Does peritoneal dialysate affect body composition assessments using multi-frequency bio-impedance in peritoneal dialysis patients ?

A Davenport

UCL Centre for Nephrology
Royal Free Hospital
University College London Medical School
Rowland Hill Street
London NW3 2PF

Address for correspondence
Andrew Davenport andrewdavenport@nhs.net
UCL Centre for Nephrology, Royal Free Hospital, University College London Medical School, Rowland Hill Street, London NW3 2PF

tel 44-2074726457 fax 44-2073178591

short title bioimpedance body composition in peritoneal dialysis patients

key words bio-impedance peritoneal dialysis body composition total body water extracellular water intracellular water

word count
abstract 210
body 1298
tables 3
references 26

Abstract

Backgroud/objectives Multi-frequency bio-impedance spectroscopy (MF-BIS) is increasingly being used to assess peritoneal dialysis patients. Protein energy wasting (PEW) is a recognised complication of peritoneal dialysis. Although MF-BIS can be used to assess body composition, measurements can be affected by fluid overload and we wished to determine whether the presence of peritoneal dialysate in the peritoneal cavity equally could affect MF-BIS derived body composition assessments.

Subjects/Methods 50 consecutive adult patients had MF-BIS measurements made with 2 l 22.7g/l dextrose dialysate instilled into the peritoneal cavity and then after draining out.

Results When full, extracellular water (ECW) and the ratio of ECW to total body water (TBW) were greater compared to empty; 143.9±3.0 l vs 13.4±3.0, and 0.393±0.01 vs 0.391±0.01, $p<0.001$ respectively. Segmental ECW/TBW was only different for the trunk, 0.395±0.01 full vs 0.392±0.01 empty, $p<0.0001$. Body composition, changed with a fall in skeletal muscle mass from 26.1±6.3 to 25.2 ±6.1 kg, $p<0.001$, and a smaller reduction in body fat from 19.3 ±8.4 to 19.1 ±8.0 kg, $p=0.0104$.

Conclusions MF-BIS measurements made in peritoneal dialysis patients with peritoneal dialysate instilled can over estimate muscle mass, and as such potentially delay the recognition of PEW, Thus for more accurate MF-BIS in peritoneal dialysis patients, the dialysate should be drained out.

Introduction

More than 100,000 patients with chronic kidney disease stage 5d (CKD5d) are treated by peritoneal dialysis worldwide. Peritoneal dialysis patients are at risk of protein energy malnutrition (PEW) [1]. The causes of PEW are multifactorial including peritonitis episodes [2], chronic volume overload [3], malabsorption secondary to secondary sclerosing peritonitis [4], reflux oesophagitis, abdominal distension, central satiety due to inhibition of the hypothalamic neuropeptide Y neurons or activation of pro-opiomelanocortin neurons consequent upon peritoneal glucose absorption, constipation, increased circulating cytokines, des-acyl ghrelin and leptin [5]. PEW is more common in the elderly peritoneal dialysis patient [6] and those with additional co-morbidities. PEW is more than simple malnutrition, typified by anorexia, increased energy expenditure and catabolism on one hand and loss of weight due to both loss of fat and protein stores and muscle mass, termed sarcopenia [1], Not surprisingly PEW is associated with an increased risk of mortality for peritoneal dialysis patients [7], and key to successful management is early detection. Until recently the subjective global assessment (SGA) score has been the tool most commonly used to assess nutritional status [8]. However the SGA is time consuming and there may be marked inter-observer differences in assesments. Alternatives include dual-energy X-ray absorptiometry [9], but this requires specialist equipment and cannot be readily performed during an outpatient assessment. More recently multi-frequency bio impedance spectroscopy (MF-BIS) which assesses the resistance of the body to an alternating current has been introduced, and can be used to obtain information about body composition as different tissues contain different amounts of water, and therefore have different resistances to the passage of electrical current.

