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PREVALENCE AND RISK FACTORS FOR PRE-DIABETES AND DIABETES AFTER KIDNEY TRANSPLANTATION

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Abstract

Introduction: Post-transplant diabetes mellitus (PTDM) after kidney transplantation is one of the main complications that increases overall cardiovascular morbidity and decreases graft and patient survival rate. Using fasting blood glucose the prevalence of diabetes is underestimated, and it is impossible to assess the existence of pre-diabetes or impaired glucose tolerance (IGT). In this cross-sectional study we evaluate the prevalence of diabetes and pre-diabetes using oral glucose tolerance test (OGTT), and the impact of potential risk factors associated with their occurrence.

Material and Methods: 59 living donor kidney transplant recipients without prior history of diabetes and any rejection episode were included in the study. All patients were on the same triple calcineurin inhibitors (CNI) based maintenance immunosuppressive therapy including Micophenolat Mofetil and steroids. OGTT with 75 grams of anhydrous glucose was performed in all patients with normal or impaired fasting glucose (IFG). According to the results, patients were divided into two groups: dysglycemia group (DM, IGT and IFG) and normal group (without glucose disorders).

Results: Before performing OGTT, IFG was already established in 8 of 59 patients (13.3%) while 51 (86.44%) were normoglycemic. After performing OGTT the overall prevalence of glucose disorders (pre-diabetic and diabetic patients) was 33.9% (20/59) while 39 remain normoglycemic. The prevalence of PTDM, IGT and IFG were 3.39% (2/59), 30.5% (18/59) 11.86 (7/59) respectively. In the whole group cyclosporine trough level (CsA) ($r = 0.37$, $p < 0.05$), total lipids TL ($r = 0.31$, $p < 0.05$), LDL-c ($r = 0.28$, $p < 0.05$) and the time since transplantation ($r = -0.26$, $p < 0.05$) were significantly correlated with the postprandial glycemia. In the dysglycemic group CsA trough level ($r = 0.38$, $p < 0.05$), TL ($r = 0.44$, $p < 0.05$) and LDL-h ($r = 0.51$, $p < 0.05$) was significantly associated with the development of glucose disorders.

Conclusion: There is a high prevalence of pre-diabetes among renal transplant recipients. Major risk factors for glucose disorder after transplantation are CsA trough levels, and concentrations of total lipids and LDL cholesterol.

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Keywords: impaired fasting glucose, diabetes, renal transplantation, immunosuppression

ПРЕВАЛЕНЦА И РИЗИК ФАКТОРИ ЗА ПРЕДИЈАБЕТЕС И ДИЈАБЕТЕС ПО РЕНАЛНА ТРАНСПЛАНТАЦИЈА

Апстракт

Пост-трансплантацискиот дијабетес мелитус (ПТДМ) е главна компликација по трансплантација на бубрег која го зголемува целокупниот кардиоваскуларен морбидитет, како и преживувањето на графтот. Со одредување на гликемија на гладно се потценува преваленцата на дијабетес, а невозможно е да се процени постоењето на предијабет или нарушена гликозна толеранција (НГТ).

Материјал и методи: Во оваа студија на пресек ние ја проценуваме преваленцата на дијабет и предијабет, користејќи орален гликоза толеранс тест (ОГТТ), како и влијанието на потенцијалните ризик фактори асоцирани со нивно настанување. Испитувани беа 59 пациенти по ренална трансплантација од жив донор кои се на иста тројна имуносупресивна терапија во дози на одржување, без претходна историја за дијабет, и без претходни епизоди на отфрлање на графтот. Кај сите пациенти со нормални гликемии или нарушени гликемии на гладно (НГГ) беше изведен ОГТТ со 75 грама анхидрирана гликоза. Согласно резултатите пациентите беа поделени во две групи: група со дисгликемии (ДМ, НГТ, НГГ) и група без гликозни нарушувања.

