**CARDIOLOGY, ORIGINAL ARTICLE**

# Myocardial Stunning During Gated Spect Indicates Presence of Severe Coronary Artery Disease

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## ABSTRACT

Transient left ventricular dysfunction is known to occur in patients following stress in coronary artery disease [CAD]. Also known as myocardial stunning, it is a transient phenomenon occurring during myocardial ischemia after treadmill exercise or pharmacological stress. Our aim was to show that myocardial stunning observed during gated SPECT [GSPECT] is a powerful indicator of severe CAD.

**Patients and methods:** Sixty two patients with chest pain underwent two days stress/rest Tc-99m-Tetrofosmin GSPECT studies. Using a twenty segment, five point scoring model, summed stress score [SSS], summed rest score [SRS] and summed diffence score [SDS] was calculated for severity of perfusion defects. LV function parameters were evaluated by calculating LVEF and performing visual analysis of regional wall motion [RWM] and regional wall thickening [RWT] after stress and rest. Results of perfusion were classified into severely ischemic [SDS>6], mild to moderately ischemic [SDS 2-6] and normal perfusion [SDS0-1] groups.

**Results:** In the patient group who showed severe ischemia [SDS>6] on the perfusion study also showed significant fall of mean global LVEF values with RWT and RWM abnormalities in ischemic myocardial segments after stress on the GSPECT study when compared to patient groups with mild to moderate ischemia [SDS 2-6] and patients with normal perfusion [SDS 0-1].

**Conclusion:** Patients with features of myocardial stunning during gated SPECT are likely to have severe coronary artery disease and should be considered for early revascularization.

**Keywords: STUNNING, GATED SPECT.**

## INTRODUCTION:

Myocardial stunning is a transient impairment of left ventricular function observed in patients with myocardial ischemia after exercise or pharmacological stress. The results of some studies using imaging modalities that diagnose ischemia on the basis of transient development of regional wall motion abnormalities or fall in global LVEF suggest that ischemic LV dysfunction manifested by global depression of LV function resolves rapidly, whereas the results of other studies indicate that regional LV dysfunction may persist[1]. Good agreement exists between the severity of ischemic perfusion pattern and LVEF degradation at stress, which is consistent with previously published data using Tc99 (m) GSPECT[2]. Post exercise wall motion abnormality (WMA) in patients with normal resting myocardial perfusion may represent prolonged post ischemic stunning, and may be related to the presence of severe angiographically confirmed coronary artery disease (CAD). WMA detected by gated Tc-99m sestamibi SPECT in patients with normal resting perfusion is a sensitive marker of severe and extensive CAD [3].

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## AIM AND OBJECTIVES

Our study was designed to look for global changes in LVEF and wall motion abnormalities [WMA] which occur during regional myocardial ischemia in patients undergoing stress myocardial perfusion scans. Because of the transient nature of these abnormalities imaging times of the patients were shortened to 30 minutes after stress since changes in LV function can resolve rapidly after stress induced ischemia. Our aim was to show that myocardial stunning occurs after stress in the presence of extensive and severe myocardial ischemia rather than mild to moderate ischemia.

## SUBJECTS AND METHODS

Sixty two patients [38 males, 24 females, mean age 47 yrs] were referred for chest pain evaluation. Exercise treadmill test was done in twenty three patients, Dipyridamole stress protocol in thirty five patients and Dobutamine stress protocol in four patients. GSPECT imaging was performed in all patients thirty minutes after stress and one hour after rest injection of Tc-99m-Tetrofosmin using a two day stress/rest Tc-99m-tetrofosmin protocol using a dual headed GE Millennium gamma camera. Scoring of perfusion was performed using a quantitative [automated] twenty segment myocardial model. Each of the twenty segments was scored for severity of perfusion reduction using a five point score ranging from 0[normal] to 4[absent] perfusion. Three representative short axis views are used for scoring as well as the vertical long axis view of the apex. The severity of perfusion defects was then calculated as Summed Stress Score (SSS) which is the sum of 20 segments at stress, Summed Rest Score (SRS) which is the sum of 20 segments at rest and Summed Difference Score (SDS) = SSS – SRS. SDS score of 0-1 was considered normal.SDS score of 2-6 was considered to be mild to moderate ischemia.SDS score >6 was considered to be severe ischemia.LV function [LVEF] and regional wall motion and regional wall thickening [RWM and RWT] were analyzed after stress and rest using quantitative[automated] QGSPECT. Student t test was used to determine statistical significance in global LVEF values after stress and rest separately in the severely ischemic group, mild to moderately ischemic group and normal perfusion group of patients.

