

*Original Article***Assessment of nutritional status in CAPD patients: serum albumin is not a useful measure**C. H. Jones<sup>1</sup>, C. G. Newstead<sup>1</sup>, E. J. Will<sup>1</sup>, S. W. Smye<sup>2</sup> and A. M. Davison<sup>1</sup>Departments of <sup>1</sup>Renal Medicine and <sup>2</sup>Medical Physics, St James's University Hospital, Leeds, UK**Abstract**

**Introduction.** In CAPD patients serum albumin is frequently used as an index of nutritional status, although it is recognized that hypoalbuminaemia may be caused by many factors. We have further examined the relationship between serum albumin and nutrition.

**Methods.** Nutritional status was assessed by biochemistry, anthropometry, mid-arm muscle circumference, muscle strength (hand grip and back), and lean body mass (from anthropometry, creatinine kinetics and bioimpedance) in a group of 76 stable CAPD patients. Correlations between biochemical and nutritional parameters were sought and data were compared between patient groups defined by serum albumin ( $\geq 37$  vs  $< 37$  g/l on two occasions 2 months apart) and separately according to subjective global assessment score (normal nutrition, A vs mild to moderate, B, and severe, C, malnutrition).

**Results.** In patients with a low SGA score, actual body weight, body mass index, mid-arm muscle circumference, lean body mass, subscapular skinfold thickness, hand grip strength (males and females) and iliac and triceps skinfold thicknesses and back strength (females only) were all significantly less than in patients with a normal SGA score. In contrast, none of these variables differed in either gender when patients were compared according to serum albumin. Serum albumin was correlated with serum creatinine ( $r=0.45$ ,  $P=0.01$ ), daily urine protein excretion ( $r=-0.42$ ,  $P=0.02$ ) and uncorrected weekly creatinine clearance ( $r=-0.39$ ) in females, but not with any index of body composition in either gender.

**Conclusion.** Whilst SGA identified a patient group with significantly abnormal body mass, muscle mass and muscle strength, serum albumin did not. Serum albumin is not a useful marker of malnutrition in stable patients on CAPD.

**Key words:** nutrition; subjective global assessment; bioimpedance; body composition

**Introduction**

Decreased serum albumin is related to an increased morbidity and mortality in patients receiving treatment for end-stage renal failure, regardless of treatment modality [1]. The prognostic significance of serum albumin in patients undergoing continuous ambulatory peritoneal dialysis (CAPD) has been emphasized [2–4]. Hypoalbuminaemia has been recognized as being multifactorial, with poor nutrition [5], increased dialysate protein loss [6], the presence of systemic illness [7] or inflammatory disorders [8], and hypervolaemia [9] all being implicated. Protein malnutrition is cited as a major cause of hypoalbuminaemia [10] and serum albumin is frequently used in clinical practice as an indicator of nutritional status [11]. However, there is controversy over the degree to which albumin and nutrition are interrelated in CAPD patients [12]. We have therefore explored the relationship between serum albumin and nutritional state further.

**Subjects and methods**

This cross-sectional study was carried out in the Renal Unit of St James's University Hospital, Leeds. Adult patients undergoing CAPD between 1/6/1995 and 31/7/1996 were evaluated. All patients had completed a minimum of 3 months of CAPD and had not had peritonitis during the 3 months prior to assessment. All patients performed three or four dialysate exchanges per day (according to residual renal function) with the largest tolerated fill volume and were receiving oral iron supplementation, with or without subcutaneous erythropoietin in order to achieve a haemoglobin  $\geq 10$  g/dl. Serum albumin (measured by bromocresol green) and nutritional state scored by subjective global assessment (SGA—based on a history of weight change, dietary intake and gastrointestinal symptoms, and a visual assessment of subcutaneous fat and muscle mass as described by Detsky *et al.* [13] and modified for dialysis patients [14]) were used to define patient groups. Further data collected included serum creatinine, ferritin, CRP, height, weight, skinfold thicknesses at four sites (biceps, triceps, subscapular and iliac), mid-arm circumference, 24-h collections of urine and dialysate, and hand grip and back strength by dynamometry (Takei Scientific Instruments). From August 1995, total body

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water was measured by whole-body electrical impedance at 25 frequencies (Xitron 4000B, Xitron Technologies) [15]. All measurements were made by a single observer (CHJ). From these data, and using standard formulae, the following were derived: residual renal function (mean of urea and creatinine clearances), dialysate creatinine clearance, Kt/V urea, body mass index (BMI), protein catabolic rate (PCR, by the methods of Randerson *et al.* [16]), lean body mass (LBM— from anthropometry [17,18], creatinine kinetics [19], and bioelectric impedance [20]), body water (Watson formula [21] and bioimpedance [22]), and mid-arm muscle circumference [23].

