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ORIGINAL ARTICLE

Coronary Artery Calcification in Renal Transplant Recipients

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ABSTRACT

Background: Vascular calcification is as an active process in dialysis patients, It remains unclear if calcification related to dialysis is ameliorated after renal transplantation or not. Multi-detector computed tomography remain as a gold standard for noninvasively determine the quantity of CAC. Our aim is to study the effect of renal transplantation on vascular calcification occurred among hemodialysis patients and the risk factors for development of vascular calcification and its progression after kidney transplantation.

Methods: Transplant registry in Mansoura Urology and Nephrology Center was reviewed for kidney transplant recipients with pre-transplant non-contrast spiral CT chest. So, 149 recipients were included and they were divided according to the presence of vascular calcification into 2 groups. Group I: 58 KTRs with pre-transplant vascular calcification, Group II: 91 KTRs without pre-transplant vascular calcification.

Results: Pre-transplant vascular calcification was predominant among old age, males with high pre-transplant intact PTH levels. After kidney transplantation, the number of patients with vascular calcification slightly increased and the severity of vascular calcification significantly increased. High pre-transplant calcium score, longer hemodialysis duration and high intact PTH levels are associated with post-transplant vascular calcification progression.

Conclusion: it is better to courage pre-emptive ki dney transplantation or to decrease the incidence of post-transplant vascular calcification. Also, candidates for renal transplantation should keep PTH within accepted level to decrease the chance for vascular calcification.

Keywords: Hyperparathyroidism, Bone-mineral disease, vascular calcification.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death in kidney transplant recipients (KTRs), with a 3.5– 5% annual risk of fatal or non-fatal cardiovascular events, much higher than in the general population despite adjustment for traditional risk factors. Death with graft function (DWGF) accounted for 42% of graft loss among KTRs: CVD is the most common cause of DWGF ranging from 36 to 55% **[1].**

There are three CVD presentations, namely coronary artery disease (CAD), left ventricular hypertrophy (LVH) and peripheral vascular disease. Except for LVH, the main lesions underlying and ultimately responsible for the clinical manifestations are atheroma and vascular calcification (VC) **[2].**

The prevalence of coronary artery calcification (CAC) in KTRs is higher than (61–75%) that assessed in stage 3 CKD and lower than that found in hemodialysis patients possibly due to a selection bias of KTRs upon admission to the waiting list**[3].**

Although the exact pathogenesis of increased vascular calcification in CKD is not fully understood there are some very plausible hypotheses and candidates: from the very beginning disturbances in the phosphorus and calcium metabolism, altered expression of many factors, which are involved or regulate the mineral metabolism, and perhaps most importantly chronic micro inflammation which is present in CKD patients early on in the disease and comes along with increased CRP levels have been discussed as important pathogenic factors**[4].**

It has also been shown in vitro that increased P and Ca levels can induce osteoblast-like changes in vascular smooth muscle cells (VSMC) via stimulation of Na-dependent co-transporters**[5].**

Molecules or pathways influencing phosphate homeostasis such as FGF-23, and Klotho, have been shown to affect both vascular calcification and bone mineralization. FGF-23 is a phosphaturic hormone that inhibits renal phosphate reabsorption and negatively regulates renal 1α-hydroxylase activity. FGF-23-null mice exhibit hyperphosphatemia, in combination with skeletal abnormalities (decreased bone mineral density and osteoidosis) and vascular calcification. The antiaging protein Klotho acts as a cofactor for the binding of FGF-23 to the FGF receptor. Klotho-deficient mice show an accelerated aging syndrome, with osteopenia and vascular calcification, in combination with both hyperphosphatemia and hypercalcemia **[6].**

Systemic and local effects of inflammation on vascular alterations in CKD but also in other segments of the general population are being discussed for quite some time **[7].**

