The Committee on Nutrition continues to monitor and review nutritional issues concerning the use of whole cow’s milk (WCM) in the diets of infants. The goal of those concerned with infant nutrition is the provision of an optimal diet. The recommendations in this statement replace those provided in the 1983 statement, "The Use of Whole Cow’s Milk in Infancy."1 The 1983 statement focused primarily on the issue of iron nutriture in infancy. In a broader context, the statement addressed a substantial number of often controversial nutrition issues, defined as "research needs," surrounding the appropriateness of using whole cow’s milk for infants during the first 12 months. The purpose of this statement is to provide new recommendations on the optimal feeding of infants. The use of skim milk and reduced-fat milk (eg, 2% milk) remains inappropriate during the first year of life and will not be reviewed in this statement.

REVIEW OF PREVIOUS STATEMENTS

During the last 20 years, the use of whole cow’s milk in infancy has been discussed by the Committee on Nutrition principally, but not exclusively, in the context of meeting infants' iron needs. In 1969, an extensive commentary2 reviewed iron requirements in infancy, and in 1971, a policy statement3 recommended that iron-fortified formulas be used for the first 12 months of life. Those recommendations were prompted by a significant prevalence of iron deficiency in older infants associated with the extensive use of whole cow’s milk in later infancy. Fluid whole milk (available in bottle or carton) or evaporated milk, both of which contain only trace amounts of iron, are substituted at the time of greatest iron need and highest prevalence of iron deficiency anemia.4-7

Several clinical studies demonstrated that feeding iron-fortified formulas to infants for the first 12 months resulted in excellent iron status.4-7 The Committee believed that adding iron to the infant’s major source of calories (milk-based formula) was a practical and effective method to alleviate the high prevalence of iron deficiency anemia.

In 1976, the Committee on Nutrition issued a statement8 recommending the use of either iron-fortified formula or infant cereal during older infancy. The Committee noted the following: "Infant formula and other heat-treated milk products are preferable to fresh [pasteurized] cow’s milk as substitutes for breast milk feeding during the first 6 to 12 months of life because excessive ingestion of fresh cow’s milk may contribute to iron deficiency by increasing gastrointestinal blood loss."8

In 1983, the Committee on Nutrition developed a new position,1 based largely on a study by Fomon et al9 of gastrointestinal blood loss in infants aged 4 to 6 months fed WCM, heat-treated WCM, or infant formula. All infants received supplemental ferrous sulfate and ascorbic acid. Enteric blood loss was greatest in WCM-fed infants younger than 4½ months of age. In infants between 4½ and 6 months of age, there was no difference among the three groups (WCM, heat-treated WCM, or infant formula) in the number of guaiac-positive stools, mean hemoglobin levels, serum iron levels, iron binding capacity, or transferrin saturation. Consequently, the 1983 statement1 suggested that whole cow’s milk could replace iron-fortified formulas when infants older than 6 months of age were consuming at least one third of their calories from supplemental foods. The question of whether feeding iron-fortified formula to infants for the first 6 months of life would be sufficient to prevent iron deficiency during the next 6 months when they are started on whole cow’s milk could not be answered from the existing data.

REVIEW OF RESEARCH QUESTIONS POSED IN THE 1983 STATEMENT ON THE "USE OF WHOLE COW'S MILK IN INFANCY."

Since the 1983 recommendations, several new studies have been published that address the five questions posed in this statement. Results of these studies require further refinement regarding the feeding recommendations for later infancy.

1. "What is the rate and variability of maturation of infant gastrointestinal mucosal barrier function?"

The gastrointestinal tract is immature early in life. Consequently, there is an increased transfer of intact dietary protein from the intestinal lumen into the circulation in the immediate neonatal period, particularly in preterm infants and infants who have gut injury.10 Although controversial, it is believed that increased intestinal permeability may contribute to the high incidence of cow’s milk protein allergy, a condition that affects 0.4% to 7.5% of the infant population.11 There is no information to suggest that WCM is more allergenic than infant formulas that contain intact cow’s milk proteins. Infants with cow’s milk protein allergy should not be fed either WCM or other heat-treated milk products as substitutes for breast milk feeding during the first 6 to 12 months of life because excessive ingestion of fresh cow’s milk may contribute to iron deficiency by increasing gastrointestinal blood loss.8
formulas containing intact WCM proteins. In nonallergic infants, the introduction of whole cow’s milk should be based on digestive and nutritional considerations, not on the development of the mucosal barrier.

2. “What is the relative importance of the amount and bioavailability of iron in the total diet when whole cow’s milk is substituted for iron-enriched formula at 6 months of age? Does iron-fortified cereal meet the infant’s need for iron?”

Six studies12-17 based on four independent surveys (Second National Health and Nutrition Examination Survey Department of Agriculture Food Consumption, Ross Mothers Study, and Gerber Nutritional Survey) have been published to date and reviewed. Five of the six studies suggest that infants fed whole cow’s milk in later infancy have median iron intakes below the recommended daily allowance. These results clearly indicate that an insufficient quantity of iron-fortified infant cereal is currently incorporated into the diet of most infants to meet iron needs. However, infant cereal is the single largest source of iron from infant solid foods available in the United States. Parents who feed their infants whole cow’s milk must also judiciously select solid foods that contain iron.

