Frontiers of Nursing • 11(2) • 2024
DOI: 10.2478/FON-2024-0014

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Frontiers of **Nursing**

Perioperative nutrition optimization: a review of the current literature†

Review

Jin-Shuai Li[a,b], Wei-Bing Shuang[b,*]

[a]*First Clinical Medical College, Shanxi Medical University, Taiyuan, Shanxi 030001, China*
[b]*Department of Urology, The First Hospital of Shanxi Medical University, Taiyuan, Shanxi 030001, China*

Received: 13 January 2024; Accepted: 23 March 2024; Published: 20 June 2024

Abstract: **Objective:** This article aims to elaborate the recent research status of perioperative nutrition optimization, in order to help clinical practice.

Methods: This study employed a comprehensive and systematic method to search prominent databases, including PubMed and Web of Science, using carefully selected keywords. Following meticulous screening, the inclusion of high-quality studies was prioritized, and a thorough review of the references was conducted to comprehensively analyze the latest evidence on perioperative nutrition optimization.

Results: The main contents include preoperative nutritional risk screening and assessment, nutritional support pathway, immune enhancing nutrition, preoperative and postoperative nutritional management, as well as personalized nutrition optimization strategies for specific populations (such as children, bariatric surgery patients, and cancer patients).

Conclusions: In clinical practice, the importance of perioperative nutrition should be emphasized, and personalized nutrition management plans should be developed based on the characteristics and needs of patients. Further research and promotion of perioperative nutrition optimization strategies will help improve the overall prognosis and quality of life of surgical patients.

Keywords: *enteral nutrition • immune enhancing nutrition • nutritional screening and assessment • parenteral nutrition • perioperative*

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1. Introduction

The 2019 Global Leadership Initiative on Malnutrition (GLIM) proposed a new definition of malnutrition that includes phenotypic (weight loss, low body mass index [BMI], muscle loss) and etiological criteria (reduced intake or impaired digestion and absorption, inflammation or disease burden) and was globally endorsed by major nutrition and medical societies around the world.[1] Malnutrition can cause catabolic and inflammatory responses to metabolic stress, leading to sarcopenia, immune dysfunction, increased morbidity, complication rates, mortality and additional costs, and prolonged length of stay (LOS).[2] Although malnutrition

†This project was supported by Emerging Industry Leading Talent Project of Shanxi Province (No. 2020587).

How to cite this article: Li JS, Shuang WB. Perioperative nutrition optimization: a review of the current literature. *Front Nurs*. 2024;2:127–138.

**Corresponding author.*
E-mail: shuangweibing@126.com (W. -B. Shuang).

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is a recognized risk factor for postoperative morbidity, it can be reversed by early appropriate nutritional intervention. However, due to economic reasons (49%), logistical issues (33%),[3] lack of awareness and clinical regulations within healthcare facilities to identify and treat malnutrition,[4] and surgeons rarely performing routine nutritional screening based on evidence-based guidelines, perioperative nutritional optimization is still not widespread in clinical practice.

Appropriate perioperative nutritional optimization is a cost-effective intervention that promotes early functional recovery in patients. Therefore, perioperative nutritional optimization should receive sufficient attention in the field of surgery. This article will review recent research on perioperative nutritional optimization to assist clinical work.

2. Methods

This study employed a comprehensive and systematic approach to gather the latest evidence and perspectives on perioperative nutrition optimization, adhering to the standards of scientific rigor. The search strategy encompassed prominent databases, namely, PubMed and Web of Science, and involved meticulous keyword selection, including “perioperative nutrition,” “nutrition screening,” “immune enhancing nutrition,” “enteral nutrition,” and “parenteral nutrition.” The initial search yielded a substantial volume of articles, which were subsequently subjected to meticulous screening based on their titles and abstracts to ascertain their relevance to the research topic. Rigorous evaluation of the methodological quality was conducted, with a preference for high-quality studies such as randomized controlled trials, systematic reviews, and meta-analyses during the selection process. Furthermore, a comprehensive review of the reference lists of the selected articles was performed to uncover any potentially overlooked relevant studies.

