Assessment of dry weight by non invasive monitoring of changes in hematocrit in chronic hemodialysis patients

Thesis
Submitted for partial fulfillment of master degree in Pediatrics

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2009


سُبْحَانَكَ لَا عِلْمَ لَنَا
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ
أَنْتَ الْعَلِيمُ الْحَكِيمُ

Acknowledgement

First of all I thank **ALLAH** for helping me and leading me throughout this work .

I'm greatly honored to work under supervision of ***Prof . Dr. Fatina Fadel, Professor of Pediatrics, Faculty of Medicine , Cairo University .*** No words can be sufficient to express my deep gratitude to her and the help she offered to bring this work to light.

I would like to express my sincere appreciation to ***Ass. Prof. Dr. Ayman Emil, Assistant Professor of Pediatrics, Faculty of Medicine , Cairo University .*** I would like to thank him for his continuous guidance and valuable suggestions .

Also, I would like to express my deep feelings and profound gratitude to ***Dr . Samuel Makar, Lecturer of Pediatrics, Faculty of Medicine , Cairo University*** for his continuous instructing guidance and unlimited help and support. I've gained valuable experience from him .

I would like to thank also all the staff members of the nephrology department, Cairo University for their help, support and cooperation.

Last but not the least, I am deeply thankful and always indebted to my parents and my family, who were always supporting and encouraging me.

Abstract

Background: Fluid balance is an integral component of hemodialysis (HD) treatments to prevent under- or overhydration, both of which have been demonstrated to have significant effects on intradialytic morbidity and long-term cardiovascular complications. Fluid removal is usually achieved by ultrafiltration to achieve a clinically derived value for "dry weight".

Objectives: To demonstrate the value of non invasive monitoring of hematocrit during HD in better understanding of hemodynamics in chronic HD patients , better estimation of the dry weight compared to conventional methods in pediatric age group and decreasing the frequency of intradialytic morbid events (IME).

Methods : In this present study, the dry weight of 15 chronic HD pediatric patients was assessed using non invasive blood volume monitoring (NIVM) device and this was compared to the dry weight previously assigned to these patients based on conventional clinical methods. Changes in blood pressure readings together with the frequency of IME, before and after dry weight estimation using NIVM, were recorded and compared.

Key words : *Dry weight, blood volume monitoring, hematocrit, intradialytic morbid events.*

Contents

List of abbreviations

^{125}I-HSA	Radioiodinated Human salt-free albumin
ABPM	Ambulatory blood pressure monitoring
ACE	Angiotensin converting enzyme
Alb.	Albumin
ALP	Alkaline phosphatase
ANP	Atrial natriuretic peptide
APD	Automated Peritoneal dialysis
ARB	Angiotensin receptor blocker
AVF	Arteriovenous fistula
AVG	Arteriovenous graft
BIS	Bioimpedance spectroscopy
BP	Blood pressure
BUN	Blood urea nitrogen
BV	Blood volume
BW	Body weight
Ca	Calcium
CAPD	Continuous ambulatory peritoneal dialysis
C_{Cr}	Creatinine clearance
cGMP	Cyclic Guanidine Monophosphate
CIN	Chronic interstitial nephritis
CKD	Chronic kidney disease
CLM III	Crit-line monitor III
CMV	Cytomegalovirus
CRF	Chronic renal failure
CRI	Chronic renal insufficiency
DBP	Diastolic blood pressure
DBPI	Diastolic blood pressure index
ECF	Extra cellular fluid
ECV	Extra cellular volume
ESRD	End stage renal disease
FSGS	Focal segmental glomerulosclerosis
GFR	Glomerular filtration rate
GN	Glomerulonephritis
Hct	Hematocrit
HD	Hemodialysis
HDF	Hemodiafiltration
HGB	Hemoglobin
HLA	Human leucocytic antigen

