Sudan University of Sciences and Technology
College of Graduate Studies

Study of Coronary Arteries in Patients with Chest Pain Using Computerized Tomography

دراسة الشرايين التاجية لمرضى آلآم الصدر باستخدام الأشعة المقطعية

A Thesis submitted for Partial Fulfillment for the Award of M. Sc. Degree in Diagnostic Radiologic Technology

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الآية

بسم الله الرحمن الرحيم

قال تعالى: ﴿ اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ الْمِصْبَاحُ فِي زُجَاجَةٍ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِنْ شَجَرَةٍ مُبَارَكَةٍ زَيْتُونَةٍ لَا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ نُورٌ عَلَى نُورٍ يَهْدِي اللَّهُ لِنُورِهِ مَنْ يَشَاءُ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ ﴾

[سورة النور:35]

Dedication

To The Soul of the most lovely, Supportive and Kindest man in my life my Grandfather

" ***Hasan Othman***"

May Allah forgive him and have mercy on him and make him at highest paradise

Acknowledgment

First of all, I thank Allah the Almighty for helping me complete this thesis.

*I will take this opportunity to express the profound gratitude from my deep heart to my beloved parents my father "**Babiker Mohammed**" and my mother "**Ebtsam Hasan**" for their love, continuous support – both spiritually and materially, sacrifices and prayers. I appreciate everything you did for me and my brothers.*

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My gorgeous lovely friends " Hadeel, Heba ,Shorooq, Sahar and Eman " ,thank you for being there for me ,thank you for your endless support , care and Love.

Abstract

Computed tomography CT, is a diagnostic medical test that produces multiple images of the inside of the body. CT images provide greater details of soft tissues and blood vessels. A cardiac CT scan for coronary calcium is a noninvasive screening study for obtaining information about the presence, location and extent of calcified plaque in the coronary arteries. This study was performed in the Radiology department of the Royal Scan center and the Royal Care International Hospital in Khartoum. The main objective of this study was to evaluate the Calcium score values in patients with chest pain who were of different risk factors (hypertension, diabetes and smoking) and different variation of age and weight. The data were collected from 53 patients, 24 (45.3%) females and 29 (54.7%) males. 28(52.8%) were hypertensive and 16 (30.1%) had preexisting diabetes mellitus and 12(22.6%) were smokers. Affected coronary arteries and total calcium scoring were recorded. The Plaque type was classified into soft, mixed and hard according to the Radiologist diagnosis. The calcium scored values ranged between 0-≥803 units. The correlation between the calcium score and risk factor was found to be significant in hypertensive at p value≤ 0.006with no significant relation was found in other patient groups. The plaque type shows that the mixed plaque was significantly correlated with calcium score values at p≤0.046. No significant correlations were found between increasing of Calcium Score values and aging and obesity. The study concluded that CT scan has great value in the diagnosis of patients with chest pain and evaluation of coronary arteries calcium score values. Although the previous studies showed reverse results, the researcher attributed the study findings to the limitation of data sampling of the study which should be wider in future studies.

الملخص

التصوير المقطعي هو فحص طبي تشخيصي ينتج صورا إشعاعية متعددة لأعضاء الجسم الداخلية. توضح صــور الأشــعة المقطعية تفاصــيل أدق لكل من الأنســجة الرخوة و الأوعية الدموية. فحص القلب بالأشــعة المقطعية للترسبات التكلسية في الشرايين التاجية هو فحص آمن حيث يتم من خلاله جمع معلومات عن وجود و مكان وامتداد الترسبات التكلسية على الشرايين التاجية. ولقد تم إجراء هذه الدراسة في مركز رويال سكان و قســم الأشــعــة فــي مســتشــفــى رويــال كــيــر الــعــالــمــيــة فــي الــخــرطــوم. الهدف الرئيسي من هذه الدراسة هو تقويم مستوى قيم الكالسيوم لدى المرضى الذين يعانون من آلام الصدر و وجود عوامل خطورة مثل (ارتفاع ضغط الدم و السكري والتدخين) في أعمار وأوزان مختلفة . جمعت البيانات لعدد 53 مريضا منهم 24 إناث بنسبة (45.3%) ، و 29 ذكور بنسبة (54.7%) . وقد وجد أن 28 منهم جميعا يعانون من ارتفاع في ضــغط الدم بنســبة (52.8%) ، و 16 منهم يعانون من الســكري بنســبة (30.1%) ، و 12 منهم مدخنون بنسـبة (22.6%). تم تسـجيل قيم الشـرايين التاجية المتضـررة ومجموع مسـتويات الكالسـيوم ، كما تم تصـنيف نوع الترسـبات التكلسـية إلى لينة و مختلطة وقاسـية اسـتنادا على تشـخيص اختصـاصـي الأشـعة. كانت النتائج الرئيسـية لقيم الكالسـيوم تتراوح بين $803 \geq$ -0 وحدة . بدراســة العلاقة بين درجة الكالســيوم وعوامل الخطورة وجدت علاقة قوية في حالات ارتفاع ضــغط الدم باحتمالية $p\ value \leq 0.006$ ، و لم توجد علاقة ذات دلالة واضــحة في مجموعات المرضــى الأخرى .في الترسبات التكلسية وجد أن الترسبات المختلطة لها علاقة ملحوظة مع قيم مستويات الكالسيوم حيث وجد أن $p \leq 0.046$. لم يتم العثور على روابط بين زيادة مسـتويات الكالسـيوم مع كل من تقدم المرضــى في العمر و زيادة أوزانهم . توصـل الدراسـة إلى أن التصـوير بالأشـعة المقطعية ذو قيمة عظيمة في تشـخيص المرضــى الذين يعانون من آلام الصـدر وتقييم مستويات الكالسيوم في الشـرايين التاجية . على الرغم من أن الدراسـات السابقة توضح نتائج مختلفة إلا أن الباحثة تبرر ذلك بمحدودية العينات في الدراسة حيث ينبغي أن تكون على نطاق أوسع في الدراسات المستقبلية .

Tables of Contents

Chapter Two

Literature Review

Theoretical background

LIST OF TABLES

List of figures

List of Abbreviations

BP	Blood Pressure
CAD	Coronary Artery Disease
CAT	Computed Axial Tomography
CCT	Coronary Computed Tomography
CSCT	Calcium Score Computed Tomography
CTA	Computed Tomography Angiogram
CT	Computed Tomography
IV	Intravenous
MDCT	Malty Detector Computed Tomography
MRI	Magnetic Resonance Imaging
NO.	Number

1. Chapter One

1.1 Introduction:

CT scanning sometimes called CAT scanning is a noninvasive medical test that helps physicians diagnose and treat medical conditions. CT scanning combines special x-ray equipment with sophisticated computers to produce multiple images or pictures of the inside of the body. These cross-sectional images of the area being studied can then be examined on a computer monitor, printed or transferred to a CD. CT scans of internal organs, bones, soft tissue and blood vessels provide greater clarity and reveal more details than regular x-ray exams (RadiologyInfo-2014).

For years coronary angiography provided the only method of imaging the coronary arteries. Although coronary angiography is a useful tool, it is invasive and is associated with a small although not insignificant risk of complications, including stroke, bleeding severe enough to require transfusion, vascular access complications, myocardial infarction, and even death. In addition, the procedure is associated with significant costs associated with personnel, equipment, and the additional costs related to the recovery time needed after arterial catheter removal, as well as the management of possible adverse events. For these reasons, coronary angiography is typically reserved for patients with serious symptoms and a high likelihood of having significant coronary artery disease, such as chest pain or after a stress test with positive findings. Advances in CT and magnetic resonance imaging technology (MRI) are changing established practices.

Cardiac CT has emerged as a less-invasive imaging modality for the diagnosis of coronary artery disease (CAD) and is often used to avoid coronary angiography in low- and intermediate risk patients, in particular.

Continuous improvements in CT detector technology and in temporal (speed) and spatial (thin slices) resolution have resulted in clinical results with cardiac CT that are similar to those obtainable with conventional catheter coronary angiography. (Lois-2011).

Atherosclerosis is a build-up of fat, plaque, and other substances, including calcium. Coronary artery calcifications a marker of coronary artery disease (CAD). Patients with CAD may exhibit no symptoms of the disease; in many patients myocardial infarction is the first sign of CAD. (Lois-2011). The goal of cardiac CT scan for calcium scoring is to determine if CAD is present and to what extent, even if there are no symptoms. It is a screening study that may be recommended by a physician for patients with risk factors for CAD but no clinical symptoms. The major risk factors for CAD are high blood cholesterol levels, family history of heart attacks, diabetes, high blood pressure, cigarette smoking, overweight or obese and physical inactivity(RadiologyInfo-2014) .