Electron beam computed tomography (EBCT) and multislice computed tomography (MSCT) are well-validated, non-invasive imaging methods and are considered the standard reference for assessing CAC, aortic and valvular calcification; they also carry no requirement for contrast administration. Scores such as the Agatston score, volume score and mass score are used for quantification of VC. The volume and mass scores are quantitative and more reproducible measurements (mm 3 or mg, respectively), in addition to being more appropriate for use with modern CT scanners than the Agatston score **[8].**

METHODS

This retrospective cohort study (STROBE guidelines) , single-center study included 149 patients with available pre-transplant non contrast computed tomography (NCCT) for chest out of 600 kidney transplant recipient who underwent renal transplantation at Mansoura urology and nephrology Centre between January 2010 and December 2015. Patients who Lost follow up or had Pre-transplant diabetes mellitus were excluded from the study.

The patients were divided according to the presence of pre-transplant vascular calcification (coronary artery calcification) by Agatston score into 2 groups: Kidney transplant recipients with pre-transplant vascular calcification (Agatston score >10) No. (58 KTRs) (Group I) and Kidney transplant recipients without pre-transplant vascular calcification (Agatston score: 0-10) No. (91 KTRs) (Group II). Kidney transplant recipients with vascular calcification were divided according to Agatston score (coronary calcium score) to 3 groups: Mild calcification (11-100), Moderate calcification (101-400), Severe calcification (>401) **[9]**. Agatston score was done after retrieval of NCCT images.

Immunosuppressive protocols:

Patients received different regimens of induction therapy (146 patients received Basiliximab and 3 patients received Antithymocyte globulin (ATG)). Different regimens of immunosuppressive protocols were used: 89 patients received steroid free protocol (Tacrolimus and Mycophenolate mofetil), 52 patients received Tacrolimus based protocol (Steroid, Tacrolimus and Mycophenolate mofetil), 5 patient received steroid, cyclosporine and Everolimus,1 patient received steroid , Tacrolimus and Everolimus, 1 patient received Cyclosporine based protocol (Steroid, Cyclospronie and Mycophenolate mofetil), 1 patient received Sirolimus-based protocol (sirolimus and Mycophenolate mofetil).

Method s: All patients underwent a baseline at time of transplantation multislice spiral coronary computed tomography (MSCT) using the Agatston technique for calcium scoring (CS) **[9].** Multislice spiral coronary computed tomography (MSCT) was done for all patients to assess calcium scoring again 2 years after transplantation.

Left main, left anterior descending, circumflex and right coronary artery were evaluated for the presence of calcified plaques and the calcium score (CS) was categorized: CS=0: no identifiable plaques, CS=1-10: minimal identifiable plaques, CS=11-100: mild atherosclerotic plaque, CS=101-400: moderate atherosclerotic plaque and CS=>401: severe atherosclerotic plaque. Agatston score was calculated using specific software (brilliance CT v2.6.2.21004 Multidetector 64 slice) in CT scan set (Philips, U.S.A).

The transplant registry at Mansoura urology and nephrology centre was reviewed for both groups to assess the transplant outcome using univariate and multivariate analysis.

Records of all kidney recipients were reviewed pre-transplantation and for 2 years post-transplant: Demographic data as recipient age and donor & recipient gender, Dialysis duration, Pre- transplant medical disorder: hypertension and post-transplant medical disorder: hypertension &diabetes mellitus, Laboratory investigations (serum creatinine, calcium, phosphorus, calcium-phosphorus products , parathormone , alkaline phosphatase, cholesterol, magnesium), Induction immunosuppressive drugs, Maintenance immunosuppressive protocol and graft outcome.

STATISTICAL ANALYSIS

The findings were recorded, tabulated and analyzed using SPSS for windows (SPSS inc.

Chicago). Student-t test was used to compare normally distributed continuous data between the two groups. While, Mann-Whitney test was used for non-parametric data. Categorical data were compared using chi square test. Logistic regression was employed in order to perform multivariate analyses.

Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

RESULTS

The recipients` age in both group ranged from 18 years to 55 years. Older age is associated with higher incidence of vascular calcification (*p value: 0.048*) with male predominance. Longer hemodialysis duration is associated with vascular calcification (***p value: 0.001***) **(table 1).** The degree of vascular calcification is affected by hemodialysis duration also **(table 2).**

Patients with vascular calcification suffered from higher intact PTH levels before transplantation (***p value: 0.023***). However, the level of intact PTH don`t affect the degree of calcification. Serum calcium, phosphorus, magnesium, cholesterol and alkaline phosphatase didn`t show any effect on pre-transplant vascular calcification incidence **(Table 1, table 2).**

After 2 years from transplantation, there was no statistical significant difference between vascular calcification and no-calcification groups regarding serum calcium, phosphorus, magnesium, cholesterol, intact PTH and alkaline phosphatase **(table 3).**

Presence of vascular calcification did not affect graft outcome over 2 years post-transplantation as no statistical significant difference is present among groups regarding serum creatinine **(table 3, table 4).**

Vascular calcification incidence increased after transplantation from 38.9% to 40.9% especially severe form with rise of median agatston score from 258.85 (21,813) to 354.55(20, 1198.8) in spite of significant improvement in serum creatinine, calcium, phosphorus, magnesium, alkaline phosphatase and intact PTH **(table5).**

So, some patients showed progression of vascular calcification after transplantation. The patients after that were divided according to progression into 2 groups: progressors (59 KTRs) and non-progressors (90 KTRs) to determine the risk factors for vascular calcification progression after kidney transplantation.

Progressors are defined as follow: For patients with detectable CAC at baseline, progressors were defined as a CAC score change was ≥25%, which represent 2.5 times the published median inter-scan variabilities and is commonly used in longitudinal studies **[10]** and For patient with CAC score of 0 and follow up ≥ 4 were considered to have progressed **[10].**

Recipients` age and sex did not affect post-transplantation vascular calcification progression. Pre-emptive transplantation is associated with lower incidence of vascular calcification **(*p value: 0.02*)** while longer hemodialysis duration is associated with higher calcification rate **(*p value: 0.001*).** Patients with high intact PTH level and calcium agatston score prior to transplantation are associated with more calcification progression (***p value: 0.046, 0.001 respectively***). Pre-transplant serum calcium, phosphorus, magnesium, alkaline phosphatase and cholesterol did not affect calcification progression. Immunosuppressive drugs have no effect on calcification progression and progression did not affect transplant outcome over 2-year follow up **(Table 6).**

So, There were 3 dependent risk factors for developing CAC progression: pre-transplant Calcium score, dialysis duration and pre-transplant PTH level with significant ***p value: <0.001, <0.001 and 0.05*** respectively. Pre-emptive transplantation is inversely proportional in determining CAC progression with *p value: 0.02* **(Table 7).**

Table (1): Baseline characteristics and laboratory investigations before transplantation:

	Presence of vascular calcification (58 Kidney transplant recipients)	Absence of vascular calcification (91 Kidney transplant recipients)	p-value
Recipient age (year) M±SD	27.52±11.788	23.78±10.768	0.048
Recipient sex (male) No.	44(75.9%)	62(68.1%)	**0.023**
Donor sex (male) No. %	34(58.6%)	36(39.6%)	0.31
Hypertension No. %	24(41.4%)	47(51.6%)	0.221
Hemodialysis No.%	54(93.1%)	81(89.0%)	0.404
Hemodialysis duration (months)	29.43±14.	18.00±8.63	**<0.001**

