Nutritional status of general medical patients—influence of age and disease

J. Woo,* Y.T. Mak,† and R. Swaminathan†

Departments of Medicine and Chemical Pathology,† The Chinese University of Hong Kong, Shatin, N.T., Hong Kong*

Arm anthropometry and biochemical indices of protein energy, vitamin, and mineral status were estimated in 294 patients admitted to the general medical wards of a district general hospital over a one-month period. Elderly patients, and those with infections, malignancies, heart failure, and chronic obstructive airways disease had poorer nutritional status. The striking abnormalities were poor protein energy and plasma retinol status. Hospital patients aged 60 years and over had poorer protein energy and vitamin status (with the exception of thiamine and riboflavin) compared to those living in the community and long-term care institutions. Increased awareness of nutritional problems in the above categories of patients would result in improved nutritional support and possibly would accelerate recovery or reduce mortality.

Keywords: protein calorie malnutrition; vitamin; mineral; elderly; hospital; Chinese

Introduction

Most studies on the nutritional status of patients in hospital have been confined to surgical wards[1] where up to 50% of postoperative patients had abnormal nutritional indices.[2] Nutritional status is of particular interest among surgical patients, mainly because of its importance as a determinant of operative morbidity and mortality.[3] Malnutrition among hospital medical patients also exists in Caucasian populations.[4,5] However, these studies mainly examined some indices of protein calorie malnutrition, and information on vitamin and mineral status was not available. The populations studied were also fairly young (mean age less than 60 years). We measured arm anthropometry and some biochemical nutritional indices of protein calorie malnutrition, vitamin, and mineral status in a group of general medical patients with a higher mean age, who were Chinese, with different dietary and disease pattern, to determine the influence of age and different types of diseases on nutritional status. Values from free-living subjects and those living in long-term care institutions aged 60 years and over were available for comparison.

Address reprint requests to J. Woo, Department of Medicine, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong.
Received August 17, 1990; accepted November 9, 1990.

Subjects and methods

All patients admitted over a one-month period to the general medical wards of a district general hospital with a catchment population of one million were recruited into the study. All subjects were seen by a nurse interviewer, who collected information on the diagnosis of the patients, the subsequent length of hospital stay, and recorded arm anthropometric measurements. Arm circumference was measured at the midpoint between the acromion and olecranon processes. Triceps skin-fold thickness was measured with Holtain calipers at the same point. The average of three readings was used. Arm muscle circumference (AMC) was derived from Equation 1:

$$\text{AMC(cm)} = \text{arm circumference(cm)} - \frac{\pi}{10} \times \text{triceps skin-fold thickness (mm)} \quad (1)$$

Corrected arm muscle area (CAMA), a measure of prognostic value for severe wasting malnutrition,[6] was calculated using Equation 2:

$$\text{Male: CAMA(cm}^2\text{)} = \frac{(\text{AMC})^2}{4\pi} - 10$$

$$\text{Female: CAMA(cm}^2\text{)} = \frac{(\text{AMC})^2}{4\pi} - 6.5 \quad (2)$$

Twenty ml of venous blood was collected from each patient in the nonfasting state within 48 hr of admission for routine blood tests (complete blood picture,

Table 1 Age group of patients by sex, duration of stay, and disease categories

	No. in age group (%)				
	<40	40–60	61–80	80+	Total
Sex					
Female	26	16	61	30	133
Male	37	38	71	15	161
Total	63 (21)	54 (19)	132 (45)	45 (15)	294
Duration of stay (days)					
<1	4	2	3	1	10 (3)
1–7	49	28	71	30	178 (61)
8–14	8	11	31	12	62 (21)
15–30	1	7	10	1	19 (6)
>30	1	6	17	1	25 (9)
				X^2 = 26.9, DF = 12, P = 0.008	
Disease categories					
Infection	8	4	12	5	29
Chronic obstructive airway disease	—	3	23	4[a]	30
Heart failure	—	2	25	12[a]	39
Malignancy	1	5	3	3	12
Others	52	34	55	18	159

[a] Significantly different compared with category (5) by Chi-square test; $P < 0.001$.

renal and liver function tests) as well as the following: prealbumin, retinol binding protein, transferrin; thiamine, riboflavin, and pyridoxine status; serum folate, cyanocobalamin, retinol, vitamin E; plasma copper, zinc and magnesium, and total lymphocyte count. Total protein and albumin were estimated by a Parallel™ Analyzer (American Monitor Corp, IN, USA). An aliquot of plasma was stored at −70° C for batch assay of prealbumin, retinol binding protein, and transferrin, using an immunoturbidimetric method with polyclonal antibodies (Dako, Bucks, UK) automated on a centrifugal analyzer—Cobas Bio (Roche Diagnostic, Basel, Switzerland).[8,9] Biochemical status of thiamine, riboflavin, and pyridoxine was estimated by measurement of red cell enzyme activation using an automated method.[10] Cyanocobalamin and serum folate were estimated by a radio-immunoassay method using kits from Diagnostic Products Corporation (Los Angeles, CA, USA). Plasma retinol and vitamin E were measured by a fluorometric method after extraction with hexane.[11] Measurement of fluorescence from extracted retinol was modified by using 550 nM as the emission wavelength to avoid interferences.[12] An aliquot of plasma was stored at −20° C for batch assay of copper, zinc, and magnesium by atomic absorption spectrophotometry, after protein precipitation with trichloroacetic acid[13] to release bound metal ions. Total lymphocyte count was determined using a Technicon H-6000 haematology analyzer (Technicon Instruments Co., Tarrytown, NY, USA).

