Role of Diet in Nickel Dermatitis

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Abstract: Nickel is the twenty-second most abundant element and the seventh most abundant transitional metal. It is an ubiquitous trace element and it is mostly adopted to manufacture stainless steel used to produce food processing equipment and containers. The metal allergy is often caused from Ni and females are affected more commonly than males. When Ni allergy develop it tends to persist life-long. Food is considered to be a major source of Ni exposure for the general population. Significant Ni concentration was found in the following foods: mixed nuts, dried fruits, tea bag, cocoa, chocolate, varieties of crisps, soy products, legumes and wheat flour. Moreover, cooking acidic food in stainless steel utensils may increase the Ni content. Nickel content in food may vary considerably due to the difference in Ni content of the soil. Nickel-sensitive person can develop dermatitis when in their diet is present the element. Then, careful selection of food with relatively low Ni concentration can bring a reduction in the total dietary intake of Ni per day. This can influence the outcome of the disease and can benefit the nickel-sensitive patients.

Keywords: Nickel, diet, contact dermatitis.

1. INTRODUCTION

Nickel is a silvery-white heavy metal and is highly resistant to attack by air and water. Nickel forms numerous alloys with other metals. Its alloy with iron, nickel steel, is extremely tough and corrosion resistant. For this reason most of the Ni produced world-wide is used for the manufacture of stainless steel, which is mostly used to produce food processing equipment and containers. It is also used to manufacture fashion jewellery, machinery parts, coins; finely-divided Ni is used as hydrogenation catalyst.

Nickel is the most allergic metal; the sensitivity is more common in females than males and the prevalence varies from 4% to 13.1% in different countries [1, 2]. Today, in female population, the prevalence is around 10% (all age groups are affected) [3]. In some occupational groups, such as hairdressers the prevalence rate may be as high as 27-38% [4]. As concern the non occupational contacts exposure (for example, ear piercing and fashion jewellery that contains free Ni), women are more commonly sensitized. On the other hand, males are mostly sensitized by occupational exposure. Nickel allergy may appear with different degree and pattern. Some times the contact dermatitis develop from even brief contact with nickel-containing items, while others times allergy can develop only after many years of skin contact with Ni. A "secondary rash" due to spread of dermatitis to distant regions is rarely observed at present [5]. The chronic contact with nickel-containing detergents, nickel-plated items, nickel-containing coins, etc. can often develop hand eczema many years after primary sensitization. It was reported that patients develop vesicular type of hand eczema following the ingestion of Ni in diet [6]. This type of eczema flares up when such patients are treated with oral nickel sulphate. Is well known that chronic urticaria, a type 1 hypersensitivity response, has been attributed to dietary Ni [7]. Cases of erythema multiforme, vasculitis and Baboon syndrome have been reported following Ni ingestion [8-10]. This last syndrome present a pattern of systemic contact dermatitis with a generalized rash with particular involvement of buttock, anogenital area, flexures and eyelids.

2. NICKEL DERMATITIS AND DIET

An average diet supplies 300-600 μg of Ni to the human body per day [11]. The presence of sufficient amounts of Ni in the diet of a nickel-sensitive person can provoke dermatitis. It has been observed that nickel sulfate when orally administered in the range of 600-5600 μg as a single dose may provoke hand eczema [12]. The hands are the most commonly affected sites for systemic Ni dermatitis. However, other body areas may be affected as well. There are reports of serious reactions such as erythema multiforme and vasculitis following oral challenge [8, 9]. Improvement of dermatitis has been noted on a low Ni diet [13] and by oral disulfiram, which chelates Ni and increases its excretion [14]. Moreover, it has been noted that children with orthodontic braces, who are therefore exposed to low continuous levels of ingested Ni, may have less subsequent Ni allergy [15].

