MJMR, Vol. 34, No. 1, 2023, pages (265-270).

Open Access
ISSN:2682-4558

Research Article

Integrated lung and inferior vena cava ultrasonography for dry weight assessment in pediatric patients on regular hemodialysis: A single center study

Essam Abd El-Aziz Ahmed[1], **Abd El Azeem Mohamed El-Mazary[1], Asmaa Natag Reyad, Moustafa Abd ElKader Abd El Wahab[2] and Hend Mohammed Moness Ali[3]**
[1] Department of Pediatric, Faculty of Medicine, Minia University, Egypt
[2] Department of Radiology, Faculty of Medicine, Minia University, Egypt
[3] Department of Clinical Pathology, Faculty of Medicine, Minia University, Egypt

DOI: 10.21608/mjmr.2023.183994.1268

Abstract

Background: Adequate assessment of fluid status is an imperative objective in the management of HD patients. An accurate assessment of dry weight is challenging. **Objective:** The aim was to assess applicability of clinical using integrated lung and IVCCI ultrasonography to assess dry weight and the adequacy of fluid removal in hemodialysis children. **Patient and method:** 60 patients classified into Group I who their dry weight adjusted by using integrated lung U/S and IVCCI. Group I (a) same group when dry weight adjusted by using clinical judgment. **Result:** Results revealed improvement in clinical scores (orthostatic giddiness and breathlessness scores), blood pressure measurements and BNP serum levels when dry weight adjusted by integrated lung–IVC USG than when was adjusted by clinical judgment. **Conclusion:** Adequacy of volume removal after a HD session can be assessed counting the number of residual B-lines on LUS and measuring IVCCI and integrated lung–IVCCI USG could be a valuable method for monitoring dry weight in pediatric dialysis patients

Keywords: Dry weight, Hemodialysis, lung and IVCCI ultrasonography.

Introduction

Dry weight is a crucial and often challenging component of hemodialysis (HD) to prevent volume overload or depletion. Both hypovolemia and hypervolemia can have adverse effects on quality of life and can lead to long-term cardiovascular complications.(1)

Volume overload is a very important prognostic factor, associated with impaired oxygenation(2), end-organ damage(3), prolonged hospital stay (4), morbidity(3), and mortality(5), perhaps being one of the most insidious and common risk factor for mortality(6,7)

Many methods exist to complete the clinical evaluation of the hydration status: cardio-thoracic index based on chest X-ray evaluation, Inferior Vena Cava (IVC) diameter evaluated by ultrasound, biomarkers like Brain Natriuretic Peptide, Bioimpedance Spectroscopy (BIS), plasmatic volume variation monitoring (8)and recently lung ultrasound(9). Measurement of IVC diameter by echocardiography is a rapid, non-invasive and relatively easy-to-use method to estimate the central venous pressure (CVP). (10)

Patient and method:

This was a single center, open label intervene-tional study among CKD patients on maintenance HD; from single dialysis unit of a tertiary care teaching hospital (Minia university hospital) in the period from 1st September 2021 to 30th October 2022.

All patients provided informed written consent. Patients aged between 6 and 18 years who were on thrice weekly maintenance HD for at least 6 months were enrolled for the study.
Patients with any one or more of the following were excluded:

- Moderate or severe left ventricular dysfunction.
- Right heart failure.
- Chronic respiratory disease.
- Hemoglobin less than 7 g/dL.
- Cardiac arrhythmia.
- Non ambulant

All hemodialysed patients were subjected to the following:
A) Personal history
B) Special history on the renal disease
C) History of cardiac symptoms
D) History of dialysis settings
E) Clinical parameters including weight, height and body mass index, Patient's clinical fluid status was assessed using physical signs including skin turgor, mucous membrane appearance, jugular venous pressure and edema. Blood pressure was measured consistent with international guidance.

- Clinical criteria for underhydration including systemic hypotension (blood pressure < 5th percentile), symptoms of muscle cramps or dizziness, signs of cool peripheries, tachycardia, sunken eyes and reduced skin turgor or dry mucous membranes.
- Clinical criteria for fluid overload included interdialytic weight gain, edema, increased jugular venous pressure, crackles on chest auscultation, low oxygen saturations, presence of a third or fourth heart sound and hypertension (blood pressure > 95th percentile).