Data were analyzed using the Statistical Package for Social Sciences (Version 3.0) on an IBM PC. The Kruskal-Wallis one-way analysis of variance was used to examine the effect of age, sex, and disease categories on nutritional variables. The Chi-square test was used to detect differences in the prevalence of diseases among different age groups. Multiple regression was used to assess the independent effects of age and disease category (independent variables) on nutritional indices (dependent variable). Unpaired Student's t test was used in the comparison of nutritional variables, with available data from those of comparable age groups living in long term-care institutions and independently in the community.

Results

Two hundred and ninety-four patients were studied. Their age and sex distribution are shown in *Table 1*. Sixty percent of all patients were aged 60 years or over, with 15% aged over 80 years. Eighty-five percent of all subjects stayed for 14 days or less, with 64% staying 7 days or less. Older patients had significantly longer duration of stay. The commonest diagnoses were gastrointestinal bleeding (15%), heart failure (13%), infection (10%), chronic obstructive airway disease (COAD) (10%), cerebrovascular disease (10%), diabetes mellitus (7%), hypertension (6%), and malignancy (3%). Nutritional status in some of these disease categories where abnormalities might have been expected were analyzed separately, and the age distribution of patients with some of these disease categories is shown in *Table 1*. Patients with heart failure and COAD were older, while there was no significant difference in age distribution among patients with infection or malignancy.

Mean values of nutritional variables by age and sex are shown in *Table 2*. Corrected arm muscle area, serum albumin, prealbumin, transferrin and zinc concentration, and total lymphocyte count decreased with age. Thiamine status was also poorer in the older age group. Plasma copper concentration increased with