A correlation matrix of nutritional and biochemical parameters was constructed and correlations were sought with Pearson's test of significance. Patients were grouped according to the presence or absence of persistent hypoalbuminaemia (defined as a serum albumin of less than 37 g/l, the lower limit of the normal range for our laboratory, on two consecutive measurements, at least 2 months apart). The same patients were regrouped according to SGA score, as well-nourished (SGA = A) or malnourished (SGA = B or C). Baseline and derived data were compared between patients with normal or low serum albumin and again between well- and malnourished patients. Results for males and females were analysed separately. Normally distributed data were compared using non-paired *t* test, with  $P \leq 0.05$  taken as significant. Other data were compared by Chi squared testing as appropriate.

## Results

Seventy-six patients (45 male, 31 female) were evaluated during the study period. Height, weight, gender, age, and biochemical indices were available in all, 24-h dialysate and urine collections in 70, anthropometry in 71, and bioimpedance in 57 patients. Missing data resulted from patient failure to perform 24-h collections or refusal of anthropometric assessment. Bioimpedance was available for only 10 months of the study. Mean

age was 50.3 years (range 18–79) and mean time on dialysis 24.3 months (range 3–91). Cause of renal failure was insulin-dependent diabetes mellitus in 13, chronic pyelonephritis in 12, glomerulonephritis in 11, hypertension/renovascular disease in nine, adult polycystic kidney disease in eight, myeloma, hereditary, obstruction, and postpartum in two each, renal stone disease in one and unknown in 14 patients. Neither the incidence of hypoalbuminaemia (8/13 vs 33/63) nor the mean serum albumin (35.0 vs 36.4 g/l) differed significantly between diabetic and non-diabetic patients. Eight of 13 patients with diabetes had an SGA score of B or C compared to 28/63 non-diabetics ( $P=0.2$ , n.s. Chi squared). SGA scores were A in 40, B in 32 and C in four patients. Patients with an abnormal score (B and C) were analysed together in view of the small number of patients with a score of C.

### Male subjects (Table 1)

Males scored as malnourished by subjective global assessment tended to be older (53.9 vs 44.7 years,  $P=0.06$ ) and have a lower serum creatinine (875 vs 1037  $\mu\text{mol/l}$ ,  $P=0.06$ ) than those scored as well nourished. Actual body weight, BMI, MAMC, LBM (by all three methods), subscapular skinfold thickness and hand grip strength were all significantly lower in malnourished as compared to well-nourished patients. There was no difference in age (49.4 vs 48.6 years) or serum creatinine (906 vs 1019  $\mu\text{mol/l}$ ) between hypo- and normoalbuminaemic males. There were no significant differences in any parameters of body composition or muscle strength according to serum albumin. In the correlation matrix, there were no significant correlations between serum albumin and any other parameter tested.

