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Water-Soluble Vitamins in Cancer Patients on Parenteral Nutrition: A Prospective Study

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ABSTRACT. Forty-three patients with mild weight loss were studied prospectively to determine whether the parenteral water-soluble vitamin doses in a commercially available preparation (MVI concentrate; USV Laboratories, Tarrytown, NY) maintained serum, red blood cell (RBC), and urinary concentrations of water-soluble vitamins in stressed cancer patients receiving total parenteral nutrition (TPN). Patients were divided into three groups: (1) oral diet, no intravenous vitamins given; (2) TPN plus 5 ml MVI; and (3) TPN plus 10 ml MVI. Vitamins C, B_1, B_2, B_3, B_6, and niacin were measured initially and weekly during a 6-week study period. Caloric and nitrogen balances were quantified. Most of the patients in all three groups had normal blood or urine levels of all water-soluble vitamins. No clinical evidence of vitamin deficiency or MVI toxicity was detected. The recommended parenteral dosages of vitamin C (100 mg/day) and B_3 (15 mg/day) provided measurably adequate levels in all patients. Levels of vitamins B_1, B_2, B_6, and niacin that were less than the normal range were noted in 4–40% of patients receiving the recommended daily dosages of 3 mg, 3.6 mg, 4 mg, and 40 mg, respectively. These deficiencies appeared to improve in group III patients who received twice the recommended parenteral vitamin dosages, although they did not completely disappear. Niacin deficiency appeared to be the most prevalent, occurring in 40% of patients studied. Since intravenous doses of B_1, B_2, B_6, and niacin are safe and well tolerated, it appears that increased daily amounts of these vitamins should be given to cancer patients on parenteral nutrition. (*Journal of Parenteral and Enteral Nutrition* **11**:243–249, 1987)

Total parenteral nutrition (TPN) is being used more and more frequently as the sole nutritional support of hospitalized patients. The Nutrition Advisory Group of the American Medical Association adopted a statement in 1979 and recommended daily dosages for parenteral multivitamin preparations.[1] The Food and Drug Administration (FDA) also recently approved these recommendations.[2] These guidelines represent daily parenteral intakes considered to be adequate for maintenance requirements. Their application to malnourished and metabolically stressed patients may be inappropriate. The intravenous vitamin requirements of very sick patients need to be better defined. This prospective study examined water-soluble vitamin requirements in three groups of hospitalized cancer patients. Group I patients received no vitamin supplements and consumed all calories orally. Group II patients were on TPN and received the recommended daily dose of water-soluble vitamins. Group III patients were identical to group II, except they received twice the recommended daily dose of water-soluble vitamins. It was hoped that this study would assess the adequacy of the presently recommended daily maintenance dosages of water-soluble vitamins in sick, hospitalized cancer patients on total parenteral nutrition.

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MATERIALS AND METHODS

Forty-three patients admitted to the Clinical Center of the National Institutes of Health were entered into the study. Forty-two patients had a primary diagnosis of malignancy, and the remaining patient had systemic vasculitis. All patients were assigned to one of three groups. Descriptions of the three groups are shown in Table I. Weight loss was similar in all groups and was 8 ± 3% of the usual body weight.

Patients were sequentially assigned to one of three vitamin groups. Group I patients received no TPN or supplemental intravenous vitamins. All calories supplied were those consumed either orally or delivered as a 5% dextrose intravenous solution. These patients were judged by the nutritional support team to not require total parenteral nutrition. Group II and III patients were composed of patients placed on TPN for the following indications: a nonfunctional gastrointestinal tract secondary to operation, obstruction, chemotherapy, or radiation therapy. A central line was placed via the subclavian vein into the superior vena cava. Caloric requirements were calculated on an individual basis using the Harris-Benedict equation.[3] The appropriate carbohydrate and protein calories were given as 20% dextrose and 4.25% crystalline amino acids (Freamine II, McGaw Laboratories, Glendale, CA). Five hundred milliliters of fat emulsion (Liposyn 10%, Abbott Laboratories) were given twice weekly to prevent essential fatty acid deficiency. Water-soluble vitamins were provided in the form of a commercial multivitamin preparation (MVI concen-

