selenium is crucial for T cell function due to its role in selenoprotein-mediated redox homeostasis [59, 60]. Vitamin supplementation significantly influences immunological functioning. Vitamins A and D enhance the synthesis of anti-inflammatory interleukin-10 (IL-10) by regulatory T cells in the gastrointestinal system, hence alleviating inflammation after meals. Vitamin C facilitates T cell maturation and B cell proliferation by being absorbed into lymphocytes through sodium-dependent vitamin C transporters [61–63]. Dietary treatments, particularly tailored regimens aimed at maximizing metabolic adaptations, have shown potential to augment antitumor immunity, irrespective of microbiome influence, thus enhancing clinical results [64–68]. Strategies that prioritize calorie restriction considerably enhance antitumor immune responses; nevertheless, the processes involved and the microbiome's influence require additional exploration.

Dietary Interventions in Cancer Treatment: Evidence-Based Approaches

The exploration of dietary interventions in oncology has given rise to various paradigms aimed at enhancing therapeutic outcomes. These strategies encompass diverse approaches, such as caloric restriction (CR), fasting, and time-restricted feeding, which emphasize the reduction of overall caloric intake or meal timing rather than dietary composition. Conversely, other interventions prioritize macronutrient modulation to achieve specific metabolic states conducive to health. Additional strategies target the supplementation or limitation of specific micronutrients to elicit antitumor effects, while certain approaches draw inspiration from regional dietary patterns, such as plant-based and Mediterranean diets, recognized for their associations with longevity and reduced disease prevalence.

Key Observations from Preclinical and Clinical Studies

Multiple studies have revealed the effectiveness of these dietary regimens in different cancer models, showing both direct antitumor effects and the augmentation of therapeutic approaches. Restriction of serine and glycine has been demonstrated to extend longevity in colorectal carcinoma (CRC) caused by genetic abnormalities such APC loss, as well as in lymphoma and pancreatic malignancies linked to Myc activation and Kras-driven pathways, respectively [19]. Ketogenic diets (KDs), frequently augmented with beta-hydroxybutyrate (BOHB), have been associated with reduced tumor burden in colorectal and melanoma models, mostly via improved antitumor immunity and heightened effectiveness of immune checkpoint inhibitors (ICIs) [40, 66, 67]. Fasting and caloric restriction have repeatedly shown reductions in tumor burden across various cancer types, including syngeneic breast cancer, colorectal cancer, and melanoma, along with other advantages such as decreased metastasis and enhanced chemotherapy efficacy. Protein restriction and fasting have been linked to the downregulation of the IGF/mTORC1 pathway, which contributes to reduced tumor growth in models of breast and prostate cancer [106, 107]. Methionine

restriction has emerged as a potential method, augmenting the efficacy of chemotherapy and radiotherapy in colorectal and breast cancer xenografts by boosting antitumor immunity [112–114]. Modulation of micronutrients, namely through the restriction of methionine and leucine, has demonstrated the ability to alter metabolic pathways and inhibit tumor growth in pancreatic and breast cancer models [117, 118]. These findings emphasize the adaptability of dietary interventions as an adjunct to traditional and experimental cancer therapies, highlighting their potential in tumor suppression and the augmentation of systemic immune responses.

