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Nutritional status and requirements 3

Objectives

- Introduction
- Recognize the value of the nutritional status
- Describe the diagnosis, prevalence, and consequences of the nutritional status
- Define the differences between nutritional screening and assessment
- Demonstrate the impact of the nutritional status on surgical outcomes
- Determine the nutritional requirements

Common questions routinely asked in everyday practice

1. How can the nutritional status impact surgical patients?
2. Can malnutrition be treated?
3. How can the nutritional requirements be established?

Response/Introduction

The nutritional status of surgical patients has been shown to impact outcomes since the classical study by Studley [1], in which he showed that patients who had lost more than 20% of the usual body weight before peptic ulcer surgery presented with increased mortality. Several studies enrolling patients who undergo different surgical procedures have corroborated this observation, and although no clinical randomized study has been carried out, which would be absolutely unethical, the relationship between the nutritional status and morbidity, mortality, costs, and length of hospital stay has been well shown. Therefore, it is highly recommended that patients who will undergo surgery, in particular, complex procedures, should be nutritional screened and assessed. If the patient is malnourished, nutrition therapy, while preparing the patient for the surgical act, should be carried out.

The goal of nutrition therapy in surgical patients is specially directed to the provision of substrates for the body to be able to adequately face the organic response and also to improve wound healing. In this regard, it is not expected to have the patient fully recover his/her previous nutritional status and also to gain weight by recovering body compartments. This happens late in the course of nutritional replenishment with updated assessment of the requirements. It is noteworthy to point out that the nutritional requirements should be individually tailored according to the nutritional and metabolic status of the patient.

The Practical Handbook of Perioperative Metabolic and Nutritional Care. https://doi.org/10.1016/B978-0-12-816438-9.00003-9

Nutritional status

The nutritional status is determined by the adequate balance between what the organism needs for its physiologic functioning, the diet intake, and the adequate use of nutrients. Under various circumstances such as famine chaos or disease-related problems, there is an imbalance of aforementioned aspects and this leads to malnutrition. Many definitions have been used to determine the condition, and Jellife [2] defined it as “a morbid state secondary to a deficiency or excess, relative or absolute, of one or more essential nutrients”.

In clinical practice whether discussing sick children, adults, or the elderly, malnutrition is related to a compromised intake or assimilation of nutrients, together with disease-associated inflammatory mechanisms, either acute or chronic. The way inflammation contributes to malnutrition is through anorexia, which accounts for decreased appetite and food intake, accompanied by an altered metabolism. The latter might lead to increased resting energy expenditure. Also, high muscle catabolism is a consequence of the inflammatory status. Thus, the deranged nutritional status is marked by impaired biological mechanisms, alterations in functionality, and body composition. In fact, malnutrition affects every tissue and organ function. For example, the gut of the malnourished patient is affected, and malabsorption due to villous atrophy and decreased gastric and pancreatic secretion is frequently present [3]. The respiratory function declines due to diaphragmatic and intercostal muscle depletion, placing the patient at increased risk of atelectasis and secondary infection, which is worsen by an impaired immunologic status [4,5]. Cardiac failure is seen in severely malnourished patients [6,7]. Glomerular filtration rate seems to be negatively affected, placing the patients at higher risk of renal failure. Another important adverse effect of malnutrition is dysphagia, which is a high risk factor for pulmonary aspiration, especially in the elderly, and in a vicious cycle contributes to the nutritional status deterioration [8]. In fact, the association between malnutrition and inadequate body functions was shown many years ago by Ancel Keys, in the famous Minnesota experiment, which enrolled healthy man who volunteered for the study as a compensation for declining joining the United States Army, in the Second World War [9–11].