TABLE I
Definition of three patient groups

	Group		
	I	II	III
Number of patients	7	20	16
Female:male	1:6	7:13	7:9
Mean age (range) (yr)	37 (16–75)[a]	51 (24–72)	54 (16–75)
Diagnosis	Malignancy (7)[b]	Malignancy (19) Vasculitis (1)	Malignancy (16)
Diet	Oral	TPN	TPN
MVI dose per day	None	5 ml	10 ml

[a] Numbers in parentheses = youngest and oldest age in years.
[b] Numbers in parentheses = number of patients.

trate, USV Laboratories). The amount of each water-soluble vitamin in this concentrate is shown in Table II. The vitamins were added daily to the TPN solutions in the first morning bottle. Group II patients received 5 ml of MVI daily, and group III patients received 10 ml of MVI daily. Two patients subsequently crossed over from group I to group II when readmitted at a later date. Each individual admission was analyzed separately according to the group the patient was in at the time. Two patients in group II were studied twice on separate admissions, but each remained in group II.

No attempt was made to limit the oral intake of any patient in any group if his condition permitted. Daily quantification of oral and intravenous nonprotein and protein calories was made. Blood collections for vitamin levels were performed weekly in the early morning before patients received breakfast and the daily MVI-containing TPN. Twenty-four-hr urine collections for vitamin levels and microKjeldahl nitrogen levels were made weekly on the same day. All patients were studied for a minimum of 3 weeks and a maximum of 6 weeks. Not all patients were on study for the full 6 weeks.

Vitamin assays were performed as described previously.[4-7] Serum concentrations of vitamin C were determined by a colorimetric technique.[4] Vitamins B_1 and B_2 were assessed by the activation of erythrocyte transketolase and glutathione reductase,[5,6] respectively. Urine levels of vitamin B_6, niacin, and pantothenic acid were measured by microbiological assays.[7] No attempt was made to exclude patients receiving antibiotics, although it was appreciated that data from the microbiological assays could be affected.

A patient was considered vitamin deficient if at least two consecutive below-normal levels were measured. Similarly, correction of a measured vitamin deficiency was judged as a minimum of two subsequent consecutive weekly normal vitamin levels following a minimum of two consecutive below-normal levels.

Statistics

Data are presented as mean ± SEM and analyzed by Kruskal-Wallis test and a Wilcoxon two-sample test.[8]

RESULTS

The only source of vitamins in group I patients was oral diet. Group II and III patients had intravenous vitamin supplementation, as well as variable amounts of oral feedings which may also provide an unknown quantity of vitamins. Before examining vitamin levels, it was necessary to compare the oral caloric intakes of the three groups. The mean weekly oral caloric intake (± SEM) per patient for each group is given in Table III. There was marked variation, but significant differences between the groups were not apparent until week 3, when group I had a greater intake than group II. At weeks 5 and 6, the oral caloric intake was significantly greater in the patients in group I than in those in groups II and III. Therefore, it was concluded that, before week 5, any differences in water-soluble vitamin levels demonstrated were a reflection of iv supplementation, and probably not due to variations in oral intake. This assumes that the amount of vitamins ingested per calorie remained the same for oral feedings in all patients. However, after week 5, differences in vitamin levels between group I and other groups may reflect differences in oral intake.

TABLE II
Concentration of water-soluble vitamins in multiple vitamin solution (MVI)

Vitamin	Dose (mg) per 5 ml MVI
C (ascorbic acid)	100
B_1 (thiamine)	3
B_2 (riboflavin)	3.6
B_3 (pantothenic acid)	15
B_6 (pyridoxine)	4
Niacin	40

The weekly nitrogen balances were significantly different only at weeks 2 and 3, at which time the group I patients were in a significantly more negative nitrogen balance than group II, and groups II and III, respectively (Table IV). The clear trend was for group I patients (not on TPN) to be in a negative nitrogen balance, whereas group II and III patients (on TPN + iv vitamins) tended to be in positive nitrogen balance.

