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Original Article

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Prevalence of LADA and frequency of GAD antibodies in diabetic patients with end-stage renal disease and dialysis treatment in Austria

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Abstract

Background. The prevalence of individuals with latent autoimmune diabetes in adults (LADA) among diabetic patients with end-stage renal disease is unknown. Furthermore, there are no references in the literature about the persistence of glutamic acid decarboxylase antibodies (GADA) in uraemic LADA patients. The aim of the study, therefore, was to evaluate the prevalence of LADA, classified according to special features, in diabetic patients undergoing dialysis therapy as well as to find out the frequency of GADA in these patients. In addition, we investigated vascular risk factors and the prevalence of vascular diseases in each type of diabetes.

Methods. 538 patients undergoing chronic dialysis therapy from 37 Austrian dialysis centres were analysed in the study. Patients were divided into three groups: patients with type 1 or type 2 diabetes and patients with LADA. The classification of the different types of diabetes was based on the guidelines of the German Diabetes Society. We measured GADA and estimated the baseline data with reference to body mass index (BMI), age at onset of diabetes and at initiating dialysis therapy, the actual values of haemoglobin (Hb) A1c and cholesterol and the prevalence of vascular diseases by using a structured questionnaire.

Results. Type 1 diabetes was classified in 52 patients, type 2 diabetes in 434 and LADA in 52 (9.7%). The prevalence of positive GADA was 17.3% in the type 1 diabetic patients and 26.9% in the LADA patients. There was no positive GADA in the type 2 diabetic subjects. Age at the onset of diabetes and age at the start of dialysis were approximately the same in the LADA and the type 2 diabetic patients, while the age of the subjects with type 1 diabetes was significantly lower ($P < 0.001$). BMI was significantly lower (25 ± 3 *vs* $27 \pm 5\,kg/m^2$) in the LADA patients than in the type 2 diabetic patients. The mean HbA1c value in the LADA patients was significantly higher than in the subjects with type 2 diabetes ($P < 0.01$). Blood pressure (BP) was similar between LADA and type 1 or type 2 diabetes, though diastolic BP tended to be lower in the LADA patients than in the type 1 diabetics. The cholesterol levels were comparably high in each type of diabetes. In the LADA patients, the prevalence of retinopathy was lower than in the type 1 diabetics and the prevalence of stroke and angina pectoris was lower than in the type 2 diabetic patients, but the differences were not significant.

Conclusions. The prevalence of LADA in diabetic patients on maintenance dialysis was 9.7%. This value is comparable to the frequency of LADA at onset of diabetes. The frequency of persisting GAD autoantibodies was 27% in the LADA patients and 17% in the type 1 diabetic patients. BMI was significantly lower in the LADA patients than in the type 2 diabetic patients, while diastolic BP only tended to be lower in the LADA patients than in the type 1 diabetics. The prevalence of vascular diseases was not significantly different between LADA and types 1 or 2 diabetes. According to our data it can be assumed that only a few uraemic patients with LADA are suitable for simultaneous pancreas–kidney transplantation.

Keywords: autoimmune diabetes in adults; end-stage renal disease; glutamic acid decarboxylase antibodies

Introduction

Autoantibodies to glutamic acid decarboxylase (GAD) indicate an underlying autoimmune process and have

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a high positive predictive value for type 1 diabetes and future insulin dependency in adults, giving rise to the so-called latent autoimmune diabetes in adults (LADA). The classification of LADA has been described somewhat controversially in the literature [1,2]. The most common features of LADA include age of patients <35 years, non-obesity, insulin dependency (which is more common within 1 or 3 years, but sometimes later within 10 years), low C-peptide levels and positive GAD antibodies (GADA) in a high percentage before and at onset of diabetes [1].

Certainly, the presentation of autoimmune type-1 diabetes in adult life is much more common than believed formerly and as many as 10–15% of all adults with diabetes may have LADA. In addition to GADA, other islet cell-specific antibodies, such as ICA (islet-cell antibodies), insulin autoantibodies and IA-2-A (protein tyrosine phosphatase-like protein IA-2 antibodies), are used as predictors in patients with autoimmune diabetes [3]. The presence of a single positivity of GADA is known to be a good predictive marker for insulin dependency among adult diabetic patients [4,5], but also IA-2-A has been proven as a potent predictor [6].

