

# Left Atrial Volume Index (LAVI) in hypervolemic patients undergoing chronic hemodialysis

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**BACKGROUND:** Mortality in chronic hemodialysis (HD) patients are occurred often due to cardiovascular diseases. Volume overloads and left atrial volume index (LAVI) are prognostic predictors both all-cause and cardiovascular mortality.

**AIM:** The aim of study is to search how there is a relationship between volume quantity and LAVI in chronic hemodialysis patients.

**STUDY DESIGN:** A prospective cross-sectional study.

**METHODS:** 102 hemodialysis patients (male: 53, female: 49) were included to this study. The patients were divided to two groups in according to

ultrafiltration (UF) (<10 mililiter (mL)/kg/hour or ≥10 mL/kg/hour). If UF was ≥ 2.5 L, it was accepted hypervolemia. Left atrial volumes (LAV) were measured by using an echocardiography by a cardiology specialist. LAVI was determined by left atrial volume divided by body surface area. ≥32 mL/m<sup>2</sup> of LAVI was accepted high, Statistical analysis was done by using Mann-Whitney U test and Pearson correlation test.

**RESULTS:** In hypervolemic group (n=53), means of LAV, LAVI and UF were 52 ± 24 cm<sup>3</sup>, 32.1 ± 14 mL/m<sup>2</sup> and 2727 ± 538mL, respectively. In normovolemic group (n=49), means of LAV, LAVI and UF were 56 ± 28 cm<sup>3</sup>, 30.3 ± 14 mL/m<sup>2</sup> and 2063 ± 589 mL, respectively.

**CONCLUSION:** Mean of LAVI values were found high in hemodialysis patients with hypervolemia.

**Key Words:** Left atrial volume index; Hypervolemia; Chronic hemodialysis

## INTRODUCTION

Interdialytic weight gain and residual postdialysis volume overload leads to predialysis volume overload. Predialysis volume overload is defined as >15% above normal extracellular fluid volume (ECV), equivalent to ≥2.5 L on average [1]. The frequency of predialysis volume overload > 15% ECV in 34 European hemodialysis (HD) centers was 28.3%. In a patient undergoing classic HD, 15% ECV overload corresponds to 2.5 L of excess volume [2,3].

Volume overload leads to a high risk for intradialytic hypotension due to the high ultrafiltration (UF) rate in patients undergoing HD [4,5]. As the UF rates increase (>10 mL/hour/kg body weight), mortality increases; therefore, interdialytic weight gain may be associated with mortality risk [6,7].

The relationship between left atrial size (left atrial volume [LAVI]) and cardiovascular outcome in end-stage renal disease have been determined. Large left atrial size is a predictor of mortality and adverse cardiovascular events [8]. It was reported that the left atrial volume index (LAVI) is an independent predictor of prognosis in patients undergoing HD [9]. High LAVI levels have been observed in hypervolemic chronic kidney disease [10].

The aim of this study was to identify LAVI values in chronic HD patients with high UF.

## METHODS

This study was a prospective cross-sectional clinical study. One-hundred and two patients undergoing chronic HD (male=53, female=49) were included. This study was approved by the local ethics committee of the medical school. Patients were categorized into two groups according to the mean UF rate over the 3-month period prior to the beginning of the study. The UF rate limit was determined to be 10 mL/body weight (kg)/hour. The blood pressure of all patients was measured during rest days after dialysis. The body surface area of the patients was calculated by the DuBois formula [11]. Biochemical values were obtained from medical records taken 1 month prior.

Exclusion criteria for the study were patients with heart failure, an active infection, atrial fibrillation, major heart valve disease, uncontrolled hypertension, no consent, or HD time<3 months.

Transthoracic echocardiography (Philips Envisor C HD) was performed together with an electrocardiogram (ECG) by a cardiology specialist who was blinded to the patients' medical information. Echocardiographic images were obtained from parasternal and apical windows while the patients were in the left lateral decubitus position. Apical four spaces and the parasternal long and short axis were evaluated as appropriate [12]. The sizes of the left ventricle, left atrium, and aortic root from the parasternal long axis, and other heart spaces from the four apical spaces were measured. Left atrial size and volume were measured during the largest size of the left atrium after the end of the T wave on ECG using the Simpson method [13]. The LAVI was calculated as LAV divided by body surface area.

