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Comparison of Malnutrition Prevalence Between Haemodialysis and Continuous Ambulatory Peritoneal Dialysis Patients: A Cross-sectional Study#

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ABSTRACT

Introduction: Malnutrition is a serious unresolved nutritional problem amongst dialysis patients associated with increased mortality and morbidity and prevalence differs according to dialysis modalities. This study compared protein-energy malnutrition (PEM) prevalence in haemodialysis (HD) and continuous ambulatory peritoneal dialysis (CAPD) patients. **Methods:** A total of 155 HD and 90 CAPD patients were enrolled. PEM prevalence was determined using body mass index (BMI), serum albumin, Dialysis Malnutrition Score (DMS) and dietary intake. **Results:** CAPD patients had significantly higher BMI (24.1 ± 4.8 kg/m^2 vs. 22.7 ± 4.8 kg/m^2; p=0.024) and mid-arm muscle area (32.1 ± 12.4 cm^2 vs. 29.5 ± 15.9 cm^2; p=0.044) than HD patients. They also had significantly lower serum albumin (31 ± 5 g/L vs. 35 ± 6 g/L; p<0.001) and dietary protein intake (0.82 ± 0.37 g/kg/day vs. 1.07 ± 0.47 g/kg/day; p<0.001) compared to the HD patients. PEM was more prevalent in CAPD patients compared to HD patients based on serum albumin <40 g/L (97% vs. 81%) and dietary protein intake <1.2 g/kg/day (79% vs. 67%). However, based on DMS scores (74% vs. 71%) and dietary energy intake <30 kcal/kg/day (84% vs. 77%), the HD and CAPD patients had equally high PEM risks. BMI of <18.5 kg/m^2, serum albumin of <40 g/L and dialysis duration of >5 years were independent risk factors of PEM in dialysis patients. **Conclusion:** Periodic nutritional assessments, education and dietary counseling should be emphasised in these patients as a preventive measure of PEM.

Key words: Dialysis, malnutrition, nutritional assessment, nutritional status

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INTRODUCTION

Protein-energy malnutrition (PEM) amongst haemodialysis (HD) and continuous ambulatory peritoneal dialysis (CAPD) patients has been a global phenomenon since the 1990s (Kopple, 1997; Cianciaruso *et al.*, 1995) and is a serious unresolved problem associated with increased mortality and morbidity (Marcen *et al.*, 1997; Chung, Lindholm & Lee, 2003). Protein-energy malnutrition is commonly characterised by progressive weight loss, depletion of skeletal muscle tissues and fat tissues as well as a reduction of serum proteins (Avesani *et al.*, 2006). It is a consequence of several factors including abnormalities in energy and protein metabolism due to uremic toxicity and chronic inflammation, quality of dialysis therapies and longer duration on dialysis, co-morbid illness such as diabetes mellitus and cardiovascular disease, decreased food intake due to reduced appetite associated with uremia, depression and gastro-intestinal disturbances (Han & Han, 2012; Lim & Kopple, 2000). Furthermore, ageing, gender differences and patients' socio-economic status have also contributed to the presence of PEM in dialysis patients (Alharbi & Enrione, 2012; Marcen *et al.*, 1997).

The Kidney Dialysis Outcomes Quality Initiative (KDOQI, 2000) guidelines proposed several diagnostic criteria for PEM among dialysis patients. Patients with serum albumin of <4.0 g/dL should be evaluated for PEM. The KDOQI also recommended that the body mass index (BMI) of maintenance dialysis patients be in the upper 50th percentile, which is approximately 23.6 kg/m^2 for men and 24 kg/m^2 for women as a preventive measure of PEM.

