

Perioperative nutritional assessment and management of patients undergoing gastrointestinal surgery

Aristea Gazouli^{a*}, Konstantinos Georgiou^{b*}, Maximos Frountzas^b, Gerasimos Tsourouflis^c, Nikola Boyanov^{d,e}, Nikolaos Nikiteas^c, Maria Gazouli^f, George E. Theodoropoulos^b

Co-Metabolism, Kalamata, Greece; Hippocrateion Athens General Hospital, Medical School, National and Kapodistrian University of Athens, Greece; Laiko General Hospital, Medical School, National and Kapodistrian University of Athens, Greece; Medical Simulation Training Centre at Research Institute of Medical University of Plovdiv, Bulgaria; UMHAT PULMED, Plovdiv, Bulgaria; Laboratory of Biology, Medical School, National and Kapodistrian University of Athens, Greece

Abstract

Malnutrition is a major issue in gastrointestinal perioperative situations, as only 40% of malnourished patients are finally treated. This literature review investigates the inconsistencies regarding the diagnostic approach to both preoperative and postoperative patients and the various underlying causes, as well as the efficiency of the various therapeutic regimens. A literature search was conducted until August 2023 in MEDLINE and Scopus. Clinical studies involving perioperative nutritional assessment in adult gastrointestinal surgery patients during the last 10 years were included in the present review. Finally, 19 articles were included in the study. Preoperative nutritional therapy is increasingly recognized as a key component of surgical care. Malnourished patients who are hospitalized and operated on, have significantly worse clinical results. Gastrointestinal postoperative malnutrition coexists with metabolic stress, as patients usually suffer from minor chronic inflammations; therefore, postoperative malnutrition is the result of a combination of the effects of inflammation and a lack of food intake. Postoperative malnutrition leads to prolonged hospitalizations and hospital complications and therefore the need to treat it is essential. There are many recognized tools for detecting malnutrition. However, all tools showed inconsistent results regarding their validity. *Per os* feeding after surgery, and dietary supplements when necessary, have been recommended. Therefore, it is very important to reduce malnutrition and define clear strategies towards that direction.

Keywords Perioperative nutritional management, assessment, gastrointestinal, surgery

Ann Gastroenterol 2024; 37 (2): 142-154

Conflict of interest: None

*These authors contributed equally

Correspondence to: Maria Gazouli, PhD, Professor, Basic Medical Sciences, Medical School, National and Kapodistrian University of Athens, Michalakopoulou 176, Athens 11527, Greece, mgazouli@med.uoa.gr

Received 31 July 2023; accepted 17 January 2023; published online 16 February 2024

DOI: <https://doi.org/10.20524/aog.2024.0867>

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms

Introduction

Malnutrition can be defined as a condition that occurs when the body does not receive enough essential nutrients to maintain healthy growth and function. This can result from insufficient nutritional intake and/or an inability to absorb nutrients properly, or an unbalanced diet [1]. Malnutrition has been associated with worse clinical outcomes, as it has been demonstrated that patients with malnutrition have a relative death risk of 1.6-1.9 and remain hospitalized for 1.5-1.7 times longer. Thus, up to 80% of patients who present with a compromised nutritional status upon admission will further deteriorate if no nutritional regimen is administered [2,3].

It has been observed that patients who are undernourished at admission also seem to be at higher risk for low nutritional intake during their hospitalization [4]. Surgery can aggravate

undernutrition via a systemic inflammatory response, which in turn increases metabolic activity, raises energy consumption, damages organ function and compromises immunity. Additionally, undernourished patients may develop surgical site infections; they therefore have a greater probability of morbidity [1]. Last but not least, there is a vast discrepancy in the literature regarding the impact of nutritional support by means of a supplementary or therapeutic regimen in the perioperative patient, making the pooling of results impossible [5].

Therefore, we thought that it might be of value to explore and update these literature gaps in diagnostics, biomarkers and therapeutics of patients with perioperative malnutrition. The primary outcome of this article was to shed light on the current knowledge regarding definitions, diagnosis and therapeutic procedures of perioperative malnutrition. Our secondary outcome was to suggest a roadmap of possible future research directions, considering the gaps in the existing literature.

Methods

Two medical electronic databases (MEDLINE and Scopus) were searched until August 2023. The search strategy included the following Medical Subject Heading (MeSH) terms: (“perioperative” OR “preoperative” OR “postoperative”) AND (“nutritional” OR “management” OR “assessment” OR “evaluation”) AND (“gastrointestinal” OR “surgery” OR “operation”). Only clinical studies involving adults and written in the English language during the last 10 years were included. An electronic language translation system would have been used had articles in any other language been returned, but this proved unnecessary. The time interval of 10 years ensured that only contemporary studies dealing with recent classifications and data concerning nutritional assessment and management in gastrointestinal surgery patients would be included.

Two of the authors (AG and KG) independently screened the abstracts of the retrieved articles to assess whether they met the inclusion criteria, and any differences were resolved. This was followed by a full-text review of those articles found suitable for further examination. Review and meta-analysis papers were excluded; however, their reference lists were used to retrieve any study that might meet the inclusion criteria. Clinical studies involving perioperative nutritional assessment in adult gastrointestinal surgery patients during the last 10 years were finally included in the present review.

^aCo-Metabolism, Kalamata, Greece (Aristea Gazouli); ^bFirst Propaedeutic Surgical Unit, Hippocrateion Athens General Hospital, Medical School, National and Kapodistrian University of Athens, Greece (Konstantinos Georgiou, Maximos Frountzas, George E. Theodoropoulos); ^cSecond Propaedeutic Department of Surgery, Laiko General Hospital, Medical School, National and Kapodistrian University of Athens, Greece (Gerasimos Tsourouflis, Nikolaos Nikiteas); ^dMedical Simulation Training Centre, Research Institute of Medical University of Plovdiv, Bulgaria (Nikola Boyanov); ^eDepartment of Gastroenterology, UMHAT PULMED, Plovdiv, Bulgaria (Nikola Boyanov); ^fDepartment of Basic Medical Sciences, Laboratory of Biology, Medical School, National and Kapodistrian University of Athens, Greece (Maria Gazouli)

Results

Inclusion

After duplicates were removed, the search strategy yielded 56 articles. Of these, 33 were excluded according to the predefined criteria through title and abstract screening. There were 23 articles selected for full text review. Additionally, 14 relevant articles were identified from the reference list of the reviews and added to the study. Full text review revealed 18 articles which were excluded. Finally, 19 articles were included in the study (Fig. 1).

Definition of malnutrition

There are multiple definitions of malnutrition in the medical literature, but they may not be current or consistent. Many definitions have been proposed by various authors, as well as world societies and organizations, such as the American Dietetic Association, the American Society of Parenteral and Enteral Nutrition (ASPEN) and the Academy of Nutrition and Dietetics (AND), that have provided an accurate definition of malnutrition over the decades (Table 1).

At first, the term “malnutrition” was used to describe either a lack of food in the general population, or inadequate food intake in hospitalized patients [6]. In 2008, Soeters *et al* described malnutrition as an acute or chronic condition in which dietary malnutrition is combined with at least 1 inflammatory activity, resulting in a change in bodily composition and reduced functioning [7].

