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How complementary feeding in infants affects allergies, chronic disease, and neurodevelopment

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ABSTRACT

Recommendations for the timing and type of complementary foods to introduce to infants have recently changed. These changes are due to increased understanding of how these foods affect the development of food allergies, risk for obesity and other chronic diseases, and infant neurodevelopment. This article brings the current recommendations and recent research together and organizes them for clinicians in pediatrics to enable them to understand and convey this information to parents of infants.

Keywords: complementary feeding, infants, food allergies, obesity risk, chronic disease, neurodevelopment

Learning objectives

- List the important features of an infant's early nutritional requirements.
- Describe the effects of infant nutrition on allergies, chronic disease, and neurodevelopment.

Complementary feeding is “nutrient- and energy-containing solid or semi-solid foods or liquids fed to infants in addition to human milk or formula.”¹ Recommendations about when to start complementary feeding have changed frequently in the past several years due to concerns about exposing children to allergens, efforts to curb pediatric obesity, and attempts to improve infant nutrition. Clinicians who provide primary care for children can find it difficult to navigate the recommendations and research to give practical, evidence-based advice to parents about optimal feeding practices. This article collates the recent changes in recommendations and the research that suggests further changes to current practice and discusses how to communicate this information with parents.

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Key points

- Complementary foods should be introduced no later than age 6 months in infants.
- Evaluate infants with severe eczema or egg allergy for peanut allergy; if negative, introduce age-appropriate peanut-containing food as early as age 4 months. Infants with mild-to-moderate eczema should be exposed to peanuts at age 6 months.
- Understanding the micro- and macronutrient needs of infants lets clinicians offer recommendations that are optimal for infant nutrition.
- Because complementary feeding recommendations for infants are continuing to evolve, clinicians who provide care for infants must be diligent in keeping current with these changes.

HISTORY OF COMPLEMENTARY FEEDING GUIDELINES

Various stakeholders have developed guidelines for introducing complementary foods to children based on their assessment of overall nutrition, concern about allergies, pediatric obesity, and prevention of heart disease.¹⁻³ The American Academy of Pediatrics (AAP) has served as the main source of information for recommendations about feeding and nutrition of children since the 1950s.

Traditionally, the AAP has considered several domains in the formulation of its recommendations:

- *Developmental readiness* includes the loss of the primitive reflexes of extrusion, sucking, and rooting; the attainment of truncal stability; and the ability to signal satiety by moving the head away from the spoon.
- *Age-appropriate nutrient requirements* have been updated over recent years as evidence has emerged that the infant gastrointestinal tract is able to absorb all essential nutrients by ages 2 to 3 months, thus changing the recommendation from a prescribed sequence and timeline for different food groups to one exposing infants to all food groups at ages 4 to 6 months.²

The recommendations also reflect growing understanding of the changing needs of the infant during the first 5 to 6 months of life and the ability of breast milk and formula to meet those needs. Specifically, the micro- and macronutrient requirements for infants change dramatically during this time. Protein requirements drop to two-thirds of the requirement per kilogram in the 6-month-old compared with the newborn; however, the absolute amount of protein required increases.² Simultaneously, the protein content of breast milk decreases.² Fat and carbohydrate needs also change. Fats account for 45% to 50% of the calories in breast milk, but the recommended proportion of fats for a 6-month-old is 30% to 40%.² Carbohydrates account for about 40% of the calories of breast milk while the intake of complementary foods changes the percentage of carbohydrates

to 55% to 60%, the percentage recommended for children ages 1 to 3 years.^{2,3} Other micronutrients also have a mismatch of supply versus need. Specifically, zinc and iron have been labeled “problem nutrients” due to the decrease in concentration in breast milk and the increase in the infant’s requirements.

- *Feeding practices* and the recommended age for introducing complementary foods have varied widely over the past 60 years. The AAP and the World Health Organization (WHO) recommend exclusive breastfeeding until age 6 months. However, evidence suggests that earlier exposure to certain allergenic foods can reduce the risk of food allergies in susceptible children.⁴ The WHO’s recommendations are based, in part, on the fact that in developing countries, access to clean water is limited and thus the use of formula can increase the risk of illness. The AAP’s recommendations consider the superiority of breast milk to formula and complementary foods based not only on nutrient content, but also the humoral immunity that breast milk confers.

Other professional organizations have made recommendations for earlier initiation. Specifically, the American Academy of Allergy Asthma and Immunology (AAAAI) recommends introduction of solid foods at ages 4 to 6 months.⁵ The European Society of Pediatric Gastroenterology, Hepatology, and Nutrition (EPSGHAN) recommends introduction at 6 months, but includes the caveat that complementary foods should be introduced no earlier than 17 weeks (4 months and 1 week) of age and no later than 26 weeks (6 months and 2 weeks).¹ Starting solid foods before age 4 months can increase the risk of obesity at 3 years and waiting until after age 6 months may lead to inadequate intake of iron and zinc in the breastfed infant.^{6,7} In the United States, clinicians in pediatrics follow the guidelines and recommendations from the AAP about the initiation of complementary foods.