Table V lists the mean weekly intravenous calories per patient for each of the groups. As expected, patients on TPN (groups II and III) received significantly more calories than group I patients after week 1.

No clinical evidence of vitamin deficiency or MVI toxicity was detected in any patient.

Vitamin C

The recommended daily parenteral dose of vitamin C is 100 mg.[1] Group II patients received 100 mg iv daily and group III patients 200 mg iv daily. The mean vitamin

TABLE III
Oral calories consumed weekly by each group[a]

Group	P.O. calories/week (mean ± SEM)					
	1	2	3	4	5	6
I	9042 (8386) n = 4	835 (322) n = 6	6284[b] (1894) n = 6	6239 (2414) n = 6	10187[bc] (3199) n = 4	13915[d] (4758) n = 4
II	393 (146) n = 22	1186 (457) n = 23	2221 (531) n = 23	1942 (484) n = 22	937 (346) n = 16	272[d] (168) n = 9
III	1668 (1213) n = 16	1845 (760) n = 16	3859 (1250) n = 16	2929 (982) n = 16	2971 (1087) n = 12	5208[d] (1667) n = 8

[a] Data are presented as mean ± SEM kcal/week.
[b] Significantly different ($p < 0.05$) than group II.
[c] Significantly different than group III.
[d] All three groups significantly different.

TABLE IV
Daily nitrogen balance analyzed weekly for each group[a]

Group	24-Hr nitrogen balances (mean ± SEM) at week					
	1	2	3	4	5	6
I	−46.2 (46.4) n = 2	−4.17[b] (5.41) n = 3	−7.52[c] (2.26) n = 6	−14.05 (12.13) n = 6	−33.75 (18.39) n = 4	−17.72 (12.8) n = 4
II	1.85 (2.96) n = 4	6.96 (2.3) n = 16	3.48 (2.32) n = 18	0.3 (1.38) n = 13	0.74 (1.81) n = 11	−5.82 (7.76) n = 6
III	11.17 (13.56) n = 3	5.12 (1.5) n = 11	3.27 (1.67) n = 15	1.14 (1.58) n = 12	1.64 (3.52) n = 8	7.07 (6.21) n = 6

[a] Data are presented as mean ± SEM, nitrogen balance per day, determined each week.
[b] Significantly different ($p < 0.05$) than group II.
[c] Significantly different than all other groups.

TABLE V
Intravenous calories for each patient group

Group	IV calories/week[a]					
	Week 1[b]	Week 2	Week 3	Week 4	Week 5	Week 6
I	2739 (1614) n = 3	859[c] (192) n = 4	1536[c] (649) n = 5	2258[c] (750) n = 6	2457[c] (1252) n = 3	2879[c] (798) n = 4
II	10096 (5669) n = 22	13114 (1356) n = 23	15907 (1072) n = 23	13808 (1556) n = 22	13845 (1447) n = 16	15851 (2208) n = 9
III	12908 (7302) n = 17	12210 (1724) n = 17	18039 (977) n = 16	16013 (1060) n = 16	13140 (2189) n = 12	13579 (1320) n = 8

[a] Data are presented as mean ± SEM intravenous calories per patient per week.
[b] After week 1, group I received significantly fewer calories than either of the other groups.
[c] Significantly different than groups II and III.

C serum levels are shown in Figure 1. Group I patients, despite receiving no iv supplementation, maintained above-normal mean serum levels until weeks 5 and 6, at which time levels dropped to within normal limits. Group II patients' mean serum levels remained above normal throughout the study. Group III patients' mean vitamin C levels were also within normal limits, but were significantly lower in value ($p < 0.05$) than group II for weeks