The bioavailability of electrolytic iron, the form of iron that is added to infant foods, remains incompletely defined and controversial. Furthermore, quantitative studies of electrolytic iron absorption have been conducted only with adult subjects. Electrolytic iron is produced by electrolytic deposition of iron that is mechanically commuted to powder (grade A-131). Fomon18 notes that cereals marketed in the United States and Canada containing electrolytic iron are fortified with 45 mg of iron/100 g of dry weight, or approximately 7 mg of iron/100 g of cereal as fed (ie, after dilution with milk or formula). Forbes et al,19 using a farina-based meal, demonstrated absorption of iron of a similar particle size to be 75% that of ferrous sulfate. Elwood20 demonstrated that absorption of commercially used iron powder in baked bread is about 5% that of ferrous sulfate. Fomon,18,21 using Elwood’s data, calculated that absorbed iron from infant cereal could only account for 0.12 mg of the 0.6 to 0.7 mg of absorbed iron that infants require each day. Both Fomon and Elwood concluded that without evidence of adequate bioavailability, the electrolytic iron used in infant cereals is not sufficient to meet the iron needs of infants fed whole cow’s milk.

The composition of whole cow’s milk (ie, high calcium, high phosphorus, and low vitamin C) may decrease the bioavailability of iron from other dietary sources such as infant cereals.22 Three studies23-25 compared the iron status of infants receiving iron-fortified formulas for the first 6 months of life and then fed WCM or iron-fortified formulas in accordance with the 1983 American Academy of Pediatrics recommendations for the next 6-month period. In all three studies, iron status was significantly poorer in infants fed WCM.

Fortification of other infant foods, including wet-pack cereal-fruit products, grape juice, or milk fortified with a highly bioavailable form of iron (ferrous sulfate with vitamin C), but less modified than regular infant formula, appear promising,26 but largely unexplored in the United States. Haschke et al27 demonstrated indices of iron adequacy similar to infants fed only iron-fortified formula using meat-containing infant foods fortified with ferrous sulfate and ascorbic acid that are commercially available in Austria and the Federal Republic of Germany, but not in the United States. Stekel et al28 in Chile studied the bioavailability of ferrous sulfate-fortified (elemental iron, 10 to 19 mg/L) low-fat and whole milks (less modified than regular commercial formula) fed to infants, many of whom were iron-deficient. Iron absorption from milk containing ascorbic acid (100 mg/L) ranged from 5.9% to 11.3% and was not influenced by the amount of milk fat, the addition of carbohydrate, or acidification. Results of longitudinal field trials of infants from age 3 to 15 months with a full-fat iron-fortified acidified milk showed effective elimination of iron deficiency.29

Evidence now suggests that the current feeding practice in the United States of using iron-fortified cereal does not meet the requirement for iron when WCM is used during the second 6 months of life. This may be due to poor compliance or insufficient bioavailability of electrolytic iron. However, providing iron-fortified formula and cereal for the first 12 months, as utilized in the Women, Infants, and Children Program, has been successful in reducing iron deficiency.30,31

3. “Can the change to cow’s milk when the infant is 6 months old produce anemia from occult blood loss when the milk is fed in excessive amounts and there is no iron supplementation?”

This question has been the subject of additional study and commentary. Both Woodruff32 and Wilson33 concluded that blood loss did occur in infants fed WCM after 6 months of age. Following the gastrointestinal blood loss study by Fomon et al,9 Ziegler et al34 used a more sensitive assay for stool hemoglobin in a second study of blood loss in 6-month-old infants fed either infant formula or WCM without iron supplementation. Intestinal blood loss increased in 30% of infants fed WCM but did not increase in the formula-fed group, even though all were previously fed iron-fortified formula or were breast-fed in the first 6 months of life.34 One infant in the WCM group was removed from the study because of iron deficiency. The investigators concluded that infants fed WCM had a nutritionally significant loss of iron in the stools. These studies clearly show that blood loss will occur in a substantial percentage of infants who receive WCM for the first time after 6 months of age. On the basis of these recent results,34 Fomon and Ziegler reversed their earlier positions,9 stating that they no longer recommended WCM in the second 6 months, but preferred breast milk or iron-fortified formula for the first 12 months of life.35,36 The reasons for these recommendations include the substantial enteric blood loss in infants fed WCM, the probable low bioavailability of iron absorbed from infant cereals, and the probable
inhibition of iron availability in WCM due to high concentrations of calcium and phosphorous and low concentration of ascorbic acid.

4. "What is the relative importance of the high solute load of whole cow's milk in the total feeding regimen of a 6- to 12-month-old infant? For example, how much of the high-solute load of whole cow's milk is diluted by other foods in the diet?"