Dry weight estimation of the enrolled patients was first done clinically (trial and error method) by nephrologists of the study center who were not participating in this study. The ultrafiltration volume for the subsequent 12 sessions of HD was decided based on this dry weight. Symptoms related to volume depletion (orthostatic giddiness) in the 24 hours following HD and symptoms related to volume overload (breathlessness) in the 24 hours following HD and the day prior to the next HD were documented during these 12 sessions.

Orthostatic giddiness and breathlessness were assessed and scored according to severity using a predesigned questionnaire. Modes for these three sets of scores for each patient were calculated. If two scores occurred at the same frequency, the higher score was taken as the mode. Symptoms during the 24 hours following HD were assessed through telephonic interview with the patient and symptoms on the pre-HD day were assessed when the patient came for the next session of HD. Peripheral BP was measured by auscultation both systolic and diastolic values are calculated and plotted to pediatric blood pressure percentiles. Inter-dialytic weight gains during this period were recorded and mean interdialytic weight gain for each patient was calculated. After these 12 sessions of HD, dry weight was redefined using integrated lung–IVC USG. USG was done by the principal investigator who received prior training. Integrated lung–IVC USG was done immediately before and 15 minutes after the HD session. New dry weight in this study was defined as the weight of the patient at which the total number of B-lines were <4 in the eight site LUS and IVCCI was between 50%–75% on the integrated lung–IVC USG done15 minutes post dialysis. Dry weights of enrolled patients were adjusted to attain the ultrasound based criteria for dry weight.

After fixing the new dry weight, the scores for orthostatic giddiness and breathlessness were again documented for 12 sessions. The changes in dry weight, symptom scores were documented. Peripheral BP was measured by auscultation both systolic and diastolic values are calculated and plotted to pediatric blood pressure percentiles. Interdialytic weight gains during this period were recorded and mean interdialytic weight gain for each patient was calculated.
Groups of the study:
Group I: who their dry weight adjusted by using integrated lung U/S and IVCCI.
Group I (a): same group when dry weight adjusted by using clinical judgment.

Results

Results revealed improvement in clinical scores (orthostatic giddiness and breathlessness scores), blood pressure measurements and BNP serum levels when dry weight adjusted by integrated lung–IVC USG than when was adjusted by clinical judgment. **Where there was** significant improvement in breathlessness score **(post)** in group I than in group I (a) $p<0.001$, Where in group I there were 66.7% of patients have NYHA score **I**, 33.3% have

NYHA score **II** and 0% have NYHA score **III** and **IV** Versus 13.3% of patients have NYHA score **I**, 73.3% have NYHA score **II**, 13.3% of patients have NYHA score **III** and 0% have NYHA score **IV** in group I (a) Also there is significant improvement in breathlessness score (pre) in group I than in group I (a) p<0.001. Where in group I there were 10% of patients have NYHA score **I**, 46.7% have NYHA score **II** ,43.3% have NYHA score **III** and 0% have NYHA score **IV** Versus 0% of patients have NYHA score **I**, 10% have NYHA score **II**, 46.7% of patients have NYHA score **III** and 43.3% have NYHA score **IV** in group I(a)

Table (1): Patients' baseline characteristics:

		Descriptive statistics (N=60)
Age (year)	Range Mean ± SD	(6-17) 11.1±3.4
Sex	Male Female	39(65%) 21(35%)
CKD etiology	Chronic GN Obstructive uropathy FSGN Congenital anomalies	28(46.7%) 16(26.7%) 10(16.7%) 6(10%)
Hemodialysis access	AV fistula CVC	53(88.3%) 7(11.7%)
Dialysis vintage (months)	Range Mean ± SD	(18-48) 25.8±7.4
Mean interdialytic weight gain (IDWG)	Range Mean ± SD	(0.4-2.2) 1.4±0.5
HB gm./dl	Range Mean ± SD	(8-12) 9.8±1
Pre-dialysis mean SBP	Normal Pre HTN Stage I HTN Stage II HTN	6(10%) 20(33.3%) 34(56.7%) 0(0%)
Pre-dialysis mean DBP	Normal Pre HTN Stage I HTN Stage II HTN	13(21.7%) 22(36.7%) 25(41.7%) 0(0%)

Table (1) showing patient's demographic characteristics (Age, Sex, CKD etiology, Hemodialysis vascular access, Dialysis vintage in months, IDWG, HB and Blood pressure) 60 patients on maintenance hemodialysis 39 male 21 female.