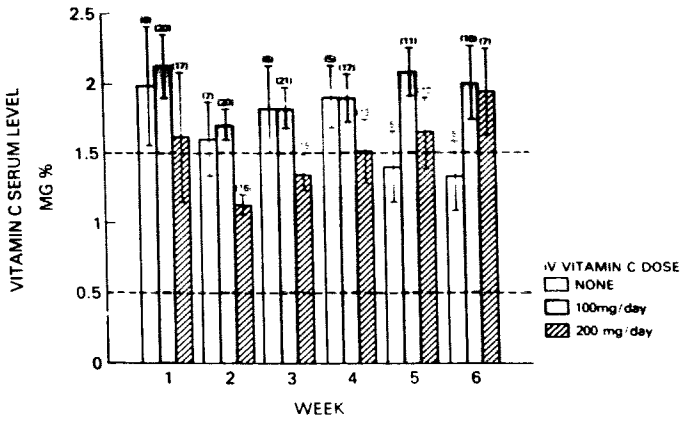

FIG. 1. Mean ± SEM serum vitamin C level (mg%) is plotted *vs* time in weeks for three iv vitamin C dosages (0, 100 mg, and 200 mg/day). The normal range is indicated by the dashed lines. Numbers of determinations are shown in parentheses. Vitamin C levels were either normal or greater than normal for all three groups during the 6-week study. Group III patients (200 mg/day) started significantly less than ($p < 0.05$) group II patients (100 mg/day), but after 3 weeks of parenteral vitamin C administration at a dose of 200 mg/day, group III patients had levels similar to those of Group II.

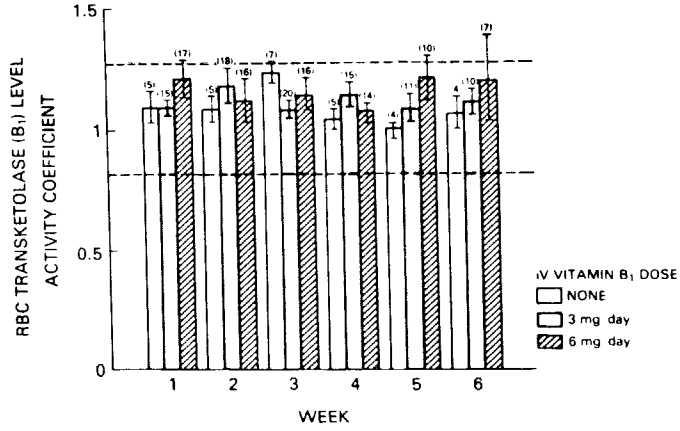

FIG. 2. The mean ± SEM activity coefficient for red blood cell (RBC) transkelatase (B_1) is plotted *vs* time in weeks for three iv vitamin B_1 dosages (0, 3, and 6 mg/day). Numbers of determinations are shown in parentheses. RBC vitamin B_1 levels remained within the normal range for all three groups during the 6-week study period. The normal range is delineated by the dashed lines.

1, 2, and 3. By week 4, the values were above normal and remained so through week 6.

Vitamin B_1 (Thiamin)

The recommended daily parenteral dose of vitamin B_1 is 3 mg.[1] Group II patients received 3 mg daily, and group III patients, 6 mg/day. All three groups, despite varying oral supplementation, had mean RBC transketolase (B_1) levels that remained within normal limits and did not differ significantly from each other [illegible] patients had two or more sequential deficient levels (Table VI). The one patient in group II had a normal level recorded for week 1, followed by four abnormally low weekly values which never corrected on 3 mg iv daily. The two group III patients had deficient levels at weeks

TABLE VI
Number of patients with two or more sequential deficient levels recorded

Vitamin	Group[a]		
	I	II	III
C	0/7	0/23	0/14
B_1	0/7	1/23	2/16
B_2	2/6	2/19	1/12
B_3	1/7	0/23	0/16
B_6	1/7	3/21	0/16
Niacin	5/5	3/14	0/1

[a] Number of patients with deficiency is given/total number of patients studied. See Methods for definition of deficiency.

2, 3, and 5, 6, respectively. Unfortunately, neither were followed long enough to see whether levels normalized on the 6 mg/day iv vitamin dose delivered.

