Benha Journal of Applied Sciences (BJAS) **print: ISSN 2356–9751**
Vol. (7) Issue (5) (2022), (95-100) **online: ISSN 2356–976x**
http://bjas.journals.ekb.eg

Lung Ultrasound: A Novel Technique for Detecting Fluid Overload in Children on Hemodialysis

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Abstract

Adult hemodialysis patients have benefited from studies on the use of lung ultrasounds. Despite this, it is still difficult to use in paediatric patients. The purpose of this research is to determine whether or not juvenile hemodialysis patients can be monitored for dry weight using lung ultrasonography to measure volume overload. Sources and Procedures: An observational research in the nephrology unit of Benha University Hospital's hospital nephrology department was conducted. The B-line scores of the dry-weight and non-dry-weight groups were compared before and after dialysis. Dialysis sessions and interdialytic periods were documented for changes in body weight and B-line scores, and the association was examined. A total of 40 lung ultrasounds were done on 20 children before to and after hemodialysis, respectively. After dialysis, all patients' B-line scores dropped significantly (p 0.001). r=0.811, p0.01 and r=0.59, p0.001 and r=0.75, p0.001 respectively) were shown to be associated with an increase in interdialytic weight, blood pressure, and the clinical fluid score prior to dialysis. When it comes to B-line score decrease, dialytic weight loss (r=0.891, p0.01) is directly and positively connected (r=0.891). Pediatric hemodialysis patients' fluid volume changes may be assessed using lung ultrasonography. In addition, lung ultrasonography may be used to assess dry weight in children undergoing hemodialysis.

Keywords: Hemodialysis, Dry weight, Fluid overload, Lung ultrasound, Ultrasonographic B-line.

1.Introduction

All patients in cardiology, critical care, and nephrology, in particular, need to have their normohydration maintained as much as possible. These patients are more likely to suffer from overhydration than others. When both the heart and kidneys are malfunctioning, overhydration is nearly a given [6[. Hypertension and cardiac preload are exacerbated in patients with abnormal fluid status, resulting in LV hypertrophy and congestive heart failure. As a result, greater cardiovascular (CV) morbidity and death have been associated to excessive hydration [7]. Similarly, fluid buildup has been demonstrated to affect prognosis in critically sick patients and those with acute renal damage (Agarwal et al., 2008). Patients with fluid overload had greater death rates at 30 days, 60 days, and release from the hospital. As for the second,. Patients with chronic kidney disease (CKD) are at increased risk of all-cause mortality and cardiovascular morbidity because of fluid overload, which leads to arterial stiffness and atherosclerosis, as well as uremic cardiomyopathy [5]. Importantly, both predialysis overhydration and predialysis underhydration are linked to an increased risk of mortality in patients with end-stage renal disease (ESRD) [6].

2.The aim of the work

During the dialysis phase and the interdialysis interval, this research intended to analyse the connection between clinical methods of volume load measurement and B-line score, and to monitor changes in dry weight in paediatric hemodialysis patients associated with B-line scores.

3. Materials and methods

3.1. Study design

Pediatric patients with ESKD who were on an maintainance hemodialysis program in the pediateric nephrology unit of the Benha University hospital were included in this prospective observational study. The study was approved by the Local Ethical Committee of the Medical Faculty of Benha University, and written informed consent was obtained from the parents. There were 25 pediatric patients who were receiving regular hemodialysis in this unit. five of these patients could not be included in the study as they had an exclusion criteria (two ARDS and three cardiac failure), that could have affected the lung ultrasonography findings. Each patient was examined before and after two different dialysis sessions. All patients received three hemodialysis sessions per week for 4 h per session.

The pediateric physicians measured blood pressure manually using a sphygmomanometer and stethoscope. Hypertension was defined as blood pressure greater than the 95th percentile for age, height, and sex according to [4]***Pediatrics' guidelines*** . The patients were weighed undressed on a calibrated weighing machine. Before each session, the physicians defined the ultrafiltration (UF) goal regarding the patients' intradialytic weight gain, and physical examinations assessing conditions including edema, crackles on chest auscultation, and hypertension were performed. The baseline weight was reviewed by the division of pediatric nephrology at the trimonthly meeting.

Demographic and clinical data, including age, sex,residence, cause of CKD, vital signs, urine out put, dry weight, use of antihypertensive drugs, laboratory measurements, and ECHO findings were collected. Additionally, the pre- and postdialysis body weight, blood pressure, and bedside ultrasonographic measurements were recorded. This hydration assessment has been used in previous studies on children [9] .