In addition, PEM is often diagnosed using several parameters which have been traditionally accepted as valid tools such as BMI, triceps skinfold (TSF) measurements, mid-arm muscle circumference (MAMC) and history of weight loss which have strong association with quality of life and survival among the HD and CAPD patients (Huang *et al.*, 2010; Noori *et al.*, 2010; Ramkumar, Pappas & Beddhu, 2005). In particular, hypoalbuminemia has been an important predictor of cardiovascular death and is associated with poor nutritional outcome in dialysis patients (Kalantar-Zadeh *et al.*, 2005; Spiegel & Breyer, 1994).

In recent years, nutritional scoring systems such as Subjective Global Assessment (SGA), Dialysis Malnutrition Score (DMS) and Malnutrition Inflammation Score (MIS) have been recommended as practical tools for the diagnosis of malnutrition in the maintenance of HD and CAPD patients (KDOQI, 2000; Steiber *et al.*, 2004). The DMS is a modified SGA with an additional parameter of duration on dialysis and was reported to be more superior to the conventional SGA. The DMS tool has also been shown to correlate well with age, dialysis vintage, and the combination of MAMC, BMI, serum albumin concentration, and total iron-binding capacity (TIBC) (Kalantar-Zadeh *et al.*, 1999).

A number of studies have investigated nutritional status in either HD (Janardhan *et al.*, 2011) or CAPD patients (Abdu *et al.*, 2011). However, limited studies have compared the nutritional status between the HD and CAPD patients. Thus, this cross-sectional study assessed the prevalence of PEM in HD and CAPD patients in two local governmental hospitals using DMS specifically. We further evaluated the comparison of nutritional parameters such as the anthropometric, biochemical and dietary assessments between the HD and CAPD patients. The key factors associated with malnutrition in HD and CAPD patients were also determined.

METHODS

Study design

A cross-sectional study was carried out on the chronic kidney disease (CKD) patients

undergoing maintenance HD and CAPD at two large hospitals i.e. Hospital Kuala Lumpur and Hospital Serdang. All recruited patients met the inclusion criteria of: (1) above 18 years old; (2) receiving adequate dialysis indicated by Kt/V levels of more than 1.2 in HD patients and more than 1.7 in CAPD patients; (3) dialysis duration of at least 6 months; (4) free of acute illness and hospitalisation for at least 3 months prior to enrollment in the study; and (5) not on enteral or parenteral feeding. Ethical approval was obtained from the Joint Committee of Ethics and Research in IMU (project identification: IMU 233/2011) as well as the Ethics Committee of the Ministry of Health Malaysia (project identification: NMRR-11-355-9148). The study protocol and execution conformed to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000). Identified patients gave informed consent prior to the study initiation and patient anonymity was maintained.

Anthropometric measurements

Patients' height and post-dialysis weight were measured using the electronic column scales (SECA 206, Germany). The BMI was calculated using the Weight (kg)/ Height x Height (m^2) formula based on the post-dialysis weight. The study patients were categorised into underweight (BMI <18.5 kg/m^2), normal weight (BMI 18.5- 24 kg/m^2) and overweight (BMI >=25 kg/m^2) cut-offs proposed in the 20th National Renal Registry (NRR) (Chee *et al.*, 2013).

The TSF was measured with the Harpenden calipers (British Indicators, United Kingdom) at the marked mid-point of the tip of the acromion process of the shoulder blade and the tip of the olecranon process of the ulna on the non-fistula arm for HD patients and right arm for CAPD patients whilst the mid-arm circumference (MAC) was measured using a flexible, non-stretchable measuring tape at the marked mid-point. The MAMC and mid-arm muscle area (MAMA) were calculated using the following equations (KDOQI, 2000):

$$MAMC\ (cm) = MAC - \pi \times TSF.$$

$$MAMA = MAMC^2/4\pi.$$

The correction for gender for MAMA (cMAMA) was as per the equations:
In men: cMAMA = MAMA – 10; in women: cMAMA = MAMA – 6.5

Biochemical measurements

Biochemical measurements were obtained retrospectively from the patients' medical records based on the routine blood tests performed by the in-house laboratories of the hospitals. Patients were required to fast 12 hours prior to blood collection by the trained hospital staff. The biochemical parameters that were obtained for analysis include the serum urea, serum creatinine, serum albumin, serum cholesterol and serum TIBC. The serum albumin levels of the study patients were further categorised into severe malnutrition (<30 g/L), moderate malnutrition (30- <35 g/L), mild malnutrition (35- <40 g/L) and normal nutrition (>=40 g/L) cut-offs proposed by the 20th National Renal Registry (NRR) (Chee *et al.*, 2013).

