CLINICAL MANAGEMENT

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Nutrition: A Critical Component of Wound Healing

CME
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This continuing educational activity will expire for physicians on December 31, 2011.

PURPOSE:

To enhance the clinician's competence in using nutrition as an integral part of wound healing.

TARGET AUDIENCE:

This continuing education activity is intended for physicians and nurses with an interest in skin and wound care.

OBJECTIVES:

After participating in this educational activity, the participant should be better able to:

1. **Analyze the effects of specific nutritional deficiencies and patient parameters on wound healing capabilities.**
2. **Accurately interpret laboratory values related to nutritional status.**
3. **Apply evidence-based nutrition guidelines for improved wound healing.**

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INTRODUCTION

With the spotlight on elaborate support surfaces, high-tech surgeries, complex wound care treatments, and products, it is easy to lose sight of the basic concept of nutrition. More than just food, nutrition encompasses the many nutrients, calories, vitamins, minerals, and fluids taken into the body, which are vital to wound healing.

Reading this article will help the clinician to better understand the importance of screening, referral for a comprehensive nutrition assessment by the registered dietitian (RD), and the development of a care plan for the prevention and/or treatment of wounds. Based on the nutrition assessment, the most appropriate interventions are chosen to manage the individual's current condition. Nutrition interventions discussed are based

on current guidelines and protocols that should be revised by the healthcare team as new research data become available.

Incorporating nutrition as part of the overall treatment plan promotes healing, improves quality of life, and contributes to reduced length of treatment.[1,2]

NUTRITION SCREENING

When an individual enters a healthcare setting, nutrition should be included in the initial screening process. Screening identifies an individual at nutritional risk who requires referral to the appropriate professional, usually an RD, for a comprehensive nutrition assessment. Any qualified member of the healthcare team, including the RD, dietetic technician registered, registered nurse, or physician, may complete the screening. Institutions should establish specific protocols for identifying patients at nutrition risk that are linked to a course of action and include referral time frames that are appropriate for their setting. Referral to the RD for assessment should be timely; for example, this should be done within 48 hours in an acute-care setting.

Validated nutrition screening tools include the Mini-Nutritional Assessment–Short Form (MNA-SF), the Malnutrition Universal Screening Tool (MUST),[3] and the Malnutrition Screening Tool (MST).[4] The MUST nutritional risk screen was developed in the United Kingdom to identify adults who are underweight and at risk of malnutrition. It has been validated in acute care, long-term care, and in the community. The MST screening tool is valid and reliable for identifying nutrition problems in acute care and ambulatory care.[5] The MNA-SF was revised to a 6-item screening tool and revalidated as a standalone screening tool. The tool has 3 cutoff points, allowing clinicians to quickly identify those who are malnourished.[6,7] The maximum score is 14. Scores of 12 to 14 indicate well nourished, scores of 8 to 11 indicate nutrition risk, and scores of 0 to 7 indicate that the individual is malnourished. The MNA-SF has been validated to identify malnutrition in older adults, age 65 and older, residing in the community or institutional settings. It has a 80% sensitivity specificity and 97% positive predictive value according to clinical status.[7] Another tool, the Simple Nutrition Appetite Questionnaire, measures appetite loss in older persons and predicts weight loss over the next 6 months.[8] Screening tools should be quick, easy to use, validated, and reliable for the patient population served.[5]

The Braden Risk Assessment Scale: Predicting pressure ulcer (PrU) risk (Braden Scale) includes a nutrition subscale that provides data that can be used in the nutrition screening and assessment process.[9] There are many other PrU risk assessment tools, such as the Norton Scale, Gosnell Scale, Knoll Scale, and the Warterlow Scale, but they do not include a nutrition component.

Although validated tools are preferred, they are not widely used. Review the screening tools currently used in your institution. Do they include basic information on weight, weight change, dietary intake, and functional capacity? Recent unintended weight loss (UWL), digestive problems, poor appetite, the inability to consume adequate food or fluid, neuropsychological problems (dementia or depression), dysphagia, PrUs, or other wounds are all trigger conditions requiring immediate assessment and intervention.

THE NUTRITION CARE PROCESS AND COMPREHENSIVE NUTRITION ASSESSMENT

The American Dietetic Association's Nutrition Care Process is the criterion standard for nutrition practice. It includes 4 components for medical nutrition therapy (MNT): nutrition assessment, nutrition diagnosis, nutrition intervention, and nutrition monitoring and evaluation.[10]

Nutrition assessment is an ongoing process of obtaining and interpreting data to determine the best possible nutrition interventions for the individual. Although in nursing homes, clinicians use the MDS 3.0 Resident Assessment Instrument, this tool does not include adequate information for a comprehensive nutrition assessment. The RD must complete an additional assessment to develop nutrition interventions that are appropriate for each individual's nutrition-related care. The MNA is the only validated nutrition assessment tool for persons 65 years or older but may not be suitable for all ages and disease states.[7] The Subjective Global Assessment addresses weight change, dietary intake, gestational intentional symptoms, functional capacity, and disease states. Research indicates it is superior to any biochemical nutrition marker alone in assessing for malnutrition. However, it is primarily used in the surgical and medical population.[11]

The comprehensive nutrition assessment provides the initial step of the nutrition care process in which the RD reviews all pertinent data including, but not limited to, anthropometric measurements, biochemical data, physical examination, and diet history. After completing the nutrition assessment, the RD can complete the nutrition diagnosis and determine appropriate nutrition interventions.