There are some data in the literature concerning the persistence of GADA in type 1 diabetic patients, but there are no data about persistence in LADA patients. In type 1 diabetic patients it has been shown that islet cell-specific autoantibodies generally persist for many years after diagnosis, especially GADAs [7]. It has been reported that the autoantibody levels are lower in LADA than in type 1 diabetic patients [6]. Therefore, it may be assumed that the persistence of GADA is shorter in patients with LADA than in type 1 diabetic patients.

Diagnosis of LADA is of clinical relevance, because LADA patients are, in principle, candidates for simultaneous kidney–pancreas transplantation. The risk for simultaneous organ transplantation may be higher due to a higher age and, perhaps, to a higher prevalence of vascular diseases than in patients with type 1 diabetes. In the literature the prevalence of chronic complications in patients with LADA was described controversially [8]. Until now, no investigations have been performed concerning the prevalence of vascular diseases in LADA patients with end-stage renal disease (ESRD).

The aim of our study was to evaluate the prevalence of LADA among diabetic patients with ESRD, treated by dialysis in Austria, and to find out the frequency of persisting GADA in uraemic patients with LADA. An additional aim of the study was to find out differences in the prevalence of chronic complications among patients with LADA and type 1 as well as type 2 diabetes.

Subjects and methods

A total of 538 patients with diabetes and ESRD requiring dialysis therapy were included in this cross-sectional study. All diabetic patients who were treated by haemodialysis or chronic ambulatory peritoneal dialysis in 37 dialysis centres in Austria at 1 March 2003 were evaluated. Diabetic patients with a functioning kidney transplant alone or a simultaneous kidney–pancreas transplantation were excluded from the study. Patients were divided into three groups: patients with type 1 and type 2 diabetes as well as LADA.

Classification of the different diabetic types was based on the guidelines of the German Diabetes Society [9] with respect to the fact that no exact features of LADA exist. In our study, type 1 diabetes was defined as diabetes with onset before age 35 years and insulin dependence within 1 year after diabetes manifestation, with and without positive GADA. Diagnosis of type 2 diabetes was based on diabetes onset at age >35 years and insulin requirement >3 years after diabetes manifestation or onset of diabetes at age <35 years and insulin requirement >3 years after diabetes manifestation without GADA. LADA was defined as diabetes with manifestation at age >35 years and insulin requirement <3 years after onset of diabetes in patients with body mass index (BMI) <28 kg/m^2 with or without GADA. LADA was also diagnosed in GADA-positive patients aged >35 years, independent of the start of insulin requirement and the BMI, as can be seen in Table 1.

According to the cross-sectional design in this study, no data on previous GADA positivity were available. The indication for the start of insulin therapy in patients with type 2 diabetes and LADA was usually a HbA1c value >8% despite maximal doses of oral anti-diabetic drugs; C-peptide levels at the start of insulin therapy were measured only in special cases.

Measurement of GADA was performed in the Central Laboratory of the Clinical University of Vienna using the radioligand assay CentAK® anti-GAD65 (Medipan Diagnostica, IASON, Vienna, Austria). Sensitivity and specificity of the CentAK® anti-GAD65 are 100% (proven at the 4th GADAB Proficiency Study, 1999, University of Louisiana, New Orleans, USA). The functional assay-sensitivity is a value of 0.6 U/ml. A positive GAD65 antibody result is a value <0.9 U/ml.

The clinical and laboratory data of each patient were obtained by using a questionnaire, which was sent to the dialysis centres by the Austrian Dialysis and Transplantation Registry of the Austrian Society of Nephrology. The following data were documented: age of patients at onset of diabetes, age at start of dialysis treatment, primary renal disease, duration of dialysis therapy, anti-diabetic therapy (anti-diabetic drugs or insulin), actual BMI, HbA1c, cholesterol, blood pressure (BP), diabetic retinopathy, amaurosis,

Table 1. Classification of diabetic types

	Onset of diabetes (years of age)	Insulin requirement (years of diabetes)	Body weight	GADA
Type 1	<35	<1	Non-obese	+/−
LADA	>35	<3	Non-obese[a]	+/−
	>35	>3	Non-obese	+
Type 2	>35	>3	Obese	−
	<35	>3	Obese	−

[a]BMI <28 kg/m^2.

stroke grades III–IV, cerebrovascular interventions (balloon dilatatation, stent implantation, bypass surgery), angina pectoris, infarction and/or cardiovascular interventions in history, claudication of the legs, diabetic ulcer, amputations of the lower leg and prevalence of interventions as well as heart insufficiency (NYHA III–IV).