Body composition, in the most simplistic form simply divides the body into fat and fat free compartments [10]. Thereafter, muscle mass can be derived from fat free mass [11]. As the resistance to electrical flow is dependent upon the length of the electrical circuit, most of the resistance to electrical flow is in the arms and legs, with only a minor contribution from the small proportion from the trunk. As such, earlier studies suggested no difference in bio-impedance results whether peritoneal dialysate was instilled or drained out in peritoneal dialysis patients [12]. However, as InBody (Seoul, Korea) recommend that bio-impedance measurements should be made with an empty bladder we decided to investigate whether the presence of peritoneal dialysate affected body composition assessments derived from bioimpedance measurements made in peritoneal dialysis patients.

Patients and methods

50 consecutive healthy adult outpatients treated by peritoneal dialysis under the care of a tertiary university hospital who attended for routine outpatient assessment had multifrequency bioimpedance measurements made with a standard 2 litre 22.7 g/l dextrose peritoneal dialysate solution (Baxter Health Care, Deerfield, USA) instilled and then repeated following drainage [13]. All patients were asked to empty their bladder prior to instillation of

dialysate. Patients with amputations, cardiac pacemakers or defibrillators were excluded from study as bio-impedance measurements were not made. Direct multi-frequency bioelectrical impedance spectroscopy (MF-BIS) analysis method was employed using an 8 tactile electrode system, using both hands and both feet (InBody 720, Biospace, Soul, Korea) (US patent 5720296) [14,15]. Height was measured by a standard wall mounted measure (Sigmeas 1, Doherty signature range,www.mediclick.co.uk). Peritoneal dialysis bags were weighed pre-infusion, post infusion and upon drainage by calibrated scales (MPSS250, Marsden, Henley on Thames, UK).

Serum biochemistry samples were analysed with a standard multi-channel biochemical analyzer using the bromcresol green method for albumin determination (Roche Integra, Roche diagnostics, Lewes, UK) [16]. Ethical approval was granted by the local ethical committee as audit and clinical service development.

Statistical analysis

Statistical analysis was by simple paired t test or Wilcoxon rank sum pair test, correlation analysis (GraphPad Prism version 5.0, San Diego, USA), analysis of variance with Bonferroni post analysis correction. Data are expressed as mean ± standard deviation, median and inter-quartile range, or percentages. Statistical significance was taken at or below the 5% level.

<u>Results</u>

50 healthy adult patients were studied, 50% male, median age 61.5 years (44-73.3), 14% diabetic, 56% Caucasoid, 24% South Asian, 6% Afro-Caribbean, with 14% from other racial origins, peritoneal dialysis vintage 27 months (3.8-42.5). Serum albumin 39.1 ±3.4 g/l and glucose 5.6 mmol/l (4.6-6.6). The measured weight change following drainage of the peritoneal dialysis effluent was 2.11 ±0.41 kg, whereas simply subtracting 2 litres from the weight with fluid in the peritoneal cavity, the amount of peritoneal dialysis fluid aimed to be instilled gave an estimated weight of 2.20 ±0.27 kg (p=0.06), a median difference of 0.2 (0-0.4) kg. Following draining out of the peritoneal dialysis fluid, total body water, intracellular (ICW) and extracellular water (ECW) volumes fell (table 1). Whereas the combined fall in ICW and ECW was 1.28 ±0.5 kg and significantly less than the fall in overall weight (p<0.001), however the percentage fall was similar; for total body weight 3.23±0.84%, total body water (TBW) 3.65±1.5%, ICW 3.43±1.5% and ECW 3.98±1.%6 respectively (p<0.001 ICW vs ECW).

Resistance and reactance measurements were similar irrespective of whether peritoneal dialysis fluid was present for the limbs, but increased for the trunk when drained out (table 2). The increase in trunk resistance ranged from 18.2 (13.3-22.9)% to 22.3 (15.3-28.1)% at 250 and 1000 kHz respectively, and reactance from 14.9 (7.6 to 26.3)% to 25 (6.7-36.4)% at 250 and 5 kHz respectively. These changes in resistance and reactance resulted in differences in body composition assessment, over estimating muscle content (table 3).