**Table 1.** Summary of nutritional parameters in male CAPD patients according to serum albumin and SGA score

Males	Serum albumin				SGA			
	$\geq 37$		$< 37$		A		B + C	
	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)
Age	22	49 (16.8)	23	49 (16.3)	24	45 (14.1)	21	54 (17.7)
Albumin (g/l)	22	38.7 (2.1)	23	33.8 (1.9)*	24	36.9 (3.2)	21	35.5 (3.1)
Se Creatinine ( $\mu\text{mol/l}$ )	22	1019 (286)	23	906 (279)	24	1037 (269)	21	875 (285)
CRP (mg/l)	15	6.7 (10.4)	20	16.9 (35.0)	19	7.8 (12.5)	16	18.2 (38.2)
LBM anthropometry (kg)	22	54.1 (7.5)	22	55.2 (6.2)	23	57.2 (7.6)	20	51.7 (4.5)†
LBM bioimpedance (kg)	16	54.5 (6.6)	18	55.5 (8.2)	19	57.4 (8.8)	15	52.0 (3.5)†
LBM creatinine (kg)	21	44.0 (10.5)	21	45.7 (9.9)	22	49.1 (11.5)	20	40.1 (5.5)†
% Fat bioimpedance	16	20.5 (6.6)	18	18.8 (8.1)	19	18.7 (8.3)	15	20.7 (6.0)
% Fat anthropometry	22	21.1 (5.3)	22	20.0 (6.1)	23	21.6 (5.3)	20	19.3 (6.0)
Subscapular sf (mm)	22	14.3 (4.8)	22	12.1 (4.2)	23	14.6 (4.8)	21	11.6 (4.0)‡
BMI ( $\text{kg/m}^2$ )	22	23.9 (3.2)	23	23.4 (3.7)	24	25.3 (3.5)	21	21.8 (2.4)*
MAMC (cm)	22	26.6 (2.4)	22	26.5 (2.6)	23	27.6 (2.6)	21	25.4 (1.6)‡
Hand-grip strength (kgf)	22	30.1 (9.1)	22	30.0 (8.9)	21	33.6 (8.8)	20	27.1 (7.9)‡
Weight (kg)	22	68.7 (11.0)	23	69.3 (10.4)	24	73.0 (11.9)	21	64.5 (6.4)†

Significance tested by Student's *t* test, with  $P \leq 0.05$  taken as significant. BMI, body mass index; sf, skinfold; MAMC, midarm muscle circumference; LBM, lean body mass. \* $P < 0.001$ ; † $P \leq 0.01$ ; ‡ $P \leq 0.05$ .

**Table 2.** Summary of nutritional parameters in female CAPD patients according to serum albumin and SGA score

Females	Serum albumin				SGA			
	≥37		<37		A		B+C	
	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)
Age	13	47 (16)	18	56 (13)	16	49 (14)	15	56 (15.5)
Albumin (g/l)	13	39.5 (2.2)	18	33.6 (2.7)*	16	35.7 (3.5)	15	36.5 (4.3)
Se Creatinine (μmol/l)	13	941 (247)	18	775 (207)	16	874 (248)	15	814 (227)
CRP (mg/l)	10	13 (16.4)	16	13.8 (16.7)	11	13.0 (17.6)	15	13.8 (15.8)
LBM anthropometry (kg)	13	42.6 (5.5)	16	41.7 (6.4)	15	43.6 (5.9)	13	40.4 (5.7)
LBM bioimpedance (kg)	10	39.8 (4.4)	13	41.9 (9.6)	12	45.1 (7.6)	11	36.5 (5.1)†
LBM creatinine (kg)	10	34.9 (11.7)	18	33.6 (8.4)	15	38.5 (8.7)	13	28.9 (7.9)†
% Fat bioimpedance	10	35.7 (6.4)	13	32.7 (8.2)	12	32.2 (6.8)	11	36.1 (7.9)
% Fat anthropometry	13	31.4 (6.4)	16	31.9 (5.8)	15	34.3 (5.6)	13	28.6 (5.1)†
Subscapular sf (mm)	13	16.3 (5.9)	16	14.6 (7.2)	15	18.6 (6.7)	13	11.7 (4.2)†
Triceps sf (mm)	13	19.1 (8.7)	16	19.3 (7.1)	15	23.3 (8.0)	13	14.8 (4.5)†
BMI (kg/m <sup>2</sup> )	13	23.5 (3.2)	18	23.2 (4.1)	16	24.9 (3.6)	15	21.6 (3.0)†
MAMC (cm)	13	23.0 (2.4)	16	23.3 (2.6)	15	23.8 (2.0)	13	22.5 (2.7)
Hand-grip strength (kgf)	13	20.5 (5.8)	12	23.9 (8.4)	13	26.3 (6.9)	10	16.9 (3.7)*
Back strength (kgf)	12	43.5 (18.6)	12	53.0 (23.9)	13	57.5 (22.6)	10	33.6 (6.9)†
Weight (kg)	13	62.6 (10.1)	18	61.1 (11.5)	16	67.0 (10.5)	15	56.1 (8.2)†

Significance tested by Student's *t* test, with  $P \leq 0.05$  taken as significant. BMI, body mass index; sf, skinfold; MAMC, midarm muscle circumference; LBM, lean body mass. \* $P < 0.001$ ; † $P \leq 0.01$ ; ‡ $P \leq 0.05$ .