CR, Fasting, and Fasting-Mimicking Approaches

Caloric restriction (CR) tactics entail diminishing caloric consumption by roughly 10–40% while maintaining sufficient nutritional equilibrium to avert malnutrition. Comprehensive studies have shown that caloric restriction extends both lifespan and health span in several model species, while reducing or postponing the emergence of inflammation-related and age-associated ailments, including type 2 diabetes, neurodegenerative diseases, and cancer. Caloric restriction (CR) causes substantial decreases in blood glucose, leading to glycogen depletion and subsequent energy production from lipid catabolism via fatty acid oxidation (FAO) in hepatocytes. This metabolic transition produces significant quantities of acetyl-CoA and ketone molecules, chiefly acetoacetate, acetone, and β-hydroxybutyrate (βOHB), which are employed by tissues including the heart, brain, and muscles for energy. The anticancer efficacy of CR in preclinical models has been established for over a century, illustrating its capacity to prevent cancer incidence, decelerate tumor progression, inhibit metastasis, bolster antitumor immunity, alleviate cachexia symptoms, and, in certain instances, entirely suppress tumor development in models with high cancer penetrance induced by chemical carcinogens. The observed effects are ascribed to various metabolic adaptations linked to reduced blood glucose levels, such as decreased insulin-like growth factor 1 (IGF-1) and insulin signaling, augmented antioxidant responses that mitigate DNA damage, diminished systemic inflammation through lowered proinflammatory cytokine levels, and enhanced host immunosurveillance [77]. Notwithstanding considerable preclinical data, CR has yet to be integrated into routine clinical cancer treatment protocols, perhaps because to difficulties in practical implementation and adherence.

Fasting entails the total suspension of caloric consumption for brief periods, generally leading to the depletion of glucose and glycogen within about 24 hours, succeeded by lipid mobilization and fatty acid oxidation in the liver. This mechanism elicits metabolic changes similar to those seen in caloric restriction, characterized by decreased glucose, insulin, and leptin levels, increased glucagon, adiponectin, and ketone bodies, reduced IGF-1 signaling, and improved tolerance to reactive oxygen species [36]. Although fasting is deemed safe [78,79], prolonged caloric deprivation, referred to as water fasting, presents considerable obstacles regarding patient adherence and offers concerns of malnutrition, especially in those with pre-existing illnesses. Therefore, dietary regimens that simulate fasting are frequently utilized to reproduce the related metabolic advantages. Intermittent fasting (IF) is a prevalent method aimed at maintaining a fasting-like condition sufficiently long to promote fatty acid oxidation (FAO) and ketosis, thus attaining comparable metabolic advantages in a more feasible and sustainable way. Cyclical intermittent fasting regimes have been effective in postponing tumor initiation, suppressing growth, and improving treatment synergy across various dietary and body composition contexts [81–86]. These regimens differ in fasting duration and frequency, encompassing time-restricted feeding, 5:2 fasting, and alternate-day fasting protocols.

Fasting-mimicking diets (FMDs) offer an effective method to harness the advantages associated with fasting. These diets entail substantial calorie restriction (>50%), are rich in fats, low in proteins, and include vitamin supplementation to avert malnutrition. FMDs are often conducted over five consecutive days every three to four weeks and have demonstrated benefits in promoting healthy aging, enhancing metabolic health, exhibiting antitumor effects across diverse cancer models, and synergizing effectively with standard cancer treatments. Ketogenic diets (KDs), defined by severe carbohydrate limitation, have surfaced as a potential intervention in cancer treatment. These diets seek to reduce glucose availability, thereby prompting metabolic changes similar to those of caloric restriction and fasting. Standard ketogenic

diets have of 80% fat, 10% protein, and less than 1% carbohydrate by weight, yielding 95% of calorie consumption from lipids. They are generally enhanced with vitamins and minerals to avert nutritional deficits [90,91]. Variants like high-fat/high-protein or Atkins-style ketogenic diets include elevated protein levels, constituting 30–40% of total calorie consumption [91,92]. The precise macronutrient composition is essential, as compensatory metabolic responses, such as anaplerotic pathways and gluconeogenesis from glucogenic amino acids, can compromise the glucose-restricted condition these diets intend to establish. Preclinical research highlights the anticancer efficacy of KDs, especially in hepatocellular carcinoma (HCC), colorectal cancer (CRC), pancreatic cancer, and malignant glioma models. Nonetheless, although the effectiveness of caloric restriction, fasting, and fasting-mimicking diets in preclinical cancer models is well-documented, the underlying mechanisms are not fully elucidated, constraining their translational applicability.