ANTHROPOMETRIC MEASUREMENTS

The RD reviews height, weight, and body mass index (BMI). Height should be measured within the past year and must be accurate to determine an appropriate body weight. An accurate height is important for the MDS assessment and because it may be used to determine caloric needs. Table 1 describes procedures for obtaining accurate heights. The review of weights includes current body weight, usual body weight, and changes in weight from usual body weight. Unintended weight loss is a risk factor for PrU development and poor wound healing.[12,13] Table 2

Table 1.
HOW TO OBTAIN ACCURATE HEIGHTS

To obtain an accurate height, the following methods may be used.

Standing Height

- To obtain an accurate height, measure the individual without shoes, standing as erect as possible.
- If using the measuring bar on the scale, it should be placed flat on the head.
- Read the measurement on the bar and record immediately.

If Using a Yardstick

- Have the individual stand against a wall, as erect as possible.
- Place the yardstick parallel to the floor, on top of the individual's head.
- Mark the wall at the top of the individual's head, using the yardstick as a guide.
- Measure from the floor to the mark (where the top of the individual's head was).

How to Obtain a Reclining Height

- The individual should lie flat, with 1 arm extended out in a 90-degree angle to the torso.
- With the individual's arm and hand extended straight out, use a tape measure to measure from the middle of the sternum to the tip of the middle finger.
- Double this number for an approximate height in inches.
- Document this height as an approximate height.

Unable to Obtain Accurate Height Measurements

- If for some reason you are unable to obtain an accurate height measurement, ask the family what the individual's normal height was.
- Document that the family provided the height because you are unable to get an accurate height on the individual.

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indicates definitions for significant/severe weight changes. Accurate weight measurements are critical in determining significant changes from usual weight. Staff should be well trained on taking accurate weights, and a documentation system should be utilized to ensure accurate recording of weights, as well as calculation of significant or severe changes in weight. Table 3 describes procedures for obtaining accurate weights. BMI can help determine the level of obesity or malnutrition. BMI is determined using the following formula: weight (in kilograms)/height (in meters squared), or weight (in pounds)/height (in inches squared) × 705. A BMI of 30 or greater indicates obesity, whereas a BMI of less than 19 may indicate undernutrition and/or risk for protein energy malnutrition, increased morbidity/mortality, and PrU development.[14–18]

BIOCHEMICAL DATA

Review of biochemical data is one aspect of the total nutrition assessment; however, caution should be applied when interpreting laboratory data. Laboratory values can be affected by numerous factors including hydration status, medications, and alterations in metabolism. Contrary to historical belief, unfortunately there is no laboratory test that can specifically determine nutritional status. Clinicians should consider evaluation of laboratory values as one aspect of the comprehensive assessment along with other factors such as oral intake, changes in body weight, medications, and diagnosis.

Although useful in determining overall prognosis or level of morbidity, prealbumin and albumin do not correlate well with clinical observation of nutritional status.[18,19] Historically used for this purpose, these laboratories are poor indicators of visceral protein status because they are affected by hydration status, changes in metabolism, infection, acute stress, and other factors. Synthesized by the liver, albumin's long half-life of 12 to 21 days results in slow changes. These changes may reflect many factors including liver disease, sepsis, congestive heart failure, renal disease, and cytokine-induced inflammatory status.[20] During periods of inflammation, cytokine production may cause albumin to be circulated back to the liver, causing a decrease in serum albumin levels, whereas dehydration can falsely elevate albumin levels.

Prealbumin, with its short half-life of 2 to 3 days, was historically thought to be a more accurate indicator of nutritional status. Unfortunately, it is subject to the same factors that influence albumin levels, making it also problematic. Prealbumin levels may decrease due to metabolic stress and inflammation, and levels may be maintained despite malnutrition, making it a poor marker of nutritional status.[21–30]

The value of monitoring prealbumin and albumin levels is that low levels can reflect how ill a person is, therefore reflecting risk of UWL, undernutrition, and protein energy malnutrition. People with these risk factors can benefit from comprehensive

Table 2.
SIGNIFICANT/SEVERE WEIGHT CHANGES

Suggested parameters for evaluating significance of unplanned and undesired weight loss are

Interval	Significant Loss	Severe Loss
1 mo	5%	>5%
3 mo	7.5%	>7.5%
6 mo	10%	>10%

The following formula determines percentage of weight loss: % of body weight loss = (usual weight − actual weight) / (usual weight) × 100.
Source: Centers for Medicare & Medicaid Services. State Operations Manual, Guidance to Surveyors for Long Term Care Facilities. Appendix PP. http://www.cms.gov/manuals/Downloads/som107ap_pp_guidelines_ltcf.pdf. Revision December 2, 2009. Last accessed September 7, 2010.

Table 3.
HOW TO OBTAIN ACCURATE WEIGHTS

To Obtain Accurate Weight
- Do not move scales from place to place.
- Balance the scale back to 0 before and after weighing each time.
- Record weight immediately after weighing each individual.
- Weigh each individual at the same time each month, and record the weight using the documentation system provided by the facility.
- Individuals should be weighed at approximately the same time of day each time.
- Individuals should be weighed in light clothing, without shoes, prior to breakfast, after voiding, and without catheter bag or with an empty catheter bag (if applicable).
- Prosthetic devices (including braces) should be removed prior to weighing. Or weigh the prosthetic device itself and subtract its weight from the individual's total weight.
- Nursing must document any casts, or appliances such as splints, and so on.
- Scales should be calibrated on a regular schedule every 3 months.

