



Diagnostic Role of Dopplerography of Renal Vessels in Patients with Late Dysfunction of the Transplanted Kidney

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Search for non-invasive methods for diagnosing late transplant kidney dysfunction, which can improve control and monitor the condition of the kidney transplant, characterization diagnostic role of dopplerography of renal vessels in patients with late dysfunction of the transplanted kidney.

Study Design: When conducting dopplerometry, blood flow indices were analyzed from 3 to 6 cycles of heart contractions, followed by an averaged indicator. In addition, the linear blood flow velocity was assessed separately from the renal vein.

Place and Duration of Study: For the period 2016-2017 Ultrasound of an allopod was performed in 60 recipients of RT (RENAL TRANSPLANT) in the late postoperative period.

Methodology: The average age of the patients was 38.89 ± 1.52 years. There were 34 men (56.67%), 26 women (43.33%). All patients were divided into two groups: patients with preserved function and patients with RT (RENAL TRANSPLANT) dysfunction. Related kidney transplantation (RRT) was performed in 55.0% of patients, in 45.0% - cadaveric kidney transplantation (CKP). The groups were comparable in the main clinical and demographic parameters.

Results: The reverse dynamics was observed when examining the level of the renal filtration function indicator, the estimated glomerular filtration rate (SKF) - at a TAMX level of more than 15 cm/sec, glomerular filtration was 51.18 ± 1.93 (47.32-55.04) ml/min ($p < 0.01$), and with a decrease in TAMX of less than 15 cm/sec, the level of SKF decreased significantly, more than twice, to the level of 25.40 ± 2.19 (21.02-29.78) ml/min (< 0.001).

Conclusion: The determination of dopplerographic parameters for TP with preserved and especially with impaired depuration function with a direct assessment of TAMX opens up wide opportunities in non-invasive assessment of RT (RENAL TRANSPLANT) changes, identification of developing complications, as well as improved transplant survival.

Keywords: Renal blood flow; late transplant dysfunction; dopplerography.

1. INTRODUCTION

With the aging of the world population and the progressive growth of kidney disease, the number of patients receiving renal replacement therapy continues to grow. Kidney transplantation (KT) is the treatment of choice in patients with established end-stage renal failure. KT leads to increased life expectancy, improved social and labor rehabilitation of this category of patients, being more cost-effective than dialysis [1,2]. However, the progress of clinical transplantology refers mainly to the first years after surgery, while the survival rate of renal transplants (RTs) in the long-term post-transplant period is still low [3,4]. Along with physical and laboratory examination, ultrasound diagnostics is a convenient and safe method for monitoring the condition of the RT (RENAL TRANSPLANT), both in the early and late postoperative period [5-8]. The main clinical indicator of renal transplant dysfunction is considered to be a tendency to increase serum creatinine levels above the baseline value. Some authors suggest that an increase in serum creatinine by 25% above the baseline is an indication for a biopsy of the RTs [9,10]. A kidney biopsy is considered an important tool that provides histopathological information about RT (RENAL TRANSPLANT) dysfunction. However, a biopsy is an invasive procedure that may be contraindicated in patients with coagulopathy and may be accompanied by the development of complications leading to RTs dysfunction [11,12]. Currently, there is a search for non-invasive methods for diagnosing late transplant kidney dysfunction, which can improve control and monitor the condition of the kidney transplant. For this purpose, this study was conducted.

2. MATERIAL AND METHODS

For the period 2016-2017 Ultrasound of an alloped was performed in 60 recipients of RT (RENAL TRANSPLANT) in the late postoperative