Mechanistic Insights into Fasting-Related Diets in Cancer Therapy

Initially, fasting-related dietary therapies were thought to leverage the metabolic needs of tumor cells, especially their dependence on glucose and other metabolites for energy and biosynthesis. Cancer cells frequently adjust to metabolic stress and nutritional deficiency by initiating defensive mechanisms and anaplerotic pathways, allowing them to fulfill their metabolic requirements even in unfavorable circumstances [157]. Although ketone bodies like βOHB have been associated with the anticancer benefits of these diets, their participation is probably complimentary rather than causative. The variability in tumor responses to ketone metabolism, influenced by differences in the expression of enzymes like succinyl-CoA:3-oxoacid CoA transferase (SCOT) and 3-hydroxybutyrate dehydrogenase (3-HBDH), highlights this intricacy. Moreover, fasting-related therapies affect numerous biological processes, such as growth signaling, inflammation, immunosurveillance, mitochondrial metabolism, and angiogenesis, which together enhance their anticancer effects [5,36,158,161]. These diets also safeguard healthy cells from DNA damage during cancer treatment [162], potentially improving the effectiveness of chemotherapeutic regimens. Preclinical research indicate that several modalities of caloric restriction, fasting, and fasting-mimicking diets have enhanced the sensitivity of cancer cells to chemotherapeutic drugs, including gemcitabine, tyrosine kinase inhibitors, and β-hydroxybutyrate mimetics, while reducing the toxicity of these treatments to healthy tissues. These findings have generated interest in utilizing these diets as adjunct therapies to enhance treatment outcomes and address therapeutic resistance, a major concern in modern cancer treatment [86,88,163–165].

Dietary Restriction Approaches

Recent research underscores the significance of amino acids in cancer genesis and progression, generating interest in protein-restricted dietary therapies. The significance of protein consumption in the initiation and progression of cancer remains debatable. Epidemiological studies have linked protein restriction to increased lifespan and healthspan, particularly in persons below 65 years of age [103,104]. Recent research demonstrates that protein intake beyond 20% of total caloric consumption markedly increases cancer risk and death relative to diets comprising less than 10% of calories from protein [105]. The research linking protein consumption to cancer risk remains ambiguous, with protein suggested to act as a "double-edged sword," potentially promoting tumor growth through amino acids while simultaneously serving a protective function in tumor formation by preserving tissue homeostasis. Investigations employing preclinical murine models have produced inconsistent outcomes. Certain studies indicate that low-protein diets inhibit tumor proliferation by downregulating the IGF/mTOR pathway and augmenting immune surveillance through the reprogramming of tumor-associated macrophages and IRE1α-mediated activation of the unfolded protein response. In contrast, recent research indicates that protein-rich diets safeguard against tumor start and progression and alleviate colitis-induced colorectal cancer (CRC) via amino acid-induced mTOR activation [110,111]. This contradiction indicates that tumor responses to protein restriction are varied, with protein consumption potentially stimulating growth signals in certain cancers while promoting tissue homeostasis to mitigate tumor proliferation in others.

Moreover, diets that limit particular amino acids have exhibited anticancer effects. Dietary depletion of methionine, serine, cysteine, and glycine inhibits one-carbon metabolism and has been demonstrated to reduce tumor growth in multiple preclinical models [19,112–116]. Limitations on leucine and asparagine have likewise yielded anticancer effects [117,118]. This study highlights the efficacy of amino acid-specific dietary treatments in addressing malignancies with unique metabolic requirements. Low-fat diets (LFDs) are a prevalent nutritional approach designed to decrease adiposity and enhance metabolic health by restricting fat intake to under 30% of daily caloric consumption and promoting the intake of plant-based foods and fiber. While LFDs do not diminish glycemic load or elevate ketone bodies, they successfully facilitate weight and body fat reduction [119,120]. Dietary and adipocyte-derived lipids have been associated with tumor growth and metastasis [26,29], indicating that lipid restriction may have anticancer effects, but definitive data from preclinical research is absent. The advantages of LFDs are mostly ascribed to their reduced caloric density relative to lipids (4 kcal/g for proteins and carbs against 9 kcal/g for fats), which passively decreases caloric consumption and obesity, resulting in enhanced metabolic health and potentially beneficial cancer outcomes. Comparative studies demonstrate that individuals adhering to low-fat diets spontaneously consume up to 800 fewer kilocalories per day than those following high-fat diets [120,121].

