

Plasma Sodium in Relation with the Extracellular Fluid Volume in Chronic Hemodialysis Patients

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ABSTRAK

Tujuan: memperoleh hubungan sebab akibat antara perubahan kadar natrium dalam plasma dan meningkatnya volume cairan ekstraselular pada pascahemodialisis dan prahemodialisis jadwal dialisis berikutnya atau kadar natrium dalam plasma berfungsi sebagai prediktor volume cairan ekstraselular. **Metode:** penelitian ini mengikutsertakan 40 subjek yang dipilih secara acak dari 247 pasien hemodialisis di Unit Hemodialisis, Divisi Nefrologi dan Hipertensi, Departemen Penyakit Dalam, Fakultas Kedokteran Universitas Indonesia – RS Cipto Mangunkusumo yang memenuhi kriteria inklusi dan eksklusi. Dilakukan pemeriksaan kadar natrium dalam plasma, berat badan pascahemodialisis dan prahemodialisis jadwal dialisis berikutnya. **Hasil:** tidak ada perbedaan kadar natrium plasma yang bermakna antara pascahemodialisis dan prahemodialisis pada jadwal dialisis berikutnya. Meskipun demikian, terdapat perbedaan berat badan yang cukup berarti antara pascahemodialisis dan prahemodialisis pada jadwal dialisis berikutnya ($p=0,0000$). Pada analisis regresi yang dilakukan untuk meneliti hubungan antara perbedaan kadar natrium prahemodialisis dikurangi dengan kadar natrium pasca-hemodialisis sebelumnya (Y) dan perbedaan berat badan prahemodialisis dikurangi dengan berat badan pasca-hemodialisis sebelumnya, ditemukan hubungan sebab akibat yang bermakna dengan rumus regresi berupa $Y = - 2,205 + 0,937 X$. **Kesimpulan:** kadar natrium plasma pada pasien hemodialisis kronik dapat dipakai sebagai prediktor volume cairan tubuh atau volume cairan ekstraselular. Di setiap unit dialisis, penambahan berat badan yang dianjurkan untuk pasien adalah 2,5 kg-2.9 kg agar dapat mencegah penurunan kadar natrium dalam plasma yang bermakna, yang dapat berujung pada kematian.

Kata kunci: kadar natrium dalam plasma, penambahan berat badan, hemodialisis.

ABSTRACT

Aim: to obtain a causal relationship between changes in plasma sodium levels and increased extracellular fluid volume between post-hemodialysis and pre-hemodialysis on the following day or plasma sodium serves as a predictor of extracellular fluid volume. **Methods:** the study was conducted on 40 subjects randomly selected from the 247 chronic hemodialysis patients in Hemodialysis Unit of Nephrology and Hypertension Division, Department of Internal Medicine, Faculty of Medicine Universitas Indonesia - Cipto Mangunkusumo Hospital that met the inclusion and exclusion criteria. Their plasma sodium levels, post-hemodialysis weight and pre-hemodialysis weight on the following day were examined. **Results:** There was no significant difference in the plasma sodium levels between post-hemodialysis and pre-hemodialysis on the following day. However, there was a considerable differences between post-hemodialysis weight and pre-hemodialysis weight on the following day ($p = 0.0000$). In regression analysis that were conducted on the relationship between the difference in pre-hemodialysis sodium levels subtracted by previous post-hemodiaysis sodium levels (Y) and the difference in

pre-hemodialysis weight subtracted by previous post-hemodialysis weight (X), a significant causal relationship was found with the regression formula of $Y = -2.205 + 0.937 X$. **Conclusion:** plasma sodium levels in chronic hemodialysis patients can be used as predictors of body fluid volume or extracellular fluid volume. At each dialysis unit, the recommended weight gain for the patients are 2.5 kg-2.9 kg, in order to prevent a significant decrease in plasma sodium levels that could lead to mortality.

Key words: plasma sodium, weight gain, hemodialysis.

