

## Prevalence of Subclinical Peripheral Vascular Disease in Obese Egyptian Patients

### Abstract

**Objective:** To detect subclinical peripheral vascular disease in obese Egyptian patients and establish relations between obesity, metabolic risk factors, and PVD. **Methods:** This was a prospective case-control study including 100 obese patients (BMI >30) (G1). In addition, 100 age and sex matched non-obese healthy subjects as a control group (G2). Both groups were subjected to duplex ultrasound, Radionuclide muscle scan. Angiography was done for 17 patients. **Results:** The image pattern of <sup>99m</sup>Tc-MIBI muscles uptake was studied and perfusion reserve (PR%) was calculated in (G1) and (G2). Comparison between the two groups showed statistically significant difference ( $P < 0.001$ ) as regarding laboratory findings. Patients were categorized according to PR% into +ve for ischemia (mean PR% was  $28.4 \pm 20.3$ ) and -ve for ischemia (mean PR% was  $65.0 \pm 11.4$ ). Among (G1) 64 patients positive for ischemia by both PR% and Doppler, 36 patients were negative by Doppler and 22 of them were positive for ischemia by PR%. Angiography was done for 17 of them and proved ischemia in all of them. **Conclusion:** The Tc-99m sestamibi muscle scan can be used as a screening and diagnostic tool of preclinical atherosclerosis in obese patients.

**Keywords:** Obesity, Metabolic Syndrome, Peripheral Vascular Disease

### Introduction

Peripheral artery disease (PAD) is an atherosclerotic disease that affects approximately 12% of the adult population.<sup>[1]</sup> Intermittent claudication is a classical symptom of PAD; however, a vast of patients are asymptomatic or present with a typical leg pain. This range of clinical presentation may explain why only 25% of patients are diagnosed and treated for PAD. There is an increased risk for cardiovascular events, cerebrovascular events, and mortality with PAD. Early control of symptoms and aggressive risk factor modification are mandatory to reduce PAD progression and its cardiovascular risk.<sup>[2]</sup>

There is multiple risk factors lead to the development of PAD; many are similar to atherosclerosis. The most common risk factors are old age, smoking, diabetes, dyslipidemia, and hypertension. Other risk factors associated with an increased risk of PAD include a family history of cardiovascular diseases, male gender, race, renal medical disease, metabolic syndrome (MS), abnormal increase of C-reactive protein, and homocysteine levels.<sup>[1]</sup>

The clinical presentation of PAD ranges from asymptomatic to marked ulceration and gangrene. The most common characteristic of PAD is pain in the lower extremities that increases with exercise and resolves with rest. The American College of Cardiology and American Heart Association (ACC/AHA) Guidelines estimate 20-50% of patients with PAD are asymptomatic.<sup>[3]</sup> These patients do not have clear symptoms, but most probably have functional impairment.

Patients with risk factors for PAD should undergo screening. Self-reporting of symptoms is not reliable and mostly relying on the classic claudication symptoms could miss the diagnosis of PAD in up to 75% of patients. Therefore, screening is critical for early detection to prevent disease progression. For these patients, an ankle-brachial index (ABI) should be performed at least every 5 years, if the results are normal.<sup>[4]</sup>

Duplex has a major role in evaluation and screening for early PAD to diagnose anatomic location and degree of stenosis. Duplex scanning can directly visualize

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vessels, providing information on arterial wall thickness, degree of flow turbulence, and changes in blood flow velocity.<sup>[5]</sup> Other techniques have been used to evaluate and detect PVD, including MR imaging and CT angiography.<sup>[6,7]</sup>

Nuclear imaging approaches reveal high sensitivity and, when applied with biologically targeted radiotracers, show new methods for the investigation of PVD, with integration of perfusion and evaluation of tissue oxygenation, metabolism, and angiogenesis.<sup>[7]</sup>

Although providing higher sensitivity, also show lower spatial resolution when compared with CT and MR. Impaired lower extremity perfusion is a key pathophysiologic mechanism that results into the complications associated with PVD,<sup>[8]</sup> making evaluation of perfusion an important tool for assessment of disease progression and the effectiveness of treatment. Whole-body 201 Tl scintigraphy has been shown to be useful for evaluating abnormal perfusion in the lower limbs of PVD patients at rest and during exercise,<sup>[9]</sup> as well as in the detection of perfusion abnormalities in asymptomatic patients presenting with normal ankle-brachial indices.<sup>[10]</sup>

Tc-99m sestamibi has been used for detection of peripheral vascular disease by assessment of the perfusion reserve (PR) in the lower limbs.<sup>[11]</sup> Though its cellular uptake is proportional to the regional blood flow, it is also related to mitochondrial abundance and cellular viability.<sup>[12]</sup>

## Patients and Methods

### Study design and population

A case-control study was carried on 100 obese patients with or without D.M, HTN, hypercholesterolemia, and hypertriglyceridemia. In addition, 100 age and sex matched non-obese healthy patients were included and served as a control group.

