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# Infant Feeding in Special Circumstances

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## Author Disclosure

Drs Cherry and Thomas have disclosed no financial relationships relevant to this article. This commentary does not contain a discussion of an unapproved/investigative use of a commercial product/device.

**Objectives** After completing this article, readers should be able to:

1. Determine the caloric requirements of neurologically impaired infants.
2. Describe nutritional problems in infants who have malignancies.
3. Plan the approach to feeding an infant who has multiple food allergies.
4. Appreciate the importance of occupational therapy support for feeding difficulties.
5. Discuss the indications for use of different types of feeding tubes.

## Introduction

Healthy infants are able to sustain themselves easily with the calories and nutrients provided from human milk or from standard infant formulas. Some infants, however, have increased caloric requirements due to chronic medical conditions such as cardiac disease, prematurity, or malignancy. Conversely, other children, such as neurologically impaired infants, may have decreased caloric requirements. Still other infants can have an intolerance to the components of standard formulas or an inability to take nourishment because of feeding dysfunction. Such differences may necessitate alternative approaches to feeding.

## Variations in Caloric Requirements

During the first few postnatal months, a healthy term infant typically has an energy requirement of approximately 100 kcal/kg per day to achieve both normal development and a weight gain of at least 20 g/d after the age of 2 weeks. This energy requirement decreases about 10% to 20% during the second 6 postnatal months, with an expected weight gain of approximately 12 g/d. The energy requirement of a low-birthweight infant ranges from 90 to 120 kcal/kg per day, depending partly on ambient temperature, activity level, and mode of feeding. Low-birthweight infants who weigh less than 1,000 g at birth, those who are sick, and those in the first 2 to 3 weeks after birth may have different requirements. In addition to a higher energy requirement than term infants, preterm infants differ in specific nutrient requirements and in the optimal intake of fats, carbohydrates, and proteins. Such infants require a specialized “preterm” (if taking <500 mL/d) or transitional (if taking >500 mL/d) formula or human milk. Preterm infants usually can advance from transitional to standard formulas at 9 months corrected age but may need to continue with a transitional formula until 12 months corrected age if growth velocity is less than expected.

Infants who have congenital heart disease (CHD), both cyanotic and acyanotic, also have increased energy requirements. Nutritional status is particularly important in these infants because it can influence timing of, type of, and recovery from cardiac surgery. Total energy expenditure (TEE) may be elevated because of increased cardiac work, increased work of breathing, or increased autonomic sympathetic stimulation. Clinical experience suggests that caloric intakes of 110 to 120 kcal/kg per day generally are needed for infants who have CHD.

Infants who have CHD tend to become malnourished despite normal birthweights. The cause of their malnutrition is multifactorial. In addition to increased TEE, causes of malnutrition include reduced oral intake from anorexia, early satiety, and frequent complicating illnesses such as respiratory infections. Intestinal malabsorption, possibly related to hypoxia of the intestinal mucosa, also leads to loss of fats and proteins in the stool.

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A randomized trial by Schwarz and associates (1) found that infants who were malnourished and had CHD experienced better growth with continuous drip feedings than with ad lib oral feedings or overnight nasogastric (NG) feedings. Because daytime drip feedings can impede the mobility of infants and their families, we generally recommend that infants who have CHD and growth failure receive continuous nighttime NG feedings with a calorie-supplemented formula to provide at least 120 kcal/kg per day.

Neurologically impaired infants are at high risk for malnutrition. Although their energy requirements typically are lower than those of most infants, several factors may lead to decreased intake of calories and nutrients. Such factors include an inability to communicate hunger and satiety, generally reduced physical activity, slow feeding with underestimation by caregivers of the amount of food consumed, and gastroesophageal reflux leading to regurgitation. Feeding dysfunction is prevalent in children who have cerebral palsy and other neurologic disorders and can cause inefficient feeding, with loss of nutrients through spillage as well as aspiration of feedings. Chronic constipation also can lead to a reduced appetite with resultant poor feeding. Due to decreased intake, neurologically impaired infants also are at risk for micronutrient deficiencies, with consequences that include iron deficiency anemia and osteopenia. Some neurologically impaired children have increased physical activity due to frequent seizures, dyskinesia, or hypertension and may have increased energy and fluid needs.