Vitamin B_2 (Riboflavin)

Group II patients received the recommended daily amount of vitamin B_2 (3.6 mg/day iv). Group III patients received 7.2 mg/day. Again, despite differences in supplementation, all groups had mean RBC glutatione reductase (B_2) levels within the normal range (Fig. 3). Five patients had deficiencies (Table VI). Two patients in group I remained deficient from the onset throughout the study. One patient in group II who was receiving chemotherapy and radiation became septic, and had deficient levels of vitamin B_2 throughout the study. Another group II patient receiving adjuvant radiotherapy became deficient 3 weeks after starting MVI. One group III patient with metastatic disease was initially deficient, and corrected after 2 weeks of vitamin B_2 supplementation.

Vitamin B_3 (Pantothenic Acid)

Group II patients received the suggested daily iv dose of vitamin B_3 (15 mg/day). Group III patients were given 30 mg/day. Urine levels of pantothenic acid (B_3) for all three groups were within normal limits. The mean levels of group I patients who received no iv supplementation were lower than that of group II and III patients for all 6 weeks. However, this difference was significant only at week 3 ($p \leq 0.04$) (Fig. 4). Only one patient in group I had two abnormally low levels measured at weeks 2 and 3, which returned to normal thereafter (Table VI).

Vitamin B_6 (Pyridoxine)

Mean urine levels of vitamin B_6 in group I patients receiving no iv supplementation remained within normal limits for weeks 2 to 6. Patients receiving 4 mg/day of iv pyridoxine (group II) had mean urine levels within or just above normal levels. Patients receiving 8 mg/day (group III) had mean urine levels above normal for most weeks measured (Fig. 5). Deficiencies were identified in one patient in group I and three patients in group II at the onset of the study. Only one of the group II patients had urine levels that returned to normal by 6 weeks. No patient in group III had abnormal levels (Table VI).

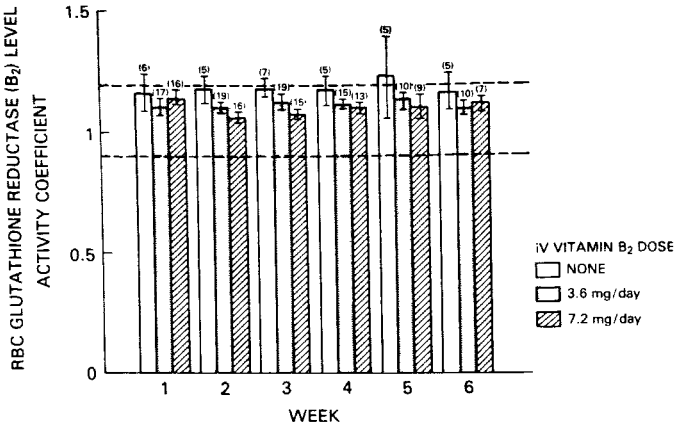

FIG. 3. The mean ± SEM activity coefficient for the red blood cell (RBC) glutathione reductase (B_2) level is plotted *vs* time in weeks for three iv vitamin B_2 dosages (0, 3.6, and 7.2 mg/day). Numbers of determinations are shown in parentheses. RBC vitamin B_2 levels remained within the normal range despite the dose of B_2 given during the entire 6-week study period. The normal range is delineated by the dashed lines.

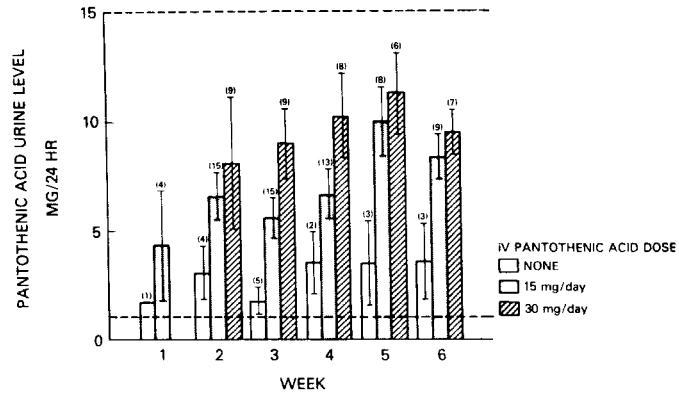

FIG. 4. The mean ± SEM level (mg/24 hr) of pantothenic acid in the urine is plotted *vs* time in weeks for three iv pantothenic acid doses (0, 15, and 30 mg/day). Numbers of determinations are shown in parentheses. Urine levels for all three groups were within normal limits; however, the levels for group I (no iv pantothenic acid) were significantly lower than for the other two groups at week 3 ($p < 0.04$). The normal range is shown by the dashed lines.

