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Assessment of Volume Status of Hemodialysis Patients using Sonographic Lung Comets

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Strictly as per the compliance and regulations of:

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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 positive correlation between the grade of lung comets and IVC diameter both before and after dialysis.

Conclusions: Ultrasound lung comets score is a promising sensitive tool for assessment of the degree of lung congestion and hence the dry weight achievement in in end stage renal disease patients on maintenance hemodialysis.

Keywords: hypervolemia, hemodialysis, dry weight, ultrafiltrtaion, lung comets score.

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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, non-ionizing, available, and inexpensive which is suitable for the assessment of ideal body weight in maintenance hemodialysis (MHD) patients.[4-7] 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.

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 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 hemi-thoraces, 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]

III. Results

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

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 (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 (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%). 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.

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.[9-11] 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 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.[16-18] 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.

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.

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Table (I) : Demonstrates patients' lung comets grades before and after dialysis

Lung comets grade	Before dialysis		After dialysis	
	Frequency	Percent	Frequency	Percent
Mild	1	4	6	24
Moderate	2	8	9	36
Severe	22	88	10	40
Total	25	100	25	100

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

Parameter	Before dialysis				After dialysis			
	Without dyspnea "NYHA class I"		With dyspnea "NYHA class II,III,VI"		Without dyspnea "NYHA class I"		With dyspnea "NYHA class II,III,VI"	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Mild lung comets degree	0	0	1	4	5	20	1	4
Moderate or severe lung comets degree	0	0	24	96	1	4	18	72
Total number	0	0	25	100	6	24	19	76

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

		Lung comets score before dialysis	Lung comets score after dialysis
Dyspnea before dialysis	r	0.418*	0.463*
	p	0.037	0.020
Dyspnea after dialysis	r	0.496*	0.635**
	p	0.012	0.001

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

Table (IV) : Correlation between ultrasound lung comets score and ultrasound lung comets grade before and after dialysis with clinical data

Parameters		ULCs score before dialysis	ULCs grade before dialysis	ULCs grade after dialysis	ULs score after dialysis	ULCs score percentage change	ULCs score Absolute Change
Mean supine BP before dialysis	r	0.222	0.281	0.358	0.286	0.406*	-0.049
	p	0.285	0.173	0.079	0.166	0.044	0.816
Mean Standing BP before dialysis	r	0.230	0.266	0.302	0.233	0.276	-0.144
	p	0.270	0.198	0.142	0.262	0.181	0.491
Mean supine BP after dialysis	r	0.266	0.305	0.427*	0.307	0.390	-0.111
	p	0.199	0.138	0.033	0.135	0.054	0.597
Mean standing BP after dialysis	r	0.319	0.356	0.363	0.286	0.204	0.257
	p	0.120	0.080	0.075	0.165	0.327	0.215
Pulse before dialysis	r	0.606**	0.192	0.639**	0.682**	0.543**	-0.281
	p	0.001	0.359	0.001	0.000	0.005	0.174
Pulse after dialysis	r	0.598**	0.225	0.719**	0.720**	0.698**	-0.206
	p	0.002	0.281	0.000	0.000	0.000	0.323
Pulse percentage change	r	-0.071	0.042	0.053	0.002	0.209	0.156

	p	0.737	0.841	0.800	0.992	0.317	0.457
RR before dialysis	r	0.485*	0.080	0.476*	0.482*	0.342	-0.321
	p	0.014	0.702	0.016	0.015	0.095	0.118
RR after dialysis	r	0.489*	0.004	0.561**	0.580**	0.554**	-0.180
	p	0.013	0.985	0.004	0.002	0.004	0.388
RR percentage change	r	0.039	-0.186	0.173	0.211	0.407*	0.234
	p	0.853	0.373	0.407	0.311	0.044	0.260

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

Table (V) : Correlations between changes of lung comets score (absolute change, percentage changes) and IVCD changes (absolute change, percentage changes) and ultrafitration volume

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

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

Table (VI) : Correlation between ultrasound lung comets and inferior vena cava diameter

		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).
**Correlation is highly significant at ≤ 0.01 level (2-tailed).