British Journal of Medicine & Medical Research
15(2): 1-7, 2016, Article no.BJMMR.25130
ISSN: 2231-0614, NLM ID: 101570965

SCIENCEDOMAIN *international*
www.sciencedomain.org

Serum Albumin and Selected Antioxidants Status in Children with Protein Energy Malnutrition in Sokoto, Nigeria

A. S. Mainasara[1], M. H. Yeldu[1*], A. C. Chikere[1], F. U. Bunza[1], B. Shehu[1] and N. M. Jiya[2]

[1]Department of Chemical Pathology, Usmanu Danfodiyo University, Sokoto, Nigeria.
[2]Department of Paediatrics, Usmanu Danfodiyo University, Sokoto, Nigeria.

Authors' contributions

This work was carried out in collaboration between all the authors. Authors ASM, MHY and FUB designed the study. Author ACC did the literature searches. Authors ASM, BS and NMJ designed the protocol. The collection of samples and analysis were handled by all the authors jointly. The first draft of the Manuscript was written by author ASM. All authors read, reviewed and approved the final manuscript.

Article Information

DOI: 10.9734/BJMMR/2016/25130
Editor(s):
(1) Alex Xiucheng Fan, Department of Biochemistry and Molecular Biology, University of Florida, USA.
Reviewers:
(1) Mustafa Volkan Demir, Malatya State Hospital, Malatya, Turkey.
(2) A. Papazafiropoulou, Tzaneio General Hospital of Piraeus, Greece.
(3) Nuhu Sambo, Bingham University, Nigeria.
Complete Peer review History: http://sciencedomain.org/review-history/14211

Original Research Article

Received 19th February 2016
Accepted 30th March 2016
Published 16th April 2016

ABSTRACT

Aims: To assess the serum albumin and selected antioxidant status in 51 children with protein energy malnutrition (PEM) in Sokoto, Nigeria.
Study Design: A cross-sectional study was performed comparing two groups of children, one with confirmed case of PEM and the other apparently healthy children; both groups were gender, age and socioeconomically matched.
Place and Duration of Study: Departments of Paediatrics, Usmanu Danfodiyo University Teaching Hospital, Sokoto and Chemical Pathology, Faculty of Medical Laboratory Sciences, Usmanu Danfodiyo University, Sokoto, between April, 2014 and September, 2015.
Methodology: We included fifty (51) children (of both sexes, aged range 6-60 months) with

**Corresponding author: E-mail: mhyeldu@gmail.com;*

confirmed cases of protein energy malnutrition were included in this study. The modified Wellcome classification was used to classify the protein energy malnourished children into underweight (14), marasmus (17), kwashiorkor (10) and marasmic-kwashiorkor (10). Fifty (50) gender- age-and socioeconomically-matched apparently healthy children were used as controls. The subject selection, anthropometric parameters and clinical examinations were performed by the consultant paediatricians in the clinic. Standard procedures were used for the analyses of biochemical parameters.

Results: Our results showed that, mean mid-upper arm circumference (MUAC), weight, body mass index (BMI), were significantly ($P<0.001$) lower in the malnourished group compared with the control group. With the exception of MUAC which decreased significantly ($p<0.001$) with increasing severity of malnutrition, the mean weight, and BMI were not significantly ($p>0.05$) different among the different classes of PEM. Serum Albumin, α-tocopherol, copper and zinc were significantly ($P<0.001$) lower in the malnourished group compared with the control group. Serum Albumin, α-tocopherol, copper and zinc decreased significantly ($P<0.001$) with increasing severity of malnutrition.

Conclusion: Our results showed that serum albumin, α-tocopherol, copper and zinc were significantly lower in the malnourished group than the control group ($p<0.001$). The decrease in the serum albumin, α-tocopherol, copper and zinc progressed with the increasing severity of malnutrition among the children. These findings suggest an altered protein and antioxidant status in protein energy malnutrition. In addition to providing proteins and calories, adequate supplementations of zinc, copper and α-tocopherol should be provided. These should be part of nutritional rehabilitation of malnourished children in order to achieve optimal results of management and avoid clinical complications associated with zinc, copper and vitamin E deficiencies.

