Acta Pediatr Mex 2011;32(5):287-291

INP

Artículo de revisión

Pediatric trace elements. Clinical updates

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RESUMEN

Durante la etapa temprana, los lactantes consumen una dieta predominantemente láctea. La leche es un producto natural, rico en oligoelementos (aproximadamente 1 g/100 mL). Los oligoelementos son compuestos inorgánicos que no se sintetizan en el cuerpo, donde existen en pequeñas cantidades; por lo tanto se deben obtener de los alimentos, ya que son esenciales para la vida. El presente artículo de revisión da a conocer los estudios más recientes de los oligoelementos y su fuente de obtención, así como la importancia de su uso en la nutrición parenteral total.

Palabras Clave: Oligoelementos, alimentos naturales, nutrición parenteral total, compuestos inorgánicos, lactantes.

ABSTRACT

During early life, infants usually consume a predominant milk diet. This is a natural food rich in trace elements (approximately 1 g/100 mL). Trace elements are not inorganic compounds synthesized in the body, which contains only small amounts; they can be obtained from natural food, since they are necessary for human life. This paper reviews the updated information on trace elements, their source from natural foods, and their importance in parenteral nutrition.

Key words: Trace elements, natural foods, total parenteral nutrition, inorganic compounds, infants.

During early life, infants usually consume a diet heavily dominated by milk. It is generally believed that breast-fed infants absorb adequate quantities of minerals and trace elements, whereas there is some concern on how well infants utilize these nutrients from cow's milk formula and other types of infant diets. Therefore, most infant formulas contain much higher concentrations of minerals and trace elements than those in breast milk (Table 1). It is difficult to assess minerals and trace elements status in infants, as well as to ascertain the potential adverse consequences of either suboptimal or excessive intakes of calcium, magnesium, iron, zinc, copper, manganese, and selenium [1]. It is equally hard to measure the biodisponibility of protein fragmentation in the gastrointestinal tract and the chemical interactions of trace elements [2].

This study shows that milk is a natural food, rich in trace elements (approximately 1 g/100 mL) whose concentration varies due to genetic factors, type of feed consumed by the cattle and also resulting from contamination in the area of production. The average mineral content of milk in mg/L was: calcium 1179, magnesium 109.7, zinc 5.89, phosphorus 637.1, copper 0.15, cadmium < 0.01, chromium < 0.02, iron 0.59, lead < 0.04, manganese < 0.02, nickel 0.36 [3]. Some natural foods also have trace elements, and they are inexpensive (Table 2).

Concentration of iron in cow's milk, 0.40-0.59 μg/mL, was found to be quite similar to that of human milk, 0.20-0.69 μg/ml. Copper concentration of cow's milk (0.06-0.09 μg/mL) is lower than in human milk (0.24-0.50 μg/mL) whereas zinc concentration is higher in cow's

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Recibido: junio, 2011. Aceptado: julio, 2011.

This article must be quoted: Calderón-Guzmán D, Hernández-García E, Barragán-Mejía G, Carmona-Aparicio L. Pediatric trace elements. Clinical updates. Acta Pediatr Mex 2011;32(5):287-91.

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Table 1. The American of Pediatric Academy suggests the next values in infant formulas

Substance	*Mínimum level*	*Máximum level*
Calcium (mg)	60	*
Fosphorus (mg)	30	*
Magnesium (mg)	6	*
Iron (mg)	0.15	2.5
Iodine (mg)	5	25
Zinc (mg)	0.5	*
Cuprum (µg)	60	*
Manganese (µg)	20	60
Potasium (mg)	80	200
Chloride (mg)	55	150
Selenium (µg)	3	*

*Insertan dates

milk (3.23-5.15 µg/mL) than in human milk (1.16-3.83 µg/mL). Cow's milk contains 4 to 5 times more calcium and magnesium, 854-1430 µg/mL and 87-131 µg/mL, respectively, than human milk (220-252 µg/mL and 26-35 µg/mL). Casein fraction in cow's milk contains a large proportion of the total amount of the elements cited above (Fe 24%, Cu 44%, Zn 84%, Ca 41%, Mg 25%) whereas human casein only binds minor amounts (Fe 9%, Cu 7%, Zn 8%, Ca 6%, Mg 6%). Whey proteins bind a major part of these elements in human milk, but not in cow's milk [4].

Trace elements are important substances for biochemical reactions in the body; likewise, these take part in hormone synthesis, food digestion, cell reproduction and the immune system [5]. Trace elements are inorganic compounds which are not synthesized in the body; these are contained in minimum quantity, and they are necessary in food consumption, are most important for human life [6].

