Nutrition Care Process of Surgical Patients in the Context of Enhanced Recovery After Surgery

A Practical Guideline

Razieh Khalooeifard, PhD
Mahdi Alemrajabi, MD
Saeed Oraee Yazdani, MD
Saeed Hosseini, MD, PhD

Dietitians and nutritionists play a key role in optimizing the nutritional status of the patients before and after performing surgery. The importance of nutrition is often overlooked because health professionals lack knowledge about nutritional problems, structured protocols for cooperation between surgeons and clinical nutritionists do not exist, dedicated resources are lacking, and preoperative and postoperative nutrition care protocols have not been disseminated. The purpose of this review is to describe various nutrition care guidelines for use during preoperative and postoperative periods for surgical patients to enhance recovery after surgery based on a review of the literature. It should help nutritionists and surgeons to make appropriate decisions on the management during preoperative and postoperative care, as well as facilitating the understanding and application of medical nutrition therapy. Nutr Today. 2022;57(3):145–158

Razieh Khalooeifard, PhD, is an anesthetist, assistant professor of Clinical Nutrition, Department of Clinical Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran.

Mahdi Alemrajabi, MD, is an associate professor of colorectal surgery, Department of Surgery, Firoozgar Clinical Research Development Center, Iran University of Medical Sciences, Tehran, Iran.

Saeed Oraee-Yazdani, MD, is an assistant professor of neurosurgery, Shohada Tajrish Neurosurgical Center of Excellence, Functional Neurosurgery Research Center, Shohada Tajrish Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

Saeed Hosseini, MD, PhD, is an associate professor of clinical nutrition, Department of Clinical Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran.

The authors have no conflicts of interest to disclose.

Author Contributions: Razieh Khalooeifard and Saeed Hosseini: conceptualization, methodology, software, and writing – original draft preparation. Mahdi Alemrajabi and Saeed Oraee-Yazdani: data curation, investigation, and validation. Razieh Khalooeifard: supervision, visualization, and writing – reviewing and editing.

Correspondence: Razieh Khalooeifard, PhD, Department of Clinical Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Ghods St, 1417613151 Tehran, Iran (shkhalooei1367@gmail.com).

DOI: 10.1097/NT.0000000000000541

Enhanced recovery after surgery (ERAS) is a term first described by Henrik Kehlet[1] in the 1990s and implemented later as an association in 2010. The ERAS association seeks to correct the physiological and psychological responses to surgery, to improve cardiovascular function, to speed up bowel function and return to normal body activity, and to reduce the surgical complications and hospital stay as well as the individual and hospital costs by collaborations among the surgeons, anesthesiologists, nutritionists, physiotherapists, and nurses.[2,3] The ERAS guidelines (Table 1) are divided into 3 categories.[3,4]

Nutrition is a key component in the ERAS concept and guidelines, but it is often overlooked owing to lack of time, knowledge about its importance by some health professionals, and lack of close collaboration between surgeons and clinical nutritionists. In addition, no existing nutritional guidelines specifically categorize nutrition care protocols in the context of the ERAS in various surgeries. This review describes the nutritional care process and how it fits into these guidelines to improve ERAS nutrition-related care, based on an extensive review of the literature. The various ERAS guidelines for each disease that mention nutritional aspects of care are provided.

CURRENT STATUS OF KNOWLEDGE

Literature Search

A literature search was performed, including electronic databases of MEDLINE/PubMed, SCOPUS, and Google Scholar, to identify the relevant studies written in English from inception to January 2021. A combination of the terms "ERAS," "enhanced recovery," "nutrition care," "preoperative," "postoperative," "fasting," "carbohydrate loading," "malnutrition," "oral feeding," "screening," "assessment," and "diet" was used. All articles were selected and evaluated for relevance to each of the domains selected for review. Finally, notes, commentaries, conference papers, letters, and reviews were all excluded in the present design.

TABLE 1 The ERAS Guidelines

Preoperative	Intraoperative	Postoperative
Patient education and counseling	Use of epidural anesthesia and short-term anesthesia	Administration of painkillers with an epidural catheter
Identifying the patients at the risk of nutrition	Prevention of hypothermia	No *nasogastric tube*
Nutritional support	Avoidance of derange tube	Prevention of nausea and vomiting
Prevention of long-term fasting	Precision in surgical incision	Timely removal of catheters
Oral carbohydrate administration	Prevention of fluid and salt overload	Use of narcotic sprays and oral painkillers
Prophylactic antibiotic administration		Early oral feeding
Prevention of blood clotting		Moving patients as soon as possible
Avoidance of premedication		Stimulation of bowel movements

Abbreviation: ERAS, enhanced recovery after surgery.

