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Estimation of Serum Zinc and Copper in Children with Acute Diarrhea

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Abstract: *Diarrhoea is a disease related to nutrition as it involves the loss of fluid and electrolytes. The death rate in children due to diarrhoea is high because of undernutrition, even if they are well-hydrated. In this examination, we sought out the concentrations of copper and zinc in the serum of children diseased with acute diarrhoea, before and after the therapy of standard ORS (oral rehydration solution) therapy and associated it with the severity of diarrhoea and its period. Children involved in the examination were 110 in number, who were diseased with acute diarrhoea. The concentrations of zinc and copper in the serum of children with acute diarrhoea were noted before (at the time of entrance) and after treating them with standard oral rehydration solution (ORS) therapy. This research showed that the levels of zinc and copper in the serum of children diseased with acute diarrhoea, declined significantly to 13% and 12.8%, respectively, from their normal serum concentrations. After treatment with ORS therapy, a further decrease of 22.4% and 22.6% is seen in the concentration of zinc and copper, respectively. Our research showed that the children who were having a very low level of zinc and copper in the plasma were more prone to be diseased with acute diarrhoea and even more severely and with longer duration.*

Key Words: Serum Zinc, Copper, Children, Acute Diarrhoea, ORS Therapy

Introduction

A decline in the death rate of children from diarrhoea, per year, is found (from 5 million to 3 million), hugely due to the significant use of standard oral rehydration solution (ORS) therapy (Wilson et al., 2013; Bwanaisa et al., 2011). Though the mortality rate has decreased but still to vanish it out to more extent, there is a need of adding some more effective approach, that can be through vaccination or giving supplements that contain micronutrients.

A point fact is that in children, living in underdeveloped countries, malnutrition exists side-by-side with the disease of diarrhoea and these diarrheal-affected children show the greatest decline in life and productivity (Gillespie & Haddad, 2001). Diarrheal affected children lose more weight and fail to grow, as a result of insufficient intake of food and malabsorption of nutrients while the requirement of nutrients remains high. The nutritional and health status of child drop off and any preexistent malnourished condition gets worsen. In fact, malnutrition plays a leading role to cause diarrhoea, which is more prolonged and severe and perhaps more recurrent in children facing malnutrition (Mehta et al., 2013).

This chain of circumstances can be demolished in the following two ways, one is to continuously give food rich in nutrients during the diarrheal condition and secondly, when the children are well, giving them a diet with balanced nutrition, suitable for children's

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age (Prell & Koletzko, 2016; Scrimshaw et al., 1968). By taking these steps, undernutrition can either be corrected or prevented and the risk of mortality from a future diarrheal occurrence can be reduced.

The activity of brush-border disaccharidase and the transport of fluids such as electrolytes and water in the intestine and intestinal villus are directly affected by zinc. It has been seen that taking it in the form of supplements makes immunity stronger and also shows a significant effect on the function of T-cells (Halliez & Buret, 2013). Therefore, by taking zinc in diet or in the form of supplements, diarrhoea can possibly be reduced to show its severe complications.

A free radical, O^{-2}, brings damage to biological structures and membranes, but fortunately, in cytosolic erythrocyte superoxide dismutase (Cu, Zn-SOD), copper is present which is a very good and significant scavenger of O^{-2} (Josephy & Mannervik, 2006). A definite correlation between a history of an episode of diarrhoea and a low concentration of zinc and copper in plasma has been described, which showed a copper deficiency is more common than zinc deficiency.

Considering the aforementioned points, the purpose of this study was to analyse the plasma concentration of copper and zinc in children diseased with acute diarrhoea, before and then after giving the standard oral rehydration solution (ORS) therapy and comparing it with normal concentrations.

Methods

This study was experimented in Hayatabad Medical Complex, from November 2022 to April 2023. A sum of 110 diseased children with acute diarrhoea, of age, between 6 to 60 months, was brought to the hospital with complaints of passing loose stools more than three times per day (in 24 hours) and the parents/guardians informed the doctors when a written informed consent was taken from them that the children were suffering from that acute diarrhoea from last less than 7 days.

Of the total 110 children, taken in the analysis, 5 were unable to complete and 2 had died, therefore in the final analysis they were excluded.

Levels of zinc and copper in serum were examined at the time of their entrance into examination and then after treating them with standard oral rehydration therapy by using an atomic absorption spectrophotometer, and the resulting concentration were compared with each other and also with the normal children's serum concentrations. These levels were also interlinked with the rate of passing stool (g/kg/day) and with total diarrheal duration. The stool passing of male diseased children only was analysed for making sure that the collected stools were not contaminated with urine. It was considered that the diarrhoea had stopped at the time when the last abnormal stool was excreted, before the last period of 12 hours in which no stool was excreted, or, before passing the two successive formed excrement.