2.1. Source of Nickel

Nickel is present in soil with a concentration ranging from 5 μg/g to 500 μg/g even if it may be higher locally. In fresh water its level vary from 5 μg/L to 100 μg/L and in plant and animal tissues the concentration is 0.5-5 μg/g and 0.1-5 μg/g, respectively [16]. The nickel content of food is strongly influenced by the concentration of Ni in the soil. The concentration of Ni in the soil varies from place to place. Some of the important factors that influence the concentration of Ni in soil are: a) type of soil; b) use of modern agricultural practices such as the use of synthetic fertilizers

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and pesticides; c) contamination of soil with industrial effluents and urban wastes; d) distance of the soil from the Ni smelters [17]. It is noteworthy that even seasons can influence the concentration of Ni in plant tissues; it has been observed that Ni concentration increases in spring and autumn and falls during mid summer [18].

2.2. Nickel in Foods and Beverages

In the general population food is the major source of Ni exposure and plant food is a major dietary source of this element. Plant tissues contain more Ni than animal tissues. Therefore, the total dietary intake of Ni per day varies depending on the amount of consumption of plant and animal foods. The amount of Ni in foods may vary considerably from place to place due to the Ni content of the soil. It was found that Ni was present in the following amounts in various foods (mg/Kg fresh weight): green vegetables, 0.11; cereals, 0.17; other vegetables, 0.09; potatoes, 0.10; carcass meat, 0.04; poultry, 0.04; fish, 0.08; eggs, 0.03; milk, <0.02; dairy products, 0.02; nuts, 2.5; fresh fruits, 0.03; oils and fats, 0.03; etc. [19]. Another study found significant Ni content in the following foods (mg/Kg): a green tea bag contained 235.57; a black tea bag, 62.79; chocolate, 27.87; crisps, 12.70; wheat flour, 12.15; welsh onion, 0.02; garlic, 0.016, milk, 0.004; egg, 0.002 [20]. Selected snack and convenience foods showed these values of Ni content (mg/Kg): instant tea, 7.8-12; instant coffee, 0.62-1.3, roasted cashews, 4.1-4.7; custard, 0.02-0.03; lentils, 1.6-2.3; mixed nuts, 0.99-5.29; dried peas, 0.39-0.76; haricot beans, 0.65-2.3; varieties of crisps, 0.06-0.61 [21]. Furthermore, the following list shows food with high Ni content irrespective of the soil content: whole wheat, whole grain, rye, oat, millet, buckwheat, cocoa, chocolate, tea, gelatin, baking powder, soy products, red kidney beans, legumes (peas, lentils, peanut, soya beans and chickpeas), dried fruits, canned foods, beverages, strong licorice, and certain vitamin supplements [13].

In the western world examples of diets are reported. In UK, the mean total dietary intake of Ni has been reported to be between 0.12-0.21 mg [19]. In Finland, USA and Canada has been reported a content of 0.13, 017 and 0.207-0.406 mg, respectively [22-24]. The dietary intake of Ni in Denmark is comparatively higher and could reach over 900 μg/day, and this was due to the high intake of oatmeal and legumes, including soybean, nuts, cocoa and chocolate [25]. Indian diets, representing the eastern example of food consumption, are rich in plant food and therefore it contains considerable amount of Ni. Cereals, pulses and vegetables constitute the main bulk of the Indian diet. Pulses comprise varieties of lentils, beans and peas, which have high Ni content. Vegetables used in Indian diets include green leaves, roots and tubers and other vegetables. Vegetables such as spinach, onion and garlic are very popular and are found to contain moderately high amounts of Ni. Even the cows' milk, which is an essential part of majority of Indians' diet, is not free from Ni and its Ni content is approximately 0.03 μg/g of Ni [21]. Tea is consumed throughout India; dried tea leaves used for beverage making have been found to contain 3.9-8.2 mg/Kg of Ni [26]. Jaggery (a locally available form of sucrose, also known as Indian sugar), which is commonly eaten in rural India, is found to have Ni in the concentration of 0.011 mg/g of jaggery [27]. Coffee, which is very popular in South India, is found to contain Ni in the concentration of 43 mg per 100 g of coffee beans (roasted, ground) [28]. Cocoa beans, from which cocoa and chocolate are made may contain up to 10 mg/Kg of Ni and are common constituents of fast-foods in India [29]. High concentration of Ni is sometimes found in processed foods. This is free Ni, picked up from the stainless steel used in the manufacture of equipment and containers. In general, cooking in stainless utensils releases negligible amount of Ni; however, cooking acidic food in these utensils may increase the Ni content.

