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Chest Ultrasound as A Screening Tool for Fluid Overload in Hemodialysis Patients

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Abstract

To set the scene, moderate to severe lung congestion was present in roughly 60% of ESRD patients prior to hemodialysis [HD], and this change is often asymptomatic. One-third to one-fourth of patients still have excessive lung water following dialysis, despite the fact that congestion in the lungs is decreased. Our research aimed to determine how useful lung ultrasonography is for identifying pulmonary congestion in hemodialysis patients. Methods: One hundred hemodialysis patients were enrolled in a prospective clinical research from August 2020 through August 2021 at the Critical care department at Benha university hospital. Conclusion: Our findings show that the B-lines and IVC width of the research patients significantly alter between before and after dialysis. It was concluded from this study that Chest US is a well validated simple and low-cost technique that can be easily applied at the bedside to assess of volume status before and after a dialysis session and to detect pulmonary congestion at a pre-clinical stage that is associated with a high death risk. In addition to chest ultrasonography, monitoring IVC diameter before and after dialysis may be utilised to evaluate volume status in patients with ESRD.

Key words: Chest Ultrasound **-** Screening Tool **-** Fluid Overload **-** Hemodialysis

1.Introduction:

An acute and chronic risk of volume overload increases dramatically in patients with end-stage renal disease [ESRD], which has serious consequences for patients' survival. For this reason, the nephrologist and the intensivist have set volume evaluation in hemodialysis as one of their key priorities [1].

Body weight changes, blood volume online monitoring, bioimpedance spectroscopy [BIS], B-natriuretic peptide, and body ultrasound [US], which includes inferior vena cava [IVC] diameter measure and lung US [LUS], are all examples of novel techniques used to determine euvolemic status alongside clinical evaluation, which is often inaccurate and subjective. [2].

Among them, LUS has lately gained popularity due to its ability to measure extravascular lung water (EVLW) and hence provide an accurate assessment of lung congestion in ESRD. Chest ultrasonography is a promising tool for volume evaluation in ESRD [3, 4] since it is noninvasive, radiation-free, easy to use, has adequate intra- and inter-operator repeatability, and can be performed with portable US machines.

However, the nephrologist who wishes to enhance his therapeutic experience using this potent instrument [3] must be aware of its strengths and limits.

Additionally, the diameter and collapse index [the percentage drop in diameter during spontaneous inspiration] of the inferior vena cava (IVC) may be evaluated using ultrasonography. Central venous pressure, right atrial pressure, intra-thoracic pressure, and intra-abdominal pressure all interact to produce these values. A number of investigations demonstrated the feasibility and efficacy of the evaluation in HD patients by correlating IVC measures with volume changes during dialysis sessions; however, these studies also highlighted certain inherent challenges [4].

This study set out to evaluate how useful chest ultrasonography [US] is for spotting lung congestion in hemodialysis patients.

2.Patients and Methods

After approval by the institutional ethics committee, a prospective clinical study was conducted over 100 patients diagnosed with chronic renal failure on regular hemodialysis three times weekly with standard bicarbonate dialysis .

The duration of hemodialysis session was three hours with ultrafiltration volume 2 liter.

Hemodialysis was done through A-V fistula.

The studied patients admitted to critical care unit at Benha university hospital with various etiologies.

This study was done between August 2020 to August 2021.

Prior to the conduct of the study, an informed consent was obtained from all patients.

2.1Study design

1. Inclusion criteria:

1. Adult >18 yrs. old.
2. On chronic hemodialysis more than 6 months.

2. Exclusion criteria:

1. Patients with lung disease.
2. Patients with heart failure.
3. BMI >35 kg/m^2.

2.2Assessment and Measurements:

2.3Every patient included in the study was subjected to a careful assessment including:

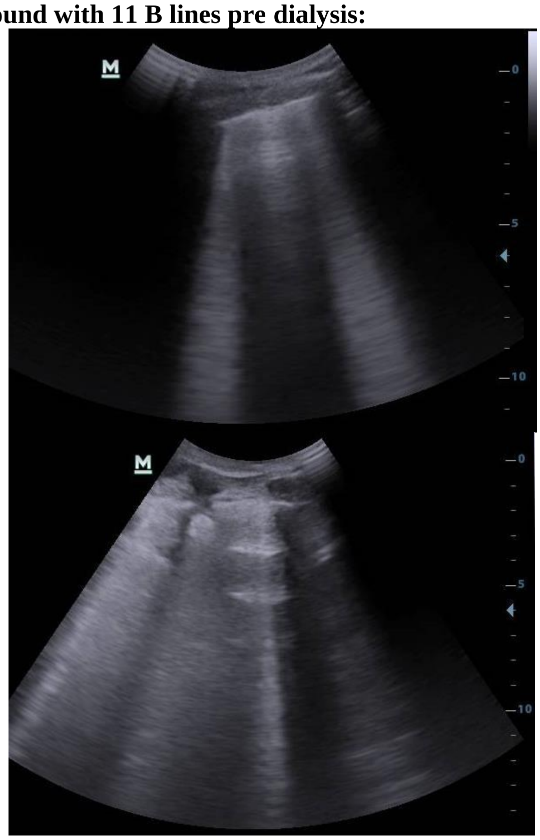
1. full history taking with attention to age, smoking history, occupational history, duration of illness, medication used and associated illness such as diabetes or hypertension.
2. full clinical examination.
3. laboratory investigations [Urea, creatinine, Hb, Na, K, calcium, phosphate].
4. plain chest radiography.
5. Echocardiography was done to exclude patients with decompensated HF.
6. Chest ultrasound pre and post dialysis.
7. IVC diameter pre and post dialysis.

2.4Chest ultrasound technique:

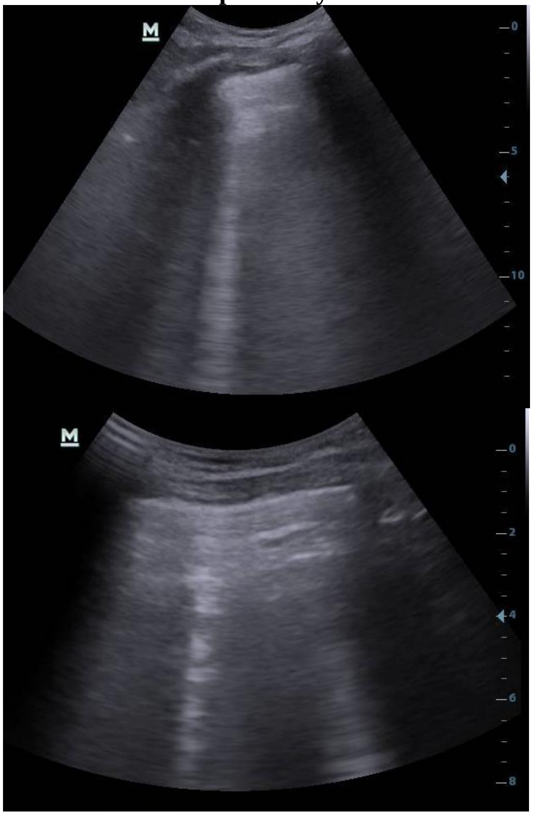
Bilateral scanning of the anterior and lateral chest walls was performed with the patient in a supine position just after the start of hemodialysis and after finishing hemodialysis session. Lung ultrasound was performed with a GE machine with linear probe. The same operator did the ultrasound pre and post hemodialysis in the same areas of the chest to reduce the bias.

Scanning of the anterior and laterals chest was performed on both sides of the chest, from the second to the fourth [on the right side to the fifth] intercostal spaces. Lung comets were defined as a hyperechoic US bundle. These comets arise from the pleural line. The sum of lung comets produces a score reflecting the extent of lung waters accumulation. Based on this score, there were three categories of patients [mild<14 comets, moderate 14-30 comets, severe >30 comets].

2.5Example of chest ultrasound with 11 B lines pre dialysis:



2.6Examples of chest ultrasound with 5 B lines post dialysis



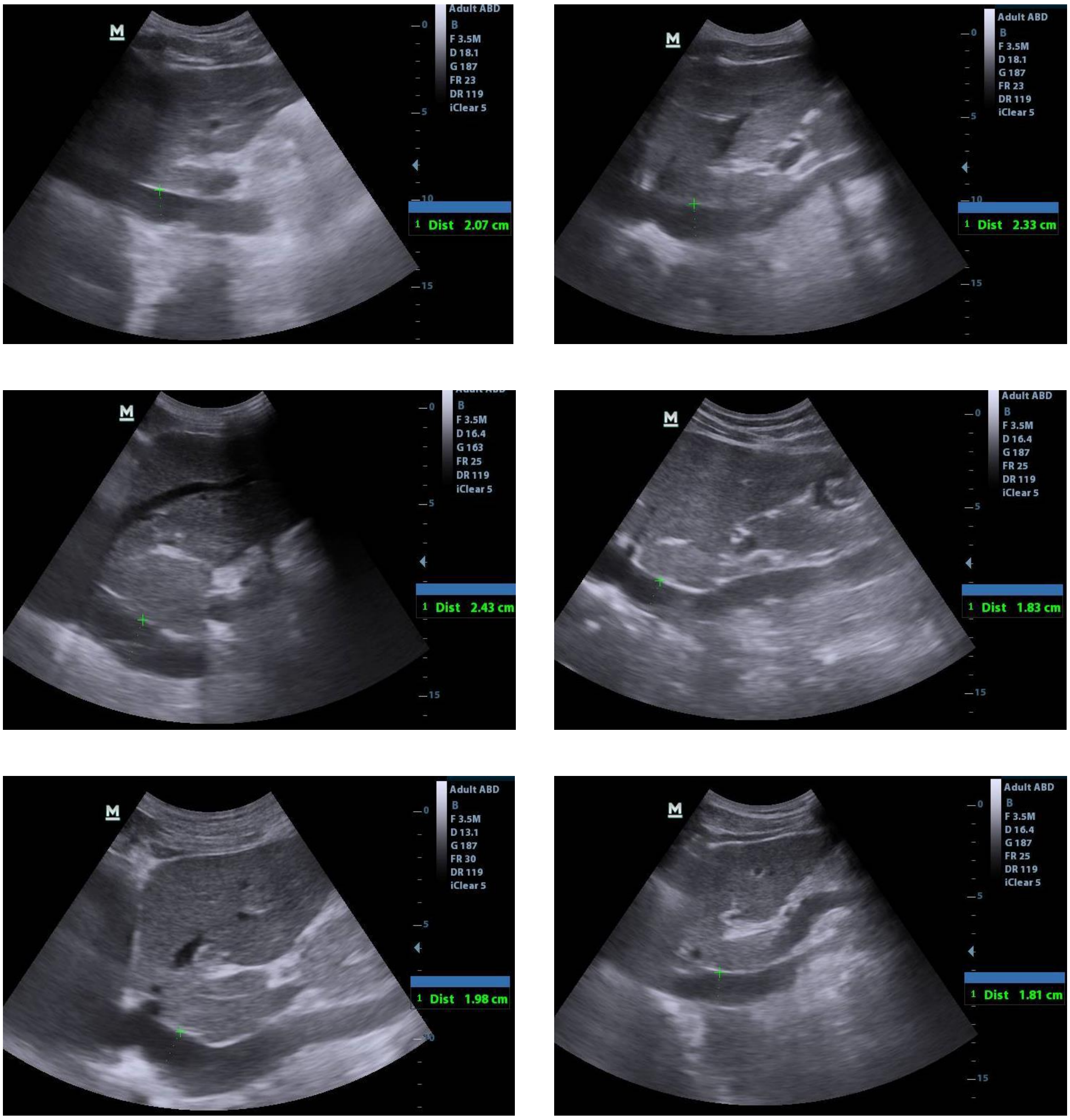
2.7 IVC diameter technique:

A curvilinear probe with was used for the scans. Longitudinal scans were done in the right hypochondrium, using the liver as the acoustic window. The IVC was visualized longitudinally, adjacent to the liver, and crossing the diaphragm. The vessel was then followed longitudinally along its course, until it enters the right atrium, and confirming it as the IVC . The IVC diameter [IVCD] was then measured at a point 2 cm from its entry into the right atrium, where its walls are most parallel. Each measurement was made thrice, and the average value recorded.

Measurements of IVC was done by the same operator in the same site pre and post HD.

- IVC diameter normal [1.2 – 1.7] cm
- IVC diameter less than 1.2 cm represent small volume.
- IVC diameter from 1.7- 2.5 cm represents dilated veins
- IVC diameter more than 2.6 represents markedly dilated vein

2.8Examples for IVC diameter Pre dialysis.