*Inclusion criteria:* Obese patients (BMI > 30) with different age (more than 18) and sex groups were included in the study with or without MS. *Exclusion criteria:* Patients with known autoimmune diseases, CKD, or other debilitating diseases, patients' age less than 18 years, pregnant, or lactating females, and patients with muscle trauma or myositis or any muscle disease or patients with DVT were excluded.

Obesity was defined as follows:

BMI  $\geq 30$  kg/m<sup>2</sup> (WHO, 1998), Waist circumference (WC)  $\geq 94$  cm for men and  $\geq 80$  cm for women, WHR (waist hip ratio)  $\geq 0.90$  in men and  $\geq 0.85$  in women, and WHtR (waist height ratio)  $\geq 0.5$ .

MS was defined according to the Third Adult Treatment Panel of the National Cholesterol Education Program, as the presence of at least three of the following criteria, with or without diabetes: Central obesity (waist circumference in men > 102 cm and in women > 88 cm), hypertriglyceridemia ( $\geq 150$  mg/dl), low HDL (men < 40

mg/dl, women < 50 mg/dl), elevated fasting glucose (> 110 mg/dl), and hypertension ( $\geq 130/85$  mmHg).

### Data collection

Data were collected for all patients and control subjects from the out-patient clinic of the Nuclear Medicine Department, Kasr El-Aini Hospital, Cairo University, during the period of April 2014 till December 2015. The protocol of the study was approved by the ethical committee.

All patients and controls were subjected to full history taking including age, sex, smoking history, history of present illness and clinical examination including measurement of blood pressure, body weight measurement using the body weight scale, and height measurement using the standing height scale; body mass index (BMI) was calculated according to the following formula:

BMI = Body weight (kg)/Height (m<sup>2</sup>) (The Quetelet Index).

Waist circumference measurement was taken using an inelastic tape and was taken after expiration at the level of mid-distance between the bottom of the rib cage and the top of the iliac crest; hip circumference measurement was taken using an inelastic tape at the level of the major trochanter.

WC, WHR, and WHtR parameters were used as measures of abdominal obesity. WHR was calculated by dividing WC in centimeter (cm) by hip circumference in cm, and WHtR was calculated by dividing WC in cm by height in cm.

All patients and controls were subjected to laboratory work up by measurement of fasting blood sugar (FBG), Serum triglycerides (TG), Serum high density lipoprotein (HDL), C-reactive protein, and urine analysis for microalbuminuria.

### Duplex ultrasound

Duplex has an important role in evaluation and screening for early PAD and also to diagnose anatomic location and degree of stenosis. The correct approach is based on morphological evaluation (B-mode US) followed by the Doppler flowmetry with color.

Based on the established normal and abnormal features of spectral waveforms, a set of criteria for classifying diseased lower extremity arterial segments has been developed. Both the absolute velocity and velocity ratios (stenotic jet velocities to proximal velocities) are important diagnostically. Thus, both parameters should be used for assessing lower extremity arterial lesions.

### Radionuclide perfusion reserve muscle scan

Before administration of Tc-99m sestamibi for measurement of PR in lower limbs, each patient moved his/her right foot to produce maximal dorsal and plantar flexion 30-40 times in sitting position (exercising limb).

370 mBq (10 mCi) of Tc-99m sestamibi was injected through intravenous line at least 10 s before exercise termination. Posterior images of each calf were obtained

**Table 1: Comparison between G1 and G2 regarding PR%**

	Group 1 (n=50)		Group 2 (n=50)		P value
	N	%	N	%	
PR%					
+VE for ischemia	86	86.0	4	4.0	<0.001
-VE for ischemia	14	14.0	96	96.0	
PR%					
Mean ± SD	28.4 ± 20.3		65.0 ± 11.4		<0.001
Median	22.5		66.0		

10 min after injection. The images were acquired for 2 min using a rectangular, large field-of-view gamma camera (Phillips vertex plus) mounted with a low-energy, high-resolution collimator with a 20% energy window setting centered at 140 keV and a 256 × 256 matrix. The processing phase was done by drawing symmetrical and equal regions of interest (ROI) over both calves during rest and stress.

