BIOIMPEDANCE ANALYSIS AND INFERIOR VENA CAVA DIAMETER FOR DRY WEIGHT ASSESSMENT IN PEDIATRIC HEMODIALYSIS PATIENTS

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ABSTRACT

INTRODUCTION AND AIMS: Dry weight (DW) assessment is a common problem in the pediatric population on regular hemodialysis. Differentiating growth from fluid overload is essential to avoid complications. The aim of this study was to assess and follow up DW in children on regular HD by various clinical and non-clinical methods and determine the effect of hemodialysis sessions on different body compartments. **METHODS:** A prospective follow up clinical study was conducted on 40 pediatric patients on regular hemodialysis. DW was assessed using the three methods at the beginning of the study and 8 months later. Clinical methods including pre and post-session blood pressure (BP). Ultra-sonographic measurement of inferior vena cava diameter (IVCD). Multi-frequency bioimpedence analysis (BIA) was done to calculate hydration variables such as total body water (TBW), intracellular water (ICW), extracellular water (ECW), overhydration (OH) and ECW/ICW (E/I ratio). BIA also measured different body tissue parameters as lean tissue mass (LTM), lean tissue index (LTI), fat mass, fat tissue index (FTI) and adipose tissue mass (ATM). All measurements were applied immediately before and two hours after dialysis session. **Study design:** DW was assessed at the beginning and the end of the study by the three methods, then changed according to BIA recommendations. Patients were followed up clinically for 8 months. A concordance rate, between the three methods, was calculated. **RESULTS:** HD sessions caused a significant effect on ECW causing a significant reduction in IVCD, TBW, OH, E/I ratio, systolic and diastolic blood pressure at the beginning and the end of the study but not on ICW. Concerning body tissue parameters, LTM and LTI were significantly decreased at the beginning of the study due to the underestimation of our patients' DW. After adjusting their DW via the BIA recommendations, HD sessions had no significant effect on both. Body fat parameters (fat, FTI and ATM) were not affected by HD sessions at the beginning and the end of the study. The study found that the concordance between clinical recommendations and both BIA and IVCD recommendations increased by the end of our study. Yet the concordance between BIA and IVCD recommendations slightly decreased. After adjusting the patients' DW according to the BIA recommendations, the number of intradialytic hypotensive episodes decreased at the end of the study. **CONCLUSIONS:** BIA and IVCD are additional useful tools that could objectively support clinical assessment. Yet BIA was proved to be an easier and slightly better method of DW assessment than IVCD. Regular adjustment of DW in children has a beneficial impact on the patients' well being and decreased the intradialytic complications occurring as a result of false estimation of DW. With optimal DW adjustment, HD exclusively affects ECW. Excess ultrafiltration (UF) in HD sessions may affect other body compartments especially lean tissue.

FUNDING

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BACKGROUND

DW is defined as the lowest tolerated postdialysis weight - achieved via gradual change in postdialysis weight - at which there are minimal signs or symptoms of hypovolemia or hypervolemia.

DW assessment is particularly problematic in pediatric patients because the body composition, i.e. the ratio of total body water to total body mass, is variable with age, especially during infancy and puberty; in addition there is a normal variation in weight through growth that is supposed to occur in pediatric patients that confuses with weight gain through hypervolemia. Difficult compliance to instructions of intradialytic weight gain adds to the problem.

Inferior vena cava diameter (IVCD) on expiration can detect intravascular overload and depletion in HD patients. It is non-invasive and fast but is greatly affected by the cardiac function. It is operator dependent, not widely available, and expensive.

Multifrequency bioimpedence analysis (BIA) allows to measure both intracellular and extracellular volume. It is non-invasive and sensitive, but expensive.

OBJECTIVES

- Determination of the effect of the dialysis session on BP, IVCD and BIA.
- Comparison of DW evaluation by clinical, IVCD and BIA.
- Follow up of the effect of application of changes in DW by various methods on patients' well being.
- Study of the value of BIA in differentiating growth from fluid overload.

METHODS

This prospective study was conducted at the Pediatric Dialysis Unit, Children's Hospital, Ain Shams University, Cairo, Egypt.