## RESULTS

Seventeen patients were classified as a group belonging to severe ischemia [SDS>6] [plot1] and showed mean post stress LVEF values of 43.8±3.65 compared to rest values of 51.8±5.19 [$p<0.05$]. Twelve patients in this group also showed RWT and RWM abnormalities in ischemic myocardial segments at stress which were absent at rest [fig 1]. Twenty five patients were classified as a group with mild to moderate ischemia [SDS 2-6] [plot2] and showed mean post stress LVEF values of 50.8±8.8 versus mean rest values of 53±8.78 [$p>0.05$]. There were no RWT and RWM abnormalities visualized in the ischemic segments at stress when compared to the rest images **[Fig 2]** in this group. Twenty patients were categorized as a group with normal scans [SDS0-1][plot3] and showed mean post stress values of 63.8±7.31 as compared to mean rest values of 57.4±6.8 [$p<0.05$] **[Fig3]**. Coronary angiography was performed in all 17 patients in the severely ischemic group and 18 patients in the mild to moderate ischemic group within two weeks of the study. All patients in the severe ischemic [SDS>6] group showed extensive and severe double /triple vessel CAD. Eighteen patients in the mild to moderate ischemic [SDS 2-6] group showed moderate but less extensive CAD than patients with severe ischemia.

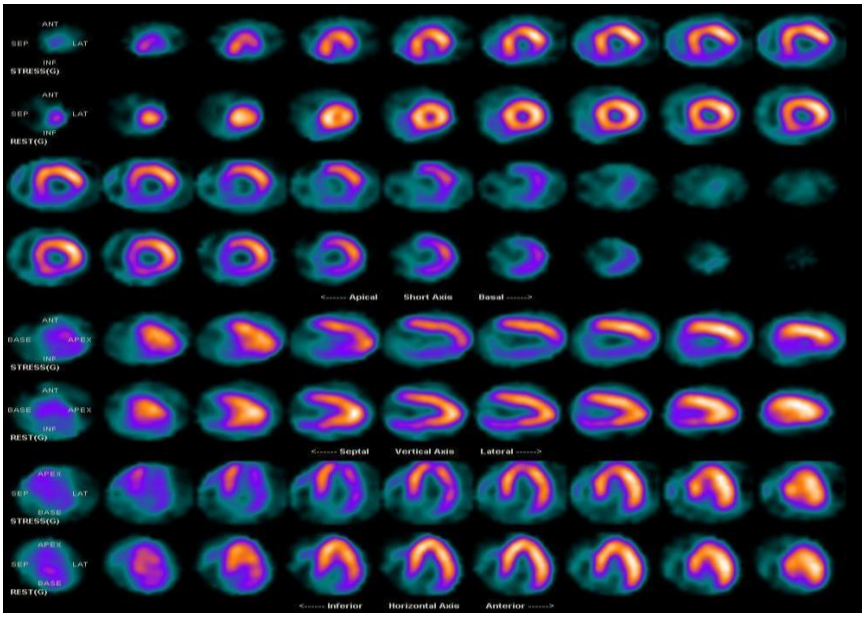


**Fig1 [a]:** shows a patient from the group with severe stress induced ischemia on inferolateral and Anteroseptal walls on stress and rest SPECT images