Standing Scale Weight
- Position the individual standing with feet in the center of the scale (must be able to stand without assistance).
- When the scale is balanced and has stopped its movement, record the weight.
- If an individual is unable to stand still and balance on the scale independently, a wheelchair, chair scale, or bed scale should be used.

Chair Scale Weight
- Position the individual in the center of the chair, with back resting on the back of chair.
- When the scale is balanced and has stopped its movement, record the weight.

Wheelchair Scale Weights
- Be sure the chair is free of extra weight (ie, side bags, catheter bags, cushions, or other items).
- Roll the wheelchair onto the wheelchair scale platform.
- Center the wheelchair on the scale.
- Weigh the wheelchair and record the total weight of the wheelchair and the individual.
- Remove the individual from the wheelchair. Weigh the wheelchair by itself.
- Carefully subtract the weight of the wheelchair and record the individual's actual weight.

assessment, aggressive interventions, and monitoring of oral intake and weight.

Because oxygen is carried by the blood to the wound bed, the presence of anemia may have an adverse effect on wound healing. Iron deficiency anemia may be the result of blood loss, poor dietary intake, malabsorption, or increased iron needs. Laboratory values used to diagnose iron deficiency anemia include low hemoglobin and hematocrit, low mean corpuscular volume (MCV), low serum iron, low ferritin, and elevated total iron-binding capacity (TIBC). Treatment for iron deficiency anemia is oral iron therapy.

Table 3.
HOW TO OBTAIN ACCURATE WEIGHTS, CONTINUED

Bed Scale Weights
- Follow manufacturer's directions for proper operation of bed scales and lift scales.
- Use the bed scale or lift scale sling to lift the individual for weighing.
- The individual should be positioned comfortably in the scale sling.
- Raise the sling slowly until it is fully suspended and still.
- Read and record weight immediately.
- Lower the person back onto the bed slowly and gently.

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Pernicious anemia or vitamin B12 deficiency is seen often in older adults and is commonly caused by inadequate intrinsic factor. Without adequate intrinsic factor, vitamin B12 cannot be properly absorbed. Laboratory results include low hemoglobin, hematocrit, and serum B12; normal or elevated MCV; and elevated serum iron, ferritin, folate, and homocysteine. Pernicious anemia is treated with vitamin B12 (oral, nasal spray, patch, or monthly injections).

Megaloblastic anemia or folate deficiency is common in adults and may be due to malabsorption of folate, vitamin B12 deficiency, deficient diet, or increased needs for folate. It is characterized by low hemoglobin, hematocrit, and folate and elevated MCV, serum iron, ferritin, and homocysteine. Megaloblastic anemia is treated with cobalamin (vitamin B12) and folate. Anemia of chronic disease is often seen in older adults and in individuals with certain diseases, such as congestive heart failure, chronic renal failure, AIDS, gastroesophageal reflux disease, and Crohn disease. Laboratory values with anemia of chronic disease indicate low hemoglobin, hematocrit, serum iron, and TIBC, but MCV and ferritin are within normal limits.[31] Table 4 provides a summary of laboratory assessment of anemia.

HYDRATION STATUS

In addition to the clinical examination, hydration status can be evaluated by reviewing significant weight changes and fluid intake records (when available) and by examining certain laboratory

Table 4.
LABORATORY ASSESSMENT OF ANEMIAS

Type of Anemia	Hemoglobin	Hematocrit	MCV	Serum Iron	Ferritin	TIBC	Folate	Homocysteine	Vitamin B_{12}
Iron deficiency anemia	↓	↓	↓	↓	↓	↑	NA	NA	NA
Pernicious anemia	↓	↓	↑ or WNL	↑	↑	NA	↑	↑	↓
Megaloblastic anemia	↓	↓	↑	↑	↑	NA	↓	↑	↓ or WNL
Anemia of chronic disease	↓	↓	WNL	↓	WNL	↓	NA	NA	WNL

Based on information from Litchford.[29]

values. If an individual has had a significant weight loss, the clinician should review fluid intake records to determine whether the weight loss could be related to fluid loss, which may lead to dehydration.

A review of laboratory values can help determine if dehydration is a problem and what type of dehydration is occurring, or alternately, whether overhydration may be an issue. There are 3 types of dehydration that are possible: hypertonic, isotonic, and hypotonic. When body water losses are greater than sodium losses, hypertonic dehydration occurs. In this case, water needs to be replaced. When losses of body water and sodium are equal, isotonic dehydration occurs. In this case, fluid and sodium are needed to rehydrate. And when sodium loss exceeds body water loss (hyponatremia), hypotonic dehydration occurs. Water and electrolyte solutions are needed in these cases to reestablish balance.[31]

Alternately, overhydration can also be problematic. Overhydration is also categorized by level of sodium and water balance as hypertonic, isotonic, or hypotonic. To evaluate hydration status, clinicians will want to review serum osmolality, serum sodium, hemoglobin/hematocrit, serum albumin, blood urea nitrogen, and, for accurate assessment of dehydration, urine specific gravity (which will be greater than normal in hypertonic and isotonic dehydration and lower than normal in hypotonic dehydration). Table 5 provides a summary of the typical pattern of values for laboratory assessment of hydration status. Please note that other comorbidities may contribute inconsistencies in test results.[31]

NUTRITION-FOCUSED CLINICAL EXAMINATION

A complete nutritional assessment should include a nutrition-focused clinical examination. Many clues about the patient's nutritional status are revealed by evaluating the hair, eyes, teeth and gums, tongue, skin, nails, abdomen, and extremities.