1.2. Problem of the Study:

Coronary artery disease is a leading cause of heart attacks and death, it occurs when plaques build up within the walls of the heart arteries, causing narrowing (atherosclerosis). The plaques are deposits in the artery walls made of fat, cholesterol and calcium. Heart scans can detect the calcium in those plaques.

The amount of calcium in plaques can be used to calculate a score that, when combined with other health information and risk factors such as high blood pressure, diabetic and smoking to help in determining the risk of coronary artery disease or heart attack and the highly effect risk factor.

1.3 Objectives:

1.3.1General Objective:

The main objective of this study is to evaluate the calcium score value in patients with chest pain during the period of time 2015- 2016.

1.3.2 Specific Objectives:

- To quantify the coronary artery calcium (CAC) detected in patients presenting with chest pain.
- To find its relation with age, gender, weight.
- To correlate the findings with patient clinical data which are diabetic, blood hypertension and smoking.

1.4 Significance of the Study:

This study was highlighted on evaluation of coronary artery calcium score in patient with chest pain and the most effective risk factor (blood pursuer, diabetic or smoking) and relating these amount of calcium score with patient findings.

1.5 Chapter Overview:

This study was consist of five chapters, chapter one was an introduction introduce briefly this thesis and contained (introduction, problem of study also contain general, specific objectives, significant of the study and overview of the study).

Chapter two was literature review about anatomy, physiology and pathology of heart and coronary arteries, and modalities used. Chapter three was describe the methodology (material, method) used in this study. Chapter four was included result of presentation of final finding of study; chapter five included discussion, conclusion and recommendation for future scope in addition to references and appendices.

2. Literature Review

2.1 Anatomical Background:

The cardiovascular system is an organ system that permits blood to circulate and transport nutrients including as amino acids and electrolytes, oxygen, carbon dioxide, hormones, and blood cells to and from the cells in the body to provide nourishment and help in fighting diseases, stabilize temperature and pH, and maintain homeostasis. The essential components of the human cardiovascular system are the heart, blood and blood vessels. It includes the pulmonary circulation, a "loop" through the lungs where blood is oxygenated; and the systemic circulation, a "loop" through the rest of the body to provide oxygenated blood. The systemic circulation can also be seen to function in two parts a macro circulation and a microcirculation.

An average adult contains five to six quarts (roughly 4.7 to 5.7 liters) of blood, accounting for approximately 7% of their total body weight. Blood consists of plasma, red blood cells, white blood cells, and platelets. Also, the digestive system works with the circulatory system to provide the nutrients the system needs to keep the heart pumping (WIKI-2015).

2.1.1 Anatomy of the Heart:

The heart is a hollow, four-chambered muscular organ located within the middle mediastinum. It is approximately the size of a large clenched fist and is situated obliquely in the chest with one third of its mass lying to the right of the median plane and two thirds to the left. The right atrium forms the right border of the heart and receives deoxygenated blood from the body via the superior and inferior venae cavae and from the coronary sinus and cardiac veins that drain the myocardium.

The right ventricle lies on the diaphragm and comprises the largest portion of the anterior surface of the heart. It receives deoxygenated blood from the right atrium and forces it into the pulmonary trunk for conveyance to the lungs. The left atrium lies posterior to the right atrium and is the most posterior surface of the heart. The left ventricle forms the apex, left border, and most of the inferior surface of the heart. It receives oxygenated blood from the left atrium and pumps it into the aorta for distribution throughout the systemic circuit. The myocardium of the left ventricle is normally three times thicker than that of the right ventricle, reflecting the force necessary to pump blood to the distant sites of the systemic circulation**.** Blood travels to and from the heart through the great vessels, which include the aorta, pulmonary arteries and veins, and superior and inferior venaecavae**.** (LORRIE and CONNIE-2007).

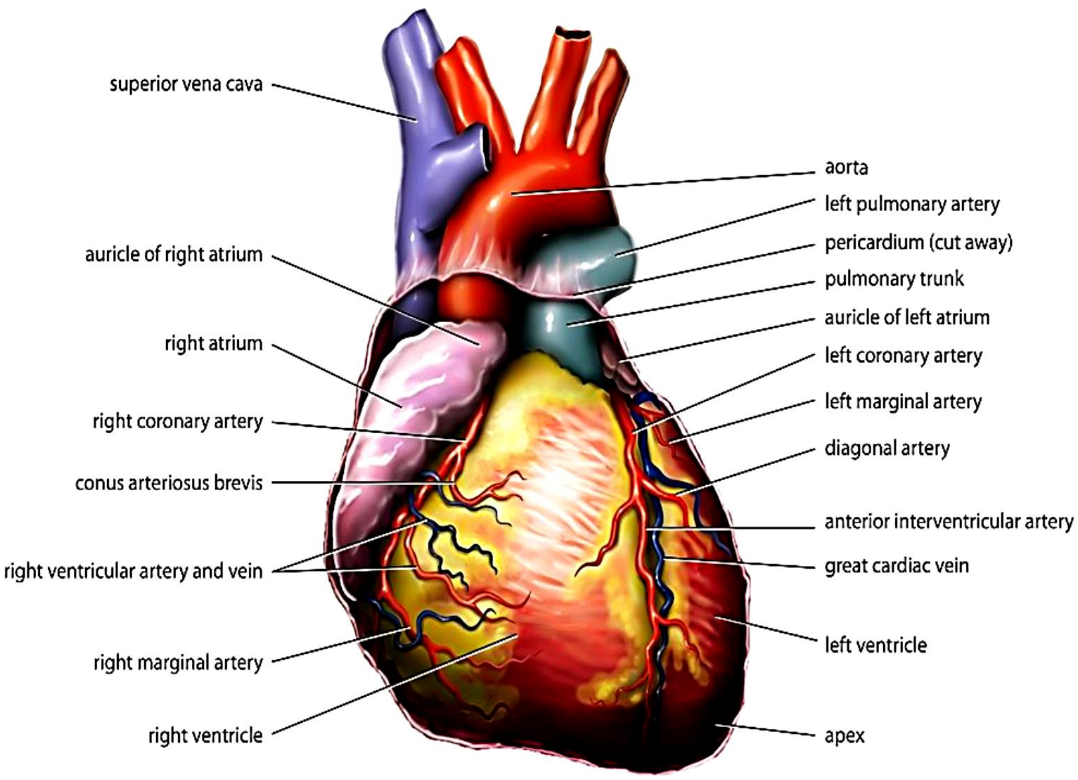

Figure (2-1): External anatomy of the human heart.(THINK SCIENS-2015)