All values were calculated as arithmetic means, standard deviations, and medians. The normality of the data distribution was investigated. Statistical analysis was conducted using Student's t-test. A p-value<0.05 was considered significant.

## RESULTS

One-hundred and two patients undergoing HD were included in this study. Mean body surface area was normal (1.73 m<sup>2</sup>). The patients had diabetes mellitus (n=33, 32%) and hypertension, controlled by medication (n=58, 57%). The mean LAVI and other parameters are summarized in Table 1.

Mortality and complications were higher in patients undergoing HD with >10 mL/body weight (kg)/hour UF rate [14,15]. Therefore, the patients were separated into two groups according to UF rate. It was accepted that patients with a ≥10 mL/kg/hour UF rate (group 1; n=53) were hypervolemic, and those with a UF rate < 10 mL/kg/hour (group 2; n=49) were normovolemic. 52% of patients were hypervolemic. Mean UF amount was 2,727 ± 538 mL in group 1 patients and 2,063 ± 589 mL in group 2 patients (p<0.001). That is, group 1 patients were hypervolemic (>2.5 L). Significant results in these groups are shown in Table 2.

LAVI values (>32 mL/m<sup>2</sup>) were high in patients with a high UF amount (>2.5 L) (Table 2). A significant two-sided, positive correlation was detected between left atrial size and LAV in all patients (r=0.548; p<0.001).

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TABLE 1

Echocardiographic results and other parameters in all of the patients (mean  $\pm$  SD).

Blood Pressure, mmHg	123 $\pm$ 14 / 74 $\pm$ 7
Mean hemodialysis time, years	6.1 $\pm$ 4.7
Mean body surface area, m <sup>2</sup>	1.73 $\pm$ 0.20
Ultrafiltration quantity, milliliter	2408 $\pm$ 652
Left Atrial Diameter, centimeter	3.7 $\pm$ 0.6
Left Atrial Volume, mm <sup>3</sup>	54 $\pm$ 26
LAVI, mL/m <sup>2</sup>	31.2 $\pm$ 14.0
Ejection Fraction, %	60 $\pm$ 4
E/A	0.91 $\pm$ 0.41
Kt/V	1.57 $\pm$ 0.20

LAVI: Left Atrial Volume Index

TABLE 2

Results of the patients separated in according to mean ultrafiltration rates (mean  $\pm$  SD).

Parameters	$\geq 10$ mL/kg/hour (Group 1)	$\leq 10$ mL/kg/hour (Group 2)	p-value
	Mean $\pm$ SD	Mean $\pm$ SD	
Age, years	49.6 $\pm$ 15	59.5 $\pm$ 13	0.001
Dialysis time, years	7.2 $\pm$ 4.6	5 $\pm$ 4.5	0.01
Body weight, kilogram	60 $\pm$ 11	78 $\pm$ 17	<0.001
Body Mass Index, kg/m <sup>2</sup>	23 $\pm$ 3.9	29 $\pm$ 6.8	<0.001
Systolic blood pressure, mmHg	121 $\pm$ 13	124 $\pm$ 15	0.264
Diastolic blood pressure, mmHg	75 $\pm$ 7.9	73 $\pm$ 7.7	0.178
Kt/V	1.6 $\pm$ 0.2	1.5 $\pm$ 0.1	0.04
UF rate, mL	2727 $\pm$ 538	2063 $\pm$ 589	<0.001
Left atrial diameter, cm	3.6 $\pm$ 0.5	3.8 $\pm$ 0.5	0.106
Left atrial volume, milliliters	52 $\pm$ 24	56 $\pm$ 28	0.447
Left atrial volume index	32.1 $\pm$ 14	30.3 $\pm$ 14	0.519
EF, %	60 $\pm$ 4.2	58.9 $\pm$ 4.8	0.07
E/A	0.9 $\pm$ 0.4	0.9 $\pm$ 0.4	0.692

LAVI values of diabetic (n=33; 32  $\pm$  15) and non-diabetic patients (n=69; 30  $\pm$  13) were not different (p=0.429). LAVI values were not different between patients with hypertension (n=59; 33  $\pm$  14), using anti-hypertensive drugs, and normotensive patients (n=43; 28  $\pm$  13) (p=0.146).

