Nutritional assessment and adequacy of dietary intake in hospitalized patients with alcoholic liver cirrhosis

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(*Received 2 September 1991–Accepted 4 June 1992*)

Nutritional assessment and adequacy of spontaneous dietary intake was evaluated in thirty-seven clinically stable hospitalized patients with alcoholic liver cirrhosis. About two-thirds of the patients had ascites or oedema, or both, and, therefore, body weight could not be used for assessment of nutritional status. Lean body mass (LBM; measured by three consecutive 24 h creatinine excretions) was 62 (range 40–95)% of reference values, mid-arm-muscle area (MAMA) was 70 (range 43–115)% and triceps skinfold (TSF) was 45 (range 20–113)% of reference values (all median values). In patients without ascites or oedema, or both, there was a rectilinear correlation between body weight and LBM and between body weight and MAMA (r 0·93 and 0·85 respectively). In patients with ascites or oedema, or both, the correlation between body weight and LBM was poor as could be expected. We suggest that LBM is a useful measure of nutritional status when body weight is unreliable because of ascites or oedema, or both. Energy balance for the group was calculated from energy intake recorded by a 24 h dietary recall and energy expenditure calculated by the factorial method. Median intake was 102 (range 34–176)% of expenditure. N loss was calculated from the average of three 24 h urea excretions. Protein intake was calculated from the 24 h dietary recall. The N balance was positive in the patients as a group (median intake was 120 (range 26–183)% of output). The most malnourished patients tended to have the most positive N balance which was due to a significantly lower N excretion. The protein requirement for N balance was 0·83 (SE 0·05) g/kg per d and only at an intake above 1·20 g/kg per d were all patients in positive N balance. The median intakes of thiamin, folacin, vitamin D, vitamin E, Mg, and Zn were judged to be insufficient. It is concluded that impaired nutritional status is common among patients with liver cirrhosis, even in a stable clinical condition. It is suggested that nutritional status in these patients is evaluated by dietary recalls, in combination with measurement of body weight in patients without ascites or oedema, or both, or in combination with determination of LBM by three 24 h creatinine excretions in patients with ascites or oedema, or both. Criteria for selection of patients that might benefit from nutritional therapy are discussed.

Nutritional status: Dietary intake: Alcoholic liver cirrhosis: Hospital patients

Malnutrition is common among patients with liver cirrhosis. In a consecutive study about 25% of patients with cirrhosis were found to be malnourished (Merli *et al.* 1987).

The nutritional status as evaluated clinically (malnourished or not malnourished) was associated with the outcome after abdominal surgery and with survival after liver transplantation in studies by Garrison *et al.* (1984) and Shaw *et al.* (1985). Further, a relationship between poor nutritional status and mortality due to infection in patients with liver disease has been shown by O'Keefe *et al.* (1980). A beneficial effect of nutritional therapy in malnourished patients with liver cirrhosis has been suggested in a number of studies (Diehl *et al.* 1985; Naveau *et al.* 1986; Simon & Galambos, 1987; Bunout *et al.* 1989; Cabre *et al.* 1990; Mezey *et al.* 1991). These studies and other aspects of nutritional

* For reprints.

therapy in patients with liver cirrhosis have recently been reviewed (Kondrup *et al.* 1992). The studies did not employ well-defined inclusion criteria regarding nutritional status or dietary intake, i.e. the presence of malnourishment was ill-defined. This makes some of the studies difficult to interpret.

The reason for this weakness of studies in patients with liver cirrhosis is the obvious limitations of the commonly available measures of nutritional status. Body weight is influenced by ascites and oedema which may also influence triceps skinfold (TSF) and mid-arm circumference (MAC) measurements. Creatinine/height index (CHI) may reflect decreased hepatic synthesis of creatine (Heymsfield *et al.* 1983) in addition to reduced lean body mass (LBM). Plasma proteins also reflect liver function, oedema and degree of acute illness in addition to nutritional status (Merli *et al.* 1987).

The use of more advanced methods such as whole-body K counting or bioelectrical impedance or total body water has been shown to be erroneous in patients with ascites and derangement of electrolytes (Delwaide, 1972; McCullough *et al.* 1991).

In the present study we have compared commonly used methods for assessment of nutritional status with clinical evaluation, since the latter was found to be related to increased surgical complications (Garrison *et al.* 1984; Shaw *et al.* 1985). The validity of the common methods was evaluated by correlating the methods with body weight in patients without ascites or oedema, in order to select methods that can be applied to patients with ascites and oedema. In addition, the adequacy of spontaneous dietary intake was evaluated in relation to the individual patient's expenditure of energy and protein and an estimated need of other essential nutrients. This together with the evaluation of the nutritional status gives suggestions for objective criteria of malnourishment in these patients. It was decided to carry out the investigation when the patients had reached a stable clinical condition after admission, since if malnourished patients spontaneously achieve a satisfactory positive balance in energy and N shortly after the admission there is little reason for a therapeutic approach to nutrition.

METHODS

All patients included had biopsy-proven alcoholic cirrhosis. Patients with hepatic encephalopathy, persistent alcoholic hepatitis, positive results for hepatitis B surface antigen, overt diarrhoea, renal disease (serum creatinine $> 0{\cdot}2$ mmol/l), diabetes mellitus, fever or malignant diseases were not included. Routine laboratory tests were analysed by standard methods. Galactose elimination capacity and antipyrine clearance were determined as described previously (Tygstrup, 1966; Døssing *et al.* 1982).

