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Vitamin K and the Newborn Infant

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Intramuscular administration of vitamin K for prevention of vitamin K deficiency bleeding (VKDB) has been a standard of care since the American Academy of Pediatrics recommended it in 1961. Despite the success of prevention of VKDB with vitamin K administration, the incidence of VKDB appears to be on the rise. This increase in incidence of VKDB is attributable to parental refusal as well as lowered efficacy of alternate methods of administration. The aim of this statement is to discuss the current knowledge of prevention of VKDB with respect to the term and preterm infant and address parental concerns regarding vitamin K administration.

BACKGROUND

Hemorrhagic disease of the newborn (HDN) was first described in the literature as an entity by Townsend in the late 1800s, although bleeding in the newborn had been described in detail long before that time.[1] The modern era of understanding the importance of vitamin K began with Dam and Doisy being awarded the Nobel Prize in 1943 for their work on identifying and isolating the new vitamin.[2] It was not until almost 20 years later that the American Academy of Pediatrics (AAP) published its seminal paper on vitamin K and its use in pediatrics.[3] This report described HDN as a "hemorrhagic disorder of the first days of life caused by a deficiency of vitamin K and characterized by deficiency of prothrombin, proconvertin [Factor VII] and probably other factors." This paper also recommended a single parenteral dose of 0.5 to 1.0 mg of vitamin K to all newborn infants as prophylaxis.

With the etiology of HDN identified, the disorder is now known as vitamin K deficiency bleeding (VKDB). This disorder is characterized by its time of presentation, namely early-onset, classic, or late-onset.[4]

Early-onset VKDB begins within the first 24 hours of age. It usually occurs in mothers who are taking medications that affect vitamin K

abstract

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metabolism. These medications include anticonvulsants, antibiotics, antituberculosis agents, and warfarin. All these agents work by inducing the CYP450 enzymes in the fetal liver. These infants may present with a spectrum of disease from cutaneous bruising to life-threatening intracranial hemorrhage. Prenatal vitamin K supplementation has not been shown to reduce early-onset VKDB, although it has been shown to increase cord vitamin K plasma concentrations.[5,6] There is insufficient evidence to recommend prenatal vitamin K supplementation to women receiving these medications.[7]

Classic VKDB occurs between 2 days and 1 week of life. Although some cases may occur in infants whose mothers were taking medications affecting vitamin K metabolism, most cases are idiopathic. Before the initiation of universal vitamin K prophylaxis, a study randomizing half of the male infants in a newborn nursery to receive vitamin K administration demonstrated a sixfold increase in postcircumcision bleeding[8] in the untreated group. In another study involving 3 preparations of (1) a placebo; (2) 0.1 mg intramuscular (IM) vitamin K; and (3) 5.0 mg IM vitamin K, the incidence of moderate to severe bleeding in the placebo group was significantly higher than either treatment group.[9] In this same study, breastfed infants were shown to have a significantly higher risk of VKDB than formula-fed infants.

Late-onset VKDB occurs between 1 week and 6 months of age, with a peak incidence between 2 and 8 weeks.[10] Late-onset VKDB is usually associated with exclusively breastfed infants who did not receive vitamin K prophylaxis at birth. It may also be associated with liver dysfunction secondary to neonatal hepatitis, bile duct atresia,[11] or intestinal malabsorption. Late-onset VKDB most commonly presents with evidence of intracranial bleeding in 30% to 60% of cases. There have been no randomized trials evaluating the efficacy of early postnatal intramuscular vitamin K in eliminating late VKDB[12]; however, there are several large national surveillance studies that have examined rates of late VKDB since the introduction of vitamin K prophylaxis in Japan, Germany, Great Britain, and Thailand. All of these studies have shown significant reductions in late-onset VKDB in the population.[13–16] The high incidence of mortality and morbidity, along with its virtual elimination with prophylactic vitamin K, has made it a focus of public health interventions around the world.