3. Discussion

3.1. Nutritional risk screening and assessment

Nutritional risk screening serves to identify the risk of malnutrition and aims to predict, to the greatest extent possible, the likelihood of malnutrition developing or worsening under the patient’s current and future conditions. All patients undergoing surgery should be screened for nutritional risk, and nutritional assessment should be performed in high-risk patients. The best tool for nutritional risk screening and assessment should be short and easy to use, inexpensive, sensitive, and specific.[5] Some of the most widely used nutritional risk screening tools are the Nutritional Risk Screening 2002 (NRS-2002) for inpatients, the Malnutrition Universal Screening Tool (MUST) for outpatients, and the Mini-Nutritional Assessment (MNA) for hospitalized elderly patients. Based on evidence-based medicine, the American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines[6] recommend the NRS-2002 as the first choice for nutritional risk screening. NRS 2002 has undergone validation in over 100 clinical trials, demonstrating its practicality and efficiency of implementation. However, the major disadvantage of these tools is the amount of time and effort required by clinicians to calculate the results.

Nutritional assessment includes both subjective and objective parameters, and the most commonly used tool is the Subjective Global Assessment (SGA).[4] In recent years, Controlling Nutritional Status score (CONUT) has also been established as a valid tool for assessing nutritional status, which can be used to evaluate the prognosis of many cancers.[7] Nutritional assessment requires a multifaceted approach that includes body measurements, assessment of dietary intake, biomarkers of nutritional status, clinical examination, and assessment of environmental and socioeconomic factors. According to the European Society of Clinical Nutrition and Metabolism (ESPEN), BMI and unintentional weight loss are the most reliable predictors of nutritional risk and malnutrition.[8] Although computed tomography (CT) and dual-energy X-ray absorptiometry (DEXA) are the most precise methods for identifying essential metabolic parameters, clinical practitioners rarely employ them since it is simple to identify accidental weight loss and low BMI.[9] Less research has been done on biomarker evaluation. Serum albumin levels are frequently used to assess nutritional status, with levels below 3.5 g/dL potentially indicating protein-energy malnutrition.[10] Because of its rapid response and short half-life, serum prealbumin is often used to evaluate nutritional status. Prealbumin and albumin, however, are liver-produced proteins with a negative acute time-phase response, and their levels drop in response to physiological stress and inflammation. Although they are separate risk factors for related complications, their measurements are unreliable for nutritional evaluation. There are a variety of nutritional screening and assessment tools today, each with specific strengths (Table 1).

3.2. Nutritional support pathway

Nutritional support should be based on the results of nutritional screening and malnutrition diagnosis. The duration and route of nutritional supplementation

Tool	Element	Forms of assessment	Efficiency assessment
NRS-2002	Impaired nutritional status (weight loss, BMI, and food intake) and disease severity	Marking Scheme	Very effective
MUST	BMI, weight loss in the past 3–6 months, and acute illness of >5 days duration	Marking Scheme	Very effective
NMA	BMI, recent weight loss status, diet, nutrient absorption status, physical health status	Marking Scheme	Effective
SGA	Medical history (weight change, dietary intake, gastrointestinal symptoms, functional capacity, and metabolic stress) and physical examination (subcutaneous fat loss, muscle wasting, edema, and ascites).	Questionnaire	Effective
PG-SGA	Subjective patient assessment: weight, food intake, symptoms, activities, and body functions + Medical staff assessment: relationship between disease and nutritional needs, metabolic needs, physical examination	Questionnaire	Effective
PNI	10 × serum albumin (g/dL) + 0.005 × total lymphocyte count (cells/mm^3)	Formula	Simple and fast, but requires lab parameters
NRI	1.489 × serum albumin (g/L) + 41.7 × (current weight/usual weight)	Formula	Simple and fast, but requires lab parameters
NRS	Unintentional weight loss in the past 3 months, BMI, appetite, ability to eat or retain food, and severity of disease	Marking Scheme	Very effective
COUNT	Serum albumin level (Ag/dL), total lymphocyte count (n/mm^3), total cholesterol concentration (mg/dL)	Marking Scheme	Simple and fast, but requires lab parameters

Note: BMI, body mass index; COUNT, controlling nutritional status score; MUST, Malnutrition Universal Screening Tool; NMA, micro-nutritional assessment; NRI, Nutritional Risk Index; NRS, Reilly Nutritional Risk Score; NRS-2002, Nutritional Risk Screening 2002; PG-SGA, patient-generated subjective global assessment; PNI, Prognostic Nutrition Index; SGA, subjective global assessment.

