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Assessment of Ischemic Coronary Arteries Prevalence, Reversibility and Relative Dose Ratio% Using ^{99}Mtc-Sestamibi and ^{201}Tl

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ABSTRACT

The aim of this study was to assess the ischemic coronary arteries prevalence, reversibility and the relative dose ratio% using 99mTc-Sestamibi and 201TL. The method was adapted from the heart scintigraphy protocol i.e. a sample of one hundred and forty four patients with known or suspected ischemic heart disease (IHD)were administrated to a typically dose of 740 MBq (20 mCi) of 99mTc-MIBI and 74 to 111 MBq (2 to 3 mCi)of 201Tl, Patients under beta-blockers or calcium channel antagonists were asked to discontinue administration for 24 - 48 hours before the stress test, using the slandered Bruce protocol exercise followed by immediate SPECT study for stress ,One to two hours after injection, a rest 201Tl SPECT acquisition was performed, While acquiring rest images for 99mTc-MIBI were obtained two to three hours post stress phase, SPECT acquisition was acquired with 90 degree configuration using contouring centered on the heart. The results analysis was carried out using EXCELL software in form of bars and correlation, which showed that: the male were more common involved by ischemic disease compared to female during the age hood with plateau occurring among age group of 50-70 years old. And the common artery of the heart involved by Ischemia was the left anterior descending artery (LAD) which represented 43% relative to 31% and 26% for LCX and RCA respectively. The reversibility of ischemia in heart arteries were high in case of LAD (43%) and LCX (31%) when detected by 201Tl among male and 99mTc-MIBI among female respectively while RCA shows the less reversibility of ischemia as17% for male by 99mTc-MIBI, 10% for male by 201Tl, 9% for female by 99mTc-MIBI and 11% for female by 201Tl.Also both Tlalium-201 and 99mTc-MIBI can detect the ischemic artery successfully during rest and stress with considerable limited and low exposure dose to other anatomical organs as GIT, Left Lung, and Right Lung.

KEYWORDS Coronary, Arteries, Ischemia, Reversibility, 201Thalium, 99mTc-MIBI.

INTRODUCTION

Coronary arteries diseases (CAD) recently have been consider as one of the major reasons of morbidity among males and females in Sudan, These coronary arteries give rise to rich capillary networks that bathe the cardiac muscle cells with blood. All arteries inside the heart walls are fed by branches of either the right or left coronary arteries, the blood flow through the heart usually keeps up with the body's demand. The demand is increased by exercise and strong emotions, both of which make the heart pump more quickly and more forcefully, causing the heart to use more oxygen, as the heart beats twice as fast it needs double as much oxygen [1]. Normally, the extra oxygen needed during exercise is supplied by a faster and a more voluminous blood flow through the coronary arteries [2], in UK Coronary artery disease is the cause of 52% (95% CI 43–61%) of incident heart failure in the general population under 75 years [3]. Other studies have observed higher long- term mortality rates among patients with proximal as opposed to distal left anterior descending (LAD) coronary artery lesions regardless to the number of diseased vessels [4, 5]. Furthermore higher prevalence of chronic obstruction of the proximal left anterior descending coronary artery in comparison to other major coronary arteries was seen in patients dying of atherosclerotic disease [6]. Schuster and Bulkley, [7] stated that: Ischemic heart disease (IHD) can be caused mainly by atherosclerosis, Myocardial Infarction (MI) and Angina pectoris in which the ischemia is less severe and does not cause death of cardiac muscle. Angina pectoris implies three types: (*stable angina, prinzmetal angina, and unstable angina*), the latter is the most threatening as a frequent harbinger of MI. Based on American Heart Association (AHA), all the seventeen (17) segments of the myocardium are supplied with those small branches (*right coronary artery (RCA), left anterior descending artery (LAD) and the left circumferential artery(LCX)*), if one of these branches blocked, will ceased the blood supply to the relevant segment of myocardium and will be deprived of oxygen [8] and the prevalence of atherosclerosis in a population consider as an index of IHD, [9]. IHD can be manifested through electrocardiographic and enzymatic changes with rare exceptions could be due to congenital anomalies of the coronary vessels, emboli, or ostial occlusion, while detection of IHD could be obtained by using echocardiogram (ECG) with correlation to wall motion abnormality (WMA) and Ejection fraction percentage of different myocardium territories [10], Delayed Enhancement method (DE) in Magnetic resonance imaging (MRI) which showed good capability of detection of (IHD) [11], diagnostic x-ray, contrast-enhanced multi-detector computerized tomography (MDCT) which is widely used as a noninvasive method of ruling out significant CAD [12] and nuclear medicine with utilization of^{99m}Tc-MIBI and ^{201}Thalium Radiopharmaceuticals to determine the adequacy of blood flow to the myocardium, especially in conjunction with exercise or pharmacologic stress for the detection and evaluation of coronary artery disease (CAD). Although the basic principles are similar, protocols for imaging vary among the radiopharmaceuticals used [13]. However ^{201}Tl showed some disadvantages for imaging due to its physical and biologic characteristics [14] and its lower photon energy, and attenuation and scattering from overlying tissues.