3. NICKEL METABOLISM IN HUMAN

In typical diet only 1-10% of the ingested dietary Ni is absorbed; following absorption, Ni is transported in blood bound to serum albumin. Most of the absorbed Ni is excreted by the kidneys linked to complexes with low molecular weight and it is also lost through sweat and bile. It is not significantly accumulated by any tissue in the body. Relatively high Ni concentrations was found in the thyroid and adrenal glands in comparison to other tissues [11]. The role of Ni in biochemical functions of human body is not quite clear and a daily dietary requirement of 25-35 μg of Ni has been suggested [29].

4. STRATEGIES FOR THE TREATMENT OF NICKEL DERMATITIS

As known over the world, Ni is one of the commonest sensitizers and once sensitized, the sensitization tends to persist for many years, often life-long. Therefore, Ni allergy shows a chronic recurring course. As concern the treatments, different strategies have been recommended: a) systemic steroids; b) cyclosporine; c) topical steroids; d) wet dressing; e) psoralen and ultraviolet A light (PUVA) therapy, etc. Unfortunately the result of different treatment is often mostly unsatisfactory as the relapse rate is high. In fact, the humans are always exposed to Ni. The contact with this metal should be avoided to a certain extent. However, this is not always helpful because Ni is present in most of the dietary items of humans. Unless this continuous supply of Ni is reduced, Ni eczema will continue to relapse, particularly the vesicular type of hand eczema. The careful selection of food with relatively low Ni concentration can result in the reduction in the total dietary intake of Ni per day. Therefore, a good knowledge of the presence of Ni in food is helpful for the management of Ni allergy [30].

5. CONTROL NICKEL DERMATITIS THROUGH THE DIET

Nickel cannot be completely avoided from diet; however, a daily reduction in the total dietary intake of Ni is possible by the selection of the food with relatively low Ni concentration. Many studies have confirmed the benefit of low Ni diet in the reduction of Ni eczema even if the dermatitis will not clear completely during the diet period. In addition to the dietary some food habit must be taken into consideration while drafting a low Ni diet. Animal tissues generally contain less Ni than plant tissues. Meat, poultry and eggs are suitable for low Ni diet. Fishes can be used for low Ni diet except tuna, herring, shellfish, salmon and mackerel that show high concentration of Ni. Milk and its products such as butter, cheese, curd and cottage cheese (paneer) can be consumed. Nickel content of cereals is low. Vegetables such as potatoes, cabbage and cucumber can be used. Onion, garlic,

bananas, apples (up to 3-4 times a week) and citrus fruits (up to 3-4 times a week), tea and coffee (up to 2 cups a day) should be used in moderation. Vegetables such as green leafy vegetables may be taken sparingly due to the possibility of high concentration of Ni. Mushroom can be used, while it is preferable to avoid all foods that are routinely high in Ni content such as cocoa, chocolate, soya beans, oatmeal, nuts, almonds, fresh and dried legumes. The avoidance of vitamin supplements with Ni and canned food may also be of help in reducing the Ni intake. Nickel dissociate from the alloy of the can and thus increase the total Ni content of the canned food. Finally, during the cooking it is important to consider that acidic food should not be cooked in stainless steel utensils. In fact, the acids may lead to the dissociation Ni from the utensils and it may increase the Ni content of the food. Nickel-plated utensils should not be used and should be replaced. Nickel may be released from the tap during night and then the initial water flow from the tap in the morning should not be drunk or used for cooking [30].

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