The management of surgical illness requires appropriate metabolic and physiologic adjustment to preserve tissue and organ function. A patient's baseline nutritional status along with optimal nutritional support will provide the substrate to meet the increase in metabolic demand. Adequate response to metabolic demands allows the host to limit catabolism, promote wound healing, and muster a defense against infection. Delivery of appropriate metabolic support begins with adequate assessment of nutritional status.

It is important to recognize and treat malnutrition as a problem often equal to the primary diagnosis. As early as the 1930s it was noted that postoperative complications and deaths were more likely if patients had disease-related malnutrition.\(^1\)\(^2\) The known physiologic consequences of malnutrition include impaired respiratory muscle function with its attendant reduction in vital capacity and minute ventilation, reduced cardiac contractility, increased thrombogenicity, and impaired renal function. The manifestations of these include hypoventilation requiring reintubation, renal failure, and nonhealing wounds.\(^3\) Also, malnutrition affects emotional and behavioral responses, leading to apathy, which impairs functional recovery and further exacerbates anorexia.\(^4\) The cost to health care is prolonged intensive care unit and hospital stays.\(^5\)\(^6\) The need to identify and treat the malnourished patient is therefore a critical aspect of patient management.

The first step in nutritional assessment is identifying patients who are malnourished or those who are at risk for malnutrition: (1) those with recent weight loss greater than 10% to 15%; (2) those experiencing near or complete starvation for 5 or more days; and/or (3) those whose recovery duration is anticipated by the surgeon to be prolonged, including time to return to adequate oral intake.\(^7\) A patient with acute cholecystitis or the person having elective peripheral vascular reconstruction is not necessarily in need of nutritional assessment and supplementation.

Once the population to be evaluated has been identified, the marker(s) for nutritional assessment should be sensitive, accurate, reproducible by different observers, applicable to all patients at the bedside, and cost-effective.\(^8\) Furthermore, the ultimate clinical utility of any method of nutritional assessment lies in its ability to assess risk of morbidity and mortality related to malnutrition, to identify causes and consequences of malnutrition, and to predicate that the patient will benefit from supplemental nutrition.\(^9\)

Many authors have provided exhaustive lists of possible markers for nutritional assessment.\(^9\)\(^10\) The focus of this discussion will be to define a practical strategy using readily available markers of nutritional assessment. The strategy should prove adequate for the academician or private practitioner, irrespective of experience or resources. Similar to any clinical evaluation, the comprehensive assessment of nutritional status outlined should progress from the thorough history and physical examination to laboratory values and other methods of diagnostic evaluation. While proposing a practical means of assessing a patient's nutritional status, we will, however, briefly outline benefits and limitations of known markers. To this end we will clarify their usefulness and demonstrate how they often prove to be nonessential. Therapeutic
strategies based on the findings of nutritional assessment data can be found elsewhere.\textsuperscript{11,12}

A comprehensive history and review of systems that uncovers impediments to deglutition and enteral absorption will identify a patient with impaired nutritional status. Specific items to inquire about include altered oral intake, lack of specific food groups, use of supplements, ability to chew and swallow, satiety, dyspepsia, vomiting, bowel habits, and symptoms related to vitamin and trace element deficiency. We believe, as do others,\textsuperscript{13} that subjective interpretation of data gained from the history is adequate. Patient response is quantified only when necessary. Nonetheless, the Nutrition Screening Initiative Checklist for Nutritional Risk allows the interested practitioner to quantify the degree of malnutrition based on the history.\textsuperscript{14} Importantly, this checklist is known to predict nutrition-related complications in both retrospective and prospective studies.\textsuperscript{15,16} However, this checklist is helpful only when preparing for high-risk procedures on patients with multiple comorbid illnesses. Its usefulness remains limited with respect to the acutely injured patient.

The simplest and oldest measure of nutritional status is body weight compared with previous personal data or ideal weight based on the Hamwi formula or tables.

The Hamwi formula:

- Men, Ideal Body Weight = 106 lb + 6 lb for Every Inch Over 5 ft
- Women, Ideal Body Weight = 100 lb + 5 lb for Every Inch Over 5 ft

The immediate limitation of using body weight only is that recent losses or gains do not directly relate to similar or proportionate changes in nutritional status. Also, this relies on comparison with a range of normal values, which is often limited to the diversity of the control population.\textsuperscript{10,17} Finally, although unintentional weight loss greater than 10% is a bad prognostic indicator,\textsuperscript{18,19} weight loss per se, as determined by history, is limited by poor predictive power.\textsuperscript{20}