MATERIAL AND METHODS:

Treadmill: The Bruce treadmill test protocol was designed in 1963 by Robert. A. Bruce, MD, as non-invasive test to assess patients with suspected heart disease. In a clinical setting, the Bruce treadmill test is sometimes called a stress test or exercise tolerance test. Today, the Bruce Protocol is also one common method for estimating VO_2 max in athletes. VO_2 max, or maximal oxygen uptake, is one factor that can determine an athlete's capacity to perform sustained exercise and is linked to aerobic endurance. VO_2 max refers to the maximum amount of oxygen that an individual can utilize during intense or maximal exercise. It is measured as "milliliters of oxygen used in one minute per kilogram of body weight" (ml/kg/min). A Typical Bruce Technique was used in accordance to the standard formula for men or women:

For Men VO_2 max = 14.8 - (1.379 x T) + (0.451 x T^2) - (0.012 x T^3)

For Women VO_2 max = 4.38 x T - 3.9.

T = Total time on the treadmill measured as a fraction of a minute (i.e. A test time of 9 minutes 30 seconds would be written as T=9.5).

Radiopharmaceuticals:

^{201}Tl-chloride:

Intravenously administration of thallium Chloride ^{201}Tl Injection is characterized by rapid bi-exponential clearance from the blood with about 91.5% of blood radioactivity disappearing with a half-life of approximately 5 minutes and the remainder with a half-life of about 40 hours. Maximal concentration by normal myocardium occurs at about ten minutes with sustained myocardial retention and adequate concentration in heart muscle.

^{99m}Tc sestamibi:

Technetium^{99m}-MIBI is taken up by the cells of the myocardium in passive diffusion, and then appears in the cytosol and is localized in the mitochondria. The uptake is proportional to the myocardial perfusion, and the washout is rather slow (excluding considerable redistribution). At stress, more than 3% of the injected dose is accumulated in the myocardium, while the non bound part is eliminated via the hepatobiliary route. Technetium-^{99m}-MIBI is also taken up in tumors and metastases, expanding its clinical application.

Method:

The study of myocardial ischemic heart disease (IHD) using different radiopharmaceutical i.e. ^{99m}Tc-Sestamibi and ^{201}Tl with accordance to gender, used to evaluate the prevalence of (IHD) among males and females, in this study the researcher used a sample of one hundred and forty four patients classified into two different groups Group (I): A sample of 66 patients (32 males) (33 Females) injected with a typically dose of 740 MBq (20 mCi) of ^{99m}Tc-MIBI ^{99m}Tc-Sestamibi using one day slandered protocol underwent Bruce's treadmill exercise technique and examined in stress and rest conditions, SPECT acquisitions were applied with (256×1024×16) Matrix size, with 20cm/second table speed, Both Supine and prone positions were performed in accordance to patients situation .Group (II) :A sample of 78 patients suffering from (IHD) (56 males) (22 females) injected with and 74 to 111MBq (2 to 3 mCi) of^{201}Tl also underwent one day protocol; using Bruce's treadmill exercise technique then examined in conditions of stress and rest following the same trend of as ^{99m}Tc-MIBlin regard to SPECT acquisition.