Table 1. Common nutritional screening and assessment tools.

should depend on the severity of the malnutrition and the patient's underlying medical condition.[9] There are 2 routes for perioperative nutritional support: enteral nutrition (EN) and parenteral nutrition (PN). Each has indications and contraindications (Table 2) as well as benefits and drawbacks.

3.2.1. PN

PN is the administration of a solution directly into the body through a central or peripheral venous fluid line that contains a combination of macronutrients (amino acids, lipids, and carbs) and micronutrients (electrolytes, trace elements, and vitamins). PN is an invasive treatment for patients who are unable to receive enteral or oral nutritional supplementation. The all-in-one (AIO) system for PN is currently utilized extensively in medical facilities,[11] taking the place of the conventional multivial system. This system's benefit is that it only needs one venous access, which saves time, lessens workload and expenses, lowers the risk of infection, and shortens the LOS.[12] However, PN has a significant relative cost.

Total parenteral nutrition (TPN) has been proven in studies to dramatically affect postoperative outcomes in severely malnourished patients, promote damage repair, and reduce complications.[13] Hyperglycemia, immunological dysfunction, volume overload, and refeeding syndrome are other negative effects of PN. PN does not transfer nutrients via the gut and can cause the degeneration of gut-associated lymphoid tissue (GALT) and mucosa-associated lymphoid tissue (MALT), which can impair both local and systemic immunity for individuals who are moderately malnourished or well-nourished, PN offers little benefit and raises the risk of death.[14]

Hyperglycemia is the most common complication of PN. Glycemic management is crucial in patients on TPN. An insulin infusion for patients who experience acute hyperglycemia can help maintain normal blood sugar levels, thereby reducing the risk of potential sepsis.[15] PN has the potential to lead to more infectious complications in critically ill patients, hence it is crucial to maintain strict adherence to aseptic measures while using either the central or peripheral venous route to avoid catheter-related bloodstream infections.[16] Overfeeding resulting from PN can lead to azotemia, hypertonic dehydration, and metabolic acidosis,[17] and it is essential to take these complications seriously.

3.2.2. EN

The largest immune organ in the body is the gut, and both intrinsic and adaptive immunity depend heavily on GALT. Perioperative malnutrition increases intestinal permeability, reduces intestinal absorption capacity, erodes barrier function, and promotes bacterial translocation.[18]

Nutritional support pathway and indication	Contraindication
Enteral Nutrition	
Preoperative and postoperative supportive care for malnourished patients	Complete mechanical intestinal obstruction, paralytic intestinal obstruction
Difficulty in swallowing or chewing	Gastrointestinal bleeding and perforation
Disorders of consciousness and coma	Abdominal or intestinal infection
Stable stage of digestive tract disease	Early stage and shock state of severe infection, trauma and other stress states
High catabolic state	Early stage of short bowel syndrome, high flow intestinal fistula
chronic wasting disease	Severe vomiting, diarrhea, malabsorption
Parenteral nutrition	
Mechanical obstruction and paralytic intestinal obstruction caused by EN	Patients with normal gastrointestinal function or indications for EN
Short bowel syndrome	Cardiovascular dysfunction or severe metabolic disorder
Absorptive dysfunction	High intestinal fistula, congenital malformation of gastrointestinal tract, and excessive gastrointestinal reaction during radiotherapy
Severe vomiting and diarrhea	Severe burns and severe infections
Severe malnutrition	Ulcerative colitis, localized enteritis, long-term diarrhea
Hyperemesis gravidarum	Necrotizing pancreatitis, acute renal failure, liver failure
High risk of aspiration	Brain death or irreversible coma

Note: EN, enteral nutrition; PN, parenteral nutrition.

Table 2. Indications and contraindications of PN and EN.

