

Fluid Volume Status Assessment by Lung Ultrasonography in Patients with Kidney Disease.

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Abstract:

Point-of-care ultrasound (POCUS) has become firmly established in acute and critical care settings and has now emerged as an important tool in the assessment of the Extra Vascular Lung Water (EVLW). Lung ultrasound (LUS) can be performed quickly and easily in critically ill patients. It has a higher diagnostic accuracy than physical examination and chest radiography combined. It enhances safety by avoiding ionizing radiation and the need for potentially dangerous transfers within the hospital. LUS can also be used to guide fluid management.

Key Words: Lung ultrasound, fluid assessment, point of care, extra vascular lung water,

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Introduction:

Fluid volume determination in patients is usually done by clinical assessment looking for signs and symptoms of fluid overload. Other methods used in patients with kidney disease include body weight measurement, blood volume online monitoring (Crit-line), bioimpedance spectroscopy (BIS) and B-natriuretic peptide (BNP). All these methods have their limitations. In the last few years we have seen increased utilization of Point of Care Ultrasonography (POCUS) which includes lung US (LUS).

Thanks to its noninvasiveness, lack of radiation, the ease of use, acceptable intra/inter-operator reproducibility and to the availability of portable ultrasound devices, chest ultrasonography can be considered one of the most interesting techniques offered to the nephrologist for volume assessment.

LUS Technique:

The US feature of pulmonary edema is "B lines". These are artifacts generated by the juxtaposition of alveolar air and septal thickening (from fluid or fibrosis). B lines appear as vertical hyper echoic reverberations originating from the pleural line and moving in harmony with pleural sliding. B lines are the ultrasound equivalent of the Kerley B lines found on chest X-ray.

Most studies were done using 24 chest zones. However, a quick and simple 3-point examination of each lung has convincing evidence that this technique yields a high diagnostic accuracy.¹ It is therefore an excellent starting point for a novice.

LUS Compared to clinical assessment:

Pre and post dialysis physical examination to look for crackles at the lung bases) and quantification of peripheral edema was compared with lung ultrasonography. Physical examination poorly reflected the severity of congestion as compared to ultrasonography.² In general, auscultation had very low discriminatory power for the diagnosis of mild, moderate and severe lung congestion, and the same was true for peripheral edema and the combination of the two physical signs.

Another study in outpatient setting in patients with Congestive Heart Failure (CHF), LUS provided the much better accuracy compared to clinical assessment and BNP.³ LUS can identify clinically silent pulmonary edema suggesting that it could be added to the clinical evaluation to improve hemodynamic profiling and treatment optimization. The aim of this study was to compare B-lines with more traditional methods, such as clinical evaluation, NT-proBNP, and echocardiographic parameters, and determine its performance to assess decompensation in a cohort of outpatients with moderate to severe systolic heart failure. This study showed that in outpatient heart failure clinic patients B-lines significantly correlated with more established parameters of decompensation, suggesting that monitoring chronic HF by LUS can be feasible and accurate in this population.

LUS and Fluid Volume Status

LUS Compared to BIS and Crit-line:

Volume assessment in hemodialysis patient with BIA was found to be comparable to clinical assessment by nephrologists. Investigators argued that in underdeveloped countries, like Pakistan, with shortage of nephrologists BIA is useful to assess volume status.⁴

Fluid status assessment study in chronic hemodialysis patient showed LUS to be more accurate than BIA and Crit-Line.⁵

Studies in Renal Patients:

In patients with End Stage Renal Disease (ESRD) on dialysis, lung water determination by ultrasonography can help in fluid management and adjusting dry weight. This is being studied in a large European trial for patients on hemodialysis.⁶ The “Lung water by Ultra-Sound guided Treatment to prevent death and cardiovascular complications in high risk ESRD patients with cardiomyopathy” (LUST) study will provide important information about the clinical value of this technique in the care of hemodialysis patients at high cardiovascular risk.

LUS has been studied in patients with Nephrotic Syndrome. Asymptomatic pulmonary edema was found in nephrotic patients using lung ultrasound.⁷

Similarly, in PD patients, LUS revealed moderate to severe lung congestion in a significant proportion of asymptomatic patients.⁸ Volume overload and cardiopulmonary congestion remain a major problem, particularly so in patients on peritoneal dialysis (PD) with minimal or no diuresis. This study showed that PD patients may present substantial lung water accumulation in the absence of dyspnea and obvious clinical evidence of volume excess. LUS is a promising technique with potential for refining volume control in PD patients.

Correlation for LUS has also been studied during CRRT.⁹ Patients undergoing CRRT were enrolled in the ICU setting. B lines were measured before CRRT and after 12 and 24 hours. In this study reduction in B-lines correlated with fluid loss with CRRT.

Accordingly, we can assume that regardless of the type of dialysis population considered (hemodialysis or peritoneal), asymptomatic pulmonary fluid overload is often present and, as it remains clinically “silent,” it can over time negatively impact the quality of life and survival of ESRD patients.¹⁰

LUS findings correlate in real time with fluid removal on dialysis. Statistically significant reductions in the number of B-lines from predialysis to the midpoint scan and from predialysis to postdialysis was noted.¹¹

Prognostic value of LUS:

Prognostic value of extravascular lung water detection by LUS was established in patients with dyspnea and/or chest pain. Events including cardiac death, non cardiac death, nonfatal myocardial infarction and hospitalization for pulmonary edema showed direct correlation with the number of B lines found on LUS.¹² Lung ultrasound predicts short-term prognosis in heart failure patients. Lung ultrasound can detect asymptomatic pulmonary congestion in hemodialysis patients, and the resulting BL-US score is a strong, independent predictor of death and cardiac events in this population. The prognostic value of extravascular lung water measured was tested by a simple, well validated ultrasound B-lines score (BL-US) in a multicenter study.¹³ Among those patients with moderate-to-severe lung congestion, 71% were asymptomatic or presented slight symptoms of heart failure. Compared with those patients having mild or no congestion, patients with very severe congestion had a 4.2-fold risk of death.

Unanswered Question:

Whether LUS can assume a pivotal role in the clinical management of the dialytic session and the real impact of the LUS in ESRD patient's therapy is still under discussion.

LUS Caveats:

Operating limits of the LUS technique have to be considered. Ultrasound devices are need and training has to be provided.

LUS may be hindered by the presence of large dressings, by possible subcutaneous emphysema and by soft tissue swelling or obesity and objective quantitation of the B-lines can be difficult.

Furthermore, the thoracic US does not combine its high sensitivity to an equally satisfying specificity. Therefore, the same sonographic appearance of numerous and scattered comets, called “B pattern,” can be caused by Extra Vascular Lung Water (EVLW) expansion of varying origin, from a diffuse interstitial pneumonia to ARDS.

Moreover, diffuse parenchymal lung disease associated with thickening of sub-pleural structures, such as pulmonary fibrosis and systemic sclerosis, can lead to the presence of diffuse fi comets not always clearly discernible from the typical B-lines described above.

Finally, a focal multiple B-lines pattern can be appreciated in various other conditions such as pneumonia, pulmonary contusion, pulmonary infarction, pleural disease, and neoplasia.

In all such cases, to obtain a correct interpretation of the ultrasonographic data, medical history and clinical picture of the patient are mandatory.

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