Резултати: Пред ОГТТ кај 13.55 % (8/59 пациенти) беше утврдена НГГ, а 86.44% (51/59 пациент) беа нормогликемични. По изведениот ОГТТ, вкупната преваленца на гликозни нарушувања (пациенти со дијабет и предијабет) беше 33.9 % (20/59), а нормогликемични беа 66.1% (39/59). Преваленцата на ПТДМ, НГТ и НГГ беа 3.39% (2/59), 30.5% (18/59), 11.86 (7/59) соодветно. Во целата група Циклоспорин нивото (ЦсА) ($r=0.37$, $p<0.05$), тоталните липиди (ТЛ) ($r= 0.31$, $p<0.05$), ЛДЛ-х ($r=0.28$, $p<0.05$) и времето по трансплантација ($r= -0.26$, $p<0.05$) покажаа сигнификантна корелација со постпрандијалната гликемија. Во групата со гликозни нарушувања ЦсА ($r=0.38$, $p<0.05$) нивото, ТЛ ($r=0.44$, $p<0.05$) и ЛДЛ-х ($r=0.51$, $p<0.05$) се сигнификантно поврзани со настанување на гликозните нарушувања.

Заклучок: Кај трансплантираните пациенти предијабетот има висока преваленца. Главни ризик фактори за гликозните нарушувања по трансплантација се нивоата на циклоспоринот, како и концентрациите на вкупните липиди и ЛДЛ холестерол.

Клучни зборови: предијабетес, дијабетес, ренална трансплантација, имуносупресија

Introduction

Post-transplant diabetes mellitus (PTDM) is a well-known complication after renal transplantation. It is a main reason for the increased cardiovascular morbidity and mortality (1) and may adversely affect patient and graft survival. (2) Its prevalence in the literature varies from 5-25%, mainly due to differences in the definition and diagnostic criteria for diabetes. (3) Fasting glucose is commonly used for the diabetes diagnosis because of its simplicity, but it is less sensitive and specific than OGTT. (4.5) Using fasting glucose the prevalence of PTDM could be underestimated. On the other hand impaired glucose tolerance can only be diagnosed with OGTT and it correlates with diabetes and cardiovascular risk. (6.7) The diagnosis of PTDM has been clarified by the Guidelines of the International Consensus, based on the principles of the American Diabetes Association (ADA) and the World Health Organization (WHO). (8) Hence, early detection of diabetes and especially pre-diabetes is a prerequisite for early and appropriate treatment. Until now, pre-diabetes following renal transplantation and risk factors associated with it have not been explored as is the case with PTDM.

The aim of this study is to assess the prevalence and potential modifiable and non-modifiable risk factors for development of pre-diabetes and diabetes in living donor kidney transplant recipients on triple CNI based immunosuppressive maintenance regimen.

Subjects and methods

Patients

In this cross-sectional study were examined 59 patients, with mean age of 35,15 ± 8,75 (range 14-53) after successful living donor kidney transplantation, satisfactory graft function (mean GFR 60,55 ± 13,77 ml / min), average 35.73± 27.03 months after the surgery. All pts were on the same triple immunosuppressive therapy, including Mycophenolate mofetil (MMF), Cyclosporine A (CsA) and Prednisone (Pred).

Inclusion criteria were: age over 14 years, the absence of a history of DM, normal or impaired fasting glycemia before testing the glucose metabolism (OGTT), satisfactory graft function and a minimum of 6 months follow-up after transplantation. Exclusion criteria included previous episodes of acute graft rejection, steroid use because of other comorbidities and DM occurring before testing of glucose metabolism.

All investigation in the study was done in accordance with the rules of the WHO and the Helsinki Declaration. All patients gave informed consent for participation.

The participants in the study had normal or impaired fasting glucose. After twelve hours fasting OGTT was performed in all enrolled patients with 75 grams of anhydrous glucose (as recommended by WHO), and post-prandial samples were harvested 2 hours after administration of glucose. Results of the survey were classified according to the revised criteria of the ADA as:

Normal - fasting blood glucose level <5.6 mmol / l,
Impaired fasting glucose (IFG) - fasting blood glucose level between 5.6-6.9 mmol / l,
Impaired glucose tolerance (IGT) – glucose level between 7.8-11.1 mmol / l 2 hours after the load,
DM > 6.9 fasting glucose and> 11 mmol / l - 2 hours after the load)

Patients were divided into two groups: dysglycemia group (IFG/IGT, DM) and normal group (without glucose disorders).

Lab

Glucose levels were measured in venous blood samples using glucose-oxidase method in the automatic analyzer (Beckman). CsA trough levels were determined from the same blood samples using FPIA technique (fluorescence polarization immunoassay) in an automatic analyzer (Abbott).