Nutritional assessment. Nutritional status was evaluated clinically by a physician, a clinical dietitian and a nurse. Nutritional status was judged to be normal, slightly malnourished, moderately malnourished or severely malnourished. When the three investigators disagreed the patient was classified according to the evaluation by the two investigators who agreed.

Body weight and height were measured. Height was expressed as a percentage of the expected height-for-age and sex (Appleyard, 1987). Actual weight was expressed as a percentage of reference weight from weight-for-height tables for the age-group 20–40 years (Lindberg *et al.* 1956). Lean body mass (LBM) was calculated from three 24 h urinary creatinine excretions (Forbes & Bruining, 1976);

$$\text{LBM} = \text{24 h creatinine (mmol)} \times 3{\cdot}29 + 7{\cdot}38. \quad (1)$$

The result was expressed as a percentage of the expected value;

$$\text{expected LBM} = 0{\cdot}74 \times \text{expected body weight (males)}, \quad (2)$$

$$\text{expected LBM} = 0{\cdot}68 \times \text{expected body weight (females)}, \quad (3)$$

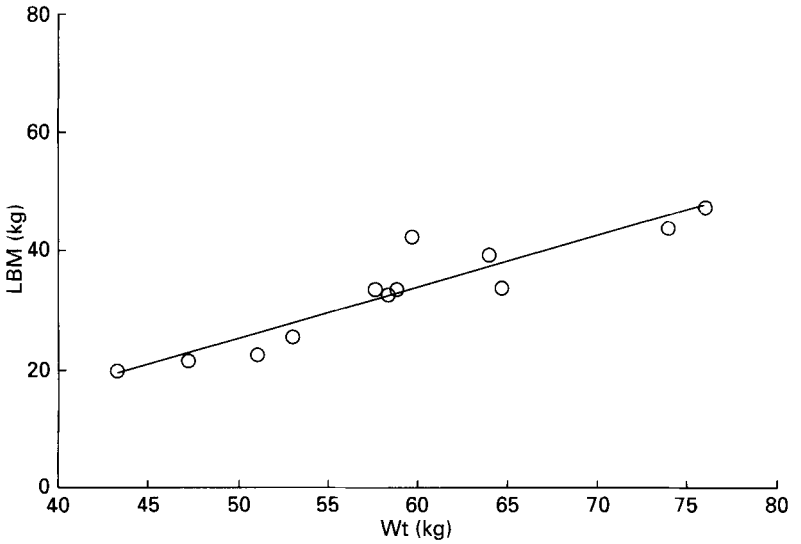

Fig. 1. Correlation between lean body mass (LBM) and body weight (Wt) in patients without ascites or oedema. LBM = −18·36 + 0·87 × Wt, r 0·93.

Table 1. *Clinical and biochemical variables in thirty-seven patients with alcoholic liver cirrhosis*

(Reference values are shown in parentheses)

	Median	Range
Age (years)	46	31–82
Males/females	26/11	
Oedema or ascites, or both (no. of cases)	25	
Alcohol consumption: g/d	100	60–400
years	10	2–30
Period from admission to interview (d)	11	2–38
Prothrombin index (0·70–1·30)	0·67	0·32–1·55
Bilirubin (μmol/l) (4–17)	23·0	3–128
Alkaline phosphatase (*EC* 3.1.3.1) (μkat/l) (0·2–0·7)	5·6	2·2–10·5
Alanine aminotransferase (*EC* 2.6.1.2) (μkat/l) (0·17–0·67)	0·42	0·17–1·90
IgG (μmol/l) (36–89)	109	28–235
IgA (μmol/l) (3·8–21·0)	44·0	9·8–156·0
IgM (μmol/l) (0·3–3·7)	2·3	0·5–11·0
Albumin (μmol/l) (550–830)	425	195–651
Transferrin (μmol/l) (31–57)	28	7–44
Hb (mmol/l) (7·0–11·0)	7·1	5·0–8·7

These equations were derived from studies of body composition (Shizgal, 1983). In order to evaluate energy and N balance in relation to nutritional status the patients were divided arbitrarily into three equally large groups by ranking of LBM as percentage of the expected value.

MAC and TSF were measured (Edwards *et al.* 1955) by a specially trained nurse by means of a Harpenden skin calliper (British Indicators, Luton, Bedfordshire). Mid-arm-muscle area (MAMA) was calculated and expressed as a percentage of the expected value for age and sex (Frisancho, 1981).

Table 2. *Nutritional assessment in patients with alcoholic liver cirrhosis*

(Median and range; no. of patients in parentheses)

Patient group...	All (37)		NM (8)		SM (13)		MM (16)				
	Median	Range	Median	Range	Median	Range	Median	Range	SM *v.* NM	MM *v.* NM	MM *v.* SM
Height: m	1·72	1·56–1·86	1·72	1·56–1·75	1·73	1·67–1·86	1·71	1·57–1·81			
% Ref	100	92–107	100	96–107	101	95–107	99	92–106	NS	NS	NS
Wt: kg	59·7	43·0–81·7	65·4	49·4–81·7	60·7	47·2–70·0	52·5	43·0–65·5			
% Ref	87	64–116	101	88–116	85	74–97	80	64–98	*	**	NS
LBM: kg	31·4	19·6–50	38·0	28·0–50·0	32·5	21·2–45·5	26·5	19·6–45·1			
% Ref	63	39–96	77	67–96	63	42–92	53	39–69	*	**	NS
MAMA: cm^2	37·4	18·2–60·2	44·9	37·4–60·2	42·0	31·7–50·9	28·1	18·2–45·6			
% Ref	70	42–115	96	72–115	68	51–101	58	42–79	*	**	NS
TSF: mm	6·5	3·5–24·0	11·3	8·9–24·0	6·0	4·2–16·0	6·4	3·5–11·8			
% Ref	45	20–113	91	35–113	48	21–92	40	20–69	NS	*	NS

NM, not malnourished; SM, slightly malnourished; MM, moderately malnourished; LBM, lean body mass; MAMA, mid-arm-muscle-area; TSF, triceps skinfold; % Ref, percentage of reference value; NS, not significant.