Moreover, according to [8, 3], the degree of fluid overload was clinically evaluated before dialysis by clinical score of 0 to 10 by the attending physician depending on some clinical parameters (dyspnea at rest, orbital edema, weight gain, hypertension and chest crepitation).

3.2. Bedside ultrasonographic measurements

Ultrasonographic examinations were performed on both lungs, using a high-frequency (8.0–12.5 MHz) linear probe. The lung ultrasound measurements were performed at the bedside by a fixed radiologist. An ultrasound scanning section was performed for each patient 15 min before dialysis and 15 min after dialysis. All patients underwent lung ultrasound in the supine position. As previously reported, lung scans proceeded from the 2nd to the 5th intercostal space on the right side and from the 2nd to the 4th on the left side, and the transducer was along the parasternal, mid-clavear, anterior axillary, and mid-axillary lines [10].

3.3. Statistical analysis

A Wilcoxon rank test (non-normally distributed data) was used to compare changes in the number of B-lines predialysis and postdialysis in the dry weight and non-dry-weight groups. Relationships between variables were tested with the Pearson product-moment correlation coefficient. Correlations were calculated for B-line scores and Weight in the interdialytic period and dialytic period. A p value < 0.05 was considered to indicate statistical significance.

4.Results

A- ***Patient baseline characteristics***

twinty patients were enrolled in the study.Of these, 10 (50%) were male. The median age was 9.66 (range 4.5 -17) years. The median follow-up time was 5 (range 1–11) months. Nephrotic was the most common cause of CKD in this study by 30%.

Table (1) Distribution of patients according to the cause of CKD.

Demographic data			Value
Residence	**Rural**	**Count**	11
		%	63.3%
	Urban	**Count**	9
		%	36.7%
Sex	**female**	**Count**	10
		%	50.0%
	male	**Count**	10
		%	50.0%
Age	**Min- Max**		4.5 -17 years
	Mean ± SD		13.417 ± 3.7511 years

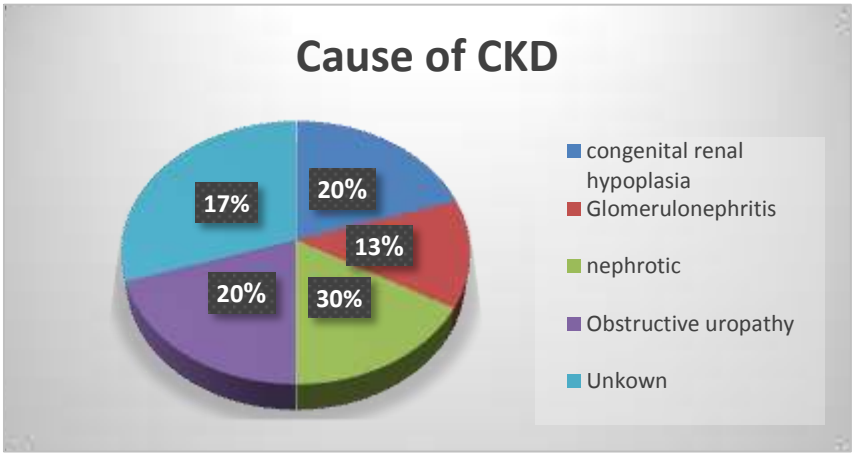

Fig.(1) Distribution of patients according to the cause of CKD.

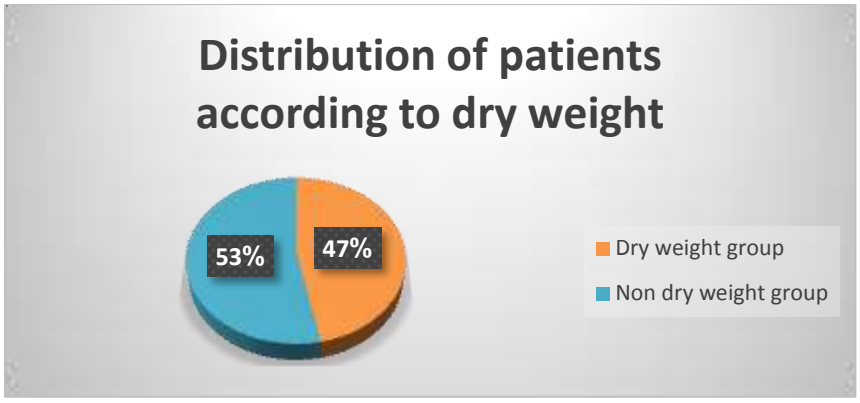

Fig.(2) Distribution of patients according to dry weight.

