The use of BCM in PD patients

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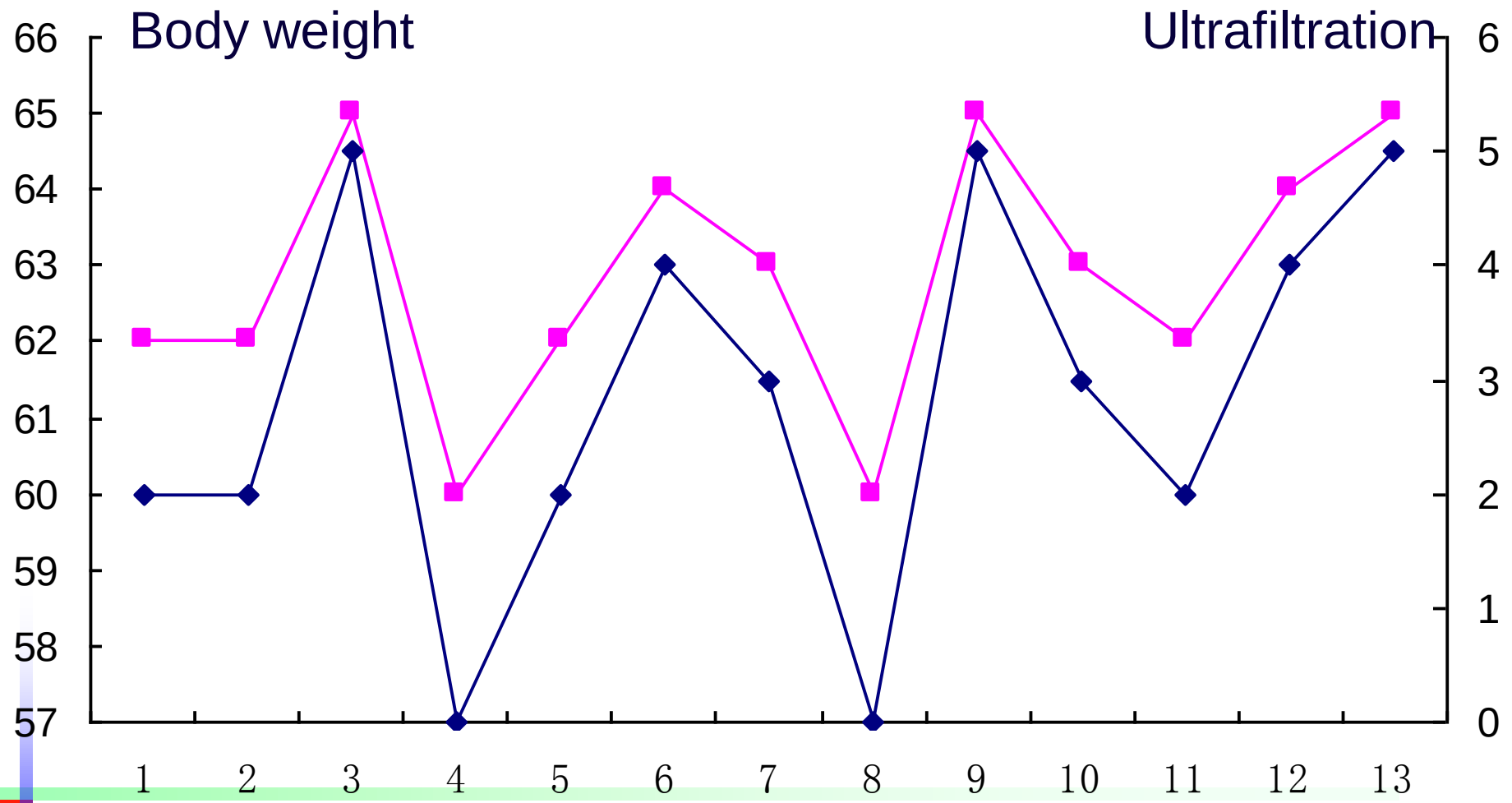
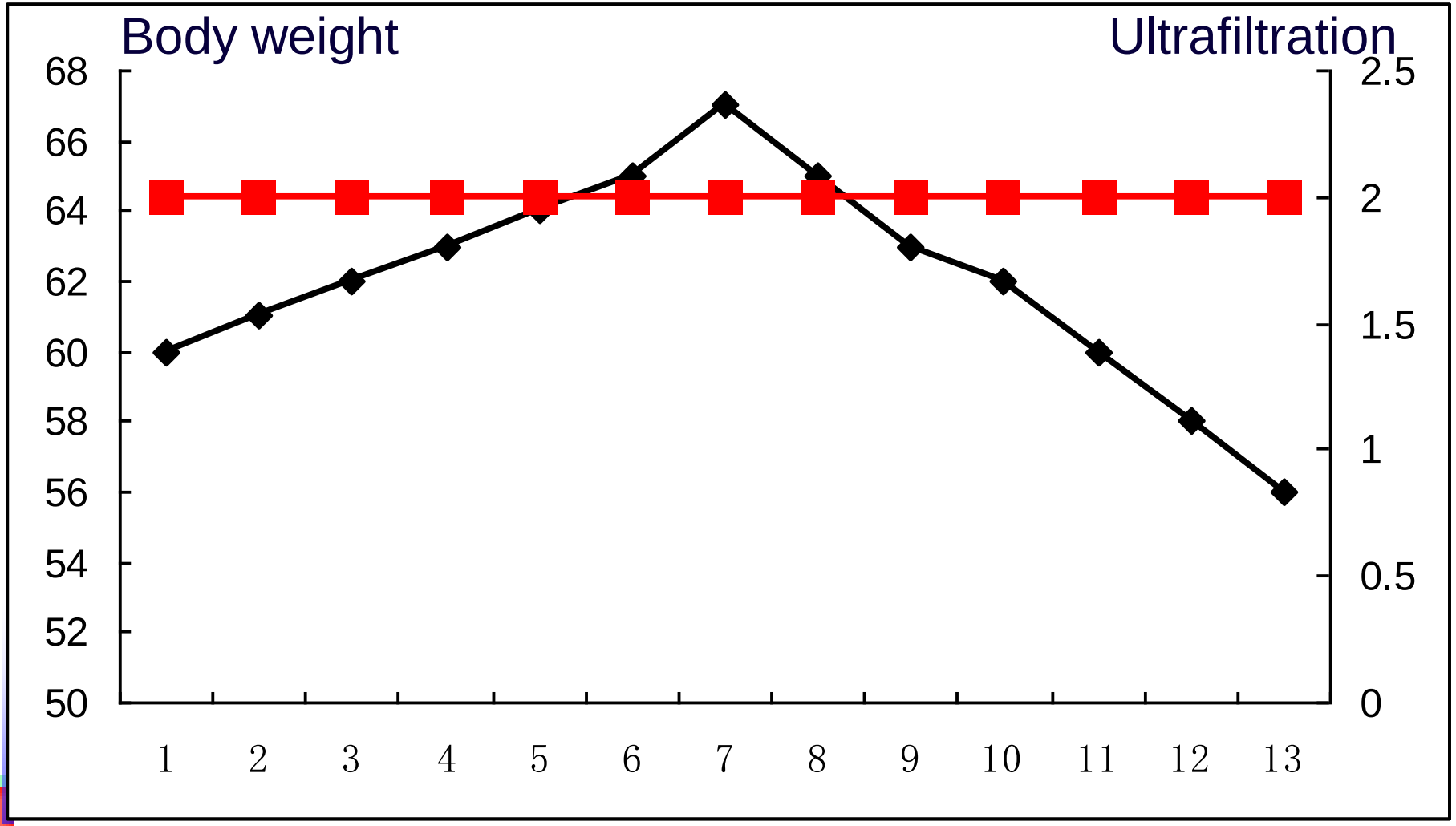
Volume control in PD patients