Data from several studies show that infants fed WCM instead of infant formula have a markedly increased intake of sodium, potassium, chloride, and protein.12-14 The sodium intake (1000 mg/d) of WCM-fed infants substantially exceeds the estimated minimum requirements (120 mg/d for infants from birth to 5 months old and 200 mg/day for infants 6 to 11 months old). By comparison, the median sodium intake for formula-fed infants (7 to 12 months old) is 580 mg/d.12 Consequently, the renal solute load of WCM-fed infants exceeds that of formula-fed infants by two- to threefold (from approximately 125 to 300 mOsm).16 Ziegler16 calculated the potential renal solute load of two hypothetical infants, 6- and 10-months-old, fed infant solids and formula versus infant solids and WCM. When WCM replaced formula, the potential renal solute load increased twofold in the 6-month-old infant (42 vs 21 mOsm/100 kcal) and nearly twofold in the 10-month-old infant (39 vs 26 mOsm/100 kcal). He concluded that both infants exceeded their recommended maximum (33 mOsm/100 kcal) potential renal solute load when fed WCM and that WCM feeding would narrow the margin of safety in situations that may lead to dehydration. Thus, the high renal solute load of WCM was not diluted by other foods in the diet.

5. "What is the relative importance of the nutrients not present in whole cow's milk but present in infant formula and breast milk, ie, essential fatty acids, tocopherol, ascorbic acid? How much of these nutrients are obtained from the other foods commonly used in the 6- to 12-month age group?"

Substitution of WCM for formula reduced the intake of ascorbic acid, but not below the recommended daily allowance.12,13 However, the median intake of linoleic acid was reduced dramatically to 1.8% of total energy intake, well below the recommended level of 3%.12,16

In one study37 of 97 older infants, intake of α-tocopherol was significantly lower in WCM-fed infants than in formula-fed infants (3.7 ± 2.6 mg/d vs 10.9 ± 3.1 mg/d). Moreover, α-tocopherol status, as assessed by plasma concentrations, was significantly greater in the formula-fed infants (1.14 ± 0.42 vs 0.86 ± 0.28).

The studies of the past 7 years demonstrate the difficulty of providing a balanced diet for older infants when WCM replaces breast milk or iron-fortified formula. Nutrients from commonly consumed solid foods do not complement nutrients from WCM; rather, they exaggerate the deficiencies (iron, linoleic acid, and vitamin E) and excesses (sodium, potassium, chloride, and protein) in the infant's diet.

NEW STUDIES ON IRON DEFICIENCY AND BEHAVIOR

Earlier studies by Oski and co-workers38 show that iron deficiency in infants and children is associated with subtle behavioral differences. Additional recent studies39-42 suggest that iron deficiency in early childhood may lead to long-term changes in behavior that may not be reversed even with iron supplementation sufficient to correct the anemia. Newly published studies on iron deficiency and behavior show the importance of iron deficiency in WCM-fed infants. The biochemical mechanism linking iron deficiency and behavior may be identified from studies from Youdim's group in experimental animals.53-54 These researchers have shown that the number of dopamine D-2 receptors in the rat brain is reduced when the experimental animals undergo a transient period of iron deficiency during infancy and are not subsequently restored with iron supplementation. Although they require confirmation and further amplification, these studies provide a possible model of a mechanism in which a transient nutritional event may produce long-term changes in the neurologic status of the brain of the animal studied. Additional research is necessary to understand the implications of iron deficiency to possible brain dysfunction in humans.

SUMMARY

The pediatrician is faced with a difficult challenge in providing recommendations for optimal nutrition in older infants. Because the milk (or formula) portion of the diet represents 35% to 100% of total daily calories and because WCM and breast milk or infant formula differ markedly in composition, the selection of a milk or formula has a great impact on nutrient intake.

Infants fed WCM have low intakes of iron, linoleic acid, and vitamin E, and excessive intakes of sodium, potassium, and protein, illustrating the poor nutritional compatibility of solid foods and WCM. These nutrient intakes are not optimal and may result in altered nutritional status, with the most dramatic effect on iron status. Infants fed iron-fortified formula or breast milk for the first 12 months of life generally maintain normal iron status. No studies have concluded that the introduction of WCM into the diet at 6 months of age produces adequate iron status in later infancy; however, recent studies have demonstrated that iron status is significantly impaired when WCM is introduced into the diet of 6-month-old infants. Data from studies abroad of highly iron-deficient infant populations suggest that infants fed partially modified milk formulas with supplemental iron in a highly bioavailable form (ferrous sulfate) may maintain adequate iron status. However, these studies do not address the overall nutritional adequacy of the infant's diet. Such formulas have not been studied in the United States.

Optimal nutrition of the infant involves selecting the appropriate milk source and eventually introducing infant solid foods. To achieve this goal, the American Academy of Pediatrics recommends that infants be fed breast milk for the first 6 to 12 months. The
only acceptable alternative to breast milk is iron-fortified infant formula. Appropriate solid foods should be added between the ages of 4 and 6 months. Consumption of breast milk or iron-fortified formula, along with age-appropriate solid foods and juices, during the first 12 months of life allows for more balanced nutrition. The American Academy of Pediatrics recommends that whole cow’s milk and low-iron formulas not be used during the first year of life.

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# The Use of Whole Cow's Milk in Infancy

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