Tissue Doppler Imaging and Intima-Media Thickness as Noninvasive Methods of Cardiovascular Risk Stratification in Patients After Kidney Transplantation

M. Dudziak[a,*], D. Rawicz-Zegrzda[a], M. Jankowska[b], A. Dębska-Ślizień[b], Z. Wołyniec[b], and B. Rutkowski[b]

[a]Noninvasive Cardiac Diagnostic Department, Medical University of Gdańsk, Poland; and [b]Department of Nephrology, Transplantology, and Internal Medicine, Medical University of Gdańsk, Poland

ABSTRACT

Background. Cardiovascular complications, including coronary artery disease and chronic heart failure, are the leading causes of death in patients with chronic kidney disease. New echocardiographic techniques, such as tissue Doppler imaging (TDI) with strain and strain rate, are noninvasive, easy-to-perform methods of the estimation of left ventricular (LV) systolic and diastolic function. The aim of the study was to analyze the utility of new noninvasive methods of cardiovascular risk stratification in patients after kidney transplantation.

Methods. We included 43 consecutive kidney transplant (KT) recipients, with 30 healthy subjects constituting the control group in the study. We evaluated LV morphology and LV systolic and diastolic function by means of echocardiography with TDI and intima-media thickness by ultrasonography of the carotid arteries.

Results. LV mass index was significantly higher in transplanted patients, and both mitral inflow E/A and Em/Am ratios from pulsed myocardial imaging were significantly lower in the KT group as compared with the control group. The systolic wave of TDI at the basal segments was much lower in KT patients than in the control patients ($P < .05$). The mean value of strain rate was reduced in KT recipients as compared with the control patients. IMT was significantly higher in KT recipients.

Conclusions. Echocardiography with TDI provided more accurate information about systolic and diastolic LV function. KT recipients showed significant alterations in LV longitudinal myocardial function parameters estimated by strain and strain rate. Strain and strain rate are noninvasive methods, easy to repeat, and valuable for detecting myocardial LV dysfunction in asymptomatic KT recipients.

CARDIOVASCULAR disease is the most prevalent cause of death in patients with chronic kidney disease (CKD) and after kidney transplantation (KT) [1]. Therefore, detection and treatment of cardiovascular disease are advocated before transplantation. Furthermore, cardiac dysfunction often influences candidate selection for KT [2]. The traditional approach to cardiovascular risk stratification appears to be inapplicable to patients on a transplant waiting list [3]. On the other hand, the high cardiac mortality rate of KT recipients continues to constitute a problem that requires special attendance. Therefore, early detection of left ventricular (LV) dysfunction could be crucial for identification of high-risk patients and for early implementation of appropriate treatment.

Echocardiography With Modern Ultrasound Technique

Tissue Doppler imaging (TDI), strain, and strain rate are new methods that provide a precise measure of LV wall motion. They offer a new possibility to quantify global and

*Address correspondence to Maria Dudziak, Noninvasive Cardiac Diagnostic Department II Chair of Cardiology, 80-210 Gdansk, Poland ul. M Skłodowskiej – Curie 3a. E-mail: mdudziak@gumed.edu.pl

360 Park Avenue South, New York, NY 10010-1710

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regional LV function. By the assessment of mitral annular velocity of the LV, the value of regional wall mechanics and ejection fraction can be accurately obtained, especially in patients with poor visualization of the endocardial border.

The aim of this study was to identify signs of LV myocardial dysfunction, applying TDI strain and strain rate and the measurements of intima-media thickness (IMT) of the carotid arteries in KT recipients.

METHODS

The study group consisted of 43 consecutive KT recipients (30 men, 13 women; mean age, 50.5 ± 14.2 years) and 30 healthy subjects (19 men, 11 women; mean age, 43.1 ± 9.8 years) as the control group. Clinical and biochemical parameters are presented in Table 1.

Echocardiography was performed with the PHILIPS HP 11HE system (Philips, USA), using a 2-3, 5-MHz transducer, comprised at end-diastole, in the parasternal long and short axes: LV dimensions were end-systolic, end-diastolic, inter-ventricular septum thickness (IVS), and posterior wall thickness. LV ejection fraction (LVEF) was assessed with the use of a software program that applied biplane Simpson's rule.