*$P < 0·05$, **$P < 0·0025$.

Dietary recall and nutritional requirements. The hospital diet was unrestricted except that Na and fluid were restricted in patients with ascites. Intake of energy, N and essential nutrients were calculated from one or three consecutive 24 h dietary recalls, in eighteen and nineteen patients respectively, by a dietitian by means of food tables (Møller, 1983). The patients recorded the food intake with help from the nurse.

The basal metabolic rate (BMR) was calculated according to Harris & Benedict (1919). No correction for ascites was made (see p. 676). Total energy expenditure (TEE) was calculated by a modification of the factorial method (Acheson *et al.* 1980*a*,*b*) in the 24 h period when the dietary recall took place; BMR was multiplied by an activity factor which was calculated from the patients' self-recording of physical activity every 15 min. The period (h/d) spent at each specific activity was divided by 24 h and multiplied by the specific activity factor. Finally, all the partial activity factors were added to give the total 24 h activity factor. Sleeping, lying awake in bed, sitting, walking (3 km/h) and training (taken to equal bicycle riding at 15 km/h) were given activity factors of 0·9, 1·2, 1·3, 2·5 and 7·0 respectively (Durnin & Passmore, 1967). An 'injury factor' (Mendenhall *et al.* 1984) was not included (see p. 676).

Protein needs were calculated from the average of three 24 h urea excretions × 1·25, to which was added 2 g N for faecal and skin losses using an equation derived from Souba & Wilmore (1988);

$$\text{protein (g)} = (\text{24 h urea (mmol)} \times 0{\cdot}028 \times 1{\cdot}25 + 2) \times 6{\cdot}25. \quad (4)$$

In seven patients N in urine was measured by a microKjeldahl technique (Keltec Systems, Tecator AB, Hoganaes, Sweden). The urinary N excretion was calculated as described previously and compared with the measured total urinary N excretion. The observed difference was 0·0 (SE 0·2) g N/d.

In order to calculate the protein requirement for N balance a linear regression analysis of protein intake/kg BW *v.* N balance was performed. This was done for all patients and separately for the patients who had one or three dietary interviews performed. The mean protein intake and the confidence limits of the mean at zero balance were then calculated from the regression analysis.

The requirements for vitamins and minerals were based on recommended dietary allowance (RDA) values (National Research Council, 1989). It was assumed that the individual requirements for essential nutrients were dependent on weight (see p. 677) and the requirement was calculated as a corrected RDA;

$$\text{corrected RDA} = \text{RDA} \times \text{actual weight/expected weight}. \quad (5)$$

In addition, the adequacy of the intake related to the corrected RDA was compared with the adequacy of dietary intake in the healthy Danish population (Haraldsdottir *et al.* 1987*a*,*b*). Blood samples were taken on the day of the dietary interview.

Statistics. Unless otherwise indicated, the values are expressed as medians and range. Comparisons between groups were made using the Kruskal–Wallis test for unpaired data and the Wilcoxon test for paired data. In Figs. 3 and 5–7 concerning energy and protein needs the values are shown as means with 2 SEM in order to make quantitative comparison possible and Scheffé's test was used for ANOVA between the groups. Linear regression analysis was performed by the least squares method. Multiple regression analysis was performed with both forward selection and backward elimination.

RESULTS

Table 1 shows the clinical and biochemical variables for all patients. The nutritional evaluation was performed when the clinical condition was judged to be stable, which was 11 (2–38) d after admission. Of the patients, 68 % has ascites or oedema, or both. None of

Table 3. *Correlation coefficients between body weight and other measures of nutritional status in patients with or without ascites or oedema, or both*

	Without (n 12)	With (n 25)	Statistical significance: P	
			without	with
LBM	0·93	0·39	< 0·00001	< 0·06
MAMA	0·85	0·79	< 0·0006	< 0·00001
TSF	0·53	0·09	NS	NS
Albumin	0·46	0·25	NS	NS
Transferrin	−0·13	0·26	NS	NS

LBM, lean body mass; MAMA, mid-arm muscle area; TSF, triceps skinfold; NS, not significant.

