

Analysis of 24-hour pulse wave velocity in patients with renal transplantation

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Abstract: The aim of our study was to assess the feasibility of using an approach to 24-hour pulse wave velocity (PWV) analysis similar to ambulatory blood pressure monitoring analysis in the management of patients with renal transplantation. Overall, 41 patients aged between 18 and 55 years who had end-stage renal disease resulting from glomerulopathy were recruited from the kidney transplant waiting list. All the measurements were performed before kidney transplantation and at 1 and 20 weeks after transplantation. The Pulse Time Index of Norm (PTIN) was calculated with the Vasotens[®] technology for the estimation of the 24-hour PWV, defined as the percentage of the 24-hour period during which the PWV does not exceed 10 m/second. Before kidney transplantation, the mean PTIN in the whole group was 56.3 (standard deviation, 18.4). Then, a week after the renal transplantation, a decrease in the PTIN was observed in most cases, going to 27.6 (standard deviation, 11.1). After 20 weeks, the mean PTIN in the whole group increased again to 52.0 (standard deviation, 23.6). In our study, we found that the persistence of arterial stiffness disturbances after kidney transplantation appears to be relatively predictable. We determined the cutoff value of PTIN that could predict the two states of PTIN: a state of improvement or a state of decline/without change. The cutoff value of PTIN at 45% had a sensitivity of 69%, specificity of 76%, and area under the curve of 0.65. The analysis of variance showed that in the group with an initial PTIN of 45% or higher, the PTIN in the remote period after transplantation changed significantly ($P < 0.05$), whereas in the group with an initial PTIN lower than 45%, there were no significant changes. Thus, the analysis of 24-hour pulse wave velocity in the management of patients with renal transplantation using PTIN is feasible.

Keywords: renal transplantation, pulse wave velocity, 24-hour monitoring, PTIN

Introduction

The question of structural and mechanical alterations of the arterial wall in the case of renal transplantation has not yet been completely resolved. An insufficiency of endogenous regulators of calcium and phosphate is well known to be a significant factor affecting extraosseous calcifications.¹ In dialysis patients and kidney transplant patients, volume overload and disturbances of calcium and phosphate metabolism add to the atherogenic profile, and these serve as independent risk factors for cardiovascular mortality.² The presence of arterial calcifications was strongly and independently predictive of the outcome in end-stage renal disease (ESRD).³ On this basis, estimating the arterial stiffness (AS) in ESRD is of great interest. Measuring the pulse-wave velocity (PWV) is a reliable means of determining the AS.^{4,5}

There are several studies of PWV in patients with renal transplantation.⁶⁻⁹ Notably, 24-hour PWV analysis has not yet been conducted in adults. Meanwhile, some modern

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devices for ambulatory blood pressure monitoring (ABPM) allow the assessment of some AS indices, and the approach to the analysis of these indices may be quite similar to that of ABPM.¹⁰ Accordingly, the aim of our study was to assess the feasibility of this approach in the management of patients with renal transplantation.

Methods

Baseline characteristics

Overall, 41 patients were recruited from the kidney transplant waiting list of the Privolzhsky District Medical Center in Nizhniy Novgorod, Russia. The inclusion criteria were the following: age between 18 years and 55 years, ESRD resulting from nondiabetic glomerulopathy (glomerular filtration rate <15 mL/min per 1.73 m²), and candidate for a first kidney transplant. Patients with a history of prior kidney transplant or who were candidates for a kidney-pancreas transplant were excluded from the study. The additional exclusion criteria were cardiac rhythm disturbances, body mass index higher than 35 kg/m², severe dyslipidemia, and unstable clinical presentation. Our study group included 27 (65.8%) men and had a mean age of 35.2 years, with a mean systolic blood pressure of 134 mmHg, mean diastolic blood pressure of 86 mmHg, and mean heart rate of 74 beats per minute. All the patients were receiving dialysis at enrollment, including 40 by hemodialysis and one by peritoneal dialysis. Management of patients included the monitoring of calcium and phosphate serum levels and their correction. All measurements were performed before kidney transplantation and at 1 and 20 weeks after transplantation. Approval for the study was obtained from the local research ethics committee, and written informed consent was obtained for each participant.

Vasotens® technology

The Vasotens® technology is an innovative method used for pulse-wave analysis based on oscillometric blood pressure measurements, using the BPLab (Nizhniy Novgorod, Russia) device for ABPM.^{11,12} The technology was developed by the Petr Telegin Company in Nizhniy Novgorod, Russia. This method involves assessing pulse waves at the brachial artery. The recordings are made using a conventional blood pressure cuff for adults. During the blood pressure measurement, the pressure waveforms in the cuff are registered while performing a step-by-step deflation. The separation and timing of the forward and reflected pulse waves are determined by a special mathematical algorithm. The distance for the PWV equation used by the Vasotens® was measured according to

