Research Article

Volume Assessment in Paediatric Hemodialysis Using Lung Ultra Sonography

Ch Muhammad Umer Razaq[1], Iftikhar Ijaz[2], Khoola Bint-e-Mansoor[3], Kashif Mehmood[4], Ayesha Tariq[5], Farnaz Abbas[6]

[1-5]Children Kidney Center (IPNA Sister Renal Center) Department of Pediatrics KEMU/ Mayo Hospital, Lahore, [6]Depatment of Pediatric Radiology Mayo Hospital Lahore

Abstract

Background: It is a significant challenge clinically to optimize the weight of children and infants. It is our hypothesis that in children receiving dialysis fluid overload can be quantified using lung ultrasound.

Objectives:

1. To determine the frequency of diagnosing pulmonary edema using lung ultrasound and clinical examination
2. To determine association of percentage decrease in weight with number of B-lines in children with renal failure undergoing hemodialysis

Methods: This cross sectional study was conducted in Division of Pediatric Nephrology, Paediatric unit II, Mayo Hospital Lahore from June 2020 till December 2020 after approval of hospital committee. Patients aged 6 to 16 years undergoing regular hemodialysis after chronic kidney disease were enrolled. Lung ultrasound examinations were performed before start of dialysis and after completion of dialysis. B lines were measured on the ultrasound along with comparing the proportional increase in weight from the target weight.

Results: Eighty one lung ultrasound assessments were performed in total. Mean age was 10.4±3.3 years. There were 56(69.1%) males and 25 (30.8%) female patients. Mean percentage decrease in weight was 5.5±2.4% before dialysis and 0.96±0.6% after dialysis, p-value <0.001. Pre dialysis B lines were 10.9±6.2 which significantly reduced after dialysis, post dialysis B lines were 4.3±2.7, p-value was significant i.e. <0.001. In 25(30.8%) patients clinical examination revealed pulmonary edema while 51(62.9%) patients had pulmonary congestion detected by lung ultrasound before dialysis.

Conclusions: In children and infants receiving dialysis lung ultrasound is a sensitive and practical method of evaluating subclinical fluid overload. Decrease in number of B-lines after dialysis represents decrease in weight after dialysis. More number of patients were diagnosed using lung ultrasound as compare to clinical examination

Corresponding Author| Dr. Ch Muhammad Umer Razzaq, Department of Paediatric Medicine, Mayo Hospital, Lahore **Email:** umerrazaq@gamail.com

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Introduction:

Prominent irregularity in fluid distribution of body is a prevalent feature of end stage renal disease, causing fluid overload. It creates a challenge for paediatric nephrologist to evaluate volume of fluids during haemodialysis. One of the primary goals of hemodiasis therapy is to establish normal extracellular fluid volume, because a prevalent complication of paediatric haemodialysis is chronic fluid overload, and in children it is directly associated with left ventricular hypertrophy, hypertension, heart failure, decrease arterial flexibility and often results in increase chance of morbidity and mortality, thus fluid overload must be prevented[1]. The minimum weight after removing all excessive fluid and after which further removal causes dehydration and hypotension which results in decreased cardiac and cerebral perfusion resulting in end organ damage, is known as optimum post dialysis weight or dry weight[2]. Maintaining euvolumia in kids undergoing hemodialy-

sis is most important factor in management of chronic kidney disease in children.

Cardiovascular prognosis in patients with end stage renal disease depends of correct measurement and control of extracellular fluid level which can't be calculated precisely by clinical evaluation of dry weight[3,4]. Clinical inspection often results in unreliable evaluation of fluid level causing either overestimation or underestimation resulting in increasing mobidity and mortality rate. Various techniques are used to assess the fluid over load in children undergoing haemodialysis. Now a days multiple techniques are in use to monitor fluid overload in children undergoing haemodialysis. One of the commonly used plan is called 5B technique. These 5B represents; blood volume monitoring online, B natriuretic peptide, blood volume changes, bio impedance spectroscopy and body ultrasound in which we perform lung ultrasound and measurement of diameter of inferior vena cava[5]. Out of these one which is receiving increasing attention is lung ultrasonography due to its ability to precisely measure extracellular volume of fluid and detect lung edema even in initial non symptomatic cases known as hidden lung congestion[6]. Improper Renal function associated with abnormal chronic volume expansion of variable status is prevalent in paediatric patient. Lung ultrasound helps us in many cases to detect asymptomatic lung edema. One of the intriguing and special characteristic of LUS is that it measures and detect edema in a dynamic way so reduction in B lines can noticed appreciably after dialysis[7].