Infants who are neurologically impaired require frequent assessment of their nutritional status. This assessment includes evaluation of weight gain, linear growth, and body mass index as well as inquiries into tolerance of feedings without coughing or choking and ability to eat foods of varying textures. Suspected gastroesophageal reflux (GER), gastrointestinal (GI) dysmotility, or constipation warrant additional investigation. Nutritionists and occupational therapists are integral participants in this evaluation and in outlining a feeding plan, which should involve all of the child's caregivers. It is common for affected children to have musculoskeletal contractures or scoliosis, which makes it difficult to obtain accurate body length measurements. Monitoring skinfold thickness and arm circumference in such children is useful to assess overall nutritional status. Longitudinal changes in these parameters can provide a measure of the adequacy of nutritional support. However, difficulties in technique and in the validity of published standards limit the helpfulness of skinfold thickness and arm circumference if measured only once.

## Variations in Tolerance of Different Nutrients

Multiple conditions do not change a child's energy requirements but do compromise his or her ability to tolerate or use different dietary components. An estimated 4% to 6% of children are allergic to one or more foods. Dietary allergies may present with such varied clinical signs and symptoms as blood in the stools, respiratory problems, rash, growth failure, emesis, and infantile colic.

A food allergy may be diagnosed through laboratory testing, although immunoglobulin E (IgE) radioallergosorbent testing has variable specificity and sensitivity, depending on the particular allergen and the decision point used. Another nonspecific means of diagnosing intolerance is by an elimination diet. In a breastfeeding infant, the mother might go on a dairy elimination diet because some of the antigens found in cow milk also can be identified in human milk. One caveat about elimination diets is that an estimated 10% to 35% of infants who have an allergy to cow milk protein also may have soy intolerance. In such a situation, it is advisable to use a hydrolyzed formula, and some children who have extreme intolerance require an extensively hydrolyzed formula (Table).

Infants who have food intolerances sometimes are taken off formula altogether by their families and can experience nutritional deficiencies, particularly when their diets are being restricted simultaneously in other ways. For example, substitution of rice milk for infant formula can lead to deficiencies of protein, essential fatty acids, calcium, and vitamin D. Calcium and vitamin D deficiencies also occur in older children who stop taking dairy products after a diagnosis of lactose intolerance. Accordingly, clinicians must be aware of the consequences of and alternatives to eliminating foods from a young child's diet. They also must be aware of situations in which parents impose drastic restrictions because of supposed food allergies or intolerances.

## Wheat Gluten

Celiac disease is seen less commonly in infants, although it has an estimated prevalence of approximately 1% in North America. This disease is caused by an autoimmune response against the gliadin portion of wheat gluten. The resultant inflammation leads to "blunting" of the small intestinal villi, with secondary malabsorption. Patients who have disease must have been exposed to gluten-containing grains, specifically wheat, rye, and barley. Most oat products also contain some gluten, due to contamination from the common practice of rotating oat

**Table. Some Formulas Used Frequently for Term Infants Who Have Nutrient Intolerances**

**Cow Milk-based Formulas**

Indication: Lactase deficiency  
 Enfamil LactoFree Lipil® (Mead Johnson, Evansville, Ind.)  
 Similac Sensitive™ (Abbott Nutrition, Columbus, Ohio)

**Soy-based Formulas\***

Indications: Lactase deficiency, galactosemia, cow milk protein allergy  
 Earth's Best Soy Infant Formula (Hain Celestial, Boulder, Colo.)  
 Enfamil Prosoabee LIPIL® (Mead Johnson, Evansville, Ind.)  
 Good Start Essentials Soy® (Nestle, Glendale, Calif.)  
 Similac Isomil Advance® (Abbott Nutrition, Columbus, Ohio)