Image & Statistical Analysis:

A fixed sized (ROI's) were drown over the whole heart ,Right, Left Lung and GIT over both sets of images i.e. stress and rest for all patients ,Next ,visual analysis of all images was performed by three experienced physicians, the aim were to evaluate reversibility in both conditions i.e. Stress , rest , using different types of radiopharmaceuticals (^{99m}Tc-Sestamibi and ^{201}Tl), Allowed to correlate the prevalence of the study among genders in terms of reversibility condition (as all patients were suffering of (IHD)), Then the collected counts/second/pixel (c/s/p) was calculated into ratios (Lungs(Rt/Lt) to Heart ratios) (GIT to heart rations) (Affected territories to heart ratios) for all arteries i.e. Left Anterior descending (LAD) Right coronary artery (RCA) Left Circumflex (LCX), Next**,** A sample was categorized into two groups in accordance to the respective radiopharmaceutical administrated i.e. Group (A) was injected with ^{99m}Tc-Sestamibi ,Group (II) was injected with ^{201}TL and both groups were calculated, Next, all calculated data were analyzed using Excel (Microsoft).

RESULTS:

The following results related to the common heart arteries involved by ischemic disease, the correlation of age versus ischemic frequency percent among male and female, reversibility% of ischemic disease in coronary arteries, the dose at organs to heart ratio% and the uptake in count/second during stress and rest for involved heart segment by ischemic disease.

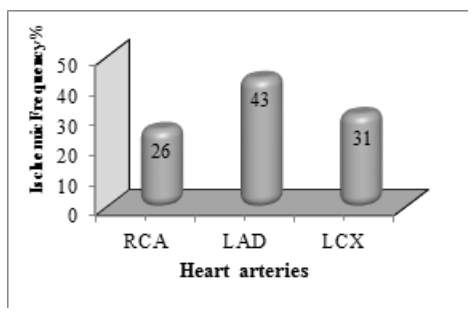

Figure 1: shows the common heart arteries (RCA, LAD and LCX) involved by Ischemic Diseases in percent.

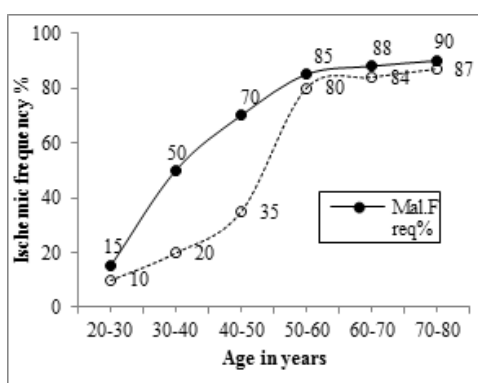

Figure 2: shows the correlation of age versus ischemic frequency percent among male and female.

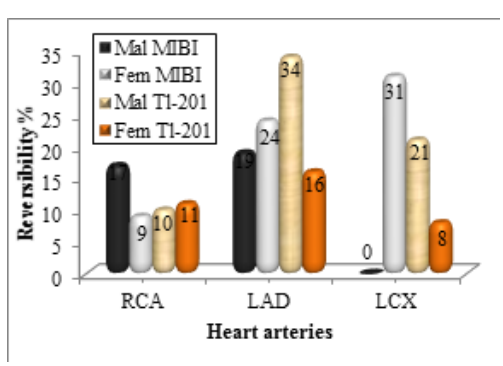

Figure 3: shows the reversibility% of ischemic disease in coronary arteries Left Anterior descending (LAD) Right coronary artery (RCA) Left Circumflex (LCX) using 99mTc-MIBI &201Tl, (M = mala, F = female).