A physical examination typically begins with a general inspection of the body and skin and moves from the head downward. Upon overall inspection, a wasted, skinny appearance indicates an inadequate intake of total energy. Protein-energy malnutrition is revealed in many areas of the body and may show up as the following: loss of appetite, flaking dermatitis, pigmentation changes in the skin, temporal muscle wasting, distended abdomen, hepatomegaly, and muscle wasting and weakness of the extremities. A protein deficiency may be revealed by edema of the extremities and transverse lines on the nails.[32]

Table 5.
LABORATORY ASSESSMENT OF HYDRATION STATUS[29]

	Indication of Dehydration			Indication of Overhydration		
Laboratory Value	Hypertonic	Isotonic	Hypotonic	Hypertonic	Isotonic	Hypotonic
Serum osmolality	>Normal	WNL	<Normal	>Normal	WNL	<Normal
Serum sodium	>Normal	WNL	<Normal	>Normal	WNL	<Normal
Hemoglobin/hematocrit	>Normal	>Normal	>Normal	<Normal	WNL or slightly low	<Normal
Serum albumin	>Normal	>Normal	>Normal	<Normal	WNL or slightly low	<Normal
Blood urea nitrogen	>Normal	>Normal	>Normal	<Normal	WNL or slightly low	<Normal

Table 6.
PHYSICAL MANIFESTATIONS OF VITAMIN AND MINERAL DEFICIENCIES

Physical Signs of Deficiency	Associated Vitamin or Mineral
Hair follicle blockage with a permanent ''goose-bump'' appearance Dry, rough, skin Small, grayish, foamy deposits on the conjunctiva adjacent to the cornea Drying of the eyes and mucous membranes	Vitamin A
Small hemorrhages in the skin or mucous membranes	Vitamin K
Weight loss Muscular wasting Sometimes edema (wet beriberi) Malaise Tense calf muscles Distended neck veins Jerky movement of eyes Staggering gait and difficulty walking Infants may develop cyanosis Round, swollen (moon) face Foot and wrist drop	Thiamine
Tearing, burning, and itching of the eyes with fissuring in the corners of the eyes Soreness and burning of the lips, mouth, and tongue with fissuring and/or cracking of the lips and corners of the mouth Purple swollen tongue Seborrhea of the skin in the nasolabial folds, scrotum, or vulva Capillary overgrowth around the corneas	Riboflavin
Dermatitis or skin eruptions Tremors Sore tongue Skin that is exposed to sunlight will develop cracks and a scaly form of dermatitis with pigmentation May also show signs of riboflavin deficiency	Niacin

Table 6.
PHYSICAL MANIFESTATIONS OF VITAMIN AND MINERAL DEFICIENCIES, CONTINUED

Physical Signs of Deficiency	Associated Vitamin or Mineral
Tongue inflammation Inflammation of the lining of the mouth Fissures in the corners of the mouth	Vitamin B6
Weakness, fatigue, and depression Pallor Dermatologic lesions	Folate
Lemon-yellow tint to the skin and eyes Smooth, red, thickened tongue	Vitamin B12
Impaired wound healing Edema Swollen, bleeding, and/or retracted gums or tooth loss; mottled teeth; enamel erosion Lethargy and fatigue Skin lesions Small red or purplish pinpoint discolorations on the skin or mucous membranes (petechiae) Darkened skin around the hair follicles Corkscrew hair or unemerged, coiled hair	Vitamin C
Tremors, muscle spasms, and tetany Personality changes	Magnesium
Skin pallor Pale conjunctiva Fatigue Thin, concave nails with raised edges	Iron
Delayed wound healing Hair loss Skin lesions Eye lesions Nasolabial seborrhea	Zinc
Hair and skin depigmentation Pallor	Copper
Goiter	Iodine
Corneal lesions	Chromium

The hair should be shiny and firm in the scalp. If the hair looks dull, brittle, or loose and falls out easily, it may be a sign of protein energy malnutrition. The eyes should be clear and bright and adjust to light easily. Signs of nutritional problems include eyes with pale membranes, spots, redness, and difficulty adjusting to darkness. These problems may indicate deficiencies of vitamin A, B vitamins, iron, and/or zinc.[33]

An oral examination is an important part of a nutritional evaluation. After having the patient remove any dental appliances, use a tongue blade and bright light to inspect the buccal mucosa, gums, and teeth. The mucous membrane should be pinkish red, smooth, and moist. Be sure to note any lesions or inflammation that may be present. The gums should have a slightly stippled, pink appearance with a clearly defined, tight margin at each tooth. The surface of the gums beneath dentures should be free of inflammation, swelling, or bleeding. Bleeding gums may be the result of ill-fitting dentures or indicative of a vitamin C or riboflavin deficiency. A healthy tongue is red, bumpy, and rough. A patient with a smooth tongue or one that is purple or swollen may be suffering from B vitamin deficiencies.[33]