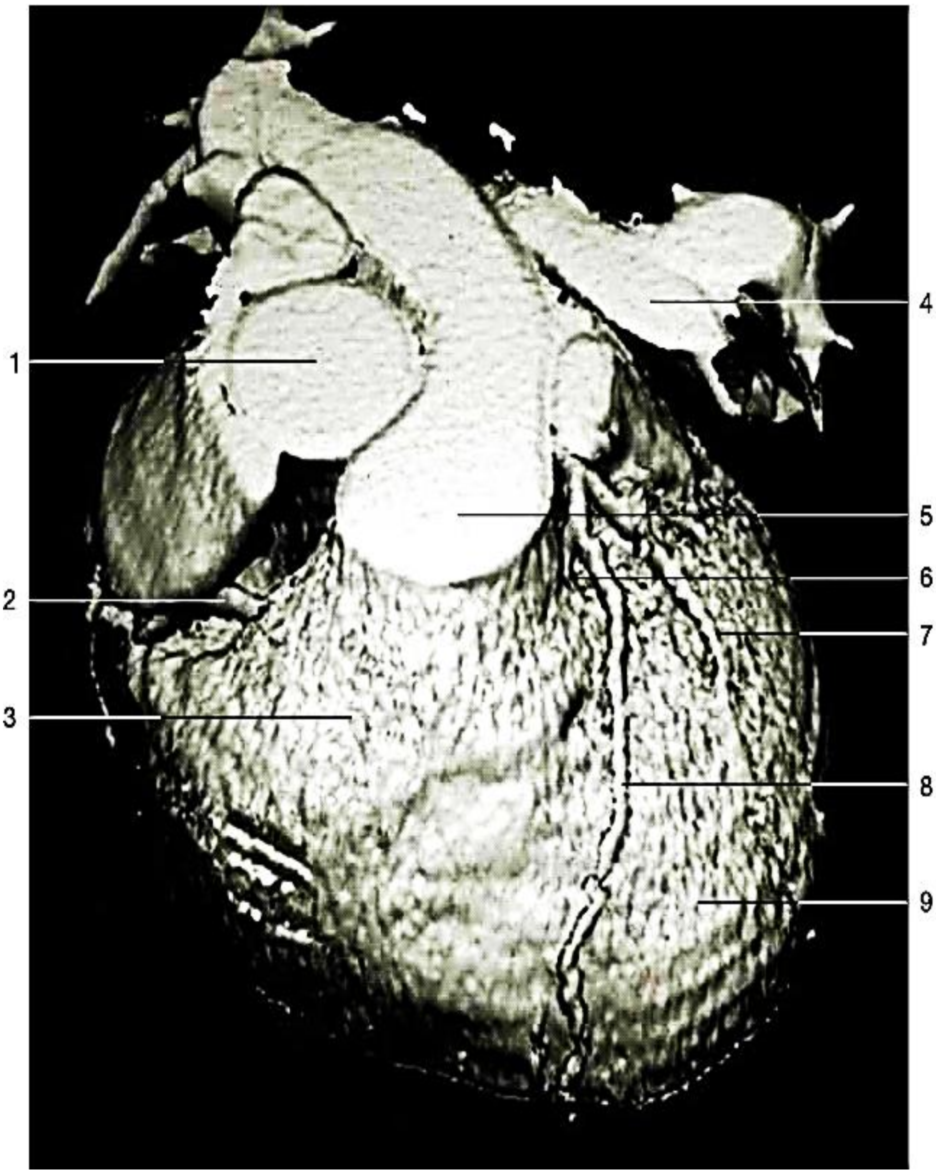

*Figure (2-2) Human Heart (3-D reconstruction of electron beam CT scans as Shaded Surface Display). (*JOHANNES et al.-2011*)*

Where :

1. Ascending aorta
2. Right coronary artery
3. Right ventricle
4. Left atrium
5. Pulmonary trunk
6. Septal branch of left coronary artery
7. Diagonal branch
8. Anterior interventricular branch of left coronary artery

2.1.2 Anatomy of the Coronary Arteries:

Arteries are vessels that carry blood away from the heart. The coronary arteries are the first blood vessels that branch off from the ascending aorta. The aorta is the largest artery in the body. It transports and distributes oxygen rich blood to all arteries. The coronary arteries extend from the aorta to the heart walls supplying blood to the atria, ventricles, and septum of the heart. The coronary arteries supply oxygenated and nutrient filled blood to the heart muscle.

There are two main coronary arteries: right coronary artery and left coronary artery. Other arteries diverge from these two main arteries and extend to the bottom portion of the heart. Some of the arteries that extend from the main coronary arteries include Right Coronary Artery Supplies oxygenated blood to the walls of the ventricles and the right atrium, Posterior Descending Artery Supplies oxygenated blood to the inferior wall of the left ventricle and the inferior portion of the septum.

Left Main Coronary Artery Directs oxygenated blood to the left anterior descending artery and the left circumflex, Left Anterior Descending Artery - Supplies oxygenated blood to the anterior portion of the septum as well as to the walls of the ventricles and the left atrium (front region of the heart) and Left Circumflex Artery - Supplies oxygenated blood to the walls of the ventricles and the left atrium (back region of the heart). (REGINA-2015).

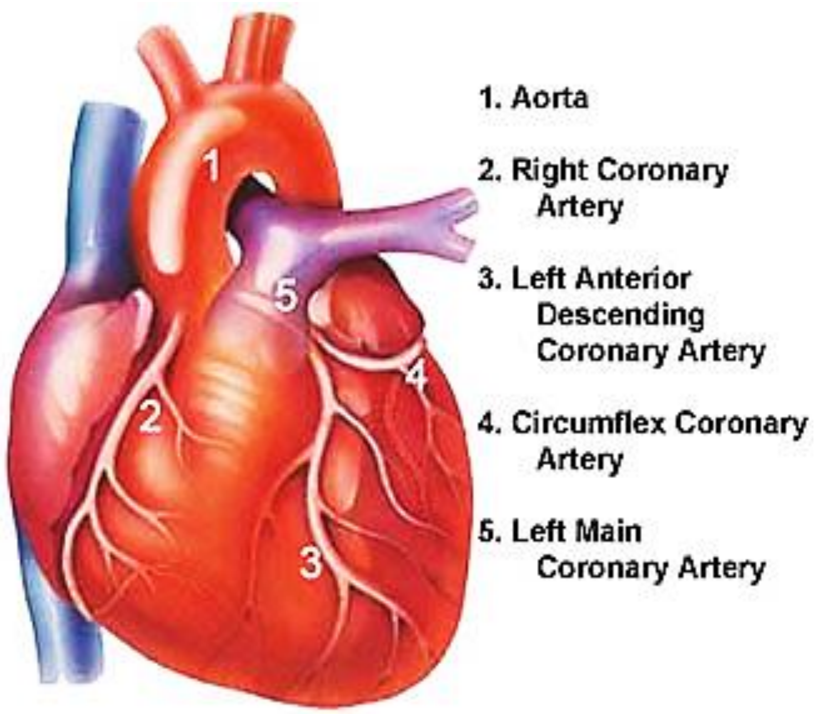

Figure (2-3) the Coronary Arteries (Daviddarling-2015)

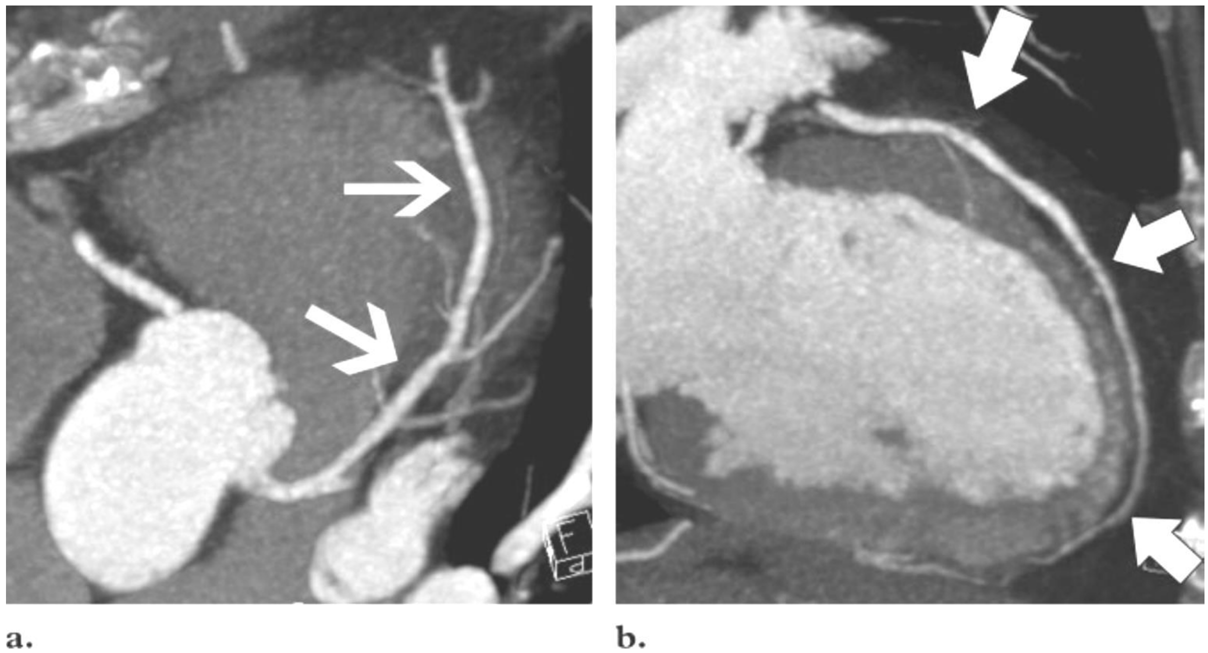

Figure (2-4) Oblique axial ***(a)****and vertical long-axis* ***(b)****MPR images show the normal LAD artery (arrows) coursing in the epicardial fat of the interventricular groove toward the LV apex.(James et all. -2007)*