There is a difference between malnutrition and sarcopenia, as the two do not have the same focus: in malnutrition there is

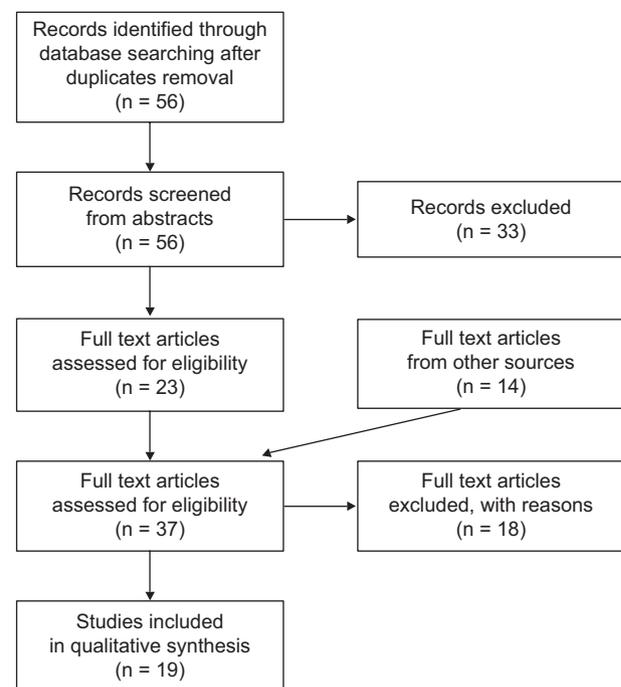


Figure 1 Flow diagram of the selection process

Table 1 Early and current definitions of nutrition assessment [1]

Year	Organization	Definition
1994	The American Dietetic Association	A comprehensive approach to define nutritional status that uses medical, nutrition and medication histories; physical examination; anthropometric measurements and laboratory data.
1995	ASPEN	A comprehensive evaluation to define nutritional status, including medical history, dietary data, physical examination, anthropometric measurements and laboratory data.
2018	ASPEN	A comprehensive approach to identify the nutrition-related problems that uses a combination of medical, nutrition, medication and client histories; nutrition-focused physical examination; anthropometric measurements; biomedical data/medical diagnostic tests and procedures.
2019	Global Leadership Initiative on Malnutrition	A two-stage procedure: A. Somatometrics (weight loss, low body mass index, decreased muscle mass), and B. Causative criteria (reduced food intake or assimilation, inflammation/disease burden).
2021	The Academy of Nutrition and Dietetics (AND)	A systematic approach for collecting, classifying and synthesizing important and relevant data to describe nutritional status-related nutrition problems and their causes.

ASPEN, American Society of Parenteral and Enteral Nutrition

loss of body mass resulting from an insufficient energy supply, while in sarcopenia a loss of muscle mass occurs. Malnutrition often leads to sarcopenia, but sarcopenia can develop without weight loss, and therefore without the criterion of malnutrition. This often happens in the elderly [8].

In 2019, a new definition of malnutrition was introduced by the Global Leadership Initiative on Malnutrition (GLIM). This definition introduces a distinction between somatometric (weight loss, low body mass index, decreased muscle mass) and etiological (reduced food intake or absorption, inflammation/disease load) criteria. Both criteria must be met for the patient to be ultimately considered malnourished [5].

Preoperative malnutrition

During the preoperative period, the primary nutritional objectives are first to evaluate any preexisting malnutrition, then to treat it, in order to achieve optimal surgical preparation, to prevent postoperative malnutrition and assist in prompt recovery [9]. It seems that even overweight patients who develop a serious acute disease or suffer from trauma may develop malnutrition, and therefore require an intensive nutritional treatment [10]. It has been claimed that up to 2 of 3 patients are malnourished preoperatively, and this risk factor becomes even more dangerous because it is underestimated [11].

Before surgery, the appearance of malnutrition may be due to a combination of several factors, with the most important contributor being a reduced food intake. Some examples are bowel-related diseases, various metabolic abnormalities, such as resistance to insulin, as well as numerous patient-related factors that may affect food intake (e.g., socioeconomic status, social isolation, etc.) [12]. Inflammation enhances the malnutrition risk and can contribute to an increased risk of mortality [5]. Thus, if inflammation is left undetected and untreated, it is likely to develop into a state of severe malnutrition [13].

Therefore, in acute or chronic disease, the diagnosis and treatment of malnutrition is very important [14]. According to the National Center for Health Statistics, the distinction

between acute and chronic illness is based solely on time interval (if it lasts 3 months or more). On the other hand, definitions by AND and ASPEN are based on the etiology of malnutrition, evaluating the time and degree of inflammatory response to categorize a disease as acute or chronic [15].

Preoperative nutritional therapy is increasingly recognized as a key element of surgical care, as it aims to store an adequate preoperative energy reserve to meet the functional requirements of the postoperative surgical stress [9], without compromising the preoperative reserves of energy and lean body mass [16]. Patients with low energy reserves who are to undergo surgery are susceptible, with a reduced ability to respond to the additional requirements of surgery [17,18].

Postoperative malnutrition

Patients undergoing surgery usually suffer from a small degree of chronic inflammation [7]. Furthermore, it worthwhile to note that hospitalized patients with low body mass index (BMI) may also deteriorate if their underlying condition provokes inflammation [15,19].

Several factors are involved in postoperative malnutrition:

Salt and water retention

The response to surgical stress manifests itself clinically as salt and water retention for preserving plasma volume. This need stems from the augmented cardiac output, from oxygen consumption, from the deployment of energy reserves (glycogen, fat, lean body mass) to maintain energy processes, and from the tissue repair and protein synthesis involved in the immune response [20].

Cytokine secretion

When inflammation occurs, cytokines increase muscle catabolism by impeding protein synthesis, triggering apoptosis and affecting muscle contractility; all these have been described

as factors contributing to protein-energy undernutrition (PEU) [5].

Many patients present a decline in their nutrition status over the course of both acute and long-term hospitalization, for such reasons as major burns, trauma, closed head injury, exploratory laparotomy, etc. The most common form of PEU is exemplified by moderate to severe inflammation with reduced intake of protein and energy, which is often self-limited [5].

Postoperatively, the secretion of cytokines from the stressful tissue injury begins, leading to hormonal, hematological, metabolic and immune changes. This condition has been identified as systemic inflammatory response syndrome. Thus, cytokines cause stress, and the stress state in turn increases catabolism [21]. This is a normal defense mechanism and it is to some extent beneficial, as the appearance of inflammation after an injury helps to heal wounds and limit infection. The negative consequences of an inflammatory reaction begin when the inflammation persists for longer, resulting in continuous catabolism, hyperglycemia, hypertension, tachycardia, and immunosuppression [22].

Protein balance

Stress causes an increase in protein breakdown and utilization without increased protein synthesis, leading to a negative protein balance. This may result in a need for increased nutritional protein intake for up to 4 months after surgery [23].

Hyperglycemia and insulin resistance

In a healthy state, blood glucose increases postprandially, thus activating insulin increase and the transporter protein GLUT-4, which transports glucose into the cells of tissues. Postoperatively, however, because of hormonal changes, an increase in glucose levels and insulin resistance is observed, with a consequent reduction in the transport of glucose inside the tissues, resulting in hyperglycemia [24].

Increased fat burning

In malnutrition, the rate of transportation of glucose to be used for energy and synthesizing glycogen within cells is reduced, and thus the breakdown of fat is activated as an alternative way of producing energy. Triacyl glycerides are broken down into glycerol and 3 fatty acids through gluconeogenesis, resulting in simultaneous hyperglycemia and loss of adipose tissue [24]. Postoperatively, the patient's reduced functionality, combined with postoperative malnutrition, has an impact on the patient's muscle mass, which in turn results in a further reduction of functionality, leading to a vicious circle [25].