The total counts (Cts) in each (ROI) were obtained through a closed program inherent to the computer system. The percentage of increase of Cts in the exercising right calf was calculated, and the percentile increase obtained was considered as the PR using the following formula:

Perfusion reserve (%)

$$= \frac{\text{Cts in the exercising calf} - \text{Cts in the resting calf}}{\text{Cts in resting calf}} \times 100$$

### Statistical analysis

Pre-coded data were entered into the Statistical Package of Social Science Software program version 21 (SPSS) to be statistically analyzed.

Data were summarized using mean, standard deviation and median for quantitative variables, and frequency and percentage for qualitative ones.

Comparison between groups was performed using the independent sample t-test or Mann–Whitney test for quantitative variables and Chi square or Fisher’s exact test for qualitative ones.

P values less than 0.05 were considered statistically significant, and less than 0.01 were considered highly significant; correlation was done by using the Spearman correlation coefficient. Graphs were used to illustrate some information.

### Results

This study included 100 obese patients; their mean age was (44 ± 3.9) a group was formed of 90 females and 10 males, classified as Group1 (G1). In addition, 100 non-obese subjects with mean age (43.6 ± 3.6) and sex matched (90 females and 10 males) served as a control group, Group 2 (G2).

**Table 2: Comparison between ischemic (+ve by PR%) and non-ischemic (-ve by PR%) patients regarding different physical and clinical parameters among G1**

	PR%			P value
	+VE (n=86)	-VE (n=14)		
WC				
Mean ± SD	118.3 ± 14.0	115.6 ± 19.0		0.7
Median	120.0	110.0		
WHR				
Mean ± SD	0.98 ± 0.06	0.97 ± 0.08		0.8
Median	0.95	0.94		
WHtR				
Mean ± SD	0.73 ± 0.09	0.70 ± 0.09		0.5
Median	0.74	0.67		
BMI				
Mean ± SD	37.5 ± 6.1	35.0 ± 4.5		0.3
Median	36.0	35.0		
SBP				
Mean ± SD	145.0 ± 8.9	137.1 ± 7.6		0.04
Median	150.0	140.0		
DBP				
Mean ± SD	92.1 ± 9.1	85.7 ± 7.9		0.1
Median	90.0	80.0		
FBG				
Mean ± SD	102.5 ± 12.7	99.6 ± 12.1		0.7
Median	100.0	100.0		
S. TG				
Mean ± SD	476.0 ± 193.2	441.1 ± 266.8		0.6
Median	420.0	412.0		
S. HDL				
Mean ± SD	33.3 ± 7.1	28.6 ± 8.9		0.1
Median	33.0	29.0		
Microalbuminuria				
Mean ± SD	34.5 ± 41.8	37.7 ± 51.4		0.7
Median	24.0	26.0		
CRP				
Mean ± SD	6.6 ± 2.7	4.0 ± 1.5		0.009
Median	6.0	4.0		

The mean of the G1 and G2 BMI were (37.1 ± 5.9) and (23.3 ± 1.3), respectively. Ninety eight patients (98%) of obese patients were found to have MS.

Comparison between the two groups showed statistically significant difference (P < 0.001) as regarding (WC, WHR, WHtR, BMI, FBS, S-TG, S- HDL, blood pressure values, microalbuminuria, and CRP). Although HDL was significantly lower among G1 compared to G2 group, its mean value was (32.7 ± 7.5) in G1 and (48.3 ± 7.7) in G2 subjects.

For statistical analysis, patients’ categorization was performed according to PR% into +ve for ischemia (mean PR% was 28.4 ± 20.3) [Figures 2, 4 and 7] and -ve for ischemia (mean PR% was 65.0 ± 11.4) [Figure 1]. A total of 86/100 (86%) subjects were positive for ischemia among

**Table 3: Association between Doppler and PR% among G1 only**

	PR%				P value
	+VE for ischemia (n=86)		-VE for ischemia (n=14)		
	N	%	N	%	
Doppler					
+VE	64	74.4	0	0.0	<0.001
-VE	22	25.6	14	100.0	

**Table 4: Correlation of PR% with physical and laboratory parameters within G1 patients**

	PR%	
	R	P value
Age	0.010	0.943
WC	0.016	0.910
WHR	0.140	0.332
WHtR	-0.069	0.635
BMI	-0.167	0.246
SBP	0.003	0.983
DBP	0.013	0.931
FBG	0.164	0.254
S. TG	-0.064	0.660
S. HDL	-0.333	0.018
Microalbuminuria	-0.134	0.415
CRP	-0.506	<0.001

r = Spearman correlation coefficient, P = P value

G1 compared to 4/100 (4%) subjects in the G2 with highly statistically significant difference (P value < 0.001) [Table 1].