Table 2 Nutritional variables by age and sex

Nutritional variables	Age group (years)	Male	Female	All
CAMA (cm^2)	<40	34.12 ± 8.02 (35)‡	34.58 ± 4.58 (26)†	
	40–60	31.58 ± 7.49 (38)	33.47 ± 7.22 (15)	
	61–80	25.44 ± 8.33 (71)	26.13 ± 10.0 (60)	
	80+	20.74 ± 8.35 (14)	25.13 ± 9.18 (30)	
Total protein (g/L)	<40	68.7 ± 10.2 (35)	74.9 ± 6.2 (23)†	71.2 ± 9.3 (58)
	40–60	68.2 ± 14.0 (37)	70.0 ± 8.6 (16)	68.7 ± 12.6 (53)
	61–80	73.6 ± 8.0 (69)	70.7 ± 9.1 (60)	72.2 ± 8.6 (129)
	80+	67.7 ± 8.8 (15)	71.4 ± 7.5 (30)	70.2 ± 8.1 (45)
Albumin (g/L)	<40	38.2 ± 6.6 (34)	40.8 ± 4.4 (25)	39.3 ± 5.9 (59)‡
	40–60	35.0 ± 6.8 (37)	37.7 ± 4.1 (15)	35.8 ± 6.2 (52)
	61–80	35.5 ± 5.6 (68)	34.7 ± 6.3 (60)	35.1 ± 5.9 (128)
	80+	30.5 ± 5.0 (15)	33.7 ± 5.8 (29)	32.6 ± 5.7 (44)
Prealbumin (mg/L)	<40	232.5 ± 148.8 (37)	187.5 ± 96.1 (26)	213.9 ± 130.7 (63)‡
	40–60	152.3 ± 85.1 (37)	236.5 ± 91.5 (16)	177.7 ± 94.6 (53)
	61–80	159.5 ± 105.7 (70)	163.8 ± 103.0 (60)	161.5 ± 104.0 (130)
	80+	89.3 ± 50.7 (15)	130.1 ± 70.7 (30)	116.5 ± 67.0 (45)
Retinol binding protein (mg/L)	<40	44.86 ± 32.99 (37)	32.00 ± 11.19 (26)	39.56 ± 26.89 (63)
	40–60	34.95 ± 19.45 (37)	46.31 ± 17.33 (16)	38.38 ± 19.39 (53)
	61–80	37.31 ± 16.79 (70)	38.47 ± 21.30 (60)	37.85 ± 18.94 (130)
	80+	23.93 ± 8.52 (15)	33.37 ± 17.81 (30)	30.22 ± 15.89 (45)
Transferrin (g/L)	<40	2.16 ± 0.57 (37)	2.30 ± 0.57 (26)	2.22 ± 0.57 (63)‡
	40–60	1.92 ± 0.55 (37)	2.21 ± 0.51 (16)	2.01 ± 0.55 (53)
	61–80	1.98 ± 0.53 (70)	2.02 ± 0.66 (60)	2.00 ± 0.59 (130)
	80+	1.56 ± 0.53 (15)	1.9 ± 0.53 (30)	1.65 ± 0.53 (45)
Total lymphocyte count ($\times 10^9$/L)	<40	1.90 ± 1.49 (32)	1.63 ± 0.66 (24)	1.79 ± 1.20 (56)‡
	40–60	1.43 ± 0.69 (34)	1.61 ± 0.88 (16)	1.49 ± 0.75 (50)
	61–80	1.12 ± 0.55 (66)	1.27 ± 0.85 (57)	1.19 ± 0.71 (123)
	80+	0.82 ± 0.61 (15)	0.95 ± 0.43 (26)	0.90 ± 0.50 (41)
Thiamine RBC.TK % activation	<40	9 ± 4 (37)	8 ± 6 (26)	8 ± 5 (63)†
	40–60	7 ± 4 (38)	8 ± 5 (16)	8 ± 5 (54)
	61–80	12 ± 8 (71)	10 ± 8 (61)	11 ± 8 (132)
	80+	16 ± 19 (15)	11 ± 8 (30)	13 ± 13 (45)
Riboflavin RBC.GTR % activation	<40	26 ± 16 (37)	27 ± 21 (26)	26 ± 18 (63)
	40–60	27 ± 20 (38)	26 ± 18 (16)	27 ± 19 (54)
	61–80	33 ± 32 (71)	28 ± 26 (61)	31 ± 29 (132)
	80+	43 ± 37 (15)	30 ± 24 (30)	34 ± 29 (45)
Pyridoxine RBC.AST % activation	<40	83 ± 48 (37)	81 ± 28 (26)	82 ± 40 (63)
	40–60	71 ± 30 (38)	70 ± 19 (16)	71 ± 27 (54)
	61–80	90 ± 58 (71)	86 ± 46 (61)	88 ± 53 (132)
	80+	78 ± 49 (15)	78 ± 51 (30)	78 ± 50 (45)
Cyanocobalamin (pmol/L)	<40	429.3 ± 229.7 (37)	509.6 ± 232.5 (25)	461.7 ± 281.0 (62)
	40–60	472.8 ± 316.4 (36)	443.4 ± 158.0 (16)	463.7 ± 276.1 (52)
	61–80	518.3 ± 261.8 (68)	536.8 ± 298.2 (57)	526.7 ± 278.0 (125)
	80+	531.5 ± 421.3 (11)	459.9 ± 331.8 (30)	479.1 ± 353.9 (41)
Serum folate (umol/L)	<40	20.3 ± 10.4 (37)	23.9 ± 8.4 (25)	21.8 ± 9.7 (62)*
	40–60	17.5 ± 6.9 (37)	24.1 ± 10.9 (16)	19.5 ± 8.8 (53)
	61–80	16.7 ± 8.6 (70)	21.9 ± 11.2 (58)	19.0 ± 10.2 (128)
	80+	12.8 ± 7.4 (15)	17.3 ± 9.4 (30)	15.8 ± 8.9 (45)
Plasma retinol (mg/L)	<40	0.49 ± 0.25 (37)	0.37 ± 0.25 (26)	0.44 ± 0.25 (63)
	40–60	0.41 ± 0.25 (37)	0.57 ± 0.28 (16)	0.46 ± 0.27 (53)
	61–80	0.41 ± 0.28 (70)	0.46 ± 0.31 (59)	0.43 ± 0.30 (129)
	80+	0.25 ± 0.12 (14)	0.36 ± 0.21 (30)	0.32 ± 0.19 (44)
Vitamin E (umol/L)	<40	13.4 ± 8.7 (36)	11.1 ± 8.1 (26)	12.4 ± 8.5 (62)
	40–60	11.6 ± 8.4 (36)	15.1 ± 9.1 (16)	12.7 ± 8.7 (52)
	61–80	11.1 ± 7.9 (65)	12.7 ± 8.8 (57)	11.9 ± 8.3 (122)
	80+	12.2 ± 7.1 (13)	10.2 ± 6.1 (27)	10.9 ± 6.5 (40)
Plasma copper (umol/L)	<40	14.70 ± 3.79 (37)	17.77 ± 5.09 (26)	15.97 ± 4.59 (63)‡
	40–60	16.83 ± 5.18 (38)	16.64 ± 4.81 (16)	16.77 ± 5.02 (54)
	61–80	19.08 ± 4.58 (71)	19.19 ± 4.79 (61)	19.13 ± 4.66 (132)
	80+	19.36 ± 4.10 (15)	19.35 ± 3.90 (30)	19.35 ± 3.92 (45)
Zinc (umol/L)	<40	12.27 ± 1.81 (37)	12.40 ± 2.25 (26)	12.32 ± 1.99 (63)
	40–60	12.22 ± 2.56 (38)	12.94 ± 1.28 (16)	12.43 ± 2.27 (54)
	61–80	11.98 ± 2.45 (71)	11.55 ± 1.99 (61)	11.78 ± 2.25 (132)
	80+	10.89 ± 2.29 (15)	11.24 ± 2.38 (30)	11.12 ± 2.33 (45)
Magnesium (mmol/L)	<40	0.85 ± 0.15 (37)	0.81 ± 0.13 (26)	0.84 ± 0.15 (63)
	40–60	0.82 ± 0.15 (38)	0.81 ± 0.28 (16)	0.81 ± 0.19 (54)
	61–80	0.82 ± 0.14 (70)	0.80 ± 0.17 (61)	0.81 ± 0.15 (131)
	80+	0.78 ± 0.15 (15)	0.78 ± 0.11 (30)	0.78 ± 0.13 (45)