Keywords: Protein energy malnutrition; tocopherol; copper; zinc Sokoto; Nigeria.

1. INTRODUCTION

Protein energy malnutrition (PEM) is a major public health problem associated with high morbidity and mortality [1]. It is widely distributed in the tropical and sub-tropical regions of the world and often arises during protein and/or energy deficit due to nutritional inadequacy, infections and poor socio-economic and environmental conditions [2]. Protein Energy Malnutrition (PEM) applies to a group of related disorders that include marasmus, kwashiorkor and intermediate states of marasmic-kwashiorkor [3].

Malnutrition may also be as a result of inadequate food intake secondary to food scarcity, ineffective or unplanned weaning secondary to ignorance, gastrointestinal infections resulting to diarrhoea and vomiting and in developed countries, decreased absorption or abnormal metabolism secondary to diseases such as cystic fibrosis, chronic renal failure, childhood malignancies and congenital heart failure [3].

Globally an estimated 925 million people were reported as undernourished in 2010, an increase of 80 million people since 1990, with most of them living in developing countries [4]. In these countries, malnutrition usually makes its greatest impact on pre-scholars (i.e. children under the age of five years) [5]. In Nigeria, 22% to 40% mortality among children below the age of five has been attributed to PEM [6] and this was thought to be due to increased nutrient requirements associated with growth [5].

Altered macronutrients and micronutrients levels were found in PEM [1]. Studies have shown that, protein energy malnourished children are oxidatively stressed resulting from the excessive production of free radicals. Studies have shown that, serum antioxidant vitamins A, C and E and minerals copper and zinc were significantly reduced in malnourished children and increased the severity of malnutrition [7,8].

Vitamin E (tocopherol) is a powerful lipophilic antioxidant which protects unsaturated lipids against peroxidation and erythrocyte membrane from oxidant stress and is associated with drug metabolism; haem biosynthesis and neuromuscular function [9] and it had also been reported to enhance immune responses and is effective against bacterial infections [10]. The concentration of vitamin E in the plasma depends on dietary intake and plasma lipid concentration [11].

Albumin binds various substances (such as hormones, iron, fatty acid and drugs) and transports them to the various sites in the body where they are needed. It is also responsible for most of the colloid osmotic pressure of the intravascular fluid, which maintains the appropriate fluid balance in the tissues [9].

Micronutrients intake could play an important role in the management of children with PEM. In the present study, the changes in serum tocopherol, copper, zinc and albumin were assayed in PEM in order to define the status in protein energy malnourished children. The results may prove useful for the improvement of the management of affected children with malnutrition.

2. MATERIALS AND METHODS

2.1 Study Subjects and Study Site

Fifty one (51) malnourished children as defined by Wellcome classification [12] are grouped into 14 cases of underweight, 17 cases of marasmus, 10 cases of kwashiorkor and 10 cases of marasmic- kwashiorkor children (age range 6-60 months) were included in the study was conducted in the Departments of Chemical Pathology and Paediatrics, Usmanu Danfodiyo University, Sokoto. Fifty (50) gender, age-and socioeconomically matched children attending the Paediatric Outpatient Clinic, of the Usmanu Danfodiyo University, Sokoto, for routine checkup served as controls. The inclusion criteria are those children with all the features suggestive of PEM such as oedema, hair and skin changes and subjects must be confirmed as having PEM. Controls are apparently healthy children attending the Paediatrics Outpatient Clinic.

2.2 Study Design

"Data were obtained by administering a structured interviewer-administered questionnaire and samples for biochemical analysis were obtained by experienced Physician (phlebotomist)."

2.3 Ethical Approval

The study was approved by the Ethics and Research Committee of Usmanu Danfodiyo University Teaching Hospital (UDUTH) Sokoto and written informed consent obtained from the mothers or surrogates of all the children before commencement of the study.

