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Brief report

Vitamin status of infants receiving long-term peritoneal dialysis

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Abstract. The oral vitamin intakes and blood vitamin concentrations of seven infants receiving long-term peritoneal dialysis were measured. The serum concentrations of vitamin A, vitamin B_{12}, vitamin C and folic acid were determined. Thiamine and riboflavin were assessed by the activation of erythrocyte transketolase and erythrocyte glutathione reductase, respectively. Vitamin B_6 was measured as plasma pyridoxal phosphate. All patients received a daily vitamin supplement devoid of vitamin A. Dietary vitamin intake was derived from infant formula. In all cases, the patients' blood concentrations of the water-soluble vitamins were equal to or greater than normal infant values. Serum vitamin A levels were elevated despite the lack of supplementation. The combined dietary/supplemental water-soluble vitamin intake of the patients exceeded the recommended daily allowance in all but one patient. These preliminary data emphasize the need to further evaluate the vitamin requirements of infants receiving long-term peritoneal dialysis.

Key words: Peritoneal dialysis – Vitamins

Introduction

Supplementation of water-soluble vitamins has routinely been recommended for patients receiving long-term peritoneal dialysis, primarily based on data derived from the adult dialysis population [1, 2]. A recent study in pediatric dialysis patients greater than 6 years of age revealed that vitamin supplementation is actually associated with normal or greater than normal serum levels of the water-soluble vitamins [3]. However, no data have been published specifically addressing the vitamin levels and vitamin intake of infants with end-stage renal disease [4]. Accordingly, we conducted the present preliminary investigation to evaluate the oral intakes and blood concentrations of the water-soluble vitamins and vitamin A in infants receiving long-term peritoneal dialysis.

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Subjects and methods

Seven dialysis patients aged 11.4±2.6 months (range 7–16 months) participated in the study. The primary diagnoses were renal dysplasia in four patients and oxalosis, posterior urethral valves and congenital nephrotic syndrome in one patient each. Six of the patients were males. All patients received automated peritoneal dialysis (10–15 exchanges per night) as provided by an automated cycling machine (Pac-X, Baxter Healthcare, Deerfield, Ill., USA). The mean time on dialysis was 10.0±3.7 months (range 6–15 months).

All patients were free of peritonitis for more than 1 month prior to participation in the study. The study was approved by the Institutional Review Board and informed consent was obtained in each case from the patient's parent. The patients received a 2.0 ml daily multivitamin supplement (Iberet – liquid, Abbott Laboratories, North Chicago, Ill., USA) (Table 1). All patients also received folic acid (6 patients – 0.1 mg, 1 patient – 0.2 mg) daily (Danbury Pharmacal, Danbury, Conn., USA).

A single, fasting (>8 h) blood sample was obtained from each participant on two occasions within a 1-month period for the assessment of vitamin status. The patient omitted the vitamin supplement for 24 h prior to sample collection. No assessment of vitamin losses in dialysate was conducted.

Serum retinol and ascorbic acid were assessed by colorimetric assay. Thiamine and riboflavin were assessed by the activation of erythrocyte transketolase (ETK) and erythrocyte glutathione reductase (EGR), respectively. ETK and EGR activities were determined as the change in enzyme activities after the addition of the coenzymes thiamine pyrophosphate (TPP) and flavin adenine dinucleotide (FAD) compared with the basal activity levels as described by Bayoumi and Rosalki [5]. ETK is expressed as the percentage activation, with a lower percentage activation indicative of increased thiamine stores [5].

$$\%\ \text{Activation} = \frac{\text{activity of ETK with TPP} - \text{activity without TPP}}{\text{activity without TPP}} \times 100$$

EGR is expressed as the activity coefficient, with a lower coefficient indicative of increased riboflavin stores [6].

Table 1. Vitamin intake in infants receiving peritoneal dialysis[a]

Vitamin	Supplement (mg/day)	Diet alone (% RDA)	Diet alone (mg/day)	Diet and supplement (% RDA)
Vitamin A	–	134±27.9	510.0 ±99.7[b]	134±27.9
Vitamin C	15	140±25.0	50.7 ±8.1	182±25.8
Thiamine	0.6	135±31.6	0.6 ±0.2	277±55.0
Riboflavin	0.6	157±32.0	0.9 ±0.2	271±48.0
Vitamin B_6	0.5	60±29.5	0.4 ±0.1	139±37.0
Vitamin B_{12}	2.5[b]	273±78.4	1.5 ±0.4[b]	752±117.4
Folic acid	0.1[c]	230±57.6	0.09±0.02	585±179.3

RDA, Recommended daily allowance
[a] Mean ± SD
[b] Vitamin A and B_{12} are µg/day
[c] 1 patient received 0.2 mg/day

$$\text{Activity coefficient} = \frac{\text{activity of EGR with FAD}}{\text{activity of EGR without FAD}}$$

Vitamin B_6 was measured as plasma pyridoxal phosphate by high-pressure liquid chromatography. Serum concentrations of vitamin B_{12} and folic acid were determined by radioassay using the Ciba Corning kit (Ciba Corning Diagnostic, Irvine, Calif., USA).

A 3-day food record was obtained from each participant before blood collection. In all cases, greater than 95% of nutrient intake consisted of infant formula (Similac PM 60/40, Ross, Columbus, Ohio, USA). One of the patients (no. 4) received 50% of his nutrient intake from a second infant formula (Pregestimil, Mead Johnson Nutritionals, Evansville, Ind., USA). Analysis of food records was performed using the Computrition Computer Program (Computrition, Chatsworth, Calif., USA). The vitamin intake data were computed as the percentage of the recommended dietary allowance (RDA) for height age [7].

