Received Date : 03-Jul-2016
Revised Date : 13-Nov-2016
Accepted Date : 08-Dec-2016
Article type : Original Article

Calcification score evaluation in patients listed for renal transplantation

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Calcification score evaluation prior to renal transplantation

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Clin Transplant

Abstract

Based on native CT scans of the pelvic region using a standardized calcification score, evaluation of iliac vascular calcification was performed between 2008 and 2012 prior to listing for renal transplantation in 205 patients with chronic kidney disease.

Vascular calcification showed a decrease from proximal to distal. The difference between the degree of calcification in the common iliac artery and in the external iliac artery was significant ($p<0.001$). Risk factors for total iliac vascular calcification were age, smoking, sex, underlying renal disease, and diabetes. Multivariate analysis revealed age to be the most relevant risk factor ($p<0.001$). The duration of hemodialysis correlated significantly with total iliac vascular calcification. Since the introduction of the standardized surgical evaluation protocol, no transplantation has

had to be broken off and no early graft loss due to calcification has occurred. Thus, careful scoring of vascular calcification prior to transplantation may be a valuable tool to support surgical decisions, and to improve patient safety and outcome in increasingly older transplant recipients.

Keywords: calcification score, evaluation, renal transplantation

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Background

Vascular calcification is a predictor of both overall and cardiovascular mortality, and is very common among long-term hemodialysis patients [1, 2, 3, 4, 5, 6]. Cardiovascular disease is the most important risk factor for morbidity and mortality in kidney transplant recipients with a 3.5-5% annual risk of fatal or non-fatal cardiovascular events [7, 8, 9]. There are two types of vascular calcification. The first type is calcification predominantly affecting the intimal layer of arteries (atherosclerosis) and the second predominantly affects the medial layer (tunica media) of arteries (Mönckeberg's sclerosis). The second type is frequently observed in patients with chronic kidney disease (CKD) and in patients with diabetes mellitus (DM). The two types of vascular calcification have different effects. Mönckeberg's sclerosis increases vascular stiffness and reduces compliance, leading to elevated systolic blood pressure, left ventricular hypertrophy, and reduced coronary artery blood flow during diastole [3, 4, 10]. London and colleagues showed arterial medial calcification to be an important risk factor for cardiovascular and overall mortality independent of classical atherogenic risk factors, due to the subsequent arterial stiffness [3, 11]. Long-term hemodialysis patients show an increased incidence and progression of vascular calcification, especially Mönckeberg's sclerosis, as compared

with the normal population [1,12]. Progression of vascular calcification usually proceeds quickly in these patients [10]. The combination of both calcification types contributes to the reported high rates of cardiovascular disease and mortality in patients with chronic kidney disease [10]. Conventional cardiovascular risk factors such as hypertension, DM, smoking, and dyslipidemia are very common in renal transplant recipients and occur in combination with the risk factors associated with chronic kidney disease (abnormal mineral metabolism, hyperparathyroidism, hyperhomocysteinemia, anemia, increased pro-inflammatory cytokines). After kidney transplantation, possible complications are impaired graft function, post-transplant DM and side effects of immunosuppression. The 2005 American College of Cardiology/American Heart Association (ACC/AHA) guidelines on peripheral artery disease do not specifically identify chronic kidney disease as being a risk factor for peripheral artery disease. The Inter-Society Consensus for the Management of Peripheral Artery Disease (TASC-II) notes the association between renal insufficiency and peripheral artery disease, but provides little supporting evidence with a higher prevalence of risk factors for peripheral artery disease such as dyslipidemia, DM and hypertension, and also older age in patients with CKD [13]. Nevertheless, CKD is independently associated with an increased prevalence of peripheral artery disease [14, 15, 3]. Patients evaluated for renal transplantation as well as organ donors are becoming increasingly older, vascular origin of CKD counts for more than 50% of potential renal transplant recipients. This situation is not comparable with earlier cohorts. Careful surgical evaluation prior to renal transplantation has to be performed in order to ensure feasibility of surgical anastomosis with the renal graft [16, 17, 18], but there is no supporting evidence in currently available guidelines [19]. In selected cases, vascular surgical intervention is necessary to make patients eligible prior to transplantation [20, 21].