Table (2): B lines and IVCCI data pre and post dialysis in group I:

		Pre HD	Post HD	P value
		N=30	N=30	
B lines numbers	**Range** **Mean ± SD**	(7-19) 12.1±2.8	(2-8) 4.7±1.6	*<0.001**
IVCCI	**Range** **Mean ± SD**	(0.1-0.3) 0.2±0.1	(0.4-0.7) 0.5±0.1	*<0.001**

Table (2) showing number of B lines and IVCCI pre and 30min. after the 12^{th} session HD based on dry weight estimated by clinical judgment where there was significant decrease in B line after dialysis (p*<0.001*) and significant increase in IVCCI after dialysis(p*<0.001*).

Table (3): orthostatic giddiness scores in the 24 h following HD between group I and group I (a):

		Group I(a) N=30	Group I N=30	P value
orthostatic giddiness	0 I II III IIII	17(56.7%) 0(0%) 10(33.3%) 3(10%) 0(0%)	27(90%) 1(3.3%) 2(6.7%) 0(0%) 0(0%)	***0.002****

Table (3) Shows that there is significant improvement in orthostatic giddiness scores in group I than in group I (a) p=**0.002**.

Table (4): Mean Blood pressure percentile values and mean interdialytic weight gain between group I and group I (a):

		Group I(a) N=30	Group I N=30	P value
Pre-dialysis mean SBP	*Normal* *Pre HTN* *Stage I HTN* *Stage II HTN*	6(20%) 8(26.7%) 16(53.3%) 0(0%)	16(53.3%) 14(46.7%) 0(0%) 0(0%)	***<0.001****
Pre-dialysis mean DBP	*Normal* *Pre HTN* *Stage I HTN* *Stage II HTN*	7(23.3%) 11(36.7%) 12(40%) 0(0%)	25(83.3%) 5(16.7%) 0(0%) 0(0%)	***<0.001****
Mean interdialytic weight gain	*Range* *Mean ± SD*	(0.5-2) 1.2±0.4	(1.1-2.9) 1.9±0.4	***<0.001****

Table (4) Shows that there is significant increase in mean IDWG in group I than in group I (a) p<***0.001***. Also shows reduction in blood pressure both systolic and diastolic in group I than in group I (a) p<***0.001***.

Figure (1): NYHA clinical score for breathlessness in the 24 h following HD (post) and the day prior to next HD (pre) between group I and group I (a):

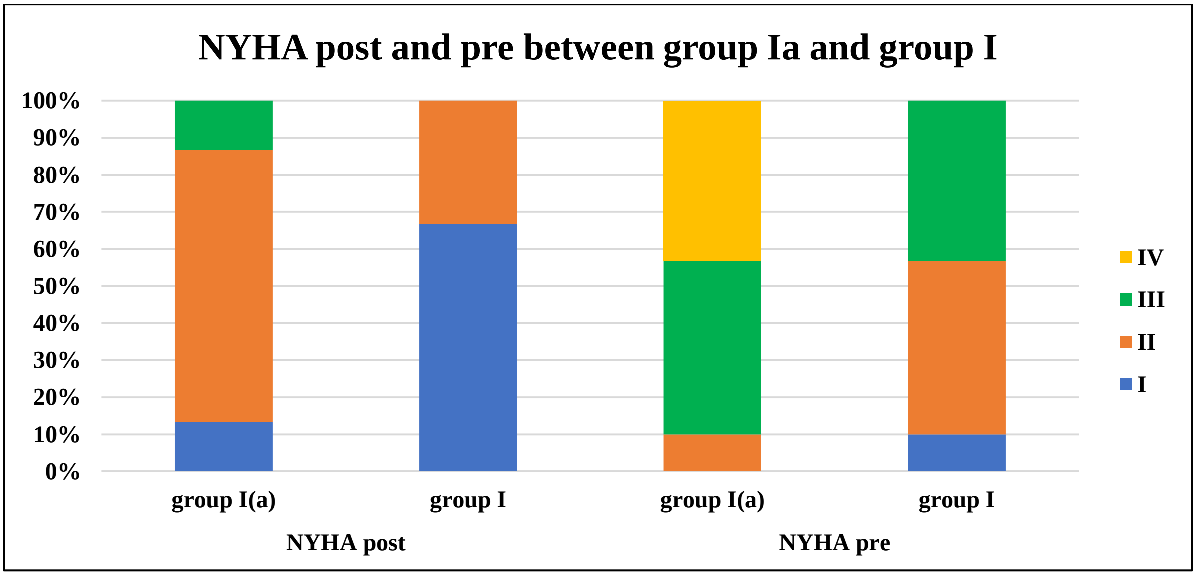

Figure (1)