- Poor volume control is one of the critical causes of high mortality of PD patients
- Euvolemia is an important adequacy parameter in peritoneal dialysis (PD) patients.
- Appropriate assessment of volume status is essential for adequate volume control in PD.
- It remains a difficult task to establish reliable indicative of volume status during routine clinical practice especially in PD.

Changes in BW and UF in HD



Changes in BW and UF in PD



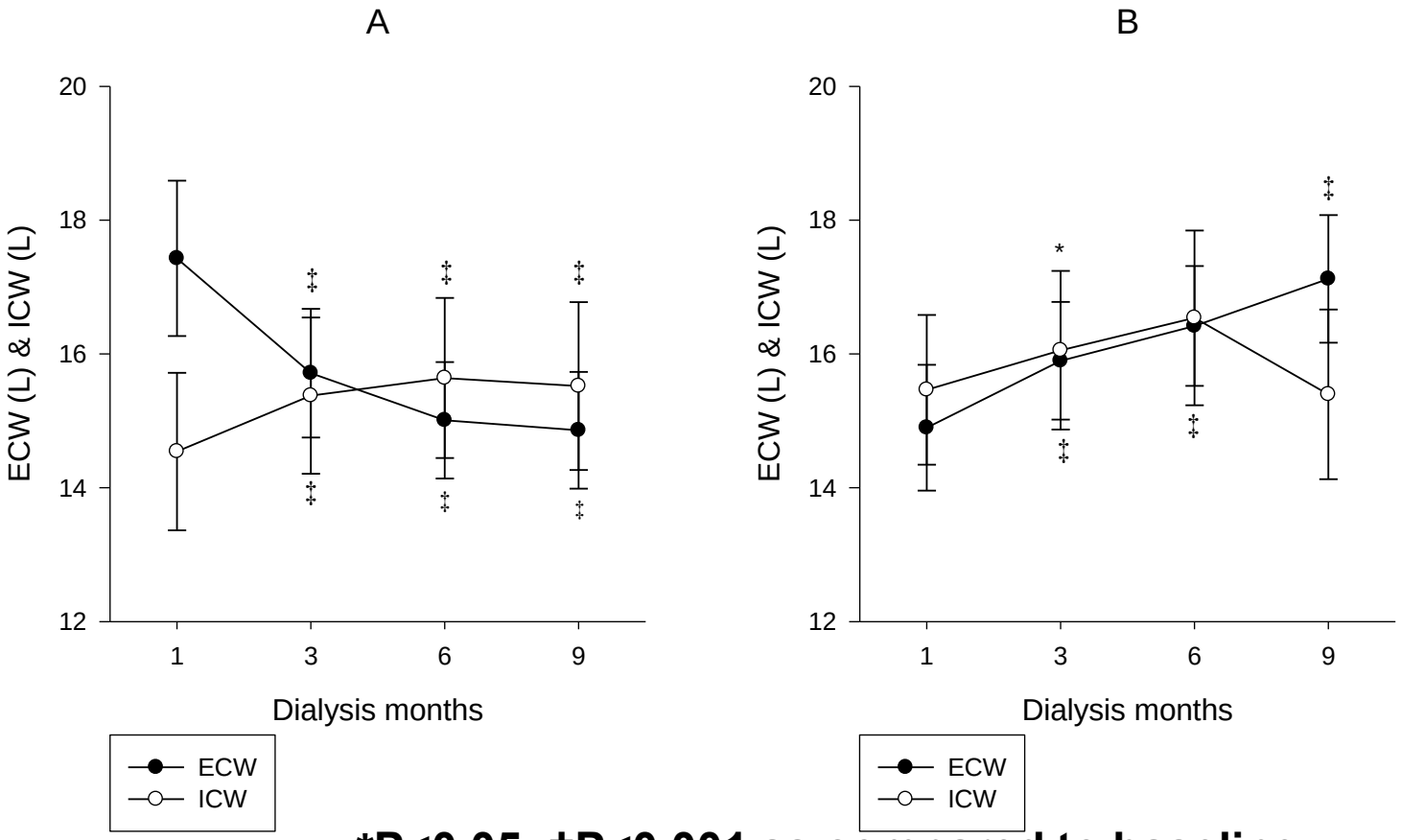
Volume assessment in dialysis patients

- Clinical assessment
  - » Edema
  - » Blood pressure
  - » Body weight
- Chest X-ray
- Biochemistry
- Ultrasound (inferior vena cavadiameter, IVC)
- On-line Hct monitoring
- Isotope methods
- BIA

The traditional bioimpedance devices

- Extracellular water (ECW)
- intracellular water (ICW)
- Total body water (TBW)

Longitudinal changes in ECW and ICW were valuable in clinical study



***P<0.05; ‡P<0.001 as compared to baseline**

American Journal of Kidney Diseases, Vol 45, No 5 (May), 2005: pp 891-902

E/I ratio: predictor of survival for PD patients.

- 227 prevalent PD patients
- Follow-up for 40 months
- The final Cox proportional hazard models for patient survival revealed that only E/I was the significant predictor of death.
- When using E/I as a time-dependent variable, for every increase of 0.1 in the E/I value, the RR of death wa1.368 (95% CI 1.100–1.702, p = 0.005).

Blood Purif 2007;25:260–266

Conclusions from previous bioimpedance studies