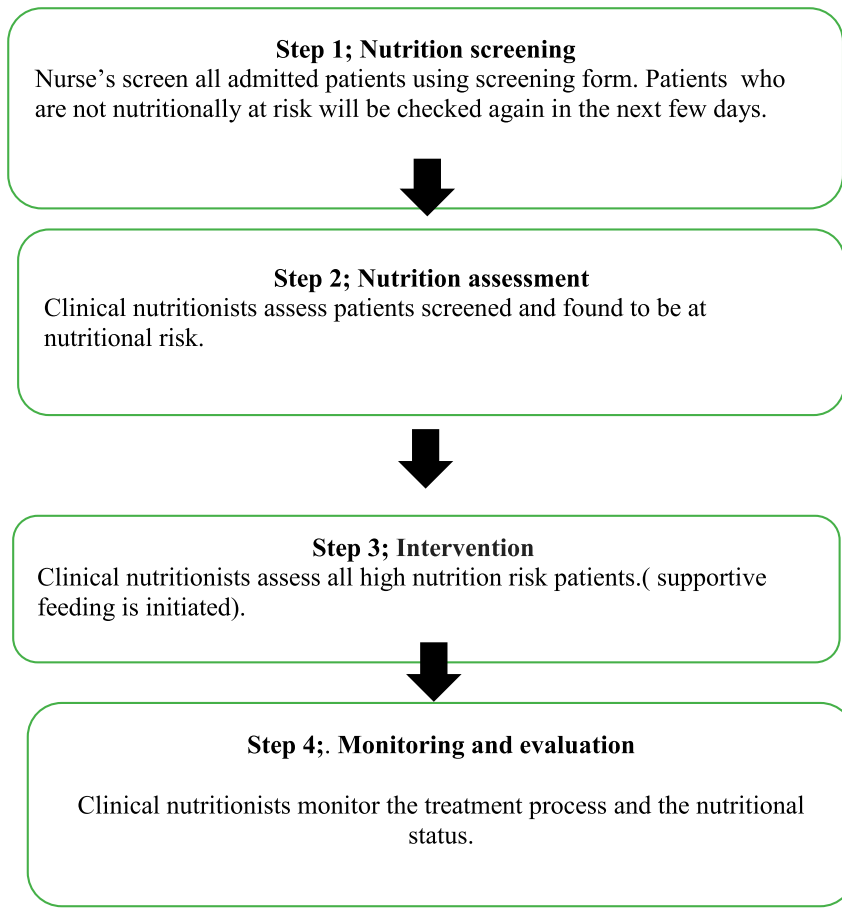

FIGURE. Steps for determining the nutritional care process for surgical patients.

INCORPORATING NUTRITIONAL ASPECTS OF CARE INTO THE ERAS GUIDELINES

Tables 2 to 8 provide relevant recommendations for nutrition-related interventions for various surgeries for which there are ERAS guidelines.[3,5–25] Recommendations are based not only on quality of evidence ("high," "moderate," "low," and "very low") but in addition on their net effects. Thus, recommendations are grades as follows: strong (desirable effects of adherence to a recommendation outweigh the undesirable effects) and weak (desirable effects of adherence to a recommendation probably outweigh the undesirable effects).

Preoperative

Nutrition Screening and Assessment of the Surgical Patients

Nutrition screening and assessment in ERAS guidelines is only recommended in esophagectomy, spinal surgery, and lung surgery (see Table 2). However, it is important to check the nutrition care plan and nutritional status in all surgeries, especially in major surgeries. According to the nutrition care plan, the nutritional status and magnitude of surgery of each patient should be checked. The nutritional care process describes what is needed to provide effective nutritional care. It consists of nutrition assessment, diagnosis, intervention, and monitoring and evaluation. A brief description of the process follows hereinafter and is summarized in the Figure. Screening and assessment are the first steps. Its goal is to identify patients who are at a high nutritional risk and should be done on all patients admitted to the hospital by nurses, because they are the first to see the patients. Basic data include weight, height, body mass index (BMI), history of weight loss over time, and mid-arm circumference, if possible. The next step is nutritional assessment using this information, along with patient history, physical examination, and laboratory tests.

(a) Historical information: the nutritional history should include the individual's health status, medical and surgical history, dietary history, use of drugs and medications, family history, socioeconomic status, ethnicity, and educational level.
(b) Anthropometric measurements should include height and weight, skinfold thickness, and abdominal girth (to ascertain abdominal fluid retention and organ size).

TABLE 2 Nutrition Screening and Assessment of Surgical Patients

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Bariatric[5]	—*	—	—
Gynecologic oncology[6]	—	—	—
Liver[7]	—	—	—
Gastrectomy[8]	—	—	—
Breast reconstruction[9]	—	—	—
Cardiac[10]	—	—	—
Cesarean delivery[11–13]	—	—	—
Colorectal[15]	—	—	—
Head and neck cancer[16]	—	—	—
Esophagectomy[17]	Yes	Low	Strong
Gastrointestinal[18,19]	—	—	—
Radical cystectomy[4]	—	—	—
Pancreaticoduodenectomy[21]	—	—	—
Elective rectal/pelvic[22]	—	—	—
Lung[23]	Yes	High	Strong
Total hip/knee replacement[25]	—	—	—
Spinal surgery[24]	Yes	—	—

*Note: Dashes (—) indicate no data.

(c) Nutrition-focused physical examination combines physical examination, vital signs, and anthropometrics with interviews of the patient, observation of health professionals, and data from the medical record.[26,27] Nutritionists can perform this after training in the interpretation of vital signs and physical findings and how they relate to notional status. Table 3 shows details and ethnic status.[26–29]
(d) Laboratory tests are helpful in detecting a developing deficiency, imbalance, or toxicity, especially in detecting early malnutrition before signs and symptoms are evident.

TABLE 3 Systems Approach to Evaluating Physical Factors for Nutrition-Focused Physical Assessment

Physical Appearance	Nerves and Cognition
Body size	Ability to communicate
Body type	Cognitive status
Appearance of wasting or obesity	Reflexes
Level of consciousness	Ability to feel pain in extremities
Paralysis or involuntary movement	Gross and fine motor skills
Amputations or contractures	
Affect	
Condition of hair and nails	
Vital Signs	**Extremities, Muscles, and Bones**
Blood pressure	Hand grip strength
Heart rate	Range of motion
Oxygen saturation/respiratory rate	Subcutaneous fat
Temperature	Muscle mass
	Edema
	Ability to stand and walk
Skin	**HEENT (Head, Eyes, Ears, Nose, and Throat)**
Skin turgor	Ability to smell and taste
Skin color	Loss of orbital (around the eye), buccal (around the cheeks), and/or facial fat
Presence of surgical wounds, pressure ulcers, stasis ulcers, or diabetic foot ulcers	Vision and hearing
Poor or delayed wound healing	Chewing or swallowing problems
Digestive System	**The Cardiopulmonary System**
Condition of the teeth; presence of dentures and/or partials	Ability to breathe
Condition of the oral cavity and tongue	Breath sounds
Inflamed or bleeding gums	Regular heart rhythm
Bowel sounds	
Abdominal pain	

Adapted from Litchford.[27]