Group I who their dry weight adjusted by using integrated lung U/S and IVCCI. **Group I (a)** same group when dry weight adjusted by using clinical judgment.
Shows that there is significant improvement in breathlessness score **(post)** in group I than in group I (a) p<0.001, Where in group I there were 66.7% of patients have NYHA score **I**, 33.3% have NYHA score **II** and 0% have NYHA score **III** and **IV** Versus 13.3% of patients have NYHA score **I**, 73.3% have NYHA score **II**, 13.3% of patients have NYHA score **III** and 0% have NYHA score **IV** in group I (a)
Also there is significant improvement in breathlessness score (pre) in group I than in group I (a) p<0.001. Where in group I there were 10% of patients have NYHA score **I**, 46.7% have NYHA score **II** ,43.3% have NYHA score **III** and 0% have NYHA score **IV** Versus 0% of patients have NYHA score **I**, 10% have NYHA score **II**, 46.7% of patients have NYHA score **III** and 43.3% have NYHA score **IV** in group I(a)

Discussion

In this study we aim to evaluate for the use of integrated lung–IVC USG as a method for dry weight assessment.

In our study we have demonstrated that the adequacy of volume removal during an HD session can be assessed by counting the number of residual B-lines on lung USG and measuring IVCCI, where there was significant reduction in number of B lines post dialysis in group I from 12.1±2.8 to 4.7±1.6 with p value <0.001, and this was in concordance with previous studies such as Arun Thomas et al.,[11] who stated that adequacy of volume removal after a HD session can be assessed by counting the number of residual B-lines on LUS and in his study the number of B-lines before and 30 min after hemodialysis based on clinically defined dry weight was reduced from 12.7 ± 9.7 to 4.8 ± 6.6.
And Torino C et al.,[12] who stated that counting B-lines on lung USG is superior to chest auscultation for detecting pulmonary edema

Also, Allinovi M et al.,[13] was compatible with our study and stated that Lung ultrasound is a practical and sensitive method of quantifying subclinical fluid overload in infants and children on dialysis and nearly same results are published in the Egyptian Journal of Hospital Medicine in October (2021) by Youssef D, et al.,[14]

Regarding IVCCI measurement:
Central venous pressure (CVP) has a positive correlation with IVC size and negative correlation with IVC collapsibility index. [15] IVCCI can be a better indicator than IVC diameter, as it is a dynamic parameter which takes the variation of diameter over the respiratory cycle into account. [16]. In our study we found that there was significant increase in IVCCI post dialysis in group I from 0.2±0.1 pre dialysis to 0.5±0.1 with p value <0.001, these results similar to Arun Thomas et al., [11] who reported an increase in IVCCI from 0.23 ± 0.09 to 0.53±0.16 with P value < 0.001.

Also Abd-Rabo DAH et al., [17] reported in his study significant decrease in IVC diameter post dialysis versus pre dialysis. Haciomeroglu P et al., [18] found an improvement in IVC collapsibility index following ultrafiltration in 16 children who were on peritoneal dialysis (PD) and nine on HD. And Youssef D, et al., [14] concludes that IVC measurement is reliable to assess intravascular fluid overload in children on HD .Unlike Torterüe et al., [19] reported that pre dialysis assessment of IVC diameter is not enough to evaluate volume status but can predict high blood pressure which is volume-dependent in children on regular HD, and other techniques are needed.

Conclusion:

Adequacy of volume removal after a HD session can be assessed counting the number of residual B-lines on LUS and measuring IVCCI and integrated lung–IVCCI USG could be a valuable method for monitoring dry weight in pediatric dialysis patients.

