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ROLE OF CHEST ULTRASOUND AND INFERIOR VENA CAVA DIAMETER IN ASSESSMENT OF VOLUME STATUS IN HEMODIALYSIS PATIENTS

By

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ABSTRACT

Background: Fluid balance is important in hemodialysis patients. ‘‘Dry’’ weight is usually assessed clinically, and also biochemical markers is considered reliable. The use of chest ultrasound to assessment of volume status received growing attention in clinical research in hemodialysis patients. Ultrasonographic lung comets (counting B-lines artifact) evaluate extravascular lung water, while ultrasonography of inferior vena cava (IVC) estimates central venous pressure. So, ultrasound is considered as a useful tool to evaluate the volume status of hemodialysis patients.

Objective: To assess the role of chest ultrasound and inferior vena cava diameter in assessment of volume status before and after a dialysis session in hemodialysis patients.

Patients and Methods: This was across-sectional study carried out at Hemodialysis Unit, Al-Hussein University Hospital, over a period of one year from September 2019 to September 2020, and conducted on 50 hemodialysis patients. Demographic data and clinical information were recorded. Laboratory data including CBC, urea, creatinine, calcium, phosphate and albumin were evaluated. Radiological examination included ultrasound lung B-lines score and diameter of inferior vena cava (IVC) before and after dialysis session.

Results: The mean lung B-lines score before dialysis was high and decreased significantly after dialysis. There was a significant improvement of pulmonary congestion manifested by reduction in number of B lines after hemodialysis. There was a significant positive correlation between the mean lung B-lines score and IVC diameter both before and after dialysis. There was no significant relation between clinical data of studied patients and degree of U/S finding after hemodialysis as regards age, sex, smoking, and associated disorders.

Conclusions: Chest US is a well-validated simple and low-cost technique, and can be easily applied by nephrologists at the bedside to assess of volume status before and after a dialysis session and detect pulmonary congestion at a pre-clinical stage that is associated with a high death risk, and to justify dry weight in hemodialysis patients.

Key words: volume status, inferior vena cava, lung B-lines score.

INTRODUCTION

Chronic kidney disease (CKD) is a progressive loss in renal function over a period of months or years. All individuals with a glomerular filtration rate of less than 15/ml/min/1.73 m2 for 3 months are classified as having end-stage renal disease (ESRD) *(Karthikeyan et al., 2016).*

The prevalence rates of CKD worldwide are high and have increased in the last few years to about 13–15%, with an increased prevalence of diabetes and hypertension *(Hill et al., 2016).*

End-stage renal disease (ESRD) is increasing worldwide. Worldwide, the prevalence of ESRD differs greatly. In the United States, the prevalence was 1811 pmp *(Ghonemy et al., 2016).* In Europe, the prevalence has increased from 760 pmp in 2004 to 889 pmp in 2008 *(Stel et al., 2011).*

In Egypt, there are no recent data about the prevalence of ESRD; however, the last statistics was performed in 2004, with a prevalence of 483 pmp. *(El-Arbagy et al., 2016)* In the El-Minia governorate, one of the Upper Egypt governorates, the prevalence was 308 pmp *(El Minshawy, 2011).*

In patients with ESRD on intermittent hemodialysis, it is vital to maintain fluid status within an optimal range to avoid circulatory complications. Dialysis solutes removal adequacy is determined by measuring the patient's dry weight *(Canaud et al., 2019).* Dry weight is determined by clinical examination and usually reflects the lowest post-dialysis weight that can be tolerated by the patient without developing hypotension, intradialytic symptoms, or excess fluid. Clinical examination of dry weight does not include nutritional status change or fat-free body mass, so it is difficult to determine whether the patient is hyper- or hypo-volumic and may cause an increase in morbidity and mortality [Sebastian et al., 2016]. However, if a patient's dry weight has not been achieved, the patient will experience the complications of inadequate dialysis. Physical examination is used as the main modality for hemodialysis patients because the availability of other diagnostic tools is limited. Yet, a diagnostic test including physical examination and chest ultrasound and inferior vena cava diameter to assess volume status and detect lung congestion in hemodialysis patients is needed *(Bucharles et al., 2019).*

The present work aimed to assess the role of chest ultrasound and inferior vena cava diameter in assessment of volume status before and after a dialysis session in hemodialysis patients.