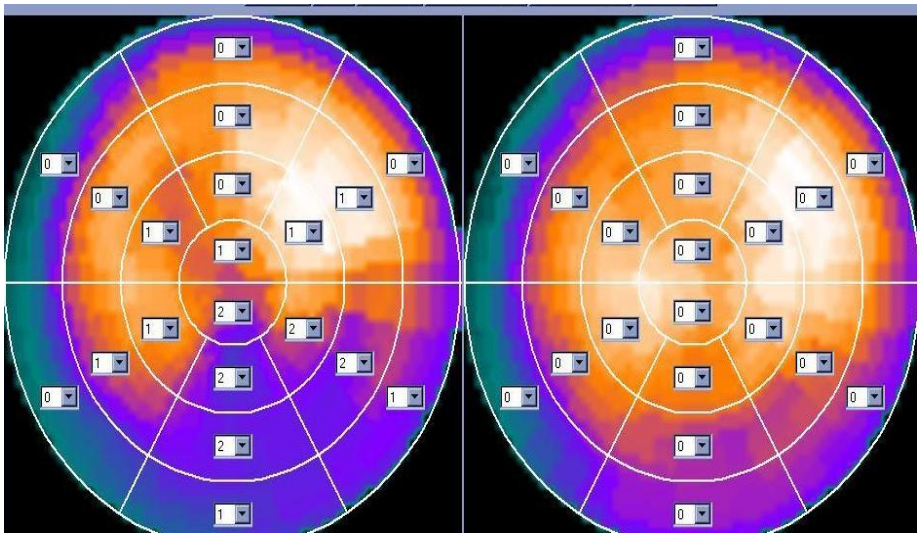

**Fig1 [b]:** 20 segment LV model of the same patient shows summed stress score [SSS] of 18 and summed rest score [SRS] of 0 amounting to summed difference score [SDS] of 18 which puts the patient in the severely ischemic group

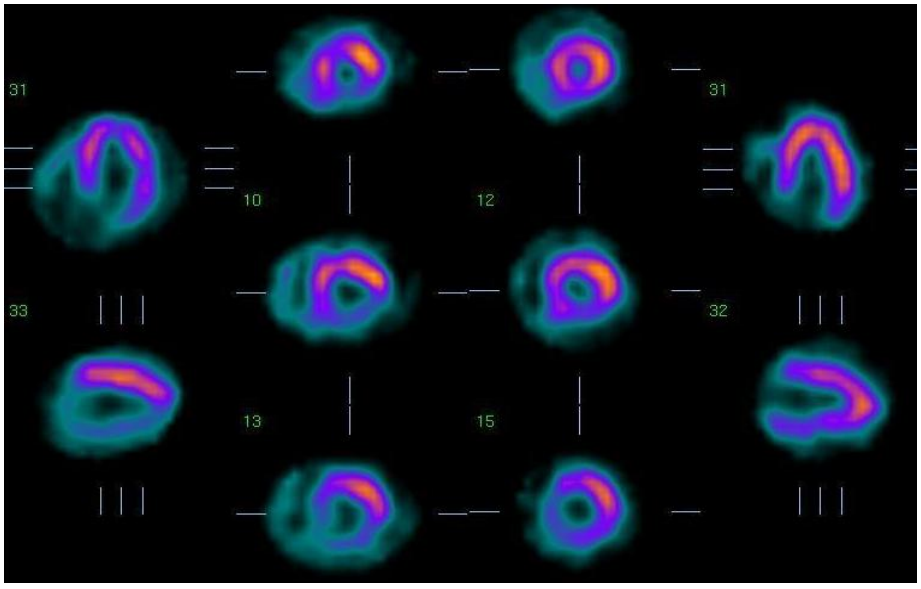


**Fig1 [c]:** [Quantitative gated SPECT [QGS] shows a post stress LVEF fall of 9% and hypokinesia of inferolateral wall at stress in the same patient indicating presence of myocardial stunning .