### DISCUSSION

Cardiovascular events occur frequently in patients with CKD, and are the most frequent causes of mortality in patients undergoing dialysis [14,15]. The predictors that decrease survival must be determined using cardioprotective dialysis methods to improve survival of patients undergoing HD.

LAVI was found an independent predictor of all-cause mortality. Based on this finding, the normal LAVI was identified to be  $\leq 28$  mL/m<sup>2</sup> in patients with normal LV filling pressure and preserved LVEF [16].

LAVI is an independent predictor of poor cardiac events, and was high in the CKD group [17]. High LAVI (>32 mL/m<sup>2</sup>) is accepted as a significant risk factor for a cardiovascular event in patients undergoing dialysis [18,19]. In additionally, it was reported that high LAVI level was an independent predictor for all-cause mortality [19]. Left atrial expansion occurs as a consequence of pressure or volume overload. Mitral valve disease or left ventricular dysfunction leads to pressure overload [20]. The causes of left atrial expansion leading to high LAVI are age, diabetes mellitus, low ejection fraction, left ventricular hypertrophy, mitral regurgitation, and high pulmonary pressure in patients with end-stage renal disease [21].

A relationship between LAV and hydration stage has been reported in review [22].

Yilmaz A. et al reported that there were hypervolemia and high LAVI values in 48.5% of patients with non-dialysis chronic kidney failure [10]. The ratio of overhydrated HD patients was high (67.1%) before HD [23]. Also, there

was hypervolemia in our patients (52%). However, volume overload in 34 European hemodialysis (HD) centers was found lower as 28.3% [2,3]. A strong correlation was observed between hydration status and LAVI. Overhydrated HD patients have high LAVI values [20]. High LAVI (>32 mL/m<sup>2</sup>) was reported in 28 (16%) of 174 patients undergoing HD [18]. In our study, high LAVI (>32 mL/m<sup>2</sup>) was 52%. The discrepancy in the frequency may be due to the clinically different patients in these studies.

It was found that fluid overload was positively associated with LAVI in CKD5 patients not undergoing dialysis [23]. Similarly, it was reported that LAVI are related on hydration status in chronic hemodialysis patients [24].

Most patients undergoing HD have chronic predialysis volume overload. Fluid overload is defined as  $\geq 2.5$  L of dry body weight [2].

In our study, mean total UF amount was 2.7 L in 52% of the patients; that is, there is hypervolemia. These patients with hypervolemia had high LAVI values. Therefore, UF rate is more important for dialysis and prognosis according to the adequacy of dialysis [25]. In the DOPPS multicenter study, better all cause-mortality was observed in patients on a slow UF (<10 mL/h/body weight) vs. fast UF rate (>10 mL/h/body weight) [7]. As a result, UF rate is a survival predictor. Thus, positive relationship was reported between ultrafiltration rate and LAVI in hemodialysis patients [26].

### CONCLUSION

In this study, LAVI values were found high in chronic hemodialysis patients with high UF ( $\geq 2.5$ L). Therefore, prognosis of these patients can be considered to be poor.

### CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## REFERENCES

1. Hecking M, Karaboyas A, Antlanger M, et al. Significance of interdialytic weight gain versus chronic volume overload: consensus opinion. *Am J Nephrol*. 2013;38(1):78-90.
2. Wabel P, Moissl U, Chamney P, et al. Towards improved cardiovascular management: the necessity of combining blood pressure and fluid overload. *Nephrol Dial Transplant*. 2008;23:2965-71.
3. Passauer J, Petrov H, Schleser A, et al. Evaluation of clinical dry weight assessment in haemodialysis patients using bioimpedance spectroscopy: a cross-sectional study. *Nephrol Dial Transplant*. 2010;25:545-51.
4. Tisler A, Akocsi K, Borbas B, et al. The effect of frequent or occasional dialysis-associated hypotension on survival of patients on maintenance haemodialysis. *Nephrol Dial Transplant*. 2003;18:2601-5.
5. Shoji T, Tsubakihara Y, Fujii M, et al. Hemodialysis-associated hypotension as an independent risk factor for two-year mortality in hemodialysis patients. *Kidney Int*. 2004;66:1212-20.
6. Parfrey PS, Foley RN. The clinical epidemiology of cardiac disease in chronic renal failure. *J Am Soc Nephrol*. 1999;10:1606-15.
7. Saran R, Bragg-Gresham JL, Levin NW, et al. Longer treatment time and slower ultrafiltration in hemodialysis: associations with reduced mortality in the DOPPS. *Kidney Int*. 2006;69:1222-8.
8. Paoletti E, Zoccali C. A look at the upper heart chamber: The left atrium in chronic kidney disease. *Nephrol Dial Transplant* 2014;29:1847-53.
9. Barberato SH, Pecoits Filho R. Prognostic value of left atrial volume index in hemodialysis patients. *Arg Bras Cardiol*. 2007;88:643-50.
10. Yilmaz A, Yilmaz B, Küçükseymen S, et al. Association of over-hydration and cardiac dysfunction in patients have chronic kidney disease but not yet dialysis. *Nephrol Ther*. 2016;12:94-7.
11. Verbracken J, Van de Heyning P, De Backer W, et al. Body surface area in normal-weight, overweight and obese adults. A comparison study. *Metabolism*. 2006;55:515-24.
12. Schiller NB, Shah PM, Crawford M, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. American Society of Echocardiography Committee on Standards, Subcommittee on Quantitation of Two-Dimensional Echocardiograms. *J Am Soc Echocardiogr*. 1989;2:358-67.
13. Folland ED, Parisi AF, Moynihan PF, et al. Assessment of left ventricular ejection fraction and volumes by real time, two-dimensional echocardiography: A comparison of cineangiographic and radionuclide techniques. *Circulation*. 1979;60:760-6.
14. Flythe JE, Kimmel SE, Brunelli SM. Rapid fluid removal during dialysis is associated with cardiovascular morbidity and mortality. *Kidney Int*. 2011;79:250-7.
15. Cheung AK, Sarnak MJ, Yan G, et al. Atherosclerotic cardiovascular disease risks in chronic hemodialysis patients. *Kidney Int*. 2000;58:353-62.
16. Patel DA, Lavie CJ, Gilliland YE, et al. Prediction of all-cause mortality by the left atrial volume index in patients with normal left ventricular filling pressure and preserved ejection fraction. *Mayo Clin Proc*. 2015;90(11):1499-1505.
17. Hee L, Nguyen T, Whatmough M, et al. Left atrial volume and adverse cardiovascular outcomes in unselected patients with and without CKD. *Clin Am Soc Nephrol*. 2014;9:1369-76.
18. Han JH, Han JS, Kim EJ, et al. Diastolic dysfunction is an independent predictor of cardiovascular events in incident dialysis patients with preserved systolic function. *PLoS ONE* 2015;10:e0118694.
19. Shizuku J, Yamashita T, Ohba T, et al. Left atrial volume is an independent predictor of all-cause mortality in chronic hemodialysis patients. *Intern Med*. 2012;51:1479-85.
20. Abhayaratna WP, Seward JB, Appleton CP, et al. Left atrial size: physiologic determinants and clinical applications. *J Am Coll Cardiol* 2006;47:2357-63.
21. Motabar A, Aftab W, Gazallo J, et al. High left atrial volume impairs survival in end-stage renal disease: results from a prospective cohort of 575 patients. *Circulation*. 2012;126:2531.
22. Juan-Garcia I, Puchades MJ, Sanjuan R, et al. Echocardiographic impact of hydration status in dialysis patients. *Nefrologia*. 2012;32:94-102.
23. Han BG, Song SH, Yoo JS, et al. Association between OH/ECW and echocardiographic parameters in CKD5 patients not undergoing dialysis. *PLoS One*. 2018;13(4):e0195202.
24. Di Gioia MC, Gascuena R, Gallar P et al. Echocardiographic findings in haemodialysis patients according to their state of hydration. *Nefrologia*. 2017;37(1):47-53.
25. Twardowski ZJ. Treatment time and ultrafiltration rate are more important in dialysis prescription than small molecule clearance. *Blood Purif*. 2007;25:90-8.
26. Kim JK, Song YR, Park G, et al. Impact of rapid ultrafiltration rate on changes in the echocardiographic left atrial volume index in patients undergoing hemodialysis: A longitudinal observational study. *BMJ Open*. 2017;7(2):e013990.