	Presence of vascular calcification (58 Kidney transplant recipients)	Absence of vascular calcification (91 Kidney transplant recipients)	p-value
M±SD			
Serum calcium(mg/dl) Mean±SD	9.31±1.03	9.21±1.07	0.575
Serum phosphorus(mg/dl) Mean±SD	6.04±1.70	6.14±1.64	0.720
Calcium phosphorus product (mg²/dl²) Mean±SD	56.37±17.46	56.60±16.49	0.933
Serum magnesium(mg/dl) Mean±SD	2.63±0.41	2.6363±0.48615	0.893
Serum cholesterol(mg/dl) Mean±SD	156.02±35.96	160.18±41.56	0.532
Intact PTH (pg/ml)Median(Min, Max)	660(10.6,2000)	442(10.8,1900)	**0.023**
Alkaline phosphatase (IU/L) Median (Min, Max)	131.5(34,1214)	128(34,811)	0.84

Table (2): Demographics and laboratory investigations of different grades of vascular calcification:

	Mild calcification (16 kidney transplant recipients)	Moderate calcification (31 kidney transplant recipients)	Severe calcification (11 kidney transplant recipients)	P value
Recipient age (year) M±SD	27±12.99	27.32±11.08	28.82±12.97	0.92
Recipient sex (male) No. %	11(68.7%)	23(74.2%)	10(90.9%)	0.397
Donor sex (male) No. %	11(68.7%)	16(51.6%)	7(63.6%)	0.492
Hypertension No. %	10(62.5%)	10(32.3%)	4(36.4%)	0.127
Hemodialysis No.%	13(81.2%)	31(100%)	10(90.9%)	***0.047***
Hemodialysis duration (months) M±SD	19.75(0.00, 29.73)	25.7(5.8, 49.4)	45.5(0.00,113.13)	***0.003***
Serum calcium(mg/dl) Mean±SD	9.58±1.17	9.14±1.05	9.41±0.88	0.378
Serum phosphorus(mg/dl) Mean±SD	6.17±1.84	6.02±1.74	5.9455±1.54	0.94
Calcium phosphorus product (mg²/dl²) Mean±SD	59.31±19.92	54.98±16.95	55.99±16.17	0.728
Serum magnesium(mg/dl) Mean±SD	2.66±0.42	2.54±0.40	2.84±0.37	0.107
Serum cholesterol(mg/dl) Mean±SD	170.81±39.31	149.48±31.03	152.90±40.90	0.149
Intact PTH (pg/ml) Median (Min, Max)	409.5(44,1117)	395(10.8,1900)	569(12,1312)	0.946
Alkaline phosphatase (IU/L) Median (Min, Max)	128 (47,541)	131 (34,827)	163(57,1214)	0.406

Table (3): Post-transplant laboratory investigations and medical disorders:

	Presence of vascular calcification (58 Kidney transplant recipients)	Absence of vascular calcification (91 Kidney transplant recipients)	p value
Serum calcium(mg/dl) Mean±SD	9.17±0.63	9.2066±0.62	0.732
Serum phosphorus(mg/dl)Mean±SD	3.51±0.94	3.25±0.98	0.1
Calcium phosphorus product(mg²/dl²) Mean±SD	29.68±8.99	32.33±8.92	0.08
Serum magnesium(mg/dl) Mean±SD	1.86±0.26	1.08±0.23	0.722
Serum cholesterol (mg/dl) Mean±SD	155.88±44.82	159.68±43.44	0.608

	Presence of vascular calcification (58 Kidney transplant recipients)	Absence of vascular calcification (91 Kidney transplant recipients)	p value
Intact PTH (pg/ml)Median(Min,Max)	76(22,245)	73(23,461)	0.668
Alkaline phosphatase (IU/L) Median (Min,Max)	91(29,560)	87(24,207)	0.517
Serum creatinine after 1 year. Mean±SD	1.1(0.3, 13)	1.2(0.1, 3.7)	0.935
Serum creatinine after 2 year. Mean±SD	1.38±0.53	1.46±0.95	0.624
Condition of last follow-up. Living with functioning graft Living on dialysis Died with functioning graft Died with failed graft	 52(89.7%) 3(5.2%) 1(1.7%) 2(3.4%)	 88(96.7%) 3(3.3%) 0(0.0%) 0(0.0%)	0.157
Post-transplant hypertension No. %	13(22.4%)	23(25.3%)	0.423
Post-transplant diabetes No. %	2(3.4%)	1(1.1%)	0.319