**Casein Hydrolysate Formulas**

Indications: Cow milk or soy allergy, feeding intolerance  
 Enfamil Nutramigen LIPIL® (Mead Johnson, Evansville, Ind.)  
 Enfamil Pregestimil® (Mead Johnson, Evansville, Ind.)  
 Similac Alimentum® (Abbott Nutrition, Columbus, Ohio)

**Amino Acid-based Formulas**

Indications: Multiple food allergies, malabsorption  
 EleCare® (Abbott Nutrition, Columbus, Ohio)  
 Neocate® (Nutricia North America, Gaithersburg, Md.)  
 Vivonex Pediatric® (for age > 12 mo) (Novartis, Basel, Switzerland)

\*Many other soy formulas are distributed nationally as store brands.

because it has a lower specificity of approximately 87%, due to the presence of this antibody in healthy individuals as well as in those who have celiac disease and, at times, in children who have other nonceliac digestive disorders. The IgA-AGA test is more specific but is not accurate in the presence of IgA deficiency. Results of celiac disease testing also can vary among different commercial laboratories. The present gold standard for diagnosis of celiac disease is a small intestinal biopsy for histologic inspection of the brush border while the patient still is consuming gluten-containing foods.

**Sugars**

An inability to digest sugars, or primary inherited disaccharidase deficiency, is rare in infants; acquired disaccharidase deficiencies, especially lactase deficiency following severe acute GI illness, is more common. Although alactasia, leading to lactose intolerance, occurs

commonly in older children and adults, particularly in nonwhite individuals, this condition typically develops after the age of 3 years. True congenital lactase or sucrase-isomaltase deficiencies present within the first postnatal weeks and require the use of lactose-free and sucrose-free diets, respectively. Galactosemia, although not a malabsorptive problem, also requires the use of lactose-free formula.

**Fats**

An inability to digest and use dietary fats occurs in patients who have pancreatic insufficiency, as in cystic fibrosis (CF), or hepatobiliary disorders such as biliary atresia, which impairs normal production and transport of bile or pancreatic secretions. Normally, pancreatic secretions contain bicarbonate as well as proteolytic, amylolytic, and lipolytic enzymes that become activated in the duodenum. The acids contained in bile act as a detergent on dietary fat and promote additional digestion by pancreatic enzymes.

CF is a classic example of a condition that can result in reduced pancreatic secretions. In affected patients, mutations of the CF transmembrane regulator lead to de-

and wheat crops in the same fields and processing them in the same mills.

The classic presentation for an infant who has celiac disease includes failure to thrive, abdominal distention, and diarrhea. Presentation can be more subtle, however, with signs that include vomiting, constipation, fussiness, and anemia. Celiac disease should be considered for an infant who fails to thrive starting after the age of 6 months, when cereals typically are introduced into the diet. Infants who have celiac disease almost always resume a normal growth pattern after removal of gluten from the diet. Over the last several years, with the development and marketing of an increasing number of gluten-free products, maintaining a gluten-free diet has become easier for families.

Screening tests for celiac disease are relatively insensitive in very young children, although sensitivities improve after the age of 3 years. The most reliable test overall is the serum antiendomysial antibody. Test results, however, are technician-dependent, and the test often is replaced or supplemented in clinical use by the antitissue transglutaminase test. The IgG anti gliadin antibody (IgG-AGA) test should be used with caution

creased secretion of chloride, bicarbonate, and water from pancreatic ductal cells. In addition, the small ducts of the pancreas can become obstructed by precipitated proteins and inspissated cellular debris due to low ductal flow. Approximately 90% of patients who have CF eventually develop pancreatic insufficiency. Patients who have CF also may have bile acid malabsorption.

