Editorial

Myocardial ^{99}Tc - MIBI washout

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Ischemic Heart Disease is defined as 'myocardial impairment due to an imbalance between coronary blood flow and myocardial requirements caused by changes in the coronary circulation[1]. Coronary artery disease is thought to arise from normal repair processes in response to chronic injuries to the arterial endothelium. As myocardial oxygen demand increases or coronary blood flow decreases, auto-regulatory mechanisms become active to try to maintain myocardial perfusion at a normal level. In patients with atherosclerotic heart disease, compensatory mechanisms to maintain myocardial perfusion stenosis are already active, so first abnormality to be apparent during ischemia is therefore reduced perfusion to the affected territory[2].

During myocardial ischemia ATP is highly utilized resulting in an increase in its metabolites. This subsequently acts as a vasodilator in an attempt to compensate for the reduced perfusion. Various catabolites such as lactate and hydrogen ions accumulate, and these can also cause coronary vasodilatation. The reduction in high energy phosphates also impairs several energy requiring metabolic processes in myocardial cells.

The main event which occurs during ischemia is contractile dysfunction[3] .initially the changes occur in a regional manner in the territory involved, but, as the insult worsens, there is global impairment of left ventricular function. Both diastolic and systolic abnormalities occur during ischemia.

As the extent of the ischemic territory increases, global ventricular dysfunction occurred. Stroke volume, cardiac output and left ventricular ejection fraction all decrease. Global systolic dysfunction is therefore a late sign of myocardial ischemia and reflects involvement of a large proportion of the myocardium [4].

The diagnosis and assessment of IHD involves clinical evaluation of symptoms and signs, identifying significant risk factors and specific cardiac investigations to confirm the diagnosis as well as identifying or excluding precipitating factors which assist in stratifying risk associated with the disease and to evaluate the efficacy of treatment [5] .

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The backbone for the diagnosis of chronic CAD comprises the patient's history, stress ECGechocardiography, computed tomography angiography, cardiac magnetic resonance, myocardial perfusion scintigraphy and positron

Emissiontomography. Selective catheterization of the coronary arteries with angiographic assessment of the lumen remains the 'gold standard' for the detection of coronary obstructive disease [6].

Radionuclide myocardial perfusion scintigraphy (MPS) has become established as one of the main functional cardiac imaging technique for ischemic heart disease (IHD), However, the underlying physiological principles that make myocardial perfusion imaging an important diagnostic tool remain unchanged.MPS is based upon the flow-dependent and/or metabolism-dependent selective uptake of a radioactive tracer by functional myocardial tissue. This method was developed to evaluate myocardial perfusion and viability and it is applied at both rest and after stress to assess inducible ischemia by the flow limiting coronary stenosis.

After initial assessment of the presence or absence of perfusion defects, a complete evaluation of the stress study includes assessment of the location, size, severity, and likely vascular distribution of the visualized abnormalities, in addition computer quantitative methods are routinely used in conjunction with image analysis. Relative perfusion is often presented in a 2-D *polar map* or *bull's-eye* display generated with circumferential slice count profiles obtained from the short-axis SPECT slices, with the apex at the center of the display and the base of the ventricle at the periphery. Stress–rest difference polar maps are commonly used to analyze for reversible ischemia. Calculation of a LVEF is obtained by measuring the change in size of the ventricular cavity during the cardiac cycle using edge detection algorithms [7].

The reported sensitivity of stress myocardial perfusion imaging has ranged from 80% to 95% and the specificity from 70% to 90%. Sensitivity for the diagnosis of CAD is considerably greater for stress myocardial perfusion scintigraphy than the exercise treadmill study alone (88% vs. 75%). Specificity is similar (77 %). The accuracy of vasodilator versus exercise stress is very similar. An important observation is that ischemic patient with normal stress perfusion scans (false negative) have a better prognosis than those with scintigraphic evidence of ischemia[8].

One of the most important advantages of MPS over other techniques is its high prognostic value. A normal MPS study not only suggests the absence of flow-limiting coronary disease, but it is also associated with a low likelihood of non-fatal MI or cardiac death (<1%/year). Conversely, an abnormal scan indicates the presence of significant CAD, and provides

valuable incremental prognostic information that is based on the extent and severity of a perfusion abnormality, as well as the presence of other adverse prognostic signs. Thus the risk stratification and prognosis have become its primary role [9].

