Iron deficiency remains the most common cause of anemia in infants and children despite the increasing availability of iron-fortified foods during the past three decades. The Committee on Nutrition published a review in 1969 of the iron requirements for infants, along with recommendations for several ways of meeting these. In 1971, the Committee issued another statement recommending the use of iron-fortified formulas until at least 12 months of age. Developments since that time indicate that there are various means for fulfilling iron needs and that a broader set of recommendations is warranted.

The risk of iron deficiency is greatest when neonatal iron stores have been depleted, after about two months in small, preterm infants and after four to six months in term infants. Previous Committee statements have made no distinction between socioeconomic groups, but recent surveys among infants and children indicate that the highest incidence of anemia, which is a late manifestation of iron deficiency, is found in lower socioeconomic populations. Possibly this reflects poor compliance with recommended feeding practices and overdependence on fresh cow’s milk in the diet. Most children in middle-income families have little or no anemia. Infants of low birthweight are more likely to develop iron deficiency regardless of economic status. Thus, recommendations for iron supplementation in infancy must be flexible and should emphasize the needs of low-birthweight infants and of normal-birthweight infants in lower socioeconomic populations.

Although there is no evidence that iron deficiency without anemia has a permanent effect on human infant growth and development, animal studies indicate that iron deficiency anemia early in postnatal development results in biochemical abnormalities of some organs (e.g., the brain) that persist long after anemia has been corrected. Therefore, it seems important to keep the intake of iron sufficiently high to prevent anemia and other clinical manifestations of iron deficiency.

The Recommended Dietary Allowance (RDA) for iron is 10 mg/day until 6 months of age and 15 mg/day between 6 months and 3 years of age. This is roughly equivalent to the 1969 Committee recommendation of 1 mg/kg/day for term infants and 2 mg/kg/day for preterm infants, up to a maximum of 15 mg/day. These figures are only guidelines because iron absorption varies considerably according to the iron compound and the food with which it is eaten. For example, iron absorption is poor from iron pyrophosphate or ferric orthophosphate, from reduced iron of large particle size, and from meals that contain little or no animal-derived protein. Absorption is good from ferrous sulfate, from reduced iron of small particle size, and from meals that contain abundant animal-derived protein.

The major sources of dietary iron for the infant are iron-fortified infant formulas and dry infant cereals. Breast milk contains a small but significant amount of iron which is well utilized, and its effectiveness in preventing iron deficiency merits further study. Meat is a good source of iron, but the amount consumed during the first year rarely supplies a large amount of iron. The diet becomes more varied after infancy, and the
major sources of iron are meats and iron-enriched cereal products.

MILK AND MILK PRODUCTS

Both breast milk and cow's milk contain about 0.5 to 1.0 mg of iron per liter. This amount is equivalent to about 1 mg of iron per 1,000 calories in milk compared to 6 mg of iron per 1,000 calories in a mixed diet.

Breast Milk

A recent Committee on Nutrition statement recommends encouraging more women to breastfeed their infants.\textsuperscript{13} Breast-feeding is believed to be only rarely associated with iron deficiency.\textsuperscript{14} This may be based, in part, on the good absorption of the small amount of iron present; an average of 49\% is absorbed.\textsuperscript{15} An additional factor may be that intestinal blood loss is rare in breast-fed infants in comparison with infants fed fresh cow's milk.\textsuperscript{16,17} The needs of breast-fed infants for supplemental iron require more investigation. The most convenient source of supplemental iron for breast-fed infants is iron-fortified dry infant cereal. This should be started at no later than 4 to 6 months of age. A liquid iron supplement in the form of drops is an alternative. When breast-feeding is discontinued before 6 months of age, the use of infant formula rather than fresh cow's milk reduces the risk of intestinal blood loss.

Fortified Formulas

Iron-fortified formulas contain 10 to 12 mg of iron per liter as ferrous sulfate; an average of about 4\% of this is absorbed.\textsuperscript{9} When an iron-fortified formula is the major source of iron, it serves as a reliable vehicle for a relatively constant and predictable amount of iron. The present level of fortification has been found to be ample for preventing iron deficiency in full-term and in preterm infants. Most infants receive formula only before 6 months, prior to the age (6 and 18 months) when the risk of iron deficiency is greatest. Nevertheless, the early use of fortified formula results in an augmentation of iron stores which helps to prevent later development of iron deficiency.