Alternative Dietary Approaches

Several dietary patterns are under investigation for their potential roles in aging and cancer prevention. These include regional diets, such as the Mediterranean diet, which emphasizes fruits, vegetables, whole grains, fish, plant-sourced protein, and unsaturated fats; as well as vegetarian and vegan diets, which replace animal products with plant-based foods. These dietary patterns are generally associated with improved cardiovascular and metabolic health, although their specific anticancer effects remain largely unexplored due to the challenges of implementing such diets in preclinical models [122–124].

Supplementation: A Promising Nutritional Therapy?

Supplementation with particular micronutrients or metabolites presents a less restricted and more pragmatic dietary intervention approach. Progress in comprehending cancer metabolism has revealed several metabolites with anticancer efficacy. Short-chain fatty acids (SCFAs) formed via microbiota-mediated fermentation of dietary fibers and β-hydroxybutyrate produced during ketogenesis have demonstrated effectiveness in inhibiting colorectal cancer (CRC) growth, indicating their potential as adjuncts in colon cancer therapy [40,166]. Moreover, acetate produced from microbiota exhibits anticancer effects during calorie restriction and has been proven to impede tumor growth when incorporated into a standard diet [54].

Strategies for supplementation are being investigated to augment the efficacy of current cancer treatments. Dietary treatment to enhance metabolites including tryptophan, 3-IAA, histidine, and mannose has been shown to improve chemotherapy results in multiple cancer models [156,167,168]. Furthermore, elevating NAD+ levels by nicotinamide riboside has demonstrated the ability to improve therapeutic effectiveness while mitigating chemotherapy-related toxicity [169]. Diets aimed at enhancing gut microbial health via supplementation constitute an interesting study domain. This can be accomplished by ingesting prebiotics (e.g., dietary fibers) to promote the proliferation of beneficial bacteria or by administering probiotics—live microorganisms that inhabit the digestive tract. As research progressively reveals the microbiota's influence on immune modulation and the augmentation of immunotherapy efficacy, dietary interventions aimed at optimizing microbiota composition may present novel techniques for addressing malignancies that are resistant to immunotherapy. Nonetheless, the intricate relationships that underpin these effects are still inadequately comprehended, and a definitive characterization of "anticancer microbiota" has not yet materialized.

Development of Dietary Interventions for Clinical Use

Although there remain significant gaps in our mechanistic understanding of dietary interventions within the context of cancer treatment, preclinical studies have catalyzed advancements in clinical research, particularly in leveraging dietary strategies as adjunct therapies. These interventions aim to enhance the efficacy of existing treatment modalities. Ongoing clinical trials investigating dietary interventions for cancer treatment are listed below. Dietary interventions have been categorized based on their mechanisms and applications. Examples include fasting regimens (e.g., fasting for 48 hours pre- and 24 hours post-immunotherapy in advanced and metastatic skin cancer [NCT04387084]) and time-restricted eating (TRE), such as a 16-hour fast over 12 weeks for colorectal cancer [NCT04722341]. Fast-mimicking diets (FMDs), like a 5-day diet cycle with metformin adjunct in breast cancer chemotherapy [NCT04248998], and caloric restriction (CR), such as a 75% CR regimen paired with radiotherapy for breast cancer [NCT04959474], have also shown potential. Additional trials focus on ketogenic diets (KDs), involving variations such as 75% fat KD during chemotherapy for breast cancer [NCT05234502], or modified Atkins KD (>20 g carbohydrates/day) for glioblastoma [NCT03278249]. Other interventions explore the Mediterranean diet, amino acid restriction, and low-protein diets. These studies aim to establish feasible, patient-centered guidelines to optimize treatment outcomes. The focus on nutrient-restricted dietary interventions emphasizes simplicity and ease of adherence while maximizing therapeutic benefits. While larger-scale data remain limited, smaller trials have provided foundational insights into their clinical application and scalability.