A study by M. Allinovi et al[8]. found that during the paediatric haemodialysis by ultrafiltration B line changes are noticed. Mean Fluid overload was 10% before dialysis and 8% after dialysis in acute kidney injury patients. The median number of post dialysis B-lines reduction was 31% as compared to pre dialysis B-lines.

Lung ultrasonography is the most safe, easy, and reliable technique due to its noninvasiveness, ease of use, availability of portable machines, avoidance of radiation, recordability, and reproduce ability in evaluation of fluid level of body. The most commonly observed finding is a comet tail fanning out from the lung-wall interface and spreading upwards to the edge of the screen, named a "B-line" The presence of multiple B-lines is the sonographic Target of lung edema and a negative lung ultrasound is superior to standard chest X-ray in excluding significant pulmonary fluid overload[9,10]. This study will help us to find a non-invasive, safe and measurable dynamic tool for assessment of fluid overload in children undergoing regular hemodialysis. Only one previous study[8] is available which included both acute kidney injury patients and hemodialysis patients. The pathogenesis of fluid overload in chronic kidney patients is entirely different from acute insult to kidney where cardiovascular system is intact and fluid overload is result of decrease urine output.

The aim of study was to determine the frequency of diagnosing pulmonary edema using lung ultrasound and clinical examination and determining association of percentage decrease in weight with number of B-lines in children with renal failure undergoing hemodialysis. Lung ultrasound can be used in children for detecting fluid overload and pulmonary edema. Many patients of pulmonary edema are missed on clinical examination which causes delay in treatment. Lung ultrasonography can detect more precisely regarding fluid overload in children of chronic kidney disease undergoing hemodialysis.

Methods:

This cross sectional study was conducted in Division of Pediatric Nephrology, Paediatric unit II, Mayo Hospital Lahore from June 2020 till December 2020 after approval of hospital committee. Written informed consent was taken from parents before enrolling in study.

Patients aged 6 to 16 years of both gender having end stage renal disease and undergoing regular dialysis session for last 3 months were enrolled. Sample of 81 patients was calculated to obtain a power of 0.80 to detect an association between B-lines and physical performance assessed by NYHA class. This has been calculated using a hypothesized low effect size of 0.15 and an alpha of 0.05[11]. Patients with interstitial lung disease, left ventricular ejection fraction <45%, grade 2 diastolic dysfunction or higher, pericardial effusion and suffered pulmonary infection in the last 2 months were excluded from study. In these conditions, B-lines may represent underlying pathology and confound the assessment of fluid overload. Patients were enrolled using non probability consecutive sampling technique.

Histories of the patients were taken carefully with spe-

cial reference to difficulty in breathing or dyspnea and was graded accordingly to NYHA classification. Clinical examinations of the patients were done in which following parameters were evaluated both pre and post dialysis; vital signs like temperature, RR, etc and symptom of hypovolemia including tachycardia, fine basal crepitations, lower limb edema, BP. ECG of the patients were done pre dialysis. CBC, urea, creatinine and other laboratory investigations were done regularly.

All patients underwent lung ultrasound 30 minute before hemodialysis and 30 minutes after completion of hemodialysis. Ultrasound was done by principal investigator after getting training from consultant radiologist, findings were reconfirmed by consultant radiologist. Radiologist doing ultrasound was kept unaware of results of clinical examination, patients' weight, and dialysis prescription. Ultrasound was done in total of 28 different lung zones in middle of clavicle, mid axillary line, anterior axillary line, parasternal spaces. In between the fourth and second intercoastal space in left hemithorax about twelve were done and about sixteen in fifth and third intercoastal space of right one. Comet tail score was obtained by quantifying B lines in each window.

Presence of 3 or more B lines in atleast two zones confirmed presence of pulmonary edema. B lines were defined by the following criteria: Hyperechogenic lines perpendicular to probe surface, origination at the pleural line, extension to the lower limit of the field, independence from A line, synchronous movement with pleural sliding. The results of pre dialysis lung ultrasound was compared with results of clinical examination and post dialysis lung ultrasound. Confidentiality of data was ensured by masking names of patients.