Possible diagnostic imaging techniques to detect vascular calcification are ultrasound-based techniques which are generally available, inexpensive, with no ionizing radiation, but which cannot differentiate between medial and intimal calcification, as well as electron beamed computed tomography which is highly sensitive but expensive and not generally available. Multislice spiral computed tomography has a higher radiation exposure, other methods are non-contrast computed tomography and plain radiography of the abdominal aorta for quantification of the calcification load.

The aim of the study was to evaluate a novel CT-based calcification score characterizing severity and distribution patterns of iliac vascular calcification in renal transplant recipients in order to select patients for renal transplantation, to avoid surgical complications and early graft loss due to vascular calcification, to make a recommendation on side preference for renal transplantation, and thus to optimize surgical outcome and improve patient safety.

Patients and methods

A new concept of surgical evaluation using a novel calcification score was established in 2004 at the Medical University of Graz, Division of Transplantation Surgery. Surgical evaluation was performed in the workup of all patients with chronic renal insufficiency prior to listing on the Eurotransplant Kidney Waiting List. It included medical history, a clinical examination and a native CT scan of the pelvic region in order to ascertain vascular calcification of the iliac vessels. Radiologic detection of vascular calcification was obtained by native CT scan of the pelvic region. Radiologic examination was performed at the time of clinical examination or not more than three months earlier. The different vascular segments in the iliac region that are possible sites for graft anastomosis were reported separately: right and left external iliac artery (REIA and LEIA), common iliac artery (RCIA and LCIA), distal aorta (AO). The grade of vascular calcification was standardized (in intervals of 0.5 from grade 0=without any radiologically visible calcification, grade 1=calcific deposits in up to one third of the arterial circumference, grade 2=calcification of up to two thirds of the circumference, to grade 3=maximum/circular calcification). Recommendation on site preference for surgical anastomosis was given based on radiological and clinical investigations. In severe cases of circumferential calcification, it was documented that anastomosis was not possible without preceding vascular surgical intervention. All patients with chronic renal insufficiency who had been evaluated for renal transplantation between 2008 and 2012 were included in the study. Preoperative surgical evaluations were analyzed retrospectively. Risk factors for vascular calcification such as age, sex, diabetes, smoking, BMI, diagnosis and duration of dialysis were evaluated in the study population. Total iliac vascular calcification without aortic segment was defined as being clinically most representative for the risk analysis in subgroups. Influence of iliac vascular

calcification on outcome was investigated. Charlson comorbidity index at the time of surgical evaluation was determined and the influence on outcome was also analyzed. Survival status, renal transplantation / need for surgical revision after renal transplantation, and reasons for graft loss were investigated with a focus on graft loss attributed to iliac vascular calcification. Median postoperative followup was 51 months (37-66 months). Early graft loss was defined as an intraoperative graft loss or graft loss within 48 hours after transplantation.

Statistics

All variables were checked for plausibility and outliers. Assumption of normal distribution was proved with the Shapiro-Wilk test ($p>0.05$) and Q-Q plots. The non-parametric Mann-Whitney U test was used for comparisons between two independent groups, the Wilcoxon signed-rank test for comparisons between two dependent groups and the non-parametric Kruskal-Wallis test for comparisons between more than two groups. Pairwise group comparisons were implemented in the Kruskal-Wallis test considering multiple testing and correcting after Bonferroni procedure. The influence of risk factors on overall calcification (without AO) was investigated with several uni- and multivariate linear regression models. Relationships between dialysis duration and overall calcification (without AO) were tested with Spearman's correlation, for all other correlations Pearman`s correlation coefficient was used. Data are presented as median, 25-percentile and 75-percentile when non-parametric methods were applied, otherwise mean +/- SD are stated. Boxplots were used for graphical visualisation.

All statistical analyses were performed using SPSS version 22.0 (SPSS Inc., Chicago, IL). A p-value of <0.05 for two tailed tests had been considered statistically significant.