Dietary intake

Dietary intake was collected for two days (dialysis and non-dialysis) by a trained dietitian using the 24-hour recall method. Household measurements and coloured visual food albums were used to help the patients estimate the nearest portion of food intake. Foods eaten were recorded using household measurements which were then converted into weight in grams. Nutrient analysis were carried out using the Nutritionist Pro software (Version 5.1.0, Axxya Systems, LLC, USA), based on the Composition of Malaysian Foods (Tee *et al.*, 1997) and other sources such as food labels. Dietary energy intake in CAPD patients was calculated taking into consideration the glucose absorbed from the peritoneal dialysate. The dietary energy intake (DEI)

and dietary protein intake (DPI) were then compared with the nutrient prescription by KDOQI guidelines (2000), which have been adopted and practised by dietitians in Malaysia. According to the guidelines, dialysis patients aged <60 years and >60 years are recommended energy intakes of 35 kcal/kg/day and 30-35 kcal/kg/day respectively. The guidelines also recommend DPI of 1.2 g/kg/day in HD patients and 1.3 g/kg/day in CAPD patients.

Dialysis malnutrition score

The DMS is a 5-point scale modified SGA assessment tool comprising history of weight loss, dietary intake, gastrointestinal symptoms, functional mobility, co-morbidity and assessment of muscle wasting, edema and loss of subcutaneous fat (Kalantar-Zadeh *et al.*, 1999). Patients' physical examination included evaluation of subcutaneous fat, muscle wasting and edema. Each component of the DMS has a score of 1 (normal) to 5 (severe). The rating for DMS is normal, moderate (any 3 areas rated as a moderate or severe level), or severe (at least 3 areas at severe level). Thus, the malnutrition score is between 7 (normal) and 35 (severely malnourished).

Demographic and medical history questionnaire

A general questionnaire was administered to collect information regarding the socio-economic background of patients, medical history including causes of kidney failure, duration on dialysis, presence of co-morbid diseases and medications.

Statistical analysis

Data was checked for normality. A frequency test was done to determine the characteristics of the study population. Mean and standard deviation was obtained for normally distributed data while median and interquartile range was obtained for not normally distributed data. Independent T-test and Mann-Whitney was used to compare the nutritional status between HD and CAPD patients. Forward stepwise multinomial logistic regression was conducted to determine factors predicting malnutrition in HD and CAPD patients.

RESULTS

Socio-economic and medical history

The total study population (Table 1) consisted of 56% male and 44% female patients with overall mean age of 52 ± 15 years. The majority of the patients were Malays (53%), followed by Chinese (34%), Indians (12%) and others (1%). Both HD and CAPD patients were mainly from the lower socio-economic group with low to middle education background. The majority of HD patients have been on dialysis for more than 10 years (41%), while most of the the CAPD patients have undergone dialysis for less than 5 years (70%).

The primary cause of kidney failure reported among the HD and CAPD patients were unknown cause (HD: 50%; CAPD: 41%), diabetes mellitus (HD: 22%; CAPD: 33%) or hypertension (HD: 16%; CAPD: 11%) while the major co-morbidities were hypertension (HD:72%; CAPD: 82%), diabetes mellitus (HD: 28%; CAPD: 49%) and cardiovascular disease (HD: 14%; CAPD: 28%). Both the HD and CAPD patients were receiving adequate dialysis indicated by Kt/V of 1.72 ± 0.38 and 2.82 ± 5.08 respectively.

