Assessment of Stress Myocardial Perfusion in SPECT using Image Processing

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Abstract: ***Myocardial infraction is the irreversible death of the heart due to lack of oxygen that occur when the blood supply is reduced or cutoff and isn't restored in an appropriate period of time.This study was Aimedto assessthe myocardial perfusion in SPECT images and manipulatethose images by a function written in the Interactive Data Language(IDL) software to normalize the image using the range of count thatclassify the muscles of the heart whether normal, mild, moderate or severe. Then after recognition of each part on the image the same process will be applied on the subsequentslice for the whole heart, and the number of pixels in each part will counted to find a percentage of the heart classes. The result shows we can estimate the classes of stress test from rest test without stress the patients.***

Keywords: SPECT, Rest, Stress, myocardial perfusion

1. Introduction

Myocardial perfusion by single photon emission-computed tomography (MPS) is one of the most important and commonly performed non-invasive cardiac imaging tests. MPS plays a key role in diagnosis of cardiovascular disease, establishing prognosis, assessing the effectiveness of therapy, and evaluating myocardial viability. When myocardial blood supply is abruptly reduced or cut off to a region of the heart, a sequence of injurious events occurs, beginning with sub-endocardial or transmural ischemia,followed by necrosis, and eventual fibrosis (scarring). If the blood supply isn't restored in an appropriate period of timeRupture of an atherosclerotic plaque followed by acute coronarythrombosis is the usual mechanism of acute myocardial infraction (MI). The ECG changes reflecting this sequence usually follow a well-known pattern depending on the location and size of the MI. MI is resulting from sub-total coronary occlusion that occurs in more homogeneous tissue causing heterogeneous damage which may be evidenced by a non-Q-wave MI pattern on the ECG. Two-thirds of MI's presenting to emergency rooms evolve to non-Q wave MI's, most having ST segment depression or T wave inversion.

Most MI's are located in the left ventricle. In the setting of a proximal right coronary arteryocclusion, however, up to 50% may also have a component of right ventricular infarctionaswell. Right-sided chest leads are necessary to recognize right ventricle (RV) MI [1].

Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) imaging have been an accepted clinical gold standard for the quantification of relative heart muscle perfusion during stress and rest [2].

Stress-Rest Studies:Stress-rest perfusion imaging is a technique for diagnosis and prediction of coronary artery disease (CAD), through identification of heart's regions that exhibit diminished perfusion, which is an indication of CAD. In the Stress–rest perfusion imaging the patient is imaged twice; once while the patient is at rest, and once after the heart is stressed either by exercise or pharmacologically[3].

If there is a visible area of reduced perfusion (hypo-perfusion) at stress and it improves at rest, it indicates that the patient is likely to have blockages in coronary arteries supplying this portion of the heart muscle (coronary artery disease) and is at increased risk of heart attack and death. Perfusion of the heart muscle can be restored before the heart attack by surgery or therapy; therefore, it would be more beneficial to detect abnormalities early prior to damage occurring.

Automated software for quantitative analysis of three-dimensional SPECT and PET myocardial perfusion images studies has become routinely used in clinical practice and research.Quantitative processing includes using the computer to produce standardized raw images for visual evaluation. The images should be fully utilized to display the heart normalized to maximal left ventricular (LV) count density, and not scaled to visceral activity.

The background subtracted images are useful for visual evaluation and are used for measurements of myocardial activity. Suitable exercise is important to detect coronary artery disease (CAD). At lower heart rates, myocardial blood flow is normal and gated perfusion images will be correspondingly normal. At high heart rates or at high double products, in patients who suffer from mild and moderate CAD, the myocardial blood flow becomes abnormal. It is very important to bring the camera head as close to or touching the patient's chest to get the highest possible count rates,as opposed to SPECT imaging, where some distance is necessary to avoid collisions with the patient during rotational acquisition [4,5].

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Artifacts and inaccuracies in comparing rest and stress images are produced due to slight differences in angulation of the camera, positioning of breasts or other soft tissue, or the pressure of the camera on the chest wall.If the regions show perfusion deficit in the stress image, but appear normal in the rest image, then their function may be restored by surgical or other intervention. Regions that appear abnormal even during rest are in a more-severe state of disease [3].

A normal database also may be incorporated in the quantitative program so that segmental tracer activity can be compared with the average obtained from the normal database [6-10].The ability to reproduce the same position on initial and delayed (or rest) images represent the significance of positioning.

Current guidelines of Food and Drug Administration (FDA) for evaluation of SPECT MPI in clinical trials recommend independent visual interpretation by multiple experts [11]. Due to the subjective nature of visual interpretation, however, the visual approach is likely to have lower repeatability than objective quantitative measurements.