### Female subjects (Table 2)

In comparison to females scored as well nourished by SGA, malnourished females had significantly lower actual body weight, BMI, iliac, triceps and subscapular skinfolds, LBM (by bioimpedance and creatinine generation), hand grip strength, and back strength. LBM by anthropometry was non-significantly lower. Persistently hypoalbuminaemic females tended to be older (55.8 vs 46.9 years,  $P = \text{ns}$ ) and to have lower serum creatinine (775 vs 941 μmol/l,  $P = 0.06$ ) than the normoalbuminaemic group. There were no significant differences in weight, BMI, LBM and muscle strength. In the correlation matrix, serum albumin was significantly correlated with serum creatinine ( $r = 0.45$ ,  $P = 0.01$ ), daily urine protein excretion ( $r = -0.42$ ,  $P = 0.02$ ) and uncorrected weekly creatinine clearance ( $r = -0.39$ ). Serum creatinine and daily urine protein excretion retained their significance in a stepwise multivariate linear regression analysis. There was no significant correlation with any index of body composition.

### All groups (Tables 1 and 2)

Serum albumin was not significantly different in male or female patients scored as malnourished by SGA. Forty-eight per cent of hypoalbuminaemic males were scored as well nourished and 41% of normoalbuminaemic males as malnourished. Sixty-one per cent of hypoalbuminaemic females were scored as well nourished and 62% of normoalbuminaemic females scored as malnourished. Weekly creatinine clearance, uncorrected for body surface area (BSA), was significantly less in females scored as malnourished. Correction for body surface area resulted in an apparent increase in creatinine clearance, as BSA was less in malnourished individuals. Creatinine clearance and weekly Kt/V urea

tended to be greater in hypoalbuminaemic females (Table 3). There were no other differences in months on dialysis, dialysis dose (assessed by weekly Kt/V urea and weekly creatinine clearance (uncorrected and corrected per 1.73 m<sup>2</sup>)), residual renal function, daily protein intake estimated from PCR and nPCR, or daily dialysate and urine protein losses according to serum albumin or nutritional status (Table 3).

Serum ferritin and C-reactive protein did not differ significantly between groups. Serum ferritin and CRP were correlated in male patients ( $r = 0.7$ ,  $P < 0.001$ ), but neither correlated with serum albumin.

All three methods of determining lean body mass were significantly correlated with each other (Figure 1). LBM from creatinine kinetics gave consistently lesser values than the other two methods. Agreement between methods was poor by the method of Bland and Altman [24] (Figure 2) with limits of agreement being: anthropometry vs bioimpedance +11.1 to -12.2 males, +11.8 to -10.0 females; anthropometry vs creatinine generation +28.9 to -5.7 males, +24.8 to -10.1 females; bioimpedance vs creatinine generation +23.5 to -3.5 males, +19.2 to -4.0 females. Hand grip and back strength were significantly correlated with LBM by all methods, MAMC, weight, age and each other (Table 4). Correction of LBM for height (lean body mass index, LBM/height<sup>2</sup>) did not alter any of the reported relationships.

## Discussion

Serum albumin is strongly predictive of survival in groups of patients treated for end-stage renal failure [1], including those maintained on CAPD [4]. Whilst a number of mechanisms of hypoalbuminaemia have

**Table 3.** Summary of dialysis adequacy and daily protein loss in males and females according to serum albumin and SGA score

Males	Serum albumin (g/l)				SGA score			
	<37		≥37		A		B+C	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Months on CAPD	23	24.3 (25.3)	22	23.5 (16.9)	24	26.1 (22.2)	21	21.3 (20.7)
CrCl (l/week)	21	72.6 (31.1)	21	60.0 (32.4)	22	66.4 (30.3)	20	67.2 (34.4)
CrCl/1.73 m <sup>2</sup>	21	68.1 (27.9)	21	59.1 (30.5)	22	61.9 (27.0)	20	65.5 (32.1)
Kt/V urea (week)	21	2.0 (0.44)	21	1.8 (0.51)	22	1.8 (0.41)	20	2.0 (0.52)
PCR (g/day)	21	69.6 (19.2)	21	67.4 (16.3)	22	71.9 (18.9)	20	64.8 (15.7)
nPCR (g/kg/day)	21	0.99 (0.26)	21	0.99 (0.19)	22	0.98 (0.22)	20	1.0 (0.24)
RRF (l/week)	21	3.2 (3.4)	21	2.1 (3.5)	22	2.4 (3.4)	20	2.9 (3.6)
Dialysate protein loss (g/24 h)	21	7.2 (4.5)	21	6.3 (2.7)	22	7.3 (4.3)	20	6.3 (3.4)
Urine protein excretion (g/24 h)	21	0.79 (0.87)	21	0.46 (0.73)	22	0.66 (0.85)	20	0.58 (0.79)