2.2 Physiology of the Heart:

The heart functions as a pump and acts as a double pump in the cardiovascular system to provide a continuous circulation of blood throughout the body. This circulation includes the systemic circulation and the pulmonary circulation. Both circuits transport blood but they can also be seen in terms of the gases they carry. The pulmonary circulation collects oxygen from the lungs and delivers carbon dioxide for exhalation. The systemic circuit transports oxygen to the body and returns relatively deoxygenated blood and carbon dioxide to the pulmonary circuit. (Betts-2013)

2.2.1 Sinoatrial (SA) Node:

Normal sinus rhythm is established by the sinoatrial (SA) node, the heart's pacemaker. The SA node is a specialized grouping of cardiomyocytes in the upper and back walls of the right atrium very close to the opening of the superior vena cava. The SA node has the highest rate of depolarization. (Betts-2013)

2.2.2Heart Sounds:

One of the simplest methods of assessing the heart's condition is to listen to it using a stethoscope**.** In a healthy heart, there are only two audible heart sounds, called S1 and S2. The first heart sound S1, is the sound created by the closing of the atrioventricular valves during ventricular contraction and is normally described as "lub". The second heart sound, S2, is the sound of the semilunar valves closing during ventricular diastole and is described as dub. (Betts-2013)

Each sound consists of two components, reflecting the slight difference in time as the two valves close. S2 may split into two distinct sounds, either as a result of inspiration or different valvular or cardiac problems (Nicholas and Simon -2009). Additional heart sounds may also be present and these give rise to gallop rhythms. A third heart sound, S3 usually indicates an increase in ventricular blood volume. A fourth heart sound S4 is referred to as an atrial gallop and is produced by the sound of blood being forced into a stiff ventricle. The combined presence of S3 and S4 give a quadruple gallop**.** (Betts-2013)

2.2.3 Heart Rate:

The resting heart rate of a newborn can be 120 beats per minute (bpm) and this gradually decreases until maturity and then gradually increases again with age. The adult resting heart rate ranges from 60-100 bpm. Exercise and fitness levels, age and basal metabolic rate can all affect the heart rate. An athlete's heart rate can be lower than 60bpm. During exercise the rate can be 150bpm with maximum rates reaching from 200 and 220 bpm (Wikipedia-2015).

2.3 Pathology of the Coronary Arteries:

2.3.1 Coronary Artery Disease:

The myocardium receives its blood supply through the right and left coronary arteries. Although the coronary arteries have numerous anastomoses at the arteriolar level, they are essentially functional end arteries. A sudden block of one of the large branches of either coronary artery will usually lead to necrosis of the cardiac muscle (myocardial infarction) in that vascular area, and often the patient dies.

Most cases of coronary artery blockage are caused by an acute thrombosis on top of a chronic atherosclerotic narrowing of the lumen. Arteriosclerotic disease of the coronary arteries may present in three ways, depending on the rate of narrowing of the Lumina of the arteries: (1) General degeneration and fibrosis of the myocardium occur over many years and are caused by a gradual narrowing of the coronary arteries.

(2) Angina pectoris is cardiac pain that occurs on exertion and is relieved by rest. In this condition, the coronary arteries are so narrowed that myocardial ischemia occurs on exertion but not at rest.

(3) Myocardial infarction occurs when coronary flow is suddenly reduced or stopped and the cardiac muscle undergoes necrosis. Myocardial infarction is the major cause of death in industrialize nations. Because coronary bypass surgery, coronary angioplasty, and coronary artery stenting are now commonly accepted methods of treating coronary artery disease (Snell- 2006)

2.3.2 Chest Pain:

The presenting symptom of chest pain is a common and classic problem in medicine. Unfortunately, chest pain is a symptom common to a large number of conditions and may be caused by disease in the thoracic and abdominal walls or in many different chest or abdominal viscera. The severity of the pain is often unrelated to the seriousness of the cause.

Myocardial pain may mimic esophagitis, musculoskeletal chest wall pain, and other non–life-threatening causes. Unless medical personnel are astute, a patient may be discharged from the hospital with a more serious condition than the symptoms indicate.

It is not good enough to have a correct diagnosis only 99% of the time with chest pain. An understanding of the anatomy of chest pain will help the physician in the systematic consideration of the differential diagnosis (Snell- 2006).

2.3.3 Coronary Artery Calcification:

Calcifications in the coronary arteries are an early sign of coronary heart disease (CHD). CHD is a disease in which a waxy substance called plaque builds up in the coronary arteries.Over time, plaque can harden or rupture. Hardened plaque narrows the coronary arteries and reduces the flow of oxygen-rich blood to the heart. This can cause chest pain or discomfort called angina .If the plaque ruptures, a blood clot can form on its surface. A large blood clot can mostly or completely block blood flow through a coronary artery. This is the most common cause of a heart attack. Over time, ruptured plaque also hardens and narrows the coronary arteries. (NIH – 2012).

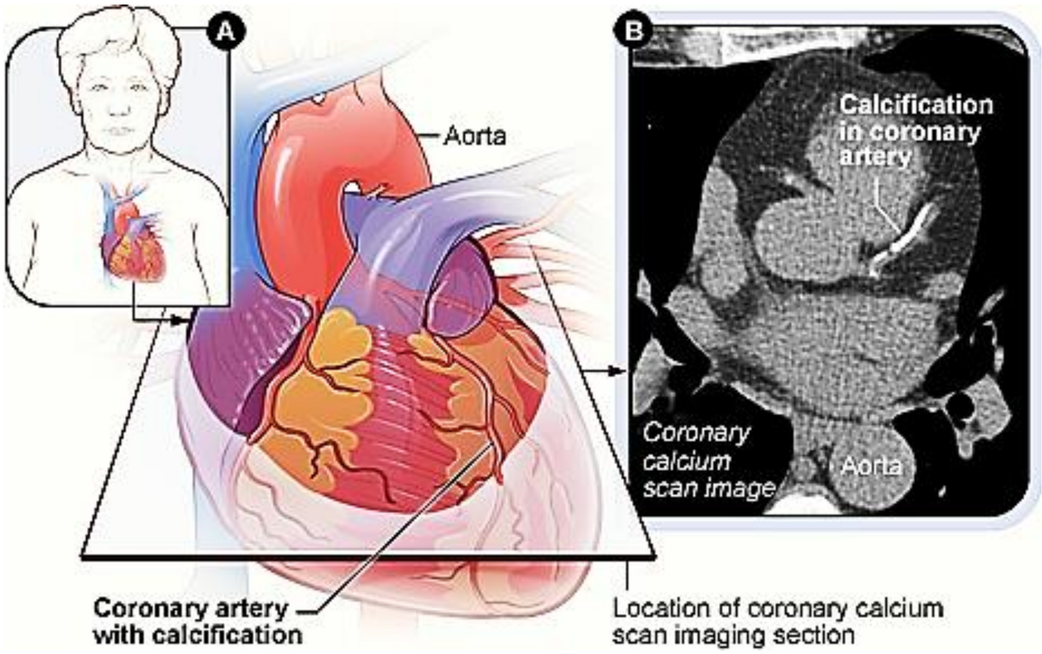

Figure (2-5) shows the position of the heart in the body and the location and angle of the coronary calcium scan image. Figure B is a coronary calcium scan image showing calcifications in a coronary artery.

2.4 Computed Tomography Physics:

2.4.1 Introduction:

Conventional radiographs depict a three-dimensional object as a two-dimensional image. This results in over lying tissues being superimposed on the image, a major limitation of conventional radiography. Computed tomography (CT) overcomes this problem by scanning thin sections

Of the body with a narrow x-ray beam that rotates around the body, producing images of each cross section.

Another limitation of the conventional radiograph is its inability to distinguish between two tissues with similar densities. The unique physics of CT allow for the differentiation between tissues of similar densities.

The main advantages of CT over conventional radiography are in the elimination of superimposed structures, the ability to differentiate small differences in density of anatomic structures and abnormalities, and the superior quality of the images (Lois-2011).

2.4.2 Historical Development of Computed Tomography:

CT scanners were first introduced in 1971 with a single detector for brain study under the leadership of Godfrey Hounsfield, an electrical engineer at EMI (Electric and Musical Industries). Thereafter, it has undergone several changes with increase in number of detectors and decrease in the scan time. The First generation detectors had pencil-like X-ray beam, tube-detector movements" translate-rotate" and the scan time was about 25-30 minutes.

The Second generation had multiple detectors (up to 30), fan shaped x-ray beam, tube-detector movements was translate-rotate and the scan takes less than 90 sec. The Third generation had multiple detectors originally 288 detectors, newer ones use over 700 arranged in an arc. The beam was fan shaped x-ray beam and the tube-detector movements rotate-rotate. The scan takes approximately 5 sec. The Fourth generation contain multiple detectors (more than 2000) arranged in an outer ring which is fixed, the beam is fan shaped x-ray beam, tube-detector movements rotate-fixed and the scan takes few seconds .