2.4 Blood Samples Collection and Processing

About five millilitres (5) of blood samples were collected by venepuncture into plain vacutainer blood specimen bottles from children with prominent veins and from femoral tap in children whose veins are tiny. The sera were separated into clean serum bottles (Eppendorf) after centrifuging at 3000 rpm for 5 minutes. The sera were rapidly frozen at -20℃ and stored until assayed in batches.

2.5 Measurement of Anthropometric Parameters

Anthropometric parameters were measured according to the method described by Abdoul Razak [13]. The children were weighed with minimum clothing to the nearest 0.1 kg with a spring scale; mothers were weighed with a weighing balance with minimum clothing; the supine lengths of children were measured to the nearest 0.1 cm against a flat horizontal surface using a standard length board; mothers heights were measured using a stadiometer to the nearest 0.1 cm; mid-upper arm circumference (MUAC) was measured to the nearest 0.1 cm with an inelastic tape. Body mass index (BMI) was calculated using the equation: weight in kg divided by the square of the height in meters [weight (kg)/height (m^2)].

2.6 Measurement of Biochemical Parameters

Serum albumin was estimated using colorimetric technique described by Doumas [14]. Serum α-tocopherol (vitamin E) was estimated by the method of Hashim and Schuttringer [15], while serum copper and zinc were estimated by atomic absorption spectrophotometric method (AAS) as described by Kaneto [16], using atomic absorption spectrophotometer, Buck model 205 manufactured by Buck Scientific Inc. 58 Fort Point St. East Norwalk, CL 06855.

2.7 Statistical Analysis

The data obtained were analysed using Microsoft Office Excel 2007 and Graphpad InStat® statistical soft ware Version 3.10, 32 Bit for windows (2009). The results were expressed as mean ± SEM. Group comparisons were made using one-way analysis of variance (ANOVA), paired comparisons were carried out using the

Student's t-test, p≤0.05 was considered as significant.

3. RESULTS AND DISCUSSION

3.1 Results

A total of one hundred and one (101) children, of both sexes, aged 6-60 months were recruited for this study. They consisted of fifty (50) controls and fifty-one (51) malnourished children (Table 1). The mean ± SEM of anthropometric parameters of PEM patients and controls is shown in Table 2. The mean MUAC, weight and BMI, in the malnourished group children were significantly (P<0.001) lower than the corresponding values in controls.

According to the modified Wellcome classification, subjects were divided into four groups as shown in Table 3. As indicated in the Table, MUAC decreased significantly (p<0.001) with increasing severity of malnutrition, but the mean weight, and BMI were not significantly (p>0.05) different among the different classes of PEM.

Table 4 showed the mean serum albumin and selected antioxidants in PEM patients and controls. Here, the mean serum albumin, copper, zinc and α-tocopherol were significantly (P<0.001) lower in the protein energy malnourished groups compared with the control group. The mean serum levels of albumin, copper, zinc and α-tocopherol also decrease significantly (p<0.001) with increasing severity of malnutrition (Table 4).

The serum albumin and selected antioxidants in PEM patients according to the modified Wellcome classification is presented in Table 5. As indicated in the Table, the serum albumin, zinc, copper and α-tocopherol decreased significantly (p<0.001) with increasing severity of malnutrition.

Table 1. Gender distribution of PEM patients and controls

Parameter	PEM patients			Controls		
	Male	Female	Total	Male	Female	Total
Frequency	35	16	51	30	20	50
Percentage (%)	65.6	31.4	100	60	40	100

Table 2. Anthropometric parameters among PEM patients and controls

Parameter	PEM patients (n=51)	Controls (n=50)	P-value
Weight (Kg)	6.1±0.18	10.5±0.27	P<0.001
Length/Height (cm)	74±1.09	79±1.15	P<0.05
MUAC (cm)	11±0.30	17±0.28	P<0.001
BMI Kg/m^2	10±0.21	15.8±0.17	P<0.001