The HD and CAPD patients were treated mainly with calcium carbonate and a few patients with lanthanum carbonate tablets routinely to prevent hyperphosphatemia. They were also prescribed with water soluble vitamins B and C. A total of 137 HD and 90 CAPD patients were on anti-hypertensive drugs such as angiotensin-converting enzyme inhibitors (HD: n= 47; CAPD: n=29), beta-blockers (HD: n=37; CAPD: n=25), calcium-blockers (HD: n=53; CAPD: n=42) and angiotensin receptor blockers (HD: n=29; CAPD: n=15). These patients were also

Table 1. Socio-economic and medical history of dialysis patients

	HD(n= 155)	*CAPD(n=90)*	*Total(n=245)*
Age (years) †	51 ± 14	54 ± 16	52 ± 15
Gender (%)			
Male	59	51	56
Female	41	49	44
Ethnicity (%)			
Malay	48	62	53
Chinese	38	28	34
Indians	13	10	12
Others	1	0	1
Education level (%)			
No formal education	3	2	2
Primary	25	24	25
Secondary	51	49	50
Collage/ university	22	24	23
Employment status (%)			
Employed	28	27	78
Unemployed	72	73	22
Income level (%)			
< RM2000	89	81	86
RM 2001 – RM 4000	7	16	10
>RM 4001	4	3	4
Primary cause of kidney failure (%)			
Unknown	50	41	47
Diabetes mellitus	22	33	26
Hypertension	16	11	14
Others[a]	12	14	13
Major co-morbidities (%)			
Hypertension	70	82	74
Hepatitis B or C	41	7	29
Diabetes mellitus	28	49	36
Cardiovascular disease	14	28	19
Others[b]	17	6	13
Duration on dialysis (years) (%)			
< 5 years	32	70	46
5-10 years	27	24	26
> 10 years	41	6	28
Dialysis adequacy (Kt/V)†	1.72 ± 0.38	2.82 ± 5.08	2.11 ± 3.06

HD: Haemodialysis; CAPD: Continuous Ambulatory Peritoneal Dialysis Patients.
All measurements expressed as percentage patients (%).
† Age and dialysis adequacy expressed as mean ± SD.
[a] Other causes of kidney failure include acute polycystic kidney disease, glomerulonephritis, kidney stone and systemic lupus erythematous.
[b] Other co-morbidities include dyslipidemia, gout nephropathy, hyperthyroidism.

Table 2. Comparison of nutritional parameters among the haemodialysis and continuous ambulatory peritoneal dialysis patients.

Nutritional parameters	*HD (n= 155)*	*CAPD (n=90)*	*p*
BMI (kg/m²)	22.7 ± 4.8	24.1 ± 4.8	0.024*
TSF (mm)	13.5 ± 6.4	14.6 ± 5.6	0.177
MAMA (cm²)†	29.5 ± 15.9	32.1 ± 12.4	0.044*
MAMC (cm)	22.2 ± 4.0	22.9 ± 3.3	0.202
Serum albumin (g/L)†	35 ± 6	31 ± 5	<0.001*
Serum cholesterol (mmol/L)	4.48 ± 1.10	5.56 ± 4.91	0.011*
Serum TIBC (µmol/L)	36.7 ± 10.5	37.3 ± 8.2	0.647
Serum urea (mmol/L)	19.9 ± 11.4	17.2 ± 20.7	0.183
Serum creatinine (mmol/L)	851 ± 261	833 ± 381	0.694
nPCR (g/kg/day)†	0.84 ± 0.62	0.86 ± 0.41	0.828
DEI (kcal/kg/day)			
<60 years old	28 ± 10	25 ± 9	0.067
>=60 years old	23 ± 8	23 ± 8	0.737
DPI (g/kg/day)†	1.07 ± 0.47	0.82 ± 0.37	<0.001*