Unintentional loss of body weight is one of the phenotypic characteristic of malnutrition, and it is usually a consequence of decreased food, alone or together with inadequate utilization of nutrients, and/or increased losses as well as requirements. In the early stages of malnutrition, especially in the absence of inflammation, muscle is protected as energy is met by use (therefore loss) of liver glycogen and body fat associated with the mobilization of labile protein stores from the viscera. It is in this phase that functional alterations occur while body composition changes might not yet be identified. As time progresses or with the inflammatory response, loss of muscle and fat compartments increases. Imbalance of micronutrients also occurs. Therefore, terms such as protein-energy or protein-caloric malnutrition should not be used because malnutrition encompasses macro- and micronutrient deficiencies. Because of the many definitions of what malnutrition is, an international committee of experts proposed the following nomenclature for malnutrition diagnoses: “Starvation-related malnutrition” when there is chronic starvation without inflammation, “chronic disease–related malnutrition" when inflammation is chronic and of mild to moderate degree, and "acute disease– or injury-related malnutrition" when inflammation is acute and of severe degree [12]. More recently, the Global Leadership Initiative on Malnutrition (GLIM) expert consensus group has proposed a new concept to diagnose malnutrition (Fig. 3.1 and Table 3.1) [13,14].

Malnutrition is a common occurrence among hospitalized patients with prevalence rates of about 50%, varying according to the primary diagnosis and the tools used to diagnose this syndrome. The highest rates are found among cancer patients undergoing surgery, in particular those with gastrointestinal disease (80%) and head and neck cancer (50%–70%) [15–19]. However, it is also important to raise attention for the acute care surgical setting, in which usually trauma patients, who enter the hospital under good nutritional status, rapidly become malnourished due to the severity of the organic response to trauma and the related inflammation, together with the inadequate approach and care by the hospital staff. *The LeRoy Catastrophe: A story of death, determination, and the importance of nutrition in Medicine*, by Michael Meguid [20], describes the sad story of a young man who, in August 1976, fell from a ledge and fractured his femur. He also had the suspicion of major internal bleeding, and because of this, he underwent a laparotomy with no internal organ damage. Thirty days later, LeRoy died in a university hospital in Boston. Why? Throughout his 30-day hospital stay, he had eaten little according to the nursing staff, despite the prescription of oral diet. He daily received about 3 L of glucose intravenous solutions, accounting for 510 calories, and no proteins and micronutrients. This was obviously not enough to reach his nutritional requirements, considering that he weighed around 68 kg. As a consequence, he lost over 20% of his usual body weight—severe malnutrition of iatrogenic cause.

A recent systematic review, in hospitalized Latin American patients, reported admission rates consistently in the range of 40%–60%, with higher prevalence in elderly and critically ill patients or those undergoing surgical procedures [21]. Data from Europe [15,22], Asia, [23] and North America [24] encompassing general or mixed populations indicated similar prevalence rates—of about 50%. Longer hospital stay is a risk factor for increased rates of malnutrition, with one study reporting a prevalence of more than 80% after 2 weeks of hospitalization [25]. In Europe, Pichard et al. [26] registered that 37% of the patients were malnourished within the first 48 h following admission, whereas those remaining in the hospital for more than 12 days presented with a rate of 55.6%. Liang et al. [27] in China, reported a significant increase in the prevalence of malnutrition between hospital admission and discharge. The increased rate of malnutrition in patients with longer hospital stay may be a consequence of a more severe underlying disease, while at the same time, the increased length of stay (LOS) may be the result of complications due to malnutrition [28]. Critically ill patients present with high energy deficits, which significantly and rapidly accumulate during the first week of hospitalization [29]. Moreover, negative energy balance is associated with clinical complications [30,31].

Considering the high rates of malnutrition in the hospital setting, which lead to worst outcomes and, per se, worsen the nutritional status in a vicious cycle mode (Fig. 3.2), it is of utmost importance to be able to early recognize this condition. It should be

Risk screening

At risk for malnutrition

- Use validated screening tools

Diagnostic Assessment

Assessment criteria

- **Phenotypic**
  - Non-volitional weight loss
  - Low BMI
  - Reduced muscle mass
- **Etiologic**
  - Reduced food intake or assimilation
    Disease burden/inflammatory condition

