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Research Article

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The validity of myocardial perfusion using 99mTc-Tetrofosmin gated single-photon emission tomography (gSPECT) in the detection of coronary artery disease in different stages of chronic kidney disease

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Abstract

Background: *Patients with advanced chronic kidney disease (CKD), subjected to hemodialysis (H.D.), May not manifest chest pain with severe coronary artery disease (CAD).*

Aim of the study: *Study the value of radionuclide myocardial perfusion using gated single-photon emission tomography (gSPECT) in recognition of the frequency and risk factors of CAD in different stages of CKD patients.*

Patients and Methods*: the current study divided 133 CKD patients (pts) into three groups according to CKD stage: 43 cases in stage 3, 43 in stage 4, and 47 in stage 5. Each stage included asymptomatic and symptomatic subgroups. The present study recorded the clinical evaluation, laboratory data (in the form of complete blood picture, fasting blood glucose and glycosylated hemoglobin (HbA1c), lipid profile, serum calcium and phosphorus, C-reactive protein [CRP]), together with imaging tests (Dipyridamole stress-rest gSPECT/C.T., coronary C.T. angiography and LVM index by echocardiography) for all patients.*

Results: *the study included ninety-nine asymptomatic and 34 symptomatic patients. CKD 3 included 33 asymptomatic and ten symptomatic, CKD 4 included 33, and 10, while CKD5 included 33 and 14, respectively. The asymptomatic group presented forty-eight cases (48.5%) abnormal gSPECT (19 fixed and 29 reversible defects). Eleven of this abnormal gSPECT were in CKD3, thirteen in CKD 4, and twenty-four in CKD 5, with a statistically higher prevalence of abnormality in CKD5 ($P<0.0001$). On the contrary, thirty cases of the symptomatic group had abnormal gSPECT (12 fixed and 18 reversible defects) seven in CKD 3, nine in CKD 4, and all the fourteen of CKD5. We Compared both groups concerning risk factors, age (senior in asymptomatic), blood pressure (greater in symptomatic), serum creatinine (higher in symptomatic), duration of hemodialysis (longer in symptomatic), cholesterol (more elevated in symptomatic) and HDL (more elevated in asymptomatic). The symptomatic group had a statistically more abundant perfusion defects size compared to the asymptomatic group. Stepwise regression discovered that the abnormal myocardium (SSS score > 4) was dependent first of all on age, which consequently revealed the substantial role of D.M., LVH, and elevated CRP.*

Conclusion: *stress-rest gSPECT is essential in the revealing of CAD in different stages of CKD, even in low-risk patients. High-risk CKD patients for CAD are those with D.M., LVH, and high CRP.*

Introduction

Chronic kidney disease (CKD) is known to be a significant risk factor for coronary artery disease (CAD). There is a strong association between CKD and cardiac events, where approximately 50% of patients with renal insufficiency may present with cardiac dysfunction. Several studies reported that CKD patients have more than a 10-to-20-fold increased risk of cardiac death compared with age- and sex-matched none CKD subjects [1, 2]. This observation attributed the frequent sudden cardiac death, myocardial infarction, and heart failure in patients with end-stage renal disease (ESRD) [3, 4].

Besides, CKD patients have an unfavorable cardiac outcome in earlier stages of kidney disease and the absence of obstructive CAD [5]. The leading cause of this strong association was reported to be microvascular dysfunction, which might accelerate to CAD

[6]. Currently, diagnosis and risk stratification of CAD by radionuclide myocardial perfusion SPECT imaging are standard [2, 7]. Accordingly, the detection of CAD and risk stratification pre-renal transplantation is mandatory by either coronary angiography or non-invasive stress imaging modalities.

Also, CKD patients with approved CAD need reassessment when renal dysfunction progress [1]. Our study aimed to use gSPECT for detection and risk stratification of CAD in different stages of CKD.

Material and Methods

Patient selection: The study included 133 CKD patients distributed as stages three and 4/or 5 (ESRD) on dialysis (Figure 1a and b), presented to the nuclear medicine department (from November 2014 to November 2017) to perform gSPECT for detection and risk stratification of CAD pre-renal transplant. Inclusion criteria: all patients with renal impairment of different degrees whether they had symptoms suggestive of coronary artery disease or not. Exclusion criteria included: patients with cerebrovascular disease, cardiomyopathy, old myocardial infarction, unstable angina, coronary revascularization, and history of heart failure. Informed consent to the study protocol, which was approved by the ethical committees of the participating hospitals, was mandatory.