Niacin

Less than 50% of patients in the three groups had urinary *n*-methylnicotinamide levels measured. However, of those measured, 40% of patients had deficient levels, and only 11/14 patients in group II (40 mg/day iv) had urine levels in the normal range (>3 ng/24 hr of *n*-methylnicotinamide). The one patient measured in group III (80 mg/day iv) had normal levels at all weeks measured (Fig. 6; Table VI).

DISCUSSION

No clinical evidence of vitamin deficiency was noted in any patient in this study, but 4–40% of the patients who received the recommended intravenous vitamin doses of B_1, B_2, B_6, and niacin had abnormally low

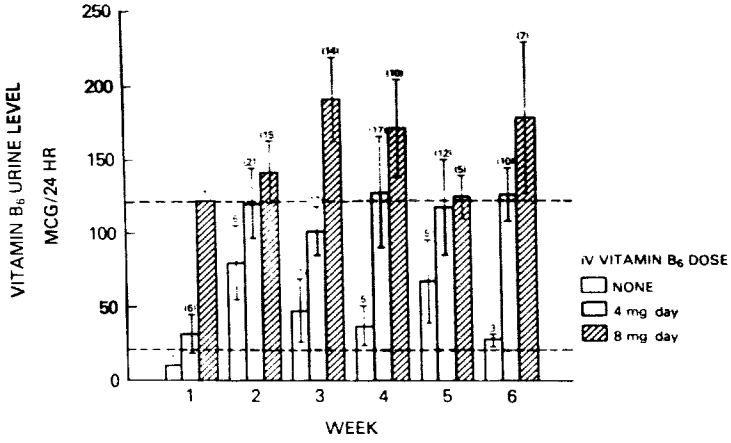

FIG. 5. The mean ± SEM 24-hr urinary level in μg for vitamin B_6 is plotted *vs* time in weeks for three iv vitamin B_6 doses (0, 4, and 8 mg/day). Numbers of determinations are shown in parentheses. Urinary B_6 levels remained within the normal range in groups I and II. Levels were greater than normal in group III. Normal range is given by the dashed lines.

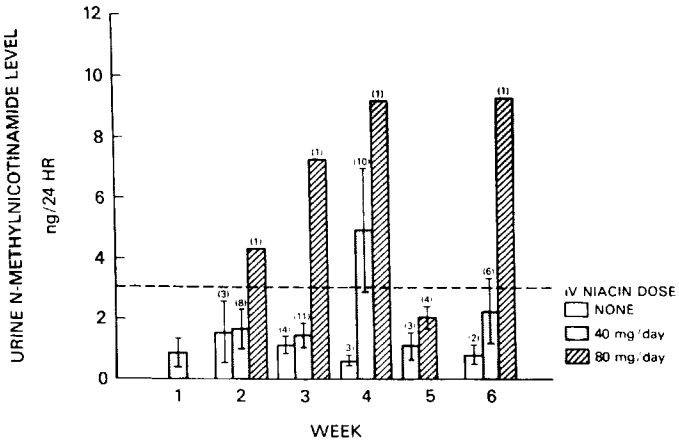

FIG. 6. Mean ± SEM 24-hr urinary level of *n*-methylnicotinamide (ng/24 hr) is plotted *vs* time in weeks for three iv niacin doses (0, 40, and 80 mg/day). Numbers of determinations are shown in parentheses. Urinary *n*-methylnicotinamide levels remained lower than normal (>3 ng/24 hr) in groups I and II. The single patient studied in group III had normal levels. Normal range is greater than the dashed line.