Results

A total of 205 patients aged between 18 and 80 years were included in the study; 59 of them were female (28.8%), 146 were male (71.2%). The mean age of all patients was 53.9 + 11.7 years. Male patients were 54.6 + 11.6, and female patients 52.0 +

12.0 years old (Table 1). There was no significant difference between men and women (p>0.05). 50.7% of the patients were 55 years or younger, and 49.3% were older than 55 years. 32 women (15.6% of all patients) and 72 men (35.1% of all patients) were 55 years or younger. 27 women (13.2% of all patients) and 74 men (36.1% of all patients) were older than 55 years. In 43.9% of the patients, the underlying renal disease was of vascular origin, in 31.7% of non-vascular and in 24.4% of unknown origin. 23.5% of all patients had diabetes; 3 (1.5%) had type 1 diabetes and 45 (22%) type 2 diabetes. Patients with type 1 diabetes were insulin-dependent for 36.7 + 2.3 years compared to 14.4 + 11.1 years of insulin-dependance and/or oral antidiabetic therapy in patients with type 2 diabetes. Of the diabetic patients, 12 had coexisting coronary disease symptoms, 4 (all with type 2 diabetes) had coexisting carotid symptoms, and 17 (2 of these with type 1 diabetes) had peripheral vascular disease symptoms. Three of the patients with type 2 diabetes had had amputations which had been bilateral in one of these cases and one patient with type 1 diabetes had an amputated leg. Because of the low number of patients with type 1 diabetes, all diabetic patients were subsumed for statistical analyses. Mean BMI was 26.2 + 4.4 in all patients, 26.4 + 4.3 in men and 25.9 + 4.6 in women. There was no significant difference between the sexes (p>0.05). 75 of all 205 patients were smokers consuming between 1 and 120 pack years (mean 27.7 + 21.0 pack years). COPD was present in 13 patients of which 4 were non-smokers. After surgical evaluation for renal transplantation, recommendations for surgery were given in 204 patients: transplantation on both sides was declared possible in 63.9%, in 3.4% (seven patients) renal transplantation was declined because of a calcification score between 2.5 and 3 in all regions of the iliac arteries, in 16.1% the right side was recommended, in 10.2% the left. In 5.9% of cases, the decision was postponed for other reasons (high BMI, interventions before transplantation). In nearly half of the patients (49.1%) with a decision on laterality, this decision was based on distinct unilateral iliac calcification according to CT-based scoring (calcification score between 2.5 and 3), or one side showing a more favorable grade of vascular calcification.

34% of the patients had been previously transplanted and the contralateral side was recommended for the subsequent renal transplantation.

1.9% had a combination of previous kidney transplantation and severe iliac calcification on one side. In 15%, there were other reasons for the decision in favor of one side.
153 (77.3%) patients were evaluated for their first kidney transplantation, 36 (18.2%) for their second, 8 (4.0%) for their third, and one (0.5%) for the patient's fourth kidney transplantation.

Vascular calcification showed a decline from proximal to distal in all patients. Median calcification score was 2.0 (0.5-2.5) in the distal aortic segment, 1.0 (0.5-2.0) in the RCIA, 1.0 (0.5-2.0) in the LCIA, 0.5 (0.0-1.0) in the REIA, and 0.5 (0.0-1.0) in the LEIA. The difference between the degree of calcification in the CIA and EIA (on both sides) was highly significant ($p<0.001$) (Fig. 1).

Independent risk factors for total iliac vascular calcification were age ($p<0.001$), smoking ($p=0.003$), sex ($p<0.001$), underlying renal disease (vascular vs. non-vascular) ($p=0.037$), and the presence of DM ($p<0.001$). Multivariate analysis revealed age to be the most relevant risk factor ($p<0.001$), followed by smoking ($p=0.001$), sex ($p=0.041$) with men showing a higher degree of calcification, and DM ($p=0.011$), with $R^2_{adj} = 0.271$. Duration of hemodialysis (being the time from the start of hemodialysis until native CT scan of the pelvic region was performed) showed no influence in the whole patient cohort. In patients listed for their first kidney transplantation, the risk factors were age ($p<0.001$), smoking ($p=0.018$), sex ($p=0.015$), DM ($p=0.003$) and total duration of hemodialysis ($p=0.032$). Multivariate analysis revealed age to be the most important risk factor ($p<0.001$), followed by smoking ($p=0.001$), the total duration of hemodialysis ($p=0.001$) and sex ($p=0.019$), with R^2_{adj} equaling 0.293. BMI was not a significant risk factor for vascular calcification, neither in the whole patient population, nor in patients without previous renal transplantation.