Infants who have CF may have poor weight gain because of their increased metabolic requirements from frequent infections as well as from impaired fat absorption. The consensus recommendations for patients who have CF are to start pancreatic enzyme replacement therapy once pancreatic insufficiency has been diagnosed and to give enzymes with all foods, including human milk. However, an excess of pancreatic replacement has been associated with fibrosing colonopathy. Enzyme doses should be less than 4,000 lipase units per gram of fat per day, given prior to each feeding. In practical experience, encapsulated pancreatic enzymes often are difficult to administer to infants.

Patients who have fat malabsorption also require supplementation with fat-soluble vitamins. Vitamins A, D, E, and K can be administered together in a multi-vitamin formulation, with the addition of individual constituents should laboratory testing demonstrate an ongoing deficiency.

**Patients who have adequate nutrition have improved survival from their malignancies . . . . nutritional status can help to predict a patient's tolerance of cancer treatment.**

## Malignancies

Infants who have malignancies have a unique combination of factors that puts them at risk for nutritional deficiencies. At the time of diagnosis, children who have cancer have a high prevalence of malnutrition, although the rates are lower (<10% to 50%) in industrialized countries than in the developing world. Solid tumors, particularly neuroblastoma, Wilms tumor, and Ewing sarcoma, are associated with a higher prevalence of malnutrition than are leukemias.

The causes of malnutrition in pediatric oncology patients are multiple and vary with the stage of treatment; in fact, treatment may worsen nutrition in the short term. Causes of malnutrition include decreased intake due to anorexia, nausea, and mucositis; increased losses due to emesis, diarrhea, and malabsorption; and increased energy requirements. Such increased energy loss may be due to hormonal factors and to alterations in metabolism such as increased gluconeogenesis related to lactate production by tumor cells.

Complicating the nutritional evaluation of infants who have malignancies is that measurements of body weight do not reflect “true” weight, especially in the presence of a solid tumor. Therefore, arm circumference and skinfold anthropometrics are likely to be more accurate than are weight and weight-to-height ratio. Biochemical measurements such as prealbumin concentration may not be helpful in the initial evaluation but can be used to track the status of an individual patient. Serum albumin measurements usually are not helpful because of altered metabolism and cytokine production.

Patients who have adequate nutrition have improved survival from their malignancies. They also have more linear growth, better preservation of immune function, and less susceptibility to infections during their course than do malnourished patients. They may experience fewer adverse effects from the medication. For example, one study showed that patients who developed cardiomyopathy after a course of anthracycline were more likely

to have been malnourished at the start of treatment. (2) Additionally, nutritional status can help to predict a patient's tolerance of cancer treatment.

Multiple studies have examined the effects of parenteral versus enteral supplementation on cancer patients. Parenteral nutrition may be indicated with some chemotherapy and radiation regimens and in bone marrow transplantation to achieve improved tolerance of and recovery from treatment. Because parenteral nutrition is associated with complications, including cholestasis and an increased infection rate, it always is advisable to consider options for enteral feeding.

## Alternative Feeding Approaches

Multiple difficulties, both morphologic and functional, can prevent successful oral feeding and require an alternative approach. Some examples of functional difficulties include suck and swallow incoordination, aspiration, GI dysmotility, and oral aversion. Some of these functional

problems are more common among children who have anatomic defects such as cleft palate or micrognathia. When an infant cannot take in adequate nutrition orally, other feeding strategies become necessary. Such strategies may be required temporarily until the child can improve his or her oral-motor function, overcome oral aversion, or resolve increased energy requirements.

Occupational and speech therapists are among the pediatrician's most important allies in determining when to seek an alternative feeding approach. In addition to helping diagnose problems with oral-motor function, these colleagues perform therapy and coach families to help children who feed dysfunctionally. Even among commonly used, commercially available nipples for term infants, for example, varied flow rate and suction are required. Infant positioning during feeding, selecting an appropriate nipple, and determining appropriate rate and texture of oral feedings fall under the purview of the feeding therapist. Techniques for decreasing oral hypersensitivity, which may be particularly helpful in preterm infants, include compression of the lips, tongue, and palate, performed according to standard protocols. Such exercises also are within the expertise of feeding therapists.