In order to correlate multiple factors presumably associated with pre-diabetes and diabetes we used data from the files of the patients and biochemical analyses made on the same day with OGTT. The necessary data were entered in special questionnaires and included: CsA trough level, daily steroid dosage, triglyceride levels, cholesterol levels, estimated glomerulal filtration rate (e-GFR) (Cockcroft-Gault formula), blood pressure, gender, age, BMI, HCV infection, length of the time after transplantation, family history of diabetes, major disease as a cause of renal failure, duration of dialysis, HCV seropositivity.

Immunosuppressive protocol

Maintenance immunosuppression in all patients was based on Neoral Cyclosporine plus mycophenolate mofetil and prednisolone. The amount of cyclosporine in transplanted patients was based on drug levels in the blood. Monitoring of CsA trough levels were done periodically at different times and dose was adjusted as needed. In our therapeutic strategy,

target therapeutic levels of Cyclosporine were 200-300 ng/ml during the first three months, 100-250 ng/ml 4-12 months and 100-200 ng/ml after a year of transplantation.

Statistical analysys

The statistical software SPSS for Windows (version 13.0) was used to perform analyses. For statistical analysis were used methods of descriptive statistics: mean and standard deviation for continuous data, categorical data were expressed as a percentage. Of analytical methods were used: Pearson's correlation coefficient for certain risk factors. Continuous data were analyzed by Student's t-test for unbound samples to detect inter-group differences. Categorical data were analyzed with chi-square test and Fisher's test for equivalent pairs of frequencies. A P-value of <0.05 was defined as statistically significant in this study.

Results

The entire group consisted of 59 patients with successfully transplanted kidney from a living donor. Of all respondents, women were 22 (37.29%), while men were 37 (62.71%) with a mean age 35.15 ± 8.75 (14-53). The median follow-up after renal transplantation was 35.73 ± 27.03 months. All included patients had no prior history of diabetes. Most patients 49 (83.05%) were anti-HCV negative, a 10 (16.94%) were anti - HCV positive. The average levels of CsA was 130.62 ± 70.64 ng / ml, and the average daily dose of prednisone was 7.45 ± 2.68 mg. The most important demographic and clinical variables are shown in Tab. 1

Table 1 Basic demographic and clinical variables

Total number (n)	59
Age (years)	35.15 ± 8.75
Gender of recipient Male (%) Female (%)	 37 (62.71%) 22 (37.29%)
Gender of donor Male (%) Female (%)	 20 (33.9%) 39 (66.1%)
BMI (kg/m^2)	25.61 ± 4.29
Mode of transplantation, n (%) Living related	 59 (100%)
HCV seropositivity, n (%) Yes No	 10 (16.94%) 49 (83.05%)
DM in first-degree relatives, n (%) Yes No	 9 (15.26%) 50 (84.74%)
Primary diagnosis, n (%) ESRD (HTA, CRF) Obstructive uropathy SLE	 20 (33.89%) 9 (15.25%) 5 (8.47%)

Glomerulonephritis Amiloidosis GIHT Focal glomerular sclerosis	16 (27.11%) 4 (6.77%) 2 (3.38%) 3 (5.08%)
Hypertension Yes No	 55 (93.22%) 4 (6.77%)

Values are expressed as mean ± SD or numbers (percentages)
ESRD- end stage renal desease, HTA- Hypertension, CRF-chronic renal failure
SLE - systemic lupus erythematosus

All 59 patients included in this cross-sectional study had fasting blood glucose levels less than 6.9 mmol / l. Before the OGTT 13,55 % (8/59 patients) were classified as IFG, and 86.44% (51/59 patients) were normal based on fasting blood glucose level alone. After the performance of OGTT, prevalence of PTDM, IGT and IFG was 3:39% (2/59), 30.5% (18/59), 11.86 (7/59) respectively. In the whole group the mean fasting blood glucose was statistically significantly lower - 5.31 mmol / l, than glucose after load amounting 6.59 mmol / l. (P<0,001) The overall incidence of glucose disorders (patients with diabetes and pre-diabetes) was 33.9% (20/59) versus 66.1% (39/59) patients with normal glucose values. Statistical analysis showed significantly lower number of patients without glucose disorders (P<0.05), and significantly higher number of patients with dysglycemia, (P<0.05) when classification is based on OGTT compared with the classification based on fasting blood glucose.