Diagnosis

Meets criteria for malnutrition diagnosis

- Requires at least 1 Phenotypic criterion and 1 Etiologic criterion

Phenotypic Criteria			Etiologic Criteria	
Weight loss (%)	**Low body Mass Index (kg/m^2)**	**Reduced muscle mass[a]**	**Reduced food intake or assimilation[b]**	**Inflammation**
>5% within past 6 months, or >10% beyond 6 months	<20 if <70 years, or <22 if >70 years Asia: <18.5 if <70 years, or <20 if >70 years	Reduced by validated body composition measuring techniques[a]	≤50% of ER >1 week, or any reduction for >2 weeks, or any chronic GI mal-absorption[b]	Acute disease/injury[c] or chronic disease-related[d]

GI=gastro-intestinal, ER=energy requirements

[a] For example fat free mass index (FFMI, kg/m^2) by dual-energy absorptiometry (DXA) or corresponding standards using other body composition methods like bioelectrical impedance analysis (BIA), CT or MRI. When not available or by regional preference, physical examination or standard anthropometric measures like mid-arm muscle or calf circumferences may be used. Thresholds for reduced muscle mass need to be adapted to race (Asia). Functional assessments like hand-grip strength may be considered as a supportive measure.

[b] Consider gastrointestinal symptoms as supportive indicators that can impair food intake or absorption e.g. dysphagia, nausea, vomiting, diarrhea, constipation or abdominal pain.

[c] Acute disease/injury-related with severe inflammation, e.g. major infection, burns, trauma or closed head injury.

[d] Chronic disease with chronic or recurrent mild to moderate inflammation; e.g. malignant disease, chronic obstructive pulmonary disease, congestive heart failure or chronic renal disease.

Figure 3.1 Global Leadership Initiative on Malnutrition (GLIM) diagnostic scheme for screening, assessment, and diagnosis of malnutrition [13,14].

Table 3.1 Global Leadership Malnutrition Initiative (GLIM)—thresholds for severity grading of malnutrition into Stage 1 (moderate) and Stage 2 (severe) malnutrition [13,14].

	Phenotypic criteria			Etiologic criteria	
	Weight loss (%)	**Low body mass index (kg/m^2)[a]**	**Reduced muscle mass[b]**	**Reduced food intake or assimilation**	**Disease burden/ inflammation**
Stage 1/moderate malnutrition (requires 1 phenotypic and 1 etiologic criterion)	5%–10% within the past 6 mo or 10%–20% beyond 6 mo	<20 if <70 yr, <22 if ≥70 yr	Mild to moderate deficit (per validated assessment methods—see below)	Any reduction of intake below ER for >2 weeks[c] or moderate malabsorption[c,d]	Moderate acute disease–/ injury-related[e] or moderate chronic disease–related[f]
Stage 2/severe malnutrition (requires 1 phenotypic and 1 etiologic criterion)	>10% within the past 6 mo or >20% beyond 6 mo	<18.5 if <70 yr, <20 if ≥70 yr	Severe deficit (per validated assessment methods—see below)	≤50% intake of ER for >1 week[c] or severe malabsorption[c,d]	Severe acute disease–/ injury-related[e] or severe chronic disease–related[f]

ER, energy requirements.

[a]Further research is needed to secure consensus reference body mass index data for Asian populations in clinical settings.

[b]For example, appendicular lean mass index (ALMI, kg/m^2) by dual-energy absorptiometry or corresponding standards using other body composition methods such as bioelectrical impedance analysis, computed tomography, or MRI. When unavailable or by regional preference, physical exam or standard anthropometric measures such as mid-arm muscle or calf circumferences may be used. Functional assessments such as hand grip strength may be used as a supportive measure [15].

[c]Consider gastrointestinal symptoms as supportive indicators that can impair food intake or absorption, e.g., dysphagia, nausea, vomiting, diarrhea, constipation, or abdominal pain. Use clinical judgment to discern severity based on the degree to which intake or absorption is impaired. Symptom intensity, frequency, and duration should be noted.