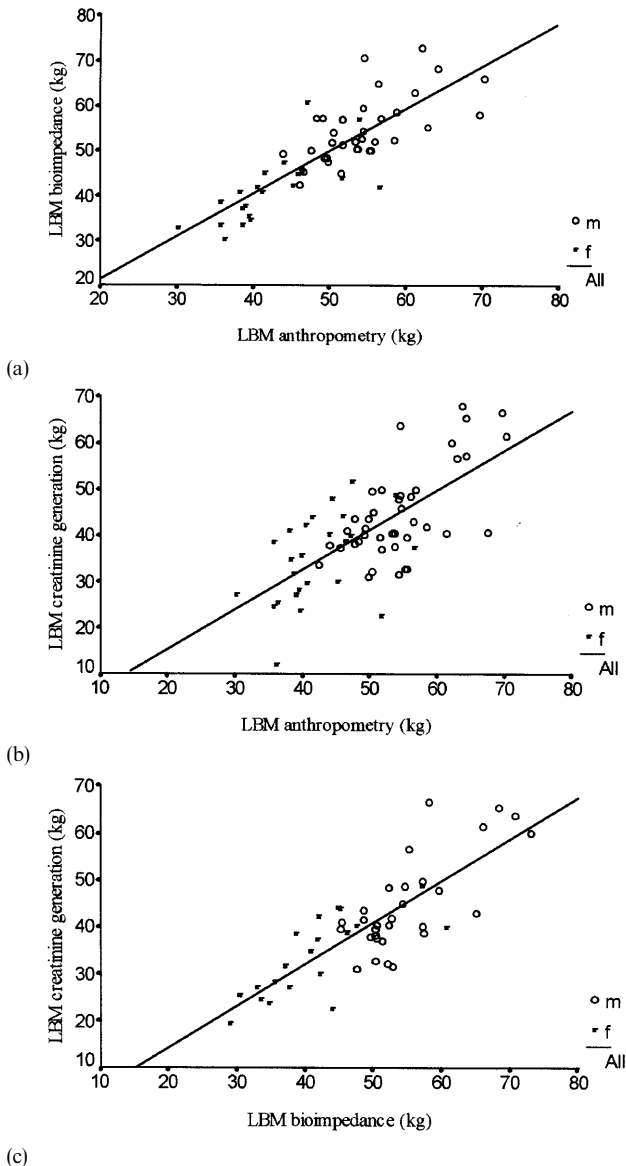
Females	Serum albumin (g/l)				SGA score			
	<37		≥37		A		B+C	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Months on CAPD	18	24.6 (23.1)	13	25.5 (25.1)	16	22.6 (20.9)	15	27.5 (26.5)
CrCl (l/week)	18	55.3 (18.3)*	10	43.6 (12.4)	15	57.5 (17.9)	13	43.7 (13.4)‡
CrCl/1.73 m <sup>2</sup>	18	58.5 (20.0)	10	45.0 (12.1)	15	58.5 (20.2)	13	48.0 (15.4)
Kt/V urea (week)	18	1.9 (0.4)*	10	1.7 (0.2)	15	1.8 (0.3)	13	1.8 (0.4)
PCR (g/day)	18	60.2 (16.1)	10	55.3 (12.4)	15	62.0 (13.9)	13	54.4 (15.4)
nPCR (g/kg/day)	18	1.00 (0.28)	10	0.88 (0.15)	15	0.94 (0.20)	13	0.98 (0.29)
RRF (l/week)	18	1.8 (2.0)	10	1.31 (1.9)	15	2.1 (2.0)	13	1.0 (1.8)
Dialysate protein loss (g/24 h)	18	6.1 (2.5)	10	5.1 (2.2)	15	6.3 (2.7)	13	5.15 (2.0)
Urine protein excretion (g/24 h)	18	0.68 (0.99)	10	0.14 (0.19)	15	0.76 (1.0)	13	0.17 (0.32)