- Longitudinal monitoring in particular patients: very helpful
- E/I ratios may be used as an illness marker
- Comparisons between different subjects: values limited
- Normalization not standardized: BW, Height?
- Difficult to estimate dry weight in PD
- Be of great research values but limited clinical values

BCM: a new way to measure hydration status

- ECW
- ICW
- TBW
- E/I
- OH

Questions

- **Are OH values reliable?**
- What Is the Upper Limitation of Volume in PD patients?
- Can OH be used in practice effectively?

Cardiac ultrasound in PD patients OH < 2L vs OH>=2L

	OH＜2 (n=42)	OH≥2 (n=38)	P
LVEDD,mm	44±6	49±7	＜0.01
EDV,L	71.1±30.2	91.7±37.1	0.03
ESV,L	29.8±13.8	39.9±24.2	0.08
LA,mm	34±7	39±6	＜0.01
RV,mm	16±3	18±4	0.04
AO,mm	33±5	36±2	＜0.01
VTI,cm	18.9±6.1	22.6±5.9	0.01
AVmax,m/s	0.94±0.17	1.02±0.20	0.04

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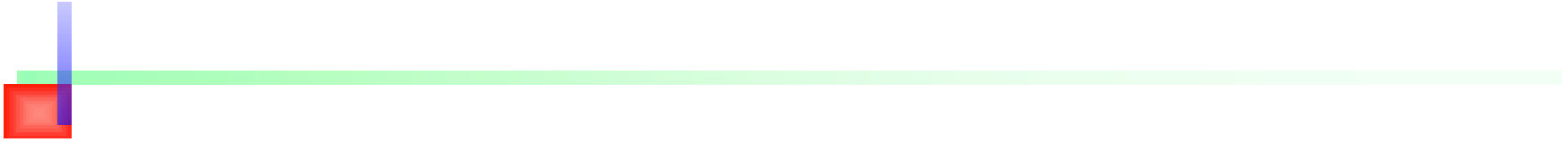
Body composition monitor measurement technique for the detection of volume status in peritoneal dialysis patients: the effect of abdominal fullness

Table 3 Correlation between echocardiographic and body composition monitor parameters in patients with a full or empty abdomen

	OH (FA, DW+)	OH (FA, DW−)	OH (EA, DW+)	OH (EA, DW−)	SBP	DBP
LVM	0.30	0.29	0.42*	0.42*	0.42*	0.32
LAV	0.44*	0.38	0.56**	0.55**	0.44*	0.37

OH Overhydration, *DW* dialysate weight, + included, − excluded, *FA* full abdomen, *EA* empty abdomen, *LVM* left ventricular mass, *LAV* left atrium volume, *SBP* systolic blood pressure, *DBP* diastolic blood pressure