Values are mean ±SEM, n= number of subjects, MUAC= mid upper arm circumference, BMI= body mass index, Kg= kilogram, cm= centimeter, Kg/m^2= kilogram per meter square

Table 3. Anthropometric parameters (Mean ± SEM) of PEM patients according to classes of malnutrition

Parameter	Classes of malnutrition				P-value
	Underweight (n=14)	Marasmus (n=17)	Kwashiorkor (n=10)	Marasmic-Kwashiorkor (n=10)	
Weight (Kg)	6.5±0.39	5.9±0.28	6.5±0.40	5.7±0.39	P>0 .05
Length/Height(cm)	74±3.38	74±1.12	76±1.5	71±1.73	P>0 .05
MUAC (cm)	12.0±0.34	9.4±0.22	9.9±0.30	9.9±0.40	P<0.0 01
BMI Kg/m^2	12.1±0.77	10.8±0.43	11.2±0.45	11.3±0.45	P>0.05

Values are mean ±SEM, n= number of subjects, MUAC= mid upper arm circumference, BMI= body mass index, Kg= kilogram, cm= centimeter, Kg/m^2= kilogram per meter square

Table 4. Serum albumin and selected antioxidants in PEM patients and controls

Parameter	PEM patients (n=51)	Controls (n=50)	P-value
Albumin (g/dl)	2.9±0.95	3.7±0.11	P<0.001
Zinc (µg/dl)	67±2.30	83±2.43	P<0.001
Copper (µg/dl)	63±2.25	81±2.94	P<0.001
α-Tocopherol (µg/dl)	0.4±0.32	0.6±0.26	P<0.001

Values are mean ±SEM, n= number of subjects, all the parameters in the patients differ significantly (p<0.001) compared with controls

Table 5. Serum albumin and selected antioxidants among PEM patients according to classes of malnutrition

Parameter	Classes of malnutrition				P-value
	Underweight (n=14)	Marasmus (n=17)	Kwashiorkor (n=10)	Marasmic-Kwashiorkor (n=10)	
Albumin (g/dl)	3.6±0.16	2.8±0.11	2.7±0.12	2.5±0.18	P<0.001
Copper (µg/dl)	84±2.04	56±2.13	55±3.14	52±3.09	P<0.001
Zinc (µg/dl)	89±1.91	62±2.03	57±3.35	56±3.4	P<0.001
α-Tocopherol (µg/dl)	0.7±0.49	0.4±0.04	0.4±0.07	0.4±0.06	P<0.001

Values are mean ± SEM, n= number of subjects, all the parameters in the patients differ significantly (p<0.001) with the severity of malnutrition

3.2 Discussion

Our observed mean weight, length/height, MUAC and BMI in PEM patients were significantly lower compared to controls. This is consistent with the report of Alatrouni [17] who indicated the mean weight of the malnourished children was significantly lower than in controls. Our report also corroborated with the previous researchers [18,19], who reported significant decreases in weight and length/height compared to controls. Our finding of a significantly decreased MUAC is in agreement with Alatrouni [17], who attributed this to muscle atrophy which is found in all types of PEM. Bhatia et al. [20] also reported that the decrease in MUAC may be due to loss of subcutaneous fat which is observed in marasmus and marasmic-kwashiorkor. The mean MUAC was significantly (p<0.001) lower in the malnourished children and the differences were more marked with the increasing severity of malnutrition, though the mean weight, and BMI were similar among the different classes of PEM.

Deficiency of macro- and micro-nutrients is associated with malnutrition with stress factors associated with malnutrition resulting in the production of reactive oxygen species and subsequent reduction in plasma antioxidants in children with protein energy malnutrition [7]. The result of low antioxidant status in these children has been confirmed in the present study. Decrease serum albumin that occurred with increasing severity of malnutrition was in agreement with the report of Adegbusi et al. [21] and Rahman et al. [22] who independently reported mean serum albumin levels that were significantly lower in malnourished children as compared to controls (p<0.05). The alterations in serum α - tocopherol levels in PEM could be explained on the basis of decreased protein intake and reduced biosynthesis [17].