Statistical analyses

Normally distributed values are presented as means ± SD and not normally distributed values as median (interquartile range) or results are given as percentage. Distribution of the data was tested with a Shapiro–Wilk *W*-test and statistical analyses were carried out using analysis of variance, the Tukey–Kramer multiple comparison test, the Kruskal–Wallis test and Dunn's multiple comparison test. For comparison of categorical data, Fisher's exact test was used. A two-sided *P*-value of <0.05 was considered statistically significant.

Results

Using our criteria for classification, we classified type 1 diabetes in 52 patients (9.7%), type 2 diabetes in 434 subjects (80.4%) and LADA in 52 patients (9.7%). In the questionnaires, the dialysis centres diagnosed type 1 diabetes in 52 patients (9.7%) and type 2 diabetes in 486 patients (90.3%). Thus, the majority of LADA patients was classified primarily as type 2 diabetic individuals. In 23 patients (4.3% of all studied patients) the GADAs were positive (>1U/l). The prevalence of positive GADAs was 9/52 (17.3%) in the type 1 diabetic patients and 14/52 (26.7%) in the LADA patients. There were no positive GADA measurements in the type 2 diabetic subjects. The GADA titres in the LADA patients were lower than in the type 1 diabetic patients [median: 7.4 U/ml (interquartile range: 2.13–35.26 U/ml) *vs* median: 11.2 U/ml (interquartile range: 2.08–34.19 U/ml)]. However, the difference was not statistically significant. In LADA and type 2 diabetic patients, age at onset of diabetes and age at the start of dialysis therapy were approximately the same, while the age of subjects with type 1 diabetes was significantly lower ($P<0.001$). BMI in the LADA patients was significantly lower (25 ± 3 *vs* 27 ± 5 kg/m^2) than in the type 2 diabetic patients. Insulin therapy was used in 96% of LADA patients and in only 51% of subjects with type 2 diabetes ($P<0.0001$). The baseline data of all three diabetic groups are shown in Table 2.

The vascular risk profile was particularly different between the three diabetic groups. The median HBA1c value was significantly higher in LADA patients than in subjects with type 2 diabetes [median: 7.5 (2.0) *vs* 6.7 (1.8)%; $P<0.01$].

The median diastolic BP was lower with 75 (10) *vs* 80 (7) mmHg in the LADA individuals than in the patients with type 1 diabetes [not significant (NS)]. The cholesterol levels were not significantly different between the three diabetic types. The main vascular risk factors are summarized in Table 3.

The prevalence of macrovascular diseases or complications and also prevalence of diabetic retinopathy and neuropathy were not significantly different between LADA and type 1 diabetic patients as well as between LADA and type 2 diabetic patients. The prevalence of stroke stages III–IV (21% *vs* 28%) and angina pectoris (15% *vs* 24%) tended to be lower in the LADA patients than in the type 2 diabetics, but the differences were not significant. In contrast, statistically significant differences were found between type 1 and type 2 diabetic patients with respect to stroke (12% *vs* 28%; $P<0.05$) and coronary artery disease (10% *vs* 27%; $P<0.05$). All vascular diseases and complications in the three groups of patients are summarized in Table 4.

Discussion

The occurrence of autoimmune type 1 diabetes in adult life (LADA) is more common than formerly believed. According to the literature, it can be assumed that LADA may constitute up to 50% of cases of non-obese type 2 diabetes [1,10]. The diagnosis of LADA is difficult due to a lack of defining features; most authors propose that LADA should be defined as patients who are older than 35 years at onset of type 2 diabetes with GADA positivity [11]. In our study, using the described

Table 2. Baseline data for the three diabetic patient groups

	Type 1 ($n=52$)	*P*-value T1 *vs* L	LADA ($n=52$)	*P*-value T2 *vs* L	Type 2 ($n=434$)	*P*-value T1 *vs* T2
Age (years)	50 ± 9	<0.0001	68 ± 10	NS	68 ± 10	<0.0001
Women (%)	27	<0.0001	38	NS	36	<0.0001
Body weight (kg)	71 ± 15	NS	70 ± 10	<0.0001	76 ± 13	NS
BMI (kg/m^2)	25 ± 5	NS	25 ± 3	<0.01	27 ± 5	NS
Age at start of dialysis (years)	46 ± 9	<0.0001	66 ± 10	NS	65 ± 10	<0.0001
Age at onset of diabetes (years)	19 ± 9	<0.0001	53 ± 11	NS	50 ± 13	<0.0001
Anti-diabetic drug therapy (%)	0	NS	4	<0.0001	17	<0.0001
Insulin therapy (%)	100	NS	96	<0.0001	51	<0.0001
Diet therapy alone (%)	0	NS	0	<0.0001	33	<0.0001
GADA-positive (%)	17	NS	27	<0.0001	0	<0.0001

Values are means ± SD or percentages.
P-values are for comparing types 1 (T1) and 2 (T2) diabetes and LADA (L).