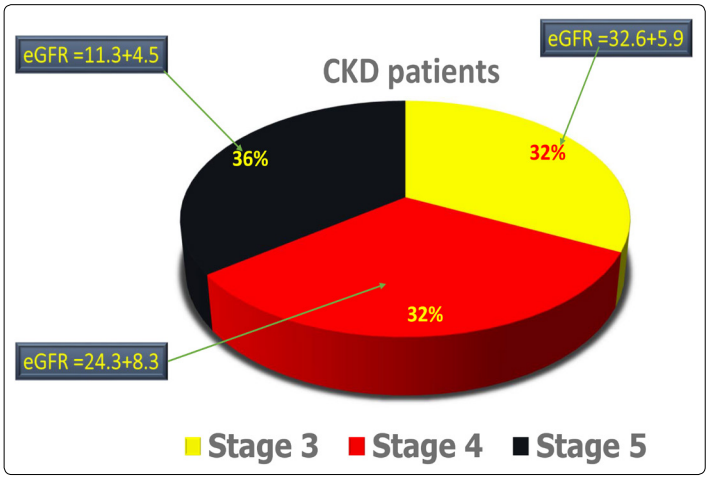

Figure (1a): Distrubution of the studied patients according to estimated glomular filtration (eGFR)

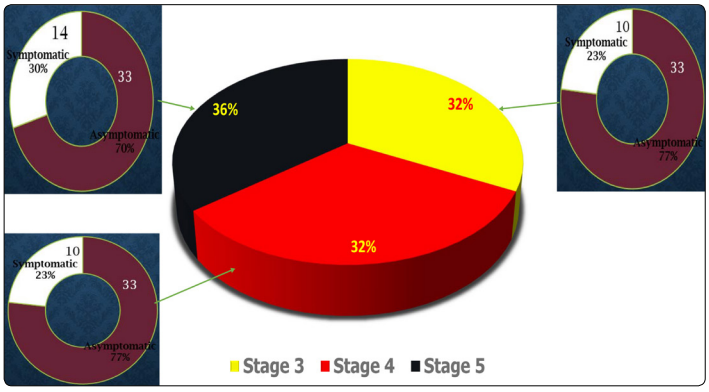

Figure (1b): Subdivision of the studied patients

Methods: Clinical assessment in the form of gender, age, risk factors for atherosclerosis (diabetes (D.M.), hypertension (HTN), dyslipidemia and smoking habits), history of angina and ischemic basal ECG as well as reference to an ECG suggestive of myocardial hypertrophy or bundle branch block, rest heart rate and baseline QRS width. The current study excluded all cases with arrhythmia. Laboratory tests included complete blood picture, glycosylated hemoglobin [HbA1c], lipid profile, calcium, and phosphates.

Imaging studies had been done: dipyridamole gated SPECT/CT, echocardiography [looking for left ventricular hypertrophy signs, and coronary C.T. angiography [8].

Gated SPECT-MPI Protocol: The current study applied stress-rest Gated SPECT-MPI protocol using 370-555 MBq after dipyridamole protocol [9]. S.T. deviation during dipyridamole and heart rate after vasodilation were recorded for analysis. If we noticed MPI abnormality in stress images, we inject 740 to 1110 MBq (20 to 30 mCi) of the tracer after three hours, acquire rest gSPECT.

All images were acquired 15 minutes after the injection of the tracer. They were performed by a hybrid system SPECT-CT, with a dual-head gamma camera (intevo, siemens), using a stop and shoot acquisition, with 64 projections per study and a 180° arc, from right anterior to left anterior oblique. Attenuation correction protocol had been followed by applying a single low-dose C.T. (computed tomography) scan (helical, 120 KeV, 1mA with 1.9 pitch) before stress and rest acquisitions.

Interpretation of images: The current study applied the same protocol for visualization and classification of the perfusion defects and following a 17 segment score system to get stress, rest, and reversibility scores (SSS, SRS, and SDS) (Figure 2) [10, 11]. Also, the current study calculated left ventricular ejection fraction (LVEF) automatically using Corridor-4DM, considering abnormal E.F. equal to or under to 45% [12].

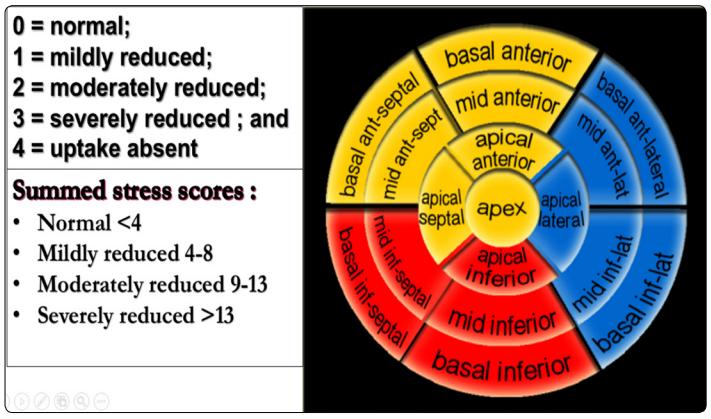

Figure 2: Myocardial Segmentation into 17 segment score system[11]

Computed tomography coronary angiography protocol: In the current study, we performed a calcification score (CCS) and coronary angiography by multidetector C.T. (CTA) using a 128-row computed tomography scanner. Descriptions of scan parameters for CCS and CTA assessment have been published previously [13, 14].