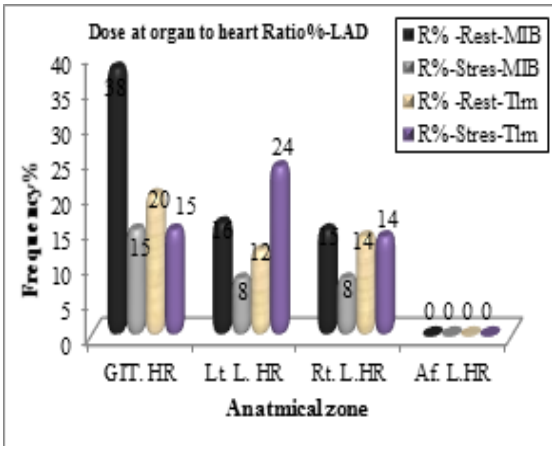

Figure 4: shows the dose at organs to heart ratio% for the common ischemic disease involving (LAD).

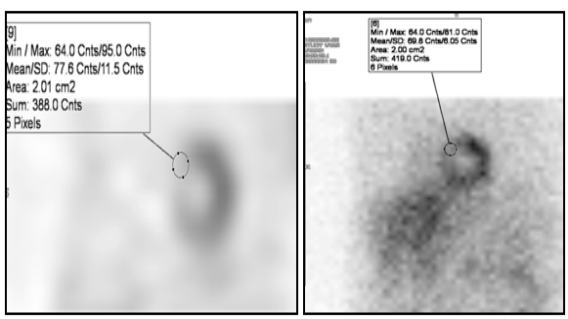

Figure 5: shows the uptake in count/second during stress and rest for involved heart segment (8) by ischemia to assess the reversibility of myocardial ischemia

DISCUSSION:

Figure 1: shows the common heart arteries right coronary artery, left anterior descending artery, and left circumferential artery (RCA, LAD and LCX) involved by ischemic diseases in percent. The analysis reveals that: the common artery of the heart involved by ischemia was the left anterior descending artery (LAD) which represented 43% relative to 31% and 26% for LCX and RCA respectively. Such result could be ascribed to the massive muscle coverage supplied by this artery and the less probability of partial occlusion and more probability of complete occlusion which include the following segments(17, 13, 14, 7, 8, 1, 2)as per American heart association (AHA),this results agreed with Burggraf and Parker, [15] and Moberg et al, [4] as they have mentioned that in several natural history studies an increased mortality in patients with single-vessel disease of the left anterior descending coronary artery of 2-470 compared with 0.5-2% for isolated right coronary artery stenosis has been reported.

Figure 2: shows the correlation of age versus ischemic frequency percent among male and female. It is analysis showed that: the male were more common involved by ischemic disease compared to female during the age hood, and the risk of ischemic increases as the age increase for both gender with plateau occurring among age group of 50-70 years old, however the female were more less susceptibility to ischemic disease during the first forth decades. Such result could be ascribed to the fact that: elder people are more suffering of elevated resting heart rate, increase in heart rate, life stress, and arteriosclerosis [16]. Same results have been highlighted by Gibbons et al, [17] in which they showed that: ischemic disease was higher incidence among male and increases as the age increases. Also these obtained results agreed with the results mentioned by Boudi et al, [18] in which he mentioned that In the United States, men over 40 years of age have a 49% chance of developing the disease in their lifetime, while the chance for women over the age of 40 years is 32%, such results can be ascribed as estrogen levels in premenopausal women protect them from some of the heart damage done by atherosclerosis, but this protection disappears after menopause. However this obtained results is disagree with the results mentioned by Go et al, [19] in which they mentioned that elderly women who have heart attacks are more likely than men and are more likely to die from them within a few weeks.