Table (4): post-transplantation laboratory investigations of different calcification grades:

	Mild calcification (16 kidney transplant recipients)	Moderate calcification (31 kidney transplant recipients)	Severe calcification (11 kidney transplant recipients)	p value
Serum calcium (mg/dl) Mean±SD	9.15±0.77	9.12±0.64	9.35±0.28	0.591
Serum phosphorus(mg/dl) Mean±SD	3.18±0.59	3.43±1.17	2.84±0.75	0.218
Calcium phosphorus product (mg^2/dl^2)Mean±SD	28.87±4.98	31.24±10.91	26.45±6.83	0.294
Serum magnesium(mg/dl) Mean±SD	1.87±0.39	1.90±0.21	1.75±0.23	0.158
Serum cholesterol(mg/dl) Mean±SD	170.44±49.07	157.68±40.29	129.64±43.15	0.061
Intact PTH (pg/ml) Median(Min,Max)	60(23,205)	73(22,245)	88(32,167)	0.273
Alkaline phosphatase (IU/L) Median(Min,Max)	97.5(36,555)	82(29,277)	113(46,560)	0.255
Serum creatinine after 1 year. Mean±SD	1.42±0.83	1.28±0.46	1.04±0.53	0.355
Serum creatinine after 2 year. Mean±SD	1.28±0.38	1.4±0.51	1.44±0.83	0.777

Table (5): Effect of transplantation:

	Pre-transplant	Post-transplant	P value
Vacular calcification No. %	58(39%)	61(41%)	0.72
Degree of calcification No. % **Mild** **Moderate** **Severe**	 16(10.7%) 31(20.8%) 11(7.3%)	 11(7.3%) 26(17.4%) 24(16.1%)	**0.04**
Agatston score Mean±SD	258.85(21,813)	354.55(20,1198.8)	**<0.001**
Serum calcium(mg/dl) Mean±SD	9.31 ±1.03	9.17 ± 0.62	0.291
Serum phosphorus(mg/dl) Mean±SD	6.04 ± 1.70	3.24 ± 0.98	**<0.001**
Calcium phosphorus product (mg^2/dl^2)Mean±SD	56.36 ± 17.46	29.68 ± 8.99	**<0.001**
Serum magnesium(mg/dl) Mean±SD	2.62 ± 0.41	1.86 ± 0.26	**<0.001**
Serum cholesterol (mg/dl)Mean±SD	156.01 ± 35.96	155.88 ± 44.82	0.983
Intact PTH (pg/ml) Median(Min,Max)	442(10.8,1900)	76.5(22, 245)	**<0.001**
Alkaline phosphatase (IU/L) Median(Min,Max)	131.5(34,1214)	91(29,560)	**<0.001**

Table (6): Comparison between non-progressors and progressors:

	Progressors No=59	Non-Progressors No=90	p value
Age Mean±SD	26.49±10.75	24.51±11.63	0.29
Sex (male) No. %	45(76.3%)	61(57.8%)	0.3
Hemodialysis No.%	53 (88.91%)	68 (83.1%)	***0.024***
Pre-emptive No. %	6(11.09%)	22(16.9%)	***0.02***
Pre-transplant hypertension. No. %	15(25.4%)	22(24.4%)	0.8
Induction therapy No. % ATG Basiliximab	 2(3.4%) 57(96.6%)	 2(2.3%) 88(97.7%)	0.33
Total steroid dose during 1st 3 months post-transplant Mean±SD(gram)	3.39±1.46	3.62±1.48	0.35
Primary plan for immunosuppressive therapy: Steroid+FK+MMF Steroid+CSA+MMF FK+MMF Rapamune+MMF Steroid+CSA+Everolimus Steroid+FK+Everolimus	 21(35.6%) 1(1.7%) 35(59.3%) 0(0.0%) 2(3.4%) 0(0.0%)	 31(34.5%) 1(1.1%) 53(58.9%) 1(1.1%) 3(3.3%) 1(1.1%)	 0.72
Pre-transplant laboratory investigations:			
Serum calcium(mg/dl) Mean±SD	9.35±1.02	9.18±1.08	0.35
Serum phosphorus(mg/dl) Mean±SD	6.06±1.68	6.14±1.66	0.76
Calcium phosphorus product (mg^2/dl^2)Mean±SD	56.87±17.84	56.36±16.27	0.85
Serum magnesium(mg/dl) Mean±SD	2.69±0.45	2.58±0.45	0.17
Serum cholesterol(mg/dl) Mean±SD	156.1±34.57	160.37±42.57	0.52
Intact PTH (pg/ml) Median(Min,Max)	655.5(10.6,2000)	567(10.8,1700)	0.046
Alkaline phosphatase (IU/L) Median(Min,Max)	135(34,1214)	128(34,811)	0.8
Post-transplant laboratory investigations:			
Serum calcium(mg/dl) Mean±SD	9.2±0.62	9.19±0.61	0.9
Serum phosphorus(mg/dl) Mean±SD	3.4±1.08	3.4±0.89	0.94
Calcium phosphorus product (mg^2/dl^2)Mean±SD	31.24±9.95	31.39±8.41	0.92
Serum magnesium(mg/dl) Mean±SD	1.87±0.2	1.82±0.22	0.17
Serum cholesterol(mg/dl) Mean±SD	155.08±44.4	160.69±43.67	0.44
Intact PTH (pg/ml) Median(Min,Max)	75(22,245)	73.5(23,461)	0.6
Alkaline phosphatase (IU/L) Median(Min,Max)	84(29,560)	87(24,207)	0.96
Serum creatinine after 1 year. Mean±SD	1.2±0.35	1.3±0.32	0.7
Serum creatinine after 2 year. Mean±SD	1.38±0.36	1.4±0.34	0.5
Serum creatinine at last follow-up. Mean±SD	1.4±0.22	1.42±27	0.8

Table (7): Multivariate analysis for risk factors predisposing for CAC progression:

Parameter	p value	Odds ratio(OR)	Confidence 95%	interval (CI)
Pre-transplant Calcium score	**<0.001**	1.04	1.02	1.05
Dialysis duration(months)	**<0.001**	1.08	1.05	1.12
Pre-emptive transplantation	**0.02**	0.34	0.13	0.92
Pre-transplant PTH level(mg/dl)	**0.05**	1.008	1	1.0015

DISCUSSION

To the best of our knowledge, this is the first report including only living related donors to study vascular calcification risk factors before and after kidney transplantation. We found that older age, male predominance, longer hemodialysis duration and pre-transplant hyperparathyroidism are the risk factors for pre-transplant vascular calcification. While, pre-transplant high agatston score, longer hemodialysis duration and pre-transplant hyperparathyroidism are associated with increased vascular calcification progression after transplantation. Vascular calcification incidence increased after kidney transplantation. Vascular calcification did not affect transplant outcome over 2 years post-transplant.

It is known that incidence of atherosclerotic changes increases with age. This explains our finding that vascular calcification increases with age among chronic kidney disease patients. Earlier studies in Western populations have shown that the amount of coronary calcium in women lags 10–15 years behind those of men **[11]**, a finding which parallels observations in the clinical incidence of coronary disease in this study. Several studies proved these findings **[12],[13],[14],[15].**

In 2002, ***Chertow et al.,*** described an increment of electron-beam computed tomography– measured agatston score of approximately 150 per 6 months during hemodialysis treatment. The rapid progression seemed to be caused mainly by altered calcium-phosphate metabolism; hence, treatment with calcium-free Phosphate binders substantially reduced further calcification **[16].** This comes in hand with our report. In the other hand, ***Mazzaferro et al.,*** found no significant association between dialysis duration and CAC. This may be due to small sample size in his study**[17].**