Data analysis: The Agatston method was applied for CCS with stratification of the studied patients to CCS 0, CCS 1 till 399, and CCS > 400. Again, the current study utilized the 17 segments model for segmenting the coronary arteries [11]. Two experienced radiologists interpreted all CTA blindly. Classification of coronary C.T. angiography (CTA) outcomes was made between non-obstructive and obstructive CAD applying luminal stenosis >50 % as a threshold for obstructive CAD lesions. Also, the number of segments and vessels involved in each category of CAD (presence of CAD, non-obstructive CAD, and obstructive CAD) was measured [14].

Statistical Analysis: The current study presented the continuous variables as mean ± one standard deviation (M ± 1SD); meanwhile, the categorical variables as their proportion in the total study population. Also, the present study used the ANOVA for comparison between the continuous variables and the U-Mann-Whitney test for comparing the nonparametric. Moreover, we analyzed categorical data by Fisher´s exact test. The current study considered the abnormal perfusion as the dependent variable and used Stepwise regression analysis to get the predictors of perfusion defects (ischemia, SSS score) The present research chose 0.05 as a level of statistical significance and employed StatView 5.0.1, version for Windows, SAS Institute to get all the results as mentioned earlier.

Results

The current study included 99 cases in the asymptomatic group (I) and 34 in the symptomatic group (II) (Fig.1). The (Table 1) recorded the demographic data of both groups. Group I is statistically different from group II in : (1) age (higher 63.4+10.9 vs. 45.9 + 16.2), (2)Blood pressure where it had statistically lower systolic (SBP) and diastolic blood pressure (DBP), (3)number of coronaries affected where multivessel disease was statistically higher in group II (90% vs. 62.5% in group I). No statistically significant difference as regards risk factors of CAD in both groups as regard sex, the prevalence of hypertension, diabetes mellitus, smoking, positive family history of CAD, and dyslipidemia.

Table (1): Demographic data of The studied patients:

	Group I (99 patients) Asymptomatic	P	Group II (34 patients) Symptomatic	Total
Variable (mean+SD)				
Age	63.42+10.9	<0.05	45.9+16.2	54.66+12.4
Body mass index	27.82+6.4	>0.05	28+7	27.9+1.14
HR (bpm)	82.1+18.4	>0.05	89+30.1	85.1+22.01
Blood pressure: SBP DBP	 144.7+18.2 90.6+20.4	 <0.05 <0.05	 157.1+35.4 100.1+22.8	 150.9+8.7 95.35+6.7
LVMI	179+32.2	<0.001	227+78.6	203+59.4
Duration of CKD	8.32+4.4	>0.05	9.14+2.76	8.78+3.23
Duration of dialysis	5.7+1.98	>0.05	7.1+1.47	6.38+1.4
Variable Number and percentage				
Sex (male%):	61/99 (61.6%)	>0.05	21/34 (61.8%)	82/133
HTN (%):	74/99 (74.7%)	>0.05	24/34 (70.6%)	98/133
DM(%):	33/99 (33.3%)	>0.05	11/34 (32.3%)	44/133
Smoking(%):	18/99 (18.2%)	>0.05	12/34 (35.3%)	30/133
Positive FH(%):	27/99 (27.3%)	>0.05	8/34 (23.5%)	35/133
Dyslipidemia(%):	66/99 (66.7%)	>0.05	24/34 (70.6%)	90/133
No. of coronaries affected: 1 VD 2 VD 3 VD	 18 (37.5%) 16 (33.3%) 14 (29.2%)	 <0.01 >0.05 <0.05	 3 (10%) 12 (40%) 15 (50%)	 21 28 29

Laboratory Findings: Hematologically, there is no statistically significant difference between both groups (Table 2). Chemically, no difference concerning blood glucose level. Concerning the lipid profile, there is statistically lower cholesterol and higher HDL in group I compared to group II. Meanwhile, the renal parameters in the form of creatinine group I showed a statistically lower level compared to group II.

Table (2): Laboratory data of the studied groups:

	Group I (99 patients)	P	Group II (34 patients)	Total
Variable (mean+SD)				
Renal Function • Creatinine • eGFR	 5.3+3.4 22.3+20.02	 <0.01 >0.05	 8.75+3.7 20.5+16.14	 7.03+2.4 21.3+16.8
Blood picture: • Hb level • HTC	 9.4+1.69 36.3+6.5	 >0.05 >0.05	 10.9+1.28 37.7+7.8	 10.02+1.4 37+6.6
Blood sugar: • Glucose: • Glycosylated HbA:	 126+49.5 7.9+2.9	 >0.05 >0.05	 120.1+33.9 7.2+2.2	 123+36 7.5+2.4
Lipid Profile: • Total cholesterol: • Triglycerides: • LDL: • HDL:	 180+35.8 126+49.6 124.8+32 52.9+17.3	 <0.05 >0.05 >0.05 <0.05	 205.3+26.9 140.5+65 128.6+28.4 47.5+9.3	 200.2+25.9 133+57.5 126+18 49.3+7.2