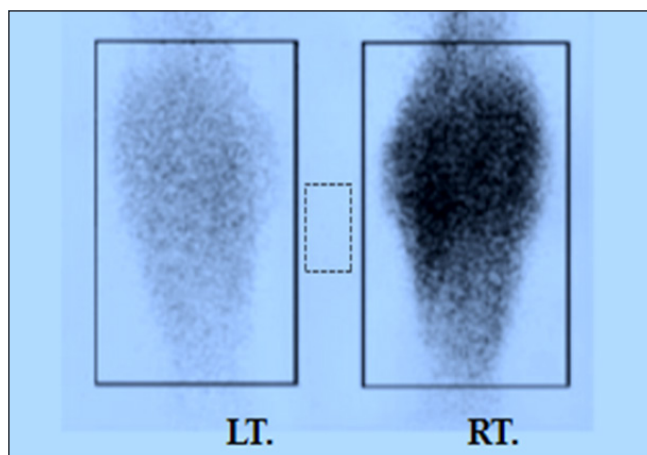
Regarding the Doppler findings, on performing this study, 64 cases out of 100 cases of G1 were positive for early ischemic changes (64%) by Doppler [Figure 3], whereas 36 were negative (36%), 22 of them were positive for ischemia by PR% [Figures 4, 5, 7 and 8], and 14 cases were negative by both Doppler and PR%. The four +ve cases detected by PR% among control subjects (G2) were also +ve for ischemia by Doppler.

**Screening analysis of PR% among G1 only regarding different parameters in the prediction of subclinical ischemia**

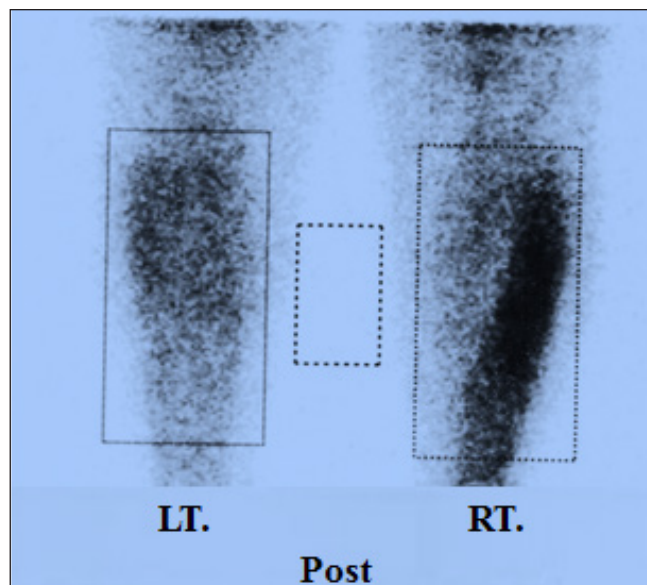
There is no significant difference regarding age and sex in the ischemic (+ve by PR%) and non-ischemic (-ve by PR%) patients among the group 1 patients; the mean age of ischemic patients was (44.1 ± 4.1), whereas the mean age in non-ischemic patients was (44.3 ± 2.9).

As shown in table 2, there is no significant association between the ischemic and non-ischemic groups regarding WC, WHR, WHtR, BMI, DBP, FBS, STG, SHDL, and Microalbuminuria, whereas SBP and CRP were significantly higher in ischemic patients rather than non-ischemic patients with P value (0.04, 0.009), respectively.

