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Plasma and Blood Volume in Patients with Severe Protein -Energy-Malnutrition

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Summary

Renner JK. Plasma and Blood Volume in Patients with Severe Protein-Energy-Malnutrition. *Nigerian Journal of Paediatrics* 1994;**21**: 3. Plasma and blood volume of 30 children with severe protein-energy-malnutrition (PEM) and 10 well-nourished and age-matched children were determined by dye-dilution technique, using Evans blue. The mean values of plasma and blood volume of the patients were 60.03 ± 16.20 and 94.84 ± 25.25cc Kg^{-1} body weight, respectively. The corresponding values for the controls were 48.43 ± 2.18 and 69.24 ± 3.46cc Kg^{-1} body weight, respectively. These differences were significant ($p<0.001$ for plasma volume and $p<0.003$ for blood volume). Both plasma and blood volumes correlated with the degree of weight deficit. The correlation co-efficient for plasma volume and the degree of weight deficit was $r = -0.64$, $p<0.001$. The corresponding value for blood volume was $r = 0.52$, $p<0.001$. It is concluded from the present findings that there is a significant expansion of both plasma and blood volumes in severely malnourished children and these expansions correlated well with the degree of weight deficit.

Introduction

Protein-energy-malnutrition (PEM) is associated with varying degrees of metabolic derrangements, including altered plasma cortisol, insulin, growth hormone and renal plasma flow.[1-4] The presence of infection in PEM acts as a superimposing stress factor which may further evoke secretion of some of the hormones that affect body fluid changes.[5] The purpose of the present study was therefore, to determine the effects of these internal environments on the plasma and blood volumes in malnourished children.

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Subjects and Methods

The study was carried out on all consecutive severely malnourished children, who were treated in the department of Paediatrics, Lagos University Teaching Hospital (LUTH). The patients were classified into kwashiorkor, marasmus and marasmic-kwashiorkor, according to the Wellcome Trust Classifications;[6] this same classification was also employed in assessing the degree of weight deficit. Healthy, well-nourished and age-matched children acted as controls; it should be noted here that these controls were not sex-matched as well, because an earlier study in

Ibadan showed no significant sex difference in the plasma and blood volume of normal children, aged between one year and three years.[7] Subjects who were vomiting, or had diarrhoea were excluded from the study. All the subjects underwent physical examination, including anthropometric measurements. At the beginning of the study, informed consent was obtained from the parents of all the subjects.

Plasma and blood volumes were determined, using the dye-dilution technique, which is a safe and accurate [8] procedure; it is also much less expensive than the radioisotope technique. On the morning of the investigation, before breakfast, five millilitre of venous blood was drawn from each subject from a peripheral vein and placed in a bottle containing heparin, as anticoagulant. Plasma was separated from this sample which served as a blank for the study. Following this, sterile dye (Evans blue) at a dose of 100ug/kg body weight was injected slowly for over a period of 30 seconds, through a peripheral vein into each subject. Ten minutes after the dye injection, four milliliter of blood was drawn without haemolysis from a peripheral vein different from the one that was used in injecting the dye. These blood samples were then transferred into a heparinized container and spun in an MSE centrifuge, at 3,000 rps for five minutes. Plasma was separated and 1.5 milliliters was mixed with 1.5 milliliters of deionized distilled water and the optical instrument was zeroed, using a mixture of 1.5 milliliters of deionized distilled water and 1.5 milliliters of subject's plasma. The true optical density was the difference in optical densities of the two processed plasma samples. The concentration of dye in the post-dye injection plasma (test plasma) was extrapolated from a standard curve which relates optical density to the quantity of dye in ug.

Haematocrit was determined on venous blood samples, using Hawksley's micro-haematocrict reader. Correction was made for trapped plasma in calculating plasma volume, [9] while plasma volume was obtained from the relationship:

$$\frac{\text{Quantity of dye injected (ug)}}{\text{Concentration of dye in test plasma (ug/ml)}}.$$

The value thus obtained, was the volume of plasma at ten minutes after the injection of the dye. In order to obtain the instantaneous plasma volume at the time the dye was injected, the plasma volume at ten minutes was multiplied by 0.98.[10] Blood volume was obtained by multiplying plasma volume by 100/(100-0.87 Hct), where 0.87 Hct was the corrected venous hematocrit.

The data were analyzed using Student's "t" test, to assess the statistical significance of observed differences. A regression analysis of the degree of the weight deficit and both plasma and blood volumes of malnourished children were also carried out. A Hewlet Packed HP IIC Programmable Calculator was used for the data analysis.

Results

There were 30 patients, aged between nine months and two years, who had PEM, consisting of two cases with marasmus, eight with kwashiorkor and 20 with marasmic -kwashiorkor. The controls numbered ten. The clinical data of age, body weight, haematocirt etc, are summarized in the Table.The age range of the patients and controls were 0.75-2.50 years and 1.0-2.25 years, respectively. The mean age and standard deviation (SD) of the patients were 1.44 ± 0.47 years, while those of the controls were 1.53 ± 0.45 years ($p>0.05$). The mean $\pm$SD weight of the patients and controls expressed as 50 percent of reference weight were 55.85 ± 10.17 percent for the patients and 96.25 ± 3.25 percent for the controls ($p<0.001$).