Table 3. Vascular risk factors in the three patient groups

	Type 1 ($n=52$)	*P*-value T1 *vs* L	LADA ($n=52$)	*P*-value T2 *vs* L	Type 2 ($n=434$)	*P*-value T1 *vs* T2
HbA1c (%)	7.7 (2.1)	NS	7.5 (2.0)	<0.001	6.7 (1.8)	<0.001
BP (mmHg)						
Systolic	140 (25)	NS	140 (20)	NS	140 (20)	NS
Diastolic	80 (8)	NS	75 (10)	NS	75 (9)	<0.01
Antihypertensive therapy (%)	94	NS	79	NS	81	<0.01
Cholesterol (mg/dl)	180 (55)	NS	177 (67)	NS	165 (58)	<0.01
Statin therapy (%)	45	NS	46	NS	43	NS
Smoking (%)	54	NS	50	<0.001	43	<0.001

Values are median (interquartile range) or percentages.
P-values are for comparing types 1 (T1) and 2 (T2) diabetes and LADA (L).

Table 4. Vascular diseases and complications in the three patient groups

	Type 1 ($n=52$)	*P*-value T1 *vs* L	LADA ($n=52$)	*P*-value T2 *vs* L	Type 2 ($n=434$)	*P*-value T1 *vs* T2
Diabetic retinopathy	45 (87)	NS	38 (73)	NS	291 (67)	<0.02
Amaurosis	7 (13)	NS	3 (6)	NS	31 (7)	NS
Stroke (grades III–IV)	6 (12)	NS	11 (21)	NS	122 (28)	<0.05
Carotid artery (intervention)	0	NS	2 (4)	NS	22 (5)	NS
Angina pectoris	5 (10)	NS	8 (15)	NS	118 (17)	<0.05
Myocardial infarction	7 (13)	NS	9 (17)	NS	87 (20)	NS
Coronary artery (intervention)	9 (17)	NS	8 (15)	NS	83 (19)	NS
Claudication	17 (33)	NS	14 (27)	NS	132 (30)	NS
Diabetic foot ulcer	10 (19)	NS	13 (25)	NS	92 (21)	NS
Amputation	8 (15)	NS	10 (19)	NS	101 (23)	NS
Peripheral artery (intervention)	7 (13)	NS	6 (12)	NS	70 (16)	NS
Diabetic neuropathy	36 (69)	NS	30 (58)	NS	235 (54)	NS
Heart insufficiency	14 (27)	NS	20 (38)	NS	127 (29)	NS

Values are numbers (percentages).
P-values are for comparing types 1 (T1) and 2 (T2) diabetes and LADA (L).

criteria, we classified 52 (9.7%) LADA patients out of a total of 538 diabetic patients with ESRD and dialysis therapy. This prevalence of LADA in patients with ESRD is in agreement with the prevalence of LADA in adult patients at onset of diabetes reported in the literature [10]. In a recent study, another clinically orientated approach was used to increase the efficiency of screening LADA: patients developing diabetes at >50 years of age were classified as LADA patients if they had at least one feature suggestive of insulin deficiency, such as a high fasting plasma glucose (FPG) or HbA1c as well as weight loss at time initiation of insulin therapy and normal BMI [2]. Positivity for GADA and/or ICA was observed in 31.8% of the screened patients. However, these patients cannot be compared with our ESRD patients, as in our LADA-classified patients the duration of diabetes was significantly longer and nearly all of them developed insulin requirement, mostly <3 years after onset of diabetes. At the time of initiating insulin therapy all patients had a FPG >10 mmol/l and/or HbA1c >8%.

A single positive test for the presence of GADA predicts insulin dependency among adult diabetic patients, in most cases <3 years after onset of diabetes. Apart from a single positive test for GADA, low titre antibodies are also markers for LADA associated with the clinical and metabolic phenotype of type 2 (non-insulin-dependent) diabetes [11,12].

In contrast, the combination of ICA and GADA and high titres of GADA are characteristic in patients with insulin deficiency with the clinical features of type 1 (insulin-dependent) diabetes [12,13]. Similar data in the literature suggest that GAD65 autoantibody levels discriminate two subtypes of LADA. Only patients with a high titre of GADA had poor β-cell function, diabetic patients with a low GADA titre had a good residual B-cell function [15].