period. Place of research - State Institute "Zaporizhzhia Medical Academy of Postgraduate Education of Ministry of Health of Ukraine". Time of late postoperative period - more than 12 months after surgery. The average age of the patients was 38.89 ± 1.52 years. There were 34 men (56.67%), 26 women (43.33%). All patients were divided into two groups: patients with preserved function and patients with RT (RENAL TRANSPLANT) dysfunction. Related kidney transplantation (RRT) was performed in 55.0% of patients, in 45.0% - cadaveric kidney transplantation (CKP). The groups were comparable in the main clinical and demographic parameters. Ultrasound was performed on a Toshiba Xario apparatus using a convex multi-frequency sensor (frequency 3-5 MHz) and consisted in assessing the condition of the graft, transplant topometry, assessing the condition of the perinephric space, color Doppler ultrasound, spectral Doppler ultrasound. The blood flow in the renal arteries was examined at the level of the main trunk (MT), segmental (ST) and interlobar branches of the renal arteries in (IB) the spectral Doppler mode, evaluating the spectral and linear velocity indices. Spectral Dopplerography assessed the shape of the Doppler curve, determined: peak systolic velocity (PSV), final diastolic velocity (FDV) of blood flow, resistance index (RI) and pulsation index (PI), systole-diastolic ratio (SDR), acceleration/acceleration time (AT), time-averaged maximum blood flow velocity (TAMX) in the main, segmental arteries of the upper, lower and middle segments of the kidneys, as well as in the interlobar arteries of these segments. The insonation angle was in the range from 30° to 60° . When conducting Dopplerometry, blood flow indices were analyzed from 3 to 6 cycles of heart contractions, followed by an averaged indicator. In addition, the linear blood flow velocity was assessed separately from the renal vein. Serum and urine creatinine concentrations were determined by a unified method using the Jaffe color reaction. All

biochemical studies were performed in the Central Clinical and Express Biochemical Laboratories of the Zaporizhzhya Regional Clinical Hospital. The normality of the data distribution was evaluated according to the Kolmogorov-Smirnov criteria. If necessary, parametric or nonparametric data analysis methods were used. The research results were processed using the statistical package of the licensed program "STATISTICA® for Windows 7.0" (Stat Soft Inc.), As well as "SPSS 17.0", "Microsoft Excel 2010". Separate statistical procedures and algorithms are implemented in

the form of specially written macros in the corresponding programs. For all types of analysis, differences were considered statistically significant at $p < 0.05$.

3. RESULTS AND DISCUSSION

When performing Doppler ultrasonography of the RT (RENAL TRANSPLANT) vessels, the greatest differences were obtained by such parameters of blood flow as FDV, and especially TAMX, at the level of the interlobar arteries of the renal transplant (Table 1).

Table 1. The parameters of the Doppler spectrum of renal blood flow of the renal transplant in patients at a long time after kidney transplantation with preserved and impaired deputation function (interlobar arteries)

Indicators	Preserved excretory function		Impaired excretory function	
	RRT (n=18)	CKP (n= 12)	RRT (n=14)	CKP (n= 16)
Upper segment				
PSV MT, cm/sec	32,13±2,23	30,10±1,04	24,10±1,52*	20,94±1,32*
FDV IB, cm/sec	13,38±1,03	12,90±0,64	8,70±0,78*	7,69±0,41*
SDR, conv.un.	2,44±0,08	2,43±0,11	2,93±0,33	2,73±0,11*
PI MT, conv.un.	0,94±0,03	0,92±0,04	1,19±0,11*	1,09±0,04*
RI IB, conv.un.	0,58±0,01	0,58±0,02	0,63±0,03	0,62±0,01
AT, sec	0,14±0,01	0,13±0,01	0,15±0,01	0,14±0,01
TAMX, cm/sec	19,99±1,38	19,05±0,63	13,18±0,88*	11,99±0,67*
Middle segment				
PSV IB, cm/sec	33,00±2,80	30,90±1,82	25,70±1,78*	24,81±1,78*
FDV IB, cm/sec	12,38±0,96	13,0±0,82	8,30±0,79*	8,01±0,70*
SDR, conv.un.	2,70±0,10	2,41±0,1 [#]	3,42±0,40*	3,21±0,16*
PI IB, conv.un.	1,02±0,04	0,93±0,02 [#]	1,29±0,12*	1,26±0,06*
RI IB, conv.un.	0,62±0,01	0,58±0,02	0,68±0,03	0,68±0,02*
AT, sec	0,13±0,01	0,14±0,01	0,14±0,01	0,13±0,01
TAMX, cm/sec	19,63±1,47	19,40±1,15	14,05±1,06*	13,41±1,02*
lower segment				
PSV IB, cm/sec	32,06±1,73	31,30±1,24	20,40±1,23*	21,25±1,55
FDV IB, cm/sec	13,31±0,78	12,90±0,46	7,60±0,60*	6,78±0,46*
SDR, conv.un.	2,43±0,09	2,42±0,12	2,80±0,20	3,26±0,27*
PI IB, conv.un.	0,94±0,04	0,93±0,05	1,14±0,08*	1,26±0,07*
RI IB, conv.un.	0,58±0,01	0,58±0,02	0,63±0,02	0,67±0,02*
AT, sec	0,13±0,01	0,16±0,01	0,14±0,01	0,14±0,01
TAMX, cm/sec	19,89±0,95	19,38±0,65	11,48±0,79*	10,78±0,97*