INTRODUCTION

Sodium is the major cation in the extracellular fluid, as well as the main determinant of solute effective plasma osmolality and tonicity. In the state of hyponatremia, the plasma osmolality /tonicity will decrease, while the opposite situation occurs in the state of hypernatremia. Furthermore, increase of water volume in the extracellular fluid will cause a decrease in osmolality or hyponatremia, while hypernatremia or increased plasma osmolality occurs in the opposite situation. Under normal renal urine concentrating function, an increase or decrease in plasma osmolality will increase or decrease the secretion of ADH (antidiuretic hormone) from the hypothalamus into the blood, causing increase or decrease water reabsorption in the renal collecting ducts in order to restore plasma osmolality to normal direction. Similarly, an increase or decrease in extracellular fluid volume will affect the carotid baroreceptors, right atrium/ventricle, and renal afferent artery, aimed to increase or decrease sodium excretion via the kidney collecting ducts in order to restore plasma volume/extracellular fluid to the normal condition.¹⁻³

In stage 5 of Chronic Kidney Disease (CKD), nephron function has decreased considerably. Therefore, the osmotic regulation that affects the plasma osmolality through the influence of ADH as well as volume regulation that control the sodium excretion through the influence of baroreceptors could not function normally anymore.⁴⁻⁶ Consequently, in CKD stage 5, extracellular fluid osmolality is strongly influenced by changes in the water volume of the extracellular fluid. Fluctuations in the sodium levels of the extracellular fluid or plasma in stage CKD 5 is only affected by the rise or fall of the fluid volume.⁷ Serum sodium is strongly

correlated with residual renal function (RRF), hyponatremia being associated with lower RRF.⁸ Intradialytic weight gain (IWG) or increase in extracellular fluid volume is correlated with several nutritional and dialytic variables and with parameters that predict survival in HD patients.⁹ Increase in extracellular fluid volume is always occurs in patients undergoing chronic hemodialysis. In their investigation, Mc Causland FR et al found that the pre-dialysis serum sodium concentration appears to be unaffected by the dialysate sodium concentration in maintenance hemodialysis.¹⁰

Extracellular fluid volume assessment is one of the parameters in succeeding the hemodialysis (HD) program for patients. Clinically, weight-gaining during inter-hemodialysis is an indicator of extracellular fluid volume expansion. In the management of chronic HD patients, the determination of dry weight is necessary in order to prevent the incidence of pulmonary edema due to excess extracellular fluid and reducing cardiovascular complications. Determination of dry weight as well as maintain its stability is important in the management of patients in hemodialysis.

Research conducted by Waikar SS et al.^{11,12}, concluded that the lower the sodium levels in pre-hemodialysis, and in the hospitalized patients, the higher the mortality rate. This suggests that in patients in chronic hemodialysis, normal sodium levels need to be maintained to avoid an increase in mortality rate. Prediction of the amount of extracellular fluid volume based on plasma sodium levels become very important, because then we can determine either the increase in extracellular fluid volume or how much weight is gained compare to dry weight of the patient to prevent hyponatremia during subsequent hemodialysis.

Therefore, the purpose of this research is to determine plasma sodium levels in relation to the of extracellular fluid volume in chronic hemodialysis patients.

METHODS

Interventional study was conducted to compare the post-hemodialysis body-weight and blood sodium level with the following day pre-hemodialysis body-weight and blood sodium level in chronic hemodialysis patient population at Cipto Mangunkusumo Hospital, Jakarta, Indonesia.

Sampling for the study subjects were done by simple random sampling, using a random number table. Chosen patients were then selected again according to the inclusion and exclusion criteria. Patients that has undergone more than 3 months hemodialysis were included, while those who either suffer from diabetes mellitus or have random blood glucose level of more than 200 mg/dL were excluded.

Sample size determination was preceded by doing a research pilot on 35 chronic hemodialysis patients in Dialysis Unit of Siloam Hospital Lippo-Village Tangerang. The sample size in this study was calculated with the formula for the two pairing groups and the formula for the correlation coefficient. A total sample of 40 subjects was obtained.