Left ventricular mass index (LVMI): Figure (3) revealed statistically significant higher LVMI in group II compared to group I. Calcification score and chronic kidney staging: Table (3) revealed a high statistical correlation between CKD stage and frequency of high calcification score which is increasing proportionally with an increase in the stage (P<0.0001)

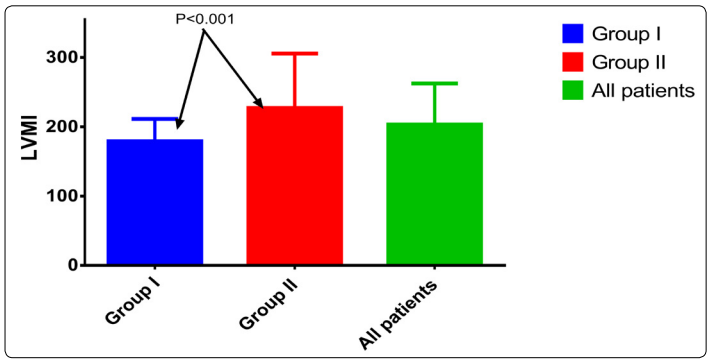

Figure 3: Mean Values of Left Ventricular mass index (LVMI) in the studied patients

Table (3): Distribution of patients in the studied subgroups according to calcification score:

	CKD3		CKD4		CKD5		Total	
	Number	%	Number	%	Number	%	Number	%
CCS 0	21	48.8	7	16.3	0	0	28	21.1
CCS 1-339	15	43.9	21	48.8	13	27.7	49	36.8
CCS >400	7	16.3	15	43.9	34	72.3	56	42.1
X2= 46.5, P<0.0001, Cramer's V= 0.418								

CKD= chronic kidney disease, CCS= calcium score

Myocardial Perfusion findings

Perfusion defect:

(1) Figure (4) revealed statistically higher positive myocardial perfusion imaging (MPI) in group II (88.2%) compared to group I (48.5%) (P<0.01). On the other hand, the reversible defects prevalence is statistically insignificant in both groups.

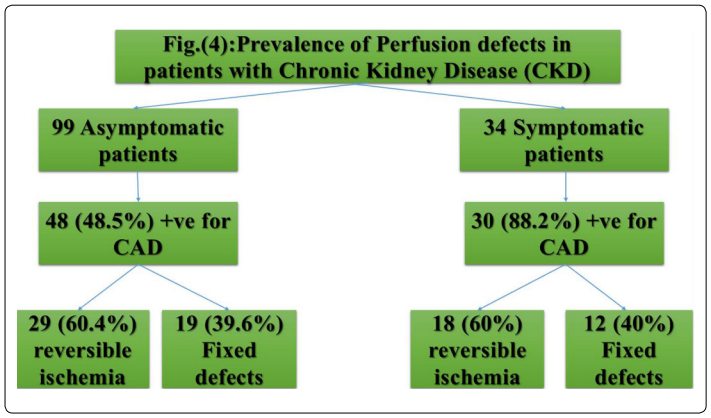

Figure 4: Prevalence of Perfusion defects in patients with Chronic Kidney Disease (CKD)

(2) perfusion defect (P.D.) size and studied groups: Figure (5) revealed a correlation between defect size and the two studied groups where the group I showed a statistically higher prevalence of small defect with a gradual reduction in the prevalence of medium-sized defects (9-13) and large defects (>13). The opposite was observed in group II.

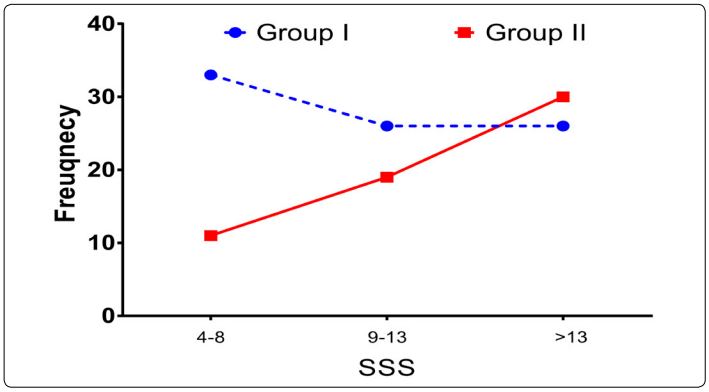

Figure 5: Frequency of Perfusion defect size and extent in studied groups

(3) Further analysis of this correlation had been done on CKD stage (Figure 6a) where: a) the statistical increase in the prevalence of perfusion defects with a rise in CKD staging (from 41.9% to 80.9%) (P<0.001). b) Similar observation of a statistical increase in the prevalence of the larger defects with the increase in CKD stage (P<0.0001).