* $P < 0.05$, ** $P < 0.01$



The use of BCM in PD patients: the longitudinal study

- 220 PD patients
- Followed for 6 months
- Grouped into:
- Sustained overloaded group (47) : all OH > 2
- Normal volume group (94): all OH < 2L
- Intermittent volume overloaded group (79): the rest

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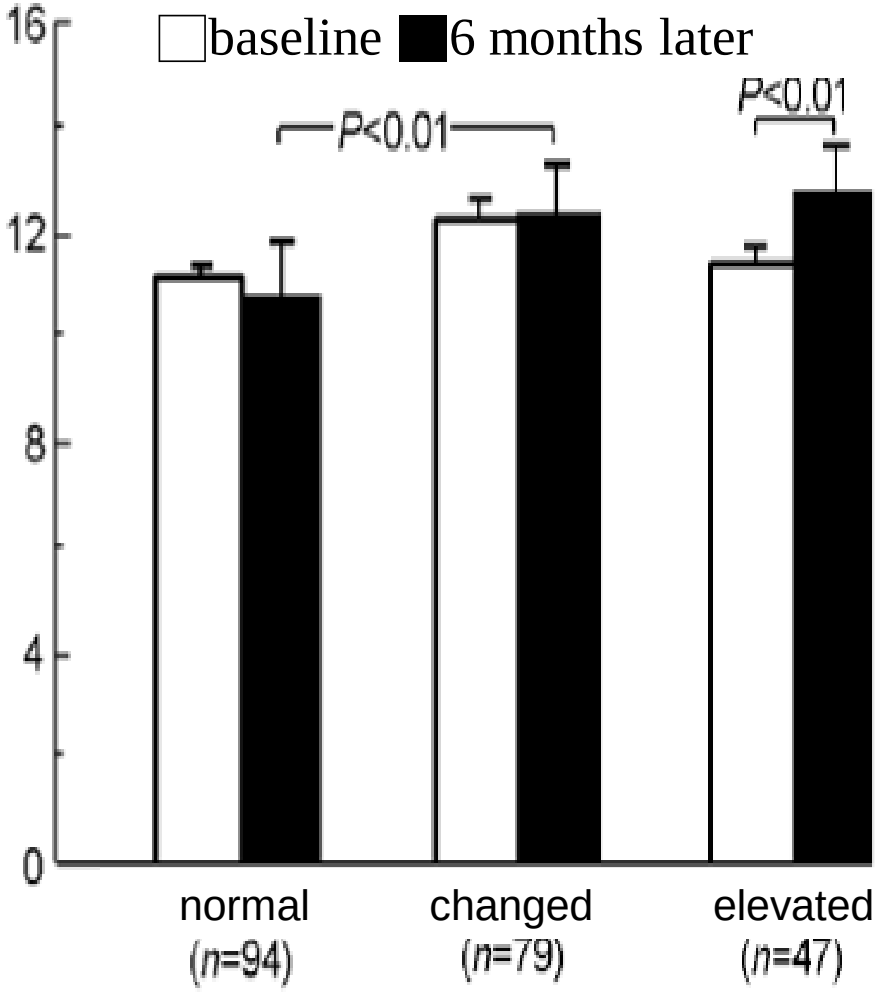
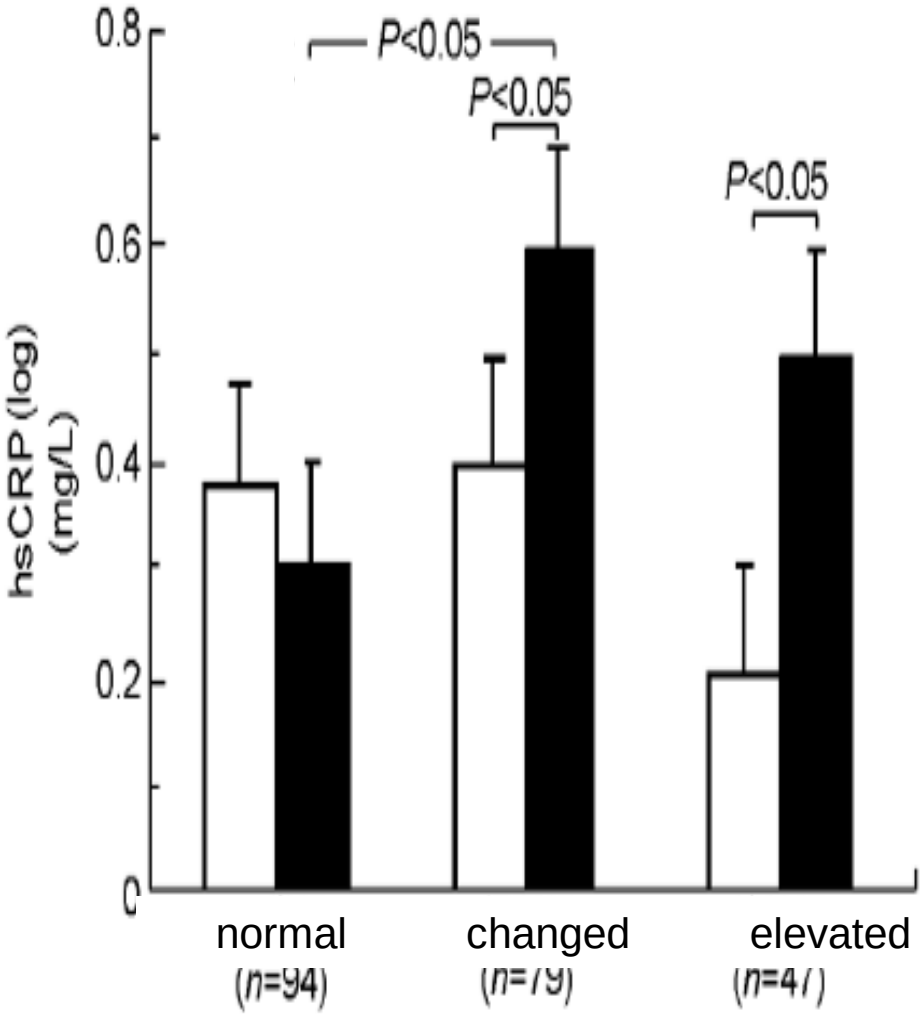
Changes in PWV and CRP in PD patients with different volume status



