REVIEW ARTICLE

Vitamin A: Nutritional Value and Role in Public Health

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ABSTRACT:

For the past nine decades, research on different aspects on vitamin A (retinol) including nutrition, biochemistry, molecular and cell biology, physiology, toxicology, medical therapy and public health is being conducted all over the world. Vitamin A is an essential micronutrient for all vertebrates. It is required for normal vision, reproduction, embryonic development, cell and tissue differentiation, and immune function in animals and humans. Many aspects of the transport and metabolism of vitamin A, as well as its functions, are well conserved among species. On the other hand, deficiency of vitamin A is also known to be associated with different specific disease conditions such as xerophthalmia, which is manifested as night blindness and corneal abnormalities, softening of the cornea (keratomalacia) and ulceration leading to irreversible blindness along with increased susceptibility to infections and abnormalities in reproduction. Research evidence suggests that diet supplemented with butter, fish, oils, milk and meat could be used as a better source to overcome vitamin A deficiency leading to a healthy life.

Keywords: Vitamin A, nutrition, public health.

INTRODUCTION

Vitamin A is a generic term that refers to compounds with the biological activity of retinol. Dietary vitamin A is ingested in two main forms, preformed vitamin A (retinyl esters and retinol) and provitamin A carotenoids (B-carotene, a-carotene, B-cryptoxanthin), although the proportion of vitamin A obtained from each of these forms varies considerably among animal species and individual human diets[1-3]. These precursors serve as substrates for the biosynthesis of two essential metabolites of vitamin A: 11-cis-retinal, required for vision, and all-trans-retinoic acid, required for cell differentiation and the regulation of gene transcription in nearly all tissues. They are provided in the diet by green and yellow or orange vegetables and some fruits and preformed vitamin A, namely retinyl esters and retinol itself: present in foods of animal origin, mainly in organ meats such as liver, other meats, eggs, and dairy products. All-trans-retinoic acid, is the most bioactive form of vitamin A, when given to vitamin A-deficient animals, retinoic acid restores growth and tissue differentiation and prevents mortality, indicating that this form alone, or metabolites made from it, is able to support nearly all of the functions associated to vitamin A. It is also evident that different forms of vitamin A differ in their biological activity per unit of mass and therefore the bioactivity of vitamin A in the diet is expressed in equivalents with respect to all-trans-retinol rather than in mass units[1-7].

LIERATURE REVIEW

Nutritional Aspects Vitamin A

Vitamin A was discovered in the early 1900s by McCollum and colleagues at the University of Wisconsin and independently by Osborne and Mendel at Yale University. Both groups were studying the effects of diets made from purified protein and carbohydrate sources, such as casein and rice flour, on the growth and survival of young rats. They observed that growth ceased and the animals died unless the diet was supplemented with butter, fish oils,

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or a quantitatively minor ether-soluble fraction extracted from these substances, milk, or from meats. The unknown substance was then called "fat-soluble A". After that, it was recognized that the yellow carotenes present in plant extracts had similar nutritional properties, and it was postulated that this carotenoid fraction could give rise through metabolism to the bioactive form of fat-soluble A, now called vitamin A, in animal tissues. Although the discoveries made in the early 1900s may now seem long ago, it is interesting to note, that physicians in ancient Egypt, around 1500 BC, were already using the liver of ox, a very rich source of vitamin A, to cure what is now referred to as night blindness[8].

Recommended Dietary Allowance (RDA) and Upper Intake Level (UL)

The recommended dietary allowance (RDA) is defined as "The average daily intake level that is sufficient to meet the nutritional requirement of nearly all (97-98%) apparently healthy individuals in a particular life stage and gender group". Similarly the upper intake level (UL) is the "highest level of daily nutrient intake that is likely to pose no risk of adverse health effects in almost all apparently healthy individuals in the specified life stage group. As intake increases above the UL, the potential risk of adverse effects increases"[9]. The Recommended Dietary allowances (RDA) and Upper Intake Level (UL) values for vitamin A by life stage group are indicated in Table-1. It is important to note that the UL applies only to chronic intakes of preformed vitamin A (not carotenoids, which do not cause adverse effects). For several life stage groups, the UL values are less than three times higher than the RDA[10]. However, the contents of vitamin A and carotenoids in foods can vary substantially with crop variety or cultivar, the environment in which it is grown, and with processing and storage conditions[11,12].

Vitamin A and Public Health

Vitamin A is considered as one of the most important fat-soluble vitamins due to its uncountable advantages for humans and animals and for this purpose its daily requirements should be fulfilled very carefully. Several research workers have proved that insufficient quantity of vitamin A (retinol) in the body may lead to serious disease conditions either temporarily or sometimes permanantly[13-33]. Some important cases of vitamin A deficiency are discussed below:

1. *Prevention of Xerophthalmia*

Retinoic acid plays an important role during embryonic eye development. It promotes normal development of the ventral retina and optic nerve through its activities in the neural crest cellderived periocular mesenchyme[34]. Its deficiency may cause a variety of retinal diseases[35]. Vitamin A is the primary cause of xerophthalmia which is manifested as night blindness and corneal abnormalities, softening of the cornea (keratomalacia). and ulceration leading to irreversible blindness. In the early 1990s, it was estimated by WHO that approximately 3 million children, most living in India, parts of Southeast Asia, and sub-Saharan Africa, had some form of xerophthalmia annually, and, on the basis of blood retinol levels, another 250 million were subclinically deficient[13]. The use of vitamin A to prevent or treat xerophthalmia represents an important break through in the field of nutritional sciences[14].