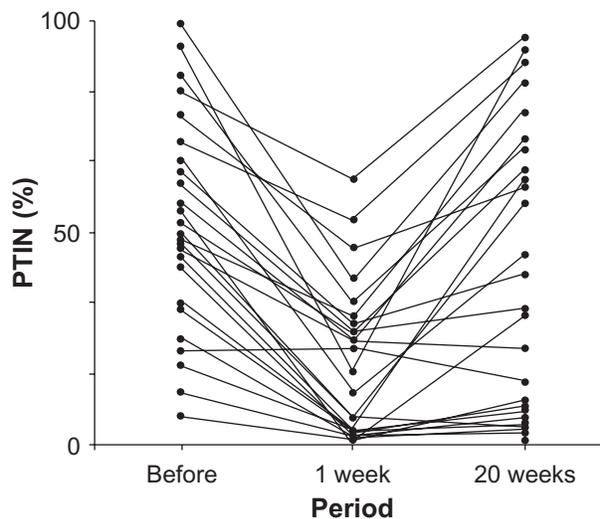


Figure 1 PTIN in patients before and after renal transplantation. **Abbreviation:** PTIN, Pulse Time Index of Norm.

the BPLab user’s guide requirements. The quality control method consists of a visual assessment of the curves in the Vasotens® clinical report screen.

The Pulse Time Index of Norm (PTIN) is calculated by the Vasotens® for the estimation of the 24-hour PWV. The principle of the PTIN calculation is

$$PTIN, \% = (T_1 + T_2 + \dots + T_n) / T_m \times 100, \quad (1)$$

where T_m is the entire period of monitoring and $T_1, T_2,$ and T_n represent the periods in which the PWV does not exceed the cut-off value of 10 m/second.

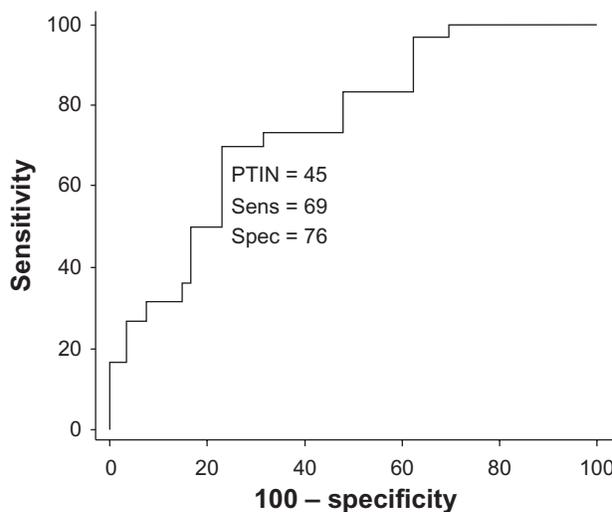


Figure 2 Receiver operating characteristic curve to determine the cut-off value and area under the curve for different PTIN states after transplantation. **Abbreviations:** PTIN, Pulse Time Index of Norm; sens, sensitivity; spec, specificity.

Table 1 Characteristics of the examined patients

	PTIN before transplantation ≥45%, n = 24	PTIN before transplantation <45%, n = 17	P (Mann–Whitney U)
Male, n (%)	16 (66.6)	11 (64.7)	
Age, m (SD) years	33 (9)	38 (11)	0.0590
Height, m (SD) cm	168 (12)	168 (11)	0.5
Weight, m (SD) kg	76 (6)	75 (7)	0.6264
Preoperative dialysis period, m (SD) years	2.5 (0.3)	3.8 (3.0)	0.0405
Carotid plaque, n (%)	4 (16.7)	3 (17.6)	
SBP, m (SD) mmHg	132 (15)	138 (16)	0.2270
DBP, m (SD) mmHg	86 (7)	87 (8)	0.9905
Heart rate, m (SD) beats per minute	74 (8)	76 (9)	0.4584
Serum calcium, m (SD) mg/dL	9.3 (0.9)	9.2 (0.8)	0.7915
Serum phosphorus, m (SD) mg/dL	4.9 (0.9)	5.1 (1.3)	0.5632

Abbreviations: DBP, diastolic blood pressure; PTIN, Pulse Time Index of Norm; SBP, systolic blood pressure; m, mean; SD, standard deviation.

Statistics

Essentially, all the data are shown as the mean and standard deviation (SD). We used BPStat software, version 05.00.04 (BPLab) to tabulate all the indices of every measured 24-hour waveform automatically. Then, analysis of variance, receiver operating characteristic analysis, and the Mann–Whitney *U* test were used.

Results

The PTINs in different periods before and after renal transplantation are illustrated in Figure 1.

As shown in Figure 1, before kidney transplantation, there was a wide range of PTIN values. The mean PTIN in the whole group was 56.3 (SD, 18.4). As our analysis showed, this value did not depend on the duration of the history of the disease or the time of the interdialysis period at which the monitoring was performed.