EN involves the delivery of food through a nasogastric tube, nasoenteric tube, direct access to the stomach (gastrostomy), or proximal small bowel (jejunostomy). Compared with PN, EN preserves gastrointestinal tract function, prevents gastric mucosal atrophy, is more physiological and less costly, significantly reduces the incidence of patient complications, and shortens the LOS.[19] Thus, EN should be the preferred method during the perioperative period.[20]

It is important not to overlook the potential complications of EN. Common gastrointestinal complications involve nausea, vomiting, diarrhea, constipation, and absorption abnormalities.[21] Mechanical complications include malabsorption and obstruction; and metabolic complications involve changes in blood glucose levels, electrolyte disorders, and withdrawal syndromes.[21]

If perioperative patients are unable to meet their calorie and protein requirements from a normal diet, nutritional optimization is primarily achieved by supplementing with oral nutritional supplements (ONS) and EN.[20] ONS are nutritional products designed to provide proteins, vitamins, minerals, and other nutrients in a nutritionally balanced and scientifically formulated way. According to several systematic reviews and meta-analyses, ONS have been shown to significantly reduce mortality and complication rates, with more pronounced benefits in patients with wound healing, lung infections, pressure ulcers and leg ulcers, the elderly, and malnourished patients.[22]

3.3. Immune enhancing nutrition

Perioperative immune enhancing nutrition is a therapeutic method that uses specific nutritional supplements to modulate immune changes caused by surgical stress. The immune response to surgery is complex, and it has been confirmed that changes in the T helper type 1 (Th1)/T helper type 2 (Th2) balance can lead to cell-mediated immune impairment.[23] Targeted immune enhancing nutrition has a positive effect on the differentiation of Th during surgery, which can reduce surgical complications and inhibit the occurrence of postoperative cachexia. Alsyouf et al.[24] found that patients undergoing radical cystectomy offset the effect of postoperative Th1/Th2 imbalance after receiving immune enhancing nutrition. A retrospective study[25] found that immunonutrition supplementation after neoadjuvant chemotherapy in patients with esophageal cancer can enhance the postoperative immune status, and reduce the incidence of infectious complications and LOS.

At present, the nutrients most often used for immune enhancing nutrition include arginine, glutamine, omega-3 fatty acids, and nucleotides (NTS). Its mechanism and effect are different.

3.3.1. Arginine

Arginine is a non-essential amino acid involved in the synthesis of nitric oxide, which can regulate gene expression and stimulate cellular immunity. During physical

injury, myeloid derived suppressor cells (MDSCs) consume arginine to expand and differentiate into granulocytes, macrophages, and dendritic cells. When arginine is depleted, MDSCs cannot differentiate, resulting in lymphocyte depletion, weakened immune response, and increased infection rate.[24] A study of patients undergoing surgery for esophageal, gastric, and pancreaticobiliary cancers found that early postoperative EN with arginine rich nutrient solution can reduce postoperative infectious complications and shorten the LOS.[26] However, there is no effective evidence to recommend intravenous or enteral arginine alone.[20]

3.3.2. Glutamine

Glutamine is the precursor of endogenous antioxidant glutathione, which provides energy for intestinal cells, maintains intestinal barrier function, and maintains the integrity of intestinal mucosa. It plays an important role in nitrogen transport in vivo. Glutamine, known as the "fuel of the immune system," is an essential nutrient for lymphocyte proliferation and cytokine production, macrophage phagocytosis and secretion of active substances, and neutrophil sterilization. Surgical trauma can cause a sharp increase in glutamine demand, which in turn leads to glutamine deficiency and severe immune impairment.[27] A meta-analysis found that perioperative parenteral glutamine supplementation could reduce the infection rate, shorten the LOS, and improve the nitrogen balance.[28] However, PN mode is required for glutamine supplementation, and whether parenteral glutamine administration combined with oral nutrition or EN is effective is still inconclusive.[20]