Hyperparathyroidism with changes in CKD-bone disease biomarkers is associated with high rate of vascular calcification prior to transplantation (p value: 0.023). However, ***London et al, and Slinin et al*** stated that vascular calcification is associated more with very low PTH levels with low bone turn-over and more adynamic bone disease**[18],[19].**

In the other hand, calcium, phosphorus, magnesium, alkaline phosphatase levels had no effect on pre-transplant vascular calcification. This is concomitant with ***Gulcicek et al., and Adamidis et al.,[20],[21*]**.**

Despite significant improvement of intact PTH and other biomarkers after transplantation, there was worsening of agatston score which reflect increased severity of vascular calcification of the patient with pre-transplant vascular calcification. However, only 3 patients with agatston score less than 10 pre-transplant converted to positive agatston score after kidney transplantation and 97% of patients remained with 0 agatston score. A report by ***Seyahi et al.,*** showed that 67% of patients remained with agatston score 0 after kidney transplantation **[22].** Other studies reported 75% to 83.3% of patients did not show progression to vascular calcification after kidney transplantation **[23],[24].**

We found that there was no relation between vascular calcification progression after transplantation and patients` age, sex, pre-transplant calcium, phosphorus, cholesterol, magnesium or alkaline phosphatase, induction immunosuppressive drugs, maintenance immunosuppressive drugs or post transplant biochemical markers including intact PTH. ***Alfieri el.,*** reported the same finding **[15].**

Risk factors for calcium progression in this study included pre-transplant CAC score, hemodialysis duration and pre-transplant hyperparathyroidism while pre-emptive kidney transplantation was associated with better prognosis regarding vascular calcification progression. Alfieri et al., correlated vascular calcification progression after kidney transplantation is associated with age, pre-transplant agatston score but not related to hemodialysis duration**[15].**

Schankel et al., claimed that there is strong correlation between hemodialysis duration and CAC score at time of transplantation and vascular calcification progression **[13].**

In contrast with our study, **Abedi et al.,** reported that the mean CAC score decreased significantly from 39.82 to 24.34 after transplantation. They concluded that renal transplantation significantly reduced CAC in patients with CKD. There was a linear correlation with decrease in parathormone levels and calcium–phosphate product at an early period after renal transplantation **[25].** The same was reported by ***Mazafferro et al., and Priyadarshini et al.,[1],[26*]**.**

The novelty of our study is the large patient's number compared to similar studies, different age group, different dialysis duration, different immunosuppressive protocols and the use of identical multislice spiral CT at baseline and follow-up.

On the other hand our study had some limitations as it was retrospective study, Lack of randomization. Inability to retrieve some laboratory results and some aspects of the dialysis period such as mineral metabolism characteristics could not be recorded, only one laboratory measurement was performed at each time point. Also we did not follow up progression of calcium score at different time points post-transplant. All patients in our unit were living donor transplant recipients; therefore, our findings might not apply to the general transplant population, which is mainly composed of patients who receive cadaveric renal transplants. The study population is representative of the renal recipients from our geographic area, but may not be representative of other areas with different ethnic composition.

CONCLUSION

We concluded from this study that Pre-transplantation duration of dialysis therapy remains a consistent pathognomonic factor of CAC and also is associated with post-transplantation progression of calcification. Higher age and serum parathyroid level are determinants for both CAC presence and CAC score. Baseline CAC and pre-transplant serum PTH level are factors associated CAC progression. No correlation between others biochemical parameters pre-transplantation and even after improvement of these parameters post-transplantation and CAC progression. Renal transplantation does not stop or reverse CAC. Progression of CAC is the usual evolution pattern of CAC in renal transplant recipients.

Declaration of interest

The authors report no conflicts of interest.

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