PCR, protein catabolic rate (nPCR, normalized to actual body weight); RRF, residual renal function. \* $P=0.06$ , ‡ $P\leq 0.05$ .

been suggested, it has been widely accepted that serum albumin reflects nutritional status in dialysis patients, with a low serum albumin indicating protein malnutrition [10]. The technique of subjective global assessment was initially described in patients admitted for gastroenterological surgery [13], but has been modified and validated for CAPD patients [14]. Serum albumin has been correlated with SGA score in females in an international study of greater than 200 subjects [25] and in males and females in a study including 23 CAPD subjects [14]. In the latter study there was no difference in body weight and MAMC between well- and poorly nourished patients. In 184 haemodialysis patients, Cano *et al.* [26] found that serum albumin did not correlate with body weight, MAMC, triceps skinfold, or serum creatinine, although serum prealbumin did. In our study, patients scored as being malnourished by SGA had a lower actual body weight, body mass index, lean body mass, mid-arm muscle circumference (in males), and muscle strength (hand grip in males and females, back in females only) than those scored as normally nourished. There were no differences in any of these parameters between patients

with normal and low serum albumin. Forty-nine per cent of normoalbuminaemic individuals were scored as malnourished and 54% of hypoalbuminaemic individuals scored as well nourished.

Serum albumin has been reported to correlate with dietary protein intake estimated from food diary [27] or from normalized protein catabolic rate [28]. In the latter study, involving a patient group of similar size to the present study, serum albumin was correlated with weekly Kt/V urea and LBM as a percentage of total body weight. However, males and females were analysed together, which may not be appropriate in view of gender-related body composition differences. LBM as a percentage of body weight reflects obesity rather than severity of malnutrition. We have found no difference in nPCR according to nutritional state and that total PCR tended to be less in malnourished patients, reflecting their reduced body weight and confirming the findings of Harty *et al.* that nPCR was not a valid marker of nutrition in patients with reduced actual body weight [29]. There was no correlation between serum albumin and PCR, whether or not normalized to actual body weight. Dialysis dose (meas-



**Fig. 1.** Correlation between lean body mass (LBM) by (a) anthropometry and bioimpedance (males  $r=0.64$ , females  $r=0.70$ ;  $P<0.001$ ), (b) anthropometry and creatinine generation (males  $r=0.68$ ;  $P<0.001$ , females  $r=0.45$ ;  $P=0.02$ ) and (c) bioimpedance and creatinine generation (males  $r=0.74$ , females  $r=0.78$ ;  $P<0.001$ ).

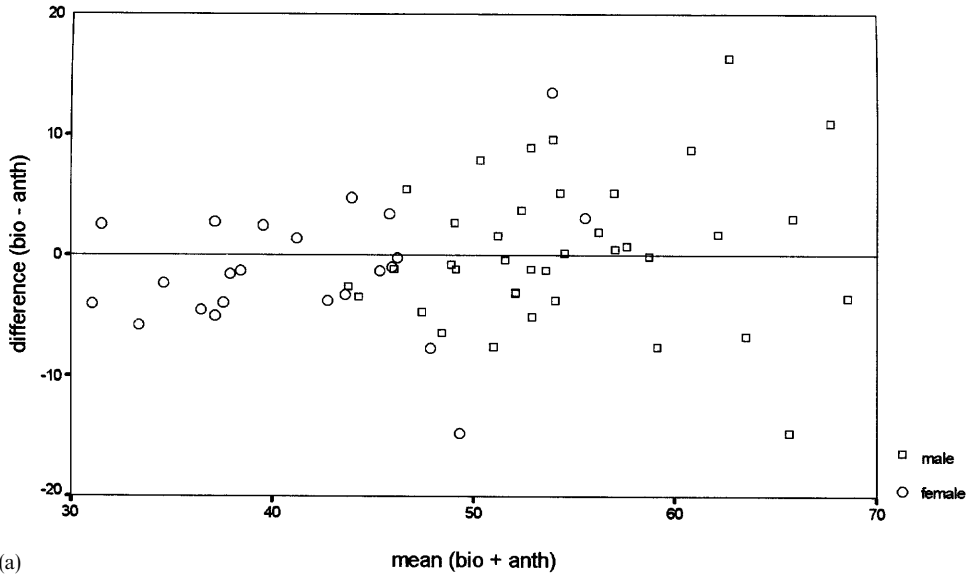
ured by  $Kt/V$  urea or creatinine clearance/ $1.73\text{ m}^2$ ) is related to survival [4] and has been correlated with protein intake estimated from PCR [30,31], although this may reflect mathematical coupling [32] in cross-sectional data. Whilst we found a lower uncorrected creatinine clearance in malnourished females, hypoalbuminaemic patients tended to have higher clearances. There was no correlation between serum albumin and dialysis dose. CAPD is associated with a significant daily peritoneal protein loss, but in this study there was no correlation between serum albumin and daily peritoneal protein loss.