2.9Statistical analysis:

Recorded data were analyzed using the statistical package for social sciences, version 26.0 [SPSS Inc., Chicago, Illinois, USA]. Quantitative data were expressed as mean± standard deviation [SD]. Qualitative data were expressed as frequency and percentage.

2.8The following tests were done: -

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square [x2] test of significance was used to compare
- proportions between qualitative parameters.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the Probability [P-value] was

2.9considered significant as the following:

- P-value <0.05 was considered significant.
- P-value >0.05 was considered insignificant.

3.Results:

Table 1: Gender of the studied patients,

Sex: n [%]	
Male	51%
Female	49%

Among 100 studied patients; 51 patients were male [51%], and 49 patients were female [49%].

Table 2: Other demographic data of the studied patients,

	Mean and standard deviation	Min – Max
Age [years]	50.53 ±6.52	[32-60]
BMI [Kg/m^2]	27.10 ±1.98	[20-30]
History of dialysis [years]	2.77 ±1.36	[1-7]

Age of the studied patients ranged between 32 and 60 years old. Patients had a mean duration of dialysis of 2.77±1.36 years. The mean BMI was [27.10±1.98 SD]

Table 3: Past medical history and special habits in the studied patients,

Risk factors	Diabetic	60 [60%]
	hypertensive	70 [70%]
	smoker	34 [34%]

The table shows that the most common risk factor was hypertension which had a prevalence of 70%. This was followed by diabetes mellitus with a prevalence of 60%. Fewer patients [34%] had a history of smoking.

Table 4: Laboratory findings of the studied patients.

Lab	Mean ±SD	Min -Max	p-value
Serum Urea [mg /dl]	167.91±32.26	[100-260]	.625
Serum Creatinine [mg/dl]	7.27±1.04	[4.5-9.6]	.688
Hb[g/dl]	8.66±.91	[7.1 -12]	.305
Albumin[g/l]	2.95±.29	[2.1 - 4]	.801
Serum Na [mEq/L]	135.69±6.6	[125-156]	.540
Serum K [mEql /L]	5.3±.61	[3.8-6.4]	.620
Serum total Calcium [mg /dl]	7.97±.50	[6.5 -9.2]	.433
Serum phosphate [mg/dl]	4.39±.57	[3.1 -5.7]	.617

This table shows that the mean HB 8.66[±.91 SD] with range[7.1-12],the mean serum urea 167.91[±32.26SD] with range[100-260],the mean serum creatinine 7.27[±1.04SD] with range[4.5-9.6],the mean serum sodium 135.69[±6.6SD] with range[125-156],the mean serum potassium 5.30[±0.61 SD] with range[3.8-6.4],the mean serum calcium 7.97[±0.5 SD] with range[9.2-6.5],the mean serum albumin 2.95[±0.29 SD] with range[2.1-4].

Table 5: Comparison between Karley B lines detected by chest ultrasound pre dialysis and post dialysis among the studied patients.

Karley B lines number	Pre-dialysis.	Post-dialysis	Test	*p*- value
Mean ± SD	22.09 ± 6.31	17.18 ± 5.83	13.9	<0.001
Min -Max	7-35	2-30 32		

This table shows that the mean B lines number pre dialysis were 22.09 [±6.31 SD] with range [7 -35], There was high significant reduction in chest US Kerley's B-lines [P<0.001] after dialysis that were 17 [±5.83 SD] with range [2 -30]

Table 6: Comparison between lung comet score grade detected by chest ultrasound pre dialysis and post dialysis among the studied patients

Lung Commet	Pre dialysis	no	Post dialysis	No
	mild	10%	mild	39%
Score	moderate	70%	moderate	57%
	severe	20%	severe	4%

This table shows that Chest US Kerley's B-lines pre dialysis were mild in ten [10%] patients, moderate in 70 [70%] patients, and severe in 20 [20%] patients. There was high significant reduction in chest US Kerley's B-lines [P<0.001] after dialysis that were mild in 39 [39%] patients, moderate in 57 [57%] patients, and severe in 4 [4%] patients post dialysis

Table 7: Comparison between IVC diameter pre dialysis and post dialysis among the studied patients

IVC diameter [cm]	Pre dialysis	Post dialysis	Test	p-value
Mean ± SD	1.97 ± .24	1.72 ± .21	16.695	<0.004
Min – Max	[1.4 -2.5]	[1.2 -2.2]		

Abbreviations: IVC, inferior vena cava**.**

This table shows that the mean IVC diameter pre dialysis was 1.97 [±.24 SD] with range [1.4 - 2.5]. There was high significant reduction in IVC diameter [P<0.004] after dialysis that was 1.72 [± .21 SD] with range [1.2 -2.2].