Nutritional evaluation

Nutritional evaluation is the procedure of acquiring, validating and interpreting the data needed to determine any

nutrition-associated challenges. Nutritional evaluation should be performed using the most appropriate tool, as judged by the attending physician. It is evident that the nutritional tool used should have previously been validated for the population to which it will be applied [26]. However, the nutritional diagnosis depends not only on a single finding of nutritional evaluation, but also on the diagnosis of malnutrition, which is recommended as a 2-stage procedure [27].

ASPEN reported that nutritional diagnosis is an integrated multifactorial methodology to identify nutritional abnormalities using a combination of the following parameters: medical and nutritional history, medication, physical examination, anthropometric measurements and laboratory data. Therefore, for an integrated approach to nutrition problems, a nutritional control tool is needed, comprising the following factors:

BMI

According to the World Health Organization a subject with a BMI $<18.5 \text{ kg/m}^2$ is underweight. The European Society for Clinical Nutrition and Metabolism (ESCNM) defines a BMI $<18.5 \text{ kg/m}^2$ as signifying malnutrition; alternatively, when BMI is less than 20 and age <70 years, or BMI less than 22 if age >70 years, combined with a weight loss of more than 10% [28].

Apart from BMI, it is worth noting that various anthropometric measurements, such as the circumference of various body parts (such as calf, thighs, hands), and the skin fold of the triceps, are measurements that can be made easily and objectively.

Body composition analysis

Fat and lean body mass can be measured easily and quickly, and quite objectively, via bioelectrical impedance devices, dual-energy X-ray absorption, computed tomography or magnetic resonance imaging.

Weight loss

Weight loss demonstrates a negative energy balance due to reduced food intake, enhanced energy expenditure, or a combination of both. Weight should be monitored frequently. Care must be exercised to uncover any fluid accumulation, as it can sometimes mask the weight loss.

Decreased appetite - anorexia

Loss of appetite is an important piece of information that can indicate possible malnutrition and weight loss.

Reduced food intake

Food intake reduction control provides useful information. A dietary history, recall of food consumed during the last 24 h

or “calorie measurements” (either observed intake/estimated waste of dishes after a meal) can be used as “evidence” of insufficient food intake.

Biochemical markers

In the past, serum albumin (Alb) was used as a nutritional indicator, but today we know that it leads to erroneous conclusions for 2 reasons: firstly, it has quite a long half-life (about 20 days), and second, its values are also impacted by the existence of inflammation [29]. Alb is a potent alternative measure for underlying disease burden, as inflammation is a prominent factor in the development of PEU through its impact on dietary intake, protein use and net protein catabolism. It is well known that acute injury can radically decrease Alb levels within 24 h; therefore, Alb reflects the severity of disease, and is not a direct measure of malnutrition [5]. However, the concentration of Alb and serum prealbumin are used as indicators of nutritional status, but without great sensitivity; nevertheless, it is recommended by ESPEN as a prognostic tool for complications and for use in surgical patients [9].

Other biochemical markers include elevated C-reactive protein, high white blood cell count, or excessive blood glucose levels.

Clinical signs

Clinical signs of inflammation may appear, including fever, hypothermia or tachycardia, that may facilitate a causatively based diagnosis.

Subjective professional assessment

This is a screening process that can detect malnutrition when performed by experienced specialists. The hand grip strength should be used to document the reduction in physical function [15].

Specific malnutrition evaluation indices

There are no clear boundaries that lead to safe conclusions about a patient’s degree of malnutrition [30-32]. More than 70 nutritional screening tools have been proposed for assessing the nutritional status of a patient or for anticipating a poor clinical outcome related to malnutrition [33]. These can range from a simple assessment of appetite, combined with involuntary weight loss, to more complex ones that take into account a variety of anthropometric and laboratory parameters [34]. Some of them are listed below (Table 2):

Nutrition Risk Index (NRI)

This is derived from serum Alb level and from the ratio of actual to usual weight by using the following formula [35]:

$$\text{NRI} = 1.519 \times \text{Alb}(\text{g/L}) + [41.7 \times (\text{present weight}/\text{usual weight})].$$

The NRI score is evaluated as follows: >100 = well nourished; 97.5-100 = mildly malnourished; 83.5-<97.5 = moderated malnourished; and <83.5 = severely malnourished.

Nutrition Risk Screening 2002 (NRS-2002)

This was initially suggested by an ESPEN working group and assesses both malnutrition and disease severity [36]. It is based on a retrospective analysis of 128 randomized controlled trials and aims to identify malnutrition in hospitalized patients, and to assess the value of nutritional support to those who would benefit from it. It was validated against Subjective Global Assessment (SGA) by 2 studies [37,38].

Geriatric Nutrition Risk Index (GNRI)

This is a modified version of NRI created especially for the elderly [39]. It considers BMI, recent weight loss and/or food intake reduction, and severity of illness. Nutrition and disease severity contribute to the score [36,40]. The total GNRI score ranges from 0-6, as follows: 0-2 = well nourished; 3-4 = medium risk; and 5-6 = nutritionally at risk.

Malnutrition Universal Screening Tool (MUST)

MUST is used to screen adult patients based on BMI, percentage of unintentional weight loss during the last 6 months and estimates of the effect of illness. The score is evaluated as [41]: 1 = medium risk; and ≥ 2 = high risk.

Malnutrition Screening Tool (MST)

MST has 2 questions, one for weight reduction and the other for reduced appetite. MST is quick, simple, valid, and reliable [39]. A score ≥ 2 requires further assessment.

Malnutrition Risk Screening Tool-hospital (MRST-H)

This focuses on the detection of elderly malnourished hospitalized patients. It contains a structured questionnaire focusing on physical activity, self-sustaining food consumption, unintentional weight loss and anthropometric measurements [42]. A score ≥ 5 means a high risk of malnutrition.

Simplified Nutritional Appetite Questionnaire (SNAQ)

This is an easy, valid, short and reproducible questionnaire for early detection of malnutrition during hospitalization. It consists of 3 questions about unintentional weight loss within the past 1-6 months, reduced appetite and supplementation usage or tube feeding during the past month. The result is