(4) Impact of CKD stage on P.D. size in both groups: Figure (6 b and c) revealed a relation between the P.D. size and CKD stage in each group, where: a) Figure (6b) showed a statistically increase in the prevalence of P.D. size with an increase in staging in-group I (P<0.0001). b) Similarly, in group II (Figure 6c). c) In each stage of CKD, there is no statistical difference in the prevalence of patients in each defect size subgroup in either group I and II

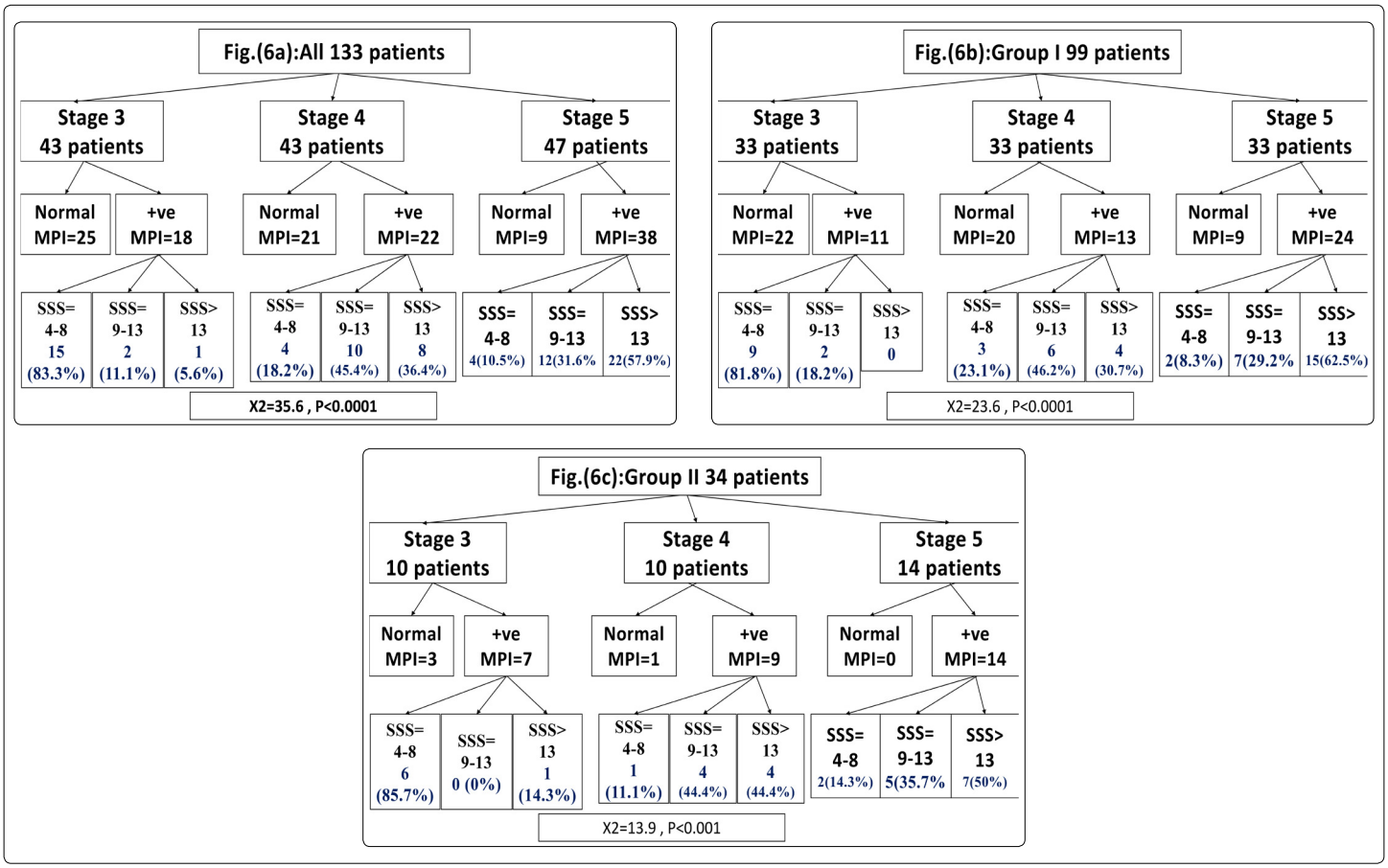

Figure 6: Impact of CKD Stage on the Perfusion defects in the Studied patients and their subgroups.

(5) Perfusion defects and CRP: Figure (7) showed statistically higher mean values of CRP in group I compared to group II in each perfusion defect size.