HD; Haemodialysis, CAPD; Continuous Ambulatory Peritoneal Dialysis Patients, BMI; Body Mass Index, TSF; Triceps Skin Folds, MAMC; Mid-arm Muscle Circumference, MAMA; Mid-Arm Muscle Area, TIBC; Total Iron-Binding Capacity, nPCR; Normalized Protein Catabolic Rate, DEI; Dietary Energy Intake, DPI; Dietary Protein Intake.
All data expressed in mean ± SD unless stated otherwise.
† Data expressed in median ± interquartile range.
* Significant at $p<0.05$.

on cholesterol lowering drugs. Thirty HD patients and 61 CAPD patients were insulin dependent while 17 HD and 5 CAPD patients were on diabetic tablets such as gliclazide and acarbose. Recombinant human erythropoietin, folic acid and iron tablets were also prescribed for anaemia.

The majority of the HD patients were dialysing with high flux polysulfone membranes (n=141) while 14 patients were using low permeability cellulosic membranes. Bicarbonate dialysate buffers were used typically by the HD patients in both hospitals during dialysis. The typical blood flow rate of the study HD patients was between 300 to 349 ml/min. The CAPD patients, however, used either the low calcium (n=87) or bicarbonate (n=3) dialysates with daily total volume of the dialysates varying between 4 to 8 litres (n=55) or more than 8 litres (n=31) or less than 4 litres (n=4).

Anthropometry

The mean BMI (HD: 22.7 ± 4.8 kg/m²; CAPD: 24.1 ± 4.8 kg/m²; p=0.024) and MAMA (HD: 29.5 ± 15.9 cm²; CAPD: 32.1 ± 12.4 cm²; p=0.044) were significantly higher among the CAPD patients. However, the MAMC showed no significant difference between the HD and CAPD patients (22.2 ± 4.0 cm vs. 22.9 ± 3.3 cm; p=0.202). Obesity was more prevalent amongst CAPD patients (CAPD 40%, HD 21%) while underweight was more prevalent amongst HD patients (HD 21%; CAPD 10%). Based on KDOQI cut-off points using BMI as an indicator of PEM, 71% of HD patients and 60% of CAPD patients can be classified as at risk of PEM.

Biochemical data

The mean serum albumin for CAPD patients was significantly lower than HD patients (31 ± 5 g/L vs. 35 ± 6 g/L; p<0.001). When serum albumin in these patients was

Table 3. Classification of body mass index, serum albumin and Dialysis Malnutrition Score of haemodialysis and continuous ambulatory peritoneal dialysis patients.

	HD (n=155)		*CAPD (n=90)*	
	n	%	*n*	%
Body mass index (kg/m²)*				
Underweight (<18.5)	33	21	9	10
Normal weight (18.5- 24)	77	50	45	50
Overweight (>=25)	45	29	36	40
Serum albumin (g/L)*				
Severe malnutrition (<30)	19	12	38	42
Moderate malnutrition (30- <35)	53	34	35	39
Mild malnutrition (35- <40)	54	35	14	16
Well-nourished (>=40)	29	19	3	3
DMS score (classification)	*HD (n=155)*		*CAPD (n=90)*	
	n	%	*n*	%
Normal (<=13)	41	26	26	29
Moderate (14- 28)	114	74	64	71
Severe (>=29)	0	0	0	0

HD; Haemodialysis, CAPD; Continuous Ambulatory Peritoneal Dialysis Patients, DMS; Dialysis Malnutrition Score. Data expressed as percentage patients (%).
* Reference: cut-offs based on Malaysian National Renal Registry (2013).

categorised according to the KDOQI cut-off, a total of 81% of HD patients and 97% of CAPD patients had serum albumin of <40 g/L indicating that these patients were at risk of PEM (Table 3). In addition, the serum cholesterol level was significantly higher in CAPD patients than in HD patients (5.56 ± 4.91 mmol/L vs. 4.48 ± 1.10 mmol/L; p=0.011). However, serum cholesterol level was within the normal range and did not indicate nutritional deficits among the HD and CAPD patients. Serum TIBC on the other hand, did not show significant difference between the HD and CAPD patients (36.7 ± 10.5 μmol/L vs. 37.3 ± 8.2 μmol/L; p=0.647).