Other CT technologies have been adapted to third and fourth generation scanners, including helical ("spiral") image acquisition used in all modern CT machines and dual energy CT scanning (MATT et all.-2015)

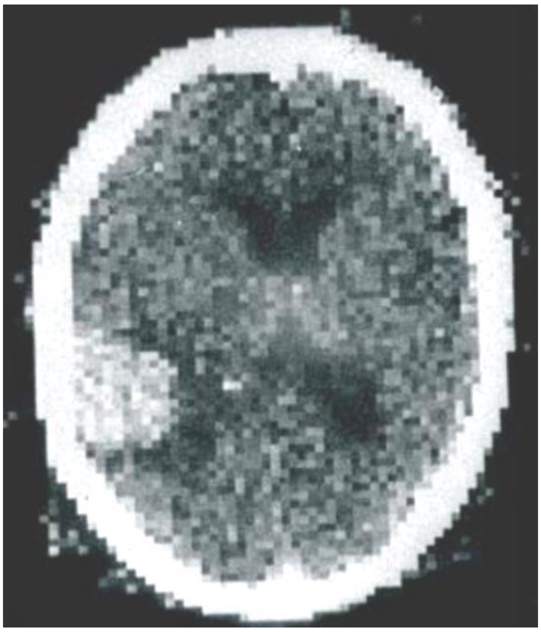

Figure (2-6) The first commercial CT scanner brain image (BERND et all. – 2007)

2.2.3 Hounsfield Unit:

In conventional film-screen radiography, only subjective means are available. That is, we must determine visually the shades of gray and surmise the densities of the structures in the patient; hence, if on a chest x-ray image we were to see a circular area of lighter gray in a lung, we would compare the shade of gray to those of other known objects on the image.

In CT, we are better able to quantify the beam attenuation capability of a given object. Measurements are expressed in Hounsfield units (HU), named after Godfrey Hounsfield, one of the pioneers in the development of CT. These units are also referred to as CT numbers, or density values.

Hounsfield arbitrarily assigned distilled water the number 0. He assigned the number 1000to dense bone and −1000 to air. Objects with a beam attenuation less than that of water have an associated negative number.

Conversely, substances with an attenuation greater than that of water have a proportionally positive Hounsfield value. The Hounsfield unit of naturally occurring anatomic structures fall within this range of 1000 to −1000 (Table 2-1).

The Hounsfield unit value is directly related to the linear attenuation coefficient: 1 HU equals a 0.1% difference between the linear attenuation coefficients of the tissue as compared with the linear attenuation coefficient of water (Lois-2011).

In a voxel with average linear attenuation coefficient μ, the corresponding HU value is therefore given by (WIKI-2015)

$$HU = 1000 \times \frac{\mu - \mu_{water}}{\mu_{water} - \mu_{air}}$$

Where μ_{water} and μ_{air} are respectively the linear attenuation coefficients of water and air.

Table (2-1) The HU of common substances (WIKI-2015):

Substance	HU
Air	**-1000**
Lung	**-500**
Fat	**-100 to -50**
Water	**0**
CSF	**15**
Kidney	**30**
Blood	**30 to 45**
Muscle	**10 to 40**
Gray Matter	**37 to 45**
White Matter	**20 to 30**
Liver	**40 to 60**
Soft tissue, Contrast	**100 to 300**
Bone	**700 to 3000**

2.4.4 Spiral and Helical Computed Tomography Scanners:

Since its clinical introduction in 1991, volumetric CT scanning using spiral or helical scanners has resulted in a revolution for diagnostic imaging. In addition to new applications for CT, such as CT angiography.

Helical CT has improved over the past eight years with faster gantry rotation, more powerful x-ray tubes, and improved interpolation algorithms. However, in practice the spiral data sets from mono slice systems suffered from a considerable mismatch between the transverse (inplane) and the longitudinal (axial) spatial resolution.

In other words the isotropic 3-dimensional voxel could not be realized apart from some very specialized cases .Similarly, in routine practice a number of limitations still remained which prevented the scanning protocol from being fully adapted to the diagnostic needs (KOPP et all.-2000).

2.5 Cardiac and Coronary Computed Tomography:

Electron Beam CT scanning (EBCT) has been established as a non-invasive imaging modality for imaging coronary calcification. Major clinical applications are the detection and quantification of coronary calcium and non-invasive CT angiography (CTA) of the coronary arteries (KOPP et all. - 2015).

Figure (2-7) 3D volume rendering of a coronary CT angiography Examination using the latest 64-slice CT generation (Bernd-2007)

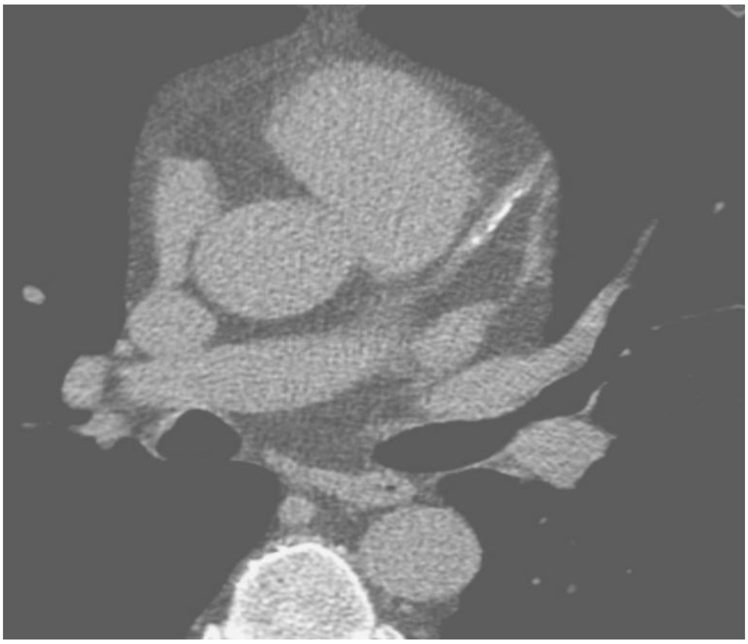

Figure (2-8) Trans axial image display of coronary calcification in LAD using ECG-triggered acquisition with sub second single slice. Mechanical CT (Bernd-2007).

2.6 Calcium Scoring:

Coronary calcium scans Computed Tomography to check for the buildup of calcium in plaque on the walls of the arteries of the heart (coronary arteries). This test is used to check for heart disease in an early stage and to determine how severe it is. Coronary calcium scans are also called cardiac calcium scoring.

A CT scan takes pictures of the heart in thin sections. The pictures are recorded in a computer and can be saved for more study or printed out as photographs (WEBMED-2014).

Coronary calcification can be assessed quantitatively using three methods: (1) calcium volume score, (2) calcium mass and (3) the Agatston score (Effarezan et all. – 2013).

The Agatston Score in its original form is assessed from 20 contiguous 3mm sections of the heart. A threshold of 130 Hounsfield Units (HU) is empirically set to identify calcifications. This threshold was introduced to exclude noise from the evaluation. In its original form, only plaques related to the coronary arteries with a minimum lesion size of 1 mm2 or two adjacent pixels are included in the calculation, to exclude random image noise. The analysis software will highlight any lesion that contains the minimum number of pixels with more than 130 HU.

The observer has to identify scoreable coronary artery lesions, and assigns each lesion to the left main coronary artery, the left anterior descending artery, the left circumflex, or the right coronary artery. A region of interest is placed around each lesion and area, and maximum CT number of each lesion is determined.

The calcium score is then calculated by multiplying the individual lesion area with a weighting factor. The maximum CT number per lesion determines this weighting factor. The factor is 1 for a peak lesion attenuation of 130–199 HU, 2 for 200–299HU, 3 for 300–399 HU, and 4 for a lesion with a density equal to or greater than 400 HU. The sum of all lesion scores is the vessel score, and all vessel scores are summed to calculate the total calcium score (Joseph-2005).

Another calcium quantification method called the calcium volume score (or volume equivalent) is based on calcium area and plaque density or volume. This was developed to provide a reproducible measurement of calcium scoring. However, there are limitations to the calcium volume score method as well. Image attenuation values can vary by scanner and patient body size, resulting in calcium score differences that do not reflect actual calcium within the coronary artery.