Completed Clinical Trials

Most completed trials have prioritized establishing safe and feasible protocols for dietary interventions. Individual dietary habits, shaped by cultural and personal preferences, pose challenges to adherence. Consequently, dropout rates can reach up to one-third of participants, even with adequate information and motivation [125–128]. To improve adherence, many studies provide preformulated meals, dietary counseling, and regular follow-ups with dieticians. Despite high dropout rates, interventions have demonstrated adequate safety and feasibility. Common side effects include mild fatigue, digestive disturbances, hypoglycemia, and acidosis, while severe effects are rare and typically associated with older patients or those with comorbidities. Short-term fasting trials have shown significant improvements in quality of life and cancer risk markers, including reductions in adiposity, fasting glucose, insulin, IGF-1, and leptin levels. Fasting, FMDs [87], and KD interventions [131–134] have successfully induced ketogenesis. Pilot studies combining short-term fasting with chemotherapy have reported enhanced quality of life, reduced fatigue, and lower incidence and severity of chemotherapy-related side effects [135, 136]. However, conclusive evidence linking these interventions to improved therapeutic responses remains limited.

FMDs, in particular, have been linked to immunomodulation favoring clinical benefits [65]. The DIRECT trial, a multicenter, open-label, randomized Phase 2 trial, evaluated FMD combined with chemotherapy in HER2-negative breast cancer. The study monitored grade III/IV toxicity and pathological complete responses over four years but did not identify substantial clinical improvements. However, the FMD cohort experienced no increase in adverse events compared to controls, despite the absence of dexamethasone during chemotherapy [137]. Recent case reports have indicated exceptional tumor responses with FMDs combined with standard therapy, including complete and durable responses in advanced tumors [138]. Ketogenic diet trials in oncology have primarily consisted of pilot studies evaluating safety and tolerability, with limited randomized controlled trials (RCTs) [139–143]. The ERGO2 trial applied a 3-day fasting cycle followed by a calorie-restricted KD in combination with re-irradiation for recurrent glioblastoma or gliosarcoma. This study assessed progression-free survival over six months and secondary measures related to safety, adherence, and quality of life. The intervention demonstrated safety, good adherence, successful blood glucose reduction, and ketosis induction after six days, though significant survival benefits were not observed due to the trial's short schedule [144]. Similarly, a randomized, controlled open-label pilot trial involving patients with locally advanced or metastatic cancer reported

adequate safety and adherence to a KD but did not identify significant improvements in therapeutic outcomes. Nonetheless, these trials have laid the groundwork for further exploration of dietary strategies in oncology.

Role of Nursing:

Nutrition plays a critical role in the management and treatment of cancer patients, significantly impacting their overall health, treatment tolerance, and quality of life. Nurses, as integral members of the oncology care team, play a pivotal role in addressing the unique nutritional needs of these patients. Their contributions encompass nutritional assessment, education, intervention, and ongoing support to optimize nutritional status and improve outcomes during cancer treatment.

Nutritional Assessment and Monitoring

Nurses are often the first to recognize signs of malnutrition in cancer patients, which can result from treatment side effects such as nausea, vomiting, anorexia, or dysphagia. Through comprehensive assessments, including weight monitoring, dietary intake evaluation, and understanding gastrointestinal symptoms, nurses identify patients at risk of malnutrition. Tools like the Malnutrition Screening Tool (MST) or Patient-Generated Subjective Global Assessment (PG-SGA) are frequently employed to guide these evaluations. Nurses also monitor biomarkers, such as serum albumin and prealbumin levels, which provide insight into the patient's nutritional status.

Implementation of Individualized Nutritional Interventions

Nurses collaborate with dietitians and oncologists to implement personalized nutrition plans tailored to the patient's cancer type, treatment regimen, and specific needs. For example, patients undergoing chemotherapy or radiation therapy may require high-protein, high-calorie diets to counteract catabolic states and weight loss. In cases where oral intake is inadequate, nurses assist in managing enteral or parenteral nutrition, ensuring that patients receive the necessary macronutrients and micronutrients. Moreover, nurses address specific dietary modifications for patients with cancer-related complications. For instance, they may recommend softer, bland foods for those with oral mucositis or suggest small, frequent meals for patients experiencing early satiety. Nurses also play a role in managing hydration and electrolyte balance, particularly in patients suffering from diarrhea or vomiting.