Another factor for consideration of timing is the role that taste and texture play in the child’s acceptance of complementary foods. Infants may have windows of opportunity in which they are most receptive to changes in the composition of their feedings and be more likely to accept a variety of foods later in life.⁸ A systematic review by Paroche and colleagues revealed that repeated exposures to the same food in infancy increases acceptance of that food and exposure to a variety of tastes and foods in infancy increased the likelihood of acceptance of new foods at age 6 years.⁹ Compared with children exposed to “lumpy solids” at ages 6 to 9 months, children exposed to these foods after age 9 months were less accepting of many food groups and had more feeding problems.⁸

INFANT GROWTH

The composition of complementary food and the infant’s age at initiation affect infant growth. Protein, fat content and quality, and carbohydrates in the form of sugars are

all important considerations. After age 6 months, the percentage of protein needed in the diet decreases. Consequently, infants who are given a high-protein diet during their first 2 years of life are at an increased risk of later obesity.¹⁰

Fat content and quality in complementary foods also affect infant growth and the likelihood of developing obesity. Exposure to n-3 fatty acids, such as that found in fish, is important for cognitive development and immune function; the balance of n-3 to n-6 fatty acids is important for growth and immune function. The optimal diet for an infant contains 30% to 45% fat.² Interestingly, recent evidence indicates that a high percentage of fat in the diet during infancy is not associated with later overweight and obesity, but that a lower percentage can increase the risk.¹⁰

Historically, sugar intake in infancy in the form of juices and other sweetened beverages has been implicated in the displacement of nutrient-dense foods and a risk of malnutrition. Recently, evidence shows that consumption of sugar-sweetened beverages increases the risk of obesity in children.¹⁰ Consumption of sugar-sweetened beverages also increases the risk of early childhood caries, which is the most common chronic illness in childhood, five times more common than childhood asthma.¹¹ The AAP recommends that infants under age 12 months not drink juice; after age 12 months, juice should be limited to no more than 4 oz/day until age 3 years.¹² Juice should be diluted with water and offered in a cup without a lid to reduce the amount of juice consumed and the amount of time the liquid is in contact with the dental surfaces.

NEURODEVELOPMENT

The first 1,000 days of life, starting at conception and extending until the beginning of the third year of postnatal life, are critical for the support of healthy development of the child and the prevention of chronic illnesses in adulthood. Complementary feeding encompasses at least 18 months of this time frame. The most active period of neurologic development occurs during a child's first 3 years, as the brain undergoes significant remodeling.¹³ Essential macronutrients for optimal brain development in children include protein, specific fats such as long-chain polyunsaturated fatty acids, and glucose. Essential micronutrients

include iron, zinc, iodine, copper, and B vitamins. Iron and zinc are often cited as problem nutrients for older breast-fed children because of the decreased availability of these nutrients in breast milk.

Ensuring adequate iron Infants are born with increased iron stores. Factors that can detrimentally affect iron stores in infants include prematurity, complications of pregnancy, and delayed cord clamping. Prenatal and early infancy iron deficiency is associated with long-term neurobehavioral damage that may not be reversible even with iron

treatment.¹³ Iron deficiency in early life has been associated with permanent deficits in recognition and procedural memory in adulthood.¹⁴ Introducing cow's milk to an infant under age 1 year is a risk factor for iron deficiency from microscopic blood loss from the stool. However, small amounts of milk in the form of yogurt or other dairy products do not increase the risk of anemia and thus can be safely consumed before age 1 year.¹⁵

Ensuring adequate zinc The concentration of zinc in breast milk is initially high and easily meets the nutritional demands of the infant in the first 6 months of life. However, regardless of maternal intake,

transport of zinc in the mammary glands decreases over time to a level that is below the infant's dietary needs.

Until recently, conventional wisdom and formal recommendations for the initiation of complementary feeding was to start with cereals, fruits, and vegetables as the initial solids, with slow progression to meats. Due to concerns about the availability of zinc and iron and recognition that the infant's gastrointestinal tract matures by ages 2 to 3 months, the recommendations now encourage the initiation of a variety of foods, including those high in zinc and iron, such as meat, earlier in the sequence.¹⁵ Vegetarian diets are unlikely to meet the infant's nutrient needs unless supplemented with fortified foods.

FOOD AND CHRONIC ILLNESS

The diversity of food offered in infancy may play a role in the development of allergy, asthma, and atopy in childhood and, potentially, adulthood. A study by Nwaru and colleagues found that a poor diversity of foods by ages 6 and 12 months was associated with an increased risk of asthma and allergic diseases in childhood.¹⁶



Children with mild-to-moderate eczema should be exposed to peanuts at age 6 months.