A third method of calcium quantification was developed to be an absolute calcium mass measurement and is performed in a manner similar to bone mineral density assessment. A standard calibration phantom is used that contains rods of various known calcium concentrations.

This phantom is positioned beneath the patient so that the length of the phantom covers the expected length of the heart. The patient is scanned and data from the calibration phantom are used in an algorithm to adjust for variations in attenuation caused by patient size and scanner (Lois-2011).

Table (2-2) CT Calcium Scoring “Agatston" and the Risk of Coronary Artery Disease (CARR et all. – 2000).

Calcium Score	Presence of Plaque	Risk of Coronary Artery Disease
0	No evidence of plaque	Very low, generally less than 5 percent
1–10	Minimal plaque	Very unlikely, less than 10 percent
11–100	Mild plaque	Mild or minimal coronary narrowing likely
101–400	Moderate plaque	Mild coronary artery disease highly likely, significant narrowing possible
More than 400	Extensive plaque	High likelihood of at least one significant coronary narrowing

Table (2-3) Prevalence of Coronary Artery Calcification Detected by CT in Asymptomatic Men and Women (Joseph-2005).

Age	Men (%)	Women (%)
–29	11	6
30–39	21	11
40–49	44	23
50–59	72	35
60–69	85	76
70–79	94	89
80–89	100	100

2.7 Cardiac CT Imaging Procedure:

2.7.1 Patient Preparation:

Following patient instructions should be given when procedure is scheduled:

1. No food or drink (except clear liquids) for 3–4 h prior to exam.

2. No caffeine products for 12 h prior to exam.

3. Do drink plenty of water prior to exam.

4. No nicotine products for 4 h prior to exam.

5. Take all regular medications the day of exam, especially blood pressure medicines.

6. No Viagra or similar medications for 24 h prior to exam.
7. Diabetic patients should ask their physicians how to adjust their medication for the day of the exam.
8. Metformin (Glucophage) often will be discontinued for 48 h after the scan.(Matthew et all. – 2008).

2.7.1.1 The Consent/Health History Forms:

Should include the following:

1. past cardiac surgeries, interventions, risk factors, and current symptoms.

2. past reactions to contrast agents, other allergic reactions and issues relating to pregnancy, lung disease, kidney disease, diabetes, or the presence of multiple myeloma.

3. Clearly state that this exam will require an intravenous (IV) injection of contrast material and that the patient may be given cardiac medications for heart rate, rhythm, or vasodilatation as needed.

4. Explain any portions of the study that might be used for research and how the patient's privacy will be protected. (Matthew et all. – 2008)

2.7.2Patient preparation:

Patient preparation should be done by an experienced nurse or nurse practitioner. Use short, 20-gauge IV catheters in normal or younger patients, but use an18-gauge catheter when necessary for more rapid infusion rates (older and hypertensive patients).

Use ante cubital veins if available. Alternate sites include the basilica or median veins of the forearm, the cephalic vein lying lateral (thumb side) of the arm, or the large upper cephalic vein above the ante cubital space. No central lines may be used other than those specifically labeled for power injection. Connect the IV to an extension tubing. Patients with diabetes or renal insufficiency or dehydration are at extra risk for contrast-induced nephropathy (CIN) defined as a rise of >0.5 in serum creatinine, Encourage all patients to drink a liter of water prior to arrival. At discharge give the patient a 500 ml bottle of water to drink and instruct them to drink approximately1500 ml more by the time they go to bed that evening.(Matthew et all. – 2008)

2.7.3 Pre Procedure Patient Medication:

Beta-blockade: Oral or IV metoprolol has become the standard because of demonstrate safety in patients with CHF and significant COPD and because of its low cost and reliability. The Oral approach is by 50 mg of metoprolol is given 12 hour before the scan with another 50 mg at the center, or the total 100 mg can be given as a tablet at the center 1 hour prior to scanning. If the heart rate is not <65, an additional 5 mg IV is given every 5 minutes to a total of 15 mg. Post-oral beta-blockade requires monitoring for 1 hour post procedure. The IV approach, after the patient is on the cardiac monitor and Blood Pressure (BP) is obtained, 5 mg of IV metoprolol is given as a test bolus with a 1–2 min pause to assess the response. A further 5–50 mg is then given as a slow push of 1 mg per 15 s, carefully monitoring the patient’s Heart Rate (HR). The average total required dose is 25 mg; however, older patients and smokers often require more dose. (Matthew et all. – 2008).

2.7.4 Breath-Hold Training:

1. Always practice breath holding and being still.

2. Have patients hold their breath in maximal inspiration.

3. Oxygen or sedation may help. (Matthew et all. – 2008).

2.7.5Post Scan:

Patients who have received no b-blockers may leave. Patients who have received a b-blocker are observed for 30 minutes to ensure their heart rate returns to normal. Images are reconstructed per specific protocol (Lois-2011).

2.8 Contrast Media:

To distinguish adjacent tissues on a CT image, the tissues must have different densities (attenuation). These varying densities will result in distinct attenuation coefficients, which produce an image that clearly displays the different tissues. In some parts of the body, such as the chest, subject contrast is inherently high. The pulmonary vessels and ribs have significantly different densities from the adjacent aerated lung, which allows easy identification on the image. Unfortunately, not all areas of the body possess this level of inherent tissue contrast. Often, many tissues have quite similar attenuation coefficients. In addition, tumors and other disease processes may have attenuation coefficients that are very similar to their surrounding tissues. An oral or intravenous administration of a contrast agent is often used to create a temporary, artificial density difference between objects(Lois-2011).

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2.8.1 Intravenous Contrast Agent:

Iodinated agents are universally used for a variety of radiology examinations because they are water soluble, easy to administer intravascularly, and have a high safety index.

Adding an iodinated agent to the bloodstream will temporarily increase the beam-attenuating ability of the blood; structures with an adequate blood supply show an increase in attenuation, which is displayed as a change from darker to lighter on the image. Two tissues must differ by at least 10 Hounsfield units (HU) to be visibly different on a CT scan (Lois-2011).

2.9 Radiation Dose:

The scientific unit of measurement for radiation dose, commonly referred to as effective dose, is the millisievert (mSv). Other radiation dose measurement units include rad, rem, roentgen, Sievert, and gray. Because different tissues and organs have varying sensitivity to radiation exposure, the actual radiation risk to different parts of the body from an x-ray procedure varies.

The term effective dose is used when referring to the radiation risk averaged over the entire body. The effective dose accounts for the relative sensitivities of the different tissues exposed. More importantly, it allows for quantification of risk and comparison to more familiar sources of exposure that range from natural background radiation to radiographic medical procedures (Radiologyinfo-2015).

Table (2-4) Shows the Typical Effective Radiation Doses for a Range of Common Cardiovascular Imaging Testes (SCAI-2014):

Test	Typical Effective Dose Estimate
Chest X-ray	0.1 mSv
Cardiac Chest CT	16 mSv
Coronary Angiogram	7 mSv
Coronary Angioplasty\Stent	15 mSv

2.10 Previous Study:

leaning et all. 2012 aimed was to determine the association of coronary artery calcification (CAC) with incident heart failure in the elderly and examine its independence of overt coronary heart disease (CHD). They found that during a median follow-up of 6.8 years, there were 78 cases of heart failure and 76 cases of nonfatal CHD. After adjustment for cardiovascular risk factors, increasing CAC scores were associated with heart failure (p for trend = 0.001), with a hazard ratio of 4.1 (95% confidence interval [CI]: 1.7 to 10.1) for CAC scores >400 compared with CAC scores of 0 to 10. After censoring participants for incident nonfatal CHD, increasing extent of CAC remained associated with heart failure (p for trend = 0.046), with a hazard ratio of 2.9 (95% CI: 1.1 to 7.4) for CAC scores >400.

Moreover, adding CAC to cardiovascular risk factors resulted in an optimism-corrected increase in the c-statistic by 0.030 (95% CI: 0.001 to 0.050) to 0.734 (95% CI: 0.698 to 0.770) and substantially improved the risk classification of subjects (continuous net reclassification index = 34.0%).**So** CAC has a clear association with the risk of heart failure, independent of overt CHD. Because heart failure is highly prevalent in the elderly, it might be worthwhile to include heart failure as an outcome in future risk assessment programs incorporating CAC (leening et all. 2012).