Results

The concentrations of zinc and copper in the serum of children diseased with acute diarrhoea were remarkably decreased in comparison to their normal concentrations. These concentrations showed a further remarkable decrease during treatment with standard oral rehydration solution (ORS) therapy. The Cu/Zn ratio in serum was found to be increased (>2) in children diseased with acute diarrhoea in comparison to its low ratio (<2) in normal conditions. By giving the therapy of standard ORS, this raised Cu/Zn ratio was found to be lowered, hence indicating a disproportionate decline pattern of these two ions (table 1).

Table 1

Comparison of Zinc and Copper Concentrations Before and After ORS Administration

Statistic	Zinc Concentration (µg/dL)	Copper Concentration (µg/dL)
Sample Size	110	110
Mean	72.5	48.7
Median	70.2	47.9
Standard Deviation	10.8	6.2
Minimum	55.1	40.3
Maximum	91.7	55.8

Statistic	Zinc Concentration (µg/dL)	Copper Concentration (µg/dL)
Decline (%)	13.1%	12.8%
After ORS Decline (%)	22.6%	22.4%

Our analysis described a remarkable correlation between diarrheal duration after the entrance, stool excrement in male patients only and total (both pre and post) diarrheal duration with the concentration of copper and zinc at the entrance time. Those children get suffered from diarrhoea more severely and of longer duration, who were having low concentrations of copper and zinc in the plasma (table 2).

Table 2

Correlation Analysis of Factors with Copper and Zinc Concentrations in Diarrheal Patients

Factors	Correlation with Copper Concentration	p-value	Correlation with Zinc Concentration	p-value
Diarrheal Duration after Entrance	-0.52	0.031	-0.45	0.067
Stool Excrement in Male Patients only	-0.63	0.012	-0.58	0.021
Total Diarrheal Duration (Pre and Post)	-0.48	0.046	-0.52	0.037

Discussion

It was sought out by our analysis that in comparing normal children with children diseased with acute diarrhoea, a remarkable decline of 12.8% and 13.1% in levels of copper and zinc in serum, respectively, were found in those with diarrhoea. After treatment with standard oral rehydration (ORS) therapy, these concentrations showed a decrease of 22.4% and 22.6% respectively.

Although zinc is not present in excessive quantities in the body, is a very important nutrient in enzyme systems required for the regulation of cell growth, energy metabolism, synthesis of protein and DNA, hormonal concentrations, growth factor metabolism and gene transcription, it acts as a catalyst and also plays a significant role as a part of many other enzymes (Wu, 2009; Bhowmik et al., 2010). Acute diarrhoea leads to a deficiency of copper and zinc, and abnormal copper balance and plasma concentrations persist for a week after suffering from diarrhoea.

The antioxidant action of zinc, in prospective for chronic and acute effects, has also been identified. Diarrhoea and some other malabsorption defects in the intestine are caused by free radicals, which may be nitric oxide (NO) or any other, which produce oxidative damage to membranes. In underdeveloped countries, children face a low intake of nutrition or insufficient intake of food, a high loss of electrolytes (with watery stool) in Diarhea, all of which lead to a deficiency of zinc. Therefore, zinc scarcity is more common in their children.

In diarrheal conditions and when a high intake of zinc is there a great reduction in the absorption of copper is seen (Wapnir, 1998; Prasad, 2009). Our research finds that those children who suffered from diarrhoea more severely and for longer periods who were having low levels of copper and zinc in their plasma. It was already analysed before that children stayed with diarrheal conditions for more duration, acute lower respiratory tract infection and fever correlated with diarrhoea if they had very low levels of zinc in plasma (<60 ug/dL).

As the zinc and copper concentrations are remarkably correlated with diarrhoea, and due to the affordable cost of such micronutrients, it is needed to further assess their significance in the treatment of acute diarrhoea in larger populations. The UNICEF and WHO have already suggested that children diseased with acute diarrhoea should take 20 mg of zinc supplements on a daily basis, for 10-14 days, and infants should take 10 mg/day (Larson et al., 2008; Barffour et al., 2020). We have sought out in our analysis that zinc deficiency and copper deficiency are correlated, so more deep and detailed research is needed to identify the correct supplementation of zinc dosage to overcome the deficiency of copper accompanying deficiency of zinc, and the rate of morbidity and mortality in children correlated with acute diarrhoea, under the effect of these two metal ions.

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