3.3.3. Omega-3 fatty acids

The main components of omega-3 fatty acids are α-Linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). Its main function is to inhibit arachidonic acid metabolism and reduce the release of proinflammatory substances, thereby reducing the inflammatory response. In addition, omega-3 fatty acids also have the effects of regulating cell membrane structure, anti-tumor, improving cognitive function, and preventing sarcopenia.[29,30] Omega-3 fatty acid deficiency can induce the production of prostaglandins, leukotrienes, and thromboxane A2, leading to severe stress response, resulting in immunosuppression, platelet aggregation, and excessive inflammatory response.[31]

Humans cannot synthesize the necessary ALA. Most people synthesize small amounts of EPA and DHA endogenously from ALA. Therefore, EPA and DHA must be supplemented from diet or supplements. Studies have shown that[32] adding omega-3 fatty acid emulsion to PN formula can improve postoperative immune function indicators, reduce inflammatory reactions, and improve postoperative effects.

3.3.4. NTS

NTS are the basic units of nucleic acid macromolecules DeoxyriboNucleic Acid (DNA) and Ribonucleic Acid (RNA). It has been confirmed that NTS can regulate immune function; improve intestinal flora, promote the growth, development, and repair of the gastrointestinal tract; and inhibit oxidative stress and inflammation.[33,34] It is also involved in various cellular processes, such as cell signal transduction, regulation of cell cycle, Adenosine Triphosphate (ATP) metabolism, and so on. Its sources include *de novo* synthesis, recovery through salvage mechanisms, and dietary intake. In the case of surgical stress, the body cannot produce enough NTS, so it is more important to obtain NTS from the diet. Viscera, fresh seafood, and dried beans are rich in NTS.

Although NTS are beneficial to health, the mechanism of exogenous supplementation of NTS and the requirement of exogenous NTS in different stages and states of the human body are still unclear. At present, the clinical application evidence of NTS mainly comes from animal models and infants, and its application in adults still needs further development.

3.4. Preoperative nutritional supplementation

Surgical stress can cause a series of reactions such as inflammation, immunity, and metabolism, which is a heavy blow to elderly patients and malnutrition patients with poor preoperative functional reserve. Surgical stress can lead to increased glycogenolysis, increased gluconeogenesis, increased protein and fat breakdown, insulin resistance, and elevated blood glucose.[35]

Traditionally, in order to avoid reflux or aspiration under anesthesia, strict fasting was implemented for several hours before surgery, but this action limited the intake of nutrition. Perioperative fasting will aggravate the surgical stress response, aggravate insulin resistance, increase glycogen and protein breakdown, and damage gastrointestinal function.[35] In most cases, overnight fasting before surgery is unnecessary. ESPEN guidelines recommend that patients without special risk of aspiration can take clean liquids 2 h before surgery and eat solids >6 h before anesthesia.[20] The cleaning liquids is emptied from the stomach within 60–90 min, and the cleaning fluid ingested 2 h before anesthesia induction will not increase the gastric volume, so it will not bring the risk of aspiration.[20] Carbohydrate intake of 50 g (8–10 oz) 2 h before surgery can reduce postoperative insulin resistance and hyperglycemia.[36]

This may be because under typical fasting conditions, the body's catabolism dominates, while when carbohydrate is ingested, anabolic pathways dominate, increasing insulin secretion, increasing glucose uptake by muscle and liver, and reducing protein catabolism. A systematic review including 1445 patients undergoing abdominal surgery reported that preoperative consumption of carbohydrate beverages can reduce insulin resistance and improve some subjective indicators of patients, including hunger, thirst, anxiety, and nausea, without increasing the incidence of adverse events. However, there is no evidence-based medical evidence on patients with slow gastric emptying and inhalation risk.

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Although people are accustomed to eating food to supplement protein and carbohydrates in most cases, the role of these foods is limited within 6 h before surgery and cannot meet the nutritional needs of patients. Therefore, regardless of nutritional status, patients are advised to receive ONS before surgery.[20] ONS is rich in whey protein isolates, amino acid supplements, low carbohydrates, and other substances, providing nutrition in the form of concentration, which is usually easier to digest and absorb.