Table 2 Screening tools for assessment of malnutrition

Tool	Definition	Scoring
Nutrition Risk Index (NRI)	$(1.519) \times \text{Alb (g/L)} + [41.7 \times (\text{present weight/usual weight})]$	>100 = well nourished 97.5-100 = mildly malnourished 83.5-<97.5 = moderately malnourished <83.5 = severely malnourished
Nutrition Risk Screening 2002 (NRS-2002)	<p>Nutritional status</p> <p>Weight loss > 5% in 3 months or food < 50-75% of normal = 1</p> <p>Weight loss > 5% in 2 months or BMI 18.5-20.5 kg/m² and food < 25-60% of normal = 2</p> <p>Weight loss > 5% in 1 month or BMI < 18.5 kg/m² and food < 0-25% of normal = 3</p> <p>[1.489 × serum albumin (g/L)] + [41.7 × (present weight/ideal weight (kg))]</p>	<p>Age > 70 years = 1</p> <p>Disease severity</p> <p>Hip fracture, cirrhosis, COPD, diabetes, oncology, hemodialysis = 1</p> <p>Major abdominal surgery, stroke, pneumonia, hepatologic malignancy = 2</p> <p>Head injury, bone marrow transplantation, ICU = 3</p>
Geriatric Nutrition Risk Index (GNRI)		0-2 = well nourished 3-4 = medium risk 5-6 = nutritionally at risk
Malnutrition Universal Screening Tool (MUST)	<p>BMI</p> <p>>20 kg/m² = 0</p> <p>18.5-20 kg/m² = 1</p> <p><18.5 kg/m² = 3</p> <p>Weight loss in past 3-6 months</p> <p><5% = 0</p> <p>5-10% = 1</p> <p>>10% = 2</p>	<p>Severely ill not likely to eat for at least 5 days = 2</p> <p>1 = medium risk</p> <p>≥ 2 = high risk</p>
Malnutrition Screening Tool (MST)	<p>Weight loss</p> <p>No = 0</p> <p>Unsure = 2</p> <p>Kg lost</p> <p>1-5 = 1</p> <p>6-10 = 2</p> <p>11-15 = 3</p> <p>>15 = 4</p> <p>Unsure = 2</p>	<p>Decreased appetite</p> <p>No = 0</p> <p>Yes = 1</p> <p>≥2 = requires further assessment</p>
Malnutrition Risk Screening Tool-hospital (MRST-H)	<p>Income dependence</p> <p>Yes = 1</p> <p>No = 0</p> <p>Eating independence</p> <p>Yes = 1</p> <p>No = 0</p> <p>Weight loss</p> <p>Yes = 3</p> <p>No = 0</p> <p>MUAC</p> <p>< 23 = 2</p> <p>≥ 23 = 0</p>	<p>CC</p> <p>< 30.1 = 1</p> <p>≥ 30.1 = 0</p> <p>≥5 = high risk of malnutrition</p>
Simplified Nutritional Appetite Questionnaire (SNAQ)	<p>Weight loss</p> <p>>6 kg in 6 months = 3</p> <p>>3 kg in 1 month = 2</p> <p>Decreased appetite</p> <p>No = 0</p> <p>Yes = 1</p> <p>Supplemental drinks</p> <p>No = 0</p> <p>Yes = 1</p>	<p>0-1 point = well nourished</p> <p>2 points and nutritional intervention = moderately malnourished</p> <p>3 points, nutritional intervention and treatment = severely malnourished</p>

(Contd...)

Table 2 (Continued)

Tool	Definition	Scoring
Mini Nutritional Assessment (MNA)	<p>Appetite loss Severe = 0 Moderate = 1 No = 2</p> <p>Weight loss >3 kg = 0 Don't know = 1 1-3 kg = 2 No = 3</p> <p>Mobility Bed or chair = 0 Not out = 1 Out = 2</p> <p>Psychological stress Yes = 0 No = 2</p> <p>Neuropsychological stress Dementia or depression = 0 Mild dementia = 1 No = 2</p>	<p>BMI <19 = 0 19-21 = 1 21-23 = 2 >23 = 3</p> <p>≥24 scores = well nourished 17-23.5 scores = at risk of malnutrition <17 scores = malnourished</p>
Subjective Global Assessment (SGA)	<p>Weight change, dietary intake, gastrointestinal symptoms, functional capacity, physical findings, disease status</p>	<p>A = well nourished B = moderate or suspected undernourished C = Severely undernourished</p>
3-Min Nutrition Screening (3-MinNS)	<p>Unintentional weight loss, Nutritional intake, BMI, Muscle wastage, Diseases with malnutrition risk</p>	<p>3-4 = moderate malnutrition 5-9 = severe malnutrition</p>
Controlling Nutrition Status (CONUT) score	<p>Albumin (g/dL) ≥3.5 = 0 3-3.49 = 1 2.5-2.9 = 4 <2.5 = 6</p> <p>Lymphocyte count (/mm³) >1600 = 0 1200-1599 = 1 800-1199 = 2 <800 = 3</p> <p>Cholesterol (mg/dL) >180 = 0 140-180 = 1 100-139 = 2 <100 = 3</p>	<p>0-1 = normal 2-4 = light risk 5-8 = moderate risk 9-12 = severe risk</p>
Global Leadership Initiative on Malnutrition (GLIM) criteria	<p>Weight Loss > 5% within past 6 months or > 10% beyond 6 months</p> <p>BMI <20 if < 70 years, or < 22 if > 70 years <18.5 if < 70 years, or < 20 if > 70 years</p> <p>Reduced muscle mass Reduced by validated body composition measuring techniques</p> <p>Reduced food intake ≤50% for > 1 week, or any reduction for > 2 weeks, or any chronic GI condition that adversely impacts food assimilation or absorption</p> <p>Inflammation Acute disease/injury or chronic disease-related</p>	<p>A = well nourished B = moderate or suspected undernourished C = severely undernourished</p>

Alb, albumin; BMI, body mass index; MUAC, mid upper arm circumference; CC, calf circumference; GI, gastrointestinal; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit

evaluated as [43]: 0-1 point = well nourished; 2 points and nutritional intervention = moderately malnourished; and 3 points, nutritional intervention, and treatment = severely malnourished.

Mini Nutritional Assessment (MNA)

This detects multifunctional causes of nutritional risk, specifically for older patients. It consists of 18 components grouped into 4 categories. The MNA score is evaluated as follows [40]: ≥ 24 = well nourished; 17-23.5 = at risk of malnutrition; and < 17 = malnourished.

Subjective Global Assessment (SGA)

SGA takes into account several clinical parameters, such as weight loss history, dietary intake changes, and gastrointestinal symptoms persisting for more than 2 weeks. It also considers physical examination findings, such as subcutaneous fat, muscle wasting, ankle and sacral edema, and the presence of ascites. Finally, it consists of doctors' clinical assessment. The result is expressed in terms of nutrition rating: A = well nourished; B = moderately undernourished or suspected; and C = severely undernourished.

The SGA is the first, and most used and validated tool for assessing malnutrition. On the plus side, it is a simple, noninvasive, economical and reliable tool. On the other hand it is time consuming and subjective [30] (Supplementary Appendix 1).

3-Min Nutrition Screening (3-MinNS)

This is a straightforward and quick variation of SGA used in acutely hospitalized patients. The receiver operator characteristics (ROC) curve of 5 parameters that contribute to the malnutrition risk is measured, and the one exhibiting the largest area under the ROC curve is chosen as the final screening tool, called the 3-MinNS [44].

Controlling Nutrition Status (CONUT) score

The CONUT score is based on the evaluation of Alb, total cholesterol and total white blood cell count. There is a satisfactory correlation between CONUT and SGA [45].

Global Leadership Initiative on Malnutrition (GLIM) criteria

In 2018, the GLIM criteria were approved and used for the first time. The criteria examine 3 phenotypic and 2 causative criteria. Phenotypes include low BMI, involuntary weight loss and decreased muscle mass. The resulting interpretation is based on nutrition rating: A = well nourished; B = moderately undernourished or suspected; and C = severely undernourished. The GLIM criteria are very sensitive and are very consistent with the SGA criteria [27].

In summary, the 2 most used tools for nutritional evaluation include the SGA [30] and the Patient Generated SGA (PG-SGA) [32]. These are both widely used under a broad variety of clinical conditions [46-48] and in a recent systematic review of malnutrition screening tools conducted by the AND, they were proposed as suitable referral standards [27,49].

Perioperative nutritional support

Perioperative nutritional support is defined as the delivery of nutrition either orally, enterally (EN) or parenterally (PN). Oral administration can be via diet and/or oral nutritional supplements (ONS). The perioperative delivery of ONS, EN and PN has a beneficial impact on postoperative recovery, as supported patients have significantly fewer complications and a shorter hospital stay [1]; therefore, it can decrease morbidity and mortality and lower healthcare costs [50]. Thus, the nutritional status of all patients should be optimized before selective surgery [9,51] as, if treated appropriately, their postoperative results may be better [52,53].

The main features of perioperative care incorporate the nutritional factor into patient management, the avoidance of long periods of preoperative fasting, the post-surgical restart of oral feeding as early as possible, and the early mobilization to facilitate protein synthesis and muscle function [9].