According the results of the OGTT patients were divided into two groups: Group A (n = 20) – patients with dysglycemia (DM, IGT, IFG) and Group B (n = 39) - normal. Table 2 showed the factors associated with the occurrence of abnormalities in glucose metabolism using univariate analysis and differences between groups. In the whole group time since transplantation, higher CsA trough levels, increased levels of total lipids and LDL-c were related to the occurrence of abnormalities in glucose metabolism through significant correlation of risk factors listed with postprandial glucose. Male recipients dominated in the group A (70% vs.33.3%, P<0.05). Time since transplantation was significantly shorter in patients with pre-diabetes and diabetes than in normal subjects (24.50±21.32 vs. 41.48±28.06, P<0.05), and CsA trough level was higher (16.90±81.21 vs. 115.10±59.90, P<0.05). The correlation of certain risk factors was repeated in the group with pre-diabetes and diabetes, and was found that CsA trough levels (r = 0.38, p <0.05), TL (r = 0.44, p <0.05) and LDL-c (r = 0.51, p <0.05) are significantly related to the occurrence of glucose disorders.

Table 2 Comparison between patients who developed dysglycemia and normal subjects

	Group A (DG) N=20	Group B (NG) N=39	P-value
Gender, n (male %)	14 (70%)	13 (33.3%)	P<0.05*
HTA, n (%) Yes No	 19 (95%) 1 (5%)	 36 (92.3%) 3 (7.7 %)	 P>0.05 p>0.05
DM in first degree relatives, n (%) No	 17 (85%)	 33 (84.6%)	 P>0.05

Yes	3 (15%)	6 (15.4%)	P>0.05
Duration of dialysis	65.5 ± 52.6	57.6 ± 44.8	P>0.05
HCV seropositivity Yes	3 (15%)	7 (17.9%)	P>0.05
Primary diagnosis, n (%) ESRD (HTA, CRF) Obstructive uropathy SLE Glomerulonephritis Amiloidosis GIHT Focal glomerular sclerosis	 7 (35%) 3 (15%) 2 (10%) 6 (30%) 1 (5%) 1 (5%)	 13 (33.3 %) 6 (15.4 %) 3 (7.7%) 10 (25.6%) 3 (7.7%) 2 (5.1%) 2 (5.1%)	P>0.05
Time since transplantation	24.50 ± 21.32	41.48 ± 28.06	P<0.05* (r=-0.26)
Prednisolone dose (mg/day)	7.50 ± 3.52	7.30 ± 2.17	P>0.05
CsA trough level (ng/ml)	160.90 ± 81.21	115.10 ± 59.90	P<0.05* (r=0.37)
Glucose (after load)	8.19 ± 2.33	5.80 ± 0.70	P<0.05*
Total lipids (mmol/l) Tg (mmol/l) TC (mmol/l) LDL-c (mmol/l)	9.52 ± 1.41 2.29 ± 0.91 5.84 ± 1.05 3,82 ± 0.91	8.86 ± 1.60 2.16 ± 0.77 5.58 ± 06 3.54 ± 1.08	P<0.05* (r=0.31) P>0.05 P>0.05 P<0.05* (r=0.28)
GFR (ml/min)	62.63 ± 16.51	59.49 ± 12.24	P>0.05
BMI (kg/m2)	26.38 ± 4.03	25.21 ± 4.41 kg/m2	P>0.05
Age of recipient (year)	36.6 ± 8.92	34.41 ± 9,51	P>0.05

Values are expressed as mean ± SD or numbers (percentages)

Continuous variables were analyzed with the use of t-tests, and all categorical data were analyzed with the use of the chi-square test.

Discusion

PTDM has been long recognized as a common complication of kidney transplantation, promoting cardiovascular disease, death, and graft failure. Its incidence varies from 2% - 50% in different studies, due to major differences in the definitions of the disorder, different populations of patients included in the studies and various immunosuppressive protocols.(9) Most studies using only fasting glucose underestimate the prevalence of PTDM and other glycaemic abnormality in kidney transplant recipients. Revealing the pre-diabetic states such as IFG and/or IGT are very important because of the increased risk of developing diabetes and cardiovascular disease. (10)