VITAMIN K PROPHYLAXIS OF THE NEWBORN INFANT

In 2003, the AAP reaffirmed the use of vitamin K to prevent VKDB and recommended that all newborn infants receive a single IM dose of 0.5 to 1.0 mg of vitamin K.[17] Whereas oral vitamin K appears to be effective in preventing classic VKDB,[18–20] there are concerns about its ability to prevent late-onset VKDB. The 2003 AAP statement cited multiple reports of late-occurring VKDB in countries that established policies of oral prophylaxis of infants, with a single oral dose of vitamin K after birth shown to be less effective than a parenteral dose.[21] Failure to prevent late-onset VKDB continues to be an issue with oral prophylaxis, despite the use of multiple-dose oral schedules. In a Swiss study using 2 oral doses of 2 mg of vitamin K on day 1 and day 4, late-onset VKDB was rare but still occurred, with an incidence of 3.79 per 100 000, and a 3-dose schedule was subsequently recommended.[22] This schedule included 3 oral doses of 2 mg of vitamin K given at birth, day 4, and week 4 of life. A 6-year follow-up surveillance study in Switzerland demonstrated a significantly lower rate of late VKDB of 0.87 per 100 000, with the main risk factors being parental refusal of any prophylaxis and undiagnosed cholestasis.[23] In a national surveillance study, the Netherlands described a rate of late-onset VKDB of 3.2 per 100 000 live births, based on an oral regimen of an initial dose of 1 mg of vitamin K followed by a daily dose of 25 μg.[24] As a result, the Dutch prophylactic dose was increased from 25 μg daily to 150 μg daily for 3 months after birth. Although this sixfold increase in dose did decrease the incidence of confirmed late-onset VKDB from 3.2 per 100 000 to 1.8 per 100 000, the confidence intervals were overlapping; thus, these results may not be significant.[25] The authors concluded that despite the increase in the oral dose, "this protection compares poorly to the efficacy of IM vitamin K prophylaxis." Factors decreasing the efficacy of oral vitamin K include poor parental compliance with the regimen and nonuniform oral drug absorption.

DOSING FOR PRETERM INFANTS

Preterm infants are potentially at greatest risk for VKDB because of hematologic and hepatic immaturity as well as a lack of adequate gut microbial colonization. The AAP has recommended a single IM dose of vitamin K of 0.3 to 0.5 mg/kg for preterm infants weighing less than 1000 g.[26] There is, however, great variability in dosing regimens for preterm infants because of the scarcity of studies performed to assess the correct dosing of vitamin K. One trial assigned preterm infants born at <32 weeks' gestation to 3 different dosing regimens: 0.5 mg IM, 0.2 mg IM, and 0.2 mg intravenous (IV).[27] Using markers of vitamin K deficiency (protein-induced vitamin K absence) and

overload (vitamin K epoxide), the authors concluded that 0.2 mg IM of vitamin K achieved satisfactory levels of vitamin K without overload for the first 3 weeks of life, the duration of the study. Twenty-seven infants weighing less than 1000 g received the 0.2-mg IM dose, which equated to a median dose of 0.279 mg/kg. Infants weighing more than 1000 g receiving the 0.2-mg IM dose also achieved satisfactory vitamin K levels, indicating that doses below 0.3 mg/kg also appeared effective in achieving normal serum concentrations. Of note, IV administration caused higher initial levels and significantly lower serum concentrations at 2 weeks, raising the concern of early vitamin K overload and late vulnerability to VKDB. In another study in which the treating physician decided on a dose of 0.5 mg or 1.0 mg for the preterm infant, vitamin K levels in both groups were over 500 times higher than fasting adult levels on day 10 of life.[28] These studies have indicated that a dose of 0.3 mg/kg for the preterm infant weighing <1000 g is sufficient.

THE BREASTFED INFANT

Minimal amounts of vitamin K are transferred across the placenta to the fetus, accounting for the low levels of vitamin K found in the newborn infant. Breast milk, which is the preferred nutrition for all newborn infants, provides relatively low levels of vitamin K, making exclusively breastfed infants particularly at risk for VKDB.[29] Because of their low baseline levels and low intake, exclusively breastfed infants' vitamin K plasma concentrations often fall below adult norms from 6 weeks to 6 months after birth. This decrease in plasma vitamin K occurs despite IM vitamin K at the time of birth.[30] Over 50 years ago, breastfeeding was identified as a significant factor in VKDB,[9] and it remains a concern to this day. In a surveillance of cases from New Zealand, VKDB was predominantly confined to exclusively breastfed infants who did not receive any vitamin K at birth.[31] In most countries with oral vitamin K supplementation policies, a late dose of oral vitamin K is recommended at 4 to 12 weeks to prevent late-onset VKDB in these infants. A small number of published studies have evaluated increasing vitamin K levels in breast milk via maternal supplementation with mixed results.[32,33]