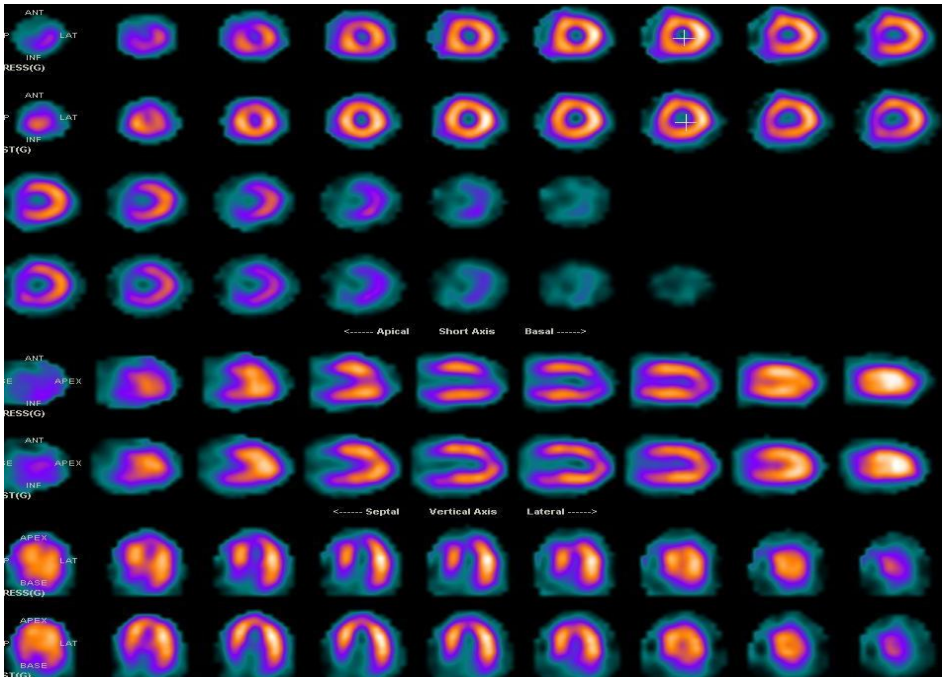


**Fig2 [a]:** Stress and rest images of a patient in the mild to moderate ischemic group showing mild to moderate ischemia on the Apico antero septal wall.

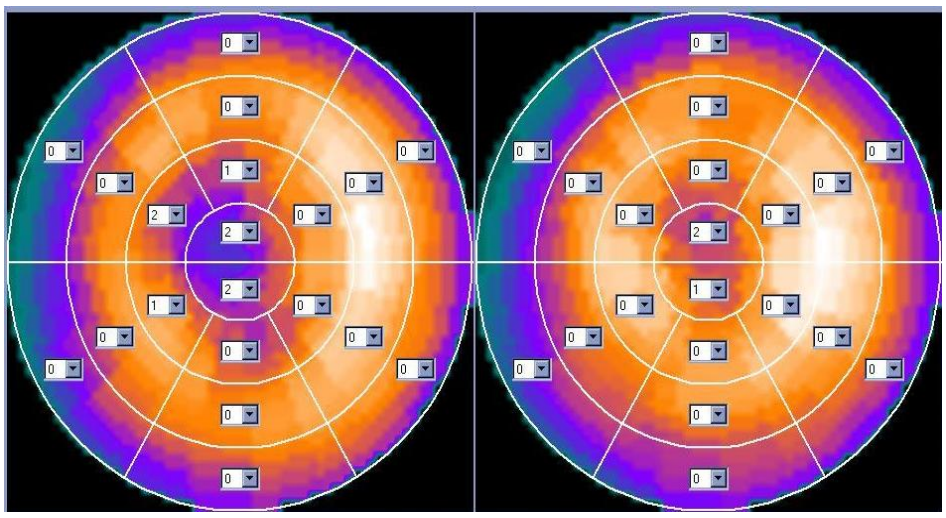

**Fig2 [b]:** 20 segment LV model of the same patient shows summed stress score [SSS] of 8 and summed rest score [SRS] of 3 amounting to summed difference score [SDS] of 5 which puts the patient in the mild to moderate ischemic group

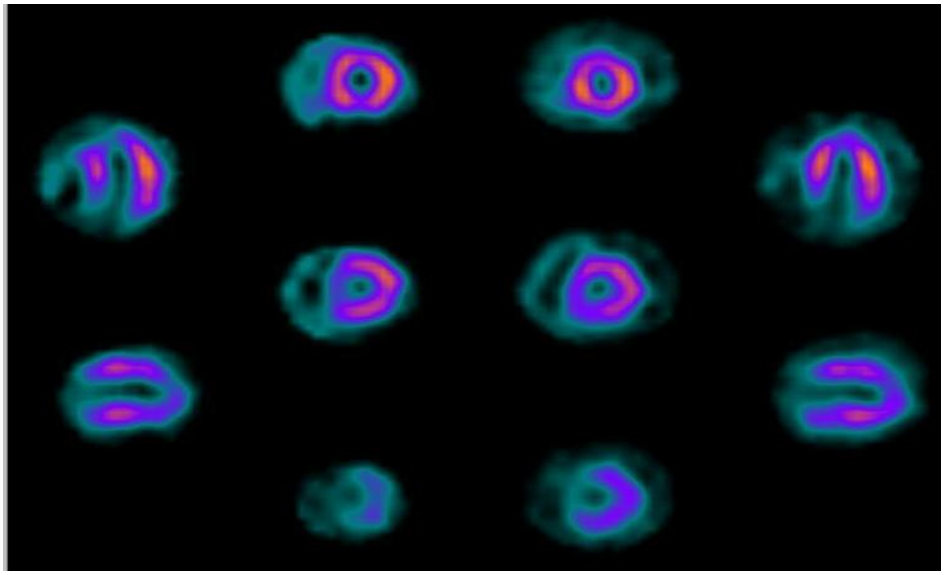

**Fig2 [c]:** QGS shows post stress and rest LVEF values of 47% and 48% respectively with no RWT/RWM abnormalities occurring at stress and rest in the same patient.