Total iliac vascular calcification correlated significantly with the duration of hemodialysis measured from the start of hemodialysis until the native CT scan of the pelvic region ($r=0.189$; $p=0.026$) and from the start of hemodialysis until the time of surgical evaluation ($r=0.206$; $p=0.007$). In the group of patients evaluated for their first kidney transplantation, the correlation between total iliac calcification and the

time from the start of hemodialysis until the date of surgical evaluation was significant (r=0.287; p=0.001) as was the time from the start of hemodialysis until the native CT scan of the pelvic region (r=0.259; p=0.008).

Male and female patients were compared regarding the degree of vascular calcification in the 5 different regions (distal segment of the AO, RCIA, LCIA, REIA, and LEIA). There was a significant difference between the sexes in total iliac vascular calcification (without aortic segment) (p=0.003), external iliac arteries (p<0.001), and also left AIC (p=0.037) with men having a higher degree of calcification (not adjusted for age) (Table 2).

The degree of calcification in the RCIA was 1.0 (0.0-1.5) for all patients who were 55 years or younger, 1.5 (1.0-2.5) for patients older than 55 years; in the LCIA, it was 0.5 (0.0-1.5) for younger patients and 1.5 (1.0-2.5) for older patients. Degree of calcification in the REIA was 0.0 (0.0-1.0) for patients under 55 years, and 1.0 (0.0-1.5) for patients over 55 years; in the LEIA, it was 0.0 (0.0-1.0) for younger patients and 1.0 (0.0-1.5) for older patients. Distal aortic calcification score was 1.0 (0.0-2.0) for patients under 55 years, 2.3 (1.5-3.0) for patients over 55 years. Total iliac vascular calcification degree (without distal aortic segment) was 0.5 (0.0-1.2) for patients under 55 years, 1.3 (0.5-2.0) for patients over 55 years. Total iliac calcification score including the distal aortic segment was 0.6 (0.1-1.3) in younger patients and 1.4 (0.8-2.2) in older patients. The difference in the degree of vascular calcification between patients who were 55 years or younger and patients older than 55 years was highly significant in the five above-mentioned regions, and also in total iliac vascular calcification with and without distal aortic segment (p<0.001) (Table 3).

Median total iliac vascular calcification was 0.6 (0.1-0.4) in non-diabetic and 1.5 (0.8-2) in diabetic patients (p<0.001).

Median total iliac vascular calcification was 0.8 (0.1-1.4) in non-smokers compared to 1.1 (0.5-2.0) in patients with a smoking history (p=0.007).

Median total calcification score was 3 (2.2-3) in the patients declined for renal transplantation, with similar results in the different regions of the iliac arteries.

134 (65.4%) patients have already been transplanted, 9.8% deceased without transplantation due to underlying diseases, and 2% of the patients died after

transplantation (which was not related to the surgical procedure). In 7 patients, the graft had to be removed. Reasons for graft loss were rejection in 3 cases (the graft had to be removed after 89 days, 2 years and 3 days, and 4 years and 87 days after transplantation), renal vein thrombosis in 3 cases (1 month after transplantation in a pair of baby kidneys, the 2 other cases accounting for “early graft loss” that was not attributed to vascular calcification of the iliac arteries). In one case, the transplanted kidney had to be removed some hours after transplantation due to malignancy detected on the contralateral donor kidney. No early graft loss due to iliac arterial calcification occurred in this patient cohort.

Charlson Comorbidity index was determined in all patients evaluated for renal transplantation. Median Charlson index was 2 (2-4) in all patients, 2 (2-2) in non-diabetic and 5 (4-5) in diabetic patients. It showed a strong correlation with survival ($p<0.001$; $r=0.361$) but no significant correlation with complications after surgery that needed surgical revision ($p=0.418$; $r=0.057$).

Charlson index correlated significantly with total iliac calcification ($p<0.001$; $r=0.408$), this correlation was significant both in non-smokers ($p<0.001$; $r=0.357$) and in smokers ($p=0.001$; $r=0.412$).

Total iliac calcification was 1 (0.3-1.5) in the whole patient cohort, 0.6 (0.1-1.4) in non-diabetic and 1.5 (0.8-2) in diabetic patients. It strongly correlated with survival ($p<0.001$; $r=0.309$) but there was no significant correlation with complications after surgery that needed surgical revision ($p=0.924$; $r=-0.007$).

