Relationship between P-Wave Dispersion and Effective Hemodialysis in Chronic Hemodialysis Patients

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Key Words

Hemodialysis • Dry body weight • P-wave dispersion

Abstract

Objective: To investigate whether or not P-wave dispersion (PWD) can be used as a good indicator of effective hemodialysis. **Subjects and Methods:** The study included 35 patients (20 males, 15 females, mean age 61 ± 10 years) who regularly received hemodialysis treatment for chronic renal failure. Following hemodialysis, the patients whose hemodynamic parameters were preserved and who reached dry body weight were included. Twelve-lead resting electrocardiogram (ECG) at a speed of 25–50 mm/s, the value of total body fluid (TBF) and bioelectric impedance using bipedal bioelectric impedance equipment were obtained before and immediately after hemodialysis. Blood samples were also taken for the assessment of blood electrolytes, urea and creatinine. PWD was defined as the difference between the maximum and minimum P-wave duration calculated on a standard 12-lead ECG before and after dialysis. **Results:** The following parameters were obtained before and after hemodialysis: blood pressure 132 ± 21 vs. 130 ± 10 mm Hg ($p > 0.05$), TBF 33.9 ± 6 vs. 32 ± 5.6 liters ($p = 0.001$), impedance

499 ± 110 vs. $596 \pm 136 \Omega$ ($p = 0.001$), P-max 103.1 ± 8.9 vs. 106.3 ± 12.7 ms ($p > 0.05$), P-min 70.2 ± 11 vs. 72.5 ± 7.9 ms ($p > 0.05$), PWD 32.2 ± 11.9 vs. 33.8 ± 13.4 ms ($p > 0.05$). Although statistically significant decreases were observed in urea and creatinine levels after hemodialysis, no such changes were observed in blood electrolytes. **Conclusion:** The P-max and PWD did not change significantly after hemodialysis, hence these two parameters can be used as an indicator of effective hemodialysis.

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Introduction

Numerous studies have demonstrated a correlation between the delivered dose of hemodialysis and patient mortality and morbidity. Evidence demonstrates that mortality among end-stage renal disease (ESRD) patients is lower when an appropriate minimum dose of hemodialysis is provided. To ensure that ESRD patients treated with chronic hemodialysis receive adequate treatments, the delivered dose of hemodialysis needs to be measured. Clinical signs and symptoms alone are not reliable indicators of dialysis adequacy [1–5].

The delivered dose of hemodialysis in adult patients should be measured using formal urea kinetic modeling or urea reduction ratio (URR). The NKF K/DOQI guidelines for hemodialysis adequacy acknowledge the ease of calculation and resultant popularity of the URR [6], which has been shown to be a statistically significant predictor of mortality for ESRD patients [1, 5]. The adequate hemodialysis dose should be equivalent to an average URR of 65% [6].

Cardiovascular disease is the major cause of morbidity and mortality in patients with ESRD [7, 8]. Data suggest that uremic factors or factors related to renal replacement therapy or dialysis may be implicated in the pathogenesis of heart disease in patients treated by dialysis, because cardiovascular survival improves after transplantation even in high-risk patients [9, 10]. Patients with ESRD have a unique excess of sudden death from cardiac arrest, which includes a separate category for arrhythmia (13% of cardiac deaths) [7, 8]. Indeed, it has been shown that the prevalence of atrial fibrillation is 13% in hemodialysis patients [11]. Furthermore, increased P-wave dispersion (PWD) may account for the increased prevalence of atrial fibrillation [12]. In this study, we aimed to determine the correlation between hemodialysis adequacy and PWP in chronic hemodialysis patients.