As regard to the association of MS with ischemic and non-ischemic patients, all ischemic patients had MS, whereas



**Figure 1:** Tc-99m sestamibi muscle scans of a control subject with (PR 64%) Case (1) Patient history: 40 years-old female subject from the control group, Physical parameters: WC=79 cm, WHR=0.77, WHtR=0.48, BMI =22.3, SBP/DBP = 110/80. Laboratory data: FBS= 92, STG= 132, SHDL=56, Microalbuminuria=13, CRP=0.8. Scintigraphic findings: After The patient moving her right foot with dorsal and plantar flexion 30-40 times in the sitting position (exercising side) the calculated PR% is 64%



**Figure 2:** Tc-99m sestamibi muscle scans in a patient with (PR 26%) Case (2) Patient history: 48 years old female patient. Physical parameters: WC=124 cm, WHR=1.01, WHtR=0.75, BMI =37, SBP/ DBP= 149/90. Laboratory data: FBS= 126, STG= 652, SHDL=34, Microalbuminuria=11, CRP=4. Scintigraphic findings: After the patient moved her right foot with dorsal and plantar flexion 30-40 times in the sitting position (exercising side) the calculated PR% is 26%

13 out of 14 non-ischemic patients also had MS .There is no significant association between MS and ischemia detected by PR%.

As shown in this table, ischemia detected by Doppler was significantly associated with ischemia screened by PR% with (P value < 0.001) [Table 3].

Angiography was done for 17 patients out of the 22 patients who were negative by Doppler but were positive by PR% and the angiography proved ischemia in all of them (true positive) [Figures 6 and 9], whereas five patients refused to do the study.



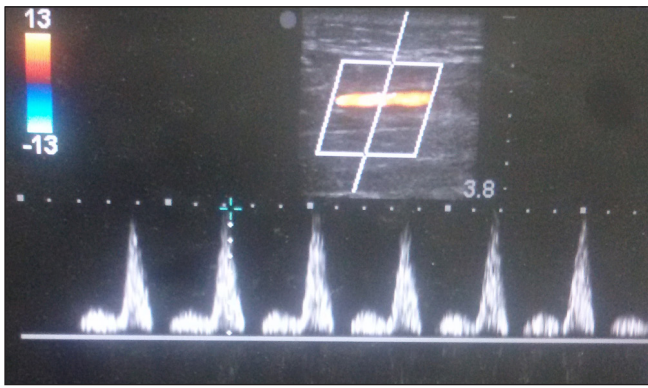


Figure 3: Mild stenosis of peroneal artery of case (2)

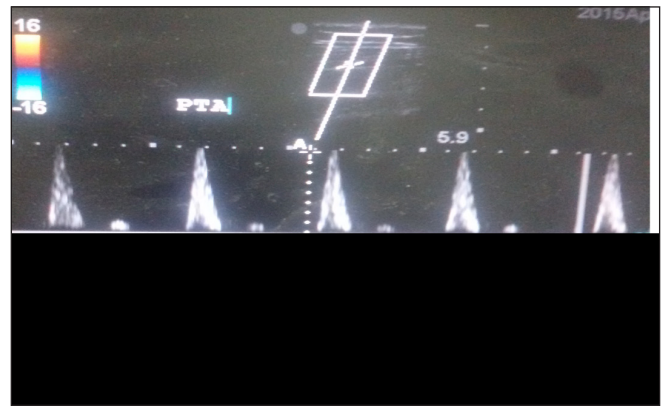


Figure 5: Normal triphasic Doppler wave forms in the posterior tibial artery of case (3) the peroneal artery is also normal

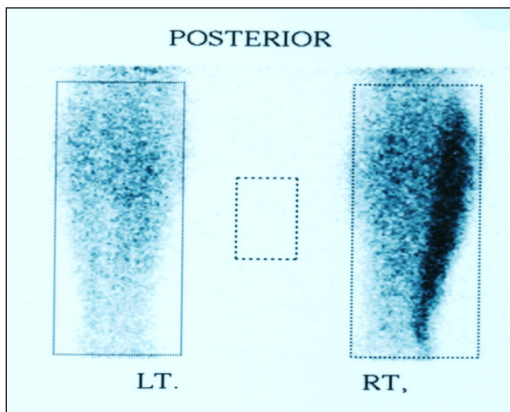


Figure 4: Case (3) Clinical background: Patient history: 52 years old male patient. Physical parameters: WC=142 cm, WHR=0.9, WHtR=0.961, BMI =50, SBP/DBP=160/100. Laboratory data: FBS= 86, STG= 468, SHDL=39, Microalbuminuria=114, CRP=8.9 Scintigraphic findings: After the patient moved his right foot with dorsal and plantar flexion 30–40 times in the sitting position (exercising side) the calculated PR% is 19%

Correlations were done between PR% and different physical and laboratory parameters in G1 patients using Spearman's correlation coefficient. All the correlations are detailed in Table 4. They were of no statistical significance except for (HDL and CRP).