Discussion

Our new score to measure the extent of vascular calcification by a standardized evaluation based on the preoperative CT scan of the pelvic region was applied in a clinical setting. Patients with CKD who were to have renal transplantation underwent clinical investigation and radiologic scoring which lead to recommendations on side preference or decline of listing for renal transplantation.

As stated in the literature, media sclerosis is strongly promoted by age, DM, CKD and duration of hemodialysis [10]. The presented study confirmed these findings, showing that age was the strongest risk factor. Vascular calcification showed a significant decline from proximal to distal ($p<0.001$) (Fig. 1).

Studies in general populations from various regions of the world and of different ethnicities have shown aortic calcification to increase both the overall and the cardiovascular mortality [22, 23, 24, 25]. After kidney transplantation, vascular calcification is an important risk factor for cardiovascular events [26]. Traditional cardiovascular risk factors for atherosclerosis, such as dyslipidemia, hypertension, smoking, gender and age, only partly explain the accelerated progression of vascular calcification in those cohorts. Calcification in the coronary arteries and other vascular sites was shown to correlate with the extent of lesions in the aorta [27, 28]. Medial calcification is common in the abdominal aorta, but it is rare in the coronary arteries [29, 30].

The gold standard for diagnosis of vascular calcification is histological examination, as only histopathology can differentiate clearly between the two types of vascular calcification in end-stage renal disease [22, 31]. Possible diagnostic imaging techniques to detect vascular calcification are electron beamed computed tomography, multislice spiral computed tomography, plain radiography of the abdominal aorta, as well as ultrasound techniques (carotid intima-media thickness, pulse wave velocity) [22, 32]. The abdominal aorta is a relatively easy target for radiological investigation, although a well-standardized method has not yet been recommended for end-stage renal disease patients [28, 32]. A system to quantify calcification was described by Kauppila et al [33] in a subgroup of the Framingham heart study [34, 35]. Abdominal aortic calcification score was described, based on lateral lumbar radiographs. Grading of calcification was assessed at the anterior and posterior wall of the abdominal aorta at the level of L1-L4. Grade 0 was no calcific deposits, grade 1 were small calcific deposits / less than 1/3 of the longitudinal aortic wall, grade 2 meant that a 1/3 to 2/3 of the wall is calcified, and grade 3 indicated that 2/3 or more of the wall is calcified. The abdominal aortic calcification score has been shown to be associated with overall as well as cardiovascular mortality in end-stage renal disease patients [36].

The Agatston Score is a well-established indicator of coronary artery disease showing good correlation with the extent of coronary calcification [37]. It is detected by an unenhanced low-dose CT scan which can be performed routinely in patients undergoing cardiac CT [37]. A good correlation between the severity of coronary calcification and between the number of stenosed coronary arteries determined by coronary angiography and the Agatston Score has been shown. Limitation of this method is quantification of the grade of stenosis especially in peripheral segments [38, 39]. However, the Agatston score offers an additional prognostic tool for cardiovascular disease independent of other cardiovascular risk factors.

The Kidney Disease Improving Global Outcomes (KDIGO) 2009 guidelines suggest a lateral abdominal radiography or an echocardiography for detection of vascular or valvular calcification in patients with chronic kidney disease stages 3-5 [40]. Overall screening for vascular calcification is not recommended due to low sensitivity and specificity of the recommended screening methods, and the lack of effective therapies. There are only preventative therapeutic options available [41, 42, 22]. Up to now, none of the above described radiologic methods has been accepted as a gold standard in cardiovascular risk assessment, due to technical limitations [43].

The situation in end-stage renal disease patients listed for renal transplantation is different. Vascular calcification of the iliac arteries has a direct impact on the surgical procedure, and on post-transplant outcome. Nevertheless, according to the European renal best practice Guideline [19] and also to the guidelines of the American Society of Transplantation, surgical evaluation for renal transplantation, including assessment of the grade of vascular calcification of the iliac arteries in end-stage renal disease patients, is not generally recommended.

Detection of iliac vascular calcification is important prior to renal transplantation, because it can cause multiple complications: clamping of the iliac vessels for anastomosis can be difficult or impossible, the anastomosis procedure can be very difficult or impossible, and time for anastomoses prolonged which has been revealed recently as an independent risk factor for inferior long-term patient survival per se [44]. There is a greater risk of arterial steal syndrome and also of postoperative development of arterial stenosis [16, 17].