Note: Data are given as mean ± SD (*n*).
Significantly different between age groups by Kruskal Wallis one-way analysis of variance: $P < 0.05$,* $P < 0.01$†, $P < 0.001$‡.
Significant difference between sexes by one-way analysis of variance: * $P < 0.05$.

Table 3 Nutritional status by disease categories

Nutritional variable	Infection	COAD	Heart failure	Neoplasm	Others
CAMA (cm^2): men	28.7 ± 7.4 (14)	22.8 ± 8.2 (22)‡	23.7 ± 8.6 (19)†	27.5 ± 5.7 (9)	30.3 ± 9.2 (81)
CAMA (cm^2): women	26.8 ± 9.4 (15)	21.8 ± 11.4 (8)	25.8 ± 8.8 (20)	13.3 ± 6.4 (3)†	27.2 ± 8.3 (78)
Total lymphocyte count ($\times 10^9$)	0.98 ± 0.43 (29)	0.92 ± 0.64 (30)*	1.07 ± 0.63 (39)	0.93 ± 0.73 (12)	1.37 ± 1.05 (159)
Total protein (g/L)	70.5 ± 9.4 (27)	73.7 ± 7.9 (28)	68.7 ± 6.2 (38)	66.8 ± 19.8 (12)	74.1 ± 9.0 (155)
Albumin (g/L)	33.5 ± 6.0 (28)*	36.9 ± 3.3 (27)	34.7 ± 4.7 (37)	31.0 ± 5.8 (12)†	36.3 ± 6.7 (154)
Prealbumin (mg/L)	92.1 ± 61.2 (28)‡	121.5 ± 79.9 (30)‡	128.1 ± 73.0 (39)‡	91.3 ± 45.6 (12)‡	203.4 ± 111.3 (157)
Transferrin (g/L)	1.61 ± 0.49 (28)‡	2.03 ± 0.48 (30)	2.22 ± 0.59 (39)	1.43 ± 0.37 (12)‡	2.04 ± 0.60 (157)
Retinol binding protein (mg/L)	21.1 ± 9.0 (28)‡	32.67 ± 14.47 (30)*	33.28 ± 13.73 (39)*	21.3 ± 8.2 (12)†	41.8 ± 21.8 (157)
Thiamine RBC.TK % activation	13 ± 8 (27)	11 ± 7 (30)	10 ± 9 (37)	7 ± 5 (12)	10 ± 9 (154)
Riboflavin RBC. GTR % activation	28 ± 22 (29)	29 ± 30 (30)	29 ± 30 (38)	18 ± 14 (12)	31 ± 25 (158)
Pyridoxine RBC. AST % activation	85 ± 44 (29)	119 ± 80 (30)‡	75 ± 44 (38)	93 ± 84 (12)	78 ± 33 (158)
Cyanocobalamin (pmol/L)	635.9 ± 314.6 (27)†	462.7 ± 187.9 (30)	498.1 ± 263.5 (37)	790.7 ± 396.6 (10)‡	477.3 ± 277.9 (150)
Serum folate (umol/L)	20.0 ± 9.0 (27)	15.4 ± 9.1 (30)*	20.0 ± 9.0 (39)	13.3 ± 6.2 (11)*	19.9 ± 10.4 (155)
Plasma retinol (mg/L)	0.25 ± 0.11 (22)‡	0.40 ± 0.17 (25)†	0.41 ± 0.27 (34)†	0.25 ± 0.11 (8)‡	0.54 ± 0.23 (145)
Vitamin E (umol/L)	33.0 ± 38.0 (23)	12.7 ± 4.5 (23)	12.5 ± 6.6 (32)	7.6 ± 7.2 (9)†	22.8 ± 73.3 (147)
Plasma copper (umol/L)	21.89 ± 5.39 (29)‡	19.58 ± 3.61 (30)‡	19.64 ± 5.22 (39)‡	20.28 ± 6.11 (12)†	16.50 ± 4.17 (159)
Plasma zinc umol/L)	10.94 ± 1.87 (29)*	11.64 ± 2.10 (30)	11.52 ± 2.47 (39)	12.33 ± 3.69 (12)	11.97 ± 2.06 (159)
Plasma magnesium (mmol/L)	0.77 ± 0.13 (29)	0.79 ± 0.14 (30)	0.81 ± 0.16 (38)	0.74 ± 0.10 (12)	0.83 ± 0.17 (159)