B- Changes in ultrasonographic B-line score

Lung ultrasound assessments were performed in the dry-weight group and non-dry-weight group. Post dialytic B-line scotes had decreased among all patients. In both dry- weight group and non dry weight group, post dialytic B-line scores were significantly reduced ($p < 0.001$). dry-weight group showed lower mean B-line scores than those of the non-dry-weight group, and the difference between the two groups was statistically significant ($p < 0.001$). The B-line score postdialysis in the dry-weight group was 6.5 (2–13). Table 2 shows the B-line scores of the dry-weight group and non-dry-weight group.

Table(2) Comparison between ultrasonographic B-line scores before and after dialysis in both dry weight and non-dry weight groups.

Before dialysis	19.5 (8–35)	48.5 (14–152)
After dialysis	6.5 (2–13)	26 (5–49)
t- test	5.1318	7.369
P value	0**	0**

C- Correlation between the total number of B-lines and other fluid status parameters

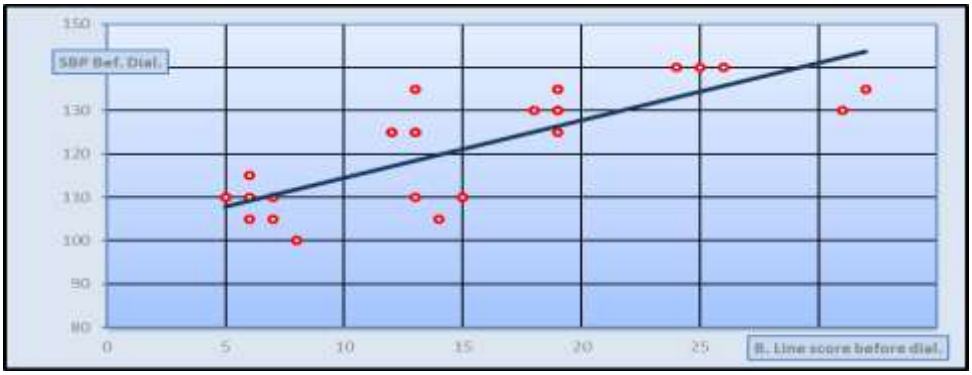

Fig. (3) Correlation between total number of B-lines before, and predialytic systolic blood pressure.

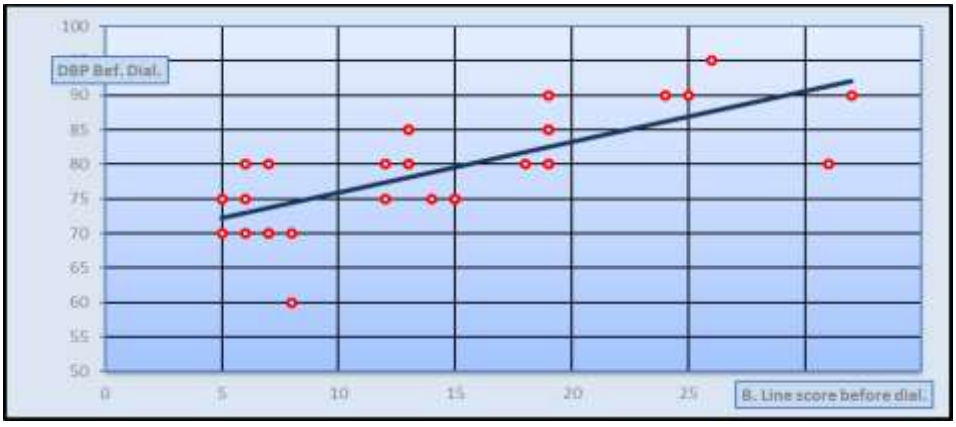

Fig. (4) Correlation between total number of B-lines before, and predialytic diastolic blood pressure.