biochemical levels. Deficiency levels of these vitamins can occur from decreased intake, malabsorption, increased demands, and increased excretion. Decreased food intake and malabsorption are common in cancer patients receiving anti-cancer therapy;[9] however, this alone was not a cause in these patients, because they received daily intravenous vitamin supplements. Another cause of vitamin deficiency is increased demand for tissue growth which has been documented in pregnancy and childhood.[10] Cancer also has an increased demand for cell growth[11] which may place a greater demand on the tumor-bearing host for vitamins. A final potential cause of vitamin deficiency may be increased excretion of vitamins or alterations in metabolic pathways which render vitamins inactive. This can occur with chemotherapeutic agents like cisplatinum or 5-fluorouracil.[12] The actual cause or causes of vitamin deficiencies demonstrated in the patients in this study cannot be elucidated. Significant variables like tumor burden, tumor type, type and amount of chemotherapy, or radiation therapy were not recorded. The goal of this study was to determine prospectively whether the recommended daily doses of water-soluble vitamins are adequate in cancer patients.

In the present study, assays were performed of serum, erythrocyte, and urine vitamin levels. No attempt was made to correlate these levels with clinical signs of vitamin deficiency or tissue vitamin stores. However, other investigators have examined this question. Low serum vitamin C levels may not indicate scurvy, but persistence of low levels are usually associated with the development of scurvy.[13] Erythrocyte transketolase measurements, as used in this study, are a good measurement of early thiamin deficiency before the clinical signs of deficiency appear.[14] Erythrocyte glutathione reductase activity coefficient measurement was employed to assess riboflavin metabolic status. This has been shown to be a sensitive method for this purpose.[15]

To measure vitamin B_6, urine levels were evaluated. Urinary excretion of vitamin B_6 probably better reflects the recent dietary intake of the vitamin than the degree of vitamin B_6 deficiency.[15] The addition of erythrocyte transaminase activity may provide further useful information in assessing vitamin B_6 nutriture.[14] However, this assay was not performed.

The niacin status in the patients was assayed by measuring urinary *n*-methylnicotinamide. This major metabolite of niacin has not been an entirely satisfactory determinant of niacin deficiency. The measurement of urine 2-pyridone, another major metabolite of niacin, expressed as a ratio between 2-pyridone *n*-methylnicotinamide excretion, may be more efficacious in interpreting niacin status.[14] Finally, pantothenic acid nutriture was followed by measuring urinary pantothenic acid levels. Urinary excretion of this vitamin appears to correlate with dietary intake.[14] Its usefulness in determining pantothenic acid deficiency is not clear.

Despite the possible limitations of certain water-soluble vitamin measurements, this study represents a prospective evaluation of different water-soluble vitamin dosages in hospitalized cancer patients. The results are important, because water-soluble vitamin requirements of a large population of patients with cancer, undergoing various treatment modalities, have not been previously studied. The Recommended Dietary Allowances (RDA)

were established based on populations with nonmalignant diseases.[16] The Nutrition Advisory Group of the American Medical Association, in recommending the daily requirements of intravenous water-soluble vitamins, merely doubled the highest RDA for each vitamin.[16] It was recognized that the requirements for various disease states may be altered, but no guidelines were given.

Vitamin C

Tissue demands for vitamin C may be increased in certain states, such as malignancy[12] and conditions of wound healing.[17] Doses of parenteral vitamin C, *larger* than the daily recommended dose, are advised. Indeed, most investigators have favored giving higher doses of vitamin C to hospitalized patients, ranging from 210 to 2250 mg/day.[18–24] The recommended maintenance parenteral dose of 100 mg/day was used in one study performed on home TPN patients.[23] Serum or urine levels in this study and those using much larger dosages all were within or above normal limits. Our data concurred with these results. A dose of 100 mg/day in patients with a multitude of clinical problems and physiological stresses maintained normal serum levels in all patients. Indeed, group I patients (no parenteral vitamins given) maintained normal serum levels as well. Therefore, it would be our recommendation that 100 mg/day of vitamin C per day intravenously would be adequate in oncology patients requiring short-term (4–6 weeks) nutritional support.