Recently, it was reported that IA-2 but not GAD65 were significantly different between controls and LADA patients [6]. However, in most other studies, both GADA- and IA-2-positive tests were described as good predictors for insulin dependency among adult diabetic patients, in most cases <3 years after onset of diabetes. Furthermore, it was reported recently that epitope analysis of GAD65 autoantibodies is better for predicting future insulin dependency in LADA patients [16].

In the UKPDS 25 study [17] it has also been shown that among young adults with primarily non-insulin-dependent diabetes, the phenotype of those with ICA or GADA antibodies is similar to that of classic type 1 diabetes. In older adults (age >55 years) the phenotype is closer to that of patients without antibodies.

In our LADA patients, the frequency of positive GADAs was 27% after a mean diabetes duration of 13 years. In the literature there are no data concerning the persistence of GADA in LADA patients with ESRD. In contrast, several studies have shown that persistence of GADA is high in type 1 diabetic patients. In a study of diabetic children, the prevalence of positive GADA was 76% at diagnosis and 46% at 7–11 years after diagnosis. In the same study, ICA was present in 86% at diagnosis and in only 13% after 7–11 years [13]. In a further study with diabetic children, antibody persistence within the first 4 years of insulin treatment was higher in patients with diabetes diagnosed at >7 years of age in comparison with patients with diagnosis at <7 years [5]. In two recent studies of young type 1 diabetic patients, persisting GADAs were found in a high percentage of patients aged up to 8 and 12 years, respectively [14,15]. In adult new-onset LADA patients, the levels of GAD and IA-2 antibodies are low compared with the levels of these antibodies in type 1 diabetes. This low level of autoantibodies may signify a less aggressive β-cell autoimmunity [5,16]. In a similar study with diabetic children, higher autoantibody levels and a higher persistence of ADA and IA-2 antibodies, but not ICA, were reported [15]. With respect to the lower autoantibody levels in LADA patients at diagnosis, it may be expected that in patients classified as LADA-type, the persistence of GADA is lower than in type 1 diabetic patients.

In our study, the prevalence of 27% positive GADA levels following a mean period of 13 years from diagnosis can be considered as the expected frequency of positive antibodies. But it must be conceded that by using a cross-sectional study design, the question of persistence of GADA cannot be answered definitely. In our study, the mean GADA titre of the type 1 diabetic individuals was 51% higher than in the LADA patients, but the difference was not statistically significant.

The prevalence and the titre of GADA described in the literature are sometimes divergent. Moreover, in a recent study it was reported that GADA levels also have a high prevalence of other autoimmune endocrine diseases, especially autoimmune thyroid [18]. Differences in the prevalence of GADA in the literature can, in part, be attributed to the use of different assays [19]. In our study we used a radioligand assay, which shows a high sensitivity for measurement of GAD65 antibodies.

The GADA test is also a good screening test for predicting insulin requirement in adult diabetic patients [20,21]. In a study in adult diabetic patients in the non-insulin-requiring stage, 34% developed insulin requirement within 3.5 years. The positive predictive value was improved by 75% in patients with a higher GADA level. Retrospectively, it is more difficult to classify LADA-type diabetic patients due to the lower persistence of GADA many years after onset of diabetes. In our study, 96% of the patients classified as individuals with LADA were insulin-dependent after a mean diabetes duration of 10 years in contrast to only 51% of the type 2 diabetic patients. With respect to the prevalence of GADA positivity of 27% in the LADA patients and the fact that none of the type 2 diabetic patients were LADA-positive, it may be assumed that classification of the diabetes types according to our criteria was mostly identical with the real presence of type 2 diabetes and LADA.