Native CT scan of the pelvic region gives a good overview of the vascular situation and calcification which is especially due to media sclerosis [18, 45]. In our scheme for assessment of iliac arterial calcification prior to renal transplantation, we use a grading similar to the one described in the subgroup of patients in the Framingham heart study [36, 38] and which was also used in the CORD study, a large multicenter study with 47 participating centers in six Northern European countries [31]. We used computed tomography, the former study mentioned used lateral lumbar radiographs. The abdominal aortic calcification score described in the CORD study and in the subgroup of the Framingham heart study [31, 36] was an epidemiologic study in hemodialysis patients, with the aim to quantify arterial calcification and stiffness to identify risk factors, and to evaluate progression of this process with a focus on the abdominal aorta. We investigated especially the iliac arteries and the distal segment of the abdominal aorta with a focus on the exact dispersion of calcific deposits, in order to optimize planning of the surgical procedure when implanting a donor kidney. Andres et al. employed helical computed tomography (HCTA) with reconstruction using maximum intensity projections (MIP) to evaluate iliac arterial calcifications and stenosis among candidates for renal transplantation. The presence and distribution of arterial calcifications in the CIA and EIA as well as stenotic and aneurysmal abnormalities were analyzed. A study by Aitken et al. showed that intraoperative vascular complications and graft loss, and also death with functioning graft were more common in the group of patients with severe iliac vascular calcification which was detected by routine plain pelvic x-rays and computed tomography angiogram (CTA) in selected patients [17]. Another study by Droupy et al. [46] analyzes the consequences of arteriosclerosis of the iliac vessels on renal transplantation. In this study, only patients with symptomatic arteriosclerosis or pathological clinical findings were investigated radiologically, first by duplex-ultrasound, then by CT or MRT in selected patients showing ultrasound signs of stenosis. The focus here was more on atherosclerosis, not media sclerosis. Droupy et al also found a highly significant correlation between age and vascular calcification [46]. A study by Hernandez et al. [47] showed VC, evaluated by preoperative posteroanterior plain radiography from aorto-iliac region at the time of transplant, to be a strong and independent predictor of long-term all-cause mortality and cardiovascular deaths in renal transplant recipients.

The strengths of our study are the fact that it deals with a real-life scenario and the availability of follow-up data from the patients based on written medical history.

The limitations of our study are general limitations of scores [48] such as over- and underestimation depending on calibration with time and site, and the fact that certain combinations of risk factors may potentiate the risks; large datasets would be a precondition to calculate the actual risk in different combinations of risk factors [48]. The data on the extent of smoking measured in tobacco product pack years are based on patient survey.

In conclusion, preoperative CT-based scoring of iliac vascular calcification has been demonstrated to be clinically useful, since no transplantation had to be broken off and no early graft loss due to calcification of iliac arteries was recorded.

The score showed significant correlation with the Charlson Comorbidity index, both showing a highly significant correlation with patient survival ($p<0.001$) [49, 50].

The development of a calculated fixed calcium score for evaluation of iliac arterial calcification comparable to the Agatston score for coronary arteries would be a good option for transplant surgeons and their patients.

Judith Kahn: wrote paper, made examinations
Leona Marleen Ram: collected data
Barbara Obermayer-Pietsch: scientific advice and parameter setting
Katharina Eberhard: analyzed data
Andrea Groselj-Strele: analyzed data
Helmut Müller: designed the study, made examinations

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Figure 1

Decline of arterial calcification from proximal to distal expressed as calcification score based on CT scans in 205 patients prior to renal transplant surgery (RTX)

Vascular calcification of CIA (common iliac arteries) and EIA (external iliac arteries) expressed as calcification grade 0 (no calcification) to 3 (maximum / circular calcification) on the y axis.

Data are presented as median, 25-percentile and 75-percentile

Table 1 I Characteristics of patients enrolled in the study.