The presence of systemic disease or active inflammation is associated with hypoalbuminaemia. Both

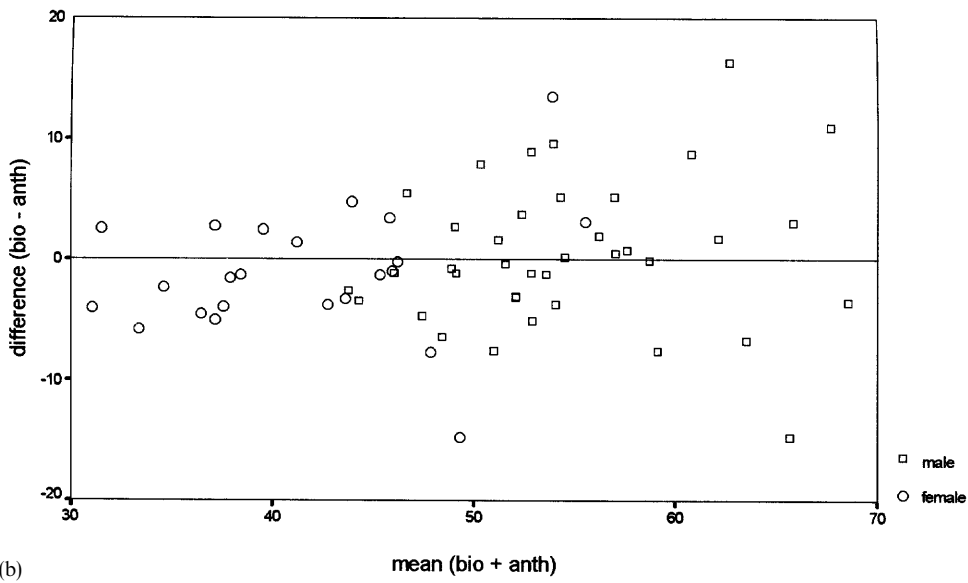
C-reactive protein and ferritin increase during acute inflammation/infection. Although there was no correlation between albumin and ferritin or CRP, a strong correlation was seen between CRP and ferritin in males, suggesting that serum albumin is not greatly influenced by inflammation in a stable population. The tendency to a higher CRP with a wide standard deviation in hypoalbuminaemic males may indicate that serum albumin does reflect CRP in individual patients. All the patients in this study were receiving oral iron and changes in ferritin as part of an inflammatory response are presumably independent of iron stores.

The best measure of nutritional state in CAPD patients remains uncertain. LBM is an excellent measure of nutrition in normal individuals and can be determined by a number of methods, of which deuterium oxide dilution [33] and estimation of specific gravity by underwater weighing [34] are the best established. Neither of these can be easily applied to peritoneal dialysis patients [35]. LBM derived from anthropometry or from bioimpedance has not been validated in CAPD. Deuterium oxide dilution, underwater weighing (and hence anthropometry), and bioimpedance all relate estimates of total body water to lean mass by assuming a constant hydration value for lean tissue in normal subjects. Abnormalities of fluid balance and distribution may invalidate these assumptions in subjects on CAPD. Bioimpedance techniques do not however appear to be affected by the presence of dialysis fluid within the peritoneal cavity [36]. LBM from creatinine kinetics has been shown to correlate well with LBM derived from total body potassium (TBK) in patients on CAPD (agreement was not assessed by the technique of Bland and Altman) and TBK to correlate well with underwater weighing in normal individuals [35]. However TBK has not been validated in CAPD patients and may not provide an accurate assessment of LBM [26]. Creatinine kinetics are reliant on complete 24-h dialysate and urine collections, on patient compliance prior to collection, and involve assumptions about extrarenal creatinine metabolism.