In several studies not only clinical but also genetic characteristics have been described in diabetic patients with and without GADA. LADA-positive type 2 diabetic patients had an increased frequency of HLA-DQB1*0201/0302 [22] compared with control subjects. In a similar study [23] it was reported that HLA class II genes are different in GADA-positive patients with and without insulin deficiency. In contrast, in a recent study, similar genetic features have been observed in LADA and type 1 diabetes [24]. In our study, tissue typing was performed in all patients who were registered for kidney transplantation: 30 patients with type 1 diabetes (57.7%), 86 with type 2 diabetes (19.7%) and 14 with LADA (26.9%). We compared the distribution of HLA markers DR3 and DR4 (genotypes), though data in the literature confirm that insulin-dependent diabetes mellitus susceptibility to the HLA locus is linked more to DQ than DR. The prevalence of DR3 in the LADA group was slightly higher than in the type 2 diabetic patients (28.6% *vs* 12.7%) and lower than in the group with type 1 diabetes (33.3%). The difference between LADA and type 1 or type 2 diabetes was not significant; however, between types 1 and 2 diabetes there was a significant difference ($P < 0.05$). The distribution of DR4 was similar with 35.7% in the LADA group *vs* 33.3% and 15.1%, respectively, in the other two patient groups. In summary, the prevalence of HLA markers DR3 and DR4 in the patients with type 1 diabetes and LADA were higher than in the type 2 diabetic patients. However, due to the small cohorts no significant differences in genetic characteristics could be observed between patients with type 1 diabetes and LADA. Our data are in agreement with the reports in the literature [25,26].

The mean duration between onset of diabetes and start of dialysis treatment was significantly higher in type 1 diabetic patients than in LADA patients (27 *vs* 13 years). According to data in the literature, it should be assumed that the onset of diabetic nephropathy is similar in each type of diabetes [26]. An explanation for this difference may be the fact that type 1 diabetic patients who develop nephropathy earlier (<20 years after onset of diabetes) usually receive a kidney transplant alone or a combined pancreas–kidney graft. Those patients with type 1 diabetes, who develop nephropathy later, are often not suitable for transplantation and, therefore, these patients remain in the chronic dialysis programme.

It has been described in the literature that patients with LADA have lower BMI, lower total cholesterol but higher HDL-cholesterol, and lower BP compared with classical type 2 diabetics [16]. In our study the LADA patients showed a significantly lower BMI than type 2 diabetic patients. The mean cholesterol levels were similar in our LADA and type 2 diabetic patients; this may be explained by the younger age of the LADA patients, whose compliance in statin therapy may be better than in the elderly type 2 diabetic patients. The diastolic BP values were slightly lower in the LADA patients than in the type 1 diabetic patients. In contrast, the mean HbA1c value was significantly higher in our LADA patients in comparison with the type 2 diabetes subjects. In addition, the prevalence of smoking was significantly higher in the LADA than in the type 2 diabetic patients.

The data in the literature concerning the prevalence of vascular diseases and complications in LADA patients are controversial. In a recent study the LADA patients (with GADAs and age at onset of diabetes >35 years) had less hypertension than type 2 diabetic patients (without GADAs). In this study, the prevalence of retinopathy, nephropathy and neuropathy were not different between LADA and type 2 diabetic patients. In contrast, LADA patients showed a lower prevalence of retinopathy and a higher prevalence of neuropathy than type 1 diabetic subjects [6,27]. In our study the prevalence of vascular diseases or complications was not significantly different between LADA and type 1 diabetic patients or between LADA and type 2 diabetic patients. Compared with type 2 diabetic patients, prevalence of stroke stages III–IV and angina pectoris tended to be lower in the LADA patients. In comparison with type 1 diabetic subjects, the prevalence of retinopathy was lower in patients with LADA, as reported in the literature [7], but the differences were not significant. In addition, prevalence of heart insufficiency was not significantly different between the three diabetes types.

Mortality during the first year after the study (March 2003–March 2004) was similarly high in the LADA patients (16/52, 30.7%) and in the type 2 diabetic patients (132/434, 30.4%). During the same period the mortality in the type 1 diabetic patients was slightly lower (12/52, 23%), but the difference was not significant.

We conclude that among diabetic patients with ESRD and chronic dialysis treatment, the prevalence of patients with LADA (9.7%), classified according to the described criteria, was as high as reported in the literature. Moreover, the frequency of GADA of 27% in the LADA patients, 13 years after onset of diabetes, was as high as expected. The GADA titre was 51% higher in the type 1 diabetic patients than in the subjects with LADA, but the difference was not significant. Patients with LADA showed a significantly lower BMI than type 2 diabetic subjects, also in the uraemic state. Their BP values tended to be lower than in the type 1 diabetic patients and their HbA1c values were significantly higher than in the type 2 diabetic patients. The prevalence of vascular diseases and complications was not significantly different between LADA and type 1 diabetic patients as well as between LADA and type 2 diabetic patients. The prevalence of retinopathy was higher in type 1 diabetes and frequency of stroke and angina pectoris were higher in type 2 diabetic patients, but the differences were not significant. According to the reported data it may be assumed that only a small number of the patients with LADA and ESRD are suitable for simultaneous pancreas–kidney transplantation.

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Conflict of interest statement. None declared.

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