The mean serum zinc, copper and α- tocopherol were significantly decreased in the malnourished children compared to the corresponding control values. Both copper and zinc are important components of superoxide dismutase, an antioxidant enzyme that catalyses the univalent reduction and oxidation of superoxide anion (O_2^-) to hydrogen peroxide (H_20_2) and molecular oxygen [23]. Alpha (α) - tocopherol is a major lipid soluble antioxidant present in all cell membranes where it protects membranes against lipid peroxidation [24]. The deficiency of these trace elements and α- tocopherol, which scavenge free radicals, leads to the accumulation of excess free radicals and subsequently leading to oxidative tissue damage.

Decreased serum copper in malnourished children may be attributable to poor dietary intake, increased losses from gastrointestinal tract, and low caeruloplasmin levels [25]. Mechanism by which lower serum levels of copper and zinc occurred concurrently is not known, since the two elements exhibit antagonistic relationships [26].

In the present study, the mean serum zinc and copper decreased significantly with increasing severity of malnutrition. Highest serum zinc values were observed in underweight patients and the least value in kwashiorkor patients. This is consistent with earlier findings indicating that antioxidant minerals copper and zinc decreased significantly in malnourished children [25-27]. Mean serum albumin and α-tocopherol levels also decrease significantly in the different classes of PEM patients. Our findings are consistent with the report of Abrol et al. [11], who reported gradual decrease in serum levels of α-tocopherol with the severity of malnutrition. This could be attributed to the disturbed low density lipoprotein (LDL) metabolism since α-tocopherol is known to be delivered to cells via the high affinity receptors for LDL. It is possible that the low levels of circulating antioxidants such as zinc, copper and α-tocopherol is due to either increased utilization of the antioxidant micronutrients or decreased synthesis of such antioxidants in protein malnourished children [7].

4. CONCLUSION

Our results showed that serum albumin, α-tocopherol, copper and zinc were significantly lower in the malnourished group than the control group. The observed decrease in the serum albumin, α-tocopherol, copper and zinc progressed with the increasing severity of malnutrition among the children. These findings suggest an altered protein and antioxidant status in protein energy malnutrition. In addition to providing proteins and calories, adequate supplementations of zinc, copper and α-tocopherol should be provided. These should be part of nutritional rehabilitation of malnourished children in order to achieve optimal results of management and avoid clinical complications associated with zinc, copper and α-tocopherol deficiencies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Muller O, Krawinkel M. Malnutrition and health in developing countries. CMAJ. 2005;173(3):279-286.
2. Quereshi MI, Quereshi Z. Effect of protein energy malnutrition on the weight and serum albumin of albino rats. J Ayub Med Coll Abbottabad. 2001;13:8-10.
3. Scheinfeld NS, Mokashi A, Lin A. Protein energy malnutrition [Online]. Available:http://emedicine.medscape.com/article/110623-Overview (Accessed July 2013)
4. Food and Agricultural Organization of the United Nation. Undernourishment around the world, In: The state of food insecurity in the world; 2004. Rome.
5. Amosu AM, Degun AM, Atulomah NOS, Olarewju MF. A study of the nutritional status of under 5 children of low income earners in a South-Western Nigerian Community. Curr Res J Biol Sci. 2011;3(6):578-585.
6. Ubesie AC, Ibeziako NS, Ndiokwelu CI, Uzooka CM, Nwafor CA. Under five protein energy malnutrition admitted at the University of Nigeria Teaching Hospital Enugu. A 10 year retrospective review. Nutritional Journal, 2012;11(43):1-7. Available:http://www.nutritionj.com/content/11/1/43
7. Etukudo MH, Agbedana EO, Akinyinka OO, Osifo BOA. Plasma electrolytes, total cholesterol, liver enzymes, and selected antioxidant status in protein energy malnutrition. Afr J Med Med Sci. 1999;28: 81-85
8. Sani B, Yeldu MH, Akuyam SA, Jiya NM, Aliyu RU. Evaluation of serum antioxidant vitamins among protein energy malnourished children in Sokoto, Northern Nigeria. Niger Biomed Sci J. 2014;10(3): 12-18.
9. Bishop ML, Fody EP, Schoeff LE. Clinical chemistry techniques, principles, correlations, 6th Edition, Lippincott Williams and Wilkins, Baltimore (MD). 2010;658:666-667.
10. Nockels CF. Protective effects of supplemental vitamin E against infection. Fed Proc. 1979;38:2134–2138.
11. Abrol P, Sharma N, Lal H. Vitamin E status in protein energy malnutrition. Ind J Clin Bioch. 1997;12(2):125-127.
12. Hendrickse RG, Barr DCG, Matthews TS. Modified wellcome classification. In: Paediatrics in the tropics. Blackwell Scientific Publ. London. 1991;119.
13. Abdoul Razak MY. Athropometric and biochemical profile of malnourished and well feed children in Magarya District,