Discussion

Multi-frequency bio-impedance is being increasingly used to assess volume status in peritoneal [17] and haemodialysis patients [18]. As the water content of different tissues varies, for example being greater in muscle compared to fat, bioimpedance can be used to assess body composition, with comparable results to dual energy X ray absorptiometry [19]. As resistance to the flow of electrical currents used in bioimpedance is predominantly in the limbs, it has been assumed that the effects of peritoneal dialysate would not be clinically relevant [10]. As such many centres measure bioimpedance when patients attend with peritoneal dialysate instilled, as this is quicker and more convenient to patients and staff [20]. However, body composition measurements made by dual energy X ray absorptiometry are carried out with peritoneal dialysate drained out, and as such we compared body composition determined by multifrequency bioimpedance when patients attended for a standard peritoneal dialysis exchange using 2 litres 22.7 g/l dextrose exchange.

Using a sensitive 8 electrode MF-BIS device [21] there were differences in TBW, ICW and ECW recorded, whereas other studies using 4 electrode devices have not demonstrated a difference [22]. The changes in ECW and ICW were less than that in total body weight, with proportionately greater change in ECW. As expected the greatest change occurred in the truncal compartment, and there were no differences in the ratio of ECW/TBW in the arms and legs. The changes in ICW and ECW were on average around 3- 4%, similar to the change in total body weight. As muscle contains more water than fat, and therefore has a lower resistance to the passage of electrical current, the estimation of skeletal muscle mass was increased by around 3.7% with peritoneal dialysate instilled, compared to 1.3% for body fat mass. As such, bioimpedance measurements made with peritoneal dialysate instilled into the peritoneal cavity will potentially over estimate muscle mass. Sarcopenia, or loss of muscle mass is a key feature of protein energy wasting [23]. Previous reports have favoured dual energy X ray absorptiometry over single frequency bioimpedance devices, for detecting sarcopenia, as bioimpedance is affected by fluid status [24]. Multi-frequency bioimpedance spectroscopy devices improve the accuracy of bioimpedance devices [25], and eight electrode devices measure both sides of the body [26]. As such these non-invasive devices could be used to obtain serial measurements and follow changes in body composition in peritoneal dialysis patients, but should be made following drainage of the peritoneal dialysate.

The author has no conflict of interest

References

1. Wang AY. Energy intake and energy expenditure profiles in peritoneal dialysis patients. Ren Nutr. 2011 Jan;21(1):31-4
2. Davenport A. Peritonitis remains the major clinical complication of peritoneal dialysis: the London, UK, peritonitis audit 2002-2003. Perit Dial Int. 2009;29:297-302
3. Fan S, Sayed RH, Davenport A. Extracellular volume expansion in peritoneal dialysis patients. Int J Artif Organs. 2012;35(5):338-45
4. Habib AM, Preston E, Davenport A. Risk factors for developing encapsulating peritoneal sclerosis in the icodextrin era of peritoneal dialysis prescription. Nephrol Dial Transplant. 2010;25:1633-1638
5. Wright M, Woodrow G, O'Brien S, Armstrong E, King N, Dye L, Blundell J, Brownjohn A, Turney J. Cholecystokinin and leptin: their influence upon the eating behaviour and nutrient intake of dialysis patients. Nephrol Dial Transplant. 2004;19(1):133-140
6. Zhang R, Ren YP. Protein-energy wasting and peritoneal function in elderly peritoneal dialysis patients. Clin Exp Nephrol. 2012 PMID: 22526487
7. Han SH, Han DS. Nutrition in patients on peritoneal dialysis. Nat Rev Nephrol. 2012;8(3):163-75
8. Detsky AS, McLaughlin JR, Baker JP, Johnston N, Whittaker S, Mendelson RA, Jeejeebhoy KN. What is subjective global assessment of nutritional status? J Parenter Enteral Nutr. 1987;11(1):8-13
9. Fürstenberg A, Davenport A. Comparison of multifrequency bioelectrical impedance analysis and dual-energy X-ray absorptiometry assessments in outpatient haemodialysis patients. Am J Kidney Dis. 2011; 57: 123-129
10. Woodrow G, Devine Y, Cullen M, Lindley E. Application of bioelectrical impedance to clinical assessment of body composition in peritoneal dialysis. Perit Dial Int 2007;27:496-502
11. Moissl UM, Wabel P, Chamney PW, Bosaeus I, Levin NW, Bosy-Westphal A, Korth O, Müller MJ, Ellegård L, Malmros V, Kaitwatcharachai C, Kuhlmann MK, Zhu F, Fuller NJ. . Body fluid volume determination via body composition spectroscopy in health and disease. Physiol Meas 2006;27:921-933
12. Than N, Woodrow G, Oldroyd B, Gonzalez C, Turney JH, Brownjohn AM. Effect of peritoneal fluid on whole body and segmental multiple frequency bioelectrical impedance in patients on peritoneal dialysis. Eur J Clin Nutr. 2000;54(5):450-451
13. Davenport A, Willicombe MK. Hydration status does not influence peritoneal equilibration test ultrafiltration volumes. Clin J Am Soc Nephrol. 2009;4:1207-1212
14. Thomas EL, Frost G, Harrington T, Bell JD. Validation on “in Body” bioelectrical impedance by whole body MRI. Laboratory report 2001