A seemingly more optimal nutritional indicator is body mass index (BMI) (body weight in kilograms divided by the square of the height in meters). This index aims to overcome the limitations of changes in body weight and the need to compare it with expected normal values. The data to support the use of BMI are solid. In any scenario, a BMI of less than 15 kg/m\textsuperscript{2} is associated with a significant increase in morbidity.\textsuperscript{18,21} In hospitalized patients, a BMI less than 18.5 kg/m\textsuperscript{2} is associated with a longer stay in the intensive care unit, increased frequency in postoperative complications, higher readmission rates, and delays in resumption of oral intake.\textsuperscript{22} The use of BMI as a measure of nutritional assessment is limited by poor sensitivity with respect to baseline assessment, particularly for overweight patients. First, individuals in the high-normal range can undergo significant change in nutritional status prior to estimation of having an abnormal status or being nutritionally depleted. Furthermore, in our practice, based on a BMI of 25.0 to 29.9 kg/m\textsuperscript{2}, we consider nearly 30% of the US population is overweight, with another 30% categorized as obese (BMI >30 kg/m\textsuperscript{2}). This elevated BMI has documented links to heart disease, diabetes, hypertension, and increased morbidity with major operations. Is the increased incidence of perioperative morbidity in patients with elevated BMIs all related to comorbid illness or is it that these patients are truly malnourished? Furthermore, comorbid illness that promotes underhydration, edema, or ascites (ie, renal failure, liver disease, or malignancy) confounds this calculation. However, BMI is a useful tool, particularly for the subset of surgical patients in the lower range, who traditionally have needed and benefited from nutrition intervention.

The limitations set forth by using weight measurements alone led to an evolution of anthropometry. Specifically, the mid-arm muscle circumference provides a measure of muscle mass while triceps and subscapular skinfold thickness provide an excellent index of body fat. These methods are more accurate in their assessment of protein-based nutritional status; however, they suffer from poor accuracy and specificity, being useful as screening tools for identifying patient populations at risk. The use of skinfold thickness and muscle mass shows that in many studies, up to 30% of healthy controls could be considered malnourished.\textsuperscript{23} Furthermore, this method is limited in elderly persons due to the variability of age-related changes in lean body mass and body fat. A limited reference database and absence of correction factors for age, hydration status, and physical activity present limiting confounders.\textsuperscript{24} Also, results are poorly reproducible by individual observers.\textsuperscript{25} Finally, these anthropometric methods are nonspecific, particularly when evaluating the acutely injured patient. Whereas our bias based on clinical experience, is that subjective evaluation of subcutaneous fat and muscle mass can help in the general assessment of a patient, its use as an objective measure remains limited to investigational studies.

As we developed an understanding of the different types of malnutrition, it became clear that the mere reliance on history and physical examination alone was insufficient. For example, Kwashiorkor-like malnutrition relates to depletion of visceral protein mass without evidence of weight loss. In such patients, serum transport proteins (ie, albumin, prealbumin, and transferrin) have been identified as useful measures to evaluate visceral protein mass.

Albumin, manufactured in the liver, has a half-life of 18 to 21 days. Total albumin varies from 3 to 4 g/kg in women and 4 to 5 g/kg in men. The serum concentration reflects synthesis, degradation, losses, and exchange between intravascular and extravascular compartments. Consequently, serum albumin is useful in gauging global nutritional status but is limited in its ability to assess acute changes.\textsuperscript{26} Also, as with any negative acute-phase reactant, there is a natural decline during acute illness, further limiting correlation with evolving nutritional status. Nevertheless, it has long been known in critical care literature that an albumin concentration of less than 3.5 g/dL is associated with increased morbidity in intensive care unit and other hospitalized patients.\textsuperscript{27-28} In 54215 patients undergoing major noncardiac operations, a serum albumin concentration of less than 2.1 g/dL was associated with substantial morbidity and mortality.\textsuperscript{29} In our clinical practice, serum albumin testing is inexpensive and a good prognostic tool, particularly in chronically ill patients.
Prealbumin and transferrin have been popularized because of their increased sensitivity to changes in nutritional status and the ability to specifically reflect protein loss. However, their erratic responses to stress or illness and the excessive cost of testing makes both less reliable and inadequate for universal application as clinical markers for nutritional status. Similarly, other markers, including insulin-like growth factor, serum cholesterol, urinary urea nitrogen, creatinine-height index, and delayed cutaneous hypersensitivity have attributes that correlate well with state of nutrition. As with prealbumin, these markers do not improve on the sensitivity and universal familiarity of albumin during recovery from illness.

A commonly overlooked parameter of nutritional status is functional capacity and muscle power. First introduced in the 1980s, Klidijian et al noted that reduction in muscle power (ie, weak hand-grip strength and respiratory muscle strength) was a better predictor of complications in postoperative patients than weight loss or arm muscle circumference. Although these seem helpful, their usefulness is limited by the need for patient cooperation, the need to avoid appropriate use of narcotic analgesics and sedatives, which impairs patient response, and an increase in the demands of staffing during an office visit.