The skin is examined using inspection and palpitation, with the most important tools being your own eyes and powers of observation. Begin by inspecting the skin for color and uniform appearance, thickness, symmetry, hygiene, and the presence of any lesions, tears, bruising, edema, rashes, or flakiness. The skin should be palpated to examine temperature, texture, and turgor. Minimal perspiration or oiliness should be present, and the skin should range from cool to warm to the touch. The texture should be smooth, soft, and even. To assess turgor and mobility, gently pinch a small section of skin on the forearm or sternal area between the thumb and forefinger and then release the skin. The skin should feel resilient, move easily when pinched, and return to place immediately when released. Turgor will be altered if the patient is dehydrated or if edema is present. If you encounter any skin lesions (a catchall term that collectively describes any pathological skin change or occurrence), then describe them according to the following characteristics: configuration (ie, size, shape, color, texture, elevation, or depression), exudates (ie, color, odor, amount, consistency), and location and distribution on the body.[33]

Table 6 delineates additional physical manifestations of various vitamin and mineral deficiencies.

DIET HISTORY

The final component of a thorough nutritional assessment is obtaining a diet history. A diet history is defined as a detailed dietary record. This may include data collection tools, such as a 24-hour recall, a food frequency questionnaire, or other means of ascertaining the usual foods consumed by the subject. Table 7 lists various methods of obtaining dietary intake information. Beyond the actual food consumed, questions should be asked pertaining to vitamin and mineral supplements, herbal preparations, and any other over-the-counter remedies the subject might consume.

As the world becomes more multicultural, it is important to ask the patient questions about any cultural or religious beliefs that may influence dietary habits. According to census data, as of 2008, 1 in 3 US citizens was a minority. Hispanics are the largest minority group, totaling 15.1% of the population, whereas African Americans are the second largest group.[34] The increase in ethnic and racial minorities poses challenges for clinicians. Practitioners must understand the underlying factors that influence individual decisions about nutrition, including culture, religion, belief systems, values, and food practices of ethnic and minority groups. In some cultures or religions, beliefs can strongly influence food intake and therefore have an effect on nutritional status.

The practitioner may find it helpful to assess cultural influence on food habits using the pneumonic ABCDE[35]:

- **A**ttitudes of clients and families within their culture
- **B**eliefs, such as religious beliefs and traditions

Table 7.
METHODS FOR OBTAINING DIETARY INTAKE INFORMATION

24-h Recall
- Information on food and fluid intake for the previous day or the previous 24 h.
- Accuracy of amounts consumed may be enhanced by having food models or illustrations of usual portion sizes available to make comparisons.

Food-frequency questionnaire
- A list of foods or food groups—the subject provides information on the frequency of consumption of each food, food group, or beverage.
- Often used in conjunction with a 24-h recall.

Food record or diary
- Subject provides 3 to 7 days of actual food consumption.
- One weekend day is typically included.

Direct observation
- Most practical for hospitalized patients or individuals in residential facilities.

Includes ''calorie counts,'' which are a recording of the specific foods served and consumed by the patient. These data are then used to estimate the actual number of calories consumed.

• **C**ontent, such as personal history, including economics, emigration, and the role of food in the family
• **D**ecision-making style within the family and culture
• **E**nvironment, such as interpreters of culture or language.

When interviewing patients and/or families, it is important to consider differences in communication styles between American/Western and non-Western cultures. For example, eye contact is valued by the white American but is considered impolite for many Asian and Native Americans. And greetings on a first-name basis may be interpreted as disrespectful in some cultures.

Once a thorough diet history is obtained and evaluated by a qualified healthcare professional, recommendations can be made regarding the proper diet and supplementation program.

FUNCTION OF NUTRIENTS

Carbohydrates

The body's first priority is for adequate energy (kilocalories) provided from carbohydrate, protein, and fat. When the total amount of calories consumed is too low, protein from both the diet and the individual's muscle stores will be used as an energy source, thus increasing the caloric requirements needed to promote anabolism and reverse catabolism.[36]

Carbohydrates provide energy and prevent gluconeogenesis when the body is forced to convert protein stores for energy use. An inadequate supply of carbohydrates can lead to muscle wasting loss of subcutaneous tissue and poor wound healing. Grains, fruits, and vegetables with complex carbohydrates are the preferred source.

Fat

Fat is the most concentrated source of energy and triglycerides. Fat carries the fat-soluble vitamins (A, D, E, K) and provides insulation under the skin and padding to bony prominences. Meats, eggs, dairy products, and vegetable oils contain fat.

Protein and Amino Acids

Protein is the only nutrient containing nitrogen and is composed of amino acids, which are the building blocks of protein. It is essential to promote positive nitrogen balance and is linked to improved healing rates.[37] Protein is responsible for
• repair and synthesis of enzymes involved in wound healing
• cell multiplication
• collagen and connective tissue synthesis
• component of antibodies needed for immune system function.

Dietary proteins that provide all 9 of the essential amino acids are considered complete proteins. Food sources of complete protein include meat, poultry, fish, eggs, milk products, and soybeans. The body needs an adequate supply of the essential amino acids and enough nitrogen and energy for the synthesis of the 11 other amino acids. Legumes, grains, and vegetables provide incomplete proteins.