In 2009, ASPEN and ESPEN developed guidelines for an etiology-based approach to the diagnosis of adult malnutrition in clinical settings (Fig. 2). Any patient found to be at risk of malnutrition should undergo a diagnostic evaluation, including the determination of phenotypic (non-voluntary weight loss, low BMI, low muscle mass) and causative (decreased intake, disease burden/inflammation) factors [54].

The Enhanced Recovery After Surgery (ERAS) Society was founded as an international network of experts implementing the evidence-based multimodal ERAS protocol, to provide postoperative guidelines for malnutrition prevention [55].

According to ESPEN Good Clinical Practice (GCP) guidelines, perioperative nutritional support therapy is indicated: (a) in malnourished patients or those who are at dietary risk; (b) if it is anticipated that the patient will be unable to eat for more than 5 days; and (c) if the patient has low oral intake and is not expected to be able to maintain more than 50% of the recommended intake for more than 7 days [56].

The GCP ESPEN surgical guidelines are in line with the aim of early oral feeding in ERAS i.e.; integration of nutrition and nutritional status in the overall management; avoiding prolonged periods of preoperative fasting starting nutritional therapy as soon as metabolic risk is apparent; metabolic monitoring of blood sugar levels; reduction in triggering stress and catabolism or gastrointestinal function factors; and encouraging early mobilization to stimulate protein synthesis and maintain muscle function. However, it is important to emphasize that screening and evaluation are different time-specific procedures and confusion between the two can lead to misdiagnosis and improper therapy [9].

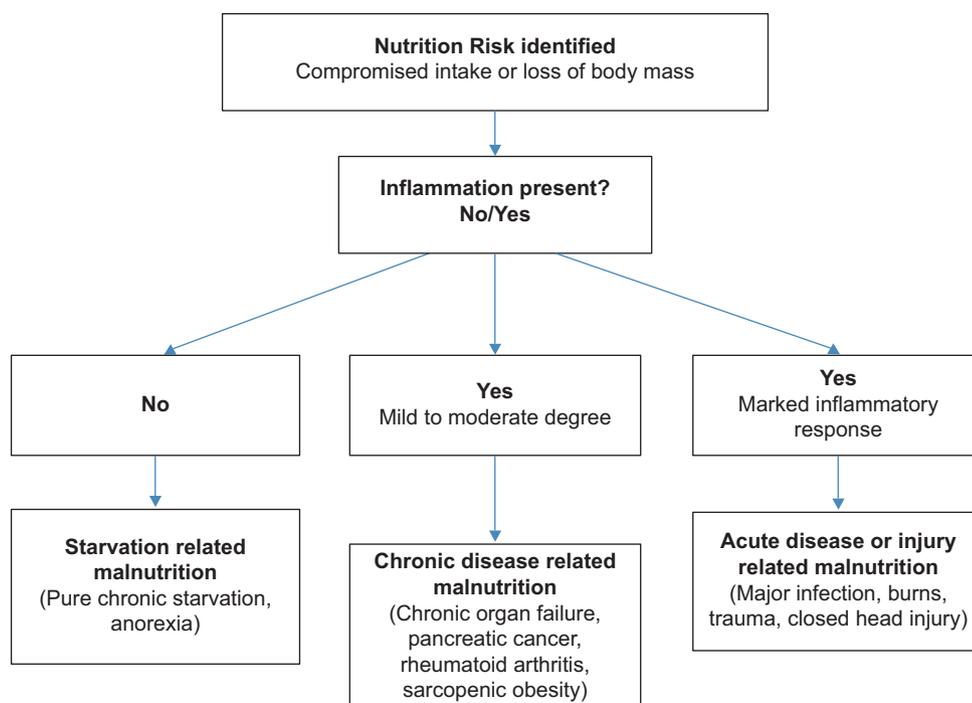


Figure 2 Guidelines developed by ASPEN and ESPEN to diagnose adult malnutrition in clinical settings [5]

ERAS recommends the consumption of a pure drink rich in carbohydrates from the night before (100 g) and 2-3 h prior to surgery (50 g), as it decreases preoperative thirst, hunger and stress, and postoperative insulin resistance [57]. For best results, the morning dose should be consumed quite quickly, not in sips. The anabolic state created by carbohydrate consumption leads to fewer postoperative losses of nitrogen and protein and better maintenance of muscle mass and strength [58].

The functional purpose of the carbohydrate load results in maximum glycogen storage achieved at the beginning of the operation, as opposed to fasting, which depletes energy reserves before the onset of surgical stress. Carbohydrate loading enables the patient to better withstand the impending surgical invasion and utilize the nutrients provided postoperatively [59]. Finally, combined oral intake of carbohydrates and proteins increases insulin concentrations preoperatively, with the added benefit of amino acids, which have a greater anabolic effect than carbohydrate regimens alone [60].

The current concepts of preparation include a period of 4-6 weeks of pre-hospital care, often using a triple methodology including physiotherapy, nutritional therapy and psychological support to decrease perioperative stress [61]. In addition, in well-fed subjects, early administration of a nutritional regimen before PEU manifestation results in a better outcome, suggesting that early feeding improves systemic inflammatory response [62-64].

Recent postoperative data show that it is better to immediately feed the patient orally after surgery to avoid malnutrition. Administering oral food as early as possible is a key intervention of the ERAS program [65]. Evidence suggests that the early start of oral fluid intake, if feasible from

the first postoperative day, can shorten hospitalization, as well as reducing postoperative complications such as ileus [66]. Intravenous nutritional assistance is recommended only for patients who have moderate or severe malnutrition, or who are at risk of malnutrition (not expected to be able to consume food in the next 7 days), or whose ability to swallow has decreased by 60% for more than 10 days [67].

To help the moderately malnourished patient, brief nutritional support (7-10 days) is necessary. In more severe malnutrition, nutritional support is necessary for longer periods and should be combined with resistance exercises. Pre- and postoperative nutritional support with parenteral nutrition has been shown to reduce morbidity only in people with severe malnutrition, so it is recommended.

ONS

ONS contain both macronutrients, such as proteins, amino acids (e.g., arginine, glutamine), fats (e.g., omega-3 fatty acids) and carbohydrates, as well as micronutrients (vitamins and trace minerals) to supplement the oral diet. Some ONS ingredients may enhance immune function and reduce the risk of developing surgical site infections [68]. In malnutrition related to disease, the aim of short-term improvement in body weight can be more easily achieved by nutritional supplements than by simple dietary advice [69]. The beneficial perioperative administration of ONS in patients undergoing surgery has been clearly demonstrated, as shown by fewer complications and good results in terms of financial savings [50,70].

An immuno-diet is diet supplementation with appropriate immune-boosting substrates, aiming at the stimulation of the immune system. This approach, though interesting, is still controversial. Furthermore, the administration of omega-3 fatty acids has been shown to produce anti-inflammatory effects [71]. Stimulation of the anticancer activity of T-cells has been proven *in vitro* for arginine and in case studies; it is thus suggested as a supplement [71]. The supplements preferred are those with high energy density, as a higher compliance and higher rates of improvement in the patients' clinical picture were found [72]. Various protocols have been suggested regarding ONS prescription to improve nutritional status. Usually, they are administered for at least 7 days before surgery and up to 4 weeks postoperatively, typically in a liquid form up to 3 times a day, at a daily dose of about 250-600 kcal in addition to the daily dietary intake [1].

The management of postoperative patients aims to improve their nutritional status as soon as possible. When it is not possible to feed the patient orally immediately postoperatively, then nutritional support with ONS together with feeding through intestinal and even parenteral nutrition may be required to avoid catabolism [73].