3.5. Postoperative nutrition management

Traditional postoperative diet management is more concerned about the risk of abdominal distension, nausea, vomiting, and lung aspiration. The management after major abdominal surgery usually includes nasogastric tube decompression and diet abstinence until the intestinal function is fully restored after surgery. However, the current view is that surgery-related stress and inadequate dietary intake after surgery can lead to additional fatigue and delayed recovery, so the strategy of fasting has also changed.

Early and adequate food intake is essential for optimizing postoperative nutrition. In abdominal and pelvic surgery, early feeding has been shown to stimulate intestinal movement and gastrointestinal function, reduce the risk of postoperative intestinal obstruction, and shorten the overall LOS. Patients who received early diet (4.5%) had fewer complications after colorectal surgery than those who received late diet (19.4%).[38] A retrospective study of 346 adult liver transplant patients reported that the incidence of sepsis decreased significantly from 21% to 5.9% when eating within 48 h postoperatively compared with >48 h ($P < 0.05$).[39] ESPEN guidelines recommend that early oral feeding is the first choice of nutrition for surgical patients.[20] The initial oral food intake should be adapted to the status of gastrointestinal function, individual tolerance, and the mode of surgery. Postoperative patients should eat as soon as they can tolerate food, preferably within 24 h, including clean liquid, and oral nutrition should be carried out continuously.[20]

If the patient is unable to start oral nutrition early or has insufficient oral intake (<50%) for >7 days, EN should be started as soon as possible.[20] Due to the limited intestinal tolerance, it is recommended to start EN at a low flow rate (10–20 mL/h), and to increase the feeding rate carefully and individually.[20] However, it may take up to 5 days after surgery to achieve the desired protein and calorie intake.[40] The conventional wisdom is that it is not safe to feed near a new gastrointestinal anastomosis. It has been found that EN near the anastomosis increases the strength of the anastomosis and makes it more resistant to rupture or leakage.[41] Therefore, the placement of nasojejunal tube or needle catheter jejunostomy (NCJ) should be considered for patients undergoing EN for upper digestive tract and pancreatic surgery.[20] When long-term EN (>4 weeks) is needed after neurosurgery such as severe craniocerebral injury, EN should be considered for percutaneous endoscopic gastrostomy (PEG).[20]

Protein decomposition can lead to skeletal muscle atrophy. In addition to preventing skeletal muscle atrophy through exercise, perioperative protein supplementation can minimize negative energy-protein balance, provide early energy-protein supply, reduce protein loss, meet amino acid needs, and resist skeletal muscle atrophy. Therefore, it is recommended to eat food rich in protein after surgery. Animal products contain higher levels of essential amino acids than plant products, which can meet the needs of human growth, optimal health, and function. For example, animal products such as chicken, beef, fish, eggs, and milk are considered to be high-quality proteins. In addition, whole food protein sources (animals and plants) are also rich in essential micronutrients, including various vitamins, minerals, omega-3 fatty acids, fiber, and antioxidants, which contribute to early functional recovery.

There is evidence that postoperative amino acid supplementation can reduce body and muscle protein

decomposition and stimulate whole body protein synthesis.[42] The optimal protein requirement for surgical patients is still uncertain, and some researchers recommend 1.2–2.0 g/kg/day.[43] β-hydroxy-β-methyl butyric acid (HMB) is the intermediate of leucine metabolism. A recent study found that postoperative supplementation of HMB can maintain muscle mass in the elderly and prevent skeletal muscle atrophy.[44] In addition, a large amount of gastric juice secretion may shorten the absorption time of food, and the high acidity of gastric juice may also denaturalize trypsin and impair bile salt function, which further hinders absorption, so proton pump inhibitors (PPI) are used to alleviate gastric hypersecretion. Opioids can achieve the best pain control, but also slow down the recovery of gastrointestinal function. Therefore, the use of anesthetics is minimized to promote recovery of postoperative bowel function.