PARENTAL REFUSAL

In recent years, there has been an increase in the number of parents who refuse IM vitamin K for their newborn infants and a resultant increase in the number of cases of late-onset VKDB.[34–37] Because VKDB remains a relatively rare occurrence, most families are unaware of the serious consequences of the disease and must be counseled on the risk of refusal. Parental objections often fall into 3 broad categories: belief systems, infant welfare, and outside influencing factors.[38] Parental refusal for infant welfare is often based on a 1990 study that found an unexpected association of vitamin K administration with childhood cancer.[39] Multiple larger studies conducted since then have refuted that unexpected association, finding no evidence that vitamin K is associated with leukemia or any other cancer.[40,41] In a study conducted through the Better Outcomes through Research for Newborns (BORN) network, predictor variables including exclusive breastfeeding, non-Hispanic white race or ethnicity, infant being female, greater gestational age, and increased maternal age were significantly associated with refusal of IM vitamin K administration.[42] Families may believe a "natural" birth is best and want to avoid what seems to be a painful intervention in the process. There was also a strong association between refusal of both ocular prophylaxis and hepatitis B vaccine with refusal of vitamin K. Parental reasons for refusal of IM vitamin K administration included lack of understanding of the indication for vitamin K, belief that it was unnecessary, concern about pain of the injection, and concern related to the preservative in the formulation.[34] There is no evidence that the small amount of preservative, benzyl alcohol, is associated with toxicity, and many infants receive preservative-free vitamin K. Outside influences often include friends and celebrities but may also include health care professionals. Pediatricians and all health care providers to newborn infants should strongly advocate for vitamin K prophylaxis. Births not attended by a physician also have been associated with parental refusal of vitamin K.[37] In a New Zealand study, 100% of physicians but only 71% of midwives believed it was important that infants receive a dose of vitamin K.[43] Refusal of vitamin K was also associated with delivery outside of the hospital and also strongly associated with general vaccine refusal at 15 months of age.[37]

Techniques to Increase Vitamin K Acceptance

Assessing and responding to parenteral concerns regarding vitamin K are important roles for the pediatric provider. Parents need to understand the importance of vitamin K and have a basic knowledge of its function to make an informed decision about their infant. An excellent fact sheet on vitamin K is available from the Centers for Disease Control and Prevention.[44] The discussion should be directed at the parent's level of understanding and include a discussion of the known benefits as well as perceived risks. Talking points for this discussion are provided in the Supplemental Information. The pediatric provider

needs to ask open-ended questions and listen carefully to the parent's responses. Parents who refuse IM vitamin K prophylaxis and request an oral dosing regimen should be aware of the increased risks of late-onset VKDB. Providers may wish to develop a vitamin K refusal form that documents their discussion on the risks of VKDB for families who decline the IM vitamin K prophylaxis.

SUMMARY AND RECOMMENDATIONS

VKDB remains a significant concern in newborn and young infants. Parenteral vitamin K has been shown to be the most effective way to prevent VKDB of the newborn and young infant, and the AAP recommends the following:

1. Vitamin K should be administered to all newborn infants weighing >1500 g as a single, intramuscular dose of 1 mg within 6 hours of birth.
2. Preterm infants weighing ≤1500 g should receive a vitamin K dose of 0.3 mg/kg to 0.5 mg/kg as a single, intramuscular dose. A single intravenous dose of vitamin K for preterm infants is not recommended for prophylaxis.
3. Pediatricians and other health care providers must be aware of the benefits of vitamin K administration as well as the risks of refusal and convey this information to the infant's caregivers.
4. VKDB should be considered when evaluating bleeding in the first 6 months of life, even in infants who received prophylaxis, and especially in exclusively breastfed infants.

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ABBREVIATIONS

AAP: American Academy of Pediatrics
HDN: hemorrhagic disease of the newborn
IM: intramuscular
VKDB: vitamin K deficiency bleeding

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