## Feeding Tubes

Some infants cannot take adequate oral feedings safely regardless of the involvement of occupational therapists and require a mechanism to bypass oral feedings. Whenever possible, it is best to use the GI tract to the extent that the child can tolerate, rather than advance to parenteral nutrition. Although parenteral nutrition may be necessary in cases of intestinal failure, postoperatively, and in other select circumstances, infants generally can tolerate at least part of their nutrition via the GI tract. At times, jejunal feedings may be required in place of the more typical gastric feedings because of pyloric or duodenal obstruction, severe GER, or gastric dysmotility. A range of feeding tubes varies in their point of entry to the body, the segment of the GI tract to which they deliver feedings, and their ease of maintenance.

NG tube feeding usually is the first step in providing nutrition to an infant who cannot eat safely or sufficiently. When intended for long-term enteral nutrition, only soft, selectively designed nasodigestive feeding tubes should be used. For bolus feeding, the tube should be taped into place after insertion into the body of the stomach. Placement of the tube should be evaluated to ascertain that it is not so deep that it is at risk of migrating through the pylorus and entering the duodenum, where

bolus feedings cause discomfort and vomiting. Similarly, esophageal placement of the tube can lead to intolerance of feedings with risk of aspiration. Bolus feedings largely mimic oral feedings in terms of endocrine stimulation, such as the production of cholecystokinin, and lead to a more typical pattern of mealtimes and satiety.

Continuous drip tube feedings sometimes are necessary in place of bolus feedings. This requirement may be necessitated by poor GI motility and slow passage of feedings through one or more segments of the GI tract or by growth failure that is more amenable to continuous drip feedings, as in patients who have CHD. Continuous drip feedings may be given through NG, nasoduodenal, or nasojejunal (NJ) tubes. Nasointestinal feeding tubes can be placed fluoroscopically under direct visualization or passed like an NG tube and allowed to migrate into the small intestine, sometimes with the added stimulation of a promotility agent such as metoclopramide or erythromycin ethylsuccinate. Of note, continuous drip feedings generally are easier than bolus feedings for families to manage overnight.

NG feeding tubes are relatively easy to place and can be used indefinitely. From the practitioner's standpoint, the major disadvantage is the ease with which they are dislodged, whether by the infant or accidentally by a curious sibling or caregiver. Although most families are comfortable replacing NG tubes at home, some must return to a clinic or emergency department each time the tube is dislodged. NJ tubes are even more problematic when dislodged because they cannot be replaced at home. From the parents' perspective, however, the unattractive appearance of the NG or NJ tube often is the major disadvantage, even outweighing the inconveniences of dislodgement.

Given the drawbacks of NG or NJ tubes, doctors and families sometimes opt for more permanent placement of a feeding tube. Typically, this is a percutaneous gastrostomy tube, surgical gastrostomy or gastrojejunostomy tube, or more rarely, a surgical jejunostomy tube.

An upper GI radiographic series prior to any surgical tube placement is necessary to rule out malrotation or other anomalies that may be contributing to any feeding intolerance and might alter the surgical plan. The extent of other required testing is controversial. Prior to any tube placement, the need for a simultaneous additional procedure, such as an antireflux procedure or a pyloromyotomy, should be considered.

When assessing the need for additional surgery in an infant awaiting a surgical feeding tube, tests for GER, such as an extended esophageal pH test or gastroesoph-

ageal scintigraphy, usually are necessary. Although delayed gastric emptying occurs in preterm neonates, it is abnormal later in infancy and can be difficult to treat medically. In contrast, GER often is normal throughout infancy. Moreover, symptomatic reflux may resolve after gastrostomy placement or become amenable to medical management. Antireflux procedures are indicated in some infants, particularly those who have neurologic impairments. Consideration should be given to performing antireflux surgery in conjunction with surgical insertion of a feeding tube in children who have a long-term risk of GER disease.