Change of PWV



Change of CRP

Chin J Hypertens, Oct 2009, Vol.17 No.10

Factor affecting edema status in PD

Logistic Regression Analysis of Independent Factors Affecting Edema Status

Variable	Regression coefficient	SE	Odds ratio	95% CI	*p* Value
Model A[a]					
FMD	−0.106	0.05	0.90	0.81–0.99	0.036
Overhydration	1.118	0.35	3.06	1.53–6.13	0.002
Gender	1.400	0.61	4.06	1.23–13.35	0.021
sALB	−0.151	0.07	0.86	0.75–0.99	0.035
Constant	2.93	2.92	18.64		0.316
Model B[b]					
FMD	−0.120	0.051	0.887	0.802–0.980	0.019
Overhydration/TBW	0.238	0.093	1.268	1.058–1.520	0.010
sALB	−0.156	0.080	0.856	0.731–1.001	0.052
Constant	5.015	3.386	150.727		0.139

FMD = flow-mediated dilatation; sALB = serum albumin; TBW = total body water; SE = standard error; CI = confidence interval.

[a] Variable(s) entered to the logistic regression model A: gender (male = 1, female = 2; male treated as the reference category), overhydration, endothelial function assessed by FMD, sALB, and total fluid removal.

[b] Variable(s) entered to the logistic regression model B: gender (male = 1, female = 2; male treated as the reference category), ratio of overhydration to TBW, endothelial function assessed by FMD, sALB, and total fluid removal.

Tang W, Xue T, Lu XH, Luo YJ, Wang T. Factors contributing to formation of edema in volume overloaded continuous ambulatory peritoneal dialysis patients. Perit Dial Int. 2011 Mar;31(2):160-7.

Interesting findings: male PD patients had significant high OH as compared to female

Tal

Index	Male	Female
OH	3.05±2.15	1.86±1.52*
n ECW	0.27±0.04	0.24±0.05*
E/T	0.49±0.04	0.50±0.04
E/I	0.96±0. 15	0.99±0. 15
DD	23.49±20.35	25.78±17.51
SBP	137.08±24.83	132.27±24.33
DBP	79.4±14.26	76.4±14.19
Scr	889.35±299.42	759.45±246.67
TG	2.08±1.29	2.65±1.68
hs-CRP (log)	0.37±0.68	0.34±0.64
Ca^{++}	2.30±0.32	2.34±0.32
P^{+++}	1.55±0.43	1.54±0.37
Tcho	4.85±1.04	5.49±1.13*
Alb	38.6±4.45	39.1±4.03
Glu	5.99±2.24	5.94±2.09
KT/V(RRF)	0.52±0.54	0.59±0.69