Dialysis malnutrition scores

Prevalence of malnutrition assessed using the DMS scores revealed that 73% of the total studied dialysis patients were moderately malnourished with no cases of severe malnutrition reported. In addition, prevalence of moderate malnutrition was equally high in HD and CAPD patients (74% vs. 71%) using the DMS scores (Table 3).

Dietary energy and protein intake

The mean DEI of HD patients was not significantly different from CAPD patients based on age <60 years old (28 ± 10 kcal/kg/day vs. 25 ± 9 kcal/kg/day; p=0.067) and >=60 years old (23 ± 8 kcal/kg/day vs. 23 ± 8 kcal/kg/day; p=0.737). The majority of HD and CAPD patients (75% vs. 89%) of age ≤60 years were unable to meet the minimum energy requirements of 35 kcal/kg/day and similarly, the majority of HD and CAPD patients (84% vs. 77%) of age >=60 years were also unable to meet their minimum energy recommendations of 30 kcal/kg/day (Table 4).

However, the mean DPI of HD patients was significantly higher compared to CAPD patients (1.07 ± 0.47 g/kg/day vs. 0.82 ±

Table 4. Dietary energy and protein intake of dialysis patients

	HD			CAPD		
	n	*Mean ± SD*	*MNT**	*n*	*Mean ± SD*	*MNT**
Dietary energy (kcal/kg/day)						
<60 years old	107	28 ± 10	35	52	25 ± 9	35
>=60 years old	48	23 ± 8	30-35	38	23 ± 8	30-35
Dietary protein (g/kg/day)	155	1.07 ± 0.47	1.2	90	0.82 ± 0.37	1.3
	HD			CAPD		
<60 years old	*n*	%		*n*	%	
Dietary energy classification (percentage patients)						
<35 kcal/kg/day	80	75		46	89	
>35 kcal/kg/day	27	25		6	11	
>=60 years old	*n*	%		*n*	%	
Dietary energy classification (percentage patients)						
<30 kcal/kg/day	40	84		29	77	
30-35 kcal/kg/day	4	8		7	18	
>35 kcal/kg/day	4	8		2	5	
Dietary protein classification (percentage patients)						
<1.2 g/kg/day	104	67		71	79	
1.2- 1.3 g/kg/day	17	11		10	11	
>1.3 g/kg/day	34	22		9	10	

HD; Haemodialysis, CAPD; Continuous Ambulatory Peritoneal Dialysis Patients.
* KDOQI guidelines (2000).
Data reported as mean ± SD and percentage patients (%).

0.37g/kg/day; $p<0.001$). Nevertheless, in both groups the DPI was far lower than the requirement of 1.2-1.3 g/kg/day. A total of 67% of HD patients and 79% CAPD patients were unable to meet the minimum protein requirement of 1.2 g/kg/day (Table 4).

Factors predicting malnutrition

Socio-economic and nutritional parameters contributing to malnutrition were explored using the forward stepwise multiple logistic regression analysis (Table 5). Body mass index of <18.5 kg/m² (OR=6.940, p=0.019) was a significant contributor to malnutrition risk in HD patients whereas duration on dialysis of >5years (OR=7.966, p<0.001) and serum albumin level of <40 g/L (OR=4.384, p<0.001) were significant contributors to malnutrition risk in CAPD patients. Malnutrition risk among the underweight HD patients (BMI<18.5 kg/m²) was 7 times greater compared to HD patients with BMI above 18.5 kg/m². Furthermore, CAPD patients who were dialysing for >5 years had 8 times greater risk of malnutrition compared to those dialysing for <5 years. The malnutrition risk in CAPD patients with serum albumin level of <40 g/L was also 4 times greater compared to patients with serum albumin level of >40 g/L.