2. *Morbidity and Mortality*

It was reported in the early 1980s by Sommer and colleagues, from the studies conducted in Indonesia, that young children suffering from night blindness were found to have died at a higher rate than children with normal eyes[15]. Some other investigators also reported that pre-school aged children in poor regions of Southeast Asia, India and Africa showed reduced rate of mortality by preventing A deficiency[16]. On this basis, it was estimated that the administration of 200,000 IU dose of vitamin A every six month would likely reduce total mortality rate by 35% in pre-school children[17], and the amounts of vitamin A similar to RDA would be helpful in 23% reduction in mortality in children less than 6 years[18], in newborns[19] and in pregnant women[20,21]. On the other hand Gogia and Sachdev[16] have suggested for not initiating such supplementation as a public health intervention in developing countries for reducing infant mortality and morbidity. There study showed no convicing evidence of a reduced risk of mortality and possibly morbidity after neonatal supplementation with vitamin A.

3. *Subclinical Deficiency*

The subclinical forms of vitamin A deficiency have been a topic of debate for a long period of time and was proved to be associated to an increased risk of developing respiratory and diarrheal infections, decrease growth rate, slow bone development, and decreased likelihood of survival from serious illness[22].

Vitamin A is also helpful to reduce measles-related morbidity and mortality[23] and therefore it is recommended by WHO to integrate vitamin A supplementation into the expanded program of immunization (EPI), at the time of measles and diphtheria, pertussis, tetanus vaccinations to deliver vitamin A to infants and children in countries where vitamin A deficiency is prevalent[24,25].

3. *Immune System Changes*

It is widely thought that the ability of vitamin A to reduce mortality is due to the effects on the immune system of animals which increases the rate of suvival and reduces the severity of disease[26,37-39]. A number of animal models have been used to understand the effects of vitamin A deficiency, and repletion, on the immune system[27] and it was concluded that vitamin A deficiency results in multiple abnormalities in natural and adaptive immunity involving cell differentiation, hematopoiesis and blood and lymphoid organ cell populations. The abnormalities are mostly or completely reversible by treatment with vitamin A or retinoic acid by stimulating natural and adaptive immune responses[28-31].

DISCUSSION

The literature review presented above has supported the fact that vitamin A has secured maximum attention of nutritionists and physicians to overcome many servere disease conditions which may occur due to its deficiency in daily routine diet. As it is considered an essential micronutrient for all vertabrates, its deficiency is also associated with several indications of reversible body disorders. A diet containing recommended amounts of vitamin A according to different life stage groups may therefore accounts for a better source to face the challenges of treating various deficiency related diseases. The contents of vitamin A and carotenoids in foods can vary substantially with crop variety or cultivar, the environment in which it is grown, and with processing and storage conditions[11,12]. Foods with the highest concentrations of preformed vitamin A are liver (4-20 mg retinol~100g) and fortified foods such as powdered breakfast dinks (3-6mg ~ 100g), ready-to-eat cereals (0.7-1.5mg ~ 100g), and margarines (0.8mg ~ 100g)[10]. The highest levels of provitamin A carotenoids are found in carrots, cantaloupes, sweet potatoes, pumpkin, kale, spinach, collards, and squash (roughly 5-10mg RAE 1~00g)[10,40]. These data are compiled for both genders and for all age groups. It is also reported by the Institute of Medicine's Micronutrients that an adequate intake of vitamin A can be obtained even if a vegetarian diet containing only provitamin A carotenoids is consumed[41].

CONCLUSION

In the light of above mentioned facts, it seems quiet clear that vitamin A is one of the most useful components for body functions and that it should be included in daily diet according to the recommended amounts (RDA) for all age groups to achieve a better life style. It protects the body from many life threatening diseases by strengthening the immune system efficiency and the organism's ability to respond to pathogens, antigens, and mitogens, effectively. Due to its requirement from infants to pregnant women for normal body functioning and high immune response, its use would surely be helpful in reducing subclinical deficiency symptoms.

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Table 1: Recommended dietary allowances (RDA) and upper level (UL) values for Vitamin A by life stage group.

Life Stage Group	RDA (µg / day)[a]	UL (µg / day)[b]
Infants		
0-12 months	400	600
Children		
1-3 years	300	600
4-8 years	400	900
Adolescent and adults males		
9-13 years	600	1700
14-18 years	900	2800
19 to > 70 years	900	3000
Adolescent and adults females		
9-13 years	600	1700
14-18 years	700	2800
19 to > 70 years	700	3000
Pregnancy		
< 18 years	750	2800
19-50 years	770	3000
Lactation		
< 18 years	1200	2800
19-50 years	1300	3000

[a] As retinol activity equivalents (RAEs).

[b] As µg preformed vitamin A (retinols).

[c] Adequate intake (RAEs).