2. Material and Methods

Material: Gamma Camera (SPECT), Dose Calibrator, Radiopharmaceutica ΙTC 99m (sestamibi), Electrocardiogram (ECG) and Sphygmomanometer.

Technique: This experimental study consists of 60 random patients with myocardium disorder. The patients given 8-30 mci of TC 99m- MIBI intravenously. patient fasting for 12 hours before examination and stop any caffeine for 3 days, ECG in place patient in supine position, heart in the center of field of view 0^0, camera position at 45^0 start imaging after 40 minutes from injection of radiopharmaceutical with ECG.

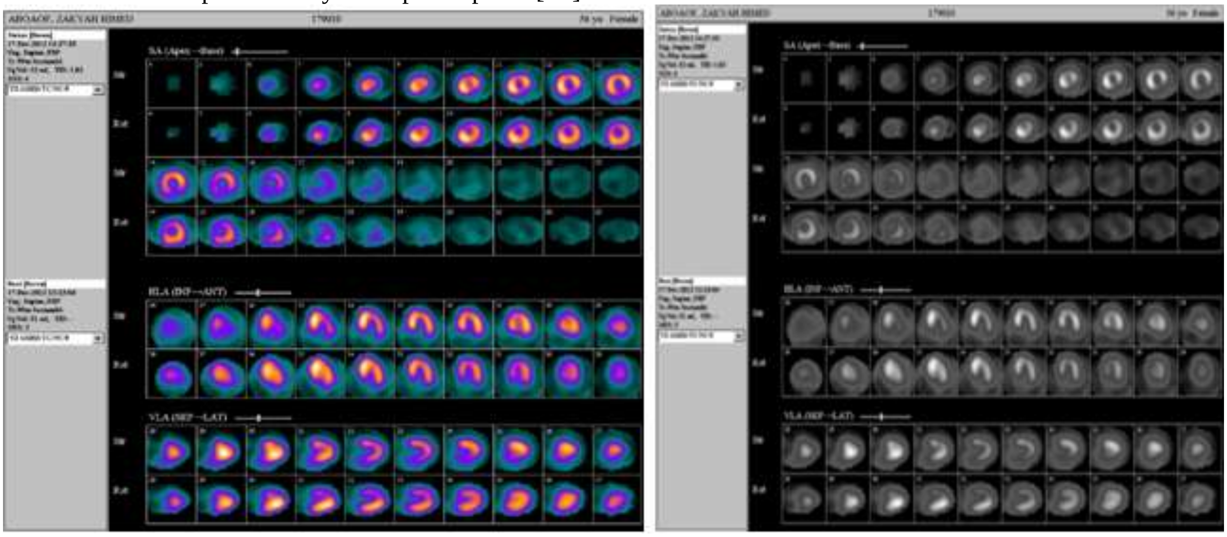

Figure 1: Original image of stress and rest quantitative polar map (left) converted to gray scale (right)

Protocol. The SPECT images manipulated by a function written in the IDL software to normalize the image using the range of count the describe the muscles of the heart as normal, mild, moderate and sever. Then after recognition of each part on the image the same process applied on the subsequent slice for the whole heart, then the number of pixel in each part were counted to find the percentage of the heart classes (normal, mild, moderate and sever).

3. Results and Discussions

Table 1: Show statistical description of rest and stress

Rest	*Mean*	*SD*	*Stress*	*Mean*	*SD*
Normal	10.28	2.87	*Normal*	10.05	2.72
MILD	18.41	7.69	*MILD*	18.05	7.64
Moderate	49.86	7.51	*Moderate*	49.36	6.49
Sever	19.46	3.84	*Sever*	21.87	4.44

Table 2: Paired samples for correlation between Rest and Stress

Paired Samples Correlations		Correlation	Sig.
Pair 1	Normal for Rest & Stress	0.680	.000
Pair 2	Mild for Rest & Stress	0.509	.000
Pair 3	Moderate for Rest & Stress	0.714	.000
Pair 4	Sever for Rest & Stress	0.635	.000