The current way of life and industrialization of food industry have caused many people deprivation of adequate amounts of trace elements. This results in the development of many chronic diseases [7]. Recent studies have shown the latest findings on trace elements and their possible biological effects (Table 3); 20% of these studies have been made in Mexican population.

Moreover, inpatients have the option of receiving trace elements in total parenteral nutrition (TPN), which is a therapeutic tool if trace elements are below amounts required by the body [39]. TPN is a therapeutic and prophylactic life sustaining method for patients in high risk of malnutrition, and cannot be fed by mouth. It is an intravenous method to supply every element required to maintain or to recover an adequate nutritional state [40].

In order to determine an individual's nutritional state, the physician should enquire about his nutritious regimens and health problems, carrying out a physical exam and running tests on blood nutrient values and of substances

Table 2. Usual doses of trace elements in foods consumed by infants and their natural source

Name	*Symbol*	*Doses per day*	*Natural source*
Iron	Fe	6-10 mg	Yeast, beans, wheat germ, chickpea, oats, beef liver, spinach.
Iodine	I	40-50 µg	Onion, seafood, seaweed
Zinc	Zn	5-10 mg	Milk, egg, meat, yeast
Magnesium	Mg	40-60 mg	Oats, almond, beans, wheat, lentils, coconut, rye, wheat germ
Selenium	Se	10-15 µg	Legumes, milk, meat, cereal, seafood
Cuprum	Cu	0.4 – 0.7 mg	Yeast, beef liver, oats, alfalfa, olives, avocado, barley.
Manganese	Mn	0.3 – 1 mg	Oats, avocado, alfalfa, beans, almond, nuts, coconut, spinach, peanuts, lettuce
Sulfur	S	NO	Peanuts, beef liver, oats, egg, lentils, parsley, nut, broccoli, fresh cod
Flúor	F	0.1 – 1 mg	seafood, fruits, meats and vegetables.
Cromium	Cr	0.01 – 0.06 mg	Chicken, milk, yeast
Cobalto	Co	No infants 1,2 µg	Milk, alfalfa, sardine
Phosphorus	P	300-500 mg	Yeast, yolk, sardine, soybean, almond, peanuts, oats, lentils
Molibdenum	Mo	15-40 µg	Milk, legumes, vegetables
Níquel	Ni	60 – 150 µg	Chocolate, nuts, cereal
Sodium	Na	115-750 mg	Salt, olives, margarine, milk serum, canned goods, wheat bread
Calcium	Ca	400-600 mg	Milk, soybean, molasses, watercress, parsley, beans, hazelnuts, lentils, salmon, cheese
Potasium	K	275-1200 mg	Milk, legumes, meat, yeast and fruit
Chloride	Cl	275-1200 mg	Milk, salt, molasses, coconut, olive

Table 3. Studies of trace elements in recent years (continúa en la siguiente página)