When an infant requires tube feeding to receive adequate nutrition, it still is important to continue oral feeding to the extent possible. This strategy helps to preserve oral feeding skills and increases the likelihood that the infant eventually will be able to transition to full oral feedings. When there is a risk of aspirating oral feedings or of other circumstances that make it impossible for the child to take any nourishment by mouth, it is important to provide feeding therapy under the direction of an occupational therapist. Such therapy allows children to learn and maintain oral motor skills and may prevent a life-long dependence on supplemental tube feedings.

## Conclusion

Infants in special medical circumstances may require nutritional approaches that take into account either differences in caloric needs, intolerances to particular nutrients, or inability to eat by mouth. Allied health professionals, including occupational therapists, are central to creating and advancing a feeding plan. Multiple possibilities are available for tube feeding for infants who cannot be sustained with oral feedings, whether for the short or long term.

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## PIR Quiz

Quiz also available online at [www.pedsinreview.org](http://www.pedsinreview.org).

10. A 6-month-old boy is brought to your clinic because of diarrhea, which has been present for 4 months. His mother denies any blood in the stool or vomiting. She has been concerned about possible poor weight gain and notes that the boy always is congested. He is alert but somewhat cachectic. His weight and length are below the 5th percentile. He has nasal congestion and bilateral wheezing, but other findings on the physical examination are normal. A foul-smelling, greasy stool is noted in his diaper. Which of the following nutrients is he *most* likely unable to absorb?
  - A. Gluten.
  - B. Iron.
  - C. Lactose.
  - D. Vitamin A.
  - E. Vitamin B12.
  
11. You are evaluating a 2-month-old girl who has been experiencing episodes of cyanosis for the past few weeks. Her mother reports that her daughter occasionally has difficulty feeding because she "gets tired." The girl is alert but in mild respiratory distress. Her heart rate is 160 beats/min, and a grade III/VI holosystolic murmur is audible at the lower left sternal border. Her weight at birth and her weight today are both at the 10th percentile. Her mother asks you if her daughter is receiving enough formula. Of the following, the *most* appropriate caloric intake for this infant is:
  - A. 80 kcal/kg per day.
  - B. 100 kcal/kg per day.
  - C. 120 kcal/kg per day.
  - D. 140 kcal/kg per day.
  - E. 160 kcal/kg per day.
  
12. A 9-month-old girl is below the 5th percentile at her health supervision visit. She grew normally at the 10th percentile until 2 months ago, when her growth began to slow. Her mother reports her daughter having five to six watery stools per day and occasional vomiting after feedings, both of which began about 2 months ago. She is breastfed with cow milk supplementation. Cereals and fruits were introduced at 6 months of age. Except for abdominal distention, findings on her physical examination are normal. Small intestinal biopsies show blunting of the brush border. Which of the following dietary changes is *most* appropriate?
  - A. Add a multivitamin with iron daily.
  - B. Change supplementation to a protein hydrolysate formula.
  - C. Place a nasogastric tube and feed her continuously at night.
  - D. Remove all dairy from the mother's diet.
  - E. Remove gluten-containing foods from the girl's diet.
  
13. A 4-week-old boy has had grossly bloody stools for the past 4 days. His mother reports that he frequently spits up after feedings and that he often is fussy. He receives a modified cow milk formula and consumes 4 oz every 3 to 4 hours. His weight has decreased from the 50th percentile at birth to the 10th percentile today. He is very alert and appears hungry, but he is somewhat cachectic. Physical examination findings are otherwise normal, and he has a grossly bloody and loose stool in his diaper. Of the following, the *best* dietary recommendation at this time is to:
  - A. Continue the same formula but decrease the amount to 2 oz every 3 to 4 hours.
  - B. Switch to a casein hydrolysate formula.
  - C. Switch to a modified cow milk formula that is lactose-free.
  - D. Switch to a soy formula.
  - E. Switch to an amino acid-based formula.

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