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Role of Lung Ultrasound in the Assessment of Hydration Status of Chronic Haemodialysis Patients

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Abstract

Background: Fluid overload is frequent in Haemodialysis (HD) and is one of the major factors of cardiovascular morbidity and mortality for chronic HD patients. The main challenge with chronic haemodialysis patients is indeed the maintenance of a normal extracellular volume through dry weight determination. Our study aimed at assessing the role of lung ultrasound in the detection of B-lines for the determination of hydration status in chronic HD patients. **Methods:** We conducted a cross-sectional study including 31 patients undergoing chronic HD treatment for at least 3 months, in the Yaounde University Teaching Hospital dialysis unit. Lung ultrasonography and clinical examinations were performed immediately before dialysis, and 30 minutes after dialysis. Differences between clinical and ultrasound variables before and after dialysis were measured to assess the effects of dialysis. Association between categorical variables was assessed with the Chi-squared test or Fischer test, and Rho's Spearman coefficient for quantitative variables. **Results:** There was a reduction in the median of B-lines score after dialysis [12 (7 - 26) versus 8 (5 - 13)], clinical score [2 (1 - 3) versus 0 (−1 - 2)], mean of systolic blood pressure (164.74 ± 26.50 versus 158.48 ± 27.89), frequency of dyspnoea in patients (32.3% versus 6.5%); and raising of the frequency of cramps in patients (0% versus 19.4%) and all statistically significant ($p \leq 0.031$). B-lines score before and after dialysis was associated with dyspnoea and raised jugular venous pressure ($p < 0.05$). B-lines score before dialysis was correlated with B-lines score after dialysis ($r = 0.805$; $p < 0.001$), B-lines reduction ($r = 0.862$; p <

0.001), and clinical score (r = 0.49; p = 0.005). Reduction of B-lines score was not correlated with weight loss. **Conclusion:** Lung ultrasound for the detection of B-lines reflects the variation of extracellular volume during dialysis and can even capture pulmonary oedema at a pre-clinical stage. It is then a reliable and sensible method for assessing extravascular lung water and thus hydration status of haemodialysis patients. It could constitute a better alternative for an objective and accurate definition of dry weight, specifically in the African and Cameroonian context, with its assets being low cost, availability, and easiness to perform in a large population of HD patients. We, therefore, recommend further multicentric studies in order to design a standardized protocol of ultrasound follow-up for all chronic HD patients' hydration status assessments.

Keywords

Haemodialysis, Lung Ultrasound, B-Lines, Hydration Status, Clinical Score

1. Background

Haemodialysis (HD) is the most common technique of Renal Replacement Therapy (RRT) used in the treatment of End-Stage Renal Disease (ESRD) over the world, representing 75% of the methods for the treatment of patients in Europe and in Central Asia [1] and 95% of patients in North-Africa [2]. It is the only RRT available in Cameroon where the mortality rate is high with a mean survival time of 8 months after initiation [3]. The main comorbidities of chronic HD patients in Cameroon are: high blood pressure, diabetes, and other cardiovascular diseases [1] [4].

Chronic fluid overload is frequent in HD and is a major factor for the high cardiovascular morbidity and mortality observed in chronic HD patients [5] [6]. It is directly associated with high blood pressure, arterial wall rigidity, left ventricular hypertrophy, and heart failure [7] [8]. One of the main challenges faced in HD is the maintenance of a normal extracellular volume through the determination of patients' dry weight [9].

The precise assessment of hydration status is very important for the optimal treatment of HD patients, as it enables a reliable determination of patients' dry weight. There are many methods used in assessing patients' hydration status: clinical examination, ultrasound measurement of inferior vena cava diameter and its collapsibility index, biomarkers (Atrial natriuretic peptide, Brain and Pro-brain natriuretic peptide), and bioimpedance methods [10].

Clinical methods are subjective and less efficient for the precise assessment of chronic HD patients' hydration status [5], and require time and precise skills from the clinician to reach the dry weight upon many consecutive dialysis sessions [11].

