Assessment of Nutritional Status, Body Composition, and Human Immunodeficiency Virus–Associated Morphologic Changes

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Nutritional status should be assessed at regular intervals as part of management of human immunodeficiency virus (HIV) infection. The simplest approach to assessment is serial weight measurement. A comprehensive nutritional assessment includes (1) anthropometric measurements of body composition; (2) biochemical measurements of serum protein, micronutrients, and metabolic parameters; (3) clinical assessment of altered nutritional requirements and social or psychological issues that may preclude adequate intake; and (4) measurement of dietary intake. Techniques for measuring body composition of fat and lean body mass include anthropometry and bioelectric impedance analysis. Other techniques, including dual X-ray absorptiometry (DXA), hydrodensitometry, total body potassium measurement, and cross-sectional computed tomography or magnetic resonance imaging are available in research centers. Anthropometry, including waist-hip ratios, regional DXA, and cross-sectional imaging, is best for detecting morphologic changes associated with fat redistribution syndrome. Nutritional assessment and intervention in children with HIV can help to prevent stunted growth and development.

Nutritional status is strongly predictive of survival and functional status during the course of HIV infection [1–6]. However, there are many important aspects to nutritional assessment beyond simple measurement of body weight. Nutritional assessment should also include measures of body composition of fat and lean body mass, biochemical assessment of serum proteins and micronutrients, clinical assessment of comorbid conditions that may affect nutritional status, and dietary intake. Although general nutritional assessment methods have been applied to persons with HIV infection, this disease has specific nutritional deficiencies and risk factors that need to be addressed in guidelines for health care professionals.

NEED FOR SPECIFIC NUTRITIONAL ASSESSMENTS

Weight loss is associated with adverse outcomes in HIV [7, 8]. In assessment of nutritional status, serial weight measurement has been used by the Centers for Disease Control and Prevention (CDC) as a way to identify the wasting syndrome [9]. Serial measurements of body mass index (BMI; the weight in kilograms divided by the square of the height in meters) predicted the development of AIDS [10]. However, in 1989, Kotler et al. [6] showed that measurement of body weight alone failed to identify dramatic losses in body cell mass leading to death because of relative increases in body water with disease progression; this finding has been confirmed [11]. Thus, measurements of body compart-

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Table 1. Minimal nutritional assessment in HIV-positive persons.

History	Premorbid weight ("usual weight" before HIV infection)
	Weight history since developing HIV
	Amount of regular exercise and/or weight training
	Presence of opportunistic infections, fever, and diarrhea
	History of eating disorders
	Social and financial issues affecting food availability or preparation
	Dietary history and intake (24-h recall; 3-d food record; food frequency questionnaire)
	Use of alcohol, narcotics, and stimulants
Measurements	Height
	Weight
	Body mass index (kg/m^2)
	Waist circumference
	Hip circumference
	Waist-hip ratio
Laboratory	Serum albumin
	Vitamin B_{12} level
	Serum free testosterone level
	Fasting lipid profile
	Fasting glucose

NOTE. Adapted from [25].

ments are crucial in identifying persons with HIV who are at risk for serious consequences of malnutrition.

Other measures of nutritional status also predict outcome with HIV infection. Studies by Chlebowski et al. and others showed that serum albumin levels predicted survival [1, 3]. Micronutrient deficiencies are common in HIV infection. Deficiencies in serum vitamin A, vitamin B_{12}, selenium, and zinc, in particular, have been associated with progression of HIV infection [12–15]. Thus, measurements of serum proteins and micronutrients can predict outcome and may identify correctable deficiencies.

Lipodystrophy, or the syndrome of fat redistribution, has been described in HIV infection and may be related to antiretroviral therapy [16–18]. Regional measures of fat must be made both to detect changes in fat distribution and to plan intervention strategies.

BASELINE ASSESSMENT OF NUTRITIONAL STATUS

A baseline nutritional assessment should be considered a standard of care for all HIV-infected individuals. Development and adoption of national recommendations for a baseline nutritional assessment protocol that is practical for routine clinical settings would greatly facilitate the introduction of nutritional assessment into clinical practice.

Standard nutritional assessment methods have been applied to the HIV-infected population [19–24]. To date, nutritional assessment guidelines for HIV disease have been developed by the American Dietetic Association (ADA) and by some AIDS organizations [22]. Because of the cumbersome nature of the ADA document and the lack of dietitians trained in HIV-related issues in many clinical settings, it is thought that nutrition guidelines similar in nature to the HIV treatment guidelines would provide a standardized model for all health care practitioners caring for HIV infected persons.