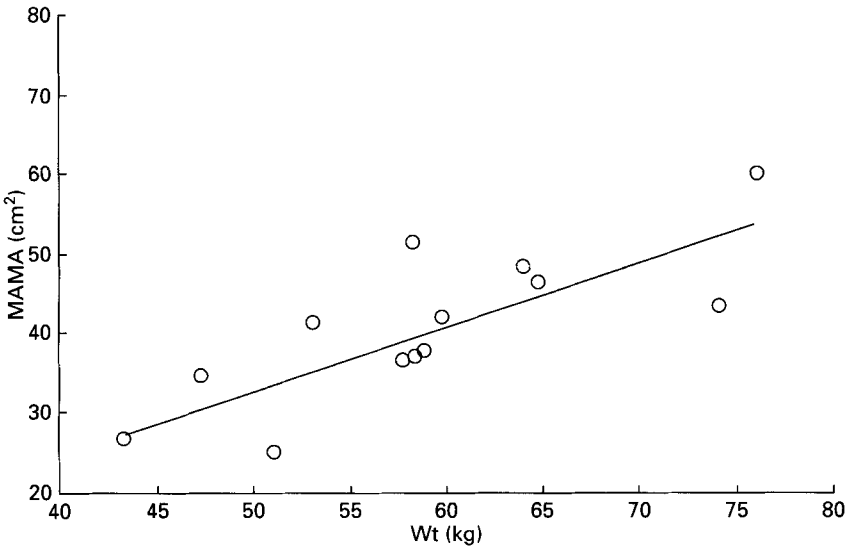

Fig. 2. Correlation between mid-arm-muscle area (MAMA) and body weight (Wt) in patients without ascites or oedema. MAMA = −8·33 + 0·82 × Wt, r 0·85.

the variables in Table 1 differed significantly among the subgroups divided according to the clinical judgment of nutritional status.

Table 2 shows the results of nutritional assessment in all patients and in the three clinically identified subgroups. Body weight expressed as a percentage of reference value showed a significant difference between the non-malnourished and the two malnourished groups. The median value of LBM and MAMA showed covariance with the clinical evaluation, although no significant difference was shown between the two malnourished groups. TSF only agreed to some extent with the clinical evaluation. We evaluated the reference values used in nine normal persons from our department. Weight, LBM, MAMA and TSF were in the range 93–97% of reference value.

The correlation coefficients between body weight and other measures of nutritional status are shown in Table 3. In patients without ascites there was a high degree of correlation between body weight and LBM (Fig. 1) and between body weight and MAMA (Fig. 2), whereas the correlation was poor with respect to TSF, albumin and transferrin. In

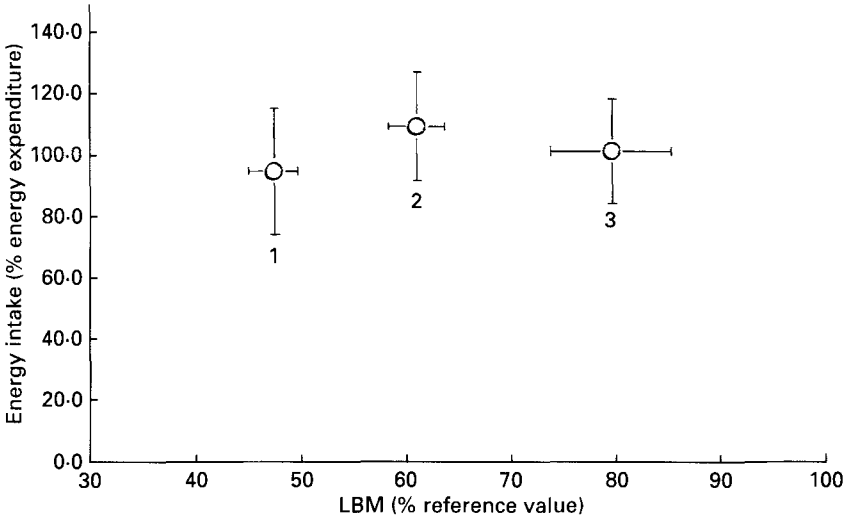

Fig. 3. Energy balance (energy intake as a percentage of total energy expenditure) in relation to nutritional status (lean body mass as a percentage of reference value (see p. 667)) in patients with alcoholic liver cirrhosis divided arbitrarily into three groups of equal size; group 1 *n* 12, group 2 *n* 12, group 3 *n* 13. Points are means with 2 SE represented by bars.

patients with ascites or oedema, or both, the correlation coefficients were poor except for MAMA. In patients without fluid retention there was an acceptable correlation between LBM and MAMA (*r* 0·82). However, in patients with ascites or oedema, or both, the correlation between LBM and MAMA was poor (*r* 0·58).

Renal function was evaluated by measurement of serum creatinine concentration. In the three groups based on LBM the values were (mmol/l) 0·11 (SE 0·01), 0·09 (SE 0·01), and 0·09 (SE 0·01) in groups 1, 2, and 3 respectively (no significant difference was shown between the groups; reference value 0·05–0·11 mmol/l).

The possible correlation between liver function and nutritional status was examined by means of galactose elimination capacity (GEC) and antipyrine clearance. GEC was determined in twenty-four patients (with or without fluid retention) and correlated with LBM ($r+0·53$). A multiple regression analysis with LBM as dependent variable and GEC, alcohol intake and years of drinking (or daily alcohol intake multiplied by years of drinking) as independent variables showed that only GEC fitted significantly. Antipyrine clearance was determined in twelve patients and correlated with LBM ($r+0·45$).

Table 4 shows the calculated BMR, activity factor and TEE for all patients. Energy intake balanced TEE. Physical activity was only about one-third of the activity in the healthy population (activity factor 1·6) which can be calculated from the findings of Haraldsdottir *et al.* (1987*b*). In the nine healthy subjects the activity factor was 1·6 and the energy intake as a percentage of TEE was 113.

Fig. 3 shows that energy intake balanced TEE irrespective of nutritional status.

Median protein intake was 120% of output (Table 5). Mean protein intake was 115 (SE 6)% (*v.* 100%, $P < 0·05$). The median protein intake was about 0·9 g/kg body weight which is 75% of the intake in the healthy population (1·2 g/kg) (Haraldsdottir *et al.* 1987*b*).