Education and Counseling for Patients and Families

Cancer treatments can significantly alter a patient's eating habits and appetite, creating confusion and distress for both patients and their families. Nurses provide education about the importance of maintaining adequate nutrition during treatment and offer practical advice to overcome common challenges. For example, they may teach patients strategies to manage taste changes or encourage the use of nutritional supplements when dietary intake is insufficient. In addition to dietary advice, nurses counsel patients on the importance of avoiding potentially harmful dietary practices, such as unproven dietary supplements or extreme diets, which can interfere with cancer treatments. By addressing cultural and personal food preferences, nurses help foster adherence to nutritional plans, making them sustainable and acceptable for patients.

Psychological Support and Addressing Eating-Related Anxiety

The psychological burden of cancer and its treatment can exacerbate nutritional challenges. Many patients experience anxiety or depression that affects their appetite or motivation to eat. Nurses play a key role in providing emotional support and fostering a positive relationship with food. They work closely with the care team to address eating disorders or psychological conditions linked to malnutrition and refer patients to mental health professionals when necessary.

Advocacy and Coordination of Care

Nurses serve as patient advocates, ensuring that nutritional needs are prioritized throughout the cancer care continuum. They coordinate with multidisciplinary teams, including oncologists, dietitians, and

palliative care specialists, to align nutritional interventions with the overall treatment plan. In settings where resources are limited, nurses advocate for access to nutritional support programs, such as meal delivery services or subsidies for nutritional supplements.

Addressing End-of-Life Nutritional Concerns

In palliative care or advanced stages of cancer, the focus of nutrition shifts from aggressive intervention to comfort and quality of life. Nurses guide patients and families through these transitions, ensuring that nutritional care aligns with the goals of care. They provide emotional support to families struggling with decisions about artificial nutrition and hydration, emphasizing the importance of maintaining dignity and comfort for the patient.

Continuing Education and Research

Given the evolving landscape of cancer care and nutrition science, nurses are committed to lifelong learning to provide evidence-based nutritional support. They participate in continuing education programs and contribute to research initiatives exploring innovative nutritional strategies for cancer patients. This ensures that their practices remain current and effective in addressing the complex needs of oncology patients. Nurses play a central role in the nutritional management of cancer patients, addressing the multifaceted challenges posed by the disease and its treatments. Through thorough assessment, personalized interventions, patient education, and ongoing support, nurses help mitigate the impact of malnutrition and improve treatment outcomes. Their holistic approach, which integrates physical, emotional, and psychological care, underscores the critical importance of nursing in the comprehensive management of cancer patients.

Conclusion:

The role of nutritional therapy in cancer treatment is gaining increasing attention, particularly in the context of chemotherapy. While conventional cancer treatments have made significant strides, many tumors continue to present substantial challenges. As a complementary approach, nutritional interventions hold promise in improving cancer patient outcomes by influencing various mechanisms such as nutrient metabolism, immune response, and tumor growth. Dietary strategies like caloric restriction (CR), ketogenic diet (KD), and intermittent fasting (IF) have emerged as potential tools to enhance the efficacy of chemotherapy, potentially slowing tumor progression and improving treatment responses. Despite the encouraging preclinical data, there are several challenges in translating these findings into clinical practice. The lack of comprehensive, large-scale clinical trials that can definitively establish the benefits and safety of dietary modifications remains a major barrier. Additionally, the complexity of tumor biology and individual variability in patient responses to dietary changes complicate the implementation of standardized nutritional treatments. The interaction between diet and cancer biology involves a range of mechanisms, including metabolic reprogramming, oxidative stress regulation, and immune modulation. These interactions highlight the importance of a tailored approach to nutrition in oncology, with careful consideration of each patient's unique needs and tumor characteristics. Research into the gut microbiome's role in cancer and its potential impact on the success of nutritional interventions is an emerging field that holds significant promise for personalized cancer care. Nurses play a pivotal role in integrating nutritional therapy into the care of cancer patients. They are uniquely positioned to educate patients, advocate for dietary changes, and collaborate with multidisciplinary teams to ensure that patients receive comprehensive care. As more evidence emerges on the relationship between diet and cancer treatment, nurses will continue to be essential in promoting and supporting the use of nutritional interventions in clinical oncology. Ultimately, the integration of nutritional therapy into cancer treatment plans requires further research, clinical validation, and widespread adoption to improve the survival and quality of life for cancer patients undergoing chemotherapy. This approach represents a promising frontier in the fight against cancer, offering a complementary strategy to conventional therapies.