4.Discussion

Regarding demographic details, the age of the cases group varied from 32-60 years old, with a mean of 56.3310.61. Most patients were male (51%), and their mean body mass index was 29.3 5.35 years. Their dialysis lengths varied from 1 to 7 years.

Koraa et al[5] .'s research corroborates our findings; they looked at 40 patients with chronic renal failure who were receiving routine hemodialysis; their ages varied from 19 to 55, and they included 26 males (65%) and 14 women (35%). A third were current smokers and another fifth had quit.

Participants in the research by Mallamaci et al. [6] had a mean age of 56 16 years. They were mostly men. The average body mass index of the group was 26. Roughly 50% of them smoked regularly.

Smoking was found to be present in 34% of the patient population, whereas hypertension and diabetes prevalence was found in 70% and 60% respectively.

Patients' rates of Kerley's B lines were not affected by their smoking status, hypertension, or diabetes history.

The findings of Cepeda et al. [7] corroborated ours; they observed that 86.9% of hemodialysis patients had high blood pressure and 45.9% had diabetes.

Among the patients examined by Trezzi et al. [8], 14.5 percent had diabetes and 54.6% had cardiovascular problems.

Results from this study indicated that the average HB was 8.66 [9.1 SD] with a range of [7.1-12], the average serum urea was 167.91 [32.26 SD] with a range of [100-260], the average serum creatinine was 7.27 [1.04 SD] with a range of [4.5-9.6], the average serum sodium was 135.69 [6.6 SD] with a range of [125-156], the average serum potassium was 5.3

In agreement with the findings of Koraa et al. [5], we found that the average HB was 8.5, the average urea was 165.750 59.596, the average creatinine was 10.710 3.373, the average sodium was 133.650 5.695, and the average potassium was 5.315 0.774.

Albumin levels in the group tested by Mallamaci et al. [6] were found to be 4.0 0.4, HB levels to be 11.8 1.4, sodium levels to be 137 3, and potassium levels to be 5.2 0.6 on average.

In the current investigation, laboratory results did not correlate significantly with the intensity of the U/S finding. Findings like these agreed with those of a research by Koraa et al. [5].

In our investigation, the number of B-lines in the chest ultrasounds of patients before and after dialysis was significantly different.

Before dialysis, the average B-lines were [22.09 6.31 SD], but after dialysis, they dropped to [17.18 5.83 SD].

Before starting dialysis, the severity of Kerley's B-lines ranged from mild (10%) to moderate (70%), and severe (20%). And, after dialysis, they were mild in 39 patients (39%), moderate in 57 patients (57%) and severe in 4 patients (4%). After starting dialysis, chest US Kerley's B-lines decreased by a statistically significant amount (P0.001).

The dynamics of B-lines clearing during HD have been studied by Noble et al. [9], who found a reduction in artefacts in real time as volume was eliminated, indicating the use of this approach to monitor euvolemia.

They analysed data from 45 patients receiving regular hemodialysis, all of whom had three lung scans; 6 of 40 individuals had zero or one B-line before dialysis, and none of these 6 patients obtained B-lines during dialysis. The number of B-lines decreased significantly (p 0.001) in 34 of 40 patients during the baseline and midway scans before dialysis and again after dialysis.

Numerous recent studies corroborate our findings regarding the severity of lung congestion in hemodialysis patients and the significant reduction [P0.001] of lung comets score after dialysis, such as that conducted by Trezzi and his Colleagues [8], who examined 41 patients receiving hemodialysis treatment in the Dialysis Unit of their hospital and found a statistically significant reduction in the total number of B-lines after dialysis [from 24 25 to 9 10] wi.

Additionally, Donadio et al. [10] studied 40 hemodialysis patients in the Dialysis Unit of the Nephrology Division at the University of Pisa and found that pre-hemodialysis B-lines varied from 0-47 (mean = 31) and dropped dramatically post-hemodialysis (mean = 16; P 0.001). The frequency of B-lines has been shown to be significantly correlated with the extra-cellular water index (ECWI; r = 0.45, P 0.001).