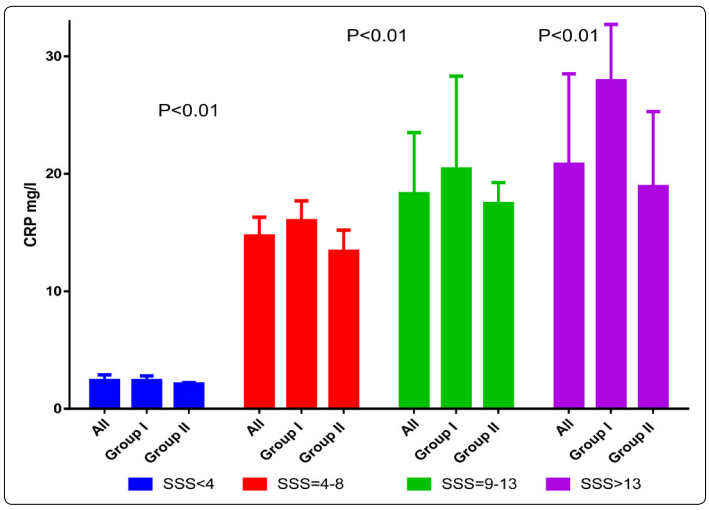

Figure 7: Comparision between mean values of CRP in both groups according to SSS score

(6) Table (4) revealed the distribution of the studied patients in both groups according to the degree of reduction in systolic function (E.F.), as there was no significant difference between both groups. However, in the same group, it had been noted that there was a marginal significantly higher prevalence of moderate to a severe reduction in E.F. in the symptomatic group (II) but not group I.

Table (4): Cardiac function of the studied patients:

	Group I (99) No.	%	P	Group II (34) No.	%	Total N0.	%
Normal	29/99	(29.3)	>0.05	10/34	29.4	39/133	29.4
Mild reduced	19/99	(19.2)	<0.05	1/34	2.9	20/133	15
Moderately reduced	12/99	(12.1)	<0.05	9/34	26.5	21/133	15.8
Markedly reduced	39/99	(39.4)	>0.05	14/34	41.2	53/133	39.8
Normal or mildly reduced	**48**	**(48.5)**	**X2=2.7**	**11**	**32.4**	**59**	
Moderate or markedly reduced	**51**	**(51.5)**	**P>0.05**	**23**	**67.6**	**74**	

(7) Impact of risk stratification on perfusion defect size:

a) Figure (8) revealed the followings: Low risk patients represent 42/133 (31.6%), 51 (38.3%) intermediate, and 40 (30.1%) high risk. Forty out of the 42 low-risk patients (95.2%) were a group I and 20/40 (50%) were positive for MPI versus none in group II (0/2) (P<0.01), Thirty-five out of the fifty-one (68.6%) intermediate-risk were a group I and 16/35 (45.7%) were positive for MPI versus 14/16 (87.5%) in group II (P<0.01), Twenty four (60%) of high-risk patients belonged to group I with 12/24 (50%) showed positive MPI versus 16/16 (100%) in group II (P<0.01). Each defect size subgroups showed insignificant change in either group I and II in each risk group.

Fig.(8a):Risk factors of studied groups

	Group I	Group II	P
Sex (Male%)	61/99 (61.6%)	21/34 (61.8%)	>0.05
HTN (%)	74/99 (74.7%)	24/34 (70.6%)	>0.05
DM (%)	33/99 (33.3%)	11/34 (32.3%)	>0.05
Smoking	18/99 (18.2%)	12/34 (35.3%)	>0.05
+ve FH of CAD (%)	27/99 (27.3%)	8/34 (23.5%)	>0.05
Dyslipidemia (%)	66/99 (66.7%)	24/34 (70.6%)	>0.05

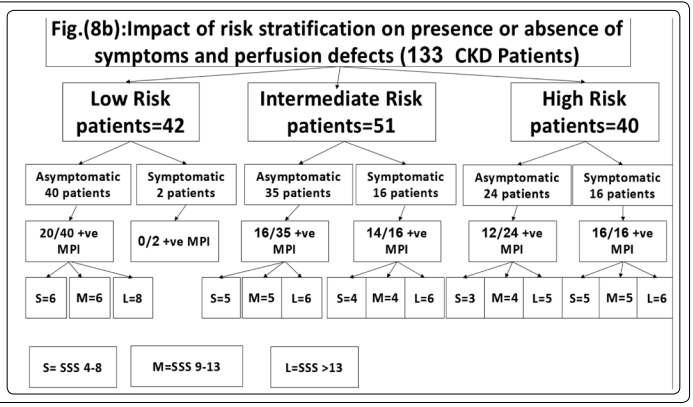

Figure 8: Risk Stratification of the studied patients according to the age (>50 years) and presence or absence of diabetes mellitus

b) Figure (9) revealed the most important risk factors contributing to positive MPI, whatever the defect size in CKD patients of all stages. The flow chart showed a statistical correlation between high CRP and positive MPI of different defect sizes where all

positive cases had elevated CRP. Most of the cases with any defect size in CKD 5 showed a statistical association with hypertension (HTN), left ventricular hypertrophy (LVH), diabetes mellitus (D.M.), and CRP. Similarly, cases of large defect size in both CKD stage 3 and 4. In the small defects subgroup of CKD 3, the fifteen cases showed a strong association of both HTN and D.M. as risk factors.