TABLE 4 Preoperative Nutritional Measures

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Bariatric[5]	Preoperative weight loss	Postoperative complications: high Postoperative weight loss: low (inconsistency, low quality)	Strong
Gynecologic oncology[6]	—*	—	—
Liver[7]	Patients at risk (weight loss, 10%–15% within 6 mo; BMI < 18.5 kg/m^2; and serum albumin < 30 g/L in the absence of liver or renal dysfunction) should receive oral nutritional supplements for 7 d before surgery. For severely malnourished patients (>10% weight loss), surgery should be postponed for at least 2 wk to improve nutritional status and allow patients to gain weight.	High	Strong
Gastrectomy[8]	Preoperative nutrition: malnourished patients should be optimized with oral supplements or enteral nutrition before surgery. Preoperative oral pharmaconutrition: there is presently insufficient evidence for this patient group.	Very low Moderate	Strong Weak
Breast reconstruction[9]	Obese: weight reduction to achieve a BMI ≤ 30 kg/m^2 before surgery	High	Strong
Cardiac[10]	Preoperative correction of nutritional deficiency	Moderate	—
Cesarean delivery[11–13]	Maternal obesity (BMI, >40 kg/m^2) significantly increases risks of maternal and fetal complications. Optimal gestational weight gain management should be used to control their weight during pregnancy.	High	Strong
Colorectal[15]	—	—	—
Head and neck cancer[16]	Preoperative comprehensive nutritional assessment and nutrition intervention are recommended for those identified as malnourished. A standard polymeric enteral nutrition formula (contains whole proteins, complex carbohydrates, and long-chain triglycerides) in patients requiring preoperative nutrition support	High Low	Strong Weak
Esophagectomy[17]	Preoperative nutritional intervention: In high-risk cases, enteral support is indicated preferably using the gastrointestinal tract with selective use of feeding tubes. Preoperative oral pharmaconutrition: Evidence in support of pharmaconutrition for patients undergoing surgery for esophageal cancer is conflicting, and its routine use cannot be supported at this time.	Low Moderate	Strong Strong
Gastrointestinal[18,19]	Nutritional status and diabetes should follow international recommendations.	Moderate	—

(continues)

TABLE 4 Preoperative Nutritional Measures, Continued

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Radical cystectomy[20]	Preoperative nutritional support should be considered, especially for malnourished patients. Correction of anemia and comorbidities for nutritional support	Moderate High	Strong
Pancreaticoduodenectomy[21]	Preoperative nutritional intervention for patients with severe weight loss (ie, >15% weight loss or BMI < 18.5 kg/m^2 secondary to their disease) Preoperative nutritional status based on BMI and weight loss based on self-reported premorbid weight and weight scaling upon admission	15% weight loss: high Moderate	Strong Weak
Rectal/pelvic[22]	—	—	—
Lung[23]	Oral nutritional supplements should be given to malnourished patients.	Moderate	Strong
Total hip/knee replacement[25]	—	—	—
Spinal[24]	Preoperative nutritional consultation and education for those high-risk patients identified BMI of <18.5 or >25 with a preoperative serum albumin level < 3.5 g/dL	—	—

Abbreviation: BMI, body mass index.
*Note: Dashes (—) indicate no data.

Preoperative Nutritional Measures

Screening and correction of malnutrition in the preoperative period are the main elements in the ERAS. Preoperative malnutrition is a recurring problem in surgical patients, which is associated with longer hospital stays, higher rates of complications and mortality, and higher hospital costs.[30] The cost of hospitalization for patients with malnutrition increases by approximately 24% in 1 study (in Spain), because of longer hospital stays, greater costs for medications to treat complications (especially infectious), and higher costs of nutritional support for the treatment of malnutrition.[31] In-hospital malnutrition is high even in developed countries such as the United Kingdom (20%)[32] and Australia (36%).[30] In developing countries such as Latin America, the prevalence of malnutrition in hospitalized patients is approximately 50%.[33] Despite the high prevalence of malnutrition, its complications and costs, diagnosis, and treatment are still less considered. There are various nutrition screening tools for identifying patients at a high nutritional risk including the Nutritional Risk Screening score (2002),[34] subjective global assessment,[35] patient-generated subjective global assessment,[36] Malnutrition Universal Screening Tool,[37] and preoperative nutrition screen.[38] Although the different scoring systems are not directly comparable, they all use the same basic structure and are easily applicable in clinical settings. Preoperative nutrition should often be considered for severely malnourished patients anticipating major surgeries such as esophageal resections, gastrectomy, and pancreaticoduodenectomy (Table 4). In addition, during the surgery, the need for insertion of an enteral access route should be considered, especially if the patient will be unable to eat for 2 or 3 weeks.

Nutritional Risk Screening is one of the most common tools for measuring nutritional risk. This questionnaire includes an initial assessment that must first be completed by the nurse. If all initial assessment questions (BMI < 20.5 kg/m^2? Weight loss within 3 months? Reduced dietary intake in the last week?) are answered in the negative, the patient was not in a nutritional risk situation. If one of the initial assessment questions' answer is "yes," then a more detailed assessment is warranted. The Nutritional Risk Screening should be repeated weekly. The more detailed assessment involves consideration of nutritional status, disease severity, and age, with each of these being scored and a final score calculated. If the Nutritional Risk Screening score is 3 or higher, then supportive feeding is initiated.[34]

It is important to remember that lean body mass decreases with age, especially when disease is present that causes its rapid loss.[39–42] Fat mass is often important to consider in evaluating whether surgery is appropriate especially when the patient is already severely malnourished or very old, because people with obesity often experience protein calorie malnutrition, micronutrient deficiencies, and electrolyte disturbances, which themselves enhance anesthesia

TABLE 5 Immunonutrition Formula

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Bariatric[5]	—*	—	—
Gynecologic oncology[6]	—	—	—
Liver[7]	There is limited evidence for the use of immunonutrition.	Low	Weak
Gastrectomy[8]	—	—	—
Breast reconstruction[9]	—	—	—
Cardiac[10]	—	—	—
Cesarean delivery[11–13]	—	—	—
Colorectal[15]	—	—	—
Head and neck cancer[16]	There are insufficient data for the use of immunonutrition.	Moderate	Conditional
Esophagectomy[17]	—	—	—
Gastrointestinal[18,19]	—	—	—
Radical cystectomy[20]	—	—	—
Pancreaticoduodenectomy[21]	Immunonutrition for 5–7 d preoperatively in patients undergoing major open abdominal surgery (2012). Immunonutrition is not recommended (2019).	Moderate High	Weak Strong
Elective rectal/pelvic[22]	—	—	—
Lung[23]	Immune-enhancing nutrition may have a role in the malnourished patient postoperatively.	Low	Weak
Total hip/knee replacement[25]	—	—	—
Spinal[24]	—	—	—

