Assessment of Volume Status of Hemodialysis Patients using Sonographic Lung Comets

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Abstract

Background: Fluid balance is important in patients with renal impairment and undergoing hemodialysis. ??Dry?? weight is usually assessed clinically, and also, bioimpedance is considered reliable. The use of chest ultrasound to detect lung water received growing attention in clinical research in intensive care patients and in patients with heart failure. Recently ultrasonographic lung comets (counting B-lines artifact) evaluates extravascular lung water while ultrasonography of inferior vena cava (IVC) estimates central venous pressure, so ultrasound is considered as a useful tool to evaluate the hydration status of hemodialysis patients. Objectives: The study was designed to use lung ultrasound to assess lung congestion before and after a dialysis session in correlation to clinical signs and symptoms and the achieved dry weight in end stage renal disease patients on maintenance hemodialysis. Methods: The present study included 25 patients on maintenance hemodialysis in Alexandria University Hospitals. All the patients were subjected to thorough history taking with special concern on grade of dyspnea and ultrafiltration volume, as well as full clinical examination before and after dialysis including vital signs and signs of hypervolemia as congested neck veins, fine basal crepitations, congested liver and lower limb edema. Radiological examination including ultrasound lung comets score and diameter of hepatic portion of inferior vena cava (IVC) before and after dialysis session. Results: The mean lung comets score before dialysis was high and decreased significantly after dialysis. There was a significant positive correlation between ultrafiltration volume and the absolute change of lung comets score while there was no correlation between the ultrafiltration volume and the absolute change of IVC diameter. There was a significant correlation between lung comets score and grade of dyspnea before dialysis as well as after dialysis. There was a significant positi Objectives:The study was designed to use lung ultrasound to assess lung congestion before and after a dialysis session in correlation to clinical signs and symptoms and the achieved dry weight in end stage renal disease patients on maintenance hemodialysis.

Index terms— hypervolemia, hemodialysis, dry weight, ultrafiltrtaion, lung comets score.

1 I. Introduction

In patients with end-stage renal disease (ESRD) on intermittent hemodialysis (HD), it is vital to maintain fluid status within an optimal range to avoid circulatory complications. Clinical assessment of body weight change, Neck veins congestion, edema together with blood pressure and chest x-ray are usually used for evaluation of

fluid status. (1) However, clinical evaluation alone is not accurate enough for evaluation of HD patients, so other methods such as biochemical markers, bio-impedance analysis and inferior vena cava diameter have been developed to assess the fluid status, yet no single method is considered a gold standard and combination of more than one method should be used for more accurate assessment. (1,2) The main issue for the achievement of dry weight in HD patients is that ultrafiltration should be tailored to the individual patient's hemodynamic tolerance taking into account cardiac performance, which is very often compromised in ESRD patients. (3) Lung ultrasound is simple, non-invasive, nonionizing, available, and inexpensive which is suitable for the assessment of ideal body weight in maintenance hemodialysis (MHD) patients. (4)(5)(6)(7) Moreover, lung comets can be used in association with IVC diameter for more accurate assessment of dry weight in HD patients. (8) So, the aim of this work was to use the lung ultrasound to assess lung congestion before and after a dialysis session in correlation to clinical signs and symptoms and the achieved dry weight in end stage renal disease patients on maintenance hemodialysis.

2 II. Patients & Methods

The present study included 25 patients on maintenance hemodialysis in Alexandria University Hospitals.Patients with congestive heart failure, those with any problem in the right side of the heart and patients with interstitial lung fibrosis, lung malignancy or mediastinal syndrome and obese patients were excluded from the study. An informed consent was taken from all patients and the study was conducted according to the declaration of Helsinki.

All the patients were subjected to thorough history taking with special concern on grade of dyspnea (it is assessed by The New York Heart Association (NYHA) classification) and ultrafiltration volume, as well as full clinical examination before and after dialysis Volume XVI Issue III Version IYear 2016 (D D D D) B © 2 016 Global Journals Inc. (US)