Note: * - the statistical significance of the differences ($p < 0.05$) in patients with preserved transplant function after RRT and CRT compared with similar ones in renal transplant dysfunction

In patients with renal transplant dysfunction after RRT and CRT, there is a statistically significant decrease in FDV and especially TAMX at the level of the interlobar branches of the renal arteries of all segments compared with patients without renal dysfunction.

In the future, to assess the diagnostic role of the dopplerographic indicator TAMX:

- conducted an analysis of laboratory markers of renal dysfunction depending on the TAMX index in RT (RENAL TRANSPLANT) recipients;
- performed a regression analysis of the relationship between TAMX and blood creatinine in recipients in the long term after TA.

An analysis of laboratory markers of renal dysfunction was performed depending on the TAMX level of the interlobar branches of the middle segment in RT (RENAL TRANSPLANT) recipients, where the critical TAMX value was 15 cm / s (Table 2).

According to the results, RT (RENAL TRANSPLANT) recipients with a TAMX level of more than 15 cm/sec had a creatinine level of 114.50 ± 3.85 (106.80-122.20) $\mu\text{mol/l}$, which was 2.35 times less than the same creatininemia in

patients with TAMX level <15 cm/sec (average, 268.59 ± 23.59 (221.43-315.78) $\mu\text{mol/l}$ ($p < 0.001$)). The reverse dynamics was observed when examining the level of the renal filtration function indicator, the estimated glomerular filtration rate (SKF) - at a TAMX level of more than 15 cm/sec, glomerular filtration was 51.18 ± 1.93 (47.32-55.04) ml/min ($p < 0.01$), and with a decrease in TAMX of less than 15 cm/sec, the level of SKF decreased significantly, more than twice, to the level of 25.40 ± 2.19 (21.02-29.78) ml/min (<0.001). Further, to assess not only the degree / orientation, but also the nature of the dependence, we performed a regression analysis, in which the TAMX level of interlobar arteries (middle segment) was included as an independent variable in the regression model, and as a dependent variable, prone to the influence of an independent argument, used a parameter that reliably characterizes the functional state of the RT (RENAL TRANSPLANT), a marker of dysfunction - the level of serum creatinine. According to the data obtained during the assessment and analysis of the scatter chart (Fig. 1), the relationship between TAMX and creatininemia was statistically significantly approximated by a polynomial (quadratic) type regression model:

$$\text{Creatinine} = 763.78 - 54.35 \times \text{TAMX} + 1,057 \times \text{TAMX}^2$$