*Note: Dashes (—) indicate no data.

and surgical risks during as well as after surgery. Surgery itself generates an inflammatory response and depletes protein stores, and so those who are at a high risk of malnutrition must be managed with nutritional and other measures, because the quality of the surgical results such as wound healing and recovery will depend on it.[43–45]

Enhanced recovery after surgery guidelines suggest evaluating BMI and considering the special risks associated with BMI in bariatric surgery, breast reconstruction, and deliveries by cesarean sections.[5,9,11] Patients' nutritional status should be determined before surgery. Biochemical and anthropometric measures have low sensitivity and specificity, and baseline clinical parameters such as BMI, whole-body protein balance and nitrogen balance, insulin resistance, albumin, prealbumin, body composition, and markers of inflammation (interleukin-6 and C-reactive protein) best reflected metabolic responses to nutrition.[46–48]

Immunonutrition

The ERAS guidelines recommend immunonutrition formulas (oral nutrition supplements with arginine, omega 3 fatty acids, glutamine, ribonucleic acids, selenium, and other antioxidants) that may be effective in reducing infections and other complications only in pancreaticoduodenectomy, where they are most likely to be effective (Table 5).[49–51] Other groups, such as the American Society of Parenteral and Enteral Nutrition and the European Society of Parenteral and Enteral Nutrition, recommend the use of immunonutrition formulas in malnourished patients who undergo major neck or abdominal cancer surgery. In addition, the European Society of Parenteral and Enteral Nutrition recommends that immunonutrition formulas should commence before surgery and continue for 5 to 7 days postoperatively.[52–57] They should not be used in patients undergoing elective surgery because evidence

TABLE 6 Length of Fasting Before Surgery

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Bariatric[5]	Clear fluids up to 2 h and solids up to 6 h before induction of anesthesia	Nondiabetic obese patients: high Diabetic patients without autonomic neuropathy: moderate Diabetic patients with autonomic neuropathy: low	Strong Weak Weak
Gynecologic oncology[6]	*	High	Strong
Liver[7]	*	Moderate	Strong
Gastrectomy[8]	*	—	—
Breast reconstruction[9]	Clear fluids up to 2 h before surgery	Moderate	Strong
Cardiac[10]	Clear liquids up until 2-4 h before general anesthesia	Low	Strong
Cesarean delivery[11–13]	*	High	Low
Colorectal[15]	*	Moderate	Strong
Head and neck cancer[16]	Caution should be applied for patients with significant dysphagia or risk of refeeding syndrome. Clear fluids should be permitted for up to 2 h and solids for up to 6 h before anesthesia.	High (fluids) Low (solids)	Strong (fluids) Strong (solids)
Esophagectomy[17]	2 h for liquids. Caution should be applied for patients with significant dysphagia or other obstructive symptoms.	High	Strong
Gastrointestinal[18,19]	*	—	Strong
Radical cystectomy[20]	*	Moderate	Strong
Pancreaticoduodenectomy[21]	6 h for solids and 2 h for liquids in patients without specific risk factors (ie, gastric outlet obstruction, diabetes with severe neuropathy)	Moderate	Strong
Elective rectal/pelvic[22]	*	Moderate	Strong
Lung[23]	*	High	Strong
Total hip/knee replacement[25]	*	Moderate	Strong
Spinal[24]	—	—	—

Note: Dashes (—) indicate no data. Asterisks (*) mean 6 h for solids and 2 h for liquids.

is lacking on whether they are effective in well-nourished surgical patients.

Duration of Fasting Before Surgery

Table 6 describes ERAS guidelines for this. Preoperative fasting should be minimized; patients should be allowed to drink clear fluids (pulp-free juice, coffee, or tea with no milk) up to 2 hours before surgery, and a light meal may be eaten up to 6 hours before surgery. For decades, anesthesiologists have advised patients not to eat or drink at all after midnight before surgery.[58,59] However, experts are now reviewing the old standard. New research suggests that the "NPO after midnight" rule is not necessary for patients who are about to undergo surgery. In addition, caution

TABLE 7 Oral Carbohydrate Use Before Surgery

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Bariatric[5]	While preoperative oral carbohydrate conditioning in patients undergoing major abdominal elective surgery has been associated with metabolic and clinical benefits, further data are required in morbidly obese patients. Similarly, further data are needed on preoperative carbohydrate conditioning in patients with gastroesophageal reflux who may be at an increased risk of aspiration during anesthetic induction.	Diabetic patients without autonomic neuropathy: moderate Diabetic patients with autonomic neuropathy: low Preoperative carbohydrate loading in obese patients: low	Strong
Gynecologic oncology[6]	Carbohydrate loading reduces postoperative insulin resistance and should be used routinely.	Carb loading: moderate (outcome: insulin resistance) Carb loading: moderate (other outcomes)	Strong
Liver[7]	Carbohydrate loading is recommended the evening before liver surgery and 2 h before induction of anesthesia.	Low	Weak
Gastrectomy[8]	—*	—	—
Breast reconstruction[9]	Preoperative maltodextrin-based drinks should be given to patients 2 h before surgery.	Low	Strong
Cardiac[10]	Preoperative oral carbohydrate loading may be considered before surgery.	Low	Strong
Cesarean delivery[11–13]	Oral carbohydrate fluid supplementation, 2 h before cesarean delivery, may be offered to nondiabetic women.	Low	Weak
Colorectal[15]	Preoperative oral carbohydrate treatment should be used routinely. In diabetic patients, carbohydrate treatment can be given along with the diabetic medication.	Carbohydrate loading, overall: low Carbohydrate loading, diabetic patients: very low	Preoperative carbohydrate drinks: strong Preoperative carbohydrate drinks, diabetic patients: weak
Head and neck cancer[16]	Preoperative carbohydrate treatment may be offered to head and neck cancer patients.	Low	Conditional
Esophagectomy[17]	Preoperative high-carbohydrate drinks should be allowed until 2 h before esophagectomy. Caution should be applied for patients with significant dysphagia or other obstructive symptoms.	Preoperative carbohydrate drinks (extrapolated): low	Moderate
Gastrointestinal[18,19]	Preoperative treatment with oral carbohydrates should be routinely administered except in patients with documented delayed gastric emptying or slow gastrointestinal motility and as well in patients undergoing emergency surgery.	Administration of preoperative carbohydrates: strong Administration of preoperative carbohydrates in diabetic and obese patients: weak	—