DISCUSSION

The overall results of this study concur with national data on prevalence of malnutrition based on serum albumin and BMI as reported in the National Renal Registry, 2013

Table 5. Forward stepwise multiple logistic regression for factors contributing to malnutrition in haemodialysis and continuous ambulatory peritoneal dialysis patients.

	HD (n=155)				*CAPD (n=90)*			
	β	*p*	*OR*	*95% CI*	*β*	*p*	*OR*	*95% CI*
Gender (male; female)	-0.048	0.905	0.953	0.431-2.107	0.828	0.171	2.289	0.699-7.496
Age (<60 years; >=60 years)	-0.193	0.690	0.825	0.320-2.126	-2.216	0.005	0.109	0.023-0.516
Education (low; highly educated)	0.581	0.198	1.788	0.737-4.334	0.665	0.303	1.945	0.549-6.892
Employment status	-0.511	0.273	0.600	0.240-1.496	-0.343	0.595	0.710	0.200-2.514
Duration on dialysis	0.026	0.958	1.026	0.387-2.725	-18.648	<0.001*	7.966	7.966-7.966
Presence of CVD	1.280	0.109	3.597	0.752-17.216	-1.879	0.020	0.153	0.031-0.746
Presence of DM	-0.528	0.290	0.590	0.222-1.569	-0.924	0.158	0.397	0.110-0.1430
Body mass index <18.5 kg/m²	1.937	0.019*	6.940	1.378-34.958	-0.751	0.503	0.472	0.052-4.251
Serum albumin <40 g/L	0.912	0.094	2.489	0.856-7.242	-19.245	<0.001*	4.384	4.384-4.384
DEI <30 kcal/kg/day	0.495	0.418	1.641	0.495-5.438	1.210	0.146	3.354	0.655-17.171
DPI <1.2 g/kg/day	-0.835	0.166	0.434	0.133-1.415	0.818	0.390	2.267	0.351-14.633

HD: Haemodialysis; CAPD: Continuous Ambulatory Peritoneal Dialysis Patients; CVD: Cardiovascular Disease; DM: Diabetes Mellitus; DEI: Dietary Energy Intake; DPI: Dietary Protein Intake; β : Coefficient; OR: Odds-Ratio; CI: Confidence Interval.
* Significant at $p<0.05$ with odds-ratio >1.

(Chee *et al.*, 2013). The present study reported that PEM prevalence rate was higher in CAPD patients compared to HD patients in the Malaysian dialysis settings based on serum albumin, dietary energy and protein intake. This is similar to the national data as reported in the 20th NRR (Chee *et al.*, 2013) whereby malnutrition rate was higher among the Malaysian peritoneal dialysis patients compared to patients on haemodialysis (90% vs. 57%). This study provides additional insight into other components of nutrition status assessment such as body composition (fat and lean body mass) as well as dietary protein and energy intakes.

In this study, we reported that the CAPD patients had significantly higher BMI and MAMA when compared to the HD patients. Evidence suggests that obesity is probably more prevalent among the CAPD patients because of excessive glucose absorption leading to over-hydration status among the CAPD patients (Heimburger, 2003). A higher percentage of HD vs. CAPD patients had BMI of <18.5 kg/m^2 indicating malnutrition. The multivariate analysis showed BMI to be a significant contributor to malnutrition in HD patients. Similarly in other studies, a lower BMI (<18.5 kg/m^2) has been associated with high mortality risk (McQuillan *et al.*, 2012) whereas a higher BMI was associated with better survival among the HD patients (Huang *et al.*, 2010; McQuillan *et al.*, 2012. Thus, the KDOQI guidelines suggest that maintenance dialysis patients be achieve and maintain a BMI target of 24 kg/m^2 (KDOQI, 2000).