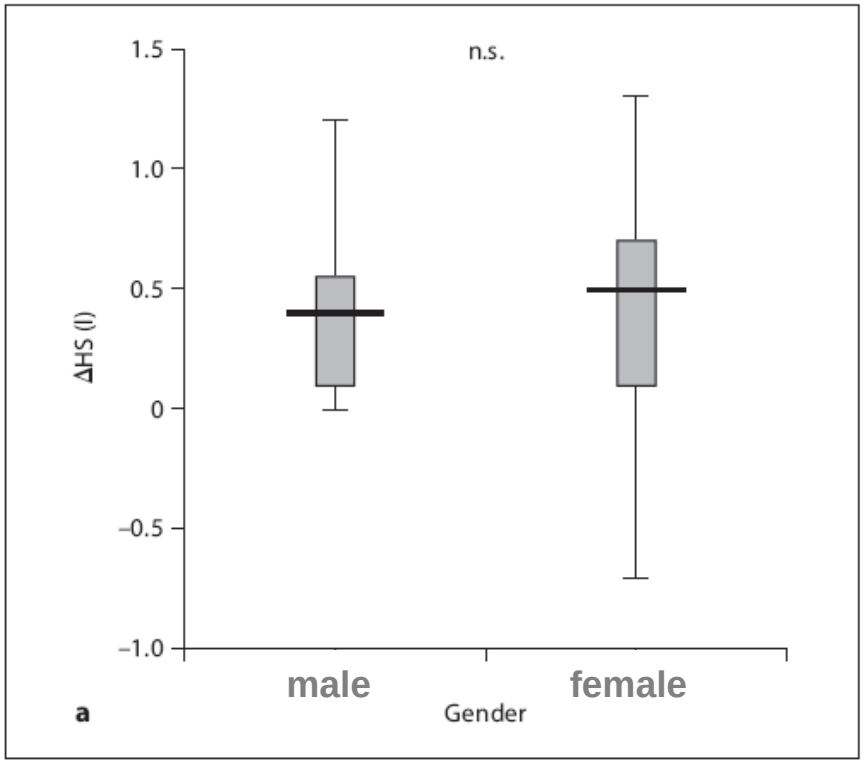
*$P<0.01$

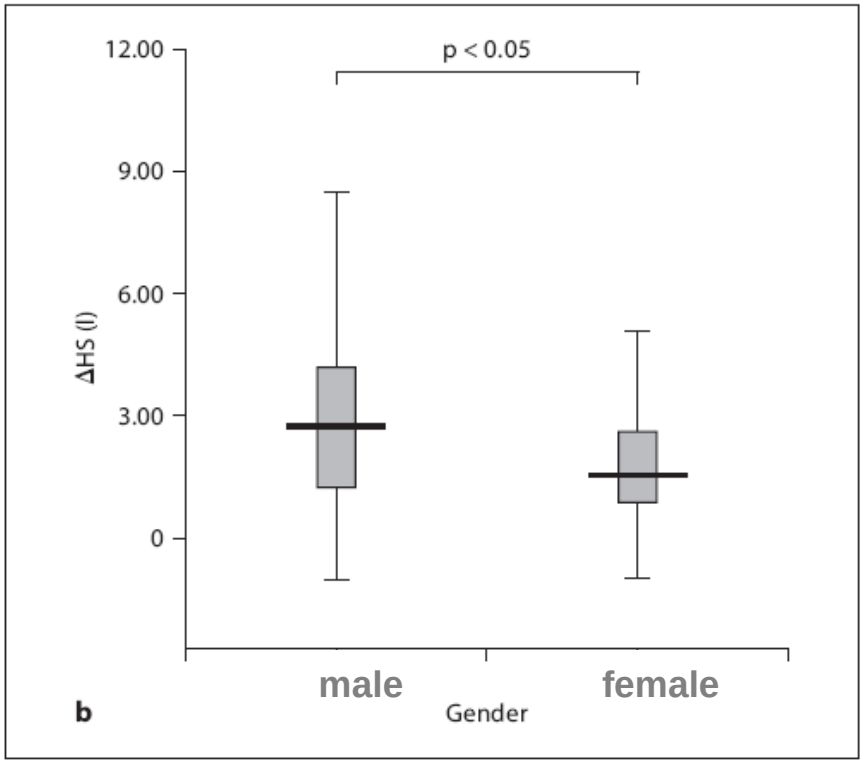
Clinical evaluation of volume status between male and female PD patients

		Volume overload		Total
		Yes 0	No 1	
Gender	Male0	61	49	110
	Female1	49	34	128
Total		155	83	238

P=0.006

Different gender and volume status in healthy control and PD patients





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Fluid Status in Peritoneal Dialysis Patients: The European Body Composition Monitoring (EuroBCM) Study Cohort

Wim Van Biesen[1]*, John D. Williams[2], Adrian C. Covic[3], Stanley Fan[4], Kathleen Claes[5], Monika Lichodziejewska-Niemierko[6], Christian Verger[7], Jurg Steiger[8], Volker Schoder[9], Peter Wabel[9], Adelheid Gauly[9], Rainer Himmele[9], on behalf of the EuroBCM study group

Δ Tissue Hydration from the subgroup of

Table 3. Multivariate linear regression for Relative ΔTissue Hydration from the subgroup of patients from Belgium, France and UK.

Parameter	Coefficient	95% CI		p-value
Intercept	**30.27**	20.65	39.88	<0.0001
Age (per year)	**0.10**	0.05	0.16	0.0002
Sex (female vs male)	**−3.04**	−4.55	−1.52	0.0001
Albumin per g/l	**−0.75**	−0.91	−0.59	<0.0001
BMI per kg/m^2	**−0.66**	−0.83	−0.50	<0.0001
Diabetes (vs no diabetes)	**4.86**	3.14	6.59	<0.0001
Systolic BP (per mmHg)	**0.09**	0.05	0.12	<0.0001
Glucose at least once 2.5% vs. 1.5% only	**−0.73**	−2.56	1.11	0.80
Glucose at least once 3.86/4.25% vs. 1.5% only	**5.18**	2.62	7.74	<0.0001

Logistic regression for Overhydration in PD

Logistic Regression for "Overhydration"

	Exponent beta	*p* Value
Age (per year)	1.004	0.8
PD vs pre-HD vs post-HD	0.47	0.007
Diabetes	0.76	0.6
Gender (male)	2.9	0.03

PD = peritoneal dialysis; HD = hemodialysis.
Total R^2 of the model: 0.38; $p < 0.001$.

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Why male PD patients are more volume overloaded?