- It included 40 pediatric patients on regular HD therapy [age 4-18 years]. All patients were regularly dialyzed for 3-4 hours/session, thrice weekly using bicarbonate dialysate and low-flux polysulfone hollow fiber. Dialysis adequacy was estimated using the kt/V method (range 0.9-1.4).
- The following were done:
  - History of symptoms of over or underhydration and their relation to HD session as well as recording of intradialytic hypotensive episodes.
  - Pre & post dialysis weight and BP measurement.
  - Maximal inferior vena cava diameter (IVCD) measured by ultrasonography by measuring the anteroposterior IVCD 1.5 cm below the diaphragm in the hepatic segment in supine position during normal expiration.
  - BIA pre and post-dialysis using body composition monitor (Fresenius, Germany) then transferring data to the fluid management tool computer software.

All measurements were performed immediately pre and 2 hours post dialysis by the same operator.

- Clinical signs recommending increasing dry weight were (1) Signs of hypotension towards the end of dialysis session, (2) Signs of dehydration post-dialysis, (3) Weight gain with increased food intake.
- Study design: DW was assessed at the beginning and the end of the study by the three methods, then changed according to BIA recommendations. Patients were followed up clinically for 8 months. A concordance rate, between the three methods, was calculated.

RESULTS

After applying BIA recommendations at 8 months, the number of intradialytic hypotensive episodes decreased from 0.46 to 0.028 episode/patient/session.

Parameter	P0	P8	Parameter	P0	P8
SBP	<0.001	<0.001	IVCD	<0.001	<0.001
DBP	<0.001	<0.001	BMI	<0.001	<0.001
Weight	<0.001	<0.001	LTI	<0.05	>0.05
Calc.DW	<0.001	<0.001	LTM	<0.05	>0.05
V urea	<0.001	<0.001	BCM	>0.05	>0.05
TBW	<0.001	<0.001	FTI	>0.05	>0.05
ECW	<0.001	<0.001	Fat	>0.05	>0.05
ICW	>0.05	>0.05	ATM	>0.05	>0.05

Table 1. Comparison of clinical, IVCD and BIA parameters pre- and post- HD session at 0 (P0) and 8 (P8) months. Total body water (TBW), intracellular water (ICW), extracellular water (ECW), over-hydration (OH), ECW/ICW (E/I ratio), lean tissue mass (LTM), lean tissue index (LTI), fat mass, fat tissue index (FTI) and adipose tissue mass (ATM).

Table 2. Concordance rates between clinical, IVCD and BIA DW recommendations at 0 and 8 months.

	Concordance rate at the start	Concordance rate at 8 months
Clinical vs IVCD	58.3%	64.5%
Clinical vs BIA	65%	68.5%
IVCD vs BIA	66.7%	64.5%

Table 3. BIA recommendations for changes in DW at 0 and 8 months.

	At the start (n = 40)	At 8 months (n = 35)
Increase DW	37 (92.5%) 3 complete	29 (82.9%) 12 Partial 17 Complete
No change in DW	1(2.5%)	2 (5.7%)
Decrease DW	2 (5%)	4 (11.4%) 1 Partial 3 Complete