The protein requirement for balance was 0·78 (SE 0·15) g/kg per d, (*r* 0·67) when calculated from the patients who had three 24 h dietary recalls performed. The requirement for balance was also calculated separately for the patients who had only one 24 h dietary

Table 4. *Energy expenditure and intake in thirty-seven patients with alcoholic liver cirrhosis*

	Median	Range
BMR (MJ)	6·0	4·4–6·9
Activity factor	1·22	1·04–2·02
TEE (MJ)	7·1	5·0–12·6
Energy intake: MJ	7·2	2·1–12·0
% of TEE	102	34–176

BMR, basal metabolic rate; TEE, total energy expenditure.

Table 5. *Dietary intake and adequacy of intake in thirty-seven patients with alcoholic liver cirrhosis*

	Median	Range
Protein: g	54	14–101
% of loss	120	26–183
Vitamin A: μg retinol equivalent	730	188–8958
% requirement	86	25–771
Vitamin D: μg	1·5	0·2–5·9
% requirement	37**	5–135
Vitamin E: mg α-tocopherol equivalent	5·6	1·3–13·0
% requirement	59**	14–148
Vitamin C: mg	118	18–514
% requirement	252	40–1084
Thiamin: mg	0·9	0·4–2·5
% requirement	71*	34–173
Riboflavin: mg	1·6	0·6–4·5
% requirement	127	53–318
Niacin: mg NE	21·5	5·7–40·6
% requirement	141	55–261
Pyridoxine: mg	1·1	0·3–2·5
% requirement	73**	27–130
Folacin: μg	132	36–275
% requirement	83*	18–148
Vitamin B_{12}: μg	3·5	0·4–28·3
% requirement	193	26–1218
Ca: mg	1040	359–2413
% requirement	145	56–382
P: mg	853	204–1903
% requirement	130	34–295
Mg: mg	213	90–569
% requirement	84*	30–218
Fe: mg	9·2	2·1–19·3
% requirement	101	21–220
Zn: mg	8·8	2·5–17·5
% requirement	72**	27–137

Median values were significantly less than 100%: $*P < 0{\cdot}0001$, $**P < 0{\cdot}025$.
† Percentage of corrected requirement (for details, see p. 669).

recall (0·84 (SE 0·07) g/kg per d; *r* 0·79) and for all patients (0·83 (SE 0·05) g/kg per d; *r* 0·75) (Fig. 4).

Fig. 5 shows that N balance tended to be most positive in the most malnourished patients. Protein intake per patient was almost the same in the subgroups (Fig. 6), while

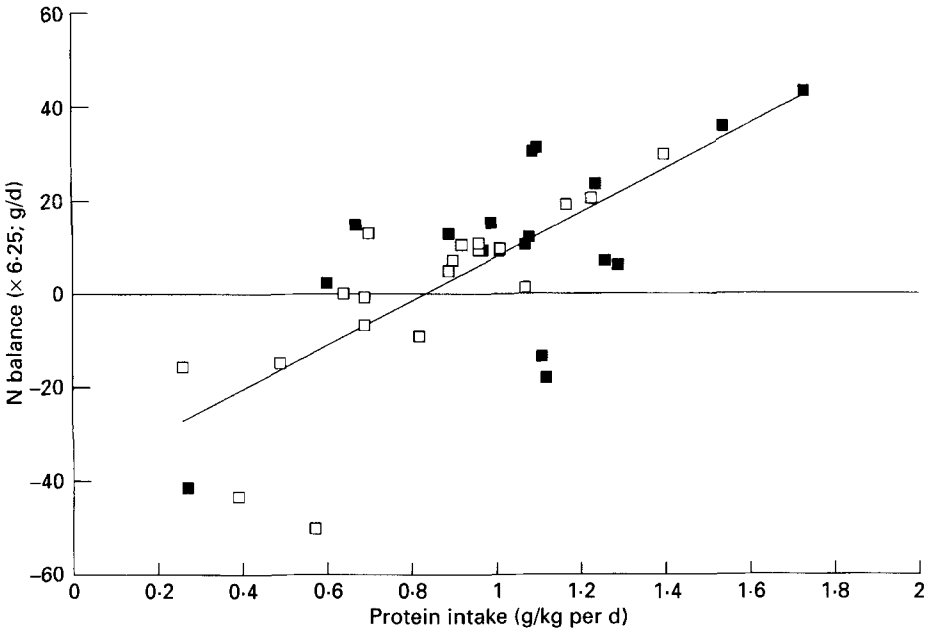

Fig. 4. Correlation between N balance (× 6·25) and protein intake in all patients with alcoholic liver cirrhosis. (□, ■), patients with one and three 24 h dietary recalls respectively. N balance × 6·25 (g/d) = −39·24 + 47·14 × protein intake (g/kg per d); r 0·75.