The clinical examination aims at detecting signs of fluid overload and those of dehydration and vascular instability [6]. According to many scholars [6] [7] [12] [13] [14] [15] [16], this classical clinical and empirical approach is less reliable, does not always help detect patients' hydration status, and could even be contradictory. The continuous removal of water during dialysis up to symptomatic hypotension [7] could help to obtain the dry weight upon several consecutive dialysis sessions. However, there is a risk of overestimation of patients' dry weight, which could cause chronic fluid overload, or underestimation of dry weight leading to immediate intra- or post-dialysis complications [17].

In many studies, multifrequency bioimpedance (BIS) has been described as a reliable dry weight determination method in chronic HD patients [15] [18] giving room to a precise assessment of patients' hydration status [15] [19].

In low-income countries, like Cameroon, the clinical approach remains the only method used in determining HD patients' hydration status given the lack of technologies such as bioimpedance. Moreover, the use of clinical methods is compromised; on one hand, the reduction of dialysis sessions from 3 to 2 sessions per week and patients' poor observance of medical instructions. On the other hand, the irregularity of dialysis sessions because of short-term challenges observed in dialysis centres, and financial difficulties faced by patients prevents continuous weight loss monitoring. Such clinical estimate is achieved by means of trial and is therefore prone to imprecision.

These difficulties observed in the prevention of chronic fluid overload highlight the need to acquire a tool that could be used for a precise, rapid, and objective assessment of hydration status and a rapid determination of HD patients' dry weight in Cameroon.

Lung ultrasound through the detection of B-lines has been described as an assessment method of HD patients' hydration status and is much more used in determining lung extravascular fluid volume [9] [10] [20]. Lung ultrasound can evaluate extravascular lung water by identifying B-lines, which are vertical artifacts arising from the pleural line, extending to the edge of the screen, and which move synchronously with respiratory. Such artifacts, in reference to Kerley B lines on chest X-ray, are described in lung ultrasound as comet-tail artifacts formed as the ultrasound beam meets thickened interlobular septa filled with water in case of interstitial lung oedema [21] [22]. This method is easy, fast, cheap, and non-invasive, requiring just an ultrasound machine with a linear, convex, or sectoral transducer [21].

This study aims at assessing the benefits of lung ultrasound in common clinical practices to determine chronic HD patients' hydration status.

2. Methods

This was a cross-sectional 07 months study (November 2016-May 2017) including 31 HD patients, aged 18 and above who have been on dialysis for more than 3 months at the Yaoundé University and Teaching Hospital (CHUY). It is one of the reference hospitals in Cameroon where patients suffering from end-stage chronic kidney disease undergo 4 hours of dialysis twice weekly.

Exclusion criteria include the presence of acute diseases or diseases that require hospital admissions such as decompensated cirrhosis, end-stage cancer, and systemic infections, patients on vacation or tourists, pregnant women, and patients who refused to sign informed consent forms.

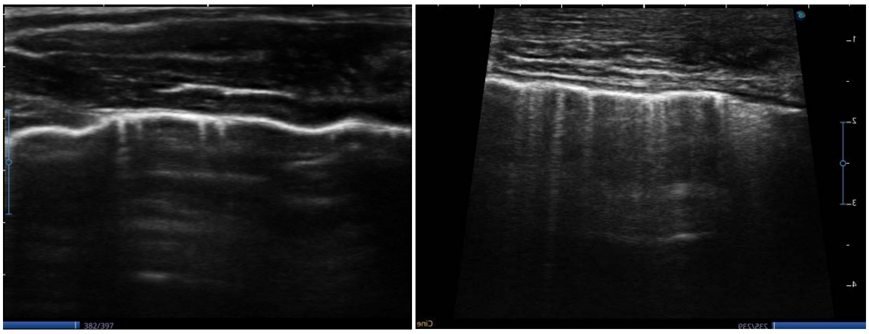
Each patient was assessed clinically and administered lung ultrasound immediately before and 30 minutes after the second dialysis session of the week.