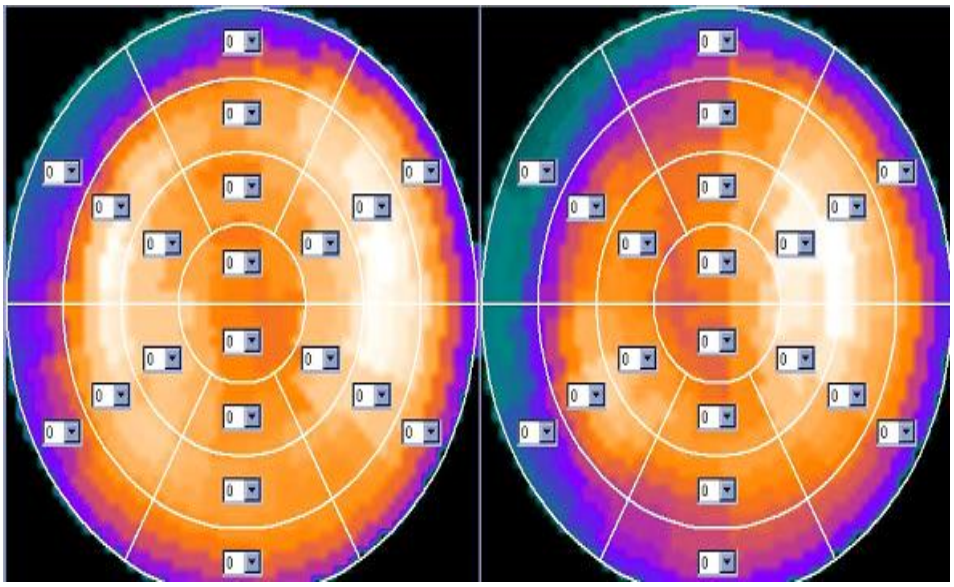

**Fig3 [a]:** 20 segment LV model of a patient shows summed stress score [SSS] of 0 and summed rest score [SRS] of 0 amounting to summed difference score [SDS] of 0 which puts the patient in the normal group