Assessment of Volume Status of Hemodialysis Patients using Sonographic Lung Comets including vital signs (Blood pressure; supine and standing position, respiratory rate, pulse, and temperature were measured before and after the dialysis session) and signs of hypervolemia as congested neck veins, fine basal crepitations, congested liver and lower limb oedema. Routine laboratory investigations were done once before dialysis. Radiological examination including ultrasound lung comets score and diameter of hepatic portion of inferior vena cava (IVC) before and after dialysis session. We were using a commercially available ultrasonograghic equipment (Siemens medical solution, with 5-10 MHz linear or 2-5 MHz convex probe).The time needed for the chest US ranged between 10 to 15 min. All patients were subjected to chest U/S examination for lung comets measurements before and within 6 hours after the dialysis session for the assessment of the lung congestion. Patients were in a supine position during the examination. Ultrasound examination of the anterolateral chest was carried out with longitudinal scan of the right and left hemithoraces, from the second to the fourth (on the right side to the fifth) intercostal space. In each intercostal space, the number of B-lines was counted at the parasternal, midclavicular, anterior axillary, and midaxillary lines for a total of 28 sectors examined. The total number of B-lines was the sum of the artefacts recorded in the 28 sectors explored yielding a score called lung comet score. The collected data were recorded in a table and the lung comets scores for each patient before and after dialysis, the absolute change of lung comets score and the percentage change of the lung comets score were calculated. (7)

3 III. Results

The patients were classified into three groups according to their lung comets grades (mild, moderate, severe) before and after dialysis:

4 a) Lunge comets grades before dialysis

The patients were classified as follow: only one patient had mild lung comets grade (4%), two patients had moderate lung comets grade (8%), 22 patients had severe lung comets grade (88%), Table (

5 I) b) Lung comets grades after dialysis

The patients were classified as follow: 6 patients had mild lung comets grade (24%), 9 patients had moderate lung comets grade (36%), 10 patients had severe lung comets grade (40%), Table (

6 I).

The patients were classified before dialysis into groups according to presence of dyspnea (NYHA class II, III,VI) or absence of dyspnea (NYHA class I) and the grade of lung comets (mild, moderate, severe):

25 patients had dyspnea (NYHA class II, III, VI) (100%) before dialysis and they were classified as follow: one patients had mild lung comets grade and the remaining 24 patients had either moderate or severe lung comets grade, Table (II).

The patients were classified after dialysis into groups according to presence of dyspnea (NYHA class II, III,VI) or absence of dyspnea (NYHA class I) and the grade of lung comets (mild, moderate, severe):

Out of the 25 patients there were 6 patients that had no dyspnea (NYHA class I) after dialysis and they were classified as follow: 5 patients had mild lung comets grade (20%) and one patient had moderate lung comets

grade (4%) while 19 patients had dyspnea (NYHA class II, III,VI) and they were classified as follow: 18 patients had either moderate or severe lung comets grade (72%) while only one patient had mild lung comets grade (4%).

7 Table (II).

There was a significant correlation between lung comets score before dialysis and NYHA class of dyspnea before dialysis, Table (III).

There was a highly significant correlation between lung comets score after dialysis and NYHA class of dyspnea after dialysis, Table (III).

Table (IV) shows the correlation between lung comets score and grade before and after dialysis, their percent and absolute change and clinical data (blood pressure, pulse and respiratory rate).

There was a significant correlation between ultrafiltration volume and the lung comets score absolute change while there was no correlation between the ultrafiltration volume and the IVCD absolute change or IVCD percentage change or the lung comets percentage change Table (V).

Table (VI) shows the correlation between lung comets and IVC diameter before and after dialysis.

8 IV. Discussion

The mean age of the studied group was 47.39 years that is comparable with other studies in the developing countries in which the age of hemodialysis patients' age ranged between 32 -42 years while the age of our patients were much lower than that in the developed world in which the hemodialysis patients' age ranged between 52 to 63 years. (9)(10)(11) Among the reasons for this difference are the delay in detecting renal disease and the failure to institute controlling and preventive measures in patients with progressive renal failure, both of which result in faster deterioration of renal function and progression to ESRD. Late referrals lead to a faster progression of co-morbid conditions, increase the cost of therapy, and worsen overall patient survival as mentioned in a study conducted by Kher (10) that studied the end stage renal disease in the developing countries.