ONS use may be limited if compliance is reduced, because of either the low palatability of the supplements or the occurrence of side effects such as nausea and diarrhea. Therefore, in practice special and repeated motivation of the patient is required [74,75].

The beneficial effect of ONS remains disputable, as it is supported by weak evidence from just a few studies with inadequate methods. For instance, one study concluded that as nutritional support without supplements is associated with the same or better outcomes than ONS nutritional support, one should reconsider the use of ONS [76].

Discussion

Malnourished postoperative patients have significantly worse clinical outcomes: they exhibit more postoperative complications [75], a 4-fold mortality risk [77], prolonged hospitalizations [78], and more frequent readmissions [77], thus increasing health care costs [79]. Nutrition screening is a process of identifying characteristics known to be associated with the risk of malnutrition. Although there is ever-increasing research regarding nutrition screening tools, a practical and implementable clinical screening tool is still lacking [80]. In this context, a recent study reviewed the concurrent validity of 3 malnutrition screening tools, namely the NRI, MUST, MST and NRS-2002, and concluded that no recommendations could be made regarding the use of one tool over another [81].

Today, the 3 major approaches for malnutrition diagnosis are SGA, AND (ASPEN version), and the 3 tools endorsed by the ESCNM, namely MUST, NRS-2002 and the short-form MNA for the elderly [30,33,56,82]. Additionally, Miller *et al* (2018) reviewed 19 studies that involved the evaluation of screening tools for malnutrition. A vast discrepancy regarding the protocols used was seen, and it was noted that 2 tools showing high sensitivity

and specificity did not comprise all components of the consensus definition criteria. They concluded that the 3-MinNS was the only tool that incorporated agreed-upon definitions and had more than >80% sensitivity and specificity [33].

Furthermore, the SGA, which is often used as the standard against which many tools are compared, has not itself been well validated, as its sensitivity and specificity were either reported as poor or even not recorded at all. Debatably, the 2 most well-known tools, i.e., MUST and NRS-2002, exhibited poor to good score variations, and showed poor consistency between the groups for they were studied. Additionally, the Nutritional Form for the Elderly had good validity, but it is not extensively applied. Finally, the "quick and easy" screening tools, such as the Short Nutritional Assessment Questionnaire and the Malnutrition Screening Tool, showed good sensitivities (in the range of ~80%) in most studies. Note that, because these tools are "quick", it is imperative for further detailed assessment to be performed by a qualified health professional if they prove positive.

Future research is needed to shed light on the existing deficiencies in diagnostics, biomarkers and therapeutics of inflammation, as well those of malnutrition [5]. Given that malnutrition is commonly unidentified, untreated and increases morbidity and mortality, there is a need to search for a simple, quick, reliable, valid and cost-effective tool to systematically screen perioperative patients [80].

Furthermore, as most studies did not comment on intervention, including varying attention to nutrition, exercise and measures to combat inflammation, more well-designed research is needed into nutritional support using a regular or therapeutic diet. As the effects of nutritional support during preoperative courses remain unclear, and only a few articles are available, more research is required into using a regular or therapeutic diet. The use of ONS should be reconsidered, to define the effects of supplements vs. consulting [1].

The present review summarizes the most recent data relating to the definition of malnutrition, nutritional assessment and therapeutic strategies for patients undergoing gastrointestinal surgery. The thorough analysis of malnutrition pathophysiology and targeted interventions towards specific pathways, in patients who undergo gastrointestinal surgery, differentiates the present review from others available in the literature, which mainly include relevant guidelines on malnutrition in surgical patients [83]. On the other hand, the narrative character of the present review is associated with certain types of bias, such as selection or publication bias, whereas that risk is reduced by several strategies, such as searching in multiple electronic databases.

Concluding remarks

Even though many tools for detecting malnutrition exist, their clinical validity remains to be established and further research is warranted, as the jury is still out. This fact also explains the great number of different definitions and assessment tools, which include both clinical signs and biochemical

markers of malnutrition. Under these circumstances, an adjusted assessment model should be adopted in different clinical settings, considering the local resources available and the prospects of nutritional interventions. The key aspects of perioperative care include integration of nutrition into the overall patient management, avoiding long periods of preoperative fasting, and reinstallation of oral feeding as early as possible after surgery. In addition, starting nutritional therapy early is essential to establish metabolic control and reduce factors that aggravate stress-related catabolism, while early mobilization will facilitate protein synthesis and muscle function.