The mean value $\pm$SD of the corrected hematocrit was 29.20 ± 6.81 percent for the patients and 30.12 ± 3.25 percent for the controls. The difference was not significant ($p>0.05$). The mean $\pm$SD for plasma volume expressed as cubic centiliter (cc) per kilogramme body weight was 68.03± 16.20 cc and 48.34 ± 2.18cc for the patients and controls, respectively (Table).

TABLE

Clinical data, Mean Values for Plasma and Blood Volumes of 30 Patients and 10 controls

Data	*Patients 30*	*Controls 10*	*P Value*
Age (years)	1.44±0.47	1.53±0.45	> 0.05
Body weight expressed as 50 percent of reference weight	55.85±10.17	96.25±3.2	< 0.001
Corrected hematocrit	29.20±6.81	30.12±3.25	> 0.05
Plasma volume cc kg $^{-1}$ body weight	68.03±16.20	48.43±2.18	< 0.001
Blood volume cc kg $^{-1}$ body weight	98.84±25.25	69.24±3.46	< 0.01

Values represent mean±SD

The difference between these two values was significant (p<0.001). The coefficient of variation for plasma of the patients and controls was 23.8 percent and 4.5 percent, respectively. The means ±SD for blood volumes of the patients and controls were 98.84±25.25cc/kg body weight and 69.24 ±3.46cc/kg body weight, respectively. The coefficient of variation for blood volume was 25.5 percent for the patients and 5.0 percent for the controls. Figures 1 and 2 show the relationship between plasma and blood volumes respectively, and the degree of weight deficit expressed as percentage of body weight in kg for expected weight for age. The inverse relationship between the two values and the degree of weight loss is evident. The correlation coefficient for plasma volume and the degree of weight loss was -0.64 (p<0.001) and that for blood volume was -0.52 (p<0.001).

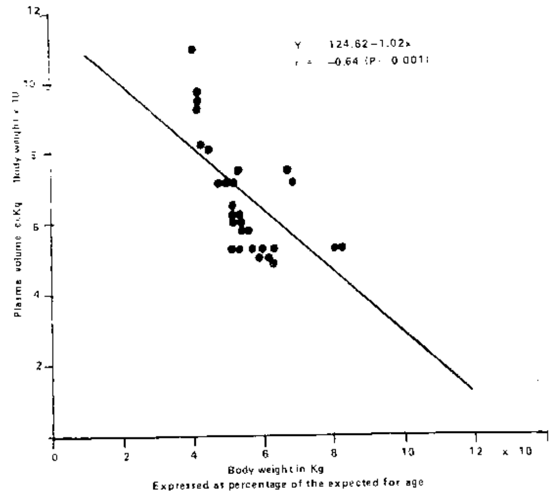

Fig 1. Relationship between plasma volume in cc kg/body weight and body weight in kg, expressed as percentage of the expected for age in patients with PEM

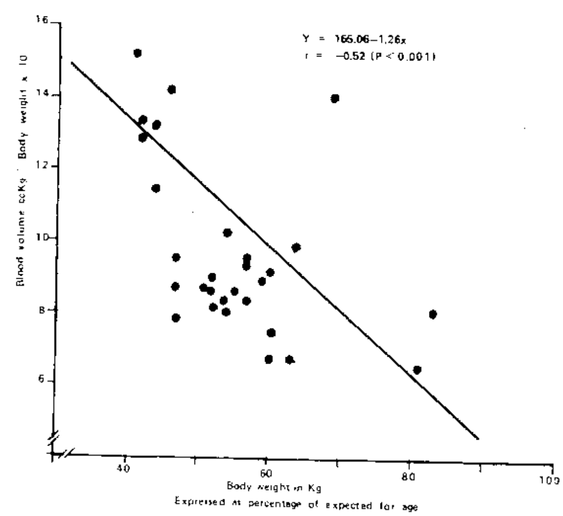

Fig 2. Relationship between blood volume in cc per kg/ body weight and body weight in kg, expressed as percentage of the expected for age in patients with PEM

Discussion

Plasma and blood volume values have been related to body surface area, height and weight either alone, or in combination by several workers.[11-13] It has, however, been argued that the existence of an abnormal lean mass may give a false derivation of plasma and blood volumes when these are related to weight.[7 9 14] Furthermore, in conditions that are associated with loss of cutaneous fat, there may be an apparent increase in the plasma and blood volumes when related to weight.[15] In the present study, in which plasma and blood volumes were related to body weight, the volumes obtained were similar to those reported by other workers.[16 17] Similarly, the values obtained for the controls compared closely with those obtained for normal children.[7] As has been reported by others,[16 17] there was a significant weight deficit among the patients in the present series.

Plasma and blood volume values in the patients with PEM were significantly higher than those obtained for the controls. This finding has been reported by others.[18] As there was no difference in the mean corrected hematocrit values between the patients and controls, the significant expansion of plasma and blood volumes in the patients, could not be attributed to the hematocrit factor. By contrast, variation in deranged sodium pump which has been described in patients with PEM,[19] might be the contributory factor to the plasma and blood volume expansion in our patients. It should be noted that there was a large co-efficient of variation in the malnourished patients. Other possible contributory factors to the plasma and blood volume expansion in the patients would include renal and cardiac dysfunctions, increased cortisol level secondary to the metabolic stress, increased aldosterone secretion, all of which have been shown to occur in PEM.[4 5 19-21] Based on the present findings which show significant plasma and blood volume expansion in PEM, it is concluded that great care must be exercised in fluid therapy in severely malnourished children in order to prevent over-loading the circulation during such therapy.

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