The effect of the timing of introducing children to various allergenic foods on the development of food allergies has been studied extensively in the last 15 years. Consequently, recommendations have changed substantially. In 2000, the AAP recommended delaying introduction of highly allergenic foods such as milk, egg, wheat, and peanuts to high-risk children with a history of atopy. However, these recommendations were withdrawn in 2008 when a dramatic increase in the incidence of food allergies was observed.¹⁵ In retrospect, the delay of exposure to highly allergenic foods can increase the risk of food allergy and early introduction of these foods can reduce its risk.¹⁶

In the Learning Early About Peanut Allergy (LEAP) study, infants at high risk of developing peanut allergy (those with severe atopy or documented allergy to eggs) were exposed to peanuts between ages 4 and 11 months.¹⁷ These children were found to have a lower risk of peanut allergy than children who were not exposed to peanuts during this time. In 2015, a consensus statement from the AAP, AAAI, and the American Society of Clinical Immunology and Allergy (ASCIA), among others, recommended that children at high risk for allergy be evaluated for peanut allergy either by skin prick test or serum immunoglobulin E (sIgE) levels.⁴ Children whose evaluation was negative should be exposed to the equivalent of 6 g of peanut over the course of 3 days each week.¹⁸ Infants exposed to peanuts in this manner were found to have an 80% relative risk reduction of peanut allergy at age 5 years, compared with children who were not given peanuts. Infants with a positive evaluation should be referred to a pediatric allergist or dermatologist for skin prick testing and medically supervised feeding trials.⁴ (Also see “Early introduction of peanuts” in the March 2017 issue of *JAAPA*.)

Infants with mild-to-moderate eczema should be exposed to peanuts at age 6 months.¹⁸ Those without a history of eczema or any food allergy should be exposed to peanuts with the introduction of other solid foods in accordance with family preferences.¹⁸

However, exposing children, especially infants, to peanuts can be difficult because of the lack of readily available peanut options for infants. This may be due in part to uncertainty about parental acceptance of feeding their children peanuts, but is more likely due to concern about inadvertent exposure of at-risk children. The LEAP trial used Bamba, a peanut puff snack, as its peanut source. For the trial, the puffs were ground and put in warm breast milk or formula and fed to the infant. Other options for introducing peanut into an infant’s diet include peanut flour and peanut powder. Peanut butter can be used but must be mixed with water, formula, or breast milk to be safely consumed by the infant.

With respect to other allergenic foods, a meta-analysis of research about the timing of introduction of specific foods and the onset of allergies found that many

of the foods that were recommended be started later, in some cases, after age 1 year, can be started in infancy.¹⁹ For example, egg introduction at ages 4 to 6 months is associated with a lower incidence of egg allergy, oral tolerance to gluten does not correlate with the development of celiac disease, and there is less evidence that early fish introduction is associated with reduced allergenic sensitization.

WORKING WITH PATIENTS

What strategy should we recommend to parents when they introduce solid foods to their infants? A culmination of the above findings and recommendations can be distilled into practical information to give to patients:

- Begin complementary foods between ages 4 and 6 months (6 months for exclusively breastfed children) when the child shows developmental readiness.
- Offer foods from all food groups to balance nutritional intake; introducing meats, cereals, vegetables, fruits, and dairy without a specific order allows optimal intake for infant nutrition and exposure to different tastes and textures during the critical window of opportunity for acceptance. Introduce a new food every 3 to 4 days.
- Do not offer fruit juice to children under age 1 year. Do not give children over age 1 year fruit juice in a bottle or covered cup.
- Infants should not consume whole milk due to the lack of nutrients in the milk and the risk of microscopic blood loss with resulting anemia. However, milk-containing foods such as yogurt may be consumed.
- Consider introducing protein-containing foods at the initiation of complementary feeding to increase zinc and iron intake.
- Children at high risk for peanut allergy (as evidenced by severe eczema or egg allergy in the first 4 to 6 months of life) should be evaluated for allergy and if negative, exposed to age-appropriate peanut-containing food at ages 4 to 6 months. Children with mild-to-moderate eczema should be exposed to peanuts at age 6 months. Children with no history of allergy should be exposed when developmentally appropriate and according to family customs and norms. Consider consulting a pediatric allergist or dermatologist with experience in peanut allergy for patients at high risk of developing allergy.

TALKING WITH PARENTS

The best time to discuss dietary recommendations with parents and caregivers is during scheduled well-child examinations, preferably the 4- and 6-month visits. During this time, introduce the topic of complementary feeding and share information about the recommendations. Resources for clinicians and parents can be found on the AAP website.^{20,21} Clinicians should read the complete information in the addendum guidelines about peanut introduction for infants.¹⁸

CONCLUSION

The importance of healthful complementary feedings in the growth and development of the infant cannot be overstated. Clinicians who care for children must be aware of the changing recommendations and clearly communicate these changes to their patients' parents. **JAAPA**

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