[d]Malabsorption is a clinical diagnosis manifest as chronic diarrhea or steatorrhea. Malabsorption in those with ostomies is evidenced by elevated volumes of output. Use clinical judgment or additional evaluation to discern severity based uon frequency, duration, and quantitation of fecal fat and/or volume of losses.

[e]Acute disease–/injury-related: Severe inflammation is likely to be associated with major infection, burns, trauma, or closed head injury. Other acute disease–/injury-related conditions are likely to be associated with mild to moderate inflammation. (C-reactive protein may be used as a supportive laboratory measure.)

[f]Chronic disease–related: Severe inflammation is not generally associated with chronic disease conditions. Chronic or recurrent mild to moderate inflammation is likely to be associated with malignant disease, chronic obstructive pulmonary disease, congestive heart failure, chronic renal disease, or any disease with chronic or recurrent Inflammation. (C-reactive protein may be used as a supportive laboratory measure.)

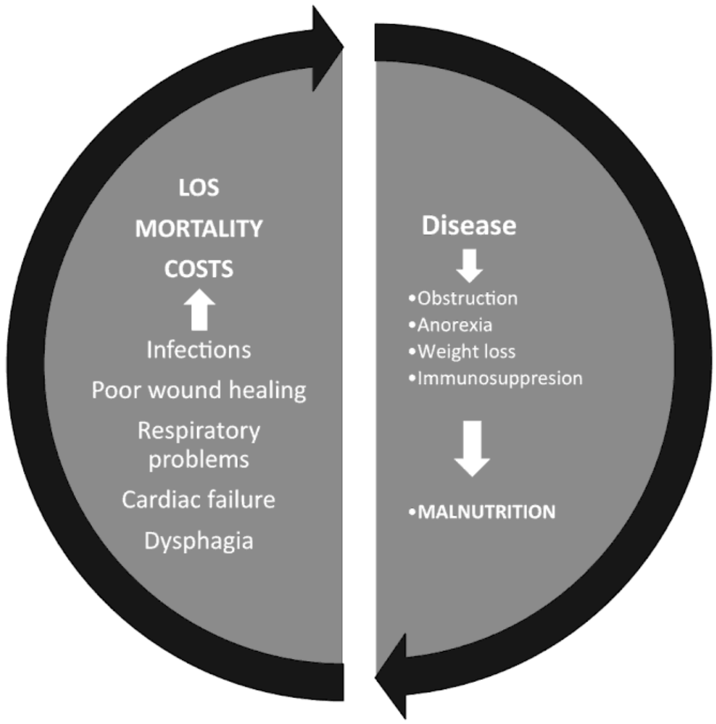

Figure 3.2 The disease, the nutritional status, and outcomes. *LOS*, Length of stay.

Table 3.2 Risk factors for malnutrition.

• The severity of the disease (inflammation)
• Decreased diet intake
• Poor appetite (anorexia)
• Increased losses (vomiting, diarrhea, open abdomen, fistulas)
• Pain
• Dysphagia
• Lack of teeth
• Depression
• Low medical awareness

emphasized that, especially, considering the world pandemia of obesity that has made it even more difficult to identify a deranged nutritional status, independently of geographic regions [27], awareness should be raised among surgeons toward the hidden burden of malnutrition and the risk factors associated with it [32] (Table 3.2).

Nutritional screening

Screening patients for malnutrition on admission to the hospital is the recommended standard of care. The origin of the word screen seems to date from medieval European, more precisely, from old north France, and its meaning was related to "barrier" or "protection" against fire. Apparently, according to Bravo, "screen as a verb cannot be defined without first defining screen as a noun" [33]. This same author states that "the dual nature of the word screen makes it complicated to be defined and, yet screen, be it noun or verb, is always a medium with a message." Therefore, its term as for the nutritional screening—the act of identifying risk factors for malnutrition—is most likely related to the means of identifying an act of protection.