(continues)

TABLE 7 Oral Carbohydrate Use Before Surgery, Continued

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Radical cystectomy[20]	Preoperative oral carbohydrate loading should be administered to all nondiabetic patients.	Not available/low	Strong
Pancreaticoduodenectomy[21]	Carbohydrate loading is recommended.	Moderate	Strong
Elective rectal/pelvic[22]	Preoperative oral carbohydrate loading should be administered to all nondiabetic patients.	Reduced postoperative insulin resistance: moderate Improved clinical outcomes: low	Strong
Lung[23]	Oral carbohydrate loading reduces postoperative insulin resistance and should be used routinely.	Low	Strong
Total hip/knee replacement[25]	Current evidence does not support the routine use of carbohydrate loading.	—	—
Spinal[24]	—	—	—

*Note: Dashes (—) indicate no data.

should be applied for the patients with significant dysphagia or other obstructive symptoms.[5] Obese patients scheduled for bariatric surgery should not be given solids 6 hours and clear fluids after 2 hours before inducing anesthesia, but special care is needed in diabetic patients with autonomic neuropathy because of the potential risk of aspiration.

Preoperative Carbohydrates

In Table 7, it has been shown oral carbohydrate before surgery based on the ERAS guidelines. The instructions for oral carbohydrate with low osmolarity (maltodextrin, 400 mL [200 kcal], 240 mOsm/L, 12.6% carbohydrates) intake before elective surgery are 200 × 4 (800 mL) the day before surgery and 200 × 2 (400 mL) 2 to 3 hours before the start of anesthesia.[60]

Enhanced recovery after surgery not only eliminates the midnight fast but also recommends preoperative carbohydrate loading. Allowing the patients to eat (and drink) puts them in an anabolic, rather than catabolic, state before surgery. In addition, surgery can have a profound effect on the body. When an injury occurs, the nerve impulses activate an endocrine response. This stress response to surgery leads to an increase in stress hormones, inflammatory markers, and insulin resistance, which are present as suppressors of the immune system, as well as an increase in cortisol secretions, which also affects carbohydrates, fats, and protein metabolisms.[61–64] Moreover, the effect of presurgery oral carbohydrate intake guidelines has been investigated in many surgeries. For example, eating carbohydrate and drinking preoperatively reduce hunger, thirst, anxiety,[65] and nausea and vomiting before surgery[66]; reduces nausea, vomiting, pain,[67] LBM loss,[68] balance nitrogen,[69] and insulin resistance by 50% after surgery[70]; and cause faster return of intestinal activity in various surgeries as a result of the reduced hospital stay.[71] In addition, in some studies, the effect of oral carbohydrate before cesarean section was seen on breastfeeding success and reduction of neonatal jaundice.[72,73] No adverse effects have been reported after oral carbohydrate intake before surgery.

Combining carbohydrate with whey protein before surgery has been suggested, but more evidence is needed.[74]

Postoperative Care

Nutrition Support

The start time of feeding and its type in different surgeries are described in Table 8.

Surgery induces inflammation, and wound health involves the resolution of inflammation. Both require energy and nutrients. In addition, adequacy and recovery depend on available nutrient resources or reserves.[53,75] Oral feeding is recommended as soon as possible after surgery. Early oral feeding is the preferred mode of nutrition for surgical patients. Nutrition interventions should be developed in consultation with the multidisciplinary team and individually according to the nutritional status and surgical procedure.[76] Postoperative diet phases include clear liquid, pureed food, soft food, and solid food, respectively. The start time of these phases will vary depending on the type of surgery and for each patient.

Chewing Gum

At present, gum chewing is recommended only for cesarean section and rectal/pelvic surgery. The action of chewing

TABLE 8 Postoperative Nutrition

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Bariatric[5]	Protein intake should be monitored. Iron, vitamin B12, and calcium supplementation is mandatory. Postoperative glycemic and lipid control has to be strict in patients with diabetes.	Nutritional supplementation: moderate Glycemic control: high	Strong Strong
Gynecologic oncology[6]	A regular diet within the first 24 h after surgery High-protein diets (2 g/kg/d)	Feeding within first 24 h: high High-protein diet: moderate	Strong
Liver[7]	Most patients can eat normal food at day 1 after liver surgery. Postoperative enteral or parenteral feeding should be reserved for malnourished patients or those with prolonged fasting due to complications (eg, ileus > 5 d, delayed gastric emptying).	Early oral intake: moderate Oral nutritional supplements: moderate No routine postoperative artificial nutrition: high	Early oral intake: strong Oral nutritional supplements: weak No routine postoperative artificial nutrition: strong
Gastrectomy[8]	Patients undergoing total gastrectomy should be offered drink and food at will from postoperative day 1. They should be advised to begin cautiously and increase intake according to tolerance. Patients clearly malnourished or those unable to meet 60% of daily requirements by postoperative day 6 should be given individualized nutritional support.	Moderate Moderate	Weak Strong
Breast reconstruction[9]	Patients should be encouraged to take fluids and food orally as soon as possible, preferably within 24 h after surgery.	Moderate	Strong
Cardiac[10]	—*	—	—
Cesarean delivery[11–13]	A regular diet within 2 h after cesarean delivery is recommended.	High	Low
Colorectal[15]	Patients should be encouraged to take normal food as soon as after surgery. Oral nutritional supplements may be used to supplement total intake.	Postoperative early enteral feeding, safety: high Improved recovery and reduction of morbidity: low Perioperative oral nutritional supplements (well-fed patients): low Perioperative oral nutritional supplements (malnourished patients): low	Postoperative early feeding and perioperative oral nutritional supplements: strong Could be considered in open colonic resections: weak
Head and neck cancer[16]	Oral diet is the first choice for all patients tolerating it. In patients for whom oral feeding cannot be established, postoperative tube feeding should be initiated within 24 h.	Moderate	Strong

(continues)