HUS	Hemolytic uremic syndrome
ICV	Intracellular volume
IDH	Intradialytic hypotension
IDWG	Interdialytic weight gain
IgA	Immunoglobulin A
IME	Intradialytic morbid events
IU	International unit
IVCD	Inferior vena caval diameter
K	Potassium
K/DOQI	Kidney Disease Outcome Quality Initiative
LVMI	Left ventricular mass index
MARP	Million of the age related population
MBP	Mean blood pressure
MBPI	Mean blood pressure index
Meq/L	Milliequivalent per litre
MFBIS	Multifrequency bioimpedance spectroscopy
MPGN	Membranoproliferative glomerulonephritis
Na	Sodium
NAPRTCS	North America Pediatric Renal Trials and Collaborative Study
NHANES III	Third National Health and Nutrition Examination Survey
NIVM	Non invasive blood volume monitoring
NKF	National Kidney Foundation
P	Phosphorus
$P_{creat.}$	Plasma creatinine
PD	Peritoneal dialysis
PET	Peritoneal equilibration test
PRR	Plasma refill rate
PTH	Parathormone hormone
PV	Plasma volume
Q_B	Blood flow rate
R	Resistance
RBCs	Red blood cells
RCV	Red cell volume
RIA	Radioactive immunosorbent assay
RRF	Residual renal failure
RRT	Renal replacement therapy
SBP	Systolic blood pressure
SBPI	Systolic blood pressure index
sCr.	Serum creatinine
SD	Standard deviation
SFBIA	Single Frequency Bioimpedance Analysis

SLE	Systemic lupus erythematosus
TBV	Total blood volume
TBW	Total body water
TQA	Transcutaneous Access
TUPEPD	Turkish Pediatric Peritoneal Dialysis
UF	Ultrafiltration
UFR	Ultrafiltration rate
UKM	Urea kinetic modeling
USRDS	United States Renal Data System
VCD	Vena caval diameter
Xc	Reactance
Z	Impedance
ΔBV	Blood volume change
ΔRBV	Relative blood volume change

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Introduction and aim of the work:

Introduction:

The current focus on Kt/V as an index for adequacy of dialysis in terms of solute removal ignores the contribution of volume as an independent factor influencing outcome. Ultrafiltration adequacy is related to the concept of dry weight achievement. Patient's dry weight is defined as the weight at the termination of a regular dialysis session, below which the patient will become symptomatically hypotensive. Incorrect estimation of dry weight will lead either to chronic fluid overload or chronic dehydration. Unfortunately, there is no standard measure of dry weight and as a consequence it is difficult to ascertain adequacy of fluid removal for an individual patient. Additionally, there is a lack of information on the effect of ultrafiltration on fluid shifts in the extracellular and intracellular fluid spaces. It is evident that a better understanding of both interdialytic fluid status and fluid changes during hemodialysis is required to develop a precise measure of fluid balance. Intradialytic hypotension continues to be a leading problem, therefore prevention of intradialytic hypotension remains an important challenge to the dialysis physician (***Goldstein, 2004***).

Aim of the work:

To assess the value of non invasive monitoring of hematocrit during HD in better understanding of hemodynamics of chronic HD patients and better estimation of the dry weight compared to conventional methods in pediatric age group, together with minimizing the frequency of IME.

Introduction:

Chronic renal failure (CRF) and chronic renal insufficiency (CRI) are clinical terms used to describe renal dysfunction of varying degrees from mild to severe in nature. In some cases, it is progressive and common to all forms of kidney injury, including that due to developmental, genetic, immunologic, metabolic, traumatic, or infectious processes. Rather than CRI or CRF, the term chronic kidney disease (CKD) more clearly defines renal dysfunction as a continuum, rather than a discrete change in renal function based on the glomerular filtration rate (GFR)***(Tarak and Bradley, 2007).***

Definition:

CKD is defined as: Kidney damage for 3 months, as defined by structural or functional abnormalities of the kidney, with or without a decreased GFR, manifested by either pathological abnormalities; or markers of kidney damage, including abnormalities in the composition of blood or urine, or abnormalities in imaging tests. ***Or,*** GFR < 60 mL/min per 1.73 m^2 for 3 months, with or without kidney damage ***(NKF. K/DOQI clinical practice guidelines, 2002).***

A staging system for stratification of CKD based on the level of kidney function, independent of the primary renal diagnosis has been developed:

Stage 1: Kidney damage with normal GFR (≥90 mL/min/1.73 m^2).

Stage 2: Kidney damage with mild decrease in GFR (GFR between 60 to 89 mL/min/1.73 m^2).

Stage 3: Moderate decrease in GFR (GFR between 30 and 59 mL/min/1.73 m^2).

Stage 4: Severe decrease in GFR (GFR between 15 and 29 mL/min/1.73 m^2).