References

- Ralph N, Brown L, McKillop KL, et al. Oral nutritional supplements for preventing surgical site infections: protocol for a systematic review and meta-analysis. *Syst Rev* 2020;**9**:37.
- Kruizenga HM, Van Tulder MW, Seidell JC, Thijs A, Ader HJ, Van Bokhorst-de van der Schueren MA. Effectiveness and cost-effectiveness of early screening and treatment of malnourished patients. *Am J Clin Nutr* 2005;**82**:1082-1089.
- Arends J, Bachmann P, Baracos V, et al. ESPEN guidelines on nutrition in cancer patients. *Clin Nutr* 2017;**36**:11-48.
- Manning F, Harris K, Duncan R, et al. Additional feeding assistance improves the energy and protein intakes of hospitalised elderly patients. A health services evaluation. *Appetite* 2012;**59**:471-477.
- Jensen GL, Bistrian B, Roubenoff R, Heimburger DC. Malnutrition syndromes: a continuum vs continuum. *JPEN J Parenter Enteral Nutr* 2009;**33**:710-716.
- Naber TH, Schermer T, de Bree A, et al. Prevalence of malnutrition in nonsurgical hospitalized patients and its association with disease complications. *Am J Clin Nutr* 1997;**66**:1232-1239.
- Soeters PB, Reijnen PL, van Bokhorst-de van der Schueren MA, et al. A rational approach to nutritional assessment. *Clin Nutr* 2008;**27**:706-716.
- Cruz-Jentoft AJ, Bahat G, Bauer J, et al; Writing Group for the European Working Group on Sarcopenia in Older People 2 (EWGSOP2), and the Extended Group for EWGSOP2. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing* 2019;**48**:16-31.
- Weimann A, Braga M, Carli F, et al. ESPEN practical guideline: clinical nutrition in surgery. *Clin Nutr* 2021;**40**:4745-4761.
- Benton MJ, Whyte MD, Dyal BW. Sarcopenic obesity: strategies for management. *Am J Nurs* 2011;**111**:38-44.
- Williams DGA, Molinger J, Wischmeyer PE. The malnourished surgery patient: a silent epidemic in perioperative outcomes? *Curr Opin Anaesthesiol* 2019;**32**:405-411.
- Saunders J, Smith T, Stroud M. Malnutrition and undernutrition. *Medicine* 2011;**39**:45-50.
- Jensen GL, Mirtallo J, Compher C, et al; International Consensus Guideline Committee. Adult starvation and disease-related malnutrition: a proposal for etiology-based diagnosis in the clinical practice setting from the International Consensus Guideline Committee. *JPEN J Parenter Enteral Nutr* 2010;**34**:156-159.
- Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al; European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. *Age Ageing* 2010;**39**:412-423.
- White JV, Guenter P, Jensen G, Malone A, Schofield M; A.S.P.E.N. Board of Directors. Consensus statement: Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). *JPEN J Parenter Enteral Nutr* 2012;**36**:275-283.
- Fearon KC, Jenkins JT, Carli F, Lassen K. Patient optimization for gastrointestinal cancer surgery. *Br J Surg* 2013;**100**:15-27.
- Amrock LG, Deiner S. Perioperative frailty. *Int Anesthesiol Clin* 2014;**52**:26-41.
- Malietzis G, Currie AC, Athanasiou T, et al. Influence of body composition profile on outcomes following colorectal cancer surgery. *Br J Surg* 2016;**103**:572-580.
- Jensen GL, Wheeler D. A new approach to defining and diagnosing malnutrition in adult critical illness. *Curr Opin Crit Care* 2012;**18**:206-211.
- Gillis C, Carli F. Promoting perioperative metabolic and nutritional care. *Anesthesiology* 2015;**123**:1455-1472.
- Kyrou I, Tsigos C. Stress hormones: physiological stress and regulation of metabolism. *Curr Opin Pharmacol* 2009;**9**:787-793.
- Scholl R, Bekker A, Babu R. Neuroendocrine and immune responses to surgery. *Internet J Anesthesiol* 2012;**30**:1-8.
- Schricker T, Meterissian S, Lattermann R, et al. Anticatabolic effects of avoiding preoperative fasting by intravenous hypocaloric nutrition: a randomized clinical trial. *Ann Surg* 2008;**248**:1051-1059.
- Mizock BA. Alterations in fuel metabolism in critical illness: hyperglycaemia. *Best Pract Res Clin Endocrinol Metab* 2001;**15**:533-551.
- Simonsen C, Kristensen TS, Sundberg A, et al. Assessment of sarcopenia in patients with upper gastrointestinal tumors: Prevalence and agreement between computed tomography and dual-energy x-ray absorptiometry. *Clin Nutr* 2021;**40**:2809-2816.
- Field LB, Hand RK. Differentiating malnutrition screening and assessment: a nutrition care process perspective. *J Acad Nutr Diet* 2015;**115**:824-828.
- Jensen GL, Cederholm T, Correia MITD, et al. GLIM criteria for the diagnosis of malnutrition: a consensus report from the global clinical nutrition community. *JPEN J Parenter Enteral Nutr* 2019;**43**:32-40.
- Compher C, Higashiguchi T, Yu J, Jensen GL. Does low body mass index predict the hospital mortality of adult Western or Asian patients? *JPEN J Parenter Enteral Nutr* 2018;**42**:467-472.
- Fuhrman MP. The albumin-nutrition connection: separating myth from fact. *Nutrition* 2002;**18**:199-200.
- Detsky A, McLaughlin, Baker J, et al. What is subjective global assessment of nutritional status? *JPEN J Parenter Enteral Nutr* 1987;**11**:8-13.
- Guigoz Y, Vellas B. The Mini Nutritional Assessment (MNA) for grading the nutritional state of elderly patients: presentation of the MNA, history and validation. In: Vellas B, Garry PhJ, Guigoz Y (eds) Nestl Nutrition Workshop Series: Clinical & Performance Program. KARGER, Basel, 1999; pp. 3-12.
- Bauer J, Capra S, Ferguson M. Use of the scored Patient-Generated Subjective Global Assessment (PG-SGA) as a nutrition assessment tool in patients with cancer. *Eur J Clin Nutr* 2002;**56**:779-785.
- Miller J, Wells L, Nwulu U, Currow D, Johnson MJ, Skipworth RJE. Validated screening tools for the assessment of cachexia, sarcopenia, and malnutrition: a systematic review. *Am J Clin Nutr* 2018;**108**:1196-1208.
- Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. *Nutrition* 1999;**15**:458-464.
- Buzby GP, Mullen JL, Matthews DC, Hobbs CL, Rosato EF. Prognostic nutritional index in gastrointestinal surgery. *Am J Surg* 1980;**139**:160-167.
- Kondrup J, Rasmussen HH, Hamberg O, Stanga Z; Ad Hoc ESPEN Working Group. Nutritional risk screening (NRS 2002): a new