15. Bedogni G, Malavolti M, Severi S, Poli M, Mussi C, Fantuzzi AL, Battistini N. Accuracy of an eight-point tactile-electrode impedance method in the assessment of total body water. Eur J Clin Nutr. 2002; 56:1143-1148
16. Davenport A, Willicombe MK. Does diabetes mellitus predispose to increased fluid overload in peritoneal dialysis patients? Nephron Clin Pract. 2010;114:c60-66
17. Davenport A, Willicombe M. Comparison of fluid status in patients treated by different modalities of peritoneal dialysis using multi-frequency bioimpedance. Int J Artif Organs. 2009;32:779-786
18. Booth J, Pinney J, Davenport A. N-terminal proBNP--marker of cardiac dysfunction, fluid overload, or malnutrition in haemodialysis patients? Clin J Am Soc Nephrol. 2010;5(6):1036-1040
19. Fürstenberg A, Davenport A. Assessment of Body Composition in Peritoneal Dialysis Patients Using Bioelectrical Impedance and Dual-Energy X-Ray Absorptiometry. Am J Nephrol. 2011;33:150-156
20. Van Biesen W, Williams JD, Covic AC, Fan S, Claes K, Lichodziejewska-Niemierko M, Verger C, Steiger J, Schoder V, Wabel P, Gauly A, Himmele R; EuroBCM Study Group. Fluid status in peritoneal dialysis patients: the European Body Composition Monitoring (EuroBCM) study cohort. PLoS One. 2011;6(2):e17148
21. Booth J, Pinney J, Davenport A. The effect of vascular access modality on changes in fluid content in the arms as determined by multifrequency bioimpedance. Nephrol Dial Transplant. 2011;26(1):227-31
22. Sipah S, Hur E, Demirtas S, Kocayigit I, Bozkurt D, Tamer A, Gunduz H, Duman S. Body composition monitor measurement technique for the detection of volume status in peritoneal dialysis patients: the effect of abdominal fullness. Int Urol Nephrol. 2011;43(4):1195-1199
23. Cesari M, Fielding RA, Pahor M, Goodpaster B, Hellerstein M, Van Kan GA, Anker SD, Rutkove S, Vrijbloed JW, Isaac M, Rolland Y, M'rini C, Aubertin-Leheudre M, Cedarbaum JM, Zamboni M, Sieber CC, Laurent D, Evans WJ, Roubenoff R, Morley JE, Vellas B; for the International Working Group on Sarcopenia. Biomarkers of sarcopenia in clinical trials-recommendations from the International Working Group on Sarcopenia. J Cachexia Sarcopenia Muscle. 2012;3(3):181-190
24. Morley JE, Abbatecola AM, Argiles JM, Baracos V, Bauer J, Bhasin S, Cederholm T, Coats AJ, Cummings SR, Evans WJ, Fearon K, Ferrucci L, Fielding RA, Guralnik JM, Harris TB, Inui A, Kalantar-Zadeh K, Kirwan BA, Mantovani G, Muscaritoli M, Newman AB, Rossi-Fanelli F, Rosano GM, Roubenoff R, Schambelan M, Sokol GH, Storer TW, Vellas B, von Haehling S, Yeh SS, Anker SD; Society on Sarcopenia, Cachexia and Wasting Disorders Trialist Workshop. Bhasin S, et al. Sarcopenia with limited mobility: an international consensus. J Am Med Dir Assoc. 2011;12:403–409