For decades surgeons have included as part of their preoperative assessment a personal clinical subjective evaluation, often termed the eyeball test. The experienced surgeon intuitively includes this in his or her assessment of the patient. A clinical method that incorporates history, physical examination, and subjective analysis is the subjective global assessment (SGA). As outlined by Abbasi, the SGA uses 5 guidelines:

1. Weight loss during the previous 6 months characterized as severe (>10%), moderate (5%-10%), or mild (<5%) with subjective alteration made for those with ascites and edema.
2. Dietary intake classified as normal or abnormal based on changes in oral intake, including calories and nutrients.
3. Gastrointestinal symptoms that impair deglutition or eating almost daily for at least the previous 2 weeks.
4. Functional capacity classified as bedridden, less than fully active, or fully active.
5. Physical signs, including subcutaneous fat loss in triceps and midaxillary line at lower ribs along with muscle wasting in the temporalis muscle, deltoids, and quadriceps.

After a brief period of questioning, the surgeon then categorizes the patient into 1 of 3 groups. (1) Class A indicates less that a 5% weight loss or greater than a 3% weight loss but recent evidence of weight gain and improved appetite (well nourished). (2) Class B indicates a 3% to 10% weight loss without recent weight gain, poor dietary intake, and mild (1+) loss of subcutaneous fat (moderately nourished). (3) Class C indicates weight loss of greater than 10% with severe loss of subcutaneous fat and muscle wasting, often with edema (severely malnourished).

The SGA has greater than 80% agreement when evaluated for interobserver variability. Furthermore, the validity of this method has been demonstrated by Detsky et al, who noted favorable predictive accuracy of preoperative SGA when compared with albumin and transferrin levels, delayed cutaneous hypersensitivity, anthropometry, and creatinine-height index. Covinsky et al later demonstrated that the SGA can define patients at risk for greater mortality and delayed functional recovery irrespective of acute illness severity, comorbidity, or functional dependence.

As previously stated, the ideal tool for nutritional assessment should be sensitive, accurate, reproducible by various observers, relevant in health and illness, applicable to all patients at the bedside, and cost-effective. Unfortunately, any method taken independently can only meet 1 or 2 of these criteria. Measurements of triceps skin-fold thickness and mid-arm muscle circumference are limited by observer variance, arm/hand dominance, and poor sensitivity to acute changes in nutritional status. Visceral protein levels (albumin, transferrin, prealbumin) are valuable for initial assessment but again are limited with respect to acute change. Cell-mediated immunity is limited by low frequency of anergy. Tests of functional capacity and body composition, such as hand grip strength, total body nitrogen or potassium, bioelectric impedance, and dual-energy x-ray absorptiometry scans are impractical due to expense and limited availability. What remains a simple and effective strategy is the SGA combined with a few easily obtainable objective parameters, such as albumin concentration and BMI. Both are simple, inexpensive, and reasonably accurate in most patients. This method has been identified based on the clinical experience of our group and that of others as well. When carefully evaluated, the ability of the SGA to identify malnourished patients correctly increases to 90% when combined with other measures, such as albumin levels.

In the pediatric surgical population, a few cautionary words are necessary. In the infant whose diet consists predominantly of breast milk or supplemented formula, protein and nutrient deficiency is unlikely, provided body weight is at or near the predicted value for age. However, older children often differ and notable exceptions should be mentioned. One should be cognizant to the degree of eating disorders in children. The adolescent with a normal appearance and a normal BMI might be severely protein malnourished along with having specific nutrient deficiencies such as iron, folic acid, and calcium.

The ultimate outcome from surgical intervention predominantly reflects the primary diagnosis and success of technical interventions. Nonetheless, concomitant malnutrition portends an unfavorable postoperative risk of complications and poor recovery, such as delayed resumption of adequate oral intake. Despite the clear understanding of complications related to malnutrition, lack of interest and knowledge in this field has limited universal assessment guidelines. This proposal advises a simple subjective assessment supported by objective measures, predominantly BMI and albumin concentration. To further simplify things, we recommend this strategy only for patients judged to be at risk. With an ever-aging population and our ability to retard the lethality of disease, the future need for inpatient and outpatient
nutritional support should increase. The ability to accurately calculate nutritional requirements, choose correct methods of delivery, and monitor or recognize complications is essential. To do so relies first on the ability to make an accurate nutritional assessment during a patient’s initial presentation. Bear in mind, the accuracy of nutritional assessment remains, after all, an element within the art rather than the science of surgery.

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