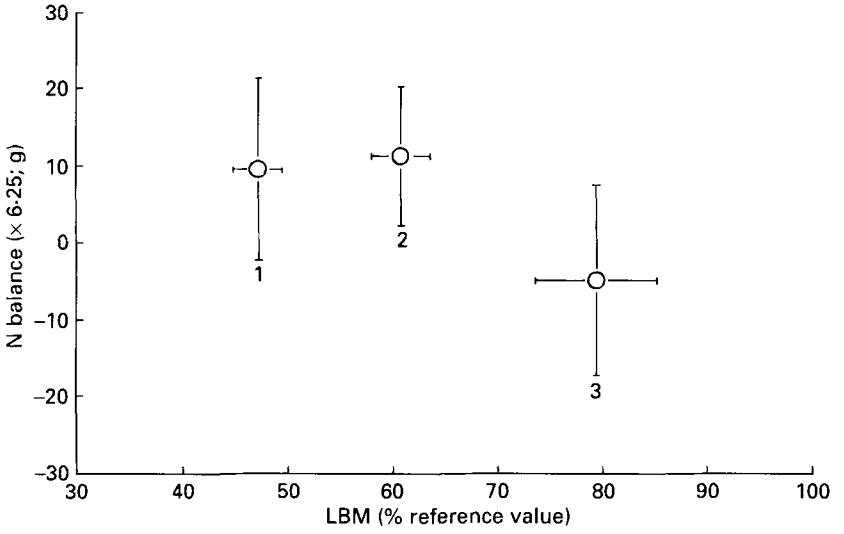

Fig. 5. N balance (× 6·25; g) in relation to nutritional status (lean body mass as percentage of reference value (see p. 667)) in patients with alcoholic liver cirrhosis divided arbitrarily into the three groups of equal size; group 1 n 12, group 2 n 12, group 3 n 13. Points are means with 2 SE represented by bars.

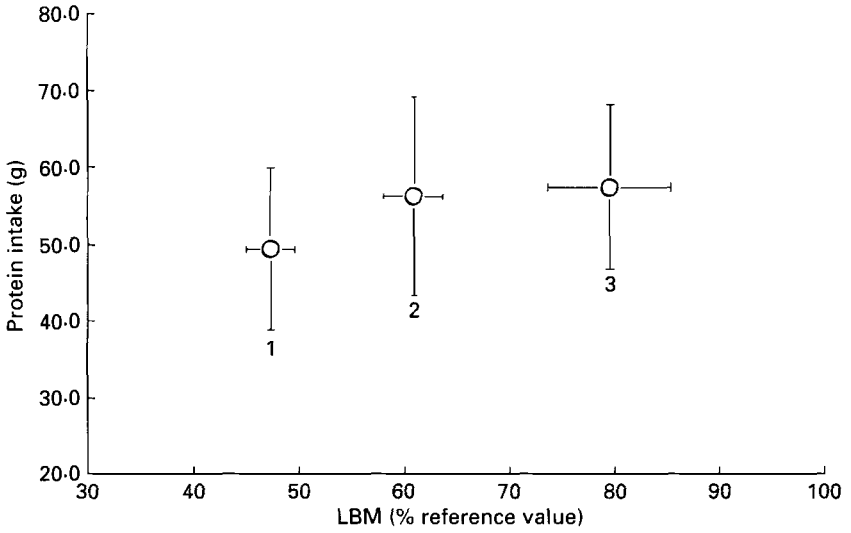

Fig. 6. Protein intake (g) in relation to nutritional status (lean body mass as percentage of reference value (see p. 667)) in patients with alcoholic liver cirrhosis divided arbitrarily into three groups of equal size; group 1 *n* 12, group 2 *n* 12, group 3 *n* 13. Points are means with 2 SE represented by bars.

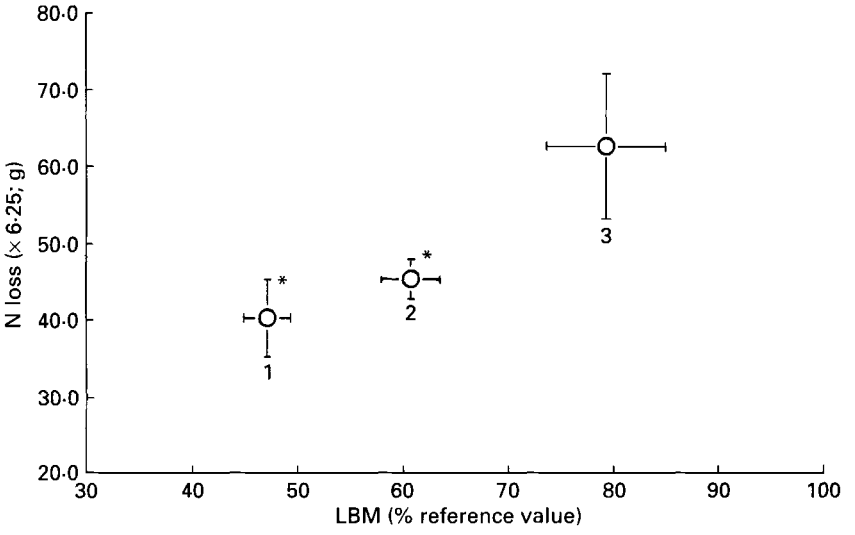

Fig. 7. Nitrogen loss (× 6·25; g) in relation to nutritional status (lean body mass as percentage of reference value (see p. 667)) in patients with alcoholic liver cirrhosis divided arbitrarily into three groups of equal size; group 1 *n* 12, group 2 *n* 12, group 3 *n* 13. Groups 1 or 2 *v.* group 3: $*P < 0{\cdot}025$. Points are means with 2 SE represented by bars.

protein loss was significantly greater in group 3 *v.* groups 2 and 1 (Fig. 7). Protein intake or protein loss may be related to LBM. Protein intake was 2·16 g/kg LBM per d in group 1 compared with 1·59 g/kg LBM per d in group 3 ($P = 0{\cdot}09$) and N loss (× 6·25) was 1·66 g/kg LBM per d in group 1 compared with 1·61 g/kg LBM per d in group 3.