ADA and WHO criteria for diabetes and prediabetes

The International Consensus Guidelines in 2003 (11) attempted to bring consistency in the diagnosis and management of PTDM. Diagnosis was to be based on ADA and WHO criteria that included the OGTT for the diagnosis of diabetes. OGTT has increased sensitivity and specificity compared to fasting glucose alone in diagnosis of diabetes in the general population. (12) As recommended by ADA screening is required for pre-diabetes and diabetes in high-risk patients such as transplant patients. There are different criteria of defining IFG according to WHO and ADA guidelines. If ADA classification is used, more people will require OGTT and more people will be classified as IFG. If you are using ADA criteria (5.6-6.9 mmol/l), then 46% of the population would require an OGTT compared with WHO criteria with only 12 % of patients who require OGTT. (4)

Some recent studies that used OGTT and ADA criteria for the diagnosis of diabetes and pre-diabetes show similar prevalence. In one study 187 patients with normal or IFG underwent

OGTT, 130 patients (69.5%) had normal test results, whereas 57 patients (30.5%) had results diagnostic of pre-diabetes. (13) In another cross-sectional study of 119 patients recruited, 31 had OGTT performed. Based on the results from OGTT, 4/31 (12.9%) patients were diagnosed IFG, 8/31 (25.8%) patients were diagnosed IGT, 4/31 (12.9%) patients were diagnosed PTDM. In the entire group of 119 patients overall prevalence of abnormal glucose metabolism was 31, 9%. (14)

Our results showed prevalence of PTDM, IGT and IFG of 3.39% (2/59), 30.5% (18/59), 11.86% (7/59) respectively, which presents a lower prevalence of DM and similar prevalence of pre-diabetes compared with other studies. (13,14) There is consistent evidence that PTDM is more common in older individuals. Cosio et al.2001 reported that recipients >45 years old were 2.9 times more likely to become diabetic post-transplant when compared with younger recipients.(15) A similar association of age with the development of abnormal glucose metabolism was found in two other studies, but their patients were older at the time of transplant. (13,14) Our results did not showed significant association between the age at the time of transplant and the development of pre-diabetes and diabetes. We believe that the possible explanation is that our patients were much younger (35.15 ± 8.75) than in the studies mentioned before.

CNI and PTDM

Despite more than two decades of research the pathogenesis of post-transplant dysglycemia is incompletely understood and a consensus on approach to screening, diagnosis and management is lacking. (16) It has been demonstrated that normal glucose levels in the morning combined with rising levels during the day are typical features of transplant patients; most presumably due to metabolic effects of immunosuppressive medications (17) and that this distinct pattern differs from that in Type 2 diabetes patients. (18) The most significant transplant specific modifiable risk factors are immunosuppressive medications specifically the use of calcineurin inhibitors (CNI - Tac and CsA) and glucocorticoids. (16) Diabetogenic impact of CsA has been described since the early 1980s. ((19) There is some evidence that dysglycemic states are related the degree of CNI exposure. The dose response effect with respect to new onset of diabetes after transplantation (NODAT) risk has also been described with the use of CsA with less dysglycemia post-transplant in those treated with low dose CsA (C2 600-800).(20) Some studies have not confirmed significant correlation between CNI and NODAT probably due to lower doses of CNI used in their centers.(13,14) Our results showed statistically significant correlation between the CsA and postprandial blood glucose levels. Also dysglycemia group had shorter time since transplantation and higher CsA trough levels than normal, which confirm the dose response effect with respect to new onset of diabetes after transplantation.

Steroids and PTDM

Steroids have been known for decades to induce impairments in blood glucose control. In transplant patients, steroid use or the cumulative prescribed steroid dosage are commonly associated with an increased risk of developing PTDM (21,13). There is consistent evidence that the number of rejection episodes to be positively correlated to pre-diabetes, whereas steroid use alone at a dose of or below 7.5 mg/day was not. (13,14) In one study forty-three patients (23%) were on a steroid-free immunosuppressive protocol and did not show a lower prevalence of pre-diabetes as compared to patients with low-dose steroids. (13) We also did not find a significant correlation between daily doses of corticosteroids and pre-diabetes and diabetes post transplantation, and our patients were on similar average daily doses of prednisone of 7.45 ± 2.68 mg. All patients who had episodes of acute graft rejection were excluded in our study due to the need for increased doses of immunosuppressive therapy and

consecutively higher exposure of higher cumulative corticosteroid dose for the treatment of acute rejection.

Sirolimus and other medications

Sirolimus, a mammalian target of rapamycin (mTOR) inhibitor, is an immunosuppressive agent used in conjunction with, or instead of, calcineurin inhibitors. Clinical data suggests that sirolimus use is not without risk for the development of NODAT (16, 22).