Note. Data are given as mean ± SD (*n*). CAMA = corrected arm muscle area.
Significantly different compared with "others," by analysis of variance: *$P < 0.05$, †$P < 0.01$, ‡$P < 0.001$.

age. Very little sex differences were observed. Unexpectedly there was no sex difference in arm anthropometry, the only difference being a lower plasma total protein concentration in men compared to women in the under-40-years age group.

Table 3 shows the mean values of nutritional indices by disease categories. Patients with infections had lower plasma albumin, prealbumin, retinol binding protein, transferrin, retinol, and zinc. Plasma copper and cyanocobalamin concentrations were significantly higher. Patients with COAD also had poor nutritional status, with lower CAMA in men, lower plasma albumin, retinol binding protein, retinol, and zinc concentration. Pyridoxine status was poorer, and these patients also had lower serum folate and total lymphocyte count. As in those with infections, plasma copper concentrations were elevated. Similar changes were also observed in patients with heart failure and malignancy. Patients with malignancy also had markedly low plasma vitamin E concentration.

Since there were more older patients with COAD and heart failure, multiple regression analysis was performed to assess the independent influence of age and disease on these nutritional variables. Patients with COAD were found to have poorer pyridoxine status, lower plasma albumin, retinol binding protein and retinol, and higher plasma copper concentrations independent of age. The lower plasma zinc and serum folate concentrations, and lower total lymphocyte count previously observed were due to aging rather than the effect of the disease. With the exception of pyridoxine status, patients with heart failure had similar changes which were independent of age.

Nutritional indices for those aged 60–80 years were compared with subjects of a similar age group living in the community. The age and sex of this group are shown in *Table 4 A* and *B*. Hospitalized patients had poorer protein nutritional status, as well as lower serum folate, plasma retinol, and vitamin E concentrations among both men and women. However, hospitalized subjects had better thiamine and pyridoxine status. Plasma copper concentration was higher among patients. Similar differences were observed in the comparison of hospitalized subjects with those living in chronic care institutions, with the exception that CAMA was even lower in subjects in chronic care.

Table 4 Comparison of nutritional indices with subjects aged over 60 years living in the community or in long-term care institutions

(A) Male	Hospital (acute ward)	Long-term care institutions[14,15]	Free-living[16-21]
Corrected arm muscle area (cm^2)	25.4 ± 8.3 (71)[a]‡ [b]†	20.4 ± 9.0 (58)	28.9 ± 7.7 (64)
Total protein (G/L)	73.6 ± 8.0 (69)[a]‡	72.3 ± 6.7 (53)	77.8 ± 5.2 (65)
Albumin (G/L)	35.5 ± 5.6 (68)[a]‡	34.3 ± 6.2 (52)	43.0 ± 3.3 (62)
Prealbumin (mg/L)	159.5 ± 105.7 (70)[a]‡ [b]†	213.8 ± 92.5 (47)	371.3 ± 152.6 (61)
Retinol binding protein (mg/L)	37.3 ± 16.8 (70)[a]‡ [b]†	49.3 ± 21.8 (47)	71.3 ± 18.7 (63)
Transferrin (G/L)	1.98 ± 0.53 (70)[a]‡	1.93 ± 0.49 (47)	2.51 ± 0.71 (62)
Thiamine RBC.TK % activation	12 ± 8 (71)[a]†	10 ± 7 (15)	17 ± 9 (79)
Riboflavin RBC.GTR % activation	33 ± 32 (71)[a]‡	36 ± 33 (37)	50 ± 26 (87)
Pyridoxine RBC.AST % activation	90 ± 58 (71)	106 ± 61 (37)	91 ± 34 (87)
Cyanocobalamin (pM/L)	518 ± 262 (68)[a]†	430 ± 256 (53)	412 ± 183 (161)
Serum folate (uM/L)	16.7 ± 8.6 (70)[a]‡	13.8 ± 6.6 (53)	19.6 ± 10.2 (161)
Plasma retinol (mg/L)	0.41 ± 0.28 (70)[a]†	0.40 ± 0.21 (47)	0.50 ± 0.13 (155)
Vitamin E (uM/L)	11.1 ± 7.9 (65)[a]‡ [b]†	21.6 ± 7.1 (46)	26.0 ± 8.7 (155)
Copper (uM/L)	19.08 ± 4.58 (71)[a]‡ [b]‡	16.17 ± 3.46 (52)	16.51 ± 3.17 (160)
Zinc (uM/L)	11.98 ± 2.45 (71)[b]‡	13.94 ± 2.38 (52)	12.27 ± 1.81 (160)
Total lymphocyte count ($\times 10^9$/L)	1.1 ± 0.6 (66)[a]‡ [b]†	1.5 ± 0.7 (47)	2.0 ± 0.7 (152)