^{99m}Tc-MIBIislipophilic univalent cationic myocardial perfusion imaging agent, it is distributed along the blood flow and taken up by myocardial cells. Its uptake is dependent on both mitochondrial and plasma membrane potentials. More than 90% of myocardial 99mTc-MIBI (MIBI) is localized within mitochondria [10]. The tracer is passively diffused into myocyte and localizes primarily in the inner membrane of mitochondria where the electronegative potential taps the charged lipophilic molecules [11, 12].

It has been considered that MIBI bound to myocardium tends remain for a relatively long period of time without redistribution as in thallium 201 [13]. However; it was observed in certain circumstances that there is acceleration of myocardial MIBI washout which is called revers redistribution [14, 15]. Reverse redistribution pattern is defined as either the worsening of an initial perfusion defect or the appearance of a new perfusion defect on the delayed images[16]. It is considered that the mitochondrial membrane potential and MIBI retention ability are significantly involved in this phenomenon i.e. change in the membrane potential significantly affect MIBI retention in the myocardium [17].

Physiologically, mitochondria are responsible to produce adenosine triphosphate (ATP) to ensure myocardial function and contractility under the normal circumstance of adequate oxidative capacit[18]. The retention of MIBI in myocyte is highly related to normal mitochondrial function to maintain the electrochemical potential on the exterior surface of mitochondria. In ischemic myocardium, because of decrease in oxygen supply, the aerobic metabolism of ATP generation is deactivated and the mitochondrial membrane eventually becomes depolarized and could not any longer preserve the electronegative potential, leading to exhibit fast clearance of MIBI [19, 20].

The interval of early or delayed image acquisition, the visual evaluation criteria and the calculation method for washout rate (WR) are not standardized in institutions, and the washout evaluation method is still debated. In the evaluation method for myocardial washout, WR is generally determined with the following equation: WR = {(early image - delayed image) / (early image)} x 100%[21] .WR using a planar image may be an effective index when the washout is determined in the whole myocardium in patients with myocardial disease [22]. However, since the washout of MIBI is increased only in a region that is subject to a coronary artery occlusion in patients with

ischemic heart disease, it is difficult to evaluate the washout using WR in the whole myocardium. Therefore, the method for assessing washout of MIBI by visual evaluation using short-axis, horizontal long-axis and vertical long-axis slice images after reconstruction is adopted in patients with ischemic heart disease [23]. In a different method, a polar map for short-axis images is used to prepare a coronary artery dominance map based on the myocardial maximum counts from the apex to the basal area, and a region with decreased tracer accumulation is regarded as an abnormal region in comparison with a normal area with enhanced washout [24].

The situations that MIBI reverse redistribution i.e. accelerated MIBI washout, is proved to be of clinical significance include ischemic heart disease, spastic angina, cardiomyopathy, heart failure and prediction of cardiac events in patient with previous myocardial infarction. ***Fig (1 A, B)*** showed a good correlation of washout rate with degree of reversibility rate vascular territories.

The severity of coronary stenosis and the time course strongly contribute to the occurrence of mitochondrial disorder. In other words, at a regional myocardial perfusion of less than 20 m*l*/min/100 gm of tissue, the amount of ATP decreased 10 minutes after ischemia, while at a regional perfusion of 20 to 40 m*l*/min/100 gm of tissue, the decrease in ATP was observed only after 60 minutes. These results revealed that ATP production depended on the volume of blood supplied to the myocardium, and also that the decrease of mitochondrial membrane potential was coupled with the decrease of ATP synthesis [25].

It is also demonstrated that the 99 mTc-MIBI WR correlated inversely with functional cardiac parameters using myocardial perfusion imaging (MPI) in patients with idiopathic dilated cardiomyopathy. As a result ^{99mTc} MIBI scintigraphy might be a valuable molecular imaging tool for the diagnosis and evaluation of myocardial damage or dysfunction severity[26].

To conclude: The rate of MIBI washout can be used as an additional parameter for CAD detection.The rate of MIBI washout can potentiate the result of stress test especially in patients who couldn't perform sufficient exercise.