Materials and Methods

The study included 35 patients (20 males, 15 females, age 61 ± 10 years), who regularly received hemodialysis treatment for at least 6 months and were in a stable condition. Patients had dry weight clinically (that is, normotensive, edema-free and cardiothoracic index <0.5) and no history of atrial fibrillation. Following parameters were obtained before and immediately after hemodialysis: body weight, blood pressure, total body fluid (TBF) and bioelectric impedance (BEI) measured with bipedal bioelectric impedance analyzer device (Tanita-450, Japan), serum electrolyte (sodium, potassium, calcium, phosphate), blood urea nitrogen (BUN), and creatinine. Data were analyzed for patients with significant change in pre- and posthemodialysis TBF and BEI and without compromised hemodynamics.

Following an approximately 5-min resting interval, 12-lead resting surface ECGs were obtained (HP, M1700A, China) at 25 and 50 mm/s paper speed. In each derivation, the time period between start and end of the P wave was determined by using a caliper. The longest P-wave duration was accepted as P maximum (P-max) and the shortest P wave as P minimum (P-min) and the PWD value was the difference between P-max and P-min. In order to avoid interobserver changes, the measurements were completed by the same observer who was blinded to the time of ECG. Pre- and posthemodialysis P-max, P-min and PWD values were compared.

Before hemodialysis, left atrial diameter, left ventricular functions and valve structures were evaluated in standard transthoracic echocardiographic examination using an echocardiography machine with 2.5-MHz transducer (GE Vingmed System FiVe, Holten, Norway) according to the recommendations of the American Society of Echocardiography. Using a bipedal BEI analyzer device, TBF (liters) and BEI (Ω) values were digitally measured by fastening bipedal BEI analyzer pedals to both ankles.

Hemodialysis sessions with F5 and F6 HPS polysulfone (Fresenius Medical Care AG, Bad Hamburg, Germany) were repeated 3 times a week for 4 h as a standard procedure (40008-B, Fresenius Medical Care). Bicarbonate dialysate fluids contained 140 mmol/l sodium, 2.0 mmol/l potassium, 1.5 mmol/l calcium and 1.0 mmol/l magnesium. During hemodialysis no drugs were administered, except isotonic NaCl and heparin. The blood samples were taken according to NKF K/DOQI guidelines [6] for the measurement of URR, and also UUR was calculated according to the formula $UUR = 100 \times (1 - Ct/Co)$ (Ct = postdialysis BUN, Co = predialysis BUN) [1].

Statistical Analysis

Statistical analysis was performed using a paired Student's *t* test for continuous variables with the Statistical Package for Windows version (SSPS 11, Chicago, Ill., USA). A *p* value <0.05 was considered statistically significant. All data were expressed as mean $\pm$ SD.

Results

The underlying causes of chronic renal failure were chronic glomerulonephritis ($n = 15$), hypertension ($n = 12$), and chronic tubulointerstitial nephropathy ($n = 8$). Mean duration of hemodialysis was 3.2 ± 0.5 years, mean left ventricular ejection fraction $60 \pm 2\%$ and mean left atrial diameter 44 ± 3.3 mm. TBF level decreased from 33.9 ± 5.9 to 32 ± 5.6 liters ($p = 0.001$), BEI level decreased from 596 ± 136 to $499 \pm 110 \Omega$ ($p = 0.001$) and there was no significant change in blood pressure levels (predialytic 132 ± 21 vs. postdialytic 132 ± 21 mm Hg).

After hemodialysis, P-max duration extended from 103.1 ± 8.9 to 106.3 ± 12.7 ms ($p = 0.68$), P-min from 70.2 ± 11 to 72.5 ± 7.9 ms ($p = 0.78$) and PWD from 32.2 ± 11.9 to 33.8 ± 13.4 ms ($p > 0.88$). The differences in P-max, P-min and PWD levels between pre- and postdialysis measurements were not always statistically significant ($p = 0.68$, $p = 0.78$ and $p = 0.88$, respectively).