In our study, patients with interstitial lung fibrosis were excluded because the thickened interlobular septae characterizing fibrosis may not be modified by the state of hydration or congestion. (7) We also excluded the presence of lung malignancy and mediastinal lesions to avoid their effect in development of dyspnea or orthopnea in the studied patients and to Assessment of Volume Status of Hemodialysis Patients using Sonographic Lung Comets avoid the pulmonary congestion resulted from pulmonary veins compression that may be encountered in case of mediastinal lesions. (12,13) We also excluded obesity as large body habitus also degrades image quality, making it difficult or impossible to obtain adequate images for clinical interpretation. (14) In our patients three main underlying cause of chronic kidney disease were found to be the hypertension (28%) followed by chronic glomerulonephritis (20%) and diabetes (16%) and this quietly matches the result of a study conducted by Barsoum et al, about burden of chronic kidney disease in North Africa that showed hypertension, glomerulonephritis and diabetes as the major underlying cause of chronic kidney disease. (15) In the present study hypertension was found in 80 % of our patients, which means that most of our cases suffer from high risk of developing cardiovascular complications. (16)(17)(18) Our result is relatively comparable with results found in several studies like that conducted by Portolés et al, (19) In our study there was a significant reduction in both of systolic supine blood pressure, Diastolic supine blood pressure, the systolic standing blood pressure and the diastolic standing blood pressure after dialysis in comparison to predialysis values. The mean blood pressure before dialysis for the whole group ranged between 80-133.33 mmHg with a mean of 111.33±15.25 mmHg while the mean blood pressure after dialysis for the whole group ranged between 70-116.67mmHg with a mean of 90.93 ±14.58 mmHg with a significant change .The mean blood pressure significantly reduced towards normal range and this could be attributed to the underlying pathology of hypertension found among our cohort to be volume dependent. This matches a study conducted by Lazarus et al, (20) who confirmed that removing excess salt and water during maintenance hemodialysis normalizes BP in at least 70% of their cases and attributed to that extracellular volume expansion causes hypertension in approximately 75% of patients with chronic renal failure and therefore their cases were found to be responsive to hemodialysis.

In the present study 68% of the whole group were receiving calcium channel blockers as antihypertensive drugs which means that calcium channel blockers (CCBs) are widely used in this category of hypertensive patients on maintenance hemodialysis that matches a study conducted by Kestenbaum et al, (21) that showed that greater than half of the ESRD were receiving calcium channel blockers and a lower relative risk of mortality reported in patients taking a calcium channel blocker. The use of any calcium channel blockers was associated with a 21% lower risk of all cause mortality and a 26% lower risk of cardiovascular specific mortality.

The lung comets score before dialysis in our study ranged between 7-136 with a mean of 54.72± 28.47 while the lung comets score after dialysis for whole patients ranged between 3-74 with a mean of 28.52±19.88 with a significant change (p=0.00). That matches a study conducted by Noble et al. (22) We also found a significant correlation between lung comets score before dialysis and NYHA class of dyspnea before dialysis and a highly significant correlation between lung comets score after dialysis and NYHA class of dyspnea after dialysis. This means that the lung comets score is a more sensitive tool in achieving dry weight rather than the clinical examination only and it reflects the state of the hypervolemia, especially in the extra vascular lung water (EVLW) compartment, that is considered an important factor related to the risk for the cardiac compromise.

Our results showed that 6 patients having pulmonary congestion, as evidenced by presence of mild lung comets in 5 patients out of them and moderate degree of lung comets in one patient of them after hemodialysis, however, they did not show any clinical manifestations and they had no dyspnea with their ordinary physical activity "NYHA class I" and this demonstrates the sensitivity of the lung comets as a marker for pulmonary congestion in asymptomatic patients, therefore the lung comets could be the only indicator for lung congestion in the preclinical phase in hemodialysis patients. This result matches a study conducted by Mallamaci et al. (5) There was a significant positive correlation between lung comets grade and IVCD before and after dialysis and also between the lung comets score and the IVCD. This reflects the reliability of the lung comets score in assessment of the hydration state in relation to the other reliable tool like IVCD. It could be used as an easy tool for hydration state assessment in comparison to IVCD which is somewhat difficult maneuver needing professional skills. Our result matches a study conducted by Basso et al. (23) In our study, there was a highly significant positive correlation between absolute change of lung comets after dialysis and body ultrafiltration volume during dialysis and this matches with the study done by Vitturi et al. (24) In the present, we found that there was a significant reduction in IVCD after dialysis but there was no correlation between the ultrafiltration volume and the IVCD absolute change or IVCD percentage change, in contrast to the significant correlation found between the lung comets absolute score change and the ultrafiltration volume. This indicates the superiority of ULCs over IVCD as a marker to ultrafiltration volume.