2.1. Lung Ultrasound

Lung ultrasounds were performed by one operator, specially trained to recognize and interpret B-lines. Lung ultrasound was performed on patient in a supine position using a Doppler portable ultrasound tool with a vascular probe of 6 - 12 MHz (BK Medical Mini Focus®) for the detection of B-lines. Comet-tails or "B-lines" are defined as hyperechoic reflections which originate only from and travel roughly perpendicular to the pleural line of the lung. They have a narrow base and form a ray spreading away from the transducer towards the bottom of the screen (similar to a rocket at lift-up) and synchronously move with lung respiration [23] [24]. Areas explored included anterior and lateral regions of the two hemithorax, from 2nd to 4th intercostal space, and from 1st to 5th intercostal space in the right side of the chest. For each intercostal space, B-lines were detected in 4 different sites: para-sternal, midclavicular, anterior axillary and mid axillary areas, giving 28 positions per test [25] [26]. For all the explored sites, B-lines ranged from 0 to 10. Number 0 indicated the absence of B-lines whereas number 10 stood for complete blank screen. All the B-lines detected on various sites explored produced a score, the score of B-lines, indicating the severity of lung congestion [25] [26]. Patients were grouped according to these scores and to the following levels of lung congestion as previously described in other studies: No congestion ≤ 5 B-lines, mild congestion: 6 - 15, moderate congestion: 16 - 30, severe congestion: >30 [9] [22] [26] [27]. **Figure 1** shows examples of B-lines.

2.2. Clinical Examination

Clinical examination was performed before the dialysis and 30 minutes after the session. All patients were evaluated during the second dialysis session of the week. Hemodynamic and anthropometric parameters such as blood pressure, heart rate, weight and height were taken. Clinical examination substantially consisted in identifying symptoms and signs of hyperhydration or fluid overload and of dehydration or hypovolemia. Each functional or physical sign related to hyperhydration such as peripheral oedema, dyspnea, high blood pressure, jugular veins turgor, ascites [6] [24] [28] [29] [30] was given a positive figure whereas negative figures were attributed to signs indicating hypovolemia such as dizziness, asthenia, cramps, low blood pressure [6] [24] [28], resulting to a clinical score as interpreted in **Table 1**.



(a) (b)

Figure 1. Lung ultrasound, 2 different patients. (a) 4 B-lines; (b) 10 B-lines.

Table 1. Description of the clinical score assessing the hydration status.

Hydration Status	Score	Description
Hypovolemia	≤−3	Patent Hypovolemia
	−2	Latent Hypovolemia
	−1	Undefined
Normal	0	Normal
Hyperhydration	1	Undefined
	2	Latent Fluid Overload
	≥3	Patent Fluid Overload

This clinical score before and after dialysis were compared, to determine the impact of dialysis on clinical signs assessing the hydration status.

2.3. Data Analysis

Data were recorded and treated with Excel 2013, then exported to BM-Statistical Package for Social Sciences (IBM-SPSS) 22.0 for statistical analysis. Tables and figures were obtained using Excel 2013.

Data were presented as mean and standard deviation, median and interquartile range, or frequency and percentage, as appropriate. We used the Shapiro Wilk test to determine the normality of our quantitative variables' distribution.

For qualitative variables, we used the Chi-square test to compare groups of patients or the Fischer test when the expected number of patients was below 5, and the Mc Nemar test was used to compare variables.

For quantitative variables, the student *test-t* was used for independent samples and the Wilcoxon signed-rank test, where appropriate. Correlations between variables were assessed using Spearman's rank correlation coefficient. The relationship between the B-lines before and after dialysis was measured using the intra-class correlation coefficient. The significance threshold was established for $p < 0.05$.

3. Results

31 patients were registered, aged between 27 to 70 years with an average age of

49 years ± 11.4. The first cause of kidney disease was hypertensive nephropathy (32.3%) followed by chronic glomerulonephritis (25.8%) and diabetic nephropathy (19.4%). The major comorbidities of these patients were high blood pressure (83.9%), diabetes (29%), heart failure (16%) and left ventricular hypertrophy (16%).

3.1. Variations in Clinical and Ultrasonographic Signs after Dialysis

After dialysis, it was observed that the number of dyspnoeic patients significantly reduced but more patients complained of cramps (Table 2). Up to 42.5% of patients proved to have fluid overload before dialysis; whereas 16.1% showed a normal clinical hydration status (Table 3).

Levels of systolic blood pressure and weight decreased considerably after dialysis. Blood pressure decreased from 164.74 (±26.50) to 158.48 (±27.89) mmHg and weight loss from 74.76 (±11.4 to 71.38 (±11.34) kg. It was also observed that their clinical score significantly dropped after dialysis ($p < 0.001$).

B-lines number median reduced considerably after dialysis ($p < 0.001$), as described in Table 4.