Figure 3: shows the reversibility% in coronary arteries Left Anterior descending (LAD) Right coronary artery (RCA) Left Circumflex (LCX) using ^{99m}Tc-MIBI &^{201}Tl. And based on the predominant of ischemic disease in LAD, the analysis reveals that: the reversibility of LAD ischemic disease detected by ^{201}Tl was higher (34%) compared with that detected by ^{99m}Tc-MIBI (19%) among male, while among female,^{201}Tl detected only 16% as reversible of the sample compared with 24% detected by ^{99m}Tc-MIBI. The reversibility of RCA ischemia was 10% detected by ^{201}Tl compared with 17% by ^{99m}Tc-MIBI among male while among female the detection was 11% and 9% by ^{201}Tl and ^{99m}Tc-MIBI respectively. And the detected reversibility of LCX ischemia among male and female was 21% by ^{201}Tl and 0%by ^{99m}Tc-MIBI respectively. These obtained results are agreed with the results mentioned by Agnieszka et al, [20]. In this realm, the ischemic reversibility judgment remains a subject of debate, as other factors such as race and heredity can play major role to determine the accurate statement, and McLaughlin, [21] has mentioned that individuals with familial hypercholesterolemia, an inherited metabolic disorder affecting the low-density lipoprotein cholesterol (LDL) receptors, carry a genetic mutation that makes it difficult for their cells to remove LDL from their blood, also Boudi et al, [18] has mentioned regarding race that Americans of Asian Indian origin are 2 to 3 times as likely as European Americans to develop coronary artery disease.

Figure 4: shows the dose at organs to heart ratio% for the common ischemic disease on LAD. The analysis showed that: the assessment of ischemic heart diseases using ^{201}Tl gives least dose ration to GIT, Lt L, Rt L which were 20%, 12%, and 14% compared with ^{99m}Tc-MIBI that gives high dose ratios as 38%, 16% and 15% respectively during patient rest, such fact indicates that low dose of ^{201}thalium can perform the study relative to ^{99m}Tc-MIBI and it showed more interpretation confidence in (Segmental Reading) than ^{99m}Tc-MIB as mentioned by Sherif et al, [22] using ^{99m}Tc-MIBI mentioned that the quantitative analysis shows increased risk in relation to the severity of the abnormality with thallium-201,At the same time both Tlalium-^{201} and ^{99m}Tc-MIBI can detect the affected artery successfully during rest and stress which shows no uptake by the heart segment, these results are similar to those obtained by Ayalew et al, [23] that the myocardial fractional retention of both ^{201}Tl and MIBI is strongly correlated with the decrease in coronary flow during ischemia.

Figure 5: shows the uptake in count/second during stress and rest for involved heart segment by ischemia to assess the reversibility of myocardial ischemia. It reveals that: the ischemic heart segment (8) within an area of 2 cm^2 i.e. about 5 pixels, at rest (a) and stress (b) where the ischemic segment (8) manage to take a little amount of radiopharmaceutical, indicating the reversibility of the case. Figures 5 (a) and (b) have an uptake of 388 and 410 count for rest and stress respectively, which indicating that: there is a probability of ischemic reversibility and returning of myocardium to normal blood supply. Such finding could add a new fact upon which the ischemic diagnosis could be confirmed or not, this result is agreed with the study mentioned by Mohammed et al, [24].

CONCLUSION:

This study reveals and confirmed the common involved coronary artery by ischemia which was the LAD and the male were more common involved by ischemic disease compared to female and the risk of IHD increases as the age increases among both gender. ^{201}Tlalium has been the radiopharmaceutical of choice for detection of ischemic portion due to its efficient

uptake mechanism (Na^+/K pump), low dose administrated and higher reliability in diagnosis of chronic IHD, in addition to the diagnosis of ischemic reversibility depending on the count per pixels.

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