Khazai et.all aims to study the Coronary Atherosclerotic Plaque Detected by Computed Tomographic Angiography in Subjects with Diabetes Compared to Those without Diabetes. Little data are available regarding coronary plaque composition and semi-quantitative scores in individuals with diabetes; the extent to which diabetes may affect the presence and extent of Coronary Artery Calcium (CAC) needs more evaluation. Considering that this information may be of great value in formulating preventive interventions in this population, we compared these findings in individuals with diabetes to those without.

Diabetes was positively correlated to the presence and extent of CAC ($P<0.0001$ for both). SIS, SSS and TPS were significantly higher in those with diabetes ($P<0.0001$). Number of mixed and calcified plaques were significantly higher in those with diabetes ($P = 0.018$ and $P<0.001$ respectively) but there was no significant difference in the number of non-calcified plaques between the two groups ($P = 0.398$).So Patients with diabetes have higher CAC and semi-quantitative coronary plaque scores compared to the age, gender and ethnicity matched controls without diabetes after adjustment for cardiovascular risk factors.

Since mixed plaque is associated with worse long-term clinical outcomes, these findings support more aggressive preventive measures in this population. (Khazai et.all-2015)

Leslee et all. Aims to study the Prognostic Value of Cardiac Risk Factors and Coronary Artery Calcium Screening for All-Cause Mortality to develop risk-adjusted multivariable models that included risk factors and coronary calcium scores determined with electron-beam computed tomography (CT) in asymptomatic patients for the prediction of all-cause mortality.

Cardiac risk factors such as family history of coronary disease (69%), hypercholesterolemia (62%), hypertension (44%), smoking (40%), and diabetes (9%) were prevalent. The frequency of coronary calcium scores was 57%, 20%, 14%, 6%, and 3% for scores of 10 or less, 11–100, 101–400, 401–1,000, and greater than 1,000, respectively. During a mean follow-up of 5.0 years ± 0.0086 (standard error of the mean), the death rate was 2.4%.

In a risk-adjusted model (model $\chi^2 = 388.2$, $P < .001$), coronary calcium was an independent predictor of mortality ($P < .001$). Risk-adjusted relative risk values for coronary calcium were 1.64, 1.74, 2.54, and 4.03 for scores of 11–100, 101–400, 401–1,000, and greater than 1,000, respectively ($P < .001$ for all values), as compared with that for a score of 10 or less. Five-year risk-adjusted survival was 99.0% for a calcium score of 10 or less and 95.0% for a score of greater than 1,000 ($P < .001$).

With a receiver operating characteristic curve, the concordance index increased from 0.72 for cardiac risk factors alone to 0.78 ($P < .001$) when the calcium score was added to a multivariable model for prediction of death. This large observational data series shows that coronary calcium provides independent incremental information in addition to traditional risk factors in the prediction of all-cause mortality.(Leslee et all – 2003).

Robyn et all. Aimed to study Distribution of Coronary Artery Calcium by Race, Gender and Age, the Results were from the Multi-Ethnic Study of Atherosclerosis (MESA) . Coronary artery calcium (CAC) has been demonstrated to be associated with the risk of coronary heart disease.

The Multi-Ethnic Study of Atherosclerosis (MESA) provides a unique opportunity to examine the distribution of CAC on the basis of age, gender, and race/ethnicity in a cohort free of clinical cardiovascular disease and treated diabetes. MESA is a prospective cohort study designed to investigate subclinical cardiovascular disease in a multiethnic cohort free of clinical cardiovascular disease. The percentiles of the CAC distribution were estimated with nonparametric techniques. Treated diabetics were excluded from analysis. There were 6110 included in the analysis, with 53% female and an average age of 62 years. Men had greater calcium levels than women, and calcium amount and prevalence were steadily higher with increasing age. There were significant b differences in calcium by race, and these associations differed across age and gender. For women, whites had the highest percentiles and Hispanics generally had the lowest; in the oldest age group, however, Chinese women had the lowest values. Overall, Chinese and black women were intermediate, with their order dependent on age.

For men, whites consistently had the highest percentiles, and Hispanics had the second highest. Blacks were lowest at the younger ages, and Chinese were lowest at the older ages.

The information provided here can be used to examine whether a patient has a high CAC score relative to others with the same age, gender, and race/ethnicity who do not have clinical cardiovascular disease or treated diabetes (Robyn et all.- 2006).

Ram and Trivedi studied about smoking, smokeless tobacco consumption and coronary artery disease – a case control study .Coronary artery disease (CAD) is a major cause of premature death and disability throughout the world. Tobacco use is an important and avertable cause of CAD. The use of tobacco is on the rise worldwide. Present study was carried out to study the role of tobacco consumption in the occurrence of Coronary artery disease.

Present study was a hospital based paired matched case-control study, carried out at civil hospital, Ahmed abad. 135 newly diagnosed cases of coronary artery disease and 135 controls were studied after taking informed written consent. Data was analyzed by using Epi-info Version 3.5.1 computer package, Chi -square test, Z test and Odds ratio was calculated. Among the total 135 cases 70.4% were male and 29.6% were female, most of the cases (40%) were belongs to the age group of 51-60 years. Smokers and smokeless tobacco users were significantly higher among the cases as compared to controls. Significant association was also observed between current smokers, smokeless tobacco users and Coronary artery disease. Strong associations were also observed between frequency and duration of smoking with CAD.

Tobacco consumption in any form is major etiology behind the occurrence of CAD(Ram and Trivedi-2012). Youssef and Budoff said that the Coronary artery calcification (CAC) is a widely used imaging modality for cardiovascular risk assessment in moderate risk patients. It has been shown to have a superior role predicting future cardiac events and survival rates when combined with other traditional risk factor scoring systems as Framingham risk score (FRS). Furthermore, it significantly reclassifies moderate risk patients into lower or higher risk categories. Higher risk groups like patients with diabetes, a higher prevalence of CAC has been shown to impart a high short term risk of CV events, while those with zero calcium score had excellent event-free survival, similar to non-diabetic patients.

Having a zero calcium score is currently used in United Kingdom practice guidelines (NICE) as a gatekeeper for any further investigations in patients presenting to the emergency department (ED) with chest pain. Unanswered questions include the concept of CAC progression that need to be standardized with respect to technique, interpretation and subsequent management strategies. Studies also demonstrated that risk assessment using CAC was motivational to patients leading to better adherence to their preventive practices as well as medications. However, statin did not consistently prove beneficial in slowing the CAC progression rate, but did reduce CV events significantly in patients with increased CAC. Accordingly, more studies need to be conducted to further help understand the ideal way to utilize this imaging tool and decreasing downstream utilization (Youssef and Budoff -2012).

Megnien et all. Aimed to study if Hypertension promotes coronary calcium deposit in asymptomatic men despite its important role in coronary disease, coronary atherosclerosis has been poorly investigated in uncomplicated hypertension. Therefore, we evaluated the presence and amount (score) of coronary calcium with ultrafast computed tomography in 73 pairs of age-matched asymptomatic hypertensive or normotensive men. We also estimated the extent of peripheral atherosclerosis as the number of arterial sites (carotid, aortic, femoral) with echographic plaque. Compared with normotensive men, hypertensive men had more frequent coronary calcium (63% versus 47%), a higher calcium score (57 +/- 111 versus 18 +/- 38), and an odds ratio of calcium deposit of 1.95 (with confidence intervals [CI] 95%, 1.01 to 3.79) for any score and of 2.38 (95% CI, 1.02 to 5.52) or 4.84 (95% CI, 1.53 to 15.3) for scores above 50 or 100, respectively.

Hypertensive men showed correlations of calcium score with age and hypertension duration but not with the height of blood pressure, and the odds ratio of calcium deposit between extensive and minor peripheral atherosclerosis was 4.67 (95% CI, 1.41 to 15.45) for any score and 8.63 (95% CI, 2.10 to 35.5) or 8.13 (95% CI, 1.64 to 40.3) for scores above 50 or 100. Thus, high blood pressure and in particular its duration rather than its value promotes the presence and overall extent of coronary calcium, a potential predictor of sudden coronary death, in parallel with the extent of peripheral atherosclerosis. The mechanisms of the interaction of hypertension and coronary calcification may be multi factorial and not specific to hypertension (Megnien et all.-1996).

3. Material and Method

3.1 Material and Method:

3.1.1 Population of the Study:

The study population was composed of patients complained of chest pain presenting to the CT department of Royal Scan and Royal Care International Hospital in Khartoum during the period of August to November 2015.

3.1.2 Study Sample:

The sample consisted of 53patients. 28 were hypertensive and 16 had preexisting diabetes mellitus and 12were smokers, all patients complained of chest pain.