Table 2. Changes in clinical signs after dialysis.

Variables	Number N (%)			
	Clinical Signs	**Before Dialysis**	**After Dialysis**	**P-value**
Signs of Congestion	Peripheral Edema	6 (19.4)	3 (9.7)	0.25
	Dyspnea	10 (32.3)	2 (6.5)	**0.008**
	AP ≥ 140/90 mmHg	27 (87.1)	22 (71)	0.125
	Jugular Veins Turgor	16 (51.6)	12 (38.7)	0.125
	Ascites	3 (9.7)	2 (6.5)	1
Signs of Hypovolemia	Low Blood Pressure	0.	1 (3.2)	1
	Dizziness	1 (3.2)	6 (19.4)	0.063
	Cramps	0.	6 (19.4)	**0.031**
	Asthenia	0.	2 (6.5)	0.5

Values are given in frequency and percentage in brackets; significant p values are in bold.

Table 3. Hydration status according to clinical score.

Clinical Score	Clinical Hydration Status	Before Dialysis N (%)	After Dialysis N (%)
≤−3	Patent Hypovolemia	0.	1 (3.2)
−2	Latent Hypovolemia	1 (3.2)	2 (6.5)
−1	Undefined	0.	5 (16.1)
0	Normal	0.	5 (16.1)
1	Undefined	11 (35.5)	8 (25.8)
2	Latent Fluid Overload	5 (16.1)	5 (16.1)
≥3	Patent Fluid Overload	14 (45.2)	5 (16.1)

Values are given in frequency and percentages in brackets.

Table 4. Changes in the number of B-lines after dialysis.

Number of B-lines	N (%) before Dialysis	N (%) after Dialysis
<6 = No Congestion	4 (12.9)	8 (25.8)
[6 - 15] = Mild Congestion	15 (48.4)	17 (54.8)
[16 - 30] = Moderate Congestion	8 (25.8)	6 (19.4)
>30 = Severe Congestion	4 (12.9)	0

Values are given in frequency and percentage in brackets; lung congestion < 6 B-lines = no congestion, [6 - 15] = mild congestion, [16 - 30] = moderate congestion, >30 = severe congestion.

3.2. Factors Associated with the Number of B-Lines

The clinical factors associated with the presence of B-lines before dialysis were dyspnoea and jugular veins turgor. This association decreased after dialysis. Indeed the number of dyspnoeic patients increased with the severity of lung congestion assessed by the number of B-lines (Figure 2). It was the same observation with the jugular vein's turgor (Figure 3). This number was very low after dialysis.

3.3. Correlation between Measured Parameters and the Number of B-Lines

We assessed the number of B lines before and after dialysis, the decrease in the number of B lines after dialysis and the various measured clinical parameters.

Clinical parameters associated with the number of B-lines before dialysis:

There was a big correlation between the number of B lines before and after dialysis ($r = 0.805$, $p < 0.001$), measured by the interclass correlation coefficient. The number of B-lines was also associated with the clinical score before dialysis ($r = 0.549$; $p = 0.001$).

Clinical and ultrasonographic parameters associated with the decrease in the number of B lines:

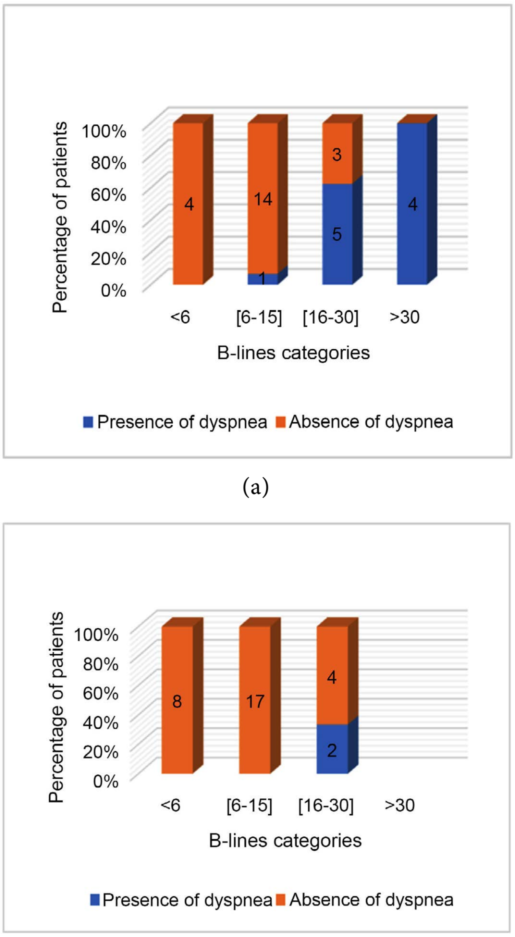
Table 5 shows that the decrease in the number of B-lines after dialysis was strongly associated with the number of B lines before dialysis ($r = 0.862$; $p < 0.001$).