Indexs	Female	Male
Na^+（mmol/L）	138.77±2.60	139.52±3.54
Na^+（out-put in urine）（mmol/24h）	36.89±38.41	48.18±47.6
Na^+（out-put in dialysate）（mmol/24h）	61.61±58.90	70.01±52.81
Na^+(total clearance) （mmol/24h）	96.47±57.34	118.13±50.26*
Dialysate in-put（ml/24h）	5824.08±1555.09	6284.62±1644.69
Ultrafitration（ml/24h）	525.94±393.77	463.78±439.74
Urine volume（ml/24h）	520.59±476.284	661.14±564.11**
Total clearance（ml/24h）	1042.56±501.98	1112.54±598.62**
KpT/V urea	1.43±0.47	1.16±0.41
KrT/V urea	0.59±0.69	0.52±0.54
Total KT/V urea	2.02±0.63	1.72±0.43*
DEI（KJ/d）	1293.37±378.23	1533.56±4.2.64*
DPI （g/d）	42.42±12.18	52.45±15.01*

*$P<0.01$; **$P<0.05$

Questions

- Are OH values reliable?
- **What Is the Upper Limitation of Volume in PD patients?**
- Can OH be used in practice effectively?

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Fluid Status in Peritoneal Dialysis Patients: The European Body Composition Monitoring (EuroBCM) Study Cohort

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- A cross sectional, observational, multi center trial in 28 centers in 6 European countries.
- Measurements of hydration and body composition by BCM
- Definition:
- fluid overload: RΔTH was greater than 7% (absolute value is 1.1 Liter)
- severe fluid overload: RΔTH ratio >15%
- AΔTH: Absolute Δ Tissue Hydration
- RΔTH = AΔTH/ECW

Overhydration in PD vs HD

Parameters in Hemodialysis (HD) Versus Peritoneal Dialysis (PD)

	Pre-HD (*n*=44)	Post-HD (*n*=44)	PD (*n*=34)	*p* Value
Age (years)	67.7±13.5		61.2±16.9	0.06
Gender (% male)	50.0		55.9	0.6
Diabetes (%)	36.4		14.7	0.04
Dialysis vintage (months)	36.4±16.5		19.9±16.5	<0.001
CAPD vs APD (%)			64.7	
Diuretics (%)	66		88	0.04
Ideal weight (kg)	71.4±18.8		70.0±10.4	0.7
Height (cm)	167±9		164.5±10	0.2
Systolic blood pressure (mmHg)	144±24	135±30	127±28[c]	0.02
Diastolic blood pressure (mmHg)	72±12	72±12	76±16	0.2
Albumin (mg/dL)	3.7±0.4		3.6±0.4	0.3
hs-CRP (mg/L)	0.5±0.8		1.3±3.2	0.3
Ultrafiltration (mL)	1796±869/session		572±597/day	
Diuresis category	2.2±0.1		2.4±0.9	0.4
TBW (L)	33.7±6.9	31.8±8.1	33.9±6.7	0.3
ECW (L)	16.4±3.9	15.3±4.9	16.8±3.3	0.3
ICW (L)	17.1±6.2	16.5±4.6	17.2±3.9	0.7
ECW/height	9.7±1.9	9.1±2.0[a]	10.2±1.9	0.05
Lean tissue mass (kg)	31.1±10.7	31.9±11.0	34.5±10.2	0.2
Fat tissue mass (kg)				
Overhydration (L)	1.9±1.7	0.6±1.7[b]	2.1±2.3	<0.001
Relative overhydration	0.11±0.08	0.03±0.09[b]	0.11±0.11	<0.001
Overhydrated (>0.15)	22.3%	10%[b]	24.1%	<0.001

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Original Paper

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What Is the Upper Limitation of Volume in Chinese Peritoneal Dialysis Patients?

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- A cross-sectional study,
- 92 stable CAPD patients
- 45 matched healthy population

Results from different cutoff values of OH

Table 3. Results from different cutoff values, %

ΔHS value	Sensitivity	Specificity	PPV	NPV
1.0 liter	87.3	44.8	77.5	61.9
1.5 liters	74.6	72.4	85.5	56.8
2.0 liters	69.8	89.7	93.6	57.8
2.5 liters	63.5	93.1	95.2	54
3.0 liters	57.1	100	100	51.8

PPV = Positive predictive value; NPV = negative predictive value.

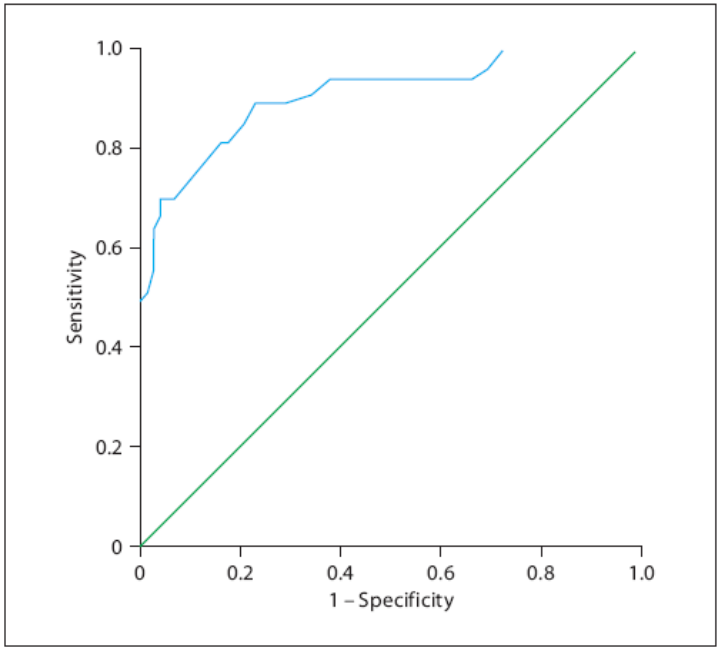

Fig. 1. Receiver-operating characteristics curve of the ΔHS value for the prediction of volume overload.