(B) Female	Hospital (acute ward)	Long-term care institutions[14,15]	Free-living[16-21]
Corrected arm muscle area (cm^2)	26.1 ± 10.0 (60)[b]†	22.3 ± 6.8 (149)	26.2 ± 6.9 (95)
Total protein (G/L)	70.7 ± 9.1 (60)[a]‡ [b]‡	75.4 ± 7.3 (135)	77.1 ± 7.4 (97)
Albumin (G/L)	34.7 ± 6.3 (60)[a]‡ [b]‡	38.0 ± 6.0 (134)	42.0 ± 3.2 (96)
Prealbumin (mg/L)	163.8 ± 103.0 (60)[a]‡ [b]†	295.4 ± 126.9 (129)	375.0 ± 167.0 (97)
Retinol binding protein (mg/L)	38.5 ± 21.3 (60)[a]‡ [b]†	62.7 ± 22.5 (128)	73.9 ± 19.1 (61)
Transferrin (G/L)	2.02 ± 0.66 (60)[a]†	2.03 ± 0.49 (129)	2.38 ± 0.73 (92)
Thiamine RBC.TK % activation	10 ± 8 (61)[a]†	12 ± 10 (73)	14 ± 89 (113)
Riboflavin RBC.GTR % activation	28 ± 26 (61)[a]‡ [b]†	41 ± 31 (115)	52 ± 30 (125)
Pyridoxine RBC.AST % activation	86 ± 46 (57)	80 ± 26 (116)	86 ± 31 (125)
Cyanocobalamin (pM/L)	537 ± 298 (57)[b]‡	349 ± 232 (134)	465 ± 186 (241)
Serum folate (uM/L)	21.9 ± 11.2 (58)[a]‡ [b]*	17.7 ± 9.3 (134)	29.5 ± 13.8 (241)
Plasma retinol (mg/L)	0.46 ± 0.31 (59)[a]† [b]†	0.52 ± 0.23 (117)	0.53 ± 0.19 (230)
Vitamin E (uM/L)	12.7 ± 8.8 (57)[a]‡ [b]‡	28.4 ± 9.6 (115)	29.5 ± 10.6 (230)
Copper (uM/L)	19.19 ± 4.79 (61)[a]‡ [b]*	17.60 ± 3.92 (131)	12.27 ± 1.81 (160)
Zinc (uM/L)	11.55 ± 1.99 (61)[a]† [b]‡	14.29 ± 2.94 (117)	12.41 ± 2.02 (240)
Total lymphocyte count ($\times 10^9$/L)	1.3 ± 0.9 (57)[a]‡ [b]†	1.7 ± 0.5 (118)	2.10 ± 0.67 (228)

Note. Data are given as mean ± SD (*n*).
Significantly different from free-living group (a), and long-term care institution group (b), by Student's *t*-test: $P < 0.05$*, $P < 0.01$†, $P < 0.001$‡.

Discussion

The nutritional status of patients in acute general medical wards is quite often neglected. Although the hospital dietitian will arrange to provide meals containing adequate nutrients and calories, intake of meals is not usually supervised and there are many factors resulting in reduced intake, particularly in the elderly.[22] Missed meals due to diagnostic procedures might not be replaced. Patients in a hypercatabolic state will require more nutrients than the normal recommended daily allowance. Clinically, unless it is severe, malnutrition is frequently unrecognized or ignored. This is aggravated by the short stay of some patients in a busy hospital with shortage of beds.

Poor nutrition among surgical patients results in higher operative morbidity and mortality.[3] Among medical patients with conditions such as chronic pulmonary lung diseases, poor nutrition adversely affects lung function by decreasing respiratory muscle function and ventilatory drive and by altering lung defense mechanisms.[23] Malnourished hospitalized patients are also at high risk for long-term health problems.[24] With the aging of the population, the proportion of patients in acute medical wards is likely to rise. Since the prevalence of nutritional deficiency is higher among the elderly,[25] it is likely that a significant proportion of patients will have nutritional problems.

Studies among Caucasians in developed countries have revealed a high prevalence of protein calorie malnutrition among hospitalized patients of up to 50%.[4,5] Few studies provided detailed information regarding vitamin and mineral status. It is also recognized that findings may vary in other populations with different diseases.[4] There has been no hospital nutritional study of Chinese patients. In this study, the nutritional assessment was limited to selected variables that would still give a reasonable indication of nutritional status. Thus, detailed dietary intake assessment was not performed. Height and weight could not be obtained easily in a large proportion of patients, particularly the elderly, and were omitted from analysis. Arm anthropometry was used instead. Owing to the large number of tests to be done on the 20 ml blood specimen, certain tests were omitted such as red cell folate or tissue zinc concentration, which would have given a more accurate reflection of nutrient status than plasma concentrations.