Cow's Milk

Feeding fresh (pasteurized) cow's milk in early infancy may contribute to iron deficiency.\textsuperscript{17} Not only is cow's milk a poor source of iron, but, in some infants, its ingestion is associated with intestinal blood loss. Such blood loss is diminished when heat-processed formula is substituted for fresh milk or when the intake of cow's milk is reduced.\textsuperscript{18,19} The incidence and severity of intestinal blood loss from this cause and its significance in the pathogenesis of anemia during the first two years of life have not been determined. Until more information is available, it is best to breastfeed infants until at least 6 months of age if possible; or, heat-treated milk products (such as proprietary infant formula, reconstituted evaporated milk, or powdered milk formulas) can be used as alternatives when breast-feeding is not possible. The feeding of large volumes of formula (more than 1 qt or liter/day) should be avoided because it probably sets the pattern for later ingestion of excessive amounts of fresh cow's milk. The intake of fresh cow's milk after 6 months of age should not exceed 0.75 qt or 0.75 liter/day to reduce the risk of blood loss and to favor a varied diet which includes fortified cereals.

Infant Cereals

Most of the dry infant cereals produced in the 1940's and 1950's contained sodium iron pyrophosphate or other sources of iron, of which probably less than 1\% was absorbed. Since 1972, dry infant cereals have been fortified with electrolytically reduced iron of small particle size. About 4\% of this form of iron is absorbed, virtually the same as the absorption of ferrous sulfate added to cereal. The usual serving of dry cereal varies from 0.25 to 0.50 oz (7 to 14 gm). This is equivalent to 3 to 6 tablespoons, containing 3 to 6 mg of iron (0.45 mg/gm of cereal). Two servings per day of dry infant cereal fortified with reduced iron of small particle size provide a sufficient supply of supplemental iron for most infants. Although dry infant cereals are currently used primarily during the first year of life, they can also be recommended as a good source of iron during the second year because iron requirements continue to be large during this period. Several other forms of cereal are available for infants, but these contain iron in a lower concentration. Ready-to-feed cereals with fruit in jars have been variable in iron content and form; however, as soon as an orderly change can be made, manufacturers will produce these wet-pack strained and junior cereals supplemented either with ferrous sulfate or with other forms of iron that are well absorbed at levels of 6.75 mg of iron per 134-gm jar in strained foods and 4.5 mg per 220-gm jar in junior foods. Farina and other cream cereals commonly fed to infants are fortified to varying degrees and contain a variety
of iron compounds, not all of which are well absorbed. Nutritional counseling should emphasize the use of dry infant cereal rather than other forms of cereal as the best source of iron during the first two years of life.

**MEDICINAL IRON**

The drops that are most widely used for iron supplementation contain ferrous sulfate, a form of iron that is inexpensive and well absorbed. The iron is best utilized when given between meals, but administration with meals may be more convenient and will also result in adequate absorption. The small doses used for prevention of iron deficiency rarely cause gastrointestinal side effects. There may be temporary staining of the teeth, but this can be removed by brushing. The concentration of iron in proprietary preparations is high because these products were designed to be used primarily for treatment of iron deficiency rather than for prevention. For example, a dose of 1 mg/kg may be difficult to measure when the lowest graduation on the dropper provides 7.5 mg of iron in 0.3 ml. The disadvantages of iron preparations designed for therapy are inconvenience and the risk of accidental poisoning when consumed in nonprescribed quantities.

**RECOMMENDATIONS**

To provide adequate iron and overall good nutrition during the first year of life, the Committee recommends the following.

Iron supplementation from one or more sources should start no later than 4 months of age in term infants and no later than 2 months of age in preterm infants, and should continue at least through the remainder of the first year of life. The best method of fortification will depend on the clinical setting. In breast-fed infants the best source is iron-fortified cereal, two portions per day; iron-containing drops are an alternative. The dose of supplemental iron should not exceed 1 mg/kg/day for term infants and 2 mg/kg/day for preterm infants, up to a maximum of 15 mg/day. No more than one month’s supply should be kept in the house to reduce the risk of accidental poisoning. In formula-fed infants, the most convenient and best sources of supplemental iron are iron-fortified formula and iron-fortified cereal. Formula provides a relatively constant and predictable amount of iron supplement and is the most reliable vehicle for infants who may be fed solid foods only sporadically.

Infant formula and other heat-treated milk products are preferable to fresh 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. If the infant receives fresh cow’s milk after 6 months of age, the intake should not exceed 0.75 qt or 0.75 liter/day. In infants who continue to receive formula, the volume should be limited to 1 qt or liter/day to encourage the introduction of iron-rich solid food into the diet to set the pattern for a more varied diet during the second year of life.

The Academy’s Standards of Child Health Care recommends screening for anemia (hemoglobin < 11 gm/100 ml or hematocrit < 33%) between 9 and 12 months of age in term infants and earlier (between 6 and 9 months) in low-birthweight infants. Because iron deficiency is the most common cause of anemia in infancy, the effectiveness of iron supplementation in each clinical setting is most easily estimated in this manner.

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