Table 5 shows the intakes, and adequacy of intakes, of essential nutrients for all patients. The adequacy of the intake of nutrients was related to corrected RDA values (see p. 669).

The median intakes of vitamin D, vitamin E, thiamin, pyridoxine, folacin, Mg and Zn were all significantly below 100%. In the healthy population (Haraldsdottir *et al.* 1987*b*) the median intakes of vitamin D and pyridoxine were also below RDA (76 and 78% respectively). Compared with the healthy population the intakes of vitamin D, vitamin E, thiamine, folate, Mg and Zn were insufficient.

DISCUSSION

All patients included in the present study were ambulatory. None had signs of encephalopathy but two-thirds of the patients had ascites or oedema, or both. These features in combination with the laboratory results in Table 1 indicate that the patients had a mild to moderate degree of disease. A median time of 11 d elapsed before the clinical condition was stable and the nutritional assessment was performed.

Nutritional assessment. In a study of 284 consecutive patients with alcoholic hepatitis and cirrhosis (Mendenhall *et al.* 1984) the CHI was 71% of standard value compared with an LBM of 62% of the reference value in the present study (both measures based on 24 h creatinine excretion). The TSF was 65% of standard value in the previous study compared with 45% of standard value in the present study. The patients included in our study had at least a similarly affected nutritional status.

The reference weight (and thereby the reference LBM) was calculated using information from a study from 1956 (Lindberg *et al.* 1956). More recent measurements of weight and height from the Danish population (Appleyard, 1987; Heitmann, 1991) are presented as BMI and are published without being stratified for height within age-groups. For the age-group 20–40 years the calculated median weight in the recent studies expressed as a percentage of the weight from 1956 for the median height of our patients was 95 and 101% for women and men respectively. The values for the age-group 20–40 years were used as a reference since the age-related increase in weight is a result of increased fat mass which we do not consider an improvement in nutritional status.

Body weight, LBM, and MAMA showed an acceptable agreement with the clinical judgement and can be used as quantitative measures instead of the clinical evaluation. Body weight is the most simple measure of nutritional status but it is unreliable in patients with ascites or oedema or both. In these patients LBM may be chosen to substitute for body weight since there was a high correlation between body weight and LBM in patients without fluid retention. MAMA is not equally reliable since oedema fluid may also accumulate in the upper extremities leading to falsely high values for MAMA. This may explain why MAMA in patients with fluid retention correlated with body weight to a higher degree than LBM (Table 3), and that MAMA did not correlate with LBM in these patients. For these reasons we suggest that LBM is the best substitute for body weight in patients with ascites or oedema, or both.

Our median LBM as a percentage of the expected LBM (63%) is similar to the percentage of ideal CHI (59%) which can be calculated from the value of Bistrian (1977; subjects of unknown age on a creatinine-free diet). Walser (1987) described the age-related decrease in creatinine excretion in healthy volunteers on a normal diet. According to his findings for height, age and sex the median creatinine excretion in our study is 58% of his reference values. LBM determined by 24 h creatinine excretion may be falsely low in cirrhotic patients since creatine is synthesized in the liver (Heymsfield *et al.* 1983). A predicted creatinine excretion in our patients without ascites or oedema, or both (n 12) was calculated from MAMA by the equation given for healthy volunteers by Heymsfield *et al.* (1982). The measured value was 84 (SE 6)% ($v.$ 100%, $P = 0{\cdot}04$) of the predicted value suggesting that LBM may be underestimated by about 16%. However, when comparing 24 h creatinine/kg body weight in our patients without ascites or oedema to the findings

from undernourished patients without organ disease (Barac-Nieto *et al.* 1978; Russell *et al.* 1983) our patients had the same, or a slightly larger, excretion (0·13 mmol/kg). This suggests that creatinine excretion is not to any major extent decreased in patients with liver cirrhosis relative to body weight. Further, serum creatinine concentration was normal and similar in all three groups based on LBM. We, therefore, consider three 24 h creatinine excretion measurements a reliable indicator of the cell mass in LBM in these patients when renal disease is absent.

The use of LBM instead of CHI is based on the conceptually easier understanding of a body mass when evaluating body weight and when relating, for example, protein and energy balance to a metabolic mass.

Plasma proteins are commonly used to evaluate nutritional status. In the present study there was a poor correlation between body weight and albumin or transferrin in patients without fluid retention and a poor correlation between LBM and the plasma proteins in patients with fluid retention (values not shown). This is in agreement with others (Merli *et al.* 1987) and indicates that albumin and transferrin are of limited value for nutritional assessment in these patients. Albumin and transferrin may be low because of decreased liver function but there was a poor correlation between GEC and the concentrations of albumin or transferrin (0·20 and 0·29 respectively) suggesting that neither nutritional status not liver function were major determinants for plasma albumin or transferrin. Instead, fluid retention and degree of acute-phase response may be responsible for the observed concentrations of albumin and transferrin.

Malnutrition in these patients may be caused separately by impaired liver function and by alcoholism since both lead to decreased food intake, malabsorption and altered processing of nutrients (Sherlock, 1984; Mezey *et al.* 1988; Hajnal *et al.* 1990). The correlation between liver function (GEC or antipyrine clearance) and LBM was not impressive, suggesting that liver function alone was not responsible for the nutritional status. A multiple regression analysis with LBM as a dependent variable and GEC, alcohol intake and years of drinking as independent variables was not significant except for GEC. The results suggest that malnutrition is associated with impaired liver function but other unregistered factors (such as anorexia) are probably of greater importance.