Subjects weighing done during post and pre-hemodialysis in the following day using the same type of scales for all subjects. Sampling for examination of post-hemodialysis sodium level was done at the end of hemodialysis after blood flow (Qb) was lowered to 50 mL/min for 10 minutes. Sampling for examination of pre-hemodialysis sodium level was done during the insertion of vascular access for hemodialysis.

Statistical analysis was done using SPSS statistics 17 with setting of determining the difference between mean of post-hemodialysis sodium plasma and the mean of following pre-hemodialysis plasma sodium level, as well as the difference between the mean of post-hemodialysis weight and the mean of following pre-hemodialysis weight (Comparative numerical variables of two pairing groups. Paired T-test is done in normal distribution, while the

Wilcoxon test is done if the distribution is not normal). Linear correlation/regression between the amount of weight gain (difference between pre-hemodialysis weight and post-hemodialysis weight on the previous hemodialysis) and the difference in pre-hemodialysis plasma sodium levels subtracted by previous post hemodialysis plasma sodium levels were also calculated.

The Ethics Committee of the Faculty of Medicine, Universitas Indonesia has given the approval for this study.

RESULTS

There are 40 subjects who participated in this study consisted of 21 men and 19 women, with mean age of 46.15 ± 14.94 years.

The mean post-hemodialysis plasma sodium was 137.20 ± 2.17 mEq/L, and mean of following day pre-hemodialysis plasma sodium was 137.53 ± 3.15 mEq/L. There was no significant difference between the mean of post-hemodialysis and subsequent pre-hemodialysis sodium levels ($p=0.54$). (**Figure 1**)

The mean post-hemodialysis weight was 54.52 ± 11.49 kg, while mean of following pre-hemodialysis weight was 57.20 ± 11.66 kg. There was a significant difference between the mean post-hemodialysis and subsequent pre-hemodialysis weight ($p=0.0000$). (**Figure 2**)

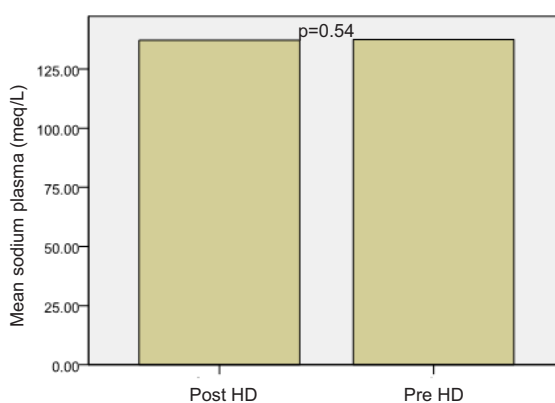


Figure 1. Mean sodium level in post-hemodialysis and pre-hemodialysis in the next session.

There was a significant weak correlation between the difference in sodium level of pre-hemodialysis subtracted by previous post-hemodialysis and the difference in the weight of pre-hemodialysis subtracted by previous post-

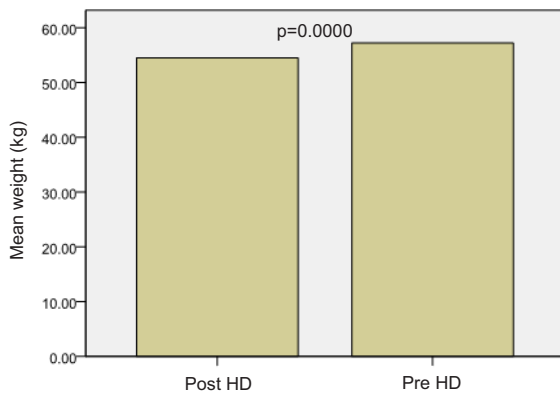


Figure 2. Mean weight in post-hemodialysis and pre-hemodialysis in the next session.

hemodialysis ($r=0.37, p=0.019$).