## Discussion

Egypt is shown to be the 5th of the top ten fattest countries in the world, based on national health surveys compiled by World Health Organization (WHO) between year 2000 and 2008.<sup>[13]</sup>

Obesity is defined by a BMI  $\geq 30\text{kg/m}^2$ , whereas abdominal obesity or central obesity is defined as: waist circumference  $> 80$  cm in females and  $> 90$  cm in males. Also, central obesity (abdominal obesity) is measured by the waist-to-hip ratio (WHR) and the waist/height ratio (WHtR). Abdominal obesity has been found to be more related to MS risk factors than the BMI.<sup>[14]</sup>

Peripheral arterial disease (PAD) occurs when there is marked narrowing of arteries distal to the arch of the aorta, mostly due to atherosclerosis. Symptoms vary from calf

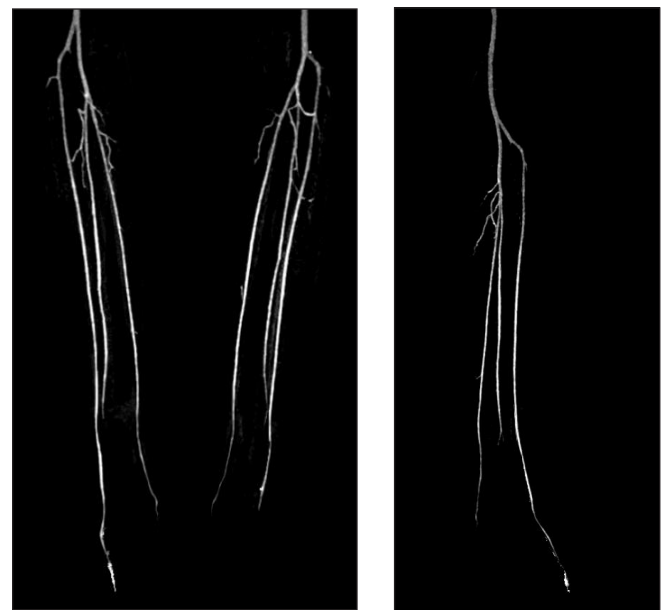
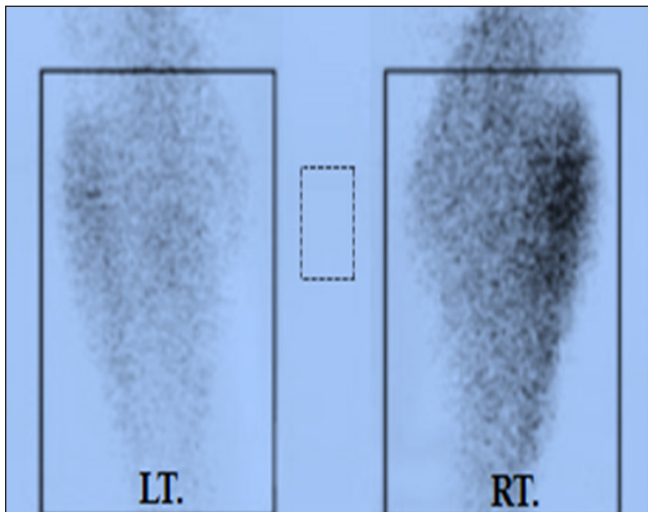


Figure 6: Multislice CT angiography of case (3) MIP (maximum intensity projection) image of the infra popliteal arteries showed mild atherosclerotic irregularities of the right posterior tibial artery with mild reduction of its caliber (Arrowed).The peroneal artery is spared

pain on exercise (intermittent claudication) to rest pain (critical limb ischemia), hair loss, skin ulceration, recurrent infections, and gangrene.

Various radio-tracer imaging techniques for noninvasive detection of arterial stenosis and for functional detection of diminished blood flow and follow-up have been developed during the last decade with the aim of replacing invasive techniques and complementing other standard methods. The measurement of arterial blood flow and muscle perfusion is used to show the morphology and to estimate the functional consequences of PVD.<sup>[15]</sup> Scintigraphic measurement of muscle perfusion should detect insufficient blood flow in peripheral muscle and thus reflect a high specificity for detection of PVD.<sup>[16]</sup>

In the current study, we attempted to detect subclinical peripheral vascular disease in obese Egyptian patients and



**Figure 7: Case (4) Patient history: 50 years old female patient. Physical parameters: WC=120 cm, WHR=1.05, WHtR=0.74, BMI =33, SBP/DBP=140/100. Laboratory data: FBS= 89, STG= 556, SHDL=38, Microalbuminuria=33, CRP=13. Scintigraphic findings: After the patient moved her right foot with dorsal and plantar flexion 30–40 times in the sitting position (exercising side) the calculated PR% is 30%**