3.1.3 Inclusion Criteria:

All patients complained of chest pain.

3.1.4 Exclusions Criteria:

All patients with allergy to contrast agent, pregnancy, renal insufficiency and unstable heart rat or heart rate above 70 beats a minute.

3.1.5 Technique:

The following table presented the examination parameters that should be applied in performing CCT:

Table (3-1) Technique Use in Performing CT Examination for Coronary Artery.

Parameter	From
Image Type	Original/ primary/ axial
Body Part Examined	Chest
Patient Position	Supine
Scout View	AP/LAT
Scout Option	Helical CT
Field of View	Small 25 cm
Slice Thickness	0.5mm
K.V.P \ MA	120kvp\300-500MA
Injection Rate	3-5
Data Collection Diameter	320.00
Protocol name	Calcium scoring Coronary Cardiac CT
Reconstruction Diameter	198.75
Gantry Detector Tilt	00.0
x-ray Tube Current	430
Focal Spot	1.6\1.4
Group Pixel Spacing	0.388 \ 0.388 \ 512*512

3.1.6 Duration of the Study:

The study was done during the period of August to November 2015.

3.1.7 Data Collection:

The data was collected by master data sheets using the variables of gender, age, Wight, clinical history and habits" BP, diabetic and smoking" their duration and calcium score and plaque type.

3.1.8. Variables of the Study:

Patient Gender, Age, Wight, clinical history (blood pressure, diabetic and smoking), calcium score and plaque type (soft, mixed and hard)

3.1.9 Data Analysis:

Data were analyzed by using SPSS program and the results were presented in form of tables.

3.1.10Ethical Consideration:

-No identification or individual details were published.

-No information or patient details will be disclosed or used for reasons other than the study

3.1.11 Imaging Interpretation:

The calcium score was measured and the values were classified according to age, gender, weight, clinical history and habits " blood pressure, diabetic, smoking and duration of them according to years" , calcium score and plaque type . The values were written as numbers , the plaque type was diagnosed according to the radiologist opinion as hard, soft and mixed. All the patents data had been evaluated.

3.2 Machines:

The equipment included Toshiba Aquilion™ 64 CFX CT scanner to perform a calcium scoring and coronary artery angiography test by using axial and 3D images Figure(3-1) and (3-2), Ivy Cardiac 3000 Trigger & EKG/ECG Monitor to chick the patient heart rate during the examination figure(3-3) and the Medrad Stellant D Dual Syringe CT Injection System that injects both contrast and saline intravenously according to examination requirements Figure(3-4) .

Figure (3-1) Toshiba Aquilion™ 64 CFX CT scanner, Gantry and protocol unit. Royal scan CT Department, Khartoum 2015

Figure (3-2) Toshiba Aquilion™ 64 CFX CT scanner ,Gantry and Table. Royal Scan, CT Department, Khartoum 2015

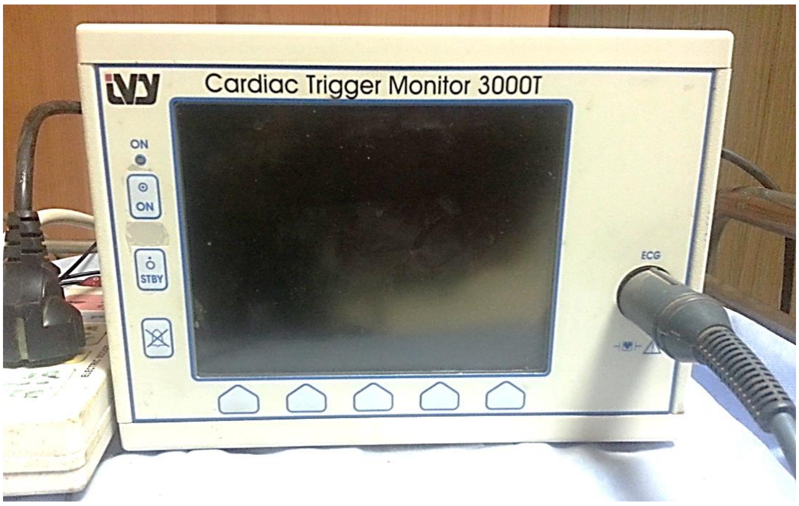

Figure (3-3) Ivy Cardiac 3000 Trigger & EKG/ECG Monitor. Royal Scan, CT Department. Khartoum 2015.

Figure (3-4) Medrad Stellant D Dual Syringe CT Injection System. Royal Scan, CT Department. Khartoum 2015.

3.3 Patients:

This study consist of 53 patient who complained of chest pain.

4. Results

The Descriptive statistics, including frequency and percentages, were calculated. T-test and Chi test were applied to test the significance of differences, *p*-value of less than 0.05 was considered to be statistically significant.

Detailed results are shown in the tables.

Table (4.1) Shows the Gender Distribution

Gender	Frequency	Percent%
Female	24	45.3
Male	29	54.7
Total	53	100.0

Table (4.2) Shows the Age Class Distribution

Age "Years"	Frequency	Percent%
30-40	1	1.9
41-51	17	32.20
52-62	15	28.40
63-73	14	26.50
74-84	5	9.50
>84	1	1.9
Total	53	100.0

Table 4.3 Shows the Weight Distribution

Weight/Kg	Frequency	Percent%
63-73	23	24.60
74-84	15	47.3
85-95	16	30.20
96-106	5	35.90
>106	4	7.60
Total	53	100.0

Table 4.4 Shows the Distribution of Sample According to Effecting with High Blood Pressure

Valid	Frequency	Percent %
No	26	49.1
Yes	27	50.9
Total	53	100.0

Table (4.5) Shows the Distribution of Patients Affected with Diabetes

Valid	Frequency	Percent %
No	37	69.8
Yes	16	30.2
Total	53	100.0

Table (4.6) shows the Distribution of Patients who were Smokers

Valid	Frequency	Percent%
No	41	77.4
Yes	12	22.6
Total	53	100.0

Table (4.7) Shows the Classification of Patients According to Clinical History

Clinical History	Disease		
	Hypertensive	Diabetes	Smokers
Number of Patients	28	16	12

Table (4.8) Shows the Number of Patients Affected with Calcifications in Aorta and Different Coronary Arteries

Affected Arteries	Aorta	LCX	LAD	RCA
NO. of Patients	10	5	12	9

Table (4.9)Shows the Number of Patients Affected with Soft Plaque

Valid	Frequency	Percent %
None	41	77.4
Yes	12	22.7
Total	53	100.0

Table (4.10)Shows the Number of Patients Affected with Mixed Plaque

Valid	Frequency	Percent %
None	17	32.1
Yes	36	67.9
Total	53	100.0

Table (4.11)Shows the Number of Patients Affected with Hard Plaque

Valid	Frequency	Percent %
None	49	92.5
Yes	4	7.5
Total	53	100.0

Table (4.12) Shows the Range of the Detected Total Calcium Scoring

Valid	Frequency	Percent%
0-200	32	60.5
201-401	13	632.30
402-602	1	1.9
603-803	5	9.50
>803	2	3.8
Total	53	100.0

Table (4.13) shows the Correlation between Total Calcium Scoring Values and Patient's Age and Weight

Variable	Correlation	Total Calcium Score
Age	Pearson Correlation	-.032-
	Sig. (2-tailed)	.819
	N	53
Weight	Pearson Correlation	.255
	Sig. (2-tailed)	.065
	N	53

Table (4.14)Shows the Correlation Between Total Calcium Scoring Values, Patient Clinical History and Plaque Types

		Correlations					
		Clinical History			Plaque Type		
		Blood Pressure	Diabetes	Smoking	Soft Plaque	Mixed Plaque	Hard Plaque
Total Calcium Score	Pearson Correlation	.371**	-.046-	.178	.131	.275*	.251
	Sig. (2tailed)	0.006	0.742	0.202	0.352	0.046	0.070
	N	53	53	53	53	53	53

Table (4.15) Shows the Range of the Detected Total Calcium Scoring Values Cross Tabulated with Soft Plaque Vessels

Cross Tabulation				Chi-Square Tests
Calcium Score	Soft Plaque		Total	Linear-by-Linear Association
	None	Yes		
0-200	26	6	32	
201-401	9	4	13	
402-602	1	0	1	
603-803	4	1	5	
>803	1	1	2	
Total	41	12	53	.347

Table (4.16) Shows the Range of the Detected Total Calcium Scoring Values Cross Tabulated with Mixed Plaque Vessels

Cross Tabulation					