From calculation of regression between the difference in weight of pre-hemodialysis subtracted by previous post-hemodialysis and the difference in sodium level of pre-hemodialysis subtracted by previous post-hemodialysis a formula $Y = - 2.205 + 0.937 X$ was obtained, and the R Square was equivalent to 0.144. Difference in sodium level of pre-hemodialysis subtracted by previous post-hemodialysis acts as dependent variable Y, while the difference in weight of pre-hemodialysis subtracted by previous post-hemodialysis acted as independent variable X. In the regression curve, it revealed that the data tend to follow a linear pattern. Although somewhat

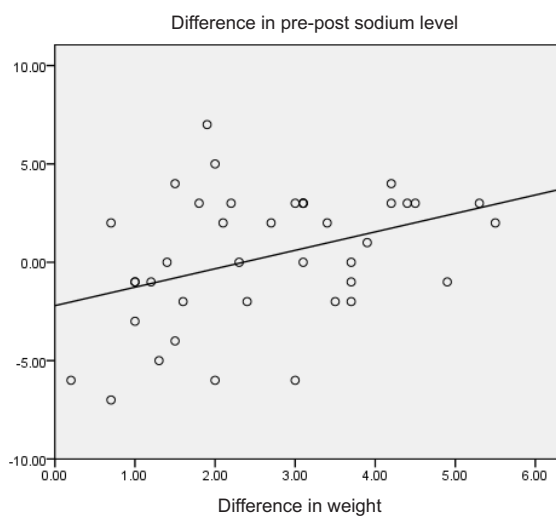


Figure 3. Regression curve of difference in sodium level of pre-hemodialysis subtracted by previous post-hemodialysis and the difference in the weight of pre-hemodialysis subtracted by previous post-hemodialysis.

diffuse, the rest of the data was not segregated (**Figure 3**).

DISCUSSION

Based on the regression formula obtained in this study, in order to prevent a decrease in sodium levels from post-hemodialysis to pre-hemodialysis on the following day, the acceptable weight gain for each hemodialysis is of 2.35 kg. $\{Y = - 2.205 + (0.937 \times 2.35) = 0\}$.

In this study, it turns out that there was no significant difference between plasma sodium levels in post-hemodialysis and pre-hemodialysis on the next session. With the increase in extracellular fluid volume that was seen in the subsequent hemodialysis weight gain between 2.5 kg and 2.9 kg, a considerable decrease in plasma sodium levels were not found. This is understandable because the increase of weight between 2.5 kg and 2.9 kg, will lead to a decrease of plasma sodium levels between 0.14 mEq/L and 0.5 mEq/L, which is a not significant decrease.

For example, to reduce about 10 mEq/L of plasma sodium in the next session of hemodialysis, an increase in extracellular fluid volume of 8.32 liters or weight gain of 8.32 kg are required if the regression formula obtained in this study is used ($- 10 = - 2.205 + 0.937 \cdot 8,32$).

In analysis which was conducted from the regression calculation, about 14.4% of the regression model Y function can be explained by factor X (R Square = 0.144). If it is observed from this side, only 14.4% of change in plasma sodium levels are caused by an increase in extracellular fluid volume. This is most likely due to the addition of extracellular fluid volume or a weight gain of about 2.35 kg in the subsequent pre-hemodialysis (according to the calculation above, the addition of 2.35 kg does not lead to changes in sodium levels from post-hemodialysis to pre-hemodialysis in the next session).

From calculation of regression ANOVA table, a value of $F = 6.405 > (F_{\alpha,1,n-2} = F_{0,05,1,674} = 4.08)$ was found, showing the regression model of $Y = - 2.205 + 0.937 X$, which was relatively satisfying. Based on this ANOVA table analysis, this regression model can still be applied eventhough there were still some weaknesses listed above.¹³

CONCLUSION

Plasma sodium levels can be used as a predictor of extracellular fluid volume in patients on hemodialysis.

There is a relationship between changes in plasma sodium levels in the next session of hemodialysis.

In chronic hemodialysis patients are recommended to have interhemodialysis weight gain, of 2.5 kg - 2.9 kg, in order to prevent decreased plasma sodium levels which will lead to increased mortality.

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