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10 V. Conclusion

Ultrasound lung comets score is highly correlated with the clinical signs and symptoms and even may precede the development of symptoms in hemodialysis patients. Moreover, lung comets score is highly correlated with ultrafiltration volume, thus, it could be used as a good marker for achieving dry weight in dialysis patients. Furthermore, ultrasound lung comets score is more superior to IVCD in assessing the volume status in hemodialysis patients and hence the target dry weight for those patients. [1]

Figure 1:

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Lung comets grade	Before dialysis Frequency	Percent
Mild	1	4
Moderate	2	8
Severe	22	88
Total	25	100

Table (II) : Classification of the patients before and after dialysis according to presence or absence of dyspne the grade of lung comets (mild, moderate, severe)

	Before dialysis			
Parameter	Without dyspnea "NYHA class I"		With dyspnea "NYHA class I	
	Frequency	Percent	Frequency	Percent Frequen
Mild lung comets degree	0	0	1	4
Moderate or severe lung comets degree	0	0	24	96
Total number	0	0	25	100

Table (III) : Correlation between dyspnea (assessed by NYHA classification) and lung comets score before a dialysis

	Lung comets score before dialysis	
Dyspnea before dialysis	r p	0.418 * 0.037
Dyspnea after dialysis	r p	0.496 * 0.012

Pearson Correlation (r)
*Correlation is significant ? 0.05 level (2-tailed).
**Correlation is highly significant at ? 0.01 level (2-tailed).

Figure 2: Table (I

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		Lung comets score absolute change	Lung comets score percentage change	Ultrafiltration volume (UF)
IVCD	r	0.228	-0.003	0.305
Absolute change	p	0.362	0.990	0.219
IVCD percentage	r	0.313	0.287	0.298
change	p	0.207	0.248	0.230
Ultrafiltration volume	r	0.564 **	-0.012	1
(UF)	p	0.003	0.955	

Pearson Correlation (r)

*[Note: *Correlation is significant ? 0.05 level (2-tailed). **Correlation is highly significant at ? 0.01 level (2-tailed).]*

Figure 3: Table (V

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		ULCs score before dialysis	ULCs score After dialysis	ULCs grade before dialysis	ULCs grade after dialysis	ULCs score percentage change	ULCs Score absolute change
IVCD before dialysis	r	0.432	0.552 *	0.650 **	0.688 **	0.496 *	-.0164
	p	0.073	0.018	0.004	0.002	0.036	0.514
IVCD after dialysis	r	0.359	0.557 *	0.559 *	0.652 **	0.628 **	-0.013
	p	0.143	0.016	0.016	0.003	0.005	0.960
IVCD percentage change	r	-0.152	0.007	-0.174	0.010	0.287	0.313
	p	0.548	0.979	0.491	0.969	0.248	0.207
IVCD absolute change	r	-0.221	-0.169	-0.310-	-0.258	-0.003	0.228
	p	0.378	0.503	0.210	0.302	0.990	0.362

Pearson Correlation (r)

*Correlation is significant ? 0.05 level (2-tailed).

*[Note: **Correlation is highly significant at ? 0.01 level (2-tailed).]*

Figure 4: Table (

[Arabi ()] 'A base for a situation analysis project'. Z Arabi . *Avicenna J Med* 2012. 2 (2) p. . (Hemodialysis in an underserved area)

[Özkan and Ulusoy ()] *Acute Complications of Hemodialysis*, G Özkan , ? Ulusoy . 2011. Turkey. Karadeniz Technical University, School of Medicine, Department of Nephrology

[Datt et al. ()] 'Airway management in patients with mediastinal masses'. V Datt , D K Tempe , Others . *Indian J Anaesth* 2005. 49 p. .

[Jaeger and Mehta ()] 'Assessment of Dry Weight in Hemodialysis An Overview'. J Q Jaeger , R L Mehta . *J Am Soc Nephrol* 1999. 10 (2) p. .

[Barsoum ()] 'Burden of chronic kidney disease: North Africa'. R S Barsoum . *Kidney Int* 2013. 3 (2) p. . (Suppl)

[Kestenbaum et al. ()] 'Calcium channel blocker use and mortality among patients with end-stage renal disease'. B Kestenbaum , D L Gillen , D J Sherrard , S Seliger , A Ball , C Stehman-Breen . *Kidney Int* 2002. 61 (6) p. .

[Basso et al. ()] 'Comparison and Reproducibility of Techniques for Fluid Status Assessment in Chronic Hemodialysis Patients'. F Basso , Milan Manani , S Cruz , D N Teixeira , C Brendolan , A Nalesso , F . *Cardiorenal Med* 2013. 3 (2) p. .