In the hospital setting, there are many available nutrition screening tools, some more sophisticated and others simpler [34–41], with some being supported by clinical nutrition societies [35,42,43]. However, when there are too many, one might argue the reason for such reality. de van der Schueren et al. [44] identified 83 studies with 32 different screening tools. Forty-two of the studies had data on construct or criterion validity versus a reference method. Fifty-one manuscripts evaluated the tools based on predictive validity on outcomes such as LOS, mortality, or complications. According to de van der Schueren et al. [44], none of the tools performed consistently well. In fact, few screening tools have been adequately evaluated by employing multivariate statistical models, which are alternative approaches for weighting the importance and the effect of independent variables with respect to the risk of the outcome variable, in the case of malnutrition, and therefore validating the adequacy of the instrument [45].

The ideal screening tool should, then, be easily performed by anyone in the health care system or even by the patient himself/herself. Also, it should be carried out quickly and present with high sensitivity and specificity, along with good accuracy not only to detect the nutrition risk but also to identify nutrition-related outcomes.

The Nutrition Risk Screening tool proposed by the Australian group of Ferguson et al. [46] is extremely easy as it encompasses key questions: loss of body weight (and how much) and food intake changes due to loss of appetite. These questions can easily be part of the patient's history carried out by the surgeon, adding little extra time to the consult. If there is a positive answer to any of the two main questions (body weight loss and decrease in food intake), then the patient should be further assessed by a nutritionist or a nutrition expert to have his/her nutritional status evaluated. Another screening instrument world widely used is the Nutrition Risk Screening 2002 [35], supported by the European Society of Parenteral and Enteral Nutrition, which demands a bit more time and labor to be carried out. Patients scored 3 or higher with this method are referred to nutritional assessment.

Nutritional assessment

Nutritional assessment differs from nutritional screening in the depth of the information provided by the patient in relation to his/her nutritional conditions (Fig. 3.3). There are several ways of assessing the nutritional status with some techniques being very sophisticated and expensive, whereas others are less complicated and available in most hospitals, and of course, each one with clinical advantages and disadvantages. Ideally, the gold standard method should be sensitive and specific to predict nutritional status–related outcomes, while at the same time be able to point out at changes in the patient's status after nutrition interventions. Several nutritional assessment

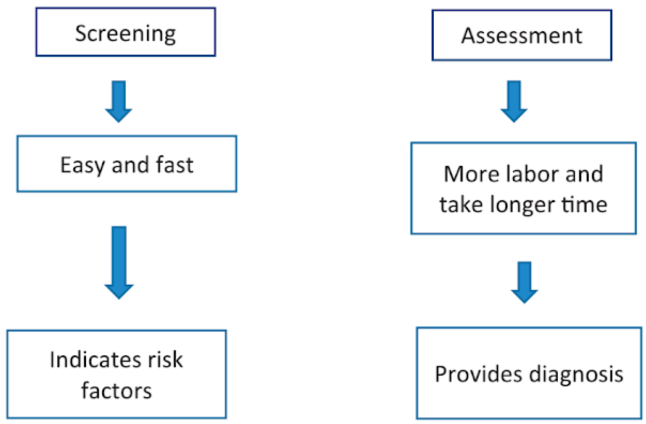

Figure 3.3 Nutritional screening and assessment: what is the difference?

instruments have been well associated with prognosis, mortality, and costs for surgical patients [28,47–50].

Among surgeons, the hepatic proteins such as albumin and prealbumin have commonly and inadequately been used as nutritional markers. Low albumin concentration has been associated to increased morbidity and mortality [51–55]. However, serum albumin is the result of the equilibrium between hepatic synthesis, albumin degradation, and losses from the body. It also reflects the balance between intravascular and extravascular compartments and water distribution, which in surgical patients, especially after the operation or stress resuscitation, is usually abundant. In a steady state, a total of about 10.5–14.0 g (200 mg/kg) of albumin are synthesized and degraded every day and, when albumin is released into the plasma, its half-life is about 21 days. It is undoubtedly that a deranged nutritional status will hinder albumin production due to lack of nutrients, fundamental to its synthesis. Nonetheless, in chronic malnourished patients, plasma albumin concentration is often normal because of the compensatory effect (lower degradation and a shift from the extracellular compartment to the intracellular). On the other hand, in acute stress situations, as those related to infection, surgery, and polytrauma, albumin levels are commonly very low as a consequence of decreased synthesis, increased degradation, transcapillary losses, and fluid replacement [56]. Therefore, under these circumstances, albumin might be altered due to factors other than malnutrition. However, low albumin values are indicative of an acute inflammatory response, and this is certainly a risk factor for malnutrition [53,54,56]. Other hepatic proteins are also questionable markers of nutritional status when used alone. Thus, nutritional assessment indexes using such markers are doomed to imply serious diagnostic bias as each measurement has its own restrictions. However, when put together to assess surgical populations, they were able to predict with increased sensitivity major morbidity [51,57].