3.6. Special population management

3.6.1. Children

Children are in the stage of rapid growth and development, and their demand for protein and energy is increasing. When children's food intake decreases or when they get sick, they are prone to malnutrition. Malnutrition in children is a cumulative lack of energy, protein, or trace elements caused by an imbalance between nutritional needs and intake. Malnutrition in children can lead to permanent damage, including cognitive impairment, stunting, and decreased academic performance. All hospitalized children should be screened for nutritional risk to identify children in need of a more comprehensive nutritional assessment. At present, the widely used nutrition screening tools include the Pediatric Nutrition Screening Tool (PNST), the Screening Tool for Risk of Impaired Nutritional Status and Growth (STRONGkids), and Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP).[45] However, there is no preoperative screening tool that has been verified in the outpatient environment. Children screened for nutritional risk should undergo a comprehensive nutritional assessment by a registered dietitian (RD) or a nutrition advisory group. Subjective Global Nutrition Assessment (SGNA) is considered as the gold standard for the diagnosis of malnutrition in children because of its effectiveness in judging baseline nutritional status.[46]. In addition, weight, height, upper arm circumference, and triceps skinfold can also be used as part of a complete assessment.

Nutrition is an important factor in surgical preparation and recovery, and providing adequate nutritional support to children before and after surgery is an important part of minimizing surgical complications. If malnutrition is identified, consideration should be given to optimizing nutritional intake before surgery. Children with mild to moderate malnutrition can receive EN at least 10–14 days before surgery to improve nitrogen balance and facilitate wound healing.[20] Children with severe malnutrition should be given PN until the weight gain is 10% and the *Z* score is >2 SD.[47] In addition, carnitine should be given to severely malnourished children during the perioperative period. Several studies have found that serum carnitine levels are decreased in children with severe malnutrition. Carnitine is an essential amino acid that plays an important role in the passage of fatty acids through mitochondria and β oxidation. Lack of carnitine is characterized by hypertriglyceridemia, reduced tolerance to fat emulsion, and reduced weight gain or failure to grow.[48]

In recent years, enhanced recovery after surgery (ERAS) has also been implemented in children, and it is recommended to reduce the duration of preoperative fasting, along with a small amount of high-carbohydrate meals to maintain intestinal integrity and reduce bacterial translocation and inflammation. If possible, newborns are recommended to start EN within 24–48 h after surgery, and breast milk is the first choice of nutrition.[49] Human milk is rich in immune and growth factors, supports the immune system, and has a direct nutritional effect on intestinal mucosa. When the amount of breast milk available to newborns is insufficient, pasteurized donated breast milk should be provided as a transitional and preferred alternative to breast milk, followed by commercial formula. For infants with a history of intestinal injury, extensive hydrolysis and amino acid-based formula are common options for optimal absorption when the mucosal barrier is damaged. It has been proved that early postoperative feeding can shorten the time of complete feeding and LOS, and reduce the risk of infection.[50]

3.6.2. Cancer patients

Cancer cachexia is the result of hypermetabolism, systemic inflammation, and anorexia. It is characterized by involuntary continuous weight loss and skeletal muscle mass loss, with or without fat loss, which cannot be reversed by conventional nutritional support. Severe malnutrition is an independent risk factor for increased postoperative morbidity and mortality, prolonged LOS, infection, and increased cost in cancer patients.[51] Perioperative nutritional optimization has not been effectively integrated into the routine management of oncology patients and nutritional assessment of cancer patients requiring surgery is often overlooked. Therefore, it is important to implement nutritional optimization as early as possible in cancer patients.

Although there is a lack of high-level evidence-based medicine evidence for the clinical benefits of nutritional screening for cancer patients, patient-generated subjective global assessment (PG-SGA) has been proven to be suitable for nutritional assessment of adult cancer patients.[52] The ESPEN guidelines also recommend that nutritional intake, weight changes, and BMI should be assessed periodically, starting with the diagnosis of cancer, and repeatedly based on the condition.[20]

Nutritional problems are more complicated due to the different locations and stages of cancer in patients. Nutritional optimization of cancer patients should be based on the assessment of each patient's condition and reasonable planning of the results. Oral feeding is still the first choice for patients.[20] ONS may be necessary for cancer patients.[20] A meta-analysis shows that oral ONS can increase nutritional intake and improve the quality of life of cancer patients, but does not reduce their mortality.[53] At present, it is recommended to give ONS with rich immunomodulatory function in cancer malnourished patients during perioperative period or at least after surgery. But there is no evidence of evidence-based medicine whether the effect of ONS containing such special immunonutrition alone before surgery is better than that of ordinary ONS.[20] A study found that in cancer patients with an experimental high-protein diet, the muscle synthesis of the high-protein diet group was significantly better than that of the control group,[54] so cancer patients can consider a high-protein diet.