PATIENTS AND METHODS

This cross-sectional study included 50 hemodialysis patients at Nephrology Unit, Al Hussein University Hospital, from September 2019 to September 2020. Written informed consent was obtained from every patient for all procedures that performed. All procedures followed Al-Azhar University Ethical Committee Regulation. All patients received 3 hemodialysis sessions weekly, aged between 18 and 60 years, duration of hemodialysis more than 6 months, using arteriovenous fistula. We excluded patients with morbid obesity, with an acute chest event (infectious episode or a hospitalization) within the 3 months preceding the study regardless of the cause, with chronic lung diseases e.g. pulmonary fibrosis, with low ejection fraction <40% by echocardiography, with confirmed malignancy.

All patients in this study were subjected to the following:

1. Personal history including; name, age, sex, occupation, residence.
2. Present history including; cause of ESRD, onset, and duration of hemodialysis.
3. Past history of any chronic illness e.g., DM, HTN or other depleting diseases.
4. Routine laboratory investigations (CBC, Urea, Creatinine, Albumin, Calcium, and Phosphrous) had been done once before dialysis.
5. Ultrasound examination: Measurement of lung B-lines and inferior vena cava diameter before and after a dialysis session.

Statistical analysis of data were tabulated and analyzed using the computer program Microsoft Office 2019 (excel) and Statistical Package for the Social Sciences (SPSS version 23.0) (IBM Corp., Chicago, Illinois, USA). Clinical and laboratory data were recorded on a report form. Descriptive data and descriptive statistics were calculated for the data in the form of mean and standard deviation (Mean ± SD). Differences between quantitative independent group by t test. P-values less than 0.05 were considered significant.

RESULTS

As regard description of demographic data, the age of the studied patients ranged from 20-65 years with mean of 49.2 ± 10.97 years. The majority of patients 33 (66%) were males. With reference to smoking habit, most of patients 28 (56%) were non-smokers. As regard associated disorders, 33 (66%) of patients were hypertensive and 24 (48%) of patients were diabetic **(Table 1)**.

Table (1): Demographic data of studied patients

Age (years):	
(Range) Mean ± SD	(2-65) 49.2 ± 10.97
Sex: n (%)	
Male	33 (66)
Female	17 (34)
Smoking: n (%)	
Smoker	16 (32)
Non-smoker	28 (56)
Ex-smoker	6 (12)
Hypertension: n (%)	
Hypertensive	33 (66)
Non-hypertensive	17 (34)
Diabetes mellitus: n (%)	
Diabetic	24 (48)
Non- Diabetic	26 (52)

As regard clinical presentation of hemodialysis, duration of hemodialysis ranged from 1-8 years with mean of 3.76 ± 2.13 years. DM was the most common cause of ESRD 23 (46%), followed by HTN 17 (34%), then chronic glomerulonephritis 10 (20%) **(Table 2)**.

Table (2): Clinical presentation of hemodialysis of studied patients

Duration on hemodialysis (years):	
(Range) Mean ± SD	(1-8) 3.76 ± 2.13
Causes of ESRD: n (%)	
Diabetes mellitus	23 (46)
Hypertension	17 (34)
Chronic glomerulonephritis	10 (20)

There was no significant correlation between laboratory data and degree of U/S finding after hemodialysis **(Table 3)**.

Table (3): Relation between Laboratory data and degree of U/S finding after hemodialysis

Pulmonary congestion / Parameters	Normal	Mild	Moderate	Severe	p-value
	(Range) Mean ± SD				
Hemoglobin (g/dl)	(5.1-12.5) 8.63 ± 2.35	(5.9-14.5) 9.8 ± 2.2	(5.8-12) 9.7 ± 1.6	(10-12) 9.8 ± 2.2	0.205
Albumin (g/l)	(2.8-4.3) 3.51 ± 0.5	(2.9-4.2) 3.62 ± 0.4	(2.9-4.2) 3.64 ± 0.3	(3-4.2) 3.6 ± 0.5	0.901
Urea (mg/dl)	(55-113) 88.3 ± 19.7	(57-122) 92.6 ± 17.2	(59-122) 95.3 ± 20.6	(66-115) 100.3 ± 22.9	0.725
Creatinine (mg/dl)	(3.5-8.4) 5.6 ± 1.78	(2.5-8.9) 5.8 ± 1.89	(2.9-8.3) 5.8 ± 1.58	(3.4-8.4) 6.7 ± 2.3	0.788
Calcium (mg/dl)	(7.5-11) 9.18 ± 1.2	(7.3-12.8) 9.47 ± 1.6	(5.6-12.3) 8.8 ± 1.3	(8.6-9.1) 8.77 ± 0.2	0.533
Phosphate (mg/dl)	(2.4-7.2) 5.04 ± 2.06	(1.7-10.7) 5.07 ± 2.2	(1.7-8.1) 4.55 ± 1.47	(2.3-6) 4.45 ± 1.6	0.817