25. Chamney PW, Wabel P, Moissl UM, Müller MJ, Bosy-Westphal A, Korth O, Fuller NJ. A whole-body model to distinguish excess fluid from the hydration of major body tissues. Am J Clin Nutr 2007;85:80-89
26. Papakrivopoulou E, Booth J, Pinney J, Davenport A. Comparison of volume status in asymptomatic haemodialysis and peritoneal dialysis outpatients. Nephron Extra. 2012;2(1):48-54

Table 1; Volume assessment made both with peritoneal dialysate instilled (full) and following drainage of peritoneal dialysate (empty). Right (R), Left (L). * p <0.05, ** p<0.01, *** p< 0.001

	Full	Empty
Weight kg	67.6 ±12.8	65.5 ±12.9 ***
Total body water (TBW) l	35.5 ±7.8	34.2 ±7.6 ***
Intracellular water (ICW) l	21.6 ±4.8	20.8 ±4.7 ***
Extracellular water (ECW) l	13.9 ±3.0	13.4 ±2.9 ***
ECW/TBW	0.393 ±0.01	0.391 ± 0.01 ***
R arm ECW/TBW	0.379 ±0.008	0.379 ±0.008
L arm ECW/TBW	0.379 ±0.007	0.379 ±0.007
Trunk ECW/TBW	0.395 ±0.012	0.392 ±0.011 ***
R leg ECW/TBW	0.391 ±0.013	0.391 ±0.013
L leg ECW/TBW	0.394 ±0.013	0.394 ±0.013

Table 2: Segmental resistance (Z) and reactance measurements over a variety of frequencies (kilo Herz) when peritoneal dialysate instilled (full) and drained out (empty). ** $p < 0.01$ and *** $p < 0.001$ vs full.

Resistance (Z)	R arm	L arm	Trunk	R leg	L leg
1 kHz					
full	384±75	389±75	22.5±14	278±58	277±60
empty	382±75	388±75	27.0±17***	276±59	276±59
5 kHz					
full	378±71	382±72	20.3±4	275±57	274±59
empty	377±70	381±72	24.4±5***	273±56	272±57
50 kHz					
full	340±67	340±72	17.9±3	253±57	250±54
empty	338±66	342±69	21.3±4***	248±51	251±61
250 kHz					
full	310±64	315±68	16.3±6	230±49	230±51
empty	308±62	312±66	18.9±6***	224±57	229±50
500 kHz					
full	299±61	299±75	15.2±7	224±48	224±51
empty	298±60	300±65	18.1±7***	223±47	223±49
1000 kHz					
full	290±60	291±61	13.0±7	219±47	220±49
empty	289±59	290±61	15.7±7***	218±46	219±48
Reactance (X)					
5 kHz					
full	16.6±5.8	16.0±4.8	1.9±4.0	10.1±3.3	9.7±3.3
empty	16.7±6.4	15.8±4.6	2.3±4.6**	9.9±3.3	9.5±3.2
50 kHz					
full	28.4±6.8	28.5±6.2	1.8±1.5	19.4±5.8	18.9±5.7
empty	28.2±6.5	28.4±5.9	2.3±1.4***	19.1±5.7	18.7±5.6
250 kHz					
full	22.6±6.0	25.6±5.4	2.2±2.5	14.8±4.1	13.5±4.1
empty	22.7±6.4	25.7±5.5	2.7±2.2***	14.7±3.9	13.3±4.0

Table3; Body composition assessment made both with peritoneal dialysate instilled (full) and following drainage of peritoneal dialysate (empty). * p <0.05, ** p<0.01, *** p< 0.001

	Full	Empty
Fat free mass kg	48.3 ±10.7	46.4 ±10.4 ***
Soft lean mass kg	45.4 ±10.0	43.8 ±9.8 ***
Skeletal muscle mass kg	26.1 ±3.68	25.2 ±6.1 ***
% body fat	28.1 ±10.3	28.6 ±9.9 *
Body fat mass Kg	19.3 ±8.4	19.1 ±8.0 *
Body cell mass kg	30.9 ±6.9	29.7 ±7.48 ***
Bone mineral content kg	2.94 ±0.7	2.7 ±0.6 ***
Waist hip ratio	0.96 ±0.07	0.933 ±0.07 ***