Measurements of protein energy status (CAMA, albumin, retinol binding protein, transferrin, and total lymphocyte count) declined with age in both sexes in this hospital population. The higher prevalence of certain types of chronic illnesses among the older age groups may account for this observation. However, these changes were still present when disease category has been taken into account. Moreover, this trend has been observed among healthy community living subjects.[26] Poorer thiamine status among older patients was again unrelated to disease category. The rise in plasma copper concentration with age was accounted for by the increasing prevalence of COAD and heart failure among older subjects. It is known that plasma copper and/or ceruloplasmin act as acute phase reactants and rises in "sick" elderly.[27]

Indices of protein energy status and plasma retinol were also poorer in the four disease categories studied, compared to patients without these diagnoses, these differences persisting even when age has been taken into account. The causes of poor nutritional states in COAD and heart failure are probably multifactorial. They may include increased energy expenditure as a result of increased respiratory effort; repeated episodes of infections resulting in depletion of nutrients; or anorexia related to dyspnea or to chronic drug therapy such as theophyllines. Patients with malignancy have the lowest serum folate concentrations, probably reflecting increased utilization by tumor cells. These patients also have strikingly low plasma vitamin E concentrations. It is possible that serum cholesterol concentrations were also lower in these patients, as vitamin E concentrations are related to serum lipoprotein levels.[28] However, there was no significant difference between mean cholesterol concentrations in patients with malignancy (4.2 ± 1.5 mM) compared with that in patients not belonging to any of the four disease categories (4.7 ± 1.5 mM). It is uncertain whether the low serum vitamin E concentration in these patients is a result of the disease, or whether it partly contributed to disease development.[29] Patients with infections and malignancies had higher serum cyanocobalamin concentrations compared to those without these diseases. As liver is a major store of cyanocobalamin, these findings may reflect a certain degree of liver cell damage. Another possibility is the increased production of cyanocobalamin by bacterial overgrowth in the small intestine. The rise in plasma copper concentrations in patients in all four disease categories is consistent with the role of ceruloplasmin as an acute phase reactant.[27] No difference in plasma magnesium concentrations was observed.

Nutritional data for nonhospitalized subjects were only available for those aged 60 years and over. Nevertheless, this group constituted 60% of the hospital population. It can be seen that the hospital population had poorer status in most of the nutritional indices measured, compared to the community group, with the exception of thiamine and riboflavin status. Some indices of protein energy status in hospitalized patients were even worse than that in subjects living in long-term care institutions, and among the latter, indices of protein energy status have been shown to predict short-term mortality.[30]

It is clear that in our Chinese population, malnutrition exists among medical patients in hosptial, with regard to both protein calorie and vitamins. Our findings highlight the fact that the age-related decline in nutritional status is accentuated among hospitalized subjects. The study also reveals that poor nutritional status accompanies many common chronic diseases such as chronic heart and lung diseases, and is not only found in those with malignancies and infection. Increased awareness of the nutritional status of patients in hospital, particularly the elderly and those with the above diseases, would result in better nutritional support and possibly would accelerate recovery or reduce mortality.

References

1 Bistrian, B.R., Blackburn, G.L., Hallowel, E., and Heddle, R. (1974). Protein status of general surgical patients. *JAMA* **230,** 858

2 Hill, G.L., Pickford, I., Young, G.A., Schorah, C.J., Blackett, R.L. Burkinshaw, L., Warren, J.V., and Morgan, D.B. (1977). Malnutrition in surgical patients. An unrecognised problem. *Lancet 1,* 689