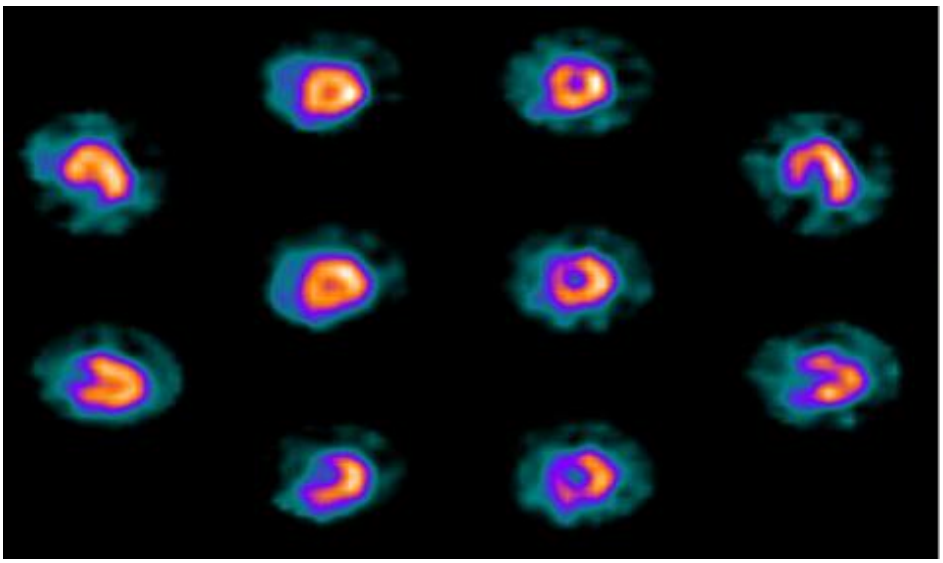

**Fig 3 [b]:** QGS shows an increase of 8 percentage points in post stress LVEF in the same patient.

## DISCUSSION:

Myocardial stunning is the reversible reduction of function of heart contraction [4] after reperfusion not accounted for by tissue damage or reduced blood flow.[5] After total ischemia occurs, the myocardium switches immediately form aerobic glycolysis to anaerobic glycolysis resulting in the reduced ability to produce high energy phosphates such as ATP and Creatinine Phosphate. At this point, the lack of the energy and lactate accumulation results in cessation of contraction within 60 seconds of ischemia (i.e. Vessel Occlusion). Subsequent to this is a period of "myocardial stunning," in which reversible ischemic damage is taking place. At approximately 30 minutes after the onset of total ischemia the damage becomes irreversible, thereby ending the phase of myocardial stunning. Hypoxia resulting from coronary occlusion is a major factor in cardiac stunning and infarct development[1]. When the ischemic myocardium is reperfused and oxygen reintroduced, there is a sudden burst of oxygen free radical production, particularly by neutrophils. This leads to the formation of other damaging reactive species such as hydroxyl radicals, hydrogen peroxide, and peroxynitrite. These reactive oxygen species damage cell membranes and impair cellular function. Reperfusion also upregulates the expression of endothelial and leukocyte adhesion molecules causing leukocyte adhesion to the vascular

endothelium, leukocyte activation, and leukocyte accumulation within tissues. Inflammatory mediators released by activated leukocytes result in further tissue damage and functional impairment. Studies have shown that inhibiting leukocyte adhesion or scavenging oxygen free radicals can reduce reperfusion-associated ventricular dysfunction, arrhythmias, and infarct size[7]. Ischemic stunning after dipyridamole stress gated SPECT may be an indicator of severe and extensive CAD[8]. The magnitude of transient wall motion abnormality after exercise was greater in patients with severe ischemia compared to those with mild to moderate ischemia. Significant correlation was found between SDS and transient wall motion abnormality after exercise.[9]. Worsening of LVEF at stress showed very high sensitivity and positive predictive values for coronary artery lesions of 70% or more in one or more vessels using thallium-201 gated SPECT [10]. No significant LVEF difference between stress and rest was seen in patients with ischemia who did not have stunning [transient ischemic stunning or TIS] using Tl-201 gated SPECT[11]. Post stress RWMA and ischemia by perfusion were the most powerful predictive parameters of cardiac events. Patients with myocardial stunning should be referred for early revascularization[12].

Our results showed significant post stress fall of LVEF in presence of severe myocardial ischemia [SDS>6].However RWM and RWT abnormalities were seen in fewer number of patients at stress compared with rest in the the same group of patients. LV function degradation was insignificant at stress in patients with mild to moderate ischemia [SDS 2-6]. Patients with normal scans showed significant rise in LVEF values at stress compared to rest .All patients with severe ischemia [SDS>6] and myocardial stunning had extensive double and triple vessel CAD on angiography. Less extensive CAD was seen in patients with mild to moderate ischemia [SDS 2-6] on coronary angiography. In a landmark study, Hung et al showed the value of ischemic stunning after dipyridamole stress gated SPECT in the detection of severe and extensive CAD[8]. In another study by Tanaka et al (2005) noticed that the magnitude of transient wall motion abnormality after exercise was greater in patients with severe ischemia compared to those with mild to moderate ischemia and significant correlation was found between summed difference score [SDS] and transient wall motion abnormality after exercise[9]. An interesting finding by Heiba et al (2002) they found no significant difference between stress LVEF and rest LVEF in patients with ischemia who did not have myocardial stunning[11]. Petex et al showed in a landmark study that post stress RWMA and ischemia by perfusion were the most powerful predictive parameters of cardiac events and patients with myocardial stunning should be referred for early revascularization[12]. Our results showed that in the patient group with severe myocardial ischemia there was significant post stress fall of LVEFand RWM and RWT abnormalities in ischemic myocardial segments. In patients group with mild to moderate ischemia [SDS 2-6] comparison of stress and rest LVEF showed no statistical significance. None of patients in this group showed any RWM or RWT after stress either. All patients in the severe ischemia group [SDS>6] showed presence of myocardial stunning and were found to have extensive double and triple vessel CAD on angiography. Less extensive CAD was seen in patient group with mild to moderate ischemia [SDS 2-6] on coronary angiography. None of the patients in this group showed evidence of stunning. In view of coronary angiographic findings it is clear that myocardial stunning is a feature of severe rather than mild to moderate CAD. In patient group with normal scans mean LVEF values were significantly higher at stress compared to rest. This is an expected finding in patients who are normal or disease free as a physiological response to stress

## CONCLUSION

Myocardial stunning is probably induced by severe rather than mild to moderate myocardial ischemia following exercise and pharmacological stress. Patients with features of myocardial stunning during gated SPECT are likely to have severe coronary artery disease and should be considered for early revascularization

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