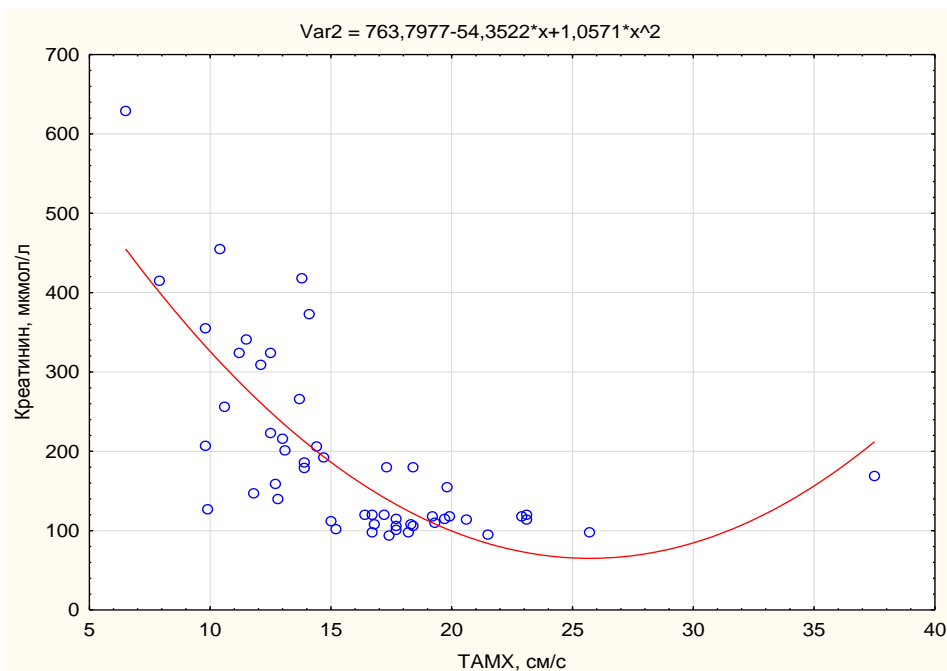


Fig. 1. Regression analysis and dispersion diagram of the relationship of the Dopplerographic indicator TAMX and blood creatinine in recipients in the long term after KT

Table 2. Parameters of renal function in RT (RENAL TRANSPLANT) recipients depending on the TAMX level of interlobar arteries (middle segment)

Indicators	The patients (n=60)		The significance level of differences between groups
	TAMX \geq 15 cm/sec (n=28)	TAMX <15 cm/sec (n= 32)	
Creatinine, μ mol/l	114,50 \pm 3,85 (106,80-122,20)	268,59 \pm 23,59 (221,43-315,78)	p<0,001
SKF, ml/min	51,18 \pm 1,93 (47,32-55,04)	25,40 \pm 2,19 (21,02-29,78)	p<0,001

During analyzing the functional relationship between TAMX and serum creatinine, it should be indicated that the approximation error and the residual variance value show the high accuracy of the linear model, thus, the regression analysis task can be considered completed ($R = 0.79$, $R^2 = 0.624$, normalized $R^2 = 0,61$ at $F = 23.56$, standard error 6.31, $p < 0.01$). The observed parabolic regression correlation shows that more than half of the total variance of the creatinemia sign can be associated with a change in the TAMX indicator (as a sign of worsening renal blood flow), with the greatest failure of the function observed in the range from 12 to 15 cm/sec, where in most cases (almost 80%), there was a deterioration in renal hemodynamics and laboratory markers of impaired renal function (creatinine higher than 200 μ mol/l).

4. CONCLUSION

The data obtained indicate a statistically significant associative relationship between the dynamics of the laboratory marker of RT (RENAL TRANSPLANT) dysfunction and the severity of hemodynamic disturbances of the reciprocal lobar arteries. The TAMX index, especially the spectrum of interlobar renal arteries, is an adequate parameter reflecting the formation of transplanted kidney dysfunction in recipients in the late stages after surgery. The determination of dopplerographic parameters for TP with preserved and especially with impaired deuration function with a direct assessment of TAMX opens up wide opportunities in non-invasive assessment of RT (RENAL TRANSPLANT) changes, identification of developing complications, as well as improved transplant survival.

CONSENT AND ETHICAL APPROVAL

As per international standard or university standard guideline Patient's consent and ethical approval has been collected and preserved by the authors.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors. The operation was performed within the framework of NDR Ultrasound and Doppler study in the diagnosis of transplanted kidney dysfunction (state registration number 0119U102220).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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