Average levels of serum potassium, serum phosphate and serum sodium decreased from 5.2 ± 0.8 to 4.7 ± 0.7 mmol/l, 2.1 ± 0.1 to 1.8 ± 0.9 mmol/l and 135 ± 3.1 to 133 ± 3.9 mmol/l, respectively, while serum free calcium concentration level increased from 2.2 ± 0.1 to 2.5 ± 0.1 mmol/l. The difference was not statistically sig-

Table 1. Pre- and posthemodialysis data

	Predialysis (n = 33)	Postdialysis (n = 33)	p value
BUN, mmol/l	30.1 ± 3.1	17.2 ± 2.2	0.001
Creatinine, μmol/l	870 ± 120	380 ± 80	0.001
Sodium, mmol/l	135 ± 3.1	133 ± 3.9	0.69
Potassium, mmol/l	5.2 ± 0.8	4.7 ± 0.7	0.50
Calcium, mmol/l	2.2 ± 0.01	2.5 ± 0.1	0.89
Phosphate, mmol/l	2.1 ± 0.1	1.8 ± 0.9	0.08

nificant. BUN and creatinine decreased significantly after dialysis (30.1 ± 3.1 vs. 17.2 ± 2.2 mmol/l, $p < 0.001$, and 870 ± 120 vs. 380 ± 80 mmol/l, $p < 0.001$, respectively, table 1).

Discussion

In this study, hemodialysis patients with a significant TBF reduction after hemodialysis had a statistically non-significant increase in P-max, P-min and PWD values. However, when considered together with significant reduction in weight, TBF and BEI, the nonsignificant change in PWD value could be an indicator of effective hemodialysis in ESRD patients.

Effective hemodialysis is an important issue in chronically hemodialyzed patients. Insufficient hemodialysis causes volume overload and inability to remove toxic substances from the body while excessive hemodialysis results in dehydration and electrolyte imbalance. Although there is no gold standard for measuring effective hemodialysis, dry body weight has been recognized as the marker of adequate fluid removal from the patient on hemodialysis.

Because the conduction velocity of depolarization in the atrial and interatrial tissue can be heterogeneous, P-wave duration can be expected to be prolonged and its dispersion from surface ECG increased. The underlying mechanism may be due to an increase in the diameter of the atrial wall, and volume and pressure overload [13, 14]. Additionally, increased sympathetic activation and electrolyte imbalance may contribute to the inhomogeneous propagation of atrial depolarization [15].

Our results differ from those of previous studies [16, 17] where increased PWD values were observed in hemodialysis patients. The differences could be due to the fact that effectiveness of hemodialysis was not assessed in

those studies. Distension of the atria and electrolyte imbalance such as hypokalemia, hyponatremia due to insufficient hemodialysis can cause an increase in PWD. Excess fluid removal may result in electrolyte imbalance and an increase in PWD. In previous studies [17, 18], a negative correlation was reported between PWD and serum potassium and phosphate levels after hemodialysis. In our study, statistically significant changes in serum potassium, phosphate, sodium and calcium levels after hemodialysis were not observed.

Effective hemodialysis was associated with no change in the level of PWD, thereby indicating that a simple parameter obtained from surface ECG is an indicator of effective hemodialysis in our study. On the other hand, an increased PWD after hemodialysis may represent ineffective hemodialysis and a risk factor for atrial fibrillation.

Study Limitation

The number of patients included in the study population was relatively limited. ECGs were obtained immediately after hemodialysis; any changes in ECG occurring later, however, were not monitored. Unfortunately we could not perform Holter monitoring of our study patients. A control group including patients with ineffective hemodialysis should have been added to our study to make our results more clear. Nevertheless, all patients had effective hemodialysis, which needs to be confirmed in further studies overcoming these limitations.

Conclusion

In hemodialysis patients, absence of an increase in PWD can be used as an effective hemodialysis indicator after dialysis. Also, occurrence of atrial fibrillation impairing hemodynamic parameters in hemodialysis patients can be avoided with effective hemodialysis.

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