Baseline nutritional assessment (table 1) can be remembered by the mnemonic "ABCD," which stands for an evaluation of anthropometric, biochemical, clinical, and dietary parameters [25]. The most critical baseline anthropometric measurements are a baseline height and weight. Recording of weight history, percentage of usual weight, and weight change over time is essential, although not universally practiced. Nutritional interventions can improve weight [26]. Calculation of BMI allows comparison of an individual with population standards [27, 28], and an abrupt decline in BMI predicts progression to AIDS [10]. BMI is calculated from measurements of height and weight, as follows: BMI = (weight in kilograms)/(height in meters)^2, or BMI = $704 \times$ (weight in pounds)/(height in inches)^2. Further measures of body composition are also needed, as discussed below, to identify losses of lean body mass or body cell

mass that has been associated with increased mortality in patients with HIV [1, 6, 8, 29].

Biochemical assessment uses laboratory measurements of serum protein, serum micronutrient levels, serum lipids, and immunological parameters to assess general nutritional status and to identify specific nutritional deficiencies. Specific laboratory tests most frequently used include measurements of albumin, prealbumin, hemoglobin, serum iron, total iron-binding capacity, magnesium, vitamin levels, trace elements, cholesterol, triglycerides, fasting glucose, CD4, CD8, virus load of HIV, renal function, and liver enzyme levels [22].

Clinical assessment includes a medical history and a physical examination to identify signs of or contributors to malnutrition. Key areas in the clinical assessment include physical appearance, evaluation of opportunistic infections and comorbid conditions, occurrence of diarrhea, symptoms of gastrointestinal distress or malabsorption, medications, use of nutritional or herbal supplements, and functional status. Assessment of social, psychological, and financial resources that may affect an individual's ability to obtain, prepare, and eat food are as important as the medical assessment in evaluating nutritional risk factors.

The dietary intake component of the nutritional assessment examines adequacy of the current diet for micronutrient as well as macronutrient composition, identifies factors affecting adequate intake, and identifies food intolerances that may affect intake and proper medication regimens [22]. It is the goal of dietary assessment and subsequent education and counseling to prevent loss of weight and lean body mass and to determine measures that may improve the overall health of a patient. Both 24-h recall and diet history have been shown to provide good estimates of dietary intake for a baseline assessment; these methods compare favorably with weighed food records and food frequency questionnaires [30–32].

Current guidelines from the ADA call for a baseline nutritional assessment to be conducted soon after an HIV diagnosis, with follow-up assessments 1–2 times a year for the asymptomatic patient and 2–6 times a year for the patient experiencing symptoms or with an AIDS diagnosis [22]. It is recognized that each patient differs in the course of HIV infection. Some patients may require more frequent monitoring on a monthly basis until stable, whereas others may require much less monitoring. National guidelines will enable practitioners to better determine who needs counseling and how aggressive that counseling needs to be.

BODY COMPOSITION MEASUREMENTS

Anthropometry, which consists of body dimension and subcutaneous fat measures, is a noninvasive method of evaluation used to characterize body composition and growth or other changes related to nutritional status [33, 34]. Combinations of measures at various sites have been used to compare individuals to population norms. Multiple regression equations have been developed to predict body density and to calculate fat and fat-free mass. Standardized methods of anthropometric measurement have been developed and are used to characterize populations [35, 36]. In HIV disease, anthropometric measurements provide an inexpensive and noninvasive means to monitor long-term nutritional status, characterize body fat deposition, and assist in screening for nutritional risk [37]. Lean body mass changes measured by anthropometry have been shown to agree well with lean body mass changes measured by dual X-ray absorptiometry (DXA) in patients with HIV infection and therefore may be regarded as a valid tool for prospectively following patients in clinical practice [38].

Disease, genetics, and other variations from a healthy, lean population will alter the usefulness of anthropometry in short-term evaluations. There may be significant differences in individual fat distribution and a difference in the response of each body landmark to added or lost weight and fat. In addition, there are a range of relationships between total body fat and subcutaneous and visceral fat stores [39]. In the era of lipodystrophy, the usual regression equations developed to predict body density may not be appropriate, and thus anthropometry may provide less accurate measures of total body fat but may be useful in detecting regional changes. Anthropometric measurement may be less helpful in short-term illness when an increase in tissue fluids occur along with a decrease in cellular mass. In addition, accurate measurement depends on appropriately trained and standardized observers. Measurements that can provide estimates of lean body mass, body cell mass, and extracellular fluid can be helpful to better define nutritional risk and physiologic changes [38, 40, 41].

Single-frequency (50 kHz) bioelectric impedance analysis (BIA) has been evaluated for its ability to estimate lean body mass, total body water, extracellular fluid, and body cell mass [42–44]. It is a quick, noninvasive, and relatively inexpensive way to assess body composition. Factors affecting impedance measures include body position, recent exercise, and, to a smaller degree, recent meals and time spent in the supine position [45]. Care should be taken to standardize measures and to record accurate data, including measured weight and height. Significant alterations in body composition evaluation in HIV disease have been characterized by BIA [3].