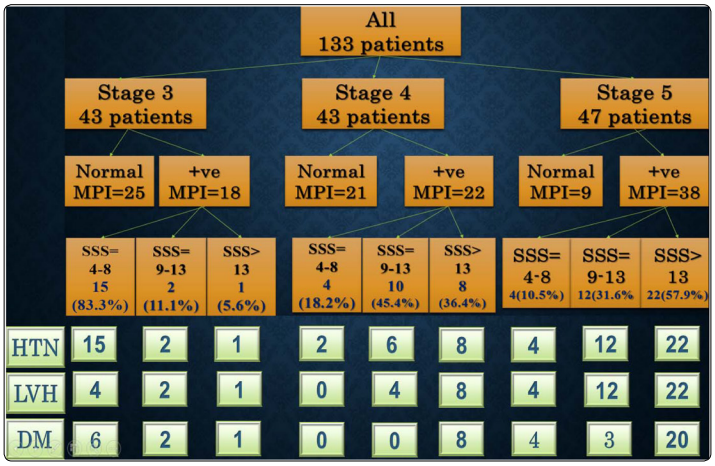

Figure 9: Impact of hypertension, left ventricular hypertrophy, diabetes mellitus and CRP on the presence or absence of the perfusion defects and their size

c) Stepwise regression had been done on two steps (Table 5): first step, any positive MPI with SSS >4, which revealed that in the presence of the insignificant age factor, D.M., LVH, and high CRP were the most critical deterministic factors (Table 5a). The second step for positive MPI with SSS > 9 where more prolonged hemodialysis, D.M., LVH, and high CRP was the most critical deterministic factors (Table 5b).

Table 5: Stepwise regression using all the available variables in two steps:
Table (5a): in the presence of all variables

Stepwise regression for SSS score >4:	
• Age	----------> P>0.05
• DM	----------> P<0.05
• LVH	----------> P<0.001
• High CRP	----------> P<0.0001

Table (5b): in the presence of SSS >9

Stepwise regression for SSS score >9:	
• Longer hemodialysis	----------> P<0.05
• DM	----------> P<0.05
• LVH	----------> P<0.001
• High CRP	----------> P<0.0001

Discussion

The current study revealed the high correlation between the staging of CKD and the prevalence of coronary artery disease. The higher the stage, the higher the prevalence of coronary artery disease (CAD), and the higher the SSS score. In addition to, higher prevalence of asymptomatic CAD in CKD5. Findings are similar to several reports which mentioned the long association of all-cause mortality, cardiac mortality, and prevalence of cardiovascular disease with a decrease in renal function as measured by the estimated glomerular filtration rate (eGFR) [1, 7, 16, 17].

Because of the inability to achieve maximal exercise in a considerable percentage of this kind of patients, the current study used pharmacologic coronary vasodilation with dipyridamole. Most of the limiting factors are aging, sedentary lifestyle, the complication of CAD, and/or peripheral artery disease [18].

Pathophysiological changes in cardiovascular microcirculation in CKD:

Go et al. (2004) reported the role of renal dysfunction in the atherosclerotic process of the coronaries. They added the synergistic effects of both the renal and cardiac failure to get poor outcome [19]. Several studies reported the controversy between the preservation of the coronary flow reserve in CKD patients and the increase of myocardial perfusion at rest, with its correlation with eGFR in mild CKD patients [7, 20].

On following early CKD (mild and moderate) for one year, Charytan et al., 2010 explained the drop in CFR by factors such as age and high body mass index but not the concomitant decline in peak coronary vasodilator function. They attributed that for an increase in myocardial work and resting blood flow in CKD due to the rise in blood pressure and age, resulting in a drop in glomerular filtration rate, and accordingly impair peak hyperemic blood flow [21-23].

Fukushima et al., (2012), did their work on early CKD patient (3 and 4) with normal coronaries but proved endothelial dysfunction to be the cause of reduced flow reserve [7]. This dysfunction causes impairment in vascular tone regulation, which predisposed atherosclerosis and, consequently, regional perfusion deficits. Besides, multiple prior studies reported the impact of the endothelial dysfunction in groups with individual cardiovascular risk factors and how this dysfunction response to modification of these risk factors - an explanation to our findings of abnormal stress MPI and presence of asymptomatic CAD in CKD3 [24-26].

Al-Mallah et al. added a doubling of regional perfusion abnormalities in patients with CKD, compared with those without, besides the retaining of the abnormal scan its incremental value to predict adverse outcome [27]. Another study observed similar findings in less advanced renal dysfunction [28]. They disclosed the increased risk of adverse events in CKD patients, whatever their stage as long as they have abnormal results on SPECT MPI. The current study confirmed that and added the increased association of abnormal MPI with increasing staging of CKD, remarking that Al-Mallah et al. study linked the magnitude of total

perfusion defect and ischemia on MPI with worse outcomes after adjusting the GFR and ejection fraction [27].

On stage 5 CKD, there are three types of overload causing cardiomyopathy, 1) pressure overload as a results of hypertension and arteriosclerosis leading to concentric left ventricular hypertrophy (LVH) and 2) fluid overload as a result of anemia, in addition to 3) volume overload as a result of arteriovenous fistulas leading to left ventricular dilatation with LVH. All three types of overload will cause an increase in oxygen demand and small vessel coronary disease, which decreases oxygen supply [29]. These attribute results of the current study and explained the higher LVM index in the symptomatic group.