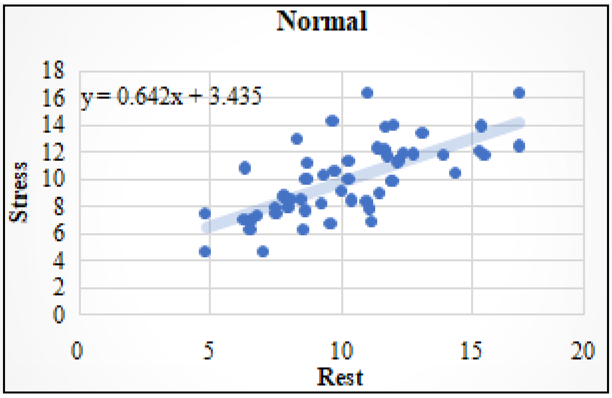

Figure 2: Correlation between stress and rest in normal

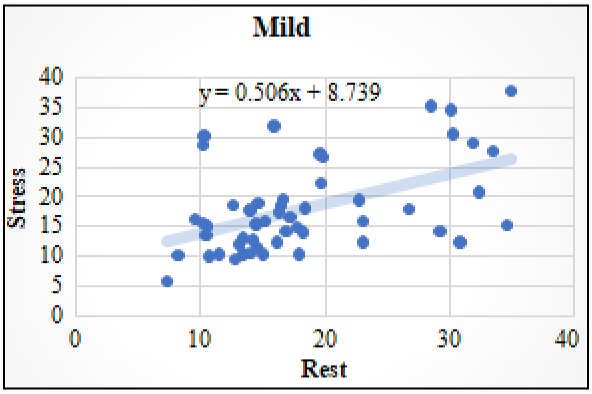

Figure 3: Correlation between stress and rest in mild

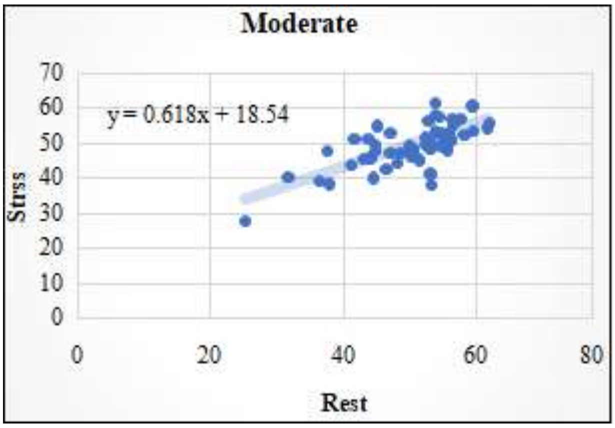

Figure 4: Correlation between stress and rest in moderate

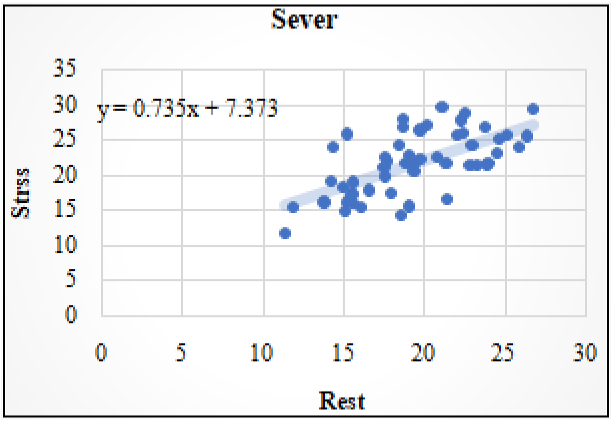

Figure 5: Correlation between stress and rest in sever

4. Discussion

The SPECT images manipulated by a function written in the IDL software to normalize the image using the range of count the describe the muscles of the heart, the statistical results shows as mean± SD using paired sample t-test in normal status the rest 10.28±2.87 and the stress 10.05±2.72, in Mild the rest 18.41±7.69 and in stress 18.05± 7.64, and in moderate the mean of rest 49.86±7.51 and in stress 49.36±6.49, and the sever situation ty e rest 19.46±3.84 and in stress 21.87± 4.44 as shown in table 1.

Paired sample for correlation between the rest and stress conditions divided to four statuses normal, mild, moderate and sever. In normal status the correlation value between the rest and stress 0.680, in mild status the correlation value between the rest and stress 0.509, the moderate condition the relation between rest and stress 0.714, and in severstatus the correlation between the rest and stress with value 0.635 as shown in fig 2.

The heart scintigraphy showed inconclusive results has strong correlation with the rest and stress status at it is four categories (normal, mild, moderate and sever), this means we can estimate the stress from rest status using the four categories according to situation of the patient's heart.

Linear regression results showed that the rate of change in stress increase by 0.643 for each unit in the normal rest (fig 3). in Mild the rate of change for the stress increase by 0.506 for each unit of the rest status fig 4. in moderate the rate of change for the stress increase by 0.618 for each unit of the rest status fig 5. and in sever the rate of change for the stress increase by 0.736 for each unit of the rest status fig 6.

5. Conclusion

Studied stress test is one of the protocol for the heart but stress might worst the heart condition of the patients, therefor in this study from the rest test can estimate the classes without stress the patients using the following linear equations:

Equation for the regression values to estimate the stress test:
Normal Stress = 0.643 (Rest Normal) + 3.44
Stress Mild = 0.506 (Rest Mild) + 8.74
Stress Moderate = 0.618 (Rest Moderate) + 18.55
Stress Sever = 0.736 (Rest Sever) + 7.37

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