Clinical and sonographical parameters associated with the number of B-lines before dialysis:

Findings in Table 6 show that the number of B-lines after dialysis was strongly correlated with that of the presence of B-lines before dialysis ($r = 0.935$; $p < 0.001$) and with the reduction of B-lines after dialysis ($r = 0.672$; $p < 0.001$).

4. Discussion

There is a correlation between hyperhydration and the high mortality rate of HD patients following quantitative assessment of hydration status [6]. The main aim of RRT in HD patients with ESRD is the adequate control of extravascular fluid level. Hyperhydration has a significant impact on high blood pressure, the development of arteriosclerosis and on the high prevalence of left ventricular hypertrophy observed in chronic HD patients [8] [16]. Despite the various methods used to assess the HD patients' hydration status, dry weight assessment remains a big challenge, notably for developing countries where there is lack of appropriate technical facilities. This study aimed at determining the contribution of lung ultrasound techniques in the assessment of the chronic HD patients' hydration status.



(a)

(b)

Figure 2. Repartition of dyspnea accordimg to B-lines. (a) = in pre-dialysis, (b) = in post-dialysis; lung congestion: absent < 6, mild = [6 - 15], moderate = [16 - 30], severe > 30.

Table 5. Correlation with the reduction of the number of B-lines.

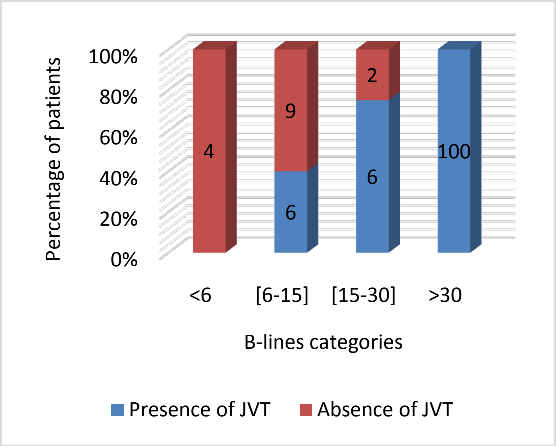
Variables	Spearman's Rank Correlation Coefficient	P-value
B1-lines	0.862	**0.000**
Δweight	0.061	0.746

B1-lines = number of B-lines before dialysis; Δweight = change of weight before and after dialysis; significant p-values are in bold.

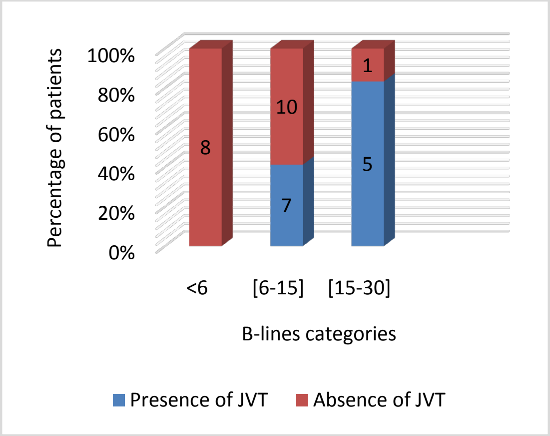
Table 6. Correlation with the number of B-lines after dialysis.

Variables	Spearman's Rank Correlation Coefficient	P-value
B1-lines	0.935	**0.000**
ΔB-lines	0.672	**0.000**
Systolic Blood Pressure	0.121	0.515
Diastolic Blood Pressure	−0.084	0.653
Pulses	0.157	0.400
SaO_2	−0.166	0.371
Clinical Score 2	0.211	0.255

B1-lines = number of B-lines before dialysis; ΔB-lines = decrease in the number of B-lines after dialysis; clinical score 2 = clinical score after dialysis; SaO_2 = oxygen saturation; significant p-values are in bold.