Symbol	*Biological effects*	*Ref.*
Zn	Zinc and micronutrients treatment increased the lymphocyte ratios of CD4(+) to CD8(+) and of CD4(+)CD45RA(+) to CD4(+)CD45RO(+).	8
Zn	Vitamin A plus zinc reduce *Giardia lamblia* incidence, whereas zinc supplementation increases Ascaris lumbricoides incidence but decreases Entamoeba histolytica-associated diarrhea.	9
Fe	Anemia was mostly associated with iron deficiency and with a lesser proportion of folate and vitamin A deficiencies. Vitamin A deficiency might be overestimated since iron deficiency may lower serum retinol concentrations.	10
Se	Concentrations of minerals and trace elements in formulas for full-term infants are generally higher than in human milk, and all appear to be more than adequate, with the possible exception of selenium, which may need to be increased in some formulas.	11
Zn	The incidence rate/ratio (IRR) of developing a cold (IRR 0.64; 95% CI 0.47 to 0.88) (P = 0.006), school absence (P = 0.0003) and prescription of antibiotics (P < 0.00001) was lower in the zinc supplementation.	12
Fe	Almost one-fourth of US children under 12 years of age, and 30% of 2-year-olds, use vitamins, fluoride, and iron supplements in a given week.	5
Se, Zn	High levels of serum lead and mercury and low levels of zinc and selenium induce some disturbances in the antioxidant system in children with recurrent wheezing.	13
Fe	Maternal hepcidin is not significantly altered as a function of placental infection and/or anemia.	14
Zn	Zinc reduces the frequency and improves recovery rates of any type of diarrhea and has better compliance and outcome with its use in suspension form.	15
Fe, Zn	Micronutrients powder probably enhances absorption of high native iron content of complementary foods in cereals and/or legumes.	16
Zn	Aspects of intellectual functioning including working memory, inhibitory control, and fine motor functioning among offspring were positively associated with prenatal iron/folic acid supplement in an area where iron deficiency is prevalent.	17
Zn	Zinc is safe in HIV-infected adults and children. It may have similar benefits in HIV-infected children and adults, and uninfected children with diarrhoea, as it does in HIV-uninfected children	18
Fe	*H. pylori* infection is associated with higher prevalence of anemia in school-age children regardless of socioeconomic variables.	19
Fe	One child was found to have a sagittal sinus venous thrombosis caused by severe dietary iron deficiency anemia.	20
Fe	Oral iron therapy, in appropriate doses and for sufficient duration, is an effective first-line strategy for most patients and in selected patients for whom intravenous (IV) iron therapy is indicated.	21
Fe	The regulatory effect of IL-6 in human hepcidin production suggests that iron deficiency is a causal link between IL-6 and anemia of chronic disease.	22
Zn	Zinc reduced the mean weight of body mass index significantly. Clinical application of zinc supplementation in childhood obesity should be carried out in future studies.	23
Se, Fe	Alterations in serum levels of trace elements in obese children may play a role in the pathogenesis of obesity.	24
Mn	Airborne Mn environmental exposure is inversely associated with intellectual function in young school-age children.	25
Se	Serum selenium level in children with simple febrile seizures was significantly lower than in the nonseizure control group. It seems that there is an association between serum selenium deficiency and simple febrile seizures.	26
Fe	Children 6-60 months of age with smear-positive malaria and anemia (hematocrit < 33%) should receive iron (2 mg/kg/day) plus folate (5 mg/day) or folate alone. Iron supplementation improved hematologic recovery in children with malarial anemia.	27
Zn	Profound changes in the thymus can also be seen in deficiency of vitamins and trace elements. Zn deficiency causes a substantial thymic atrophy.	28
Fe	Ferrous fumarate and ferrous sulfate are well absorbed in non-anemic, iron sufficient infants and young children, and can be recommended as a useful fortifying compound for complementary foods designed to prevent iron deficiency.	29
Se	Se status is depressed in pediatric patients with burns and the recommended intake for healthy children is insufficient for this population.	30
Zn	Zinc supplementation is effective in hepatic encephalopathy and consequently improves patient health-related quality of life.	31

Table 3. Studies of trace elements in recent years (continuación)

Symbol	*Biological effects*	*Ref.*
Zn	Concentrations of Zn, Ca, K, and Mg were lower in scalp hair and blood but higher in urine samples in children with night blindness.	32
I	Iodine intake of infants up to four months of age should be raised from currently 40 µg/d to at least 60 µg/d.	33
Fe	In children older over six years of age, there was a nearly 2-fold increase in iron absorption from ferrous fumarate given with orange juice	34
Mn	Brain MRI showed a high frequency (64%) of T1 hyperintensity in basal ganglia of patients with portal hypertension, which correlated positively with blood manganese levels.	35
Se	Studies on children exposed to methyl-mercury (MeHg) by ingestion Se-rich ocean fish showed improved their IQ instead of harm.	36
Fe	Lead level >/= 10 µg/dl was significantly associated with anemia, decreased iron absorption and hematological parameters disturbances. High blood lead levels were associated with low serum iron and ferritin	37
Se	Cerebro-spinal fluid Se values were 32 times lower compared with those for plasma and there was an association between CSF Se and GPX activity.	38

Zn=Zinc, Fe=Iron, Se=Selenium, Mn=Manganese, I=Iodine.

related to these values: hemoglobin, thyroid hormone or transferrin, the latter as indicator of metabolic damage [3].

To determine a person's nutritious regimen background, the physician should also ask what foods he ingested in the last 24 hours, and what foods he or she takes regularly. The patient can then make a list all of the foods taken for three days. A person's behavior, general aspect, body fat distribution and the body organ functioning can be assessed during the physical exam.

An individual's nutritional state can be determined in different ways. One of them is to measure size and weight, and compare them with standard tables. Another way is to determine the body mass index, i.e. by dividing weight (kg) by the square hight (m^2). If the body mass index is between 20 and 25, it is considered normal for males or females [41].

It is very important to define the intended type of parenteral nutrition intravenously for an individual, once his nutritional state has been determined [42].

The preparation of parenteral nutrition is more a complex formula due to the large number of components it requires: amino acids, carbohydrates, lipids, electrolytes, vitamins and trace elements. There is the risk of incompatibility among them, limited stability, and potential contamination which might adversely affect the pediatric patient, sometimes with serious consequences [43], given the fact that pediatric standardized formulas are still unavailable.

Trace elements are therapeutic tools necessary for human life and should be prescribed or recommended by the physician or the specialist in pediatric nutrition.

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