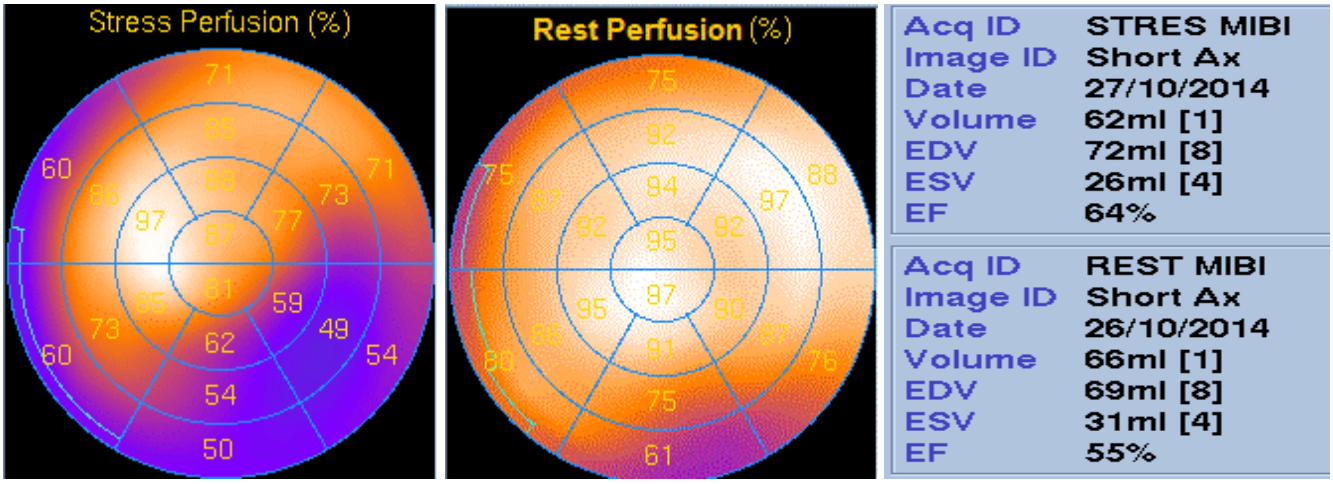
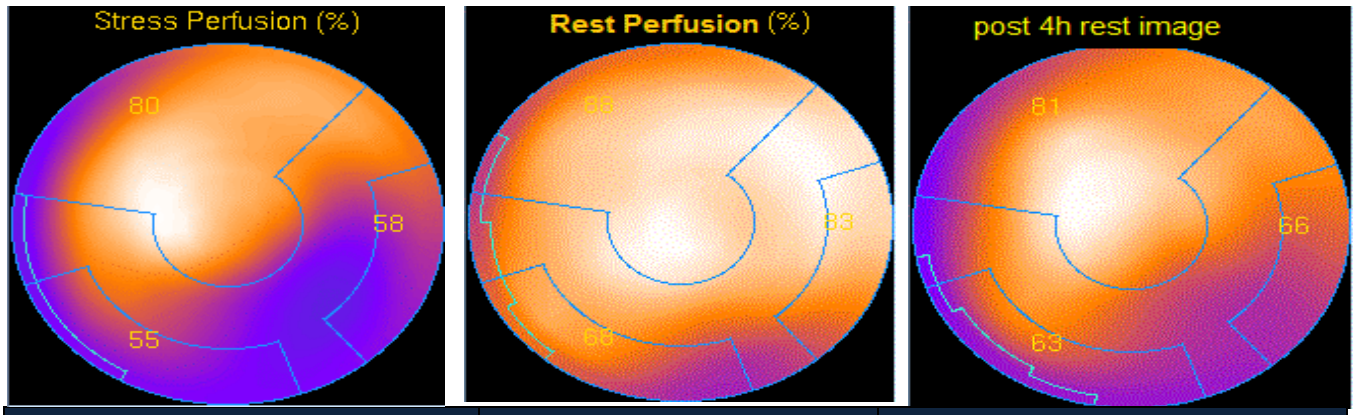


***Fig. (1 A)*:**qualitative cardiac perfusion; A case of ischemic heart disease with showing moderate ischemic changes in the lateral and inferior walls with normal left ventricular ejection fraction



SSS	SRS	SDS
16	3	13

% of Reversibility			% of Washout rate		
LAD	LCx	RCA	LAD	LCx	RCA
1%	11 %	15 %	8 %	19%	21%

Fig. (1 B): Correlation of the degree of reversibility and washout ratereveledgood correlation in LCx and RCA vascular territory.

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