Dietitians still use anthropometric methods to provide the diagnosis of malnutrition. It is of no doubt that body weight is a simple measure of total body mass, which when either compared to previous (usual weight) or ideal weight (based on the weight of healthy populations) provides insights into the patient's nutritional status. A loss of more than 10% of the usual body weight suggests malnutrition and is associated with higher morbidity and mortality [58]. However, weight loss might be difficult to determine in some individuals due to lack of information, illiteracy, or mental disorientation. Moreover, weight change alone, in severely critically ill patients, may account erroneously for the nutritional status of the patients because it is influenced by confounding factors, mainly related to hydration status. Weight together with height provides the body mass index (BMI), which alone does provide nutritional status, but it does serve to classify the patient in terms of body composition as underweight ($<18.5\,kg/m^2$), normal weight ($18.5–25.0\,kg/m^2$), overweight ($25.1–30.0\,kg/m^2$), and obese ($>30\,kg/m^2$). These values are especially important when calculating fluids, calories, and proteins because for overweight and obese patients, the weight to be used should be corrected for the ideal body weight considering the patient's height. There are several formulas to calculate ideal body weight, but the simplest one is based on the adequate range of BMI [59].

Other body compartment measurements as the triceps and subscapular skinfolds, and arm circumferences indicate the status of adipose and muscle tissue. However, the interference of obesity and edematous states together with intra- and interobservers errors are great disadvantages of these measurements, which are compared to tables derived from healthy populations, further interfering in its quality. Thuluvath and Triger indicated that 20%–30% of healthy controls would be considered malnourished based on the standards of those tables [60]. Currently, more sophisticated body composition methods, such as computed tomography (CT), ultrasound (US), nuclear magnetic resonance, whole body conductance and impedance, dual-energy X-ray absorptiometry, and others, have been used as body composition assessment tools for sick populations. However, they have several drawbacks as nutritional assessment markers and even as body compartments since, for example, CT exposes the patient to high radiation. Because of this, it is considered a method of convenience, this is to say, if the CT exists, there is the software and the expert to assess it, then it can be used as a complement to the nutrition assessment method [18,61]. Nonetheless, CT and US have been shown to indicate important losses of muscle mass and subcutaneous tissue as well as the presence of intermuscular adipose tissue which impacts surgical outcome [61,62].

Functional tests such as handgrip dynamometry, ability to perform work in an ergometer, changes of heart rate during maximal exercise, and respiratory muscle strength may indicate muscle loss, fiber quality, and functionality, while at the same time may provide a better evaluation of nutrition repletion after therapy [63–68]. However, the absence of standardized equipment and protocols related to dynamometry has limited its usage. In routine clinical practice, the use of most of the herein discussed instruments may be hampered related to the disadvantages, the costs, and the availability, thus it is of utmost importance to rely in clinical judgment.

Subjective global assessment (SGA), as described by Detsky et al. [69,70] in surgical patients, is a clinical method of assessing the nutritional status. SGA evaluates various aspects of a patient's nutritional history from body weight changes, diet intake, gastrointestinal symptoms, and functional capacity alterations, which with the help of a direct physical examination will provide the diagnosis (Table 3.3). It has been described by several authors its capacity of providing the diagnosis and predicting morbidity, mortality, LOS, and costs [16,25,47–49,71–74]. Also, SGA was shown to