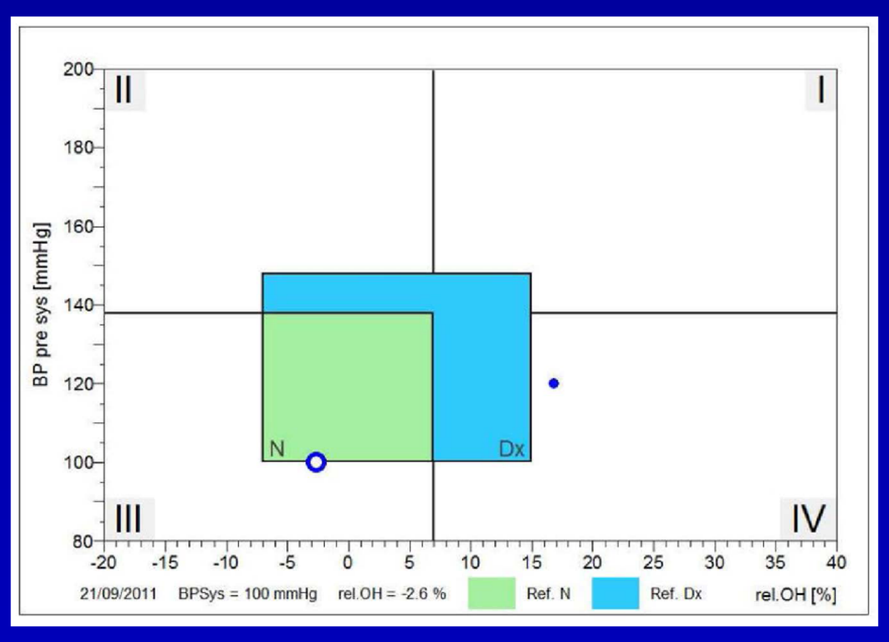

Figure 1. Hydration reference plot of a 16-year-old male patient. It shows that the patient was overhydrated and normotensive before the session (closed circle) then became normo-hydrated and still normotensive after the session (open circle).

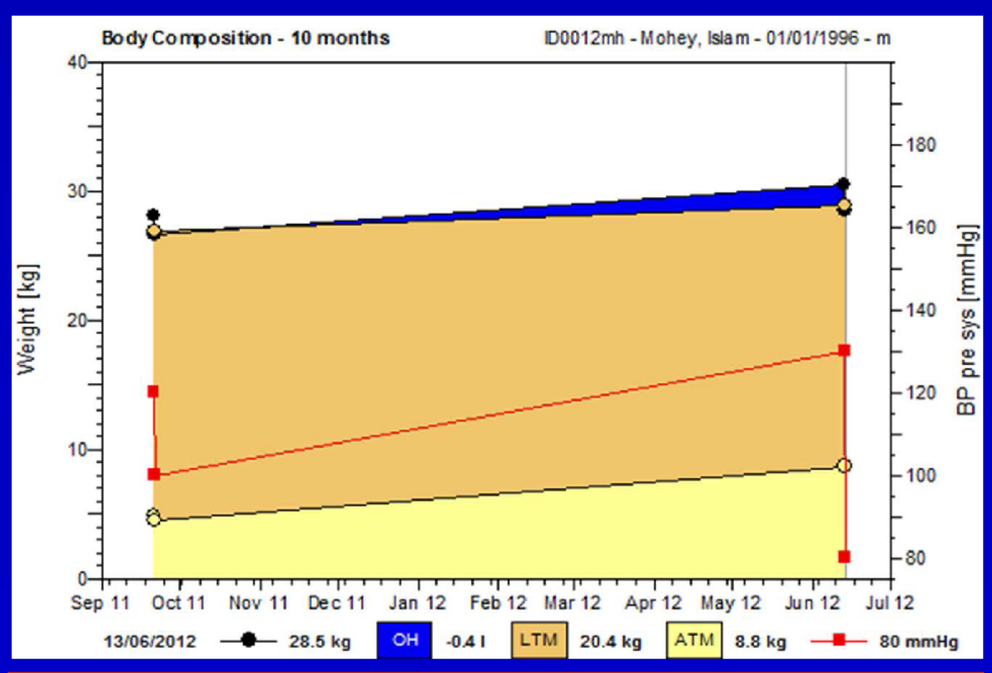

Figure 2. Body composition plot of a 16-year-old male patient.
Dry weight increased from 27 to 28.5 Kg
Lean Tissue Mass decreased from 22.4 to 20.4 Kg
Adipose Tissue Mass increased from 4.6 to 8.8 Kg
Overhydration changed from -0.2 to -0.4 Liters.

CONCLUSIONS

- Clinical evaluation of DW is still the most important method of DW assessment.
- BIA is a useful tool that could objectively support clinical decision and, is easier and slightly better than IVCD.
- Echocardiographic evaluation of all HD patients is essential before deciding changes in DW to avoid unnecessary cardiovascular risks.
- In all situations that necessitate a change in DW, doing so in a gradual manner with close clinical observation is recommended.