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Combining inferior vena cava diameter and right atrial volume index with pro-bnp in assessment of volume status in haemodialysis patients

Abstract

Background: The need for a concept of dry weight derives from an awareness of the dangers of being fluid overloaded. Which reflected by strain on the heart also abnormal low fluid load is also harmful and it might be associated with unacceptable degrees of low blood pressure and consequently of ischemia of vital organs. To judge excess volume, there are no gold standards, but its assessment has been done using a variety of tools. Physical examination which based on patient's interdialytic weight gain and clinical signs, the assessment of volume is made poorly by physical examination. The assessment of inferior vena cava (IVC) diameter and its collapse with inspiration have been the most commonly used echocardiographic techniques to assess intravascular volume. Right atrial volume index which is noninvasive echocardiographic tool for assessment of volume overload but not widely used due to lack of data about right atrial volume even in normal population. NT-pro BNP is one of natriuretic peptides which secreted mainly upon mechanical stretching of cardiomyocytes, Both BNP and NT-proBNP are eliminated during hemodialysis, but they show different behaviors depending on the chosen dialysis membrane.

Methods: The study was conducted on two groups group I include 20 ESRD patients maintained on regular HD three times/week, four hour/session which they subdivided into two subgroups. The 1st subgroup included ten patients using high flux dialyzers and the 2nd subgroup included ten patients using low flux dialyzers. Group II: include ten healthy subjects as a control group. We estimate Urea, Cr, Hg and NT pro BNP by enzyme linked immune-sorbent assay (ELISA), trans-thoracic echocardiography stressing on inferior vena cava diameter and collapsibility index, right atrial volume index to the patients before and after HD and also in 2nd group.

Results: There was statistical significant difference between the pre HD and post HD in mean BP, Rt. at volume index, IVC diameter, and IVC collapsibility index. There were statistical significant difference between the Pro BNP low flux in pre HD and post HD, the Pro BNP high flux in pre HD and post HD.

Conclusion: Mean BP, Rt. at volume index, IVC diameter and pro BNP high flux were significantly decreased post HD session, and IVC collapsibility index, and proBNP low flux were increased post HD. So we can combine these parameters for effected evaluation of dry weight.

Keywords: ESRD, hemodialysis, dry weight, proBNP, IVC collapsibility; Right atrial volume

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Abbreviations: RRT, renal replacement therapy; ESRD, end stage renal disease; IVC, inferior vena cava; RAV, right atrial volume; NT-proBNP, N-terminal pro brian natriuretic peptide; HD, hemodialysis; Cr, creatinine; LL oedema, lower limb oedema; ELISA, enzyme linked immune - sorbent assay; BP, blood pressure; DW, dry weight; RA, right atrium; RAP, right atrial pressure.

Introduction

Hemodialysis is still the most common renal replacement therapy (RRT) modality in end stage renal disease patients (ESRD), The Dry Weight (DW) may be described as the weight at which the patient has no excessive extracellular fluid in the tissue, the body fluid is more similar to the healthy condition, and the normal balance of fluid intake and output is maintained.[1] To judge excess volume, there are no gold standards, but its assessment has been done using a variety of tools.[2] Underestimation of the dry weight of hemodialysis patients can result in unwelcome symptoms and interdialytic hypotension, which may be associated with adverse outcomes.[3,4] Similarly, overestimation of dry weight can lead to chronic volume overload, which increases cardiovascular morbidity and mortality[5] Physical examination which based on patient's interdialytic weight gain and clinical signs,[6] the assessment of volume is made poorly by physical examination.[7,8] Inferior vena cava diameter and collapsibility index the assessment of inferior vena cava (IVC) diameter and its collapse with inspiration have been the most commonly used echocardiographic techniques to assess intravascular volume.[9–12] Right atrial volume index The ability to visualize the right atrium (RA) allows a quantitative, highly reproducible assessment of the RA volume that can be indexed to body surface area.[13,14] Echocardiography is most widely used and best available noninvasive imaging technique for determination of RA volume.[15]

Aim of the study

The aim of this work is to evaluate the validity of IVC diameter and right atrial volume index with Pro-BNP in assessing volume status in the patients on hemodialysis.

Methods and subjects

The present study included two groups: Group I: included 20 subject patients maintained on regular bicarbonate hemodialysis three times/week four hours/session using a polysulfone membrane and this group subdivided into two categories. The 1st subgroup included ten subject patients using high flux dialyzers and the 2nd subgroup included ten subject patients using low flux dialyzers. Group II: include ten healthy subjects as a control group. With Exclusion criteria:- Patients with left heart failure (excluded by LVEF <50%), patients with significant right sided heart disease. Eg: sever tricuspid valve regurgitation, endomyocardial fibrosis, ebstein's anomalis, and constrictive pericarditis. Chronic atrial fibrillation with right atrial dilatation.Protocol measurement was carried out on the same day of before hemodialysis and next to the session. Included: height, bodyweight, body mass index, systolic and diastolic blood pressure, clinical signs of volume overload and hydration (LL oedema, dyspnea, chest crepitations, congested neck vein), laboratory investigation including Urea, Cr, Hg and NT pro BNP by (ELISA), trans-thoracic echocardiography stressing on inferior vena cava diameter and collapsibility index, right atrial volume index.