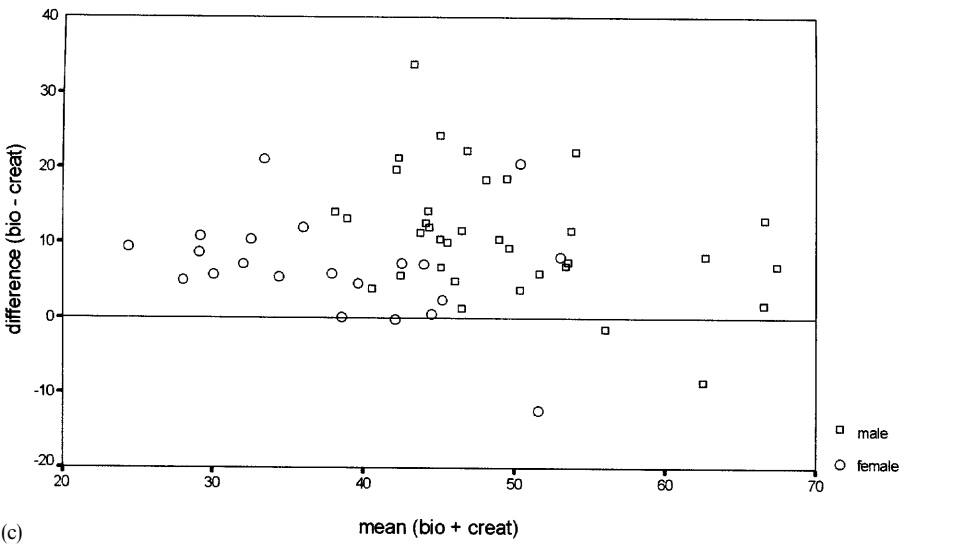
In this study, the three techniques of estimating LBM gave highly correlated results as expected, although the limits of agreement between them were large. However, all three methods were sensitive to nutritional state determined by SGA and correlated with MAMC and hand-grip strength, suggesting that all three methods are valid for cross-sectional studies. Whether or not they are valid for longitudinal studies of individual patients requires further investigation. The correlation between forearm muscle strength and total body water measured by impedance is consistent with the hypothesis that electrical conduction occurs principally through muscle tissue and whole body electrical impedance is dictated by limb impedance [37]. Hand-grip strength was highly correlated with estimates of LBM and with MAMC, is simple and quick to perform, and may therefore provide a useful tool for monitoring nutritional state.



(a)



(b)



(c)

**Table 4.** Correlation of muscle strength by dynamometry with indices of estimated muscle mass and age

	Back strength (r)		Hand grip strength (r)	
	Male	Female	Male	Female
LBM (bio)	0.53*	0.43	0.56‡	0.53‡
LBM (anth)	0.46*	0.59*	0.41*	0.38
LBM (cre)	0.58‡	0.55*	0.68‡	0.55*
Weight	0.31†	0.58*	0.30	0.46†
MAMC	0.36†	0.18	0.49‡	0.18
Age	-0.07	-0.58*	-0.39*	-0.63‡

† $P \leq 0.05$ ; \* $P \leq 0.01$ ; ‡ $P \leq 0.001$ .

In conclusion, SGA identifies a patient group with significant abnormalities of body mass, muscle mass and muscle strength, lending further support to its validity in defining nutritional state in CAPD patients. There were no differences in these parameters between patients with persistent hypoalbuminaemia and those maintaining a normal serum albumin. Evidence of serious malnutrition was seen in dialysis patients with normal serum albumin values and serum albumin cannot be regarded as an accurate index of malnutrition in patients with ESRF maintained on CAPD. The best method of serially monitoring nutritional state is uncertain, and serial studies of estimates of LBM by each method and hand grip strength require further evaluation.

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**Fig. 2.** Plots of the difference between and the mean of the three different estimates of LBM (method of Bland and Altman). The limits of agreement are (a) anthropometry vs bioimpedance, +11.1 to -12.2 males, +11.8 to -10.0 females; (b) anthropometry vs creatinine generation, +28.9 to -5.7 males, +24.8 to -10.1 females; (c) bioimpedance vs creatinine generation, +23.5 to -3.5 males, +19.2 to -4.0 females.

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