Several regression equations have been formulated through correlation with criterion methods of hydrodensitometry, DXA, total body potassium counts, and deuterium oxide perfusion to predict body compartment volume of fat, fat-free mass, body cell mass, and total body water [44, 46–49]. Equations used to translate an impedance measure into clinically meaningful estimates of tissues, however, do not always take into account

injury and disease [48–50]. The accuracy of BIA may vary not only by equations but by sex and percentage of body fat [51]. In addition, BIA measures only whole-body fat and lean body mass. Thus, it cannot diagnose abnormalities of fat redistribution and may be inaccurate in the setting of lipodystrophy. In view of the limitations of BIA, it is crucial to develop and validate BIA equations specific for the population and disease in which the technique is to be applied. Two studies have validated BIA against reference methods (intracellular water or total body potassium measurements) for measuring body cell mass in patients with HIV infection [49, 52].

Other techniques, such as DXA, correlate well when compared with reference standards such as total body potassium measurements [51]. However, these are available only in research settings. Cross-sectional area of muscle has been shown to be a good predictor of functional status [53].

ASSESSMENT OF MORPHOLOGIC CHANGES

Methods to assess the morphologic changes associated with lipodystrophy and fat redistribution are still being developed. Standardization of measurements of fat distribution is needed and could be provided by national nutritional guidelines. Measurements that have been used include direct patient self-assessment, anthropometry with waist-hip circumference ratios, single slice and volumetric measurement of visceral fat by CT or MRI scan, and regional fat measurements by DXA [17, 18, 54–57].

ASSESSMENT OF NUTRITIONAL STATUS IN CHILDREN

Because HIV-infected children are at high risk of malnutrition and failure to thrive, nutritional assessment and interventions are of paramount importance. Children have unique nutritional needs related to the physiological demands of growth and development, and the consequences of malnutrition can be devastating, resulting in growth retardation, increased susceptibility to infection, and decreased functional capacity [58–61]. As with adults, nutritional assessment includes anthropometric, biochemical, clinical, and dietary parameters that include techniques and strategies specifically developed for children.

Anthropometric assessment of HIV-infected children should include serial measurements of weight and height, assessed via standardized methods, which are plotted on CDC–National Center for Health Statistics (NCHS) growth charts as weight for age, height for age and weight for height [22]. Weight and height are sensitive indexes of nutritional status in children, and tracking trends over time ensures early identification of nutritional deficits, wasting, or growth failure [58, 61]. BMI is calculated and compared with percentiles for age on CDC/NCHS BMI growth charts for children aged 2–18 years. Midarm circumference, subscapular and triceps skinfolds, and midarm muscle circumference/area in children aged >1 year reflect fat and lean body mass stores [22, 58]. BIA has been used to assess body composition in HIV-infected children, but interpretation of the results is difficult because of lack of standards for children [22, 58, 60]. Children may experience morphologic changes attributable to lipodystrophy, including loss of subcutaneous adipose tissue, facial wasting, and visceral fat accumulation. A multifaceted approach including patient self-reporting and measurements of abdominal circumference and skinfolds may be useful in identifying changes over time [58, 62]. DXA and CT and MRI scans to assess body composition in children remain largely research tools and are not widely available in the clinical setting.

Biochemical assessment in children includes laboratory measurements similar to those used for adults. The nutritional implications of laboratory values must be considered in the context of other parameters of the nutritional assessment. Clinical assessment parameters specific to children include detailed medical history and physical examination. Special attention is paid to the presence of gastrointestinal disease or opportunistic infections that affect nutritional health, medications, dental health, developmental assessment, neurological disease, and behavioral issues. With infants, it is important to consider perinatal factors such as nutrition of the mother, exposure to drugs or alcohol, birth weight, and birth history, because these may affect feeding ability, growth, and development. The nutritional status of dependent children is also influenced by their caregiver's health, psychosocial environment, cultural practices, and financial status.

The assessment of dietary intake in children reviews past dietary intake, examines factors affecting current intake, determines macronutrient and micronutrient requirements and the ability to meet them, and identifies risks for nutritional problems. Key areas that should be explored include the following:

- appetite, expression of hunger, and satiety
- duration of meals and feeding dynamics between child and caregiver
- feeding ability and tolerance
- appropriateness of infant diet and preparation of infant formula
- use of appropriate food and water safety strategies
- quality of diet and food availability
- food-medication interactions
- use of vitamin or herbal therapies
- use of drugs/alcohol by the child or caregiver.

Early and regular nutritional assessment of HIV-infected children facilitates early nutritional intervention strategies de-

signed to maintain normal growth and development, to prevent nutrient deficits, to support the immune system, and to improve quality of life.

CONCLUSIONS

Nutritional assessment in HIV-infected persons can identify those at risk for adverse outcomes, including death, from nutritional deficiencies. Minimally invasive, proven, and acceptable methods exist for accurate nutritional assessment. National guidelines for adults and children with HIV are needed to provide the information and impetus for appropriate nutritional screening and intervention in persons with HIV infection.

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