Doppler Assessment

Pulsed Doppler measurements of LV inflow from the 4-chamber apical view, in which the sample volume was placed at the level of the valve tips, consisted of mitral early peak velocity (m/s) of the early wave (E), the atrial wave (A), time duration of the A wave (A–dur), early to atrial velocity ratio (E/A), deceleration time (ms) of the E-wave (decTE), and isovolumic relaxation time. Pulmonary venous flow peak velocities were systolic wave (S), diastolic wave (D), atrial reversal wave (a′), and atrial reversal wave duration (a-dur).

Longitudinal TDI was assessed from basal levels of the LV in apical 4 and −2-chamber projections. Tissue Doppler myocardial imaging was performed with the use of the minimal optimal gain. Pulsed TDI was characterized by myocardial waves: systolic (S_m), diastolic early (E_m), and atrial (A_m) and E_m/A_m ratio.

Table 1. Clinical and Biochemical Characteristics of Study Groups

Characteristic	KT Recipients (n = 43)	Control Patients (n = 30)
Age, years (SD)	50.5 (14.2)	43.1 (9.8)
BMI, kg/m^2 (SD)	25.9 (4.1)	23.2 (3.3)
Systolic blood pressure, mm Hg	139 (20)	115 (12)
Diastolic blood pressure, mm Hg	85 (12)	72 (11)
Serum total cholesterol, mg/dL (SD)	215.1 (69.2)	203 (22)
Serum triglycerides, mg/dL (SD)	192.6 (111.7)	145 (13.2)
Serum uric acid, mg/dL (SD)	6.3 (1.3)	5.4 (1.3)
Serum creatinine, mg/dL (SD)	1.5 (0.7)	0.8 (0.3)
GFR, mL/min (MDRD-4) (SD)	59 (16.1)	86 (11.3)
Duration of renal failure, years (SD)	8.8 (6.4)	–
Duration of HD/CADO treatment, months (SD)	22.7 (23.6)	–
Hb, g/dL (SD)	13.1 (1.8)	14.9 (2.2)
History of cardiovascular disease, % of patients	30.2	–
Current smoking, %	16.2	–
Fasting serum glucose, mg/dL (SD)	102.3 (33.9)	89 (12.7)
Type 1 diabetes, % of patients	6.9	–
Type 2 diabetes, % of patients	18.3	–
β-Blocker treatment, % of patients	88	–
Ca channel inhibitor treatment, % of patients	62	–
α-Blocker treatment, % of patients	39.5	–
Statin treatment, % of patients	41.8	–
CsA treatment, % of patients	25.5	–
Tacrolimus treatment, % of patients	74.5	–

Data are presented as mean ± standard deviation (SD).

Abbreviations: BMI, body mass index; CADO, continuous ambulatory peritoneal dialysis; CsA, cyclosporine; GFR, glomerular filtration rate; HD, hemodialysis; KT, kidney transplant.

Strain Rate Imaging

Digital data were transferred to an optical disk for off-line analysis with the use of the Q-lab system, which allowed determination of the strain rate and strain of selected samples for each instant during 3 cardiac cycles. The time difference of the pulmonary atrial reversal wave to mitral atrial wave duration (a-dur−A-dur) was measured to estimate LV pressure. The pulmonary systolic-to-diastolic wave ratio was estimated to differentiate normal from "pseudo-normal" mitral inflow pattern.

Intima-Media Thickness

A linear transducer (L/12-3) equipped with Q-lab software was used for IMT measurements. The depth of focus was 4 cm and the gain settings were as recommended to obtain the best image quality. IMT was defined as the distance between the leading edge of the lumen interface and the boundary between the media and the adventitia of the far wall of common carotid artery; it was measured from 2-D presentation in a longitudinal image, bilaterally, from 3 positions: anterior, lateral and posterior, with the patient lying on his back with the head in axis. The point of measurement was 1 to 3 cm proximal to the bifurcation, in the plaque-free distance, during cardiac diastole. Along a minimum 10-mm length of an arterial segment, the automatic computer-assisted image was used for analysis, according to Touboul et al [4]. The image was frozen and stored in the device memory and automatically analyzed off-time.

Statistical Analysis

Data are expressed as mean ± standard deviation. For normally distributed continuous variables, a 2-sample unpaired t test or analysis of variance was used. A value of $P < .05$ was considered significant.

The study protocol was approved by the Institutional Medical University of Gdansk Bioethics Committee. All participants gave informed consent.

RESULTS

The KT patients and control patients did not differ significantly in respect to sex, heart rate, and body mass index. The mean age of KT recipients, although higher than in control patients, did not differ significantly. At rest, both mean systolic blood pressure and diastolic blood pressure differed significantly. Echocardiographic and IMT data obtained from KT patients and control patients are presented in Table 2.