Analysis found that the combination of sirolimus with a CNI created a higher HR for cumulative 1yr incidence of NODAT compared to CNI with mycophenolate/ azathioprine (MMF/AZA) or sirolimus with MMF/AZA. Indeed higher sirolimus levels in the absence of CNI may have increased the risk of NODAT (16).

Lastly, as with CNI, it is likely that there is an important interaction between modifiable and nonmodifiable risk factors. For example, a multivariate analysis has found that older age and higher sirolimus trough levels were associated with increased hazard for NODAT (21), once again suggesting that drug level targets in older recipients could be reviewed, for both effect and toxicity.

BMI and PTDM

In many studies obesity expressed as BMI $\geq$ 30 kg / m2 has been demonstrated as a risk factor for the development of PTDM (21, 23, and 24). In contrast to other publications in our study BMI as a continuous and categorical variable was not associated with deranged glucose metabolism. Our results are consistent with the results of several authors. (25, 13, 14) The reason is probably because of the fact that our patients were relatively thin and the average BMI was 25.61 $\pm$ 4.29, indicating overweight but not obesity.

Chronic Hepatitis C and PTDM

Chronic hepatitis C infection is associated with an increased incidence of PTDM in liver transplantation. (26) Fabrizi F et all, 2005 using a meta-analysis has also shown a significant relationship between anti-HCV seropositive status with the development of PTDM after renal transplantation with adjusted odds ratio 3.97. (27) The prevalence of HCV positivity among our patients was small, amounting to around 16% in both groups, so that we could not verify connectivity of dysglycemic conditions and anti - HCV seropositive status.

Lipids and PTDM

Lipid disorders are frequently observed in renal transplant recipients. Mean serum lipid levels and incidence and prevalence of hyper TC, especially LDL-c, was significantly higher in patients receiving CsA when compared with Tac. (28) Also, patients with PTDM had significantly higher total serum cholesterol and triglycerides (TG), higher systolic blood pressure and higher pulse pressure throughout the post-transplant period. Of interest, all of these abnormalities preceded the development of PTDM. Hypertriglyceridemia was particularly pronounced in PTDM and elevated TG levels correlated with the subsequent development of PTDM, independent of other risk factors (P = 0.001 by multivariate Cox). (28) There is also a higher amount of oxidized LDL cholesterol. (29) In other study risk factors for hyperglycemia were higher cyclosporine level, impaired kidney function, and reduced high-density lipoprotein cholesterol values. (30) In other study dyslipidemia had weak correlation with age of recipient, serum creatinine, C0 and C2 levels of CsA. At logistic regression, serum creatinine was the only risk factor for hypercholesterolemia development after kidney transplantation (OR = 1.6, CI 95%: 1.4 -1.8). (31) We found a significant positive correlation of total lipids (TL) and LDL-c with postprandial glucose. So, our results showed that hyperlipidemia and dyslipidemia are associated with hyperglycemia

after renal transplantation. We cannot exclude that dyslipidemia as a metabolic abnormality could be an effect of CsA, or a diminished graft function.
A limitation in our study might be the underestimation of patients with pre-transplant dysglycemia. In the pretransplant examination, the diagnosis of diabetes mellitus was based on routine fasting blood glucose only. Lack of mandatory use of OGTT might include patients with dysglycemia in our study and overestimate the prevalence of pre-diabetes after transplantation. Although all of our patients were on a maintenance immunosuppressive protocol, the point in time of testing was not pre-determined by the study protocol. This resulted in marked differences in the time-delay from transplantation to OGTT between patients. There was significant difference in this time-delay between the two study populations.

In conclusion, the prevalence of diabetes and pre-dijabetes (IFG/IGT) in our renal transplant recipients was 3,39% and 30.5%, respectively. Thus the overall prevalence of hyperglycemia was 33.9%. Higher therapeutic CsA trough levels positively correlate with postprandial glucose, while daily doses of corticosteroids in maintenance doses do not affect glucose disorders. Significant correlation existed between total lipids and LDL-c and hyperglycemia after transplantation. Intensive glucose monitoring before and early after transplantation, treatment of potentially modifying risk factors and the application of dietary regimen may contribute to reducing the prevalence of pre-diabetes and diabetes in renal transplant recipients.

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