[Basso et al. ()] 'Comparison and Reproducibility of Techniques for Fluid Status Assessment in Chronic Hemodialysis Patients'. F Basso , Milan Manani , S Cruz , D N Teixeira , C Brendolan , A Nalesso , F . *Cardiorenal Med* 2013. 3 (2) p. .

[Mallamaci et al. ()] 'Detection of pulmonary congestion by chest ultrasound in dialysis patients'. F Mallamaci , F A Benedetto , R Tripepi , S Rastelli , P Castellino , G Tripepi . *JACC Cardiovasc Imaging* 2010. 3 (6) p. .

[Donadio et al. ()] 'Effective and timely evaluation of pulmonary congestion: qualitative comparison between lung ultrasound and thoracic bioelectrical impedance in maintenance hemodialysis patients'. C Donadio , L Bozzoli , E Colombini , G Pisanu , G Ricchiuti , E Picano . *Medicine* 2015. 94 (6) p. e473.

[Kher ()] 'End-stage renal disease in developing countries'. V Kher . *Kidney Int* 2002. 62 (1) p. .

[Rutkowski and Ritz ()] 'Explosion of renal replacement therapy after the implosion of the Soviet Empire'. B Rutkowski , E Ritz . *Ethn Dis* 2006. 16 (2) p. . (Suppl)

[Lazarus et al. ()] 'Hypertension in chronic renal failure: treatment with hemodialysis and nephrectomy'. J M Lazarus , C L Hampers , J P Merrill . *Arch Intern Med* 1974. 133 (6) p. .

[Cheigh et al. ()] 'Hypertension is not adequately controlled in hemodialysis patients'. J S Cheigh , C Milite , J F Sullivan , A L Rubin , K H Stenzel . *Am J Kidney Dis* 1992. 19 (5) p. .

[Trezzi et al. ()] 'Lung ultrasonography for the assessment of rapid extravascular water variation: evidence from hemodialysis patients'. M Trezzi , D Torzillo , E Ceriani , G Costantino , S Caruso , P T Damavandi . *Intern Emerg Med* 2013. 8 (5) p. .

[Vitturi et al. ()] 'Lung ultrasound during hemodialysis: the role in the assessment of volume status'. N Vitturi , M Dugo , M Soattin , F Simoni , L Maresca , R Zagatti . *Int Urol Nephrol* 2013. 46 (1) p. .

[Ripamonti ()] 'Management of dyspnea in advanced cancer patients'. C Ripamonti . *Support Care Cancer* 1999. 7 (4) p. .

[Ozkahya ()] 'Pharmacological and nonpharmacological treatment of hypertension in dialysis patients'. M Ozkahya . *Kidney Int* 2013. 3 (4) p. . (Suppl)

[Portolés et al. ()] J Portolés , J M López-Gómez , P Aljama . *Cardiovascular risk in hemodialysis in Spain: prevalence, management and target results (MAR study)*, 2005. 25 p. .

[Siriopol et al. ()] 'Predicting mortality in haemodialysis patients: a comparison between lung ultrasonography, bioimpedance data and echocardiography parameters'. D Siriopol , S Hogas , L Voroneanu , M Onofriescu , M Apetrii , M Oleniuc . *Nephrol Dial Transplant* 2013. 28 (11) p. .

[Mcadams et al. ()] 'Recent Advances in Chest Radiography'. H P Mcadams , E Samei , J Dobbins , G D Tourassi , C E Ravin . *Radiology* 2006. 241 (3) p. .

[Fishbane et al. ()] 'Role of volume overload in dialysis-refractory hypertension'. S Fishbane , E Natke , J K Maesaka . *Am J Kidney Dis* 1996. 28 (2) p. .

[Wu et al. ()] 'The assessment of fluid status in hemodialysis patients: usefulness of the Doppler echocardiographic parameters'. C-C Wu , Y-P Lin , Yu W-C Lee , W-S Hsu , T-L Ding , Py-A . *Nephrol Dial Transplant* 2004. 19 (3) p. .

[Noble et al. ()] 'Ultrasound assessment for extravascular lung water in patients undergoing hemodialysis. Time course for resolution'. V E Noble , A F Murray , R Capp , M H Sylvia-Reardon , Djr Steele , A Liteplo . *Chest* 2009. 135 (6) p. .