As the lung's comets score was mild [14] in 28 patients, moderate [14-30] in 26, and severe [>30] in 21, it markedly reduced post-dialysis session [P0.001], which was similar to the result of Zoccali et al [11], who found that 60% of the patients had moderately to severely lung congestion at pre-dialysis.

Further, Koraa et al. [5] conducted research in the hemodialysis unit of Dar El Shefa Hospital on 40 patients undergoing regular hemodialysis and discovered that pre-dialysis Kerley's B-lines were mild in 9 (22.5%), moderate in 17 (42.5%), and severe in 14 (35%) of the patients. Also, after dialysis, seven patients (17.5%) had normal, nineteen (47%), mild, twelve (30%), moderate, and two (5%) patients had severe. After dialysis, there was a statistically significant decrease in chest US Kerley's B-lines [P0.001].

Lung congestion is a prominent component involved in the poor physical performance of individuals with end-stage renal illness on PD, even before the manifestation of clinically detectable dyspnea, as was shown in our investigation and a study by Enia et al. [12] including 51 PD patients. Since lung congestion is changeable, intervention studies are necessary to conclusively confirm this theory and to provide the necessary foundation before chest ultrasonography may be suggested as a technique for regular screening of PD patients.

Before dialysis, the average IVC diameter in our research was [1.97.24 SD], with a range of [1.4 -2.5], while after dialysis, the average IVC diameter for entire individuals was [1.72.21 SD], with a range of [1.2 -2.2].

Dialysis significantly decreased IVC width [p0] .004]

Trezzi et al[5] .'s findings that the diameter of the inferior vena cava decreased significantly during dialysis were corroborated by these numbers (p .001 for both tests). The mean IVC diameter before dialysis was [16.6 3.8SD], whereas after dialysis it was [11.9 4.6SD].

Our findings corroborated those of Vitturi et al. [13], who observed that the number of B-lines [p=0.007] and the diameters of the IVCs [1.71 vs. 1.37] decreased significantly during the course of dialysis, and that a strong correlation existed between B-lines before and after dialysis [p=0.004].

Ultrasound of the inferior vena cava (IVC) was also conducted before to and during hemodialysis by Liang and colleagues [14]. Their research led them to the conclusion that dialysis patients may benefit from lung ultrasonography.

They used transthoracic and inferior vena cava (IVC) ultrasonography to examine 35 hemodialysis patients before and after treatment. The lungs' B-line scores and the IVC diameter were examined before and after dialysis treatment.

They went on to assess the links between various ultrasonic parameters and ultrafiltration volumes. Pre-dialysis ultrafiltration settings were fine-tuned in anticipation of future hemodialysis. As a consequence, ultrafiltration led to a drop in intravascular as well as extravascular water levels. Both the end-expiration IVC diameter (17.51 3.33 mm) and the B-line score (0-42 points) were significantly larger in the former group than in the latter (14.26 3.45 mm vs. 0-30 points, p 0.001).

The IVC diameter before dialysis in our study ranged from 0.7 to 3.6, whereas in the recent study by Mokhtar Mabrouk El-Atar et al [15], conducted at the Hemodialysis Unit, Al-Hussein University Hospital, over a period of one year from September 2019 to September 2020 on 50 hemodialysis patients, chest ultrasound and IVC diameter were discussed in assessment of volume status in hemodialysis patients.

Before dialysis, the number of B lines was [22.42 11.47 SD], with a range of [2-45]. After dialysis, the number of B lines was [13.0 8.9 SD], with a range of [0-35]. .001]

The researchers came to the conclusion that nephrologists can easily use Chest US to evaluate their patients' volume status before and after dialysis sessions, as well as to detect pulmonary congestion in its pre-clinical stage, which is associated with a high death risk, and to justify dry weight in hemodialysis patients.

5.Conclusion

Based on the findings of this research, bedside Chest US may be used to check volume status before and after dialysis sessions and to identify pulmonary congestion at a pre-clinical stage, which is linked with a high fatality risk. In addition to chest ultrasonography, monitoring IVC diameter before and after dialysis may be utilised to evaluate volume status in patients with ESRD.

6.References:

[1]. M. Hecking, H. Rayner & P. Wabel. What are the consequences of volume expansion in chronic dialysis patients? Defining and measuring fluid overload in hemodialysis patients. In Seminars in dialysis.Vol. 28, No. 3,pp. 242-247,2015.