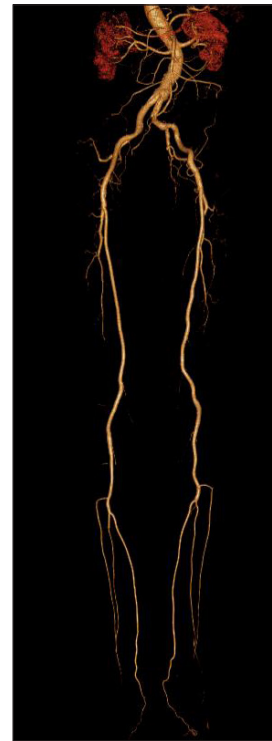
**Figure 8: Normal arterial duplex of case (4) Angiographic findings**

establish relations between obesity, metabolic risk factors, and peripheral vascular disease. In the current study, we included 100 obese (G1) patients with mean age ( $44 \pm 3.9$ ), a group formed of 90 females and 10 males. In addition, 100 age ( $43.6 \pm 3.6$ ) and sex (90females and 10 males) matched non-obese subjects served as a control group (G2).

The mean BMIs of G1 obese patients and G2 were ( $37.1 \pm 5.9$ ) and ( $23.3 \pm 1.3$ ), respectively.

Comparison between the two groups showed statistically significant difference [ $P < 0.001$ ] regarding WC, WHR, WHtR, BMI, FBS, S-TG, S- HDL, blood pressure values, microalbuminuria, and CRP.

In our study, most of G1 patients were detected to have PVD either by PR%, Doppler, or by angiography.



**Figure 9: Multislice CT angiography 3D images of both lower limb arteries showed diffuse mild stenosis of the right peroneal artery compared to the left side (Arrowed) sparing the posterior tibial artery**

In concordance with our results regarding physical parameters of the obese patients associated with PVD, Planas *et al.* mentioned that PAD was correlated with the waist–hip ratio, but it was not correlated with the BMI. So that the BMI is not a proper indicator of obesity in subjects  $\geq 60$  years old, because of loss of lean body mass, the BMI can remain constant or even decrease although adipose tissue increase.<sup>[17]</sup>

In Ix *et al.* study, in a large sample of old people with good health status and non-smokers, the greater BMI in middle age and in older age were associated with PAD incidence and prevalence.<sup>[18]</sup>

In a study done in Belgrade, patients with PAD had mean BMI about  $26.0 \text{ kg/m}^2$ , mean body fat about 29.0%, and mean waist circumference about 92.0 cm in women and 98.0 cm in men, though general obesity, abdominal obesity, and percent of body fat were not correlated with the severity of PAD.<sup>[19]</sup>

In our study, SBP, DBP, FBS, and sTG were significantly higher among G1 patients compared to G2 subjects, with mean values of ( $143.9 \pm 9.1$ ), ( $91.2 \pm 9.2$ ), ( $102.1 \pm 12.5$ ), ( $471.1 \pm 202.2$ ) for G1, and ( $113 \pm 10.4$ ), ( $71.8 \pm 9.4$ ), ( $93.1 \pm 12.1$ ), ( $151.3 \pm 31.6$ ), respectively, for G2. HDL was significantly lower among G1 patients ( $32.7 \pm 7.5$ ) compared to G2 subjects ( $48.3 \pm 7.7$ ). We also found that among G1 patients there is no significant association between the ischemic and non-ischemic

patients regarding WC, WHR, WHtR, BMI, DBP, FBSs TG, SHDL, Microalbuminuria, whereas SBP and CRP were significantly higher in ischemic patients rather than non-ischemic patients with *P* value (0.04, 0.009), respectively.