CKD and calcification score (CCS):

Comparing CCS and CAD existence in early CKD patients (3 and 4) and control (no CKD), statistically higher score, and a higher prevalence of CAD was in CKD cases [30, 31]. These studies recorded two sites of calcification in the vessel wall in ESRD cases; these are the media and intima. Calcification in the media occurs at the internal elastic lamina without macrophages and intimal hyperplasia. Meanwhile, the intimal calcification, which occurs in the coronary arteries, is usually associated with lipid-laden macrophages and hyperplasia, resulting in atherosclerosis. Yiu et al. 2013 added to the above data how those classes of CKD got more diffuse coronary calcification and a consequently more significant number of CAD. Accordingly, they declared the higher cut-off value of CCS to diagnose obstructive CAD in patients with CKD (3 and 4) than patients without significant CKD [32]. The current study confirmed these findings where the higher CKD stage, the more senior the prevalence of high CCS.

CKD and MPI:

Venkataraman et al. (2008) reported 85% myocardial ischemia in ESRD patients besides the drop in left ventricular ejection fraction below 40% in 30% of cases [33]. Forty percent of their patients had multivessel. The current study revealed 68.5% of positive MPI in all patients of CKD and nearly 81% in ESRD. Also, the present study showed 70.5% reduction in LVEF, with 39.7% of them had marked reduction. On the contrary, Robalo 2014 reported a lower incidence of positive MPI (22.3%) in ESRD patients, attributing that for technical factors such as attenuation correction [34].

Risk stratification:

Patients with CKD have several concomitant diseases, which makes it challenging to separate the impact of CKD on vascular pathophysiology. A previous study reported the statistically higher prevalence of cardiac death in CKD patients with normal stress MPI than in non-CKD patients (2.7% vs. 0.8%, $p < 0.0001$). Similarly, the major cardiac event rate (13% vs 1.1%, $p < 0.001$) [35]. On the other hand, Hakeem et al. (2014) added a higher risk of cardiac death more than five times in those with high SSS [36]. That is why stress MPI had been used for risk stratification in CKD. According to several studies, there was a strong association between the high SSS and greater degrees of renal dysfunction (on one side) with higher risks of cardiac complications (on the other side) [19, 27, 37].

Accordingly, we studied the Stepwise regression of SSS more than four generally. We found that age-based selected cases had the most important predictors were DM (similar to Ragosta 2004, and Bourque and Beller, 2011 who reported higher cardiac events in diabetic patients), LVH (similar to Franczyk-Skóra et al., 2014) and elevated CRP (similar to Stenvinkel et al., 2003 who suggested great association between the reduction of renal function and the inflammatory response) [33, 37, 38]. On the other hand, Venkataraman et al. reported the poor prognosis of the more extensive stress defect size in patients on long-term hemodialysis. The current study confirmed this fact by doing Stepwise regression of SSS more than nine and revealed replacement of the age base selection of cases by longer hemodialysis irrespective of age, with more association of the inflammatory process (high CRP) and volume overload causing more LVH. Sarnak et al. attributed the impact of dialysis on defect size of MPI by both aortic compliance reduction combined with elevated pulse pressure with a consequent rise in systolic blood pressure, LVH, and drop in coronary perfusion [28]. Franczyk-Skóra et al., 2014 added that higher left ventricular muscle mass in dialysis patients compared to CKD stage II subjects [38]. The current study confirmed this information where 72/78 (92.3%) of the patients with positive MPI had hypertension (HTN) [with 100% of CKD5 had HTN], LVH in 57/78 (73.1%) [100% of CKD5 had LVH] (Fig. 9).

Figure (9) summarized risk stratification using defect size in different CKD stages in the flow chart, where the prevalence of higher SSS increased with an increase in CKD stage [39, 40]. It revealed the higher SSS score the more association of HTN (91.3% vs 92.7% in SSS >4 but <9 and >9 respectively), LVH (34.8% vs 89.1%). It should be noted that the high prevalence of HTN in CKD5 may be the main cause of asymptomatic ischemia. One of the notorious observations of the current study is the presence of high CRP in all cases with SSS > 4. Several reports explained this observation by considering CRP is part of both the immune response within oxidized LDL and decreases eNOS expression and bioactivity in human aortic endothelial cells [41]. Also, the current study revealed that the numeric value of CRP was statistically higher with a higher SSS score (that is why it was considered deterministic value for the SSS >4 in stepwise regression).

Conclusion

Radionuclide myocardial perfusion stress-rest gated SPECT/CT protocol can be used as the test of choice in the assessment of chronic kidney disease patients during their management and before proceeding to any surgical procedures. The current study revealed the acceleration of coronary artery disease pathogenesis in in early stages of chronic renal impairment especially in diabetic and hypertensive patients.

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