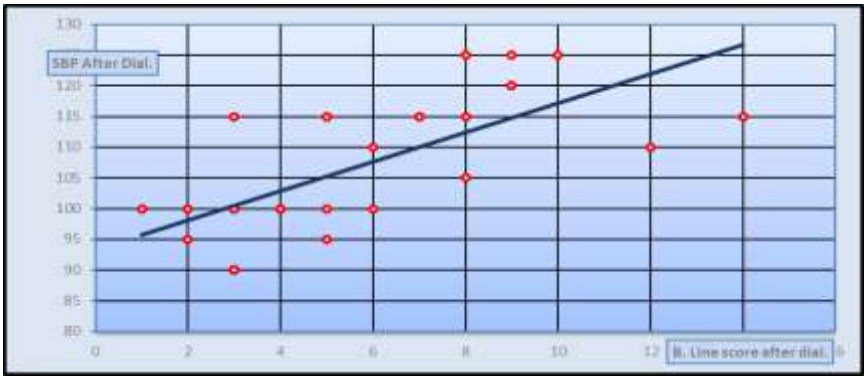

Fig. (5) Correlation between total number of B-lines after dialysis, and postdialytic systolic blood pressure**.**

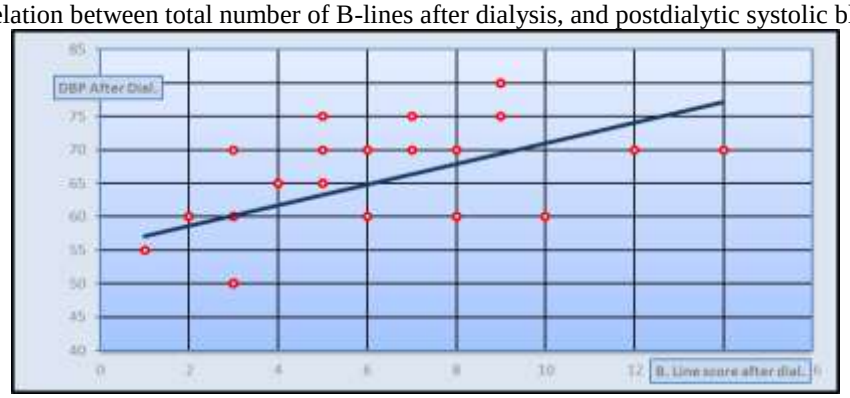

Fig. (6) Correlation between total number of B-lines after dialysis, and postdialytic diastolic blood pressure.

5. Discussion

As a tiny percentage of all CKD patients, children provide special difficulties to the health care system and to their clinicians, who must treat not just the underlying renal illness, but also the multiple extrarenal symptoms of CKD that complicate the management of the disease [11].

Chronic renal illness may lead to kidney failure, but it can also raise one's risk of heart disease and other diseases of the cardiovascular system. Chronic renal disease-related problems in children should be promptly identified and treated, according to evidence-based clinical practise recommendations, in order to promote healthy growth and development as well as a better quality of life for such children. Pediatric treatment may help prevent the development of this difficult and costly disorder [12].

Indeed, despite the fact that juvenile CKD has many of the same physiopathological processes as adult CKD, it may be considered a distinct illness. These clinical aspects, which are unique to childhood CKD, include the disease's negative influence on growth. There are other unknowns associated with paediatric CKD, such as the aetiology or cardiovascular problems, which may have an influence on both the patient's health now as a kid and his or her future as an adult [13].

Chronic kidney disease (CKD) epidemiology is challenging to study since the term CKD describes renal failure as a continuous state rather than a single change to renal function. Chronic kidney disease may be underreported in epidemiological studies because CKD is frequently clinically undetected, particularly in its early stages [14].

As a result of this, in most research, estimations of CKD are based on individuals with moderate to severe CKD or end-stage renal disease (ESRD) [15].

The surviving nephrons hypertrophy structurally and functionally as a consequence of nephron loss [16]. A combination of efferent arteriole vasodilatation, proximal NaCl, fluid, and phosphate reabsorption and collecting duct secretion of K+ and H+ results in a rise in intraglomerular plasma flow and intraglomerular pressure in the single nephron [17].

The most prevalent consequence in children with CKD is hypertension, which affects between 54% and 71% of patients. However, it may also be caused to excess renin from damaged kidneys or the use of corticosteroids or cyclosporin or tacrolimus to treat any underlying renal illness. This is mainly related to volume expansion [18].

Patients with tubulointerstitial illness or congenital abnormalities are less likely to have systemic hypertension than those with primary glomerular disorders or renal vascular accidents [19].