Serum albumin was a significant contributor of malnutrition in CAPD patients. In CAPD patients, loss of albumin in peritoneal fluid may range from 5.5-11.8 g/day (Blumenkrantz *et al.*, 1982). In comparison, low flux dialyzers account for amino acid losses of 5.6-7.1 g/day in HD patients (Ikizler *et al.*, 1994). Hence, higher protein losses were observed among the CAPD patients and with poor dietary protein intake, these patients were unlikely to compensate the protein loss. Incidence of hypoalbuminemia was found to reflect malnutrition state in dialysis patients (Kalantar-Zadeh *et al.*, 2005; Spiegel & Breyer, 1994). Serum albumin level of <30 g/dL in CAPD patients has been associated with a 3-fold increased risk of mortality (Mehrotra *et al.*, 2011). Significant increase in death risk was also evident for HD patients with serum albumin <4.0 g/dL and for CAPD patients with serum albumin of <3.8 g/dL (Mehrotra *et al.*, 2011). Therefore, the KDOQI guidelines suggest that dialysis patients should target serum albumin level of >=40 g/L as the outcome goal for prevention of PEM.

Duration of dialysis has a significant impact on nutrition status of CAPD patients. It has been similarly reported that CAPD patients who were on peritoneal dialysis for >2 years had higher mortality risk compared to patients on haemodialysis modality (Termorshuizen *et al.*, 2003). It was also reported that long-term survival rate was better in patients who were initially on peritoneal dialysis followed by a transfer to haemodialysis after a number of months or years (Termorshuizen *et al.*, 2003). In the Malaysian dialysis settings, acceptance of the haemodialysis treatment was greater than peritoneal dialysis treatment with higher death risk reported among the peritoneal dialysis patients compared to haemodialysis patients (Chee *et al.*, 2013). Thus in Malaysia, the HD treatment seemed to confer better nutritional outcomes compared to CAPD treatment.

For the majority of the HD and CAPD patients dietary energy and protein intakes were below the recommended levels. This is similarly reported by other studies revealing that dietary energy intake among the HD patients ranged from 26-30 kcal/kg/day while dietary protein intake was less than 1.11 g/kg/day (Cupisti *et al.*, 2010). For CAPD patients, it was also reported that dietary energy intake ranged from 23 -27 kcal/kg/day (Sutton, Higgins & Stevens, 2007) while dietary protein intake was less

than 1.01 g/kg/day (Sutton *et al.*, 2007). The poor dietary energy intake further exacerbates the higher malnutrition rate in CAPD. Anorexia among the CAPD patients can result from distention due to fluid in the abdomen. Over-hydration and early satiety due to absorption of glucose from peritoneal fluid can also result in poor dietary intake among the CAPD patients (Sezer *et al.*, 2005). Therefore, improving dietary energy and protein intakes among the dialysis patients should be emphasised as low dietary intake leads to poor quality of life, and increased mortality and hospitalisation among the dialysis patients (Kalantar-Zadeh *et al.*, 2004).

Clinical factors commonly associated with malnutrition such as high age, presence of cardiovascular disease and diabetes mellitus were not significant in this study. This is possibly due to the sample size limitation. Nevertheless, it has been shown that Asians with diabetes have poor nutrition status (Nath *et al.*, 2013) and this is associated with increased mortality (Yang *et al.*, 2013).

CONCLUSION

This study showed that protein-energy malnutrition was highly prevalent amongst the dialysis population regardless of dialysis modality. Adequate attention should be given to these patients to improve their nutritional status through continuous monitoring of nutrition status, dietary intervention, education and counseling. Dietary counseling focusing on weight gain to improve BMI and dietary energy and protein intake is warranted to reduce occurrence of malnutrition among HD and CAPD patients.

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CONFLICT OF INTEREST

The authors declare that they have no competing interest.

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