TABLE 8 Postoperative Nutrition, Continued

Type of Surgery	Recommendation	Level of Evidence	Recommendation Grade
Esophagectomy[17]	Early enteral feeding with target nutritional rate on days 3–6 should be strongly considered after esophagectomy. Either feeding jejunostomy or nasojejunal/nasoduodenal tubes may be used. Oral vs jejunostomy: introduction of early enteral nutrition is beneficial in patients undergoing surgery for esophageal cancer.	Moderate Moderate	Moderate Strong
Gastrointestinal[18,19]	Prophylactic use of *nasogastric tube* is not recommended for patients undergoing elective colorectal surgery, whereas its use in patients undergoing gastrectomy and oesophagectomy is still debatable. Patients with delayed gastric emptying after surgery should be treated by inserting a *nasogastric tube*.	—	Strong
Radical cystectomy[20]	Early oral nutrition should be started 4 h after surgery.	Moderate	Strong
Pancreaticoduodenectomy[21]	Patients should be allowed a normal diet after surgery without restrictions according to tolerance. Artificial nutrition should be considered as an individual approach according to the nutritional status assessment. The enteral route should be preferred.	Moderate	Strong
Elective rectal/pelvic[22]	Early oral intake: an oral ad-libitum diet is recommended 4 h after rectal surgery. Oral nutritional supplements: in addition to normal food intake, patients should be offered oral nutritional supplements to maintain adequate intake of protein and energy.	Moderate Low	Strong Strong
Lung[23]	—	—	—
Total hip/knee replacement[25]	An early return to normal diet should be promoted.	Low	Strong
Spinal[24]	—	—	—

*Note: Dashes (—) indicate no data.

gum can be seen as sham feeding, which activates the cephalovagal pathway, which increases the promotability of neural and humoral factors that act on different parts of the gastrointestinal tract. These are the results of increasing the serum concentration of the peptide hormone gastrin, neuropeptide neurotensin, pancreatic polypeptide, and duodenal alkaline secretion.[77,78] The results suggested that chewing gum tricks the body into thinking it is eating, causing the digestive system to start working again. Because many patients cannot tolerate a diet immediately after abdominal surgery, few doctors encourage the patients to eat immediately after surgery. As a result, gum chewing, which mimics food intake and can be considered as sham feeding, seems to be a better alternative for enhancing recovery of the gastrointestinal tract function with no actual feeding. In addition, one possible way of preventing ileus is by chewing gum. Furthermore, patients readily accept this treatment after abdominal surgery. Given this, gum chewing might be a safe and inexpensive way to provide the benefits of early stimulation of the gastrointestinal tract (the first aerofluxus, intestinal sounds, and defecation time) and also promotes faster recovery of the surgery.

CONCLUSIONS

The nutrition guidelines for surgeries presented in this article are helpful to ensure cooperation of all members of the ERAS team.