- method based on an analysis of controlled clinical trials. *Clin Nutr* 2003;**22**:321-336.
37. Chi J, Yin S, Zhu Y, et al. A comparison of the Nutritional Risk Screening 2002 tool with the subjective global assessment tool to detect nutritional status in Chinese patients undergoing surgery with gastrointestinal cancer. *Gastroenterol Nurs* 2017;**40**:19-25.
 38. Ryu SW. Comparison of different nutritional assessments in detecting malnutrition among gastric cancer patients. *World J Gastroenterol* 2010;**16**:3310-3317.
 39. Abd Aziz NAS, Teng NIMF, Abdul Hamid MR, Ismail NH. Assessing the nutritional status of hospitalized elderly. *Clin Interv Aging* 2017;**12**:1615-1625.
 40. Barbosa-Silva MC, Barros AJ. Indications and limitations of the use of subjective global assessment in clinical practice: an update. *Curr Opin Clin Nutr Metab Care* 2006;**9**:263-269.
 41. 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**:799-808.
 42. Sakinah H, Suzana S, Noor Aini MY, Philip Poi JH, Shahrul Bahyah K. Development of a local malnutrition risk screening tool-hospital (MRST-H) for hospitalised elderly patients. *Malays J Nutr* 2012;**18**:137-147.
 43. Borkent JW, Schuurman LT, Beelen J, et al. What do screening tools measure? Lessons learned from SCREEN II and SNAQ65. *Clin Nutr ESPEN* 2020;**38**:172-177.
 44. Lim SL, Tong CY, Ang E, et al. Development and validation of 3-Minute Nutrition Screening (3-MinNS) tool for acute hospital patients in Singapore. *Asia Pac J Clin Nutr* 2009;**18**:395-403.
 45. González-Madroño A, Mancha A, Rodríguez FJ, Culebras J, de Ulibarri JI. Confirming the validity of the CONUT system for early detection and monitoring of clinical undernutrition: comparison with two logistic regression models developed using SGA as the gold standard. *Nutr Hosp* 2012;**27**:564-571.
 46. Isenring E, Cross G, Daniels L, Kellett E, Koczwara B. Validity of the malnutrition screening tool as an effective predictor of nutritional risk in oncology outpatients receiving chemotherapy. *Support Care Cancer* 2006;**14**:1152-1156.
 47. Jager-Wittenaar H, Ottery FD. Assessing nutritional status in cancer: role of the Patient-Generated Subjective Global Assessment. *Curr Opin Clin Nutr Metab Care* 2017;**20**:322-329.
 48. da Silva Fink J, Daniel de Mello P, Daniel de Mello E. Subjective global assessment of nutritional status—a systematic review of the literature. *Clin Nutr* 2015;**34**:785-792.
 49. Skipper A, Coltman A, Tomesko J, et al. Adult malnutrition (undernutrition) screening: an evidence analysis center systematic review. *J Acad Nutr Diet* 2020;**120**:669-708.
 50. Elia M, Normand C, Norman K, Laviano A. A systematic review of the cost and cost effectiveness of using standard oral nutritional supplements in the hospital setting. *Clin Nutr* 2016;**35**:370-380.
 51. Lobo DN, Gianotti L, Adiamah A, et al. Perioperative nutrition: Recommendations from the ESPEN expert group. *Clin Nutr* 2020;**39**:3211-3227.
 52. Stratton RJ, Elia M. Who benefits from nutritional support: what is the evidence? *Eur J Gastroenterol Hepatol* 2007;**19**:353-358.
 53. Jie B, Jiang Z-M, Nolan MT, Zhu S-N, Yu K, Kondrup J. Impact of preoperative nutritional support on clinical outcome in abdominal surgical patients at nutritional risk. *Nutrition* 2012;**28**:1022-1027.
 54. Cederholm T, Jensen GL, Correia MITD, et al; GLIM Working Group. GLIM criteria for the diagnosis of malnutrition - a consensus report from the global clinical nutrition community. *Clin Nutr* 2019;**38**:1-9.
 55. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: a review. *JAMA Surg* 2017;**152**:292-298.
 56. Cederholm T, Bosaeus I, Barazzoni R, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. *Clin Nutr* 2015;**34**:335-340.
 57. Małczak P, Pisarska M, Piotr M, Wysocki M, Budzyński A, Pędzwiatr M. Enhanced recovery after bariatric surgery: systematic review and meta-analysis. *Obes Surg* 2017;**27**:226-235.
 58. Melnyk M, Casey RG, Black P, Koupparis AJ. Enhanced recovery after surgery (ERAS) protocols: time to change practice? *Can Urol Assoc J* 2011;**5**:342-348.
 59. Nygren J, Thorell A, Ljungqvist O. Preoperative oral carbohydrate therapy. *Curr Opin Anaesthesiol* 2015;**28**:364-369.
 60. Schrickler T, Lattermann R. Strategies to attenuate the catabolic response to surgery and improve perioperative outcomes. *Can J Anesth* 2007;**54**:414-419.
 61. Hughes MJ, Hackney RJ, Lamb PJ, Wigmore SJ, Christopher Deans DA, Skipworth RJE. Prehabilitation before major abdominal surgery: a systematic review and meta-analysis. *World J Surg* 2019;**43**:1661-1668.
 62. Lewis SJ, Egger M, Sylvester PA, Thomas S. Early enteral feeding versus "nil by mouth" after gastrointestinal surgery: systematic review and meta-analysis of controlled trials. *BMJ* 2001;**323**:773-776.
 63. Artinian V, Krayem H, DiGiovine B. Effects of early enteral feeding on the outcome of critically ill mechanically ventilated medical patients. *Chest* 2006;**129**:960-967.
 64. Perel P, Yanagawa T, Bunn F, Roberts IG, Wentz R. Nutritional support for head-injured patients. *Cochrane Database Syst Rev* 2006;**2006**:CD001530.
 65. Wischmeyer PE, Carli F, Evans DC, et al; Perioperative Quality Initiative (POQI) 2 Workgroup. 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**:1883-1895.
 66. Lassen K, Soop M, Nygren J, et al; Enhanced Recovery After Surgery (ERAS) Group. Consensus review of optimal perioperative care in colorectal surgery: Enhanced Recovery After Surgery (ERAS) Group recommendations. *Arch Surg* 2009;**144**:961-969.
 67. Weimann A, Braga M, Harsanyi L, et al; ESPEN (European Society for Parenteral and Enteral Nutrition). ESPEN guidelines on enteral nutrition: surgery including organ transplantation. *Clin Nutr* 2006;**25**:224-244.
 68. Nutrition support for adults: oral nutrition support, enteral tube feeding and parenteral nutrition. National Institute for Health and Care Excellence (NICE), London 2017.
 69. Baldwin C, Parsons TJ. Dietary advice and nutritional supplements in the management of illness-related malnutrition: systematic review. *Clin Nutr* 2004;**23**:1267-1279.
 70. Tropea P, Schlieter H, Sterpi I, et al. Rehabilitation, the great absentee of virtual coaching in medical care: scoping review. *J Med Internet Res* 2019;**21**:e12805.
 71. Geiger R, Rieckmann JC, Wolf T, et al. L-arginine modulates t cell metabolism and enhances survival and anti-tumor activity. *Cell* 2016;**167**:829-842.
 72. Hubbard GP, Elia M, Holdoway A, Stratton RJ. A systematic review of compliance to oral nutritional supplements. *Clin Nutr* 2012;**31**:293-312.
 73. Waitzberg DL, Saito H, Plank LD, et al. Postsurgical infections are reduced with specialized nutrition support. *World J Surg* 2006;**30**:1592-1604.
 74. Grass F, Bertrand PC, Schäfer M, et al. Compliance with preoperative oral nutritional supplements in patients at nutritional risk—only a question of will? *Eur J Clin Nutr* 2015;**69**:525-529.
 75. Sorensen J, Kondrup J, Prokopowicz J, et al; EuroOOPS study group. EuroOOPS: an international, multicentre study to implement nutritional risk screening and evaluate clinical outcome. *Clin Nutr* 2008;**27**:340-349.
 76. van Noort HHJ, Ettema RGA, Vermeulen H, Huisman-de Waal G;

- Basic Care Revisited Group (BCR). Outpatient preoperative oral nutritional support for undernourished surgical patients: a systematic review. *J Clin Nurs* 2019;**28**:7-19.
77. Tangvik RJ, Tell GS, Eisman JA, et al. The nutritional strategy: four questions predict morbidity, mortality and health care costs. *Clin Nutr* 2014;**33**:634-641.
 78. Agarwal E, Ferguson M, Banks M, et al. Malnutrition and poor food intake are associated with prolonged hospital stay, frequent readmissions, and greater in-hospital mortality: results from the Nutrition Care Day Survey 2010. *Clin Nutr* 2013;**32**:737-745.
 79. Curtis LJ, Bernier P, Jeejeebhoy K, et al. Costs of hospital malnutrition. *Clin Nutr* 2017;**36**:1391-1396.
 80. Identifying patients at risk: ADA's definitions for nutrition screening and nutrition assessment. Council on Practice (COP) Quality Management Committee. *J Am Diet Assoc* 1994;**94**:838-839.
 81. Deftereos I, Djordjevic A, Carter VM, McNamara J, Yeung JM, Kiss N. Malnutrition screening tools in gastrointestinal cancer: A systematic review of concurrent validity. *Surg Oncol* 2021;**38**:101627.
 82. White JV, Guenter P, Jensen G, Malone A, Schofield M; A.S.P.E.N. Board of Directors. Consensus statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). *J Acad Nutr Diet* 2012;**112**:730-738.
 83. Martínez-Ortega AJ, Piñar-Gutiérrez A, Serrano-Aguayo P, et al. Perioperative nutritional support: a review of current literature. *Nutrients* 2022;**14**:1601.
 84. Guenter P, Blackmer A, Malone A, Phillips W, Mogensen KM, Becker P. Current nutrition assessment practice: A 2022 survey. *Nutr Clin Pract* 2023;**38**:998-1008.

Supplementary material

Supplementary Appendix 1 Subjective Global Assessment (SGA) form for diagnosing malnutrition in adults [84]

Select appropriate category with a checkmark or enter numerical value indicated by #

- A. History
1. Weight change
Overall change in past six months: = # ____ kg, % loss= # ____
 2. Dietary intake change (relative to normal)
____ No change
____ Change ____ duration = # ____ weeks
____ type: ____ suboptimal solid diet, ____ full liquid diet
____ hypocaloric liquids, ____ starvation
 3. Gastrointestinal symptoms (that persisted for > 2 weeks)
____ none, ____ nausea, ____ vomiting, ____ diarrhea, ____ anorexia
 4. Functional capacity
____ No dysfunction (e.g., full capacity)
____ Dysfunction ____ duration= # ____ weeks
____ type: ____ working suboptimally, ____ ambulatory, ____ bedridden.
 5. Disease and its relation to nutritional requirements
Primary diagnosis (specify) _____
Metabolic demand (stress): ____ no stress, ____ low stress
____ moderate stress, ____ high stress
- B. Physical (for each treat specify: 0 = normal, 1+ = mild, 2+ = moderate, 3+ = severe)
- # ____ loss of subcutaneous fat (chest, triceps)
 - # ____ muscle wasting (quadriceps, deltoids)
 - # ____ ankle edema
 - # ____ sacral edema
 - # ____ ascites
- C. SGA rating (select one)
- ____ A = Well nourished
 - ____ B = Moderately (or suspected of being) malnourished
 - ____ C = Severely malnourished