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Questions

- Are OH values reliable?
- What Is the Upper Limitation of Volume in PD patients?
- **Can OH be used in practice effectively?**

Original Paper

Blood Purification

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Volume Control in Peritoneal Dialysis Patients Guided by Bioimpedance Spectroscopy Assessment

Ya-Jun Luo[a] Xin-Hong Lu[a] Feidhlim Woods[b] Tao Wang[a]

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- A prospective, randomized, controlled study
- 160 stable CAPD patients were enrolled
- followed up 12 weeks
- To test if the usage of OH as a guide to volume management would get better volume and hypertension management
- Group intenvetion
- In Group 1: the patients and primary nurses were informed of OH values provided by a BCM
- in Group 2: OH values were withheld from the patients and the primary nurses, who then based their patient management solely on the previous protocols.

Demographic data at baseline for study patients

	Group 1	Group 2
Patients	78	82
Male	34 (43.6)	40 (48.8)
DM	21 (26.9)	23 (28.0)
Age, years	59.63 ± 13.89	60.28 ± 16.01
Height, cm	159.83 ± 8.17	160.10 ± 8.38
Weight, kg	63.71 ± 12.46	60.67 ± 10.79
OH, l	2.30 ± 1.95	2.20 ± 1.66
ECW, l	16.05 ± 3.55	15.29 ± 3.12
ICW, l	16.75 ± 4.03	16.04 ± 4.01
E/I	0.98 ± 0.16	0.97 ± 0.15
SBP, mm Hg	137.63 ± 19.12	132.96 ± 22.35
DBP, mm Hg	80.68 ± 14.52	75.59 ± 14.66
Dialysis vintage, months	35.2 ± 32.34	33.2 ± 30.97
Urine volume, ml	751.63 ± 382.95	804.33 ± 398.24
Ultrafiltration, ml/day	587.3 ± 287.66	532.6 ± 389.63
Total fluid removal, ml	1,342.08 ± 403.67	1,438.9 ± 451.85
Total sodium removal, g/day	2.95 ± 1.03	2.81 ± 1.47
Glucose exposure, g/day	113.5 ± 18.52	123.33 ± 17.59
Glucose concentration, %	1.89 ± 0.11	1.86 ± 0.2
Total DDD	2.51 ± 1.76	2.49 ± 1.42

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Changes in fluid status and BP in the 2 groups during the study period

Group	Baseline	6 weeks	12 weeks
Weight, kg			
1	63.71 ± 12.46	63.60 ± 12.57	62.89 ± 13.22
2	60.67 ± 10.79	60.86 ± 11.14	61.09 ± 11.21[a]
OH, l			
1	2.30 ± 1.95	2.12 ± 1.65	1.72 ± 1.51[a]
2	2.20 ± 1.66	2.43 ± 1.75[a]	2.52 ± 1.83[a, b]
ECW, l			
1	16.05 ± 3.55	15.80 ± 3.43	15.49 ± 3.45[a]
2	15.29 ± 3.12	15.51 ± 3.34	15.52 ± 3.43[a]
ICW, l			
1	16.75 ± 4.03	16.50 ± 3.96	16.60 ± 4.16
2	16.04 ± 4.01	15.91 ± 3.98	15.81 ± 3.92[a, b]
E/I			
1	0.98 ± 0.16	0.97 ± 0.14	0.95 ± 0.13[a]
2	0.97 ± 0.15	0.99 ± 0.14	1.00 ± 0.14[a]
SBP, mm Hg			
1	137.63 ± 19.12	134.87 ± 21.18	132.99 ± 19.47[a]
2	132.96 ± 22.35	137.11 ± 23.76	139.07 ± 22.40[a, b]
DBP, mm Hg			
1	80.68 ± 14.52	78.51 ± 12.28	77.63 ± 12.04[a]
2	75.59 ± 14.66	79.16 ± 14.16	80.85 ± 14.15[a]
Urine volume, ml			
1	751.63 ± 382.95		688.34 ± 298.56
2	804.33 ± 398.24		786.51 ± 379.74
Ultrafiltration, ml/day			
1	587.3 ± 287.66		663.8 ± 342.86
2	532.6 ± 389.63		789.5 ± 241.73
Total fluid removal, ml			
1	1,342.08 ± 403.67		1,384.96 ± 397.52
2	1,438.9 ± 451.85		1,607.93 ± 369.79

Blood Purif 2011;31:296–302

Conclusions

- Dry weight estimation in dialysis patients especially in PD has been difficult.
- The traditional bioimpedance assessment is an effective way in monitoring fluid changes in PD but had limited clinical values
- Our studies showed that BCM is of significant clinical values and could be used to guide clinical practice
- BCM made it easier to control the volume status in PD patients