Data were entered and analyzed using SPSS 22.0. Mean and standard deviation was calculated for quantitative variables. Frequency and percentage was calculated for qualitative variables. Linear regression was done for percentage of weight increased and presence of pre dialysis B line. Simple dot plain was created for comparison of detection of pulmonary edema detected by clinical examination and lung ultrasound. Quartiles were presented for pre dialysis and post dialysis B line. Co-relation r value and p-value was calculated, p-value ≤ 0.05 was taken significant.

Results:

Eighty one (81) ultrasounds were done in total varying from 5 to 11 minutes in total length of procedure. It was allowed by patient less hesitantly, and was well acceptable by children as it causes no pain, fear or tension. During study 2 patients drop out from study. Finally data of 79 patients was analyzed for pre dialysis and post dialysis lung ultrasound and percentage weight gain.

Mean age was 10.4±3.3 years, minimum age was 6 years and maximum age was 16 years. Patient distribution was equal in both age groups i.e. 40(49.4%) in 6-10 year sage group and 41(50.6%) in 11-16 years age group. 56(69.1%) males and 25 (30.8%) female patients making male to female ratio of 2.2:1. Dry weight was 23.3±11.2 kg. Mean percentage increase weight was 5.5±2.4% before dialysis and 0.96±0.6% after dialysis, p-value <0.001. Pre dialysis B lines were 10.9±6.2 and post dialysis B lines were 4.3±2.7, p-value <0.001 (figure I). In 25(30.8%) patients clinical examination

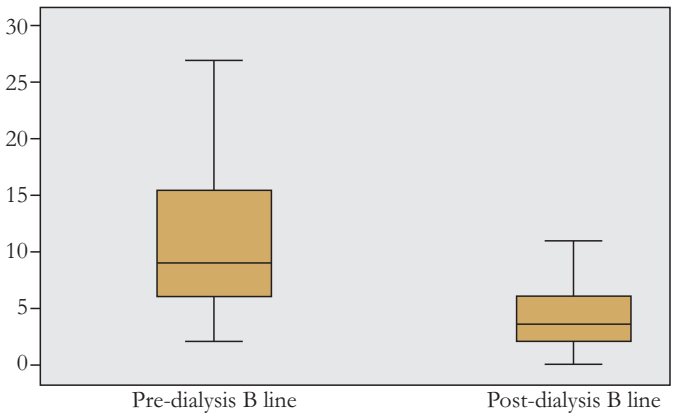

Figure I: *Comparison of pre dialysis and post dialysis B Line*

revealed pulmonary edema while 51(62.9%) patients had pulmonary congestion detected by lung ultrasound before dialysis. In 6 hemodialysis session pulmonary congestion was detected by lung ultrasound after dialysis. In these haemodialysis sessions the set weight was not achieved. The main cause for this is symptoms occuring during dialysis that forces us to stop dialysis early and the extra weight before dialysis that exceeds the limit for ultrafiltration. It was noted that clinically pulmonary edema was detected when weight gain was more than 7% from dry weight while in lung ultrasound fluid over load was detected when there was more than 4% raise in dry weight (figure II & III). There was signi-

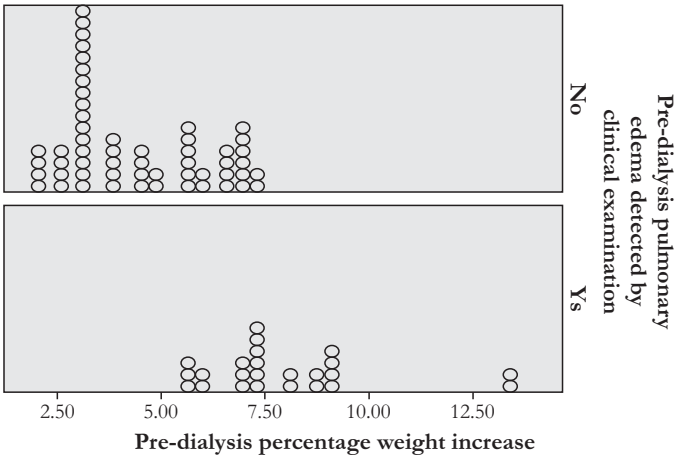

Figure II: *Pre dialysis pulmonary edema detected by clinical examination*

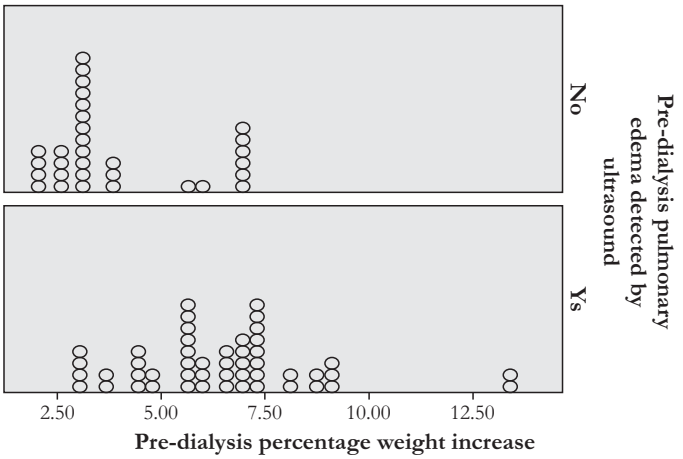

Figure III: *Pre dialysis pulmonary edema determined by lung ultrasound*

ficant co-relation between pre dialysis weight gain and number of B lines, R-value 0.73 (indicating that factors other than percentage weight gain are also involved in

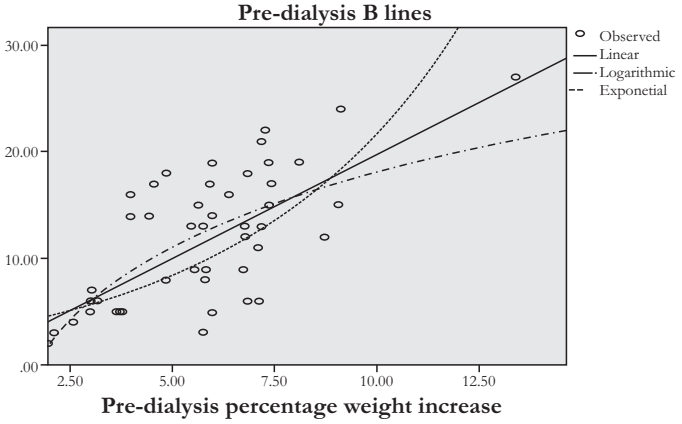

Figure IV: *Correlation of percentage weight gain and quantity of B line before dialysis*

development of B lines) and p-value <0.001 (ANOVA applied), for every 1% increase in weight 1.9 B lines will be increased (figure IV). Median reduction in weight gain percentage correlated with presence of B line before and after dialysis indicating that this modality can be used to get real time information for lung congestion (figure V).

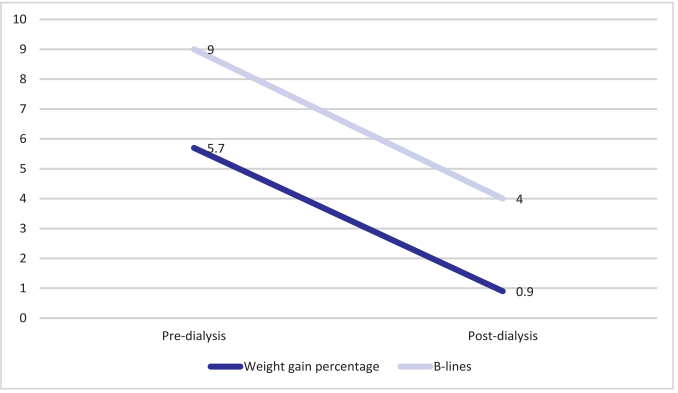

Figure V: *Comparison of pre dialysis and post dialysis median weight gain percentage and B lines*

Discussion:

This study is part of pilot research project for estimating fluid overload in children undergoing hemodialysis after chronic kidney disease irrespective of etiology. Previously available methods including clinical examination in not a reliable method, serum marker B-natriuretic peptide is not available in our hospitals, devices like bioimpedance spectroscopy (BIS) are very costly and require technical support and large financial support. So, there is desire need of a developing method to exactly quantitate lung fluid volume so that chronic fluid overload can be prevented. This diagnostic modality should be cost effective, reliable, available in all hospital, standardized and reproducible. Lung ultra sound is promising technique which can full fill all these criteria but lack of evidence-based practice it is not being used in pediatric population on regular hemodialysis[11-13].

In our study we found that lung ultra sound can quantify lung fluid and it co related with percentage of weight gain from dry weight and B lines reduce after hemodialysis which can be used to assess adequacy of hemodialysis. Focused ultrasound examinations for B-lines take approximately 5– 10 min to perform at the bedside and were well tolerated by children.

Previously one single center study was done in pediatric population. Total number of patients of Acute kidney

injury that were treated with dialysis were 8. Multiple modalities were employed like one continuous venous haemoinfiltration, 6 haemodialysis, 1 peritoneal dialysis. End stage renal disease patients that were included were 15 in number. From the 15 patients of end stage renal disease 4 had oliguria passing less than 0.5 ml per kg urine, 4 were anuric, and 7 had urine output of greater than 1 per ml per kg. 4.7 yrs was the average age of patients having a bdy weight of fifteen and a half kg. These 23 children were subjected to 142 ultrasounds in total each having a duration of 3 to 8 mins. The mean B line score decreases to 1.5 at resolution from 5 at (0 to 22) at presentation. During fluid removal there were obvious changes in B Lines score in lung ultrasound.

As the weight reduces from seven point 2 Percent to 0% the decrease in BLines were harmonious with lowering of fluid overload. The lowest number of twelve B lines were noticed on ultrasound of patients with moderate or severe fluid overload[8]. In this study all patients of AKI and ESRD irrespective of residual renal status was enrolled so results cannot be generalized with hemodialysis patients and r value was not very significant in patients of ESRD.

Lung ultrasound is also investigated in adult patients on hemodialysis and cardiogenic pulmonary edema with good results that it can be used for quantifying fluid over load[14]. diaphragm function assessment and monitoring of pulmonary embolism and pleural effusion are also some cases in which lung Ultrasound is used[15]. Torinio et al found that 61% of lung ultrasound assessments had evidence of moderate or severe lung congestion by US but clinically they were not accompanied by the presence of crackles[16]. Serio found that prevalence of pulmonary congestion as assessed by LUS and persistent or recurrent B-line score >15 were quite prevalent findings in euvolemic HD patients. [17]

Mallamaci et al observed that dialysis improves the lung water but thirty-one% of patients still has mediocre to severe degree of pulmonary effusion. Cardiac functions play an important role in fluid balance in ESRD shown by left atrial volume pressure ®= 0.30 and p= 0.01) and by pulmonary pressure (p=0.061, r=0.39)[18].

Various adult studies recommended use of lung ultrasound for detecting pulmonary edema in patients undergoing regular hemodialysis[19-22].

Conclusion:

Dialysis of children with end stage renal disease have a significant expansion of EVLW compartment without dyspnea and/or obvious clinical evidence of volume excess. The important factors involve in pathology of hidden lung congestion is increased lung permeability and reduced LV performance. LUS is strictly related to both these pathophysiological factors, so it is an effective tool to be used. If correctly performed and interpreted, in patients either with or without symptomatic lung edema, Lung ultrasonography provided a valuable tool in evaluation of prognosis of ESRD with high sensitivity. During clinical examination many patients of pulmonary edema can be missed which can be picked by ultrasonography. Decrease in number of B-lines can be used as subjective marker of fluid removal during dialysis and quantify adequacy of dialysis in children.

Limitation of Study

In our study etiology of CKD was not addressed due to limited sample size. Studies with larger sample size including tubulopathy and glomerulopathy should be done to see effect of etiology of CKD on detection of pulmonary edema by lung ultra sound.

Limitations of Lung Ultra Sound

The utility of LUS findings of lung odema is still in a need for further debate and explanation, importantly in separating those patients with other conditions like pneumonia, infarction, pleural disease and atelectasis as they all produce B line artifact.

Future Direction

We can use lung ultrasound to get dry weight estimation, because it is more reliable and give real time information of extravascular fluid over load. Determining the exact dry weight will help in exact dosing of medication. Moreover we can get good control of blood pressure by using dry weight calculated by lung ultrasound guided. Keeping ultrafiltration according to number of B lines will help in removing all excess lung water hence will maintain blood pressure and euvolumic state. More over attempt should be made to make lung ultrasound more convenient and simple for children with end stage kidney disease by doing lung ultra sound in four or six anatomical zone instead of 28 zones, this technique is already under investigation in adults suffering from

cardiogenic fluid over load.

Ethical Approval: Given

Conflict of Interest: The authors declare no conflict of interest.

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