LVH and LV dysfunction, stiffness and increased intima-media thickness (IMT) of the carotids, and coronary artery calcification have all been recognised in the recent decade as early indicators of cardiomyopathy and atherosclerosis. Cardiovascular mortality and morbidity in the general population and persons with CKD are strongly associated with these variables. Research in adolescents and young adults with chronic kidney disease (CKD) has shown that these

abnormalities are also present and that the risk factors for cardiac and vascular damage among these populations mirrors those for adults [20]. In patients with moderate to high proteinuria, treatment of hypertension decreases the course of renal failure [21].

Most current hemodialysis machines incorporate relative blood volume transducers. Real-time monitoring of hematocrit and protein concentration changes in response to ultrafiltration during hemodialysis is possible with this method [22].

Hematocrit (Ht) levels may either be measured using an ophthalmic approach known as the Crit-Line method, or by determining the velocity of ultrasonographic waves going through the blood. This velocity is influenced by total blood protein content and can be used to determine hematocrit (Ht). As a result, both procedures offer a relative increase or decrease in the blood volume. Ht, or the concentration of total blood proteins, will grow as a percentage of blood volume decreases.

The slope of the RBV curve is dictated by the rate of fluid loss during ultrafiltration. In studies on adult patients, this approach was shown to reduce symptoms of hypotension and help determine goal weight [24].

GFR, urine abnormalities such proteinuria and microhematuria, and ultrasonography structural kidney changes are used to diagnose CKD. For those who have been diagnosed with CKD or fear they have it, the initial imaging test they get is a US–CDI [25].

The longitudinal kidney diameter, the parenchymal thickness/echogenicity, and the state of the urinary tract should all be assessed in patients with renal disease. This It is well accepted that the length of the renal tubules is an important indicator of CKD since it decreases when GFR lowers over time [26].

More than the longitudinal diameter, the distance between the kidney capsule and the base of the mesorenal pyramid in longitudinal scans corresponds with GFR [27].

Although cortical echogenicity rises as parenchymal thickness decreases in individuals with chronic kidney disease (CKD), even in the absence of renal sinus sclerolipomatosis, these two diseases coexist [28].

In chronic interstitial nephropathy, the atrophy index has recently been advocated as a way to track the course of renal damage. It's derived from a coronal scan's measurement of the ratio between the maximum diameter of the renal sinus and the longitudinal kidney diameter [26].

Even in the most severe stages of primitive chronic glomerulopathies (CGN), renal volume diminishes with time, but kidneys remain symmetrical and easily identifiable in the retroperitoneum. The kidney profile becomes erratic, and the distinction between cortex and medulla becomes less distinct with time, yet the renal sinus may still be easily seen [27].

CGNs linked with CKD stages 4–5 had a length of 10–11 cm and a parenchymal thickness of 16–20 mm in the majority of cases. Interstitial edoema may cause the cortex to seem hyper- or hypoechoic, with globular hypoechoic pyramids. These glomerulopathies, which are caused by vasculitis, amyloidoses at an advanced stage, and collagenopathy are frequent in the United States. Hypoechoic and uneven renal parenchyma is common in renal lymphoma [29].

As the illness progresses, the ultrasonography characteristics of diabetic nephropathy take on varying morphologies. The kidney's volume, parenchymal thickness, and hypoechogenicity are all elevated in the early stages (longitudinal diameter > 12 cm). The renal longitudinal diameter exceeds 10 cm in CKD stages 4–5. [30].

Chronic tubulointerstitial nephropathies caused by medicines or toxic chemicals have normal kidney volume and profile, but abnormal parenchymal structure and hyperechoic tones are present [31].

The most common consequence of vesicoureteral reflux is a urinary tract infection. Hydronephrosis and parenchymal loss in young patients contribute to the progression of GFR decline up to ESRD. The parenchymal scar is a common symptom of chronic pyelonephritis and vesicoureteral reflux nephropathy. Corticalization, dilation, and distortion of the relative calyx might all be contributing factors to this uneven retraction of the renal profile [32].

6.Conclusion

Finally, our results show that lung ultrasound can be used to diagnose and predict outcomes in paediatric patients with chronic kidney disease (CKD). However, additional randomised trials comparing a treatment strategy based on this technique to a standard approach are needed to confirm its clinical utility. The results of the current LUST research will supplement data from BUST and firmly demonstrate the clinical usefulness of this approach in the care of HD patients at high CV risk.

7. Acknowledgment

Thank you to everyone at the Benha University's Faculty of Medicine's Pediaterics and Radiology Departments for their assistance and cooperation.

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