Zinder, Niger Republic. A Research proposal submitted to the Department of Anatomy, Faculty of Medicine Ahmad Bello University Zaria. 2010;17.
14. Doumas BT, Watson WA, Biggs HG. Albumin standards and the measurement of serum albumin with bromocresol green. Clin Chim Acta. 1971;31(1):87-96.
15. Hashim SA, Schuttringer GR. Rapid determination of tocopherol in macro and micro quantities of plasma. Results Obtained in various nutrition and metabolic studies. Ame J Clin Nutr. 1966;19(2):137-145.
16. Kaneko JJ. Clinical biochemistry of animals, (4^{th}edn), Academic Press, New York; 1999.
17. Alatrouni AM. Study of serum levels of insulin growth factor, insulin like growth factor binding protein and prealbumin and amino terminal propeptide of type procollagen in infants and children with protein energy malnutrition. Unpublished Ph D thesis at the Tanta University, Egypt; 2004.
18. Sandeep M. Thyroid hormone status, serum total protein and albumin levels in children with protein energy malnutrition. Unpublished master thesis at the Rajiv Ghandhi University of Health Sciences Karnataka, Bangalore; 2014.
19. Turkay S, Kus S, Gokalp A, Baskin E, Onal A. Effects of protein energy malnutrition on circulating thyroid hormones. Indian J Pediatr. 1997;32(2):193-197.
20. Bhattia RC, Pooni PA, Singh H, Singh D. MUAC for detecting malnutrition during infancy. Indian J Paediatr. 1999;66(6):834-838.
21. Adegbusi H, Sule MS. Anthropometric and biochemical assessment among under five children in Kusada local government area, Katsina state, Nigeria. 2011;4(2):137-140.
22. Rahman MA, Mannan MA, Rahman MH. Serum iron and total iron binding capacity in severely malnourished children. Bangladesh J Pharmacol. 2007;2:61-65.
23. Halliwell B, Gutteridge JMC. Free radical biology and medicine, Fourth Edition, Clarendon Press, Oxford; 2006.
24. Marklund S. Distribution of Cu-Zn superoxide dismutase and Mn superoxide dismutase in human tissues and extracellular fluids. Acta Physiol Scand Suppl. 1980;492:19-23.
25. Khubchandani A, Saghani H, Sidhu G, Sendhav S, Ghandhi P, Solanki V. Serum copper and zinc levels in preschool children with protein energy malnutrition. Int J Res Med. 2013;2(1):7-10.
26. Ugwuja EI, Nwosu KO, Ugwu NC, Okonji M. Serum zinc and copper levels in malnourished pre-school age children in Jos North Central Nigeria. Pak J Nutr. 2007;6(4):349-354.
27. Raj B. Estimation of copper and ceruloplasmin in protein energy malnutrition in Coastal Mangalore. Kantaka Paediatr J. 2012;26(2):21-25.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14211