Stage 5: Kidney failure (GFR of less than 15 mL/min/1.73 m^2) ***(NKF. K/DOQI clinical practice guidelines, 2003).***

The use of serum creatinine alone is widely acknowledged as an inaccurate measure. It is well known that >50% of functioning nephron mass must be lost prior to a perceivable change in serum creatinine, and

that the absolute levels need to be interpreted within the context of muscle mass and gender. Thus, serum creatinine alone as a measure of kidney function is a poor tool ***(Levin, 2003)***.

Irrespective of the formula used to estimate GFR e.g. Schwartz formula, the important issue is that any calculation is a better estimate of kidney function than serum creatinine alone. The purpose of the guidelines emphasis on estimated GFR is to improve the identification of kidney disease by transforming serum creatinine into a more meaningful measure. The implications of this approach and improvement in identification of significant kidney impairment were studied . It was found not only that a single time point measurement of creatinine when transformed could be interpreted as significantly abnormal, but of those patients with abnormal kidney function, previous values tabulated up to 4 years demonstrated previously a steady decline in kidney function, despite normal range values for serum creatinine; this was true for over 20% of the population in whom there was available data ***(Duncan et al., 2001).***

The GFR is equal to the sum of the filtration rates in all of the functioning nephrons; thus, estimation of the GFR gives a rough measure of the number of functioning nephrons. A reduction in GFR implies either progression of the underlying disease or the development of a superimposed and often reversible problem, increase in GFR, on the other hand, is indicative of improvement in renal function, whereas a stable GFR implies a stable condition ***(Tarak and Bradley, 2007).***

The normal GFR varies with age, gender, and body size. Children achieve adult values for mean GFR at approximately two years of age (table 1).

Table 1 : Normal GFR in children and young adults

Age (gender)	Schwartz equation	Mean GFR ± SD mL/min/1.73m^2
1 week (males and females)	GFR=0.33*(Length/SCr) in Preterm	40.6±14.8
	GFR=0.45*(Length/SCr) in Term	
2-8 weeks (males and females)	GFR=0.45*(Length/SCr)	65.8±24.8
>8 weeks (males and females)	GFR=0.45*(Length/SCr)	95.7±21.7
2-12 years (males and females)	GFR=0.55*(Length/SCr)	133.0±27.0
13-21 years (males)	GFR=0.70*(Length/SCr)	140.0±30.0
13-21 years (females)	GFR=0.55*(Length/SCr)	126.0±22.0

SD: standard deviation; ***sCr***: serum creatinine in mg/dL.

(NKF. K/DOQI clinical practice guidelines, 2002)

Multiple prediction equations, therefore, have been developed to estimate GFR from the serum creatinine concentration. In children, the level of GFR can be estimated from the Schwartz equation. Although this equation is imprecise with more advanced renal insufficiency, it is convenient and practical in daily clinical practice. In the Schwartz equation, GFR is calculated by the following:

GFR = K X Height (cm) / P_{creat}.

Height represents the body height measured in centimeters, and P_{creat}. is the plasma creatinine. The constant K is directly proportional to the muscle component of body, and varies with age. The value for K is 0.33 in premature infants through the first year of life, 0.45 for term infants through the first year of life, 0.55 in children and adolescent girls, and 0.7 in adolescent boys ***(Schwartz and Gauthier, 1985; Schwartz et al., 1984).***

Incidence:

The epidemiological studies that have been performed provide evidence that end stage renal disease (ESRD) represents the "tip of the iceberg" of CKD and suggest that patients with earlier stages of disease are likely to exceed those reaching ESRD by as much as 50 times. Large population-based studies, such as the Third National Health and Nutrition Examination Survey (NHANES III), have made it possible to estimate the incidence and prevalence of CKD in the adult population. According to this report, the prevalence of patients with early stages of CKD (stages 1–4; 10.8%) is approximately 50 times greater than the prevalence of ESRD (stage 5; 0.2%) ***(Coresh et al., 2003).***

There is no comparable information available in the United States on the prevalence of the earlier stages of CKD in children and its relationship to ESRD. This is, in large part, due to differences in disease etiology for children and adults ***(Warady and Chadha, 2007).***

Population-based data from Italy (ItalKid Project) has reported a mean incidence of preterminal CKD (C_{Cr} < 75 mL/min per 1.73 m^2) of 12.1 cases per year per million of the age-related population (MARP), with a point prevalence of 74.7 per MARP in children younger than 20 years of age ***(Ardissino et al., 2003).***

The incidence rate of ESRD, adjusted for race and gender, is much higher among adults than among children. Data from the USRDS