3 Mullen, J.L., Buzby, G.P., Waldman, M.T., Gertner, M.H., Hobbs, C.L., and Rosato, E.F. (1979). Prediction of operative

morbidity and mortality by preoperative nutritional assessment. *Surg. Forum* **30,** 80
4 Bistrian, B.R., Blackburn, G.L., Vitale, J., Cochran, D., and Naylor, J. (1976). Prevalence of malnutrition in general medical patients. *JAMA* **235,** 1567
5 Wood, B., Lo, L., Cleary, J. Bontoft, J., Kelleher, D., Burns, E., and Thien, C. (1985). Nutritional status in hospital inpatients: implication for nutritional support services. *Aust. N.Z. J. Med.* **15,** 435
6 Friedman, P.J., Campbell, A.J., and Caradoc-Davies, T.H. (1985). Prospective trial of a new diagnostic criterion for severe wasting malnutrition in the elderly. *Age Aging* **14,** 149
7 Heymsfield, S.B., McManus, C., Smith, J., Stephens, V., and Nixon, D.W. (1982). Anthropometric measurement of muscle mass: revised equations for calculating bone-free arm muscle area. *Am. J. Clin. Nutr.* **36,** 80
8 Cheung, C.K., Swaminathan, R., and Cockram, C. (1987). Contributions of tubular proteins to the proteinuria of diabetes mellitus. *Clin. Chem.* **33,** 1033
9 Hamlin, C.R. and Pankowsky, D.A. (1987). Turbidimetric determination of transthyretin (prealbumin) with a centrifugal analyzer. *Clin. Chem.* **33,** 144
10 Mak, Y.T. and Swaminathan, R. (1988). Assessment of vitamin B_1, B_2 and B_6 status by coenzyme activation of red cell enzymes using a centrifugal analyzer. *J. Clin. Chem. Clin. Biochem.* **26,** 213
11 Hansen, L.G. and Warwick, W.J. (1969). A fluorometric micromethod for serum vitamins A & E. *Tech. Bull. Reg. Med. Technol.* **39,** 70
12 Steveninck, J. and van de Geoij, A.F. (1973). Determination of vitamin A in blood plasma of patients with carotenaemia. *Clin. Chim. Acta* **49,** 61
13 Pesce, A.J. and Kaplan, L.A. (1987). *Methods in clinical chemistry.* (Cat. No. KFEDI, Los Angeles, CA) C.V. Mosby, St. Louis
14 Woo, J., Ho, S.C., Mak, Y.T., MacDonald, D., and Swaminathan, R. (1989). Vitamin nutritional status in elderly Chinese subjects living in chronic care institutions. *Nutr. Res.* **9,** 1071
15 Woo, J., Ho, S.C., Cheung, C.K., Mak, Y.T., and Swaminathan, R. (1989). Protein calorie malnutrition in elderly chronic care institutions in Hong Kong. *Nutr. Rep. Int.* **40,** 1011
16 Woo, J., Ho, S.C., Donnan, S.P.B., and Swaminathan, R. (1988). Nutritional indices in healthy active Chinese elderly. *Brit. J. Nutr.* **60,** 21
17 Woo, J., Ho, S.C., Mak, Y.T., Tsao, S., Lam, L.M., Donnan, S., and Swaminathan, R. (1988). Nutritional status of the water soluble vitamins in an active Chinese elderly population in Hong Kong. *Eur. J. Clin. Nutr.* **42,** 415
18 Woo, J., Ho, S.C., Mak, Y.T., Shek, C.C., and Swaminathan, R. (1988). Vitamin A and E status in healthy elderly Chinese in Hong Kong. *Eur. J. Clin. Nutr.* **42,** 689
19 Woo, J., Cheung, C.K., Ho, S.C., Mak, Y.T., and Swaminathan, R. (1988). Protein nutritional status in elderly Chinese in Hong Kong. *Eur. J. Clin. Nutr.* **42,** 903
20 Woo, J., Ho, S., Mak, Y.T., Donnan, S.P.B., and Swaminathan, R. (1990). Intake and blood levels of some minerals in an elderly Chinese population. *Clin. Nutr.* **9,** 9
21 Woo, J., Arumanayagam, M., Ho, S.C., and Swaminathan, R. (1989). Haematological indices and the prevalence of anaemia in an elderly Chinese population. *Pathology* **21,** 31
22 Kors, M.B., Czajka-Narins, D.M., and Nordstrom, J.W. (1989). Factors affecting nutritional status of the elderly. In *Nutrition, aging, and the elderly.* (H. Munro, D.E. Danford, eds.), p. 305, Plenum Press, New York & London
23 Pingleton, S.K. and Harmon, G.S. (1987). Nutritional management in acute respiratory failure. *JAMA* (SEA) **3,** 38
24 Linn, B.S. (1984). Outcomes of older and younger malnourished and well-nourished patients one year after hospitalization. *Am. J. Clin. Nutr.* **39,** 66
25 Exton-Smith, A.N. (1980). Nutritional status: Diagnosis and prevention of malnutrition. In *Metabolic and nutritional disorders of the elderly,* (A.N. Exton-Smith, F.I. Caird, eds.), p. 66, John Wright & Sons Ltd., Bristol
26 Munro, H. Protein nutriture and requirements of the elderly. (1989). In: *Nutrition, aging, and the elderly,* (H. Munro, D.E. Danford, eds.), p. 154, Plenum Press, New York & London
27 Murphy, P., Wadiwala, I., and Sharland, D.E., Rai, G.S. (1985). Copper and zinc levels in "healthy" and "sick" elderly. *J. Am. Geriatr. Soc.* **33,** 847
28 Davies, T., Kelleher, J., and Losowskey, M.S. (1969). Interrelation of serum lipoprotein and tocopherol levels. *Clin. Chim. Acta* **24,** 431
29 Menkes, M.S., Comstock, G.W., Vuilleumier, J.P., Helsing, K.J., Rider, A.A., and Brookmeyer, R. (1986). Serum betacarotene, vitamin A and E, selenium, and the risk of lung cancer. *N. Engl. J. Med.,* **315,** 1250
30 Woo, J., Chan, S.M., Mak, Y.T., and Swaminathan, R. (1989). Biochemical predictors of short-term mortality in elderly residents of chronic care institutions. *J. Clin. Pathol.* **42,** 1241