[2]. C. Ronco, M. Kaushik, R. Valle, N. Aspromonte, & IV. Peacock, F. W. Diagnosis and management of fluid overload in heart failure and cardio-renal syndrome: the “5B” approach. In Seminars in nephrology.Vol. 32, No. 1,pp. 129-141.WB Saunders,2012.

[3]. **D. W. Ross, R. L. Barnett, & H. H. Shah.** Lung ultrasonography: a novel clinical tool to consider in nephrology. Kidney International.vol.89[3],pp.720-721,2016.

[4]. **E. Picano, L. Gargani, & M. Gheorghiade2015.** Why, when, and how to assess pulmonary congestion in heart failure: pathophysiological, clinical, and methodological implications. Heart failure reviews.vol.15[1],pp.63-72,2015.

[5]. **E. E. D. A. W. Koraa, T. M. Aly, , H. S. Hussein & S. K. Beshara,** The role of chest ultrasound in detection of pulmonary congestion in hemodialysis patients. Egyptian Journal of Bronchology.vol.12[4],pp.482,2018.

[6]. **F. Mallamaci, F. A. Benedetto, R. Tripepi, , S. Rastelli, P. Castellino, G. Tripepi, , C. Zoccali.** Detection of pulmonary congestion by chest ultrasound in dialysis patients. JACC: Cardiovascular Imaging.vol.3[6],pp.586–594,2010.

[7]. **JL. Cepeda Marte, A. Javier, C. Ruiz-Matuk, R. Paulino-Ramirez**. Quality of Life and Nutritional Status in diabetic patients on hemodialysis. Diabetes Metab Syndr. 2019 Jan-Feb.vol.13[1],pp.576-580.

[8]. **M. Trezzi, D. Torzillo, E. Ceriani, G. Costantino, , S. Caruso, P. T. Damavandi, & C. Cogliati,** Lung ultrasonography for the assessment of rapid extravascular water variation: evidence from hemodialysis patients. Internal and emergency medicine.vol.8[5],pp.409-415,2013.

[9]. V. E. Noble, A. F. Murray, R. Capp, M. H. Sylvia-Reardon, , D. J. Steele, & A. Liteplo, Ultrasound assessment for extravascular lung water in patients undergoing hemodialysis: time course for resolution. Chest.vol.135[6],pp.1433-1439,2009.

[10]. **C. Donadio, L. Bozzoli, E. Colombini, G. Pisanu, G. Ricchiuti, E. Picano, & L. Gargani,** Effective and timely evaluation of pulmonary congestion: qualitative comparison between lung ultrasound and thoracic bioelectrical impedance in maintenance hemodialysis patients. Medicine.vol.94[6].,2015.

[11]. **C. Zoccali, F. A. Benedetto, F. Mallamaci, G. Tripepi, G. Giacone, A. Cataliotti & L. S. Malatino.** Prognostic value of echocardiographic indicators of left ventricular systolic function in asymptomatic dialysis patients. Journal of the American Society of Nephrology, 15[4], 1029-1037,2004.

[12]. **G. Enia, R. Tripepi, V. Panuccio, C. Torino, M. Garozzo, G. G. Battaglia, & C. Zoccali,** Pulmonary congestion and physical functioning in peritoneal dialysis patients. Peritoneal dialysis international.vol.32[5],pp.531-536,2012.

[13]. **N. Vitturi, M. Dugo, M. Soattin, F. Simoni, L. Maresca, R. Zagatti, et al.** Lung ultrasound during haemodialysis : the role in the assessment of volume status. International urology and nephrology.vol.46[1],pp.169-174,2014.

[14]. **X. K. Liang, L. J. Li, X. H. Wang, X. X. Wang, Y. D. Wang, and Z. F. Xu,** Role of Lung Ultrasound in Adjusting Ultrafiltration Volume in Hemodialysi ,2019.

[15]. **M. Mokhtar Mabrouk El-Atar, N. Fathy Esmael Hasan, F. Shawky Basiony & S. Farrag Ahmed.** Role of Chest Ultrasound and Inferior Vena Cava Diameter in Assessment of Volume Status in Hemodialysis Patients. Al-Azhar Medical Journal.vol.51[2],pp.1145-1154,2022.