(a)



(b)

Figure 3. Repartition of jugular veins turgor according to B-lines. (a) = in pre-dialysis, (b) = in post-dialysis; lung congestion: absent < 6, mild = [6 - 15], moderate = [16 - 30], severe > 30.

4.1. Analysis of the Variation in Clinical and Sonographical Signs after Dialysis

In this study, we observed that there is a significant decrease in the number of B-lines after dialysis, as described in many previous studies [9] [20] [24] [31]. B-lines are associated with the accumulation of water during the interdialytic period and reflect the variation in the level of extravascular lung water which occurs during dialysis [32]. In their study, Khamis *et al.* also showed a significant decrease of number of B-lines post-dialysis, especially for the group of patient with interdialytic hypertension (from 10 to 4 B-lines) [20]. Noble *et al.* [33] and Mallamaci *et al.* [22] proved that the number of B-lines rapidly and in a reliable manner reflects the extracellular fluid variation, with an average duration of 4 minutes for the change on the screen [22]. Whereas inferior vena cava ultrasound can only be performed two hours after dialysis because of the equilibration time between interstitial and intravascular compartments [22] [34] [35]. Equally, multifrequency bioimpedance should be done 30 minutes to two hours after dialysis [36] [37].

After dialysis, we observed a significant drop in the systolic blood pressure, though it was low compared to studies carried out in Europe [9] [22] [31] [38]. This could be explained by the fact that the patients described within this study presented with a higher blood pressure probably related to the reduction of weekly dialysis sessions and the irregular intake of antihypertensive drugs. There was also a significant drop in the clinical score showing that it could reflect the variation in hydration status after dialysis.

4.2. Analysis of Factors Associated with the Presence of Sonographical B-Lines

A correlation between dyspnea and the presence of B-lines was observed before dialysis; a similar correlation was also observed by Siriopol *et al.* [9] and Mallamaci *et al.* [22]. The role of fluid overload in the development of pulmonary oedema was highlighted by the significant decrease in the number of dyspnoeic patients after dialysis [9] [22].

We also observed a correlation between the presence of B-lines in pre-and post-dialysis and jugular veins turgor ($p = 0.005$). This correlation reduced after dialysis ($p = 0.022$). Furthermore, jugular veins turgor was more sensitive than dyspnoea in predicting pulmonary oedema. Indeed, jugular veins turgor could be felt with mild lung congestion (**Figure 2**). This correlation with jugular veins turgidity was not found in the literature, thus the specificity of our study. Moreover, dyspnea and jugular veins turgor were observed only after a minimum of 6 B-lines, indicating that lung ultrasound could help detect the formation of pulmonary oedema at the preclinical stage, also shown by Mallamaci *et al.* [22] and Allinovi *et al.* [28]. Therefore, it is a sensitive indicator of the efficiency of ultrafiltration given the regression of dyspnea post-dialysis (**Figure 3**).

We did not find any significant difference in peripheral oedema at pre- and post-dialysis. This explains the non-specificity of this clinical sign in the assessment of hyperhydration as described by Torino *et al.* [39].

We could also establish a clinical score based on patients' physical and functional signs, and this score was positively correlated with the number of B-lines before dialysis ($r = 0.49$, $p = 0.005$). These findings are similar to those presented by Allinovi *et al.* [28] who found a linear correlation between B-lines number and the clinical assessed level of fluid overload.

4.3. Analysis of the Correlation of Measured Parameters and B-Lines

Despite significant weight loss post-dialysis (−3.38 kg, $p < 0.001$), there was no correlation between the number of B-lines after dialysis and weight variation. This is similar to findings by Siriopol *et al.* [9], Khamis *et al.* [20] and Mallamaci *et al.* [22]. Whereas Vitturi *et al.* [24] obtained a relatively low number of B-lines, and they described a high correlation between the decrease in the number of B-lines and weight loss after dialysis. However, their target population was made up only of asymptomatic patients with clinically determined dry weight [24]. Therefore, the absence of a correlation between weight variation and the reduction of the number of B-lines in our study could probably be due to the fact that patients were not at their dry weight, thus the relatively high number of B-lines; and secondly from the high number of dyspnoeic patients.