Then, a week after the renal transplantation, we observed a decrease in the PTIN in most cases. The mean PTIN in the

whole group at this period was 27.6 (SD, 11.1). After 20 weeks, the mean PTIN in the whole group increased again to 52.0 (SD, 23.6), but the detailed analysis showed that those patients who had a higher value of PTIN before transplantation had a higher increase at this time. Using the receiver operating characteristic curve, we determined the cutoff value of PTIN that could predict the two PTIN states: a state of improvement or a state of decline/without change (Figure 2). The cutoff value of PTIN at 45% had a sensitivity of 69%, specificity of 76%, and area under the curve of 0.65 to predict these states. For the detailed baseline characteristics of the patient groups separated according to this cut-off point, please see Table 1.

As shown in Table 1, there was no significant difference between the groups for almost all characteristics except the PTIN. The difference in preoperative dialysis period ($P = 0.0405$) and the tendency toward a difference in age ($P = 0.0590$) should be noted. The PTIN at different periods before and after renal transplantation in the groups with PTIN of 45% or higher or less 45% is illustrated in Figure 3.

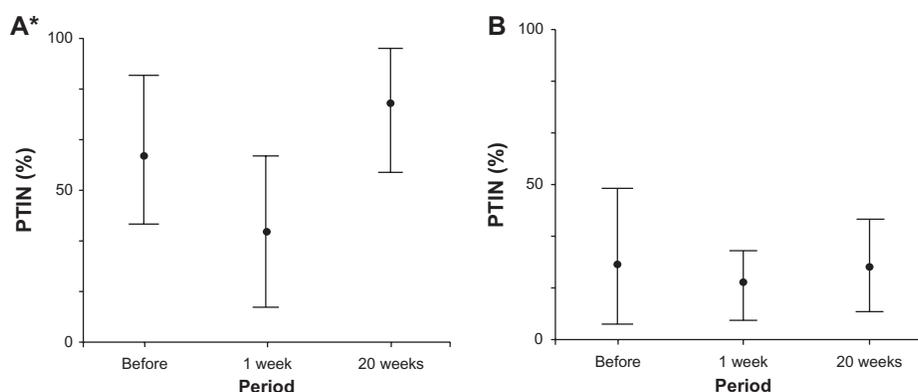


Figure 3 The PTIN in the patients before and after renal transplantation.

Notes: * $P < 0.05$ (analysis of variance). (A) The group with PTIN before transplantation $\geq 45\%$. (B) The group with PTIN $< 45\%$.

Abbreviation: PTIN, Pulse Time Index of Norm.

The analysis of variance showed that in the first group, the PTIN changed significantly ($P < 0.05$), whereas in the second group, the PTIN was not significantly different. The effect of renal transplantation on blood pressure (Table 2) was similar to the effect on the PTIN.

Discussion

Some authors have noted an improvement in the AS after kidney transplantation.^{6–8} A number of studies have shown that after kidney transplantation, the disturbances in calcium and phosphate metabolism improve in general, but the media calcification, structural alterations of the arterial wall, and disturbed mechanical vessel wall properties persist.^{9,13–15}

In our study, we found that the persistence of these disturbances after kidney transplantation appears to be relatively predictable: there are clear differences in the clinical conditions of patients who develop an excess in the PWV over the cutoff value for either a small or large percentage of the monitoring period. If PTIN is 45% or higher before kidney transplantation, there appears to be a good chance that the PTIN will improve in the remote period after transplantation. This improvement is particularly important for the management in the initial period after implantation, when increased damage to the arterial wall, resulting in a decreased PTIN in most patients, is observed. It is known that the prevalence of postoperative hypertension in patients with renal transplantation is high, and this is one reason for an aggressive therapeutic approach by physicians, reflected by administering more antihypertensive medications.¹⁶ The PTIN seems to give us an opportunity to optimize this approach.

Regarding the influence of hemodialysis on the variability of the PWV, a study in which the measurements were performed immediately before (pre) and 1 hour after (post) the end of each dialysis session should be noted. Cyclic intradialysis changes in the PWV were similar during the three dialysis sessions; as a consequence, all postdialytic PWV values were lower with respect to the predialytic levels.¹⁷

Table 2 The effect of renal transplantation on blood pressure in separated groups of patients, m (SD) mmHg

	PTIN before transplantation ≥45%, n = 24		PTIN before transplantation <45%, n = 17	
	Systolic	Diastolic	Systolic	Diastolic
Before	132 (15)	86 (7)	138 (16)	87 (8)
1 week	143 (16)	95 (7)	147 (17)	97 (8)
20 weeks	136 (15)	86 (7)	145 (18)	98 (9)

Abbreviations: PTIN, Pulse Time Index of Norm; m, mean; SD, standard deviation.

As our analysis showed, the PTIN did not depend on the time of the interdialysis period at which the monitoring was performed. In our opinion, this mismatching is a result of the smoothing effect of the nocturnal pattern of PWV in PTIN, which integrates the PWV values over the course of 24 hours.

Thus, the analysis of the 24-hour pulse wave velocity in the management of patients with renal transplantation using PTIN is feasible.

Disclosure

The authors report no conflicts of interest in this work.

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