Parameter	Subgroups	N	% or mean±SD
Gender	male	146	71.2
	female	59	28.8
Age	male	146	54.60±11.60
	female	59	52.02±11.95
Body mass index	male	123	26.38±4.28
	female	56	25.92±4.58
Age (years)	up to 55 years	104	50.7
	more than 55 yeras	101	49.3
Body mass index		179	26.24±4.37
Age		205	53.86±11.73
Underlying diseases	unknown	45	22.0
	renal degeneration	35	17.1
	glomerulonephritis	32	15.6
	hypertensive nephropathy	13	6.3
	diabetic nephropathy	27	13.2
	nephrosclerosis	12	5.9
	zystic nephropathy	22	10.7
	Wegener`s diesease	3	1.5

	congenital	8	3.9
	reflux nephropathy	3	1.5
	others	5	2.4
Diabetes	no antidiabetic therapy	157	76.6
	DM1	3	1.5
	DM2	45	22.0
Number of RTX	evaluated for first RTX	153	77.3
	evaluated for second RTX	36	18.2
	evaluated for third RTX	8	4.0
	evaluated for fourth RTX	1	0.5
Decision	declined for RTX	7	3.4
	decision postponed	12	5.9
	RTX possible on both sides	131	63.9
	RTX possible only right-sided	33	16.1
	RTX possible only left-sided	21	10.2
Cause for decision	vascular calcification	26	49.1
	preceding surgery	18	34.0
	other reasons	8	15.1
	vascular calcification and preceding surgery	1	1.9
Status of surgery	not yet transplanted	99	48.3
	already transplanted	106	51.7

Data are given as mean ± standard deviation, N (%). RTX, Renal transplantation; DM1, Diabetes mellitus type 1; DM2, Diabetes mellitus type 2;

Table 2 | Comparison of calcification grade in the 5 different positions [AO (distal aortic segment), RCIA (right common iliac artery), LCIA (left common iliac artery), REIA (right external iliac artery) and LEIA (left external iliac artery)] and of total iliac calcification without AO between men and women
Data are presented as median, 25-percentile and 75-percentile

	male	female	N men/ N women	p-value
total iliac calcification (without AO)	1.00 (0.25-1.75)	0.50 (0.13-1.13)	142/56	**P=0.003**
calcification of AO	2.00 (0.50-3.00)	1.50 (0.50-2.50)	134/50	P=0.511
calcification of RCIA	1.00 (0.50-2.00)	1.00 (0.00-2.00)	141/56	P=0.139
calcification of LCIA	1.00 (0.50-2.00)	1.00 (0.00-1.88)	142/56	**P=0.037**
calcification of REIA	1.00 (0.00-1.50)	0.00 (0.00-0.50)	136/55	**P<0.000**
calcification of LEIA	1.00 (0.00-1.50)	0.00 (0.00-0.50)	136/54	**P<0.000**

AO, distal aortic segment; RCIA, right common iliac artery; LCIA, left common iliac artery; REIA, right external iliac artery; LEIA, left external iliac artery;

Table 3 | Comparison of calcification grade in the 5 different positions [AO (distal aortic segment), RCIA (right common iliac artery), LCIA (left common iliac artery),
REIA (right external iliac artery) and LEIA (left external iliac artery)) and of total iliac calcification with/without AO between patients younger
than 55 years and patients older than 55 years
Data are presented as median, 25-percentile and 75-percentile

	younger than 55 yrs	older then 55 yrs	N younger than 55 yrs/ N older than 55 yrs	p-value
total iliac calcification (without AO)	0.50 (0.00-1.16)	1.25 (0.50-2.00)	98/100	**P<0.000**
total iliac calcification (including AO)	0.55 (0.10-1.34)	1.40 (0.75-2.15)	98/97	**P<0.000**
calcification of AO	1.00 (0.00-2.00)	2.25 (1.50-3.00)	88/96	**P<0.000**
calcification of RCIA	1.00 (0.00-1.50)	1.50 (1.00-2.50)	98/99	**P<0.000**
calcification of LCIA	0.50 (0.00-1.50)	1.50 (1.00-2.50)	98/100	**P<0.000**
calcification of REIA	0.00 (0.00-1.00)	1.00 (0.00-1.50)	95/96	**P<0.000**
calcification of LEIA	0.00 (0.00-1.00)	1.00 (0.00-1.50)	94/96	**P<0.000**

AO, distal aortic segment; RCIA, right common iliac artery; LCIA,left common iliac artery; REIA, right external iliac artery; LEIA, left external iliac artery;