Vitamin B_1

The recommended daily maintenance parenteral dose of vitamin B_1 (thiamin) is 3 mg/day. It is well recognized that thiamin requirements vary with the caloric requirements and energy expenditure of the patient.[25] Therefore, it is difficult to recommend a minimum daily requirement to include all patients. Several recent studies have looked at the effectiveness of daily dosages ranging from 1.2 mg/day to 55 mg/day.[23,24,26,27] Two of thirty-nine postoperative patients became deficient in thiamin, as measured by erythrocyte transketolase activity.[27] The authors attributed this to the severe catabolic state of these two patients. In the present study, one postoperative patient was deficient and remained so on 3 mg/day. Two patients who received 6 mg/day became deficient: one became septic postoperatively, and the second had a completely obstructing esophageal cancer. Therefore, it is recommended that daily dosages of more than 6 mg/day be supplied to very catabolic patients. No toxic effects of thiamin have been noted when up to 200 times the maintenance dose is given.[25]

Vitamin B_2 (Riboflavin)

Riboflavin is a constituent of two of the coenzymes involved in electron transport. Cellular growth is not possible in the absence of riboflavin, and daily requirements parallel protein requirements.[28] Two reports, one using 1.8 mg/day[27] and the other 10 mg/day[24] describe no measurable deficiencies in surgical patients. However, 3.6 mg/day was not sufficient for two patients in the present study, both of whom were receiving adjuvant therapy for their malignancies. Again, it may be advisable to supply a larger dose than the daily recommendation. The largest dose, 7.2 mg/day, produced no deficiencies and measurably corrected one.

Vitamin B_3

The deficiency of this vitamin is reported to be rare in patients consuming a natural diet.[18] The findings in this study support this, in that all but one patient in group I had normal urinary levels of pantothenic acid, and he corrected quickly on an adequate oral diet alone. Those patients who were supported with the recommended 15 mg/day dose delivered intravenously, maintained normal urinary levels of the vitamin. Therefore, it is concluded that this dose is adequate for this patient population.

Vitamin B_6

There were four patients, one in group I and three in group II who had reduced urine levels of vitamin B_6. Three of these four patients were receiving chemotherapy. However, three patients in group I and three patients in group II who were receiving chemotherapy had normal urine levels. No patient in group III, including four patients on chemotherapy, had abnormal levels.

Vitamin B_6 dosages as low as 2 mg daily have been reported to maintain normal erythrocyte levels of aspartate aminotransferase activity in a post-surgical population.[27] Fifteen mg daily in a group of critically ill patients maintained normal erythrocyte levels in all patients.[24] The reduced urine levels in three of our patients who received 4 mg/day, and the fact that even very large doses produced only minimal toxicity may support the use of at least 8 mg/day of vitamin B_6 for similar patients, especially those undergoing chemotherapy regimens.

Niacin

The measurement of urinary *n*-methylnicotinamide levels as an assessment of niacin nutrition was performed in nearly half the patients. Forty percent of patients had abnormally low urine levels of this niacin metabolite. Despite receiving 40 mg daily, 3/14 patients still had deficient urinary levels. The reason for this is unclear. Niacin deficiencies have been associated with the presence of a malignancy.[12] The quantity of protein intake and, hence, tryptophan (a precursor of niacin) availability can affect niacin nutrition. In patients on TPN, protein intake was adequate. It appears that 40 mg/day of niacin may not be adequate for patients with malignancies undergoing various treatments, and this dosage should be increased.

Conclusions

This prospective study has examined the requirements of parenteral water-soluble vitamins in a patient population with a primary diagnosis of malignancy in all but

one. All patients were undergoing various treatment-related physiological stresses. No patient had any clinical evidence of vitamin deficiency or toxicity from MVI. The current recommended parenteral vitamin formulation provided measurably adequate levels of vitamin C and pantothenic acid in all patients. Deficient levels of B_1, B_2, B_6, and niacin were detected in some patients receiving the recommended daily dosages. Since increased parenteral dosages of these vitamins have low toxicity, increased daily dosages appears to be appropriate. Further studies are needed to determine exactly what dosages are necessary in stressed oncology patients.

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