Reliability of bioimpedance methods in dialysis patients.

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Background

Bioimpedance
•Reflects body composition
•Is easy, inexpensive and non-invasive to perform
•Some measures of bioimpedance have been shown to predict death[1]

Volume status
•Is difficult to assess
•Many correlates of volume status appear to be on causal pathways towards cardiovascular disease and death
•Can be manipulated
•Is a potential therapeutic target

Hypotheses

•Bioimpedance measures are reliable, and much of the variance derives from patient characteristics rather than intra- and inter-operator error and random error
•The resistance (R) – Reactance (Xc) graph method described by Piccoli and colleagues[2] can be operationalized as a dichotomous assessment of volume overload

Table 1. Reliability study design

Period 1		Period 2	
Replicate 1, observer 1	Replicate 2, observer 2	Replicate 1, observer 2	Replicate 2, observer 1
3 readings	3 readings	3 readings	3 readings

Methods

Patients
- Inclusion
  - Prevalent patients, on haemodialysis more than 6 months
    - Aged > 18 y
- Stable on 3 times weekly haemodialysis
  - Consenting
- Exclusion
  - Amputees, patients with pacemakers

Bioimpedance methods
- Quadscan 4000, Bodystat Inc
- Whole body impedance at 5, 50, 100, 200
- Supine, tetrapolar lead placement
- Proprietary software to calculate phase angle, resistance and reactance
- Correct resistance and reactance for height
- Calculate vector length corrected for height from resistance and reactance
- Piccoli software to plot resistance and reactance[3]
- Interpret each graph in duplicate
- Resolve differences by consensus

Measurements
- Measurements before midweek dialysis, two occasions, 1 week apart
- 2 observers on each occasion, masked to each other's procedures and results
- 48 patients

ANOVA
- GLM in Minitab (copes with missing data)
- Random effects
  - Observer, patient, replicate and period

Results

Table 2. Patient characteristics

	Mean (SD), %
Age, y	60 (16)
Male	69%
Caucasian	63%
Hypertension	75%
Diabetes mellitus	39%
Ischaemic heart disease	9%
Congestive heart failure	3%
Ideal body weight, kg	80 (18)

First observation
Median phase angle was 4.63 degrees (quartiles 3.87, 5.73)
Median vector length was 258 ohm/m (quartiles 239, 304).
By the RXc graph method, 46% were volume overloaded.

Figure 1 Plots of height-corrected resistance against reactance for 48 prevalent haemodialysis patients, each on 4 occasions, stratified by gender

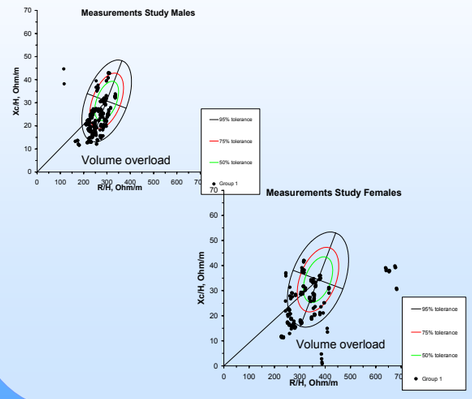
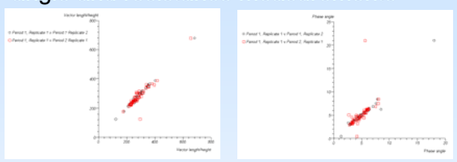


Figure 2. Scatter plots of repeated phase angle and resistance measurements



Variance components

Variance components for phase angle from analysis of variance using a generalised linear model, observer, patient, replicate and period all random effects, eliminating one patient with extreme low body weight (29.4 kg): **Observer 0%, Patient 87%, Replicate 0%, Period 0%, Error 13%**

Variance components for vector length from analysis of variance using a generalised linear model, observer, patient, replicate and period all random effects: **Observer 0%, Patient 92%, Replicate 0%, Period 0%, Error 8%**

Conclusion

About 90% of the observed variance in phase angle and in vector length is due to true variation between patients. The test is not operator dependent and a period of a week between tests did not account for variance beyond error variance.

References

1. Pillon L, Piccoli A, Lowrie EG, Lazarus JM, Chertow GM. Vector length as a proxy for the adequacy of ultrafiltration in hemodialysis. Kidney Int. 2004;66:1266-71
2. Piccoli A, Rossi B, Pillon L, Bucciante G. A new method for monitoring body fluid variation by bioimpedance analysis: the RXc graph. Kidney Int. 1994;46:534-9
3. Piccoli A, Pastori G. BIVA Software 2002, Department of Medical and Surgical Sciences, University of Padova, Padova Italy 2002. Il vettore di impedenza: le formule del Prof Piccoli 2002Available from: URL: http://www.renalgate.it/formule_calcolatori/bioimpedenza.htm (last accessed 2009-10-10)