Results

The characteristics of the 20 HD patients (10 M, 10 F) before and after a dialysis session and 10 subject healthy controls are reported in Table 1. There was statistical significant difference between the pre HD and post HD in mean BP, Rt. at volume index, IVC diameter, and IVC collapsibility index %. There were statistical significant difference between the Pro BNP low flux in pre HD and post HD, the Pro BNP high flux in pre HD and post HD. There were an insignificant positive correlation between RAV index and Pro BNP In group I pre HD and post HD. In group I pre HD there was an insignificant negative correlation between IVC collapsibility index and Pro BNP but in group I post HD There was an insignificant positive correlation between IVC collapsibility index and Pro BNP (Tables 2–4).

Table 1 Comparison between Group I per and post HD according to the pro BNP

	Group I Pre HD (n=10)	Group I Post HD (n=10)	P
Pro BNP Low Flux	1011-1851	1213-2642	0.027
R. Mean±SD	1237.20±251.63	1609.10±419.02	
Pro BNP High Flux R.	1042-2812	671-1532	0.003
Mean±SD	1661.60±477.81	1058.50±289.56	

R =Ranged M = Mean SD = Standard deviation

Px: value for comparing between the pre HD and post HD.

Py: value for comparing between the two studied groups.

Table 2 Correlation between RAV index and Pro BNP in Group I pre/post HD: rs: Pearson coefficient

Pro BNP	RAV Index		IVC Collapsibility Index	
	Rs	p	Rs	p
Group I Pre HD	0.068	0.777	-0.185	0.434
Group I Post HD	0.347	0.134	0.353	0.127

Table 3 Characteristics of the 20 hemodialysis patients, with measurements before and after a dialysis session

	Pre HD		Post HD		Group II (Control)			
	Mean±SD	R	Mean±SD	R	Mean±SD	R	P	P
Age	41.45±11.98	22-60	41.45±11.98	22-60	37.70±10.71	22-55	0.41	0.41
Mean BP	100.25±10.35	83-120	86.80±10.76	70-103	95±4.22	93-103	<0.001	0.137
Body Weight	74.74±12.33	53-103	70.91±12.26	49.50-98	75.9±9.219	95-62	0.331	0.795
Rt. at Volume Index	22.81±8.60	11.05-40-93	14.84±5.54	8.64-27.69	19.09±7.53	10.10-28.42	0.001	0.255
IVC Diameter	1.59±0.51	0.74-2.90	1.27±0.38	0.65-1.90	1.21±0.14	1-1.5	0.03	0.029
IVC Collapsibility Index %	30.07±15.44	8.87-61.82	44.43±10.12	28.13-64.29	71.77±7.15	60-81.82	0.001	<0.001

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Discussion

To judge dry weight, there are no gold standards. But its assessment has been done using a variety of tools[16] some of them discussed in our study. Physical examination. Inferior vena cava diameter and collapsibility index.[17–20] Right atrium volume index. Biochemical parameter: like ex:, NT- pro BNP Agarwal et al.[21] 2009 a prospective randomized controlled trial of 150 chronic hemodialysis patients found that DW reduction has a positive effect on blood pressure. Elevation of blood pressure, especially if persistent, usually indicates a need to reduce the DW Charra.[22] These data coincides with our study where there was a statistical significant between BP before and after HD ($p<0.001$). Natriuretic peptides has potential role in the assessment of fluid status in HD patients. BNP has a 20-minute half-life and for NT-BNP 1 to 2 hours.[23–26] It is for this reason that we chose the NT-Pro BNP test, instead of the BNP test, as a parameter for assessment of dry weight. NT-pro BNP is the hormonally inactive component of pro BNP, which is a precursor of pre- pro BNP, which released on ventricular myocyte stretch. NT-pro BNP concentrations can be increased in the setting of hemodialysis.[27–30] In our study NT-pro BNP was measured and samples were drawn pre and post HD from 20 chronic HD patients [10 men and 10 women] and assigned to either high-flux or low-flux membranes [10 high-flux and 10 low-flux]. The term high-flux membrane refers to a membrane with a high ultra filtration rate.