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دور الممرضات في تعزيز العلاج الغذائي لمرضى السرطان الذين يخضعون للعلاج الكيميائي: نهج متعدد التخصصات

الملخص:

الخلفية: لا يزال السرطان من الأسباب الرئيسية للوفيات على مستوى العالم، مع بذل جهود كبيرة لتحسين العلاج ونتائج البقاء على قيد الحياة. على الرغم من التقدم في استراتيجيات العلاج، إلا أن هناك فجوة كبيرة في فعالية العلاج لبعض أنواع السرطان. تشير الدراسات الحديثة إلى إمكانات العلاج الغذائي في رعاية السرطان، حيث يلعب النظام الغذائي دورًا محوريًا في تعديل بيولوجيا السرطان، بما في ذلك النمو، والتمثيل الغذائي، والاستجابات المناعية.

الهدف: يهدف هذا الاستعراض إلى استكشاف دور الممرضات في تعزيز العلاج الغذائي لمرضى السرطان الذين يخضعون للعلاج الكيميائي، مع التركيز على النهج متعدد التخصصات لتعزيز دمج التدخلات الغذائية في العلاجات التقليدية للسرطان.

الطرق: تم إجراء استعراض شامل للأدبيات الحالية لتقييم استراتيجيات النظام الغذائي مثل تقليل السعرات الحرارية، والأنظمة الغذائية الكيتونية، والصيام المتقطع، وفحص تأثيراتها المحتملة على العلاج ونتائج البقاء على قيد الحياة في السرطان. كما تم تقييم الآليات التي يتفاعل من خلالها النظام الغذائي مع السرطان، بما في ذلك تمثيل العناصر الغذائية، والإشارات الهرمونية، وتفاعلات الميكروبيوم.

النتائج: أظهرت التعديلات الغذائية نتائج واعدة في التأثير على نمو الأورام، ومقاومة العلاج الكيميائي، والصحة العامة للمريض. تم تحديد استراتيجيات غذائية معينة، مثل تقليل تناول الجلوكوز وتعزيز الميكروبيوم المعوي، كخيارات علاجية محتملة. علاوة على ذلك، يمكن أن تؤثر هذه التغيرات الغذائية على المسارات الأيضية الحيوية لتقدم السرطان، مثل تنظيم الإجهاد التأكسدي وتعديل المناعة. ومع ذلك، لا تزال هناك حاجة إلى بيانات سريرية قوية لتأكيد فعالية هذه التدخلات .

الخاتمة: يقدم دمج العلاج الغذائي في علاج السرطان إمكانات كبيرة لتحسين نتائج المرضى، خاصة في العلاج الكيميائي. تلعب الممرضات دورًا حيويًا في تعزيز هذه العلاجات من خلال تثقيف المرضى وتنسيق الرعاية متعددة التخصصات. تؤكد الأبحاث المتزايدة على ضرورة إجراء المزيد من التجارب السريرية لتحديد الاستراتيجيات الغذائية الأكثر فعالية لمرضى السرطان .

الكلمات المفتاحية: السرطان، العلاج الغذائي، العلاج الكيميائي، تمريض الأورام، الرعاية متعددة التخصصات، تفاعلات النظام الغذائي مع السرطان، تعديل المناعة.