REFERENCES

1. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *Br J Anaesth*. 1997;78(5):606–617.
2. Nygren J, Hausel J, Kehlet H, et al. A comparison in five European Centres of case mix, clinical management and outcomes following either conventional or fast-track perioperative care in colorectal surgery. *Clin Nutr*. 2005;24(3):455–461.
3. Nelson G, Altman AD, Nick A, et al. Guidelines for postoperative care in gynecologic/oncology surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations—part II. *Gynecol Oncol*. 2016;140(2):323–332.
4. Donat SM, Slaton JW, Pisters LL, et al. Early nasogastric tube removal combined with metoclopramide after radical cystectomy and urinary diversion. *J Urol*. 1999;162(5):1599–1602.
5. Thorell A, MacCormick AD, Awad S, et al. Guidelines for perioperative care in bariatric surgery: enhanced recovery after surgery (ERAS) society recommendations. *World J Surg*. 2016;40(9):2065–2083.
6. Nelson G, Bakkum-Gamez J, Kalogera E, et al. Guidelines for perioperative care in gynecologic/oncology: Enhanced Recovery After Surgery (ERAS) Society recommendations—2019 update. *Int J Gynecol Cancer*. 2019;29(4):651–668.
7. Melloul E, Hübner M, Scott M, et al. Guidelines for perioperative care for liver surgery: enhanced recovery after surgery (ERAS) society recommendations. *World J Surg*. 2016;40(10):2425–2440.
8. Mortensen K, Nilsson M, Slim K, et al. Consensus guidelines for enhanced recovery after gastrectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Br J Surg*. 2014;101(10):1209–1229.
9. Temple-Oberle C, Shea-Budgell MA, Tan M, et al. Consensus review of optimal perioperative care in breast reconstruction: enhanced recovery after surgery (ERAS) society recommendations. *Plast Reconstr Surg*. 2017;139(5):1056e–1071e.
10. Engelman DT, Ben Ali W, Williams JB, et al. Guidelines for perioperative care in cardiac surgery: enhanced recovery after surgery society recommendations. *JAMA Surg*. 2019;154(8):755–766.
11. Wilson RD, Caughey AB, Wood SL, et al. Guidelines for antenatal and preoperative care in cesarean delivery: enhanced recovery after surgery society recommendations (part 1). *Am J Obstet Gynecol*. 2018;219(6):523.e521–523.e515.
12. Caughey AB, Caughey AB, Wood SL, et al. Guidelines for intraoperative care in cesarean delivery: enhanced recovery after surgery society recommendations (part 2). *Am J Obstet Gynecol*. 2018;219(6):533–544.
13. Macones GA, Caughey AB, Wood SL, et al. Guidelines for postoperative care in cesarean delivery: Enhanced Recovery After Surgery (ERAS) Society recommendations (part 3). *Am J Obstet Gynecol*. 2019;221(3):247.e241–247.e249.
14. Gustafsson UO, Scott MJ, Schwenk W, et al. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *World J Surg*. 2013;37(2):259–284.
15. Gustafsson UO, Scott MJ, Hubner M, et al. Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) society recommendations: 2018. *World J Surg*. 2019;43(3):659–695.
16. Dort JC, Farwell DG, Findlay M, et al. Optimal perioperative care in major head and neck cancer surgery with free flap reconstruction: a consensus review and recommendations from the enhanced recovery after surgery society. *JAMA Otolaryngol Head Neck Surg*. 2017;143(3):292–303.
17. Low DE, Allum W, De Manzoni G, et al. Guidelines for perioperative care in esophagectomy: enhanced recovery after surgery (ERAS®) society recommendations. *World J Surg*. 2019;43(2):299–330.
18. Scott MJ, Baldini G, Fearon KC, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 1: pathophysiological considerations. *Acta Anaesthesiol Scand*. 2015;59(10):1212–1231.
19. Feldheiser A, Aziz O, Baldini G, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 2: consensus statement for anaesthesia practice. *Acta Anaesthesiol Scand*. 2016;60(3):289–334.
20. Cerantola Y, Valerio M, Persson B, et al. Guidelines for perioperative care after radical cystectomy for bladder cancer: Enhanced Recovery After Surgery (ERAS®) society recommendations. *Clin Nutr*. 2013;32(6):879–887.
21. Lassen K, Coolsen MM, Slim K, et al. Guidelines for perioperative care for pancreaticoduodenectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Clin Nutr*. 2012;31(6):817–830.
22. Nygren J, et al. Guidelines for perioperative care in elective rectal/pelvic surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Clin Nutr*. 2012;31(6):801–816.
23. Batchelor TJP, Rasburn NJ, Abdelnour-Berchtold E, et al. Guidelines for enhanced recovery after lung surgery: recommendations of the Enhanced Recovery After Surgery (ERAS®) Society and the European Society of Thoracic Surgeons (ESTS). *Eur J Cardiothorac Surg*. 2019;55(1):91–115.
24. Ali ZS, Ma TS, Ozturk AK, et al. Pre-optimization of spinal surgery patients: development of a neurosurgical enhanced recovery after surgery (ERAS) protocol. *Clin Neurol Neurosurg*. 2018;164:142–153.
25. Wainwright TW, Gill M, McDonald DA, et al. Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Acta Orthop*. 2020;91(1):3–19.
26. Ireton-Jones C. *Outpatient Nutrition Care and Home Nutrition, Support: Practical Guidelines for Assessment and Management*. Boca Raton: CRC Press; 2016.
27. Litchford MD. *Nutrition Focused Physical Assessment: Making Clinical Connections*. Greensboro, NC: Case Software & Books; 2015.
28. Mahan LK, Raymond JL. *Krause's Food & the Nutrition Care Process, Mea Edition E-Book*. St. Louis, MO: Elsevier; 2016.
29. Posthauer ME, Banks M, Dorner B, et al. The role of nutrition for pressure ulcer management: national pressure ulcer advisory panel, European pressure ulcer advisory panel, and pan pacific pressure injury alliance white paper. *Adv Skin Wound Care*. 2015;28(4):175–188.
30. Middleton MH, Nazarenko G, Nivison-Smith I, et al. Prevalence of malnutrition and 12-month incidence of mortality in two Sydney teaching hospitals. *Intern Med J*. 2001;31(8):455–461.
31. Álvarez-Hernández J, Planas Vilá M, León-Sanz M, et al. Prevalence and costs of malnutrition in hospitalized patients; the PREDyCES Study. *Nutr Hosp*. 2012;27(4):1049–1059.
32. Edington J, Boorman J, Durrant ER, et al. Prevalence of malnutrition on admission to four hospitals in England. The Malnutrition Prevalence Group. *Clin Nutr*. 2000;19(3):191–195.
33. Correia MI, Campos AC, ELAN Cooperative Study. Prevalence of hospital malnutrition in Latin America: the multicenter ELAN study. *Nutrition*. 2003;19(10):823–825.
34. Kondrup J, Rasmussen HH, Hamberg O, et al. Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. *Clin Nutr*. 2003;22(3):321–336.
35. Detsky AS, McLaughlin JR, Baker JP, et al. What is subjective global assessment of nutritional status? *JPEN J Parenter Enteral Nutr*. 1987;11(1):8–13.