Because high-flux membranes tend to have larger pores, clearance of mid-molecular weight molecules is usually higher than with low-flux membranes. All patients (n=20) showed increased concentrations of NT-pro BNP (mean=1449.40 pg/mL) in pre HD specimens in relation to the control group (n=10) where (mean=55.70 pg/mL). also HD caused (mean (SE)) decreased in NT-pro BNP where treatment done using high-flux membrane in contrast to treatment using low-flux membrane led to increase in NT-pro BNP and these result in agreement with Hans Gunther et al.[31] 2006 which investigate the effect of the dialysis procedure on BNP and NT-pro BNP concentrate by HD, in our study there was statistical significant ($p=0$) between NT-pro BNP pre and post HD session and these result in agreement with Clerico and Emdin.[31] The hypothesis is supported by longitudinal studies that have demonstrated a direct correlation bet change in NT-pro BNP concentration and change in surrogate measures of volume status.[32,33]

RAP is an essential component in the hemodynamic assessment of patient and provides an estimation of intravascular volume. The gold standard for the evaluation of right atrial pressure (RAP) is invasive monitoring using a central venous catheter. Yet this is an invasive method not without risks.[34–36] Echocardiography is routinely used to noninvasively estimate right atrial pressure included assessment of many parameter two of them will be mentioned in our study; IVC diameter and collapsibility index and right atrial volume index.[37] In our study right atrial volume index was significantly differ between the pre and post HD ($P=0.001$). Right atrial volume index pre HD was significantly correlated with BP pre HD ($r=-0.039$) and right atrial volume index post HD was significantly correlated with weight post HD ($r=-0.050$). Moreover, these results are in disagreement with Patel et al.,[38] 2011 who have found that 2D – echocardiography measurement of right atrial volume not significantly correlated with right atrial pressure39 However RAV by 3D-echocadiography was found to be correlated with RAP.

Patel et al.,[38] 2011 explained his result by that the quantitation of right atrial volume by 2D may not be provide an accurate measurement of true chamber size due to the use of only one imaging plane, as well as in patients with heart failure the geometric assumption involved with 2D-echo analysis may be less accurate because the distortion of the RA shape by chamber enlargement and 3D avoid these technical limitation but our result in the present study is similar to that of 3D in spite of using 2D due to exclusion of heart failure patient in our study.

As we mention before that the diameter and collapsibility of the inferior cava vein (IVC) is strongly related to right atrial pressure and plasma volume and is therefore an interesting tool in monitoring fluid status in dialysis patients. IVC diameter was shown to predict hemodynamic changes during dialysis.[40] Vena cava diameter and collapsibility was significantly different between patient before and after HD ($p=0.0294$ and $p<0.001$ respectively) and these result prove the usefulness of vena cava echography as a tool to assess dry weight and this is in agreement with Van De Pol et al.,[41] 2007 which was a prospective study conducted upon hemodialysis patient before and after HD compare between BNP and pro BNP and blood volume changes with other. Invasive techniques used to assess dry weight.

Charra et al.,[22] 2007 mentioned that inferior vena cava diameter (IVCD) and collapsibility measurement can evaluate the amount of intravascular volume in HD patients, that is, it can detect intravascular volume overload or depletion, and correlates well with central venous pressure and this is in agreement with our study. Also our result with agreement, where we found that IVCD and collapsibility can be useful in dry weight assessment in haemodialysis patients in combination with clinical assessment and has been shown to predict haemodynamic changes during dialysis the use of IVC echography as a parameter to assess DW result in improvement in patient clinical situation and quality of life and there is in agreement with Change ST et al 2004.[42,43] In the present clinical study, IVCD was measured 12h after HD session to allow for refill of plasma volume from interstitial compartment.[44] An obvious drawback of the present study is the lack of a gold standard method. However, no real gold standard method for the assessment of dry weight in dialysis patients exists at present. Vena cava echography is established methods in the assessment of hydration state in dialysis patients.[45–47] But echocardiography has drawbacks of being operator dependency, timing of the measurements,[48] and questionable reliability in patients with cardiac disease.[49]

Conclusion

Based on the results of the present study, it could be concluded that: Good assessment of dry weight is necessary for effective management of hemodialysis patient and for better life style of end stage population whose are on maintenance HD. Many methods should be combined in evaluation of dry weight because of the absence of gold standard until now. Measurement of NT pro-BNP in ESRD on maintenance HD showed an increase than normal population, NT pro-BNP level significantly decreased in high flux and increased in low flux filter. NT pro-BNP levels affected by the volume status either by decrease or increase when determine the type of filter used. When IVC diameter was assessed by echo pre and post HD session showed decrease in size when IVC collapsibility was assessed pre and post HD session showed increase in its ratio and these data indicate the role of IVC diameter and collapsibility index as a volume dependent in HD patient assessment. Right atrial volume index when measured using echocardiography in its assessment showed decrease in volume post

HD session rather than that pre HD session so right atrial volume index is a good novel volume marker but not in patient with right side heart failure and severe valvular disease of right side.

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Conflicts of interest

The author declares there is no conflict of interest.

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