Certain nonessential amino acids become conditionally essential during periods of trauma, such as thermal injury, sepsis, PrUs, etc. l-Arginine is 32% nitrogen and in some studies has been shown to increase concentrations of hydroxyproline, which is an indicator of collagen deposition and protein in the wound site.[38–40] Glutamine has been shown to be used by inflammatory cells within the wound for proliferation and as a source of energy. Studies on the effectiveness of consuming supplements containing arginine and glutamine are inconclusive; thus, additional research is needed to determine the impact of both arginine and glutamine on PrU healing.[41,42]

Water

Water constitutes for 60% of an adult's weight and is distributed throughout the body in 3 fluid compartments (intracellular, interstitial, and intravascular). Water functions include
• aiding in hydration of wound sites and in oxygen perfusion. Epithelial cells require moisture to migrate from the wound edge to close the wound.
• acting as a solvent for minerals, vitamins, amino acids, glucose, and other small molecules and enabling them to diffuse into and out of cells
• transporting vital materials to cells and removing waste away from cells.

Individuals with draining wounds, emesis, diarrhea, elevated temperature, or increased perspiration need additional fluids to replace fluid lost.[43] A recent study denotes that improving fluid intake may increase tissue oxygenation, which is required for wound healing.[44] The dehydrated individual exhibits weight loss (loss of 1 L of fluid represents a loss of 1 kg, or 2.2 lb), dry skin, and mucous membranes, rapid pulse, decreased venous pressure, subnormal body temperature, low blood pressure, and altered sensation. The American Medical Directors' guideline for the management of dehydration contains practical information for managing hydration in older adults.[43]

Total fluid needs are met from the water content of food plus liquids. Food accounts for 19% to 27% of the total fluid intake of healthy adults.[45]

Vitamins

Water-soluble vitamins C and B are found in the watery compartment of food. They are absorbed into the bloodstream and are excreted if blood concentrations are too high. Foods do not deliver toxic doses of water-soluble vitamins, but large amounts in supplements can reach toxic levels.

Vitamin C enhances activation of leukocytes and macrophages in the wound bed and is essential for collagen synthesis. A deficiency of vitamin C prolongs the healing time and contributes to reduced resistance to infection.[46] There is no clinical evidence that wound healing is improved by providing megadoses of vitamin C above the Dietary Reference Intake (DRI of 70–90 mg/day).[47] Good sources of ascorbic acid are citrus fruits, strawberries, tomatoes, potatoes, tomatoes, broccoli, mangoes, and green peppers.

Coenzymes (B vitamins) are essential for the production of energy from glucose, amino acids, and fat. Pyridoxine (B6) and folic acid assist in the production of red blood cells. Protein foods are rich sources of B6, and folic acid is found in legumes, green leafy vegetables, and foods fortified with folate. Thiamine and riboflavin are needed for adequate cross-linking and collagenation, but their effect has not been demonstrated in PrUs.

Fat-soluble vitamins A, D, E, and K dissolve in fat and are transported in the body attached to lipids. Unlike water-soluble vitamins, they are stored in the liver and fatty tissue until blood concentration declines, and the body retrieves them from storage. Daily consumption of foods rich in fat-soluble vitamins is not necessary, but consuming foods rich in fat-soluble vitamins over time is beneficial.

Vitamin A is responsible for epithelium maintenance, and it also stimulates cellular differentiation in fibroblasts and collagen formation. Vitamin A deficiency, which is uncommon, may result in delayed wound healing and increased susceptibility to infection. Dark green and yellow fruits and vegetables, such as carrots, sweet potatoes, apricots, spinach, and broccoli, are rich sources of vitamin A and beta-carotene.

Vitamin E is an antioxidant responsible for normal fat metabolism and collagen synthesis. The majority of vitamin E comes from vegetable oils and the products made with them, such as salad dressings and margarine. Vitamin E deficiency does not appear to play an active role in wound healing,[48] and it impedes the absorption of vitamin A by reducing the rate of hepatic retinyl ester hydrolysis.[49]

Minerals

Iron is a component of hemoglobin, the oxygen-carrying protein of the red blood cells and is necessary for collagen transport and to generate energy from cells. Transferrin, a blood protein, transports iron to tissues throughout the body. Sources of iron include meat, fish, poultry, and dried beans.

Zinc, a cofactor for collagen formation, also metabolizes protein, liberates vitamin A from storage in the liver, and assists in immune function. Wounds with increased drainage, excessive gastrointestinal losses, or inadequate dietary intake for long periods of time may trigger a zinc deficiency. There is no clinical evidence supporting supplementation, such as with zinc sulfate 200 to 300 mg daily containing more than 40 mg of elemental zinc. The DRI tolerable upper intake level limit for elemental zinc is 40 mg.[50] Zinc is abundant in protein foods such as meat, oysters, and liver.

Copper is responsible for collagen cross-linking and erythropoiesis. High-serum zinc levels may inhibit healing, impair phagocytosis, and interfere with copper metabolism,[34,51] thus inducing a copper deficiency. Food sources of copper include legumes, whole grains, seafood, and nuts. If the diet is inadequate or deficiencies are suspected or confirmed, a multivitamin with minerals, with 100% of the US DRI, is the general recommendation.