Adequacy of dietary intake. TEE was calculated by the factorial method (Acheson *et al.* 1980*a*,*b*). In patients with liver cirrhosis, the measured resting O_2 uptake agrees closely with BMR calculated from the Harris-Benedict equation (Owen *et al.* 1983; Shanbhogue *et al.* 1987; Schneeweiss *et al.* 1990; Müller *et al.* 1991), also in patients with ascites (Dolz *et al.* 1991). In unpublished studies we have confirmed this observation. In addition we found that the exercise-induced increase in O_2 uptake in patients with cirrhosis was almost identical to that in healthy control subjects, indicating that the factorial calculation of energy expenditure is acceptable (Martinsen *et al.* 1990*a*). Further, in three patients we found only a small difference between TEE measured by the doubly-labelled water method or calculated by the factorial method (Martinsen *et al.* 1990*b*).

Since only a 24 h dietary recall was performed in the first eighteen patients the validity of these recalls was examined in two ways. In the subsequent nineteen patients the 24 h dietary recall was extended to three consecutive days. The energy intake of the 3 d period was 103 (SE 2)% of the first 24 h period and protein intake was 106 (SE 4)% of the first 24 h period. In addition, fifteen of the patients continued into a hyperalimentation study (K. Nielsen, J. Kondrup, L. Martinsen, H. Døssing & B. Stilling, unpublished results). After 3 d screening of habitual food intake the food was prepared in our metabolic ward containing the same amount of energy and protein. Leftovers were collected and weighed. The intake was kept constant for the next 4 d. During the latter 4 d period urea-N excretion was 109 (SE 5)% of the first 24 h urea-N excretion and protein intake was 100 (SE 3)% of

the first 24 h dietary recalls. The use of only one 24 h recall in eighteen of the patients does not invalidate the study.

The energy intake of the patients as a group balanced their expenditure but was only 61% of the intake by the healthy population (Haraldsdottir *et al.* 1987*b*). The low energy intake was associated with a reduced body size and a low physical activity. The median activity factor of the patients was 1·22 compared with 1·60 in the healthy population (Haraldsdottir *et al.* 1987*b*), and 1·60 in the nine healthy subjects. This means that the physical activity of the patients as a group was about 40% of the activity of healthy people. It is not possible from the present study to determine whether the reduced energy intake was responsible for the reduced body size and reduced physical activity, or vice versa.

The patients as a group were in a positive N balance (Table 5). The mean protein requirement for balance in all patients was 0·83 g/kg per d which is in agreement with the findings by Swart *et al.* (1989) who, in patients with cirrhosis, reported N balance at an intake of 0·75 g protein/kg per d. This is higher than the amount required to keep malnourished people without organ disease in balance (0·40 g/kg per d; Barac-Nieto *et al.* 1979) as well as healthy people (0·60 g/kg per d; National Research Council, 1989). All patients with an intake above 1·20 g/kg per d had a positive balance. This is similar to the recommendation by Swart *et al.* (1989), and close to the protein recommendation in hospitalized patients (1·6 g/kg per d) with medical diseases reached by elaborate measurements of N intake and excretion (Isaksson, 1973).

The two most malnourished groups of patients tended to have the most positive N balance (Fig. 5). This was due to a significantly lower N excretion at a protein intake which was only slightly lower than that of the least malnourished patients. N excretion on a per kg LBM basis was the same in all groups, while protein intake on a per kg LBM basis tended to be higher in the most malnourished patients. This observation indicates that N loss, rather than protein intake, is related to lean body mass.

The individual needs of vitamins and minerals were not measured. Instead it was assumed that the need was proportionate to body weight. Since many of our patients had ascites it might be speculated that the need is related to cell mass rather than to weight. In patients with liver cirrhosis and ascites the BMR/kg body weight is normal while the BMR/kg body cell mass is increased (Shanbhogue *et al.* 1987; Schneeweiss *et al.* 1990; Müller *et al.* 1991). We have assumed that the need for essential nutrients is related to BMR and, therefore, we have related needs to body weight. The median intakes of vitamin D, vitamin E, thiamin, pyridoxine, folacin, Mg and Zn were significantly lower than the corrected RDA values. When compared with the Danish population which also has a low intake of vitamin D and pyridoxine, pyridoxine intake was sufficient. This suggests that patients with liver cirrhosis in hospital, although being in energy and N balance, have an insufficient intake of many vitamins and minerals which might lead to increasing malnutrition if no nutritional support is given.

We suggest that the nutritional status of patients with cirrhosis is quantified by body weight or LBM measured by three 24 h creatinine excretions in conjunction with dietary recalls. The present findings do not by themselves suggest criteria for selection of patients for nutritional therapy. The study by Harvey *et al.* (1981) showed an increase in cutaneous anergy, infection and mortality in different kinds of malnourished hospitalized patients when LBM (CHI) was less than 60% of the reference value. Similar studies in cirrhotic patients are lacking but this value may be used tentatively to select patients that might benefit from nutritional therapy. Since a protein intake in the range 0·83–1·20 g protein/kg per d does not assure a positive N balance, an intake below this level should be corrected.

The least malnourished patients did not spontaneously achieve a positive N balance. The most malnourished patients had a positive balance which, however, equalled the synthesis

of only about 50 g LBM/d. This is not impressive considering that LBM was reduced by about 20 kg, an observation that stresses the importance of nutritional support in these patients.

The work was supported by the Danish Medical Research Council (grant no. 12–8112), the Hvass Foundation and the hospital's Committee on Data Technology.

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Printed in Great Britain