References

1. Hecking M, Rayner H, Wabel P. What are the consequences of volume expansion in chronic dialysis patients?: Defining and

measuring fluid overload in hemodialysis patients. Semin Dial. 2015;28:242–247.
2. Arikan AA, Zappitelli M, Goldstein SL, Naipaul A, Jefferson LS, Loftis LL: Fluid overload is associated with impaired oxygenation and morbidity in critically ill children. Pediatr Crit Care Med 2012; 13: 253–258.
3. Hassinger AB, Wald EL, Goodman DM: Early postoperative fluid overload precedes acute kidney injury and is associated with higher morbidity in pediatric cardiac surgery patients. Pediatr Crit Care Med 2014; 15: 131–138.
4. Magee G, Zbrozek A: Fluid overload is associated with increases in length of stay and hospital costs: pooled analysis of data from more than 600 US hospitals. Clinicoecon Outcomes Res2013;5:289-296
5. Vaara ST, Korhonen AM, Kaukonen KM, Nisula S, Inkinen O, Hoppu S, et al.,: Fluid overload is associated with an increased risk for 90-day mortality in critically ill patients with renal replacement therapy: data from the prospective FINNAKI study. Crit Care 2012; 16:R197.
6. Mees EJ: Volaemia and blood pressure in renal failure: have old truths been forgotten? Nephrol Dial Transplant 1995; 10: 1297–1298.
7. Zoccali C, Torino C, Tripepi R, Tripepi G, D'Arrigo G, Postorino M, et al.,: Pulmonary congestion predicts cardiac events and mortality in ESRD. J Am Soc Nephrol 2013; 24: 639–646.
8. Arkouche W, Giaime P, Mercadal L. Fluid overload and arterial hypertension in hemodialysis patients. Nephrol Ther. 2013;9(6):408–15.
9. Cosgun Z, Dagistan E, Cosgun M, Ozturk H. Can Inferior Vena Cava Diameter and Collapsibility Index Be a Predictor in Detecting Preoperative Intravascular Volume Change in Pediatric Patients? J Cardiovasc Emergencies. 2021;7(2):47–51.
10. de Scordilli M, Pinamonti B, Albani S, Gregorio C, Barbati G, Daneluzzi C, et al., Reliability of noninvasive hemodynamic assessment with Doppler echocardio-graphy: comparison with the invasive evaluation. J Cardiovasc Med. 2019;20(10):682–90.
11. E. T. Arun Thomas, M. K. Mohandas, Jacob George. Comparison between clinical judgment and integrated lung and inferior vena cava ultrasonography for dry weight estimation in hemodialysis patients. International Society for Hemodialysis doi:10.1111/hdi.127621**, 2019**.
12. Torino C, Gargani L, Sicari R, et al., The agreement between auscultation and lung ultrasound in hemodialysis patients: The LUST study. Clin J Am Soc Nephrol. **2016**;11:2005–2011.
13. Allinovi M, Saleem M, Romagnani P, Nazerian P, Hayes W. Lung ultrasound: a novel technique for detecting fluid overload in children on dialysis. Nephrol Dial Transplant. **2017** Mar 1;32(3):541-547. doi: 10.1093/ndt/gfw037.
14. Doaa Youssef Mohammed Youssef, Al-Shaymaa Ahmed Ali, Huda Al sayed Mohammed Saadoon, Mayy Abd Alfattah Neemat-Allah. Dry Weight Assessment in Children on Regular Hemodialysis with Special Relation Between Acute and Chronic Renal Failure .The Egyptian Journal of Hospital Medicine, October 2021 Vol. 85 (2), Page 3953-3959.
15. Patil S, Jadhav S, Shetty N, et al., Assessment of inferior vena cava diameter by echocardiography in normal Indian population: A prospective observational study. Indian Heart J. **2016**;68:S26–S30.
16. Kaptein MJ, Kaptein EM. Focused real-time ultrasonography for nephrologists. Int J Nephrol. **2017**;2017: 3756857.
17. Abd-Rabo DAH, Mohamed FAA, Ibrahim AH, Abd El-Hafez MA. Evaluation of dry weight in haemodialysis patients. JRAM 2022; 3(1):38 44. DOI: 10.21608/jram.2021.75991.1118.
18. Haciomeroglu P, Ozkaya O, Gunal N, and Baysal K. Venous collapsibility index changes in children on dialysis. Nephrology. 12:135-139, 2007.
19. Torterüe X, Dehoux L, and Macher MA. Fluid status evaluation by inferior vena cava diameter and bioimpedance spectroscopy in pediatric chronic hemodialysis. BMC Nephrol. 18:373, 2017.