Ylitalo *et al.* stated that individuals with PVD were more likely to be older, to be women, to be African American or black. They had higher waist circumference, BMI, glucose, and systolic and diastolic blood pressure with a greater prevalence of diabetes and hypertension that is in concordance with our study.<sup>[20]</sup>

A few studies have investigated the potential role of skeletal muscle imaging with <sup>99m</sup>Tc-MIBI in the assessment of peripheral vascular disease.<sup>[21]</sup>

Kusmierek *et al.* studied scintigraphic assessment of segmental blood supply of thigh and calf muscles using <sup>99m</sup>Tc-MIBI as a radiopharmaceutical, in early stages of atherosclerosis revealed during duplex examination of lower limbs, in patients without typical clinical symptoms of chronic ischaemia of lower limbs and with normal Doppler arterial flow. Moreover, basic relations between early signs of lower limb atherosclerosis and abnormal myocardial perfusion, as well as asymptomatic hypoperfusion of lower limbs, were analyzed. Statistical analysis showed that in the group of patients with atherosclerotic changes, mean values of stress and rest perfusion indices of thighs as well as calves were statistically significantly lower (*P* < 0.001) than in the control group.<sup>[22]</sup>

In our study, an alternative look was considered when we use the ratio of counts between both lower limbs, with one limb exercising only to calculate PR%, and our findings according to PR% divided the patients into either +ve for ischemia or -ve for ischemia. A total of 86/100 (86%) subjects were positive for ischemia among G1 compared to 4/100 (4%) in the G2 with highly statistically significant difference (*P* value < 0.001), 64/100 subjects (64%) were positive for early ischemic changes by Doppler among G1, whereas 36/100 (36%) subjects were negative for early ischemic changes, 22 of them were positive for ischemia by PR%, whereas 14 cases were negative by both Doppler and PR%.

Some authors adopted a concept that the Tc-99m sestamibi lower limb muscle scan is an important technique that can be used to diagnose preclinical atherosclerosis; also it has a role as a screening tool considering the fact; whenever the diagnosis results in better result.

Amr Amin *et al* <sup>[23]</sup> used the Tc-99m sestamibi muscle scan to investigate the prevalence of preclinical atherosclerosis in RA patients by PR measurement.

A significant difference was found between the means of PR in RA and controls (30.7 ± 22.6% vs. 48.3 ± 27.2%, *P* = 0.015). The previous study was in an agreement with our study regarding the mean value of PR% in cases

and control groups (28.4 ± 20.3% and 65.0 ± 11.4%), respectively. The comparisons between the PRs of the two groups were statistically significant (*P* < 0.001).

Also Celen *et al.* investigate the microvascular pathology in the lower limbs of diabetic patients without symptoms or findings of peripheral ischaemia by measuring PR scintigraphically. A significant difference was found between the PRs of the diabetic and control groups (*P* < 0.001) that were close to our result, so the main advantage of PR% in their study is determining microvascular pathology in the lower limb muscles in diabetic patients.<sup>[21]</sup>

In our study, ischemia detected by Doppler is significantly associated with ischemia screened by PR% with (*P* value < 0.001).

Angiography was done for 17 patients out of the 22 patients who were negative by Doppler, and they were positive by PR% and angiography was positive for ischemia in all of them (true positive) while five patients refuse to do the study. Thus, our findings revealed that the Tc-99m sestamibi lower limb muscle scan is an important technique that can be used to diagnose preclinical atherosclerosis as well as a screening tool.

Also, the study of Rashid Rasheed was done to evaluate the clinical utility of <sup>99m</sup>Tc-MIBI lower limb muscle perfusion single photon emission tomography (SPECT) for detection and followup of PAD; he stated that the <sup>99m</sup>Tc-MIBI lower limb muscle perfusion scan is an important tool for detection and followup in PAD and may be used as a baseline tool for evaluation of patient followup post-treatment. Comparison of patient SPECT data with normal population showed significant hypoperfusion of lower limbs in terms of counts (*P* value < 0.001). Comparison of SPECT study with other modalities revealed higher sensitivity than duplex ultrasound (*P* value < 0.05) and ABI (*P* value < 0.001).<sup>[24]</sup>

On the other hand, Miles *et al.* used leg muscle scintigraphy with the <sup>99m</sup>Tc-MIBI in the assessment of peripheral vascular (arterial) disease. There was a significant difference in MIBI uptake in the calf (*P* < 0.000 01) and thigh (*P* < 0.0001) between patient and control groups on exercise. They mentioned that this technique can also effectively evaluate the severity of disease as shown by significant correlations between exercise calf flow and angiographic severity (*P* < 0.05) and Doppler, ankle/arm pressure measurements (*P* < 0.0005).<sup>[25]</sup>

## Conclusion

So, we can conclude that the TC99m MIBI muscle scan and calculating PR% is considered a useful tool in early diagnosis of subclinical ischemia and if PVD-established followup is helpful to monitor the disease behavior and effectiveness of the treatment and if combined with SPECT



images, more advantages can be reached over other diagnostic modalities.

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### Conflicts of interest

There are no conflicts of interest

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