36. Ottery FD. Rethinking nutritional support of the cancer patient: the new field of nutritional oncology. *Semin Oncol*. 1994;21(6):770–778.
37. Stratton RJ, Hackston A, Longmore D, et al. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. *Br J Nutr*. 2004;92(5):799–808.
38. Wischmeyer PE, Carli F, Evans DC, et al. American Society for Enhanced Recovery and Perioperative Quality Initiative joint consensus statement on nutrition screening and therapy within a surgical enhanced recovery pathway. *Anesth Analg*. 2018;126(6):1883–1895.
39. Samaras TT, Storms LH, Elrick H. Longevity, mortality and body weight. *Ageing Res Rev*. 2002;1(4):673–691.
40. Cohen S, Nathan JA, Goldberg AL. Muscle wasting in disease: molecular mechanisms and promising therapies. *Nat Rev Drug Discov*. 2015;14(1):58–74.
41. Khalooeifard R, Shariatpanahi ZV, Ahani A, et al. Effect of protein supplement on paraspinal muscles in spine fusion surgery: a randomized, double-blind, placebo-controlled trial. *Int J Spine Surg*. 2021;15(1):47–54.
42. Khalooeifard R, Oraee-Yazdani S, Keikhaee M, et al. Protein supplement and enhanced recovery after posterior spine fusion surgery: a randomized, double-blind, placebo-controlled trial. *Clin Spine Surg*. 2021;35:E356–E362.
43. Gawande A. *Complications: A Surgeon's Notes on an Imperfect Science*. New York, NY: Henry Holt. Profile Books; 2010.
44. Stefan N, Häring HU, Hu FB, et al. Metabolically healthy obesity: epidemiology, mechanisms, and clinical implications. *Lancet Diabetes Endocrinol*. 2013;1(2):152–162.
45. Cid Conde L, Fernández López T, Neira Blanco P, et al. Hyponutrition prevalence among patients with digestive neoplasm before surgery. *Nutr Hosp*. 2008;23(1):46–53.
46. McFarlane H, Ogbeide MI, Reddy S, et al. Biochemical assessment of protein-calorie malnutrition. *The Lancet*. 1969;293(7591):392–395.
47. Forse RA, Shizgal HM. The assessment of malnutrition. *Surgery*. 1980;88(1):17–24.
48. Stoppe C, Wendt S, Mehta NM, et al. Biomarkers in critical care nutrition. *Crit Care*. 2020;24(1):499.
49. Bharadwaj S, Trivax B, Tandon P, et al. Should perioperative immunonutrition for elective surgery be the current standard of care? *Gastroenterol Rep*. 2016;4(2):87–95.
50. McCowen KC, Bistrian BR. Immunonutrition: problematic or problem solving? *Am J Clin Nutr*. 2003;77(4):764–770.
51. Zhu X, Herrera G, Ochoa JB. Immunosupression and infection after major surgery: a nutritional deficiency. *Crit Care Clin*. 2010;26(3):491–500.
52. Weimann A, Braga M, Carli F, et al. ESPEN guideline: clinical nutrition in surgery. *Clin Nutr*. 2017;36(3):623–650.
53. McClave SA, Taylor BE, Martindale RG, et al. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.). *JPEN J Parenter Enteral Nutr*. 2016;40(2):159–211.
54. Marik PE, Zaloga GP. Immunonutrition in high-risk surgical patients: a systematic review and analysis of the literature. *JPEN J Parenter Enteral Nutr*. 2010;34(4):378–386.
55. Cerantola Y, Grass F, Cristaudi A, et al. Perioperative nutrition in abdominal surgery: recommendations and reality. *Gastroenterol Res Pract*. 2011.
56. Matsugu Y, Ito K, Oshita A, et al. Postoperative oral energy and protein intakes for an enhanced recovery after surgery program incorporating early enteral nutrition for pancreaticoduodenectomy: a retrospective study. *Nutr Clin Pract*. 2021.
57. Low DE, Allum W, De Manzoni G, et al. Guidelines for perioperative care in esophagectomy: enhanced recovery after surgery (ERAS®) society recommendations. *World J Surg*. 2019;43(2):299–330.
58. Scott MJ, Fawcett WJ. Oral carbohydrate preload drink for major surgery—the first steps from famine to feast. *Anaesthesia*. 2014;69(12):1308–1313.
59. Warner MA, Warner ME, Weber JG. Clinical significance of pulmonary aspiration during the perioperative period. *Anesthesiology*. 1993;78(1):56–62.
60. Sjöback R, Nygren J, Kubista M. Absorption and fluorescence properties of fluorescein. *Spectrochim Acta A Mol Biomol Spectrosc*. 1995;51(6):L7–L21.
61. Pogatschnik C, Steiger E. Review of preoperative carbohydrate loading. *Nutr Clin Pract*. 2015;30(5):660–664.
62. Awad S, Varadhan KK, Ljungqvist O, et al. A meta-analysis of randomised controlled trials on preoperative oral carbohydrate treatment in elective surgery. *Clin Nutr*. 2013;32(1):34–44.
63. Blackburn GL. Metabolic considerations in management of surgical patients. *Surg Clin*. 2011;91(3):467–480.
64. Bilku DK, Dennison AR, Hall TC, Metcalfe MS, Garcea G. Role of preoperative carbohydrate loading: a systematic review. *Ann R Coll Surg Engl*. 2014;96(1):15–22.
65. Hausel J, Nygren J, Lagerkranser M, et al. A carbohydrate-rich drink reduces preoperative discomfort in elective surgery patients. *Anesth Analg*. 2001;93(5):1344–1350.
66. Bisgaard T, Kristiansen VB, Hjortsø NC, et al. Randomized clinical trial comparing an oral carbohydrate beverage with placebo before laparoscopic cholecystectomy. *Br J Surg*. 2004;91(2):151–158.
67. Hausel J, Nygren J, Thorell A, et al. Randomized clinical trial of the effects of oral preoperative carbohydrates on postoperative nausea and vomiting after laparoscopic cholecystectomy. *Br J Surg*. 2005;92(4):415–421.
68. Yuill KA, Richardson RA, Davidson HI, et al. The administration of an oral carbohydrate-containing fluid prior to major elective upper-gastrointestinal surgery preserves skeletal muscle mass postoperatively—a randomised clinical trial. *Clin Nutr*. 2005;24(1):32–37.
69. Soop M, Nygren J, Thorell A, et al. Preoperative oral carbohydrate treatment attenuates endogenous glucose release 3 days after surgery. *Clin Nutr*. 2004;23(4):733–741.
70. Nygren J, Soop M, Thorell A, et al. Preoperative oral carbohydrate administration reduces postoperative insulin resistance. *Clin Nutr*. 1998;17(2):65–71.
71. Thorell A, Nygren J, Ljungqvist O. Insulin resistance: a marker of surgical stress. *Curr Opin Clin Nutr Metab Care*. 1999;2(1):69–78.
72. Fard RK, Tabassi Z, Qorbani M, et al. The effect of preoperative oral carbohydrate on breastfeeding after cesarean section: a double-blind, randomized controlled clinical trial. *J Diet Suppl*. 2018;15(4):445–451.
73. Fard RK, Tabassi Z, Qorbani M. The effect of maternal precesarean oral carbohydrate supplementation on neonatal jaundice: a randomized, double-blind clinical trial. *J Nutr Sci Diet*. 2016;2(2):20–24.
74. Ho CY, Ibrahim Z, Abu Zaid Z, et al. Fast-track-recovery surgery with a whey-protein-infused carbohydrate-loading drink preoperatively and early oral feeding post-operatively among surgical gynaecological cancer patients: study protocol of an open-labelled, randomised controlled trial. *Trials*. 2020;21(1):533.
75. Velnar T, Bailey T, Smrkolj V. The wound healing process: an overview of the cellular and molecular mechanisms. *J Int Med Res*. 2009;37(5):1528–1542.
76. Cross JM, Hardin W Jr. American Burn Association Board of Trustees, 2004–2005. *J Burn Care Rehabil*. 2004;25(4):17a–18a.
77. Ge W, Chen G, Ding YT. Effect of chewing gum on the postoperative recovery of gastrointestinal function. *Int J Clin Exp Med*. 2015;8(8):11936–11942.
78. Bhatiyani B, Bhasani D, Dhumale S. Effect of chewing gum on the postoperative recovery of gastrointestinal function after gynaecological laparoscopic surgery. *Int J Reprod Contracept Obstet Gynecol*. 2018;7(2):644–647.