Studies carried out by Mallamaci *et al.* [22] showed a high correlation between the number of B-lines, the reduction of the number of B-lines and the cardiographic parameters, particularly the ejection fraction of left ventricle. According to them, the presence of B-lines essentially depends on the fraction of systolic ejection rather than on the fluid overload. In the same light, Siriopol *et al.* [38] found that lung ultrasound could produce the same information as echocardiography; and so, could improve treatment and prognosis of chronic HD patients, since it's easier, more accessible and cheaper than echocardiography.

In the light of these analyses, lung ultrasound could be a good alternative for an objective and precise assessment of HD patients' hydration status. It could contribute to a reliable weight loss determination, as described by other researchers [24] [30] [34]. It is a non-invasive test, easy to perform by non-specialists [22] [28], and could easily be used in Africa and in Cameroon, particularly given the availability of ultrasound machines in our hospitals and in some nephrology units. Compared to BIS or inferior vena cava diameter measurement which are costly, this test simply requires standard equipment [23] [31]. Its intra- and inter-observator reproducibility is good and higher than that of inferior vena cava ultrasound measurement [22] [24] and with a good inter probe reproducibility [22], making it easy to perform this test even with a probe for kidney evaluation (3.5 MHZ). Moreover, studies have shown that determination of extravascular lung water using a lung ultrasound machine was highly associated with the mortality and the occurrence of cardiovascular difficulties in chronic HD patients [9]

[27], thus indicating its role in assessing haemodialysis prognosis. This ultrasound technique has the advantage that it can be performed immediately after a dialysis session on different categories of HD patients (young children, patients with metallic implants, amputees, etc.). One of the major benefits of lung ultrasound is its superior correlation with every other hydration status assessment techniques (bioimpedance, sonographic measurement of inferior vena cava, clinical methods) [24] [28] [31].

From the analysis above, the integration of lung ultrasound in the follow up of chronic HD patients is recommended for an objective assessment of their hydration status and the precise determination of their dry weight.

5. Limitations

Our study is limited by the small sample population obtained from just one dialysis centre, because of the unavailability of ultrasound machines.

Ultrasound measurements of the inferior vena cava and multifrequency bioimpedance were not available to enable a direct comparison with our findings.

Most of the chronic HD patients from our centre had no clinically determined dry weight because of the difficulties faced by the centre during our study period.

6. Conclusions

The findings of our study show that lung ultrasound could be efficient in the rapid evaluation of fluid overload in chronic HD patients through the detection of lung oedema in the preclinical stage. It, therefore, contributes to the optimisation of ultrafiltration and the improvement in prognosis.

It could be a good alternative for the objective and precise determinations of chronic HD patients' dry weight in Africa and in Cameroon, particularly because it is easy to perform, available, cheaper, and can apply to the majority of chronic HD populations. It would be interesting to carry out a study with a larger sample population (multicentric study) in order to design a standardised protocol of ultrasound follow-up for all chronic HD patients' hydration status assessments.

Acknowledgements

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Availability of Data and Materials

The data (in French) analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' Contributions

All authors contributed to the study conception and study design and were responsible for ethical approval. SFD and JRTM supervised data collection. SGC, JRTM, and SFD conducted the interviews, the clinical exams, and the lung ultrasounds. SFD performed the data analysis and data interpretation in collaboration with SGC, JRTM, DGT, and BM. SFD and JRTM participate in drafting the manuscript. DGT, FJFK, and MB made critical revisions for important intellectual content. The final version of the manuscript was read and approved by all authors.

Ethics Approval and Consent to Participate

This study was performed in accordance with Helsinki Declaration, and has been approved by the ethics committee of the Faculty of Medicine and Biomedical Sciences of the University of Yaoundé I. The ethical clearance reference number is 162/UYI/FMSB/VDRC/CSD. Written informed consent was obtained from each participant prior to the data collection.

Consent for Publication

Not applicable, since all the data was de-identified and presented on a group level to protect the providers' anonymity.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Abbreviations

BIS: Bioimpedance Spectroscopy;
CHUY: Yaoundé University and Teaching Hospital;
HD: Haemodialysis;
JVT: Jugular Vein Turgor.