3.6.3. Bariatric surgery patients

Obesity is a global disease and a malnutrition caused by vitamin and mineral deficiency. It is generally believed that obese patients have a large amount of energy storage and do not need nutritional intervention. However, this is not the case. Many patients are sarcopenic obesity and face greater risk.[55]

Nutrition management is the most important link in medical management for obese patients undergoing bariatric surgery. Preoperative assessment includes comprehensive medical history, social and psychological history, physical examination, and laboratory examination. The nutritional deficiencies found should be corrected according to the clinical indications before surgery. Patients with bariatric surgery have been found to have at least one vitamin or mineral deficiency before surgery, so these nutrients should be fully evaluated before bariatric surgery.[56] Many protocols recommend a very low-calorie diet (VLCD <800 kcal) or a low-calorie diet (LCD <1000 kcal) before surgery, but it is difficult to meet the recommended daily vitamins and minerals for patients.[57]

The various procedures of bariatric surgery change the anatomy and physiology of the stomach, thus changing chemical and mechanical digestion, thus reducing the patient's ability to digest food and extract specific nutrients from food after surgery. Because patients are unable to ingest the nutrients needed to provide normal nutritional status, patients must take vitamins and minerals (including thiamine, iron, selenium, zinc, and copper) for life. In order to minimize potential nausea and vomiting, it is recommended to eat liquid food or a very soft diet early after surgery to adapt to reduced gastric volume and maintain good hydration, and increase the consistency of food very slowly in the first week after surgery, and turn to solid chewables in 2–4 weeks.[58] In view of the early postoperative gastric protein intolerance, it is recommended to supplement liquid protein supplements (30 g/day) as a means to promote adequate protein intake in the first few months after surgery.[59] Specific nutritional problems, such as late dumping syndrome and reactive hypoglycemia, should be treated mainly through diet.[56] It is recommended to reduce food consumption per meal, avoid drinking water during the meal and 30min after eating, and avoid intake of rapidly absorbable carbohydrates and alcohol, so as to reduce rapid food emptying and prevent the occurrence of hypoglycemia. At the same time, it is recommended to eat high-fiber, high-protein foods and eat slowly and chew fully.

4. Conclusions

Perioperative nutrition optimization, especially for patients with malnutrition, children, cancer, and bariatric surgery, can reduce the incidence of complications, LOS, and mortality. Perioperative nutrition optimization should be regarded as an important means of clinical treatment. A large number of high-quality evidence and guidelines provide guidance for the implementation of nutrition optimization. However, the thinking of surgeons is still influenced by traditional ideas and stereotypes. There are many tools for preoperative nutrition screening and assessment, and each has its own advantages and disadvantages. Medical staff are required to be proficient in the use of various tools to identify those who may benefit from nutrition optimization as soon as possible. However, there are no guidelines indicating that there is a single nutrition assessment tool that can comprehensively assess the nutritional status of all types of patients. Immunonutrition is a new direction of perioperative nutrition optimization, and most studies support the use of immunonutrition. However, the specific use scheme is not unified, and the mechanism and prognosis are not clear, which need to be further

studied and discussed. Avoiding fasting for a long time before surgery does not increase the risk of aspiration, and carbohydrate load can reduce stress response. Early feeding within 24 h should be encouraged after full postoperative resuscitation. PN is suitable for patients with severe malnutrition and persistent gastrointestinal dysfunction. Most researchers advocate the combination of EN and PN, with proper proportion allocation to fully meet the nutritional needs of patients. There is an urgent need for close communication and information exchange between clinicians and dietitians to develop more reasonable and effective individualized programs according to the specific conditions of patients, in order to achieve better clinical results. Perioperative nutrition optimization to improve surgical outcome by affecting metabolism is a new field, which still needs further exploration and discovery in future research.

Ethical approval

Ethical issues are not involved in this paper.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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