Correlations between vitamin intakes and blood vitamin concentrations were analyzed by linear regression. Statistical significance was defined as P less than 0.05. Results are expressed as mean plus or minus standard deviation.

Results

The serum concentrations of the water-soluble vitamins and vitamin A of the individual infants studied are shown in Table 2. Normal infant vitamin levels reported from various sources are also included. In all cases, the patients' serum concentrations of the water-soluble vitamins were comparable to or greater than the values reported in normal infants. The patients' serum vitamin A levels were elevated compared with normal values, despite the lack of vitamin A in the patients' oral vitamin supplement.

The vitamin intake data of the patients are listed in Table 1. The combined dietary and vitamin supplement intake exceeded the RDA for the water-soluble vitamins in all but one patient (no. 6) who received only 79% of the RDA for vitamin B_6 because of inadequate formula intake (65 calories/kg per day). There was no statistical correlation between vitamin intake and blood vitamin levels.

Discussion

While multiple reports of the caloric and protein intake of infants with end-stage renal disease have been published, little attention has been given to the vitamin status of these patients, despite the fact that the water-soluble vitamins are essential for normal human growth and development [3, 8]. Although our evaluation of a supplemented population of infants prohibits determination of specific vitamin requirements, our data do highlight an aspect of care in which little information is available.

The majority of previous studies on vitamin needs have reported serum thiamine and riboflavin levels to be normal in peritoneal dialysis patients, with or without supplementation, in association with negligible losses during dialysis [9]. The current study revealed that, as in older children receiving peritoneal dialysis, the combined dietary/supplemental intake of thiamine and riboflavin by the infants approached 3 times the RDA and was associated with a normal serum vitamin status [3]. In contrast, deficiency of vitamin B_6 can result from poor dietary intake as well as impaired formation or increased clearance of pyridoxal phosphate, with only minimal losses of vitamin B_6 in the dialysis fluid [10]. In the current study, the infants dietary intake provided 60% of the RDA and the addition of supplemental vitamin B_6 yielded a combined intake of 1.3 times the RDA. Although a wide range of results were seen in the individual patients, all values were outside the range normally associated with clinical manifestations of inadequate vitamin B_6 status [10].

Table 2. Serum vitamin levels in infants receiving peritoneal dialysis

	Vitamin A (µmol/l)	Vitamin C (µmol/l)	Thiamine assessment (%)	Riboflavin assessment (Coefficient)	Vitamin B_6 (nmol/l)	Vitamin B_{12} (pmol/l)	Folic acid (nmol/l)
Normal	0.7–2.8 [14]	22.8–113.8 [15]	20 [14]	0.9±0.08 [16]	26–70 [17, 18]	89–590 [19]	13–18 [20]
Patient no.							
1	4.12	148	14.6	0.8	55	754	>45
2	4.47	102	–	0.9	82	889	>45
3	4.64	170	12.0	1.2	113	837	>45
4	4.36	62	18.5	0.7	81	1,242	>45
5	3.49	68	19.1	0.9	35	1,273	>45
6	4.43	102	6.7	0.6	23	1,074	>45
7	6.98	165	–	1.0	45	1,045	>45
Mean ± (SD)	4.6 (1.1)	116.7 (44.6)	14.2 (5.1)	0.88 (0.19)	62.0 (31.5)	1,016.3 (199.2)	>45

The importance of vitamin B_{12} and folic acid lies in their participation in red cell formation, and a deficiency of either vitamin can impair the effectiveness of recombinant human erythropoietin therapy [11]. Previous studies have demonstrated that losses of folic acid in peritoneal dialysis effluent can be significant while only small quantities of vitamin B_{12} are cleared [2]. Accordingly, supplementation with 0.8–1.0 mg folic acid is routinely recommended, while the necessity of vitamin B_{12} supplementation remains unsettled. In turn, it is of interest that supplementation of our patients with only 0.1 mg/day folic acid and 2.5 μg/day vitamin B_{12} was associated with serum folic acid and vitamin B_{12} levels that were greater than normal in each case.

Supplementation with vitamin C is recommended because of the significant quantity that can be lost through the peritoneal dialysis procedure [3]. While adequate levels of vitamin C are necessary for the formation of collagen, excessive intake of vitamin C in the dialysis population may result in elevated oxalate levels as an end-product of vitamin C metabolism and lead to the development of significant vascular complications [12]. Our patients received a daily supplement of 15 mg of vitamin C which resulted in normal, but not excessive, serum vitamin C levels.

Finally, the vitamin A levels of our patients were elevated despite the lack of excessive dietary vitamin intake and the absence of vitamin A supplementation. The elevated levels are a result of the loss of the kidneys normal ability to excrete vitamin A metabolites [13]. Since elevated levels of vitamin A can be associated with the development of hypercalcemia and complications related to high calcium-phosphorus product, it is critically important to avoid the use of vitamin supplements that include vitamin A in most infants and children receiving chronic dialysis.

In summary, this preliminary study demonstrates that the provision of a daily water-soluble vitamin supplement, in combination with the dietary vitamin intake provided by infant formula, is associated with normal or greater than normal vitamin levels in infants receiving long-term peritoneal dialysis. However, more definitive quantitative data on the vitamin needs of this population will require careful study of the vitamin intake and the losses of vitamins in the dialysate effluent of a previously unsupplemented group of infants. Only then will the development of a vitamin formulation specifically designed for this population be possible.

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