Diabetes

The primary goals of MNT in patients with diabetes are to maintain blood-glucose levels in the reference range and achieve optimal body weight, which minimizes future complications of disease. Because the evidence linking diabetes to heart disease and stroke has strengthened during the past decade, it is also important to maintain a lipid and lipoprotein profile that minimizes the risk of macrovascular complications. MNT also helps control blood pressure levels, which is beneficial because many persons with diabetes battle hypertension as well. To achieve these goals, the clinician should educate both the patient and the patient's family members about the role of MNT in diabetes management. The typical diet order restricts calorie, sodium, and fat intake. The patient may need several sessions with a nutrition professional to learn how to manage the therapeutic diet within the context of his/her individual preferences and lifestyle. To facilitate diabetes self-management, Medicare Part B began covering the cost of MNT in 2002 for persons with a diagnosis of diabetes. Patients with wounds should be encouraged to use this new benefit. The patient must have a referral from a physician, and an RD or other approved nutrition professional must provide the services. The benefit consists of an initial visit for an assessment and follow-up visits for intervention and reassessment, as necessary, to ensure compliance with the dietary plan.

RECOMMENDATIONS FOR DIABETES MANAGEMENT[52]

- Many cases of diabetes are undiagnosed. Watch for signs and symptoms of insulin resistance and diabetes, particularly in overweight patients with nonhealing wounds.
- Request a hemoglobin A1C test for patients with risk factors for and symptoms of diabetes. Some patients may have blood-glucose levels in the reference range when a single fingerstick test is

performed, but may have high levels at other times of day. Hemoglobin A1C provides a broader, longer-range picture.

- Diet management must be individualized to each patient's medical condition, ability, and readiness to comply.
- Diet control is no longer simply controlling ''sugar.'' The goal of a diet is to control the entire metabolic syndrome, including obesity, dyslipidemia, and hypertension.
- Portion size is key to weight management. Patients should be encouraged to weigh foods with a food scale until they become well skilled at estimation.
- A multidisciplinary approach should be used to reinforce the importance of controlling blood glucose during wound healing.
- Progressive resistance exercise can offset lean body mass loss and increase the body's anabolic drive.

PRESSURE ULCERS

Undernutrition has been defined as pure protein and energy deficiency, which is reversed solely by the administration of nutrients.[53] Declining nutritional status and factors, such as UWL and reduced food intake, impact the healing process for PrUs. Conditions leading to undernutrition include the inability to eat independently[54] and chewing and swallowing problems. Early nutrition intervention can reverse poor outcomes associated with undernutrition and promote healing. Caloric, protein, and fluid requirements should be individualized and increased or decreased, depending on the nutrition assessment. Hypermetabolic conditions, such as infection, stress, and trauma, require calories above the baseline requirements. Renal function should be assessed routinely to ensure that high levels of protein are appropriate.[55] Certain conditions require the provision of additional fluids for patients with dehydration, elevated temperature, diarrhea, or heavily draining wounds.[43]

Clinicians should periodically review the type and amount of food and fluid consumed to determine when fortified foods and/or oral supplements should be offered to meet the patient's requirements. Fortified foods include commercial products, such as cereal, soup, cookies, or dairy products enriched with additional calories and protein or enriched menu items, such as those listed in Table 8. Research supports the theory of providing oral nutrition supplements to reverse undernutrition and promote PrU healing.[12,13] One particular study indicated that individuals who consume supplements between meals, in addition to the usual diet, experience better absorption of nutrients.[56]

Therapeutic or restricted diets often result in unappealing meals that are refused, thus delaying wound healing. The American Dietetic Association's 2010 position statement notes that the quality of life and nutritional status of older adults residing in healthcare communities can be enhanced by individualization to the least restrictive diet appropriate.[57] Obese patients with PrUs should be evaluated carefully prior to recommending diets restricting calories when the primary goal is wound healing. Ideally, the consumption of a healthy, balanced diet, which includes good sources of vitamins and minerals, is preferred; however, if intake is poor, a vitamin and mineral supplement should be considered.[57]

Table 8.
TIPS FOR ENRICHING MENU ITEMS

- Substitute milk or half and half for water in cream soups, cereal, or instant cocoa.
- Add dry milk to cream soups, hot cereal, mashed potatoes, casseroles, or pudding.
- Add cheese to vegetables, salads, potatoes, rice, noodles, and casseroles.
- Mix commercial supplements with ice cream or sherbet.
- Add yogurt to fruit and cereal.
- Add nuts, seeds, or wheat germ to casseroles, breads, muffins, pancakes, and cookies.
- Sprinkle nuts, seeds, or wheat germ on fruit, cereal, ice cream, or yogurt.
- Add peanut butter to sandwiches, toast, crackers, or muffins; use as a dip for vegetables.
- Add dry beans to soups or casseroles.

When oral intake is inadequate and compromises healing, the RD and the healthcare team may recommend consideration of enteral or parenteral nutrition consistent with the patient's wishes. If the gastrointestinal tract is functioning, enteral (tube) feeding is the preferred route. The risks and benefits of nutrition support should be discussed with the patient and caregivers and should reflect the patient's preferences and goals for care. Studies, to date, on enteral nutrition for improved outcomes for PrUs have been disappointing.[58,59]

Guidelines are systematically developed statements that assist practitioners and patients to make decisions about appropriate healthcare for specific conditions, such as PrUs. Recommendations may not be appropriate in all circumstances, and practitioners should use clinical judgment prior to adopting any guideline. The 2009 National Pressure Ulcer Advisory Panel/European Pressure Ulcer Advisory Panel Nutrition Treatment Guideline was developed following a systematic, comprehensive review of peer-reviewed, published research on PrU treatment from 1998 through January 2008. Supplemental searches were conducted on related nutrition issues, and evidence tables from previous guidelines were reviewed to identify relevant studies published prior to 1998. Studies meeting inclusion criteria were reviewed for quality, summarized in evidence tables, and classified according to their level of evidence using a schema developed by Sackett et al.[60] Table 9 summarizes the nutrition recommendations and supporting evidence for PrU treatment.

Table 9.
ROLE OF NUTRITION IN PRESSURE ULCER HEALING

1. Screen and assess nutritional status for each individual with a PrU at admission and with each condition change and/or when progress toward PrU closure is not observed. (Strength of evidence = C)
   1.1 Refer all individuals with a PrU to the dietitian for early assessment and intervention of nutritional problems. (Strength of evidence = C)
   1.2 Assess weight status for each individual to determine weight history and significant weight loss from usual body weight (>5% change in 30 days or >10% in 180 days). (Strength of evidence = C)
   1.3 Assess the individual's ability to eat independently. (Strength of evidence = C)
   1.4 Assess adequacy of total nutrient intake (food, fluid, oral supplements, enteral/parenteral feedings). (Strength of evidence = C)
2. Provide sufficient calories. (Strength of evidence = B)
   2.1 Provide 30–35 kcal/kg body weight for individuals under stress with a PrU. Adjust formula based on weight loss, weight gain, or level of obesity. Individuals who are underweight or who have had significant UWL may need additional kilocalories to cease weight loss and/or regain lost weight. (Strength of evidence = C)
   2.2 Revise and modify (liberalize) dietary restrictions when limitations result in decreased food and fluid intake. These adjustments are to be managed by a dietitian or medical professional. (Strength of evidence = C)
   2.3 Provide enhanced foods and/or oral supplements between meals if needed. (Strength of evidence = B)
   2.4 Consider nutritional support (enteral or parenteral nutrition) when oral intake is inadequate. This must be consistent with individual goals. (Strength of evidence = C)
3. Provide adequate protein for positive nitrogen balance for an individual with a PrU. (Strength of evidence = B)
   3.1 Offer 1.25–1.5 g protein/kg body weight daily for an individual with a PrU when compatible with goals of care and reassess as condition changes. (Strength of evidence = C)
   3.2 Assess renal function to ensure high levels of protein are appropriate for the individual. (Strength of evidence = C)
4. Provide and encourage adequate daily fluid intake for hydration. (Strength of evidence = C)
   4.1 Monitor individuals for signs and symptoms of dehydration: changes in weight, skin turgor, urine output, elevated serum sodium or calculated serum osmolality. (Strength of evidence = C)

Table 9.
ROLE OF NUTRITION IN PRESSURE ULCER HEALING, CONTINUED

   4.2 Provide additional fluid for individuals with dehydration: elevated temperature, vomiting, profuse sweating, diarrhea, or heavily draining wounds. (Strength of evidence = C)
5. Provide adequate vitamins and minerals. (Strength of evidence = B)
   5.1 Encourage consumption of a balanced diet that includes good sources of vitamin and minerals. (Strength of evidence = B)
   5.2 Offer vitamin and mineral supplements when dietary intake is poor or deficiencies are confirmed or suspected. (Strength of evidence = B)

Adapted with permission from the European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel. Prevention and Treatment of Pressure Ulcers: Quick Reference Guide. Washington, DC: National Pressure Ulcer Advisory Panel; 2009.

SUMMARY

Nutrition is a key component in the treatment plan for individuals with PrUs, diabetic ulcers, or chronic wounds. Early identification of undernutrition and the correction of nutritional deficits promote healing and improve the patient's quality of life. The focus of care should be on achieving optimal nutrition status for each individual. Goals should be evaluated frequently and revised with each condition change or when progress toward healing is not occurring. The amount and type of nutritional support should be consistent with medical goals and the patient's wishes.

After reading this article, the clinician should be able to better screen patients, evaluate patients, refer patients for a comprehensive nutrition assessment by the RD, and develop a care plan for the prevention and/or treatment of wounds.

PRACTICE PEARLS

- Screen and assess nutritional status for each patient with a PrU.
- Refer all patients with a PrU to the dietitian immediately for early assessment and intervention for nutritional problems.
- Provide 30 to 35 kcal/kg body weight for patients under stress with a PrU.
- Revise and modify (liberalize) dietary restrictions when limitations result in decreased food and fluid intake.
- Provide enhanced foods and/or oral nutritional supplements between meals, if needed.
- Offer 1.25 to 1.5 g protein/kg body weight for an individual with a PrU when compatible with goals of care, and reassess as condition changes.

• Monitor for signs and symptoms of dehydration and provide and encourage adequate daily fluid intake for hydration.
• Consider nutritional support (enteral or parenteral nutrition) when oral intake is inadequate.
• Encourage consumption of a balanced diet, which includes good sources of vitamin and minerals.
• Offer vitamin and mineral supplements when dietary intake is poor or deficiencies are confirmed or suspected.

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