Regarding the effect of hemodialysis on volume status of patients, there was significant improvement of pulmonary congestion manifested by reduction in number of B lines after hemodialysis. Moreover, there was significant reduction in IVC diameter after hemodialysis **(Table 4)**.

Table (4): Changes in pulmonary congestion and IVC diameter before and after hemodialysis.

Pulmonary congestion / Parameters	Before hemodialysis	After hemodialysis	p-value
	(Range) Mean ± SD		
Number of B lines	(2-45) 22.42 ± 11.47	(0-35) 13.0 ± 8.9	0.001
IVC diameter (cm)	(0.7-3.6) 1.95 ± 0.85	(0.6-2.6) 1.3± 0.54	0.001

Wilcoxon signed-rank test was used.

Regarding the effect of hemodialysis in patient's weight, there was significant improvement of pulmonary congestion manifested by reduction in number of B lines and IVC diameter in patients which matched their dry weight after hemodialysis. There was no significant change in patient's weight after hemodialysis; however, there was mild reduction in patient's weight after hemodialysis **(Table 5)**.

Table (5): Relation between pulmonary congestion and IVC diameter with patient's weight after hemodialysis - Changes in patient's weight before and after hemodialysis

Parameters \ Patient's weight	Dry weight	Extra weight	p-value
	(Range) Mean ± SD		
Number of B lines	(0-22) 10.32 ± 6.62	(1-35) 17.47 ± 10.49	0.005
IVC diameter (mm)	(0.7-2) 1.18 ± 0.42	(0.6-2.6) 1.5 ± 0.67	0.048
	Before hemodialysis	**After hemodialysis**	
Patients weight (kg)	(56-103) 83.78 ± 11.99	(55-101) 81.54± 11.56	0.348

Paired t test was used.

DISCUSSION

This study was carried out at Hemodialysis Unit of Al-Hussein University Hospital over a period of one year from September 2019 to September 2020, and conducted on 50 Hemodialysis Patients.

As regard description of demographic data, the age of cases group ranged from 20-65 years. The majority of patients (66%) were males, 56% were non-smokers, 66% were hypertensive and 48% were diabetic. Three main underlying cause of ESRD were found to be diabetes (46%), followed by hypertension (34%) and chronic glomerulonephritis (20%). This quietly matches the result of a study conducted by *Barsoum (2013)*.

The present study showed significant high number of B-lines in patient's pre dialysis and reduction in B-lines post dialysis with a significant change. These data were consistent with *Trezzi and his Colleagues (2013)* who observed a statistically significant reduction in the total number of B-lines visualized in 28 lung zones after dialysis. *Donadio et al. (2015)* observed that the number of post-HD B-lines significantly reduced than the number of B-lines pre-HD.

The IVC diameter before dialysis in our study ranged between 0.7-3.6, while the IVC diameter after dialysis for whole patients ranged between 0.6-2.6 with a significant change. These data were consistent with Trezzi and his Colleagues (2013) who observed a significant reduction of inferior vena cava diameter after dialysis. Also, Liang and his colleagues (2019) they performed ultrasound of the IVC before and after dialysis. They concluded that lung ultrasound is a useful imaging tool for dialysis patients.

There was no significant effect of age, sex, smoking, duration of hemodialysis, history of hypertension and history of diabetes on the number of B lines in the patients of this study. Also, there was no significant relation between laboratory data and degree of U/S finding after hemodialysis in the present study. This matched the results of a study conducted by *Koraa et al. (2018).*

Regarding the effect of hemodialysis in patient's weight, there was significant improvement of pulmonary congestion manifested by reduction in number of B lines in patients which matched their dry weight after hemodialysis. Moreover, there was significant reduction in IVC diameter in patients which matched their dry weight after hemodialysis, and this matched with the study done by *Annamalai and his Colleagues (2019)* who showed B lines statistically significant reduction with dialysis. The absolute reduction of B lines showed significant correlation with ultrafiltration volume and weight loss. *El-Wakil et al. (2020)* showed significant positive correlation between ultrafiltration volume and the absolute change of lung B lines score. There was a significant positive correlation between the grade of lung B lines score and IVC diameter both before and after dialysis.

CONCLUSION

Chest US is a well validated simple and low cost technique, and can be easily applied at the bedside to assess of volume status before and after a dialysis session, and detect pulmonary congestion at a pre-clinical stage that is associated with a high death risk, and to justify dry weight which still a challenge for the nephrologists and therefore represents the ultimate goal of our study.

REFERENCES

1. **Annamalai I, Balasubramaniam S and Fernando ME (2019):** Volume Assessment in Hemodialysis: A Comparison of Present Methods in Clinical Practice with Sonographic Lung Comets. Indian J Nephrol., 29(2):102-110.
2. **Barsoum RS (2013):** Burden of chronic kidney disease: North Africa. Kidney Int Suppl; 3(2): 164–6.
3. **Bucharles, S., Wallbach, K., Moraes, T. P. and Pecoits-Filho R. (2019):** Hypertension in patients on dialysis: diagnosis, mechanisms, and management. Jornal brasileiro de nefrologia : 'orgao oficial de Sociedades Brasileira e Latino-Americana de Nefrologia, 41(3): 400–411.
4. **Canaud B, Chazot C, Koomans J, and Collins A (2019):** Fluid and hemodynamic management in hemodialysis patients: challenges and opportunities. Brazilian Journal of Nephrology, 41(4): 550-559.
5. **Donadio C, Bozzoli L, Colombini E, Pisanu G, Ricchiuti G and Picano E (2015):** Effective and timely evaluation of pulmonary congestion: qualitative comparison between lung ultrasound and thoracic bioelectrical impedance in maintenance hemodialysis patients. Journal of Medicine (Balimore) 94(6): e473.
6. **El Minshawy O (2011):** End-stage renal disease in the El-Minia Governorate, Upper Egypt: An epidemiological study. Saudi J Kidney Dis Transpl., 22:1048-54.
7. **El-Arbagy AR, Yassin YS and Boshra BN (2016):** Study of prevalence of end-stage renal disease in Assiut governorate, Upper Egypt. Menoufia Med J., 29:222-7.
8. **El-Wakil S, El-Gohary I, Emara D, El Wahab R (2016):** Assessment of Volume Status of Hemodialysis Patients using Sonographic Lung Comets.Global Journal of Medical Research. 16:e3-b.
9. **Ghonemy TA, Farag SE, Soliman SA, El-okely A and El-hendy Y (2016):** Epidemiology and risk factors of chronic

kidney disease in the El-Sharkia Governorate, Egypt. Saudi J Kidney Dis Transpl.,27:111-7

10. **Hill, N. R., Fatoba, S. T., Oke, J. L., Hirst, J. A., O'Callaghan, C. A., Lasserson, D. S and Hobbs, F. D. (2016):** Global Prevalence of Chronic Kidney Disease - A Systematic Review and Meta-Analysis. PloS one, 11(7): e0158765.

11. **Karthikeyan V,Karpinski J,Nair R and Knoll G (2016):** The burden of chronic kidney disease in renal transplant recipients. American Journal of Transplantation, 14: 262–269.

12. **Koraa EDA, Aly TM, Hussein HS and Beshara SK (2018):** The role of chest ultrasound in detection of pulmonary congestion in hemodialysis patients. Egypt J Bronchol., 12:482-5.

13. **Liang, X. K., Li, L. J., Wang, X. H., Wang, X. X., Wang, Y. D., and Xu, Z. F (2019):** Role of Lung Ultrasound in Adjusting Ultrafiltration Volume in Hemodialysis Patients. Ultrasound in Medicine & Biology, 45(3):732-740.

14. **Sebastian, S., Filmalter, C., Harvey, J., and Chothia, M. Y (2016):** Intradialytic hypertension during chronic haemodialysis and subclinical fluid overload assessed by bioimpedance spectroscopy. Clinical Kidney Journal, 9(4): 636–643.

15. **Stel VS, van de Luijtgaarden MW, Wanner C and Jager KJ (2011):** On Behalf of the European Renal Registry Investigators. The ERA-EDTA registry annual report-a précis. NDT Plus, 4:1-13.

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

دور الموجات فوق الصوتية على الصدر وقياس قطر الوريد الأجوف السفلي لتقييم حالة حجم السوائل في مرضي الإستصفاء الدموي

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خلفية البحث: توازن السوائل مهم في مرضى غسيل الكلى وعادة ما يتم تقييم الوزن "الجاف" سريريًا، وكذلك تعتبر الدلالات البيوكيميائية موثوقة وتلقى إستخدام الموجات فوق الصوتية للصدر لتقييم حالة الحجم إهتمامًا متزايدًا في الأبحاث السريرية لمرضى غسيل الكلى، كما تُقيِّم مذنبات الرئة بالموجات فوق الصوتية مياه الرئة خارج الأوعية الدموية، بينما يُقدِّر التصوير بالموجات فوق الصوتية للوريد الأجوف السفلي الضغط الوريدي المركزي. لذلك تعتبر الموجات فوق الصوتية أداة مفيدة لتقييم حالة حجم مرضى غسيل الكلى.

الهدف من البحث: تقييم دور الموجات فوق الصوتية للصدر وقطر الوريد الأجوف السفلي في تقييم حالة حجم السوائل قبل وبعد جلسة الغسيل في مرضى غسيل الكلى.

المرضى وطرق البحث: أجريت هذه الدراسة المقطعية في وحدة غسيل الكلى في مستشفى الحسين الجامعي على مدى عام واحد من سبتمبر 2019 إلى سبتمبر 2020 ، وأجريت على 50 مريضًا غسيل الكلى. وقد تم تسجيل البيانات الديموغرافية والمعلومات السريرية، كما تم تقييم البيانات المختبرية بما في ذلك صورة الدم واليوريا والكرياتينين والكالسيوم والفوسفور والألبومين والفحص الإشعاعي بما في ذلك درجة خطوط الرئة بالموجات فوق الصوتية وقطر الوريد الأجوف السفلي قبل وبعد جلسة غسيل الكلى.

نتـــائج البحـــث: كـــان متوســـط درجـــة خطـــوط الرئـــة قبـــل غســـيل الكلـــى مرتفعًـــا وانخفـــض بشـــكل ملحـــوظ بعـــد غســـيل الكلـــى. وكـــان هنـــاك تحســـنًا كبيـــرًا فـــي إحتقـــان الرئـــة تجلـــى فـــي إنخفـــاض عـــدد خطـــوط الرئـــة بعـــد غســـيل الكلـــى. وكـــان هنـــاك ارتباطًاإيجابيًـــا معنويًـــا بـــين متوســـط درجـــة خطـــوط الرئـــة وقطـــر الوريـــد الأجـــوف الســـفلي قبـــل وبعـــد غســـيل الكلـــى. ولـــم تكـــن هنـــاك علاقـــة ذات دلالـــة إحصـــائية بـــين البيانـــات الســـريرية للمرضـــى الخاضـــعين للدراســـة ودرجـــة خطـــوط الرئـــة بعـــد غســـيل الكلـــى فيمـــا يتعلـــق بـــالعمر والجنس والتدخين والاضطرابات المرتبطة بها.

الإســـتنتاج: الموجـــات فـــوق الصـــوتية علـــى الصـــدر هـــي تقنيـــة موثوقـــة بشـــكل جيـــد وبســـيطة ومنخفضـــة التكلفـــة ويمكـــن تطبيقهـــا بســـهولة بجانـــب الســـرير لتقيـــيم حالـــة حجـــم الســـوائل قبـــل وبعـــد جلســـة غســـيل الكلـــى، والكشـــف عـــن الإحتقـــان الرئـــوي فـــي مرحلـــة مـــا قبـــل ظهـــور الأعـــراض الســـريرية المرتبطـــة بـــه مـــع وجـــود مخـــاطر عاليـــة للوفـــاة، ولإمكانية تعديل الوزن الجاف في مرضى غسيل الكلى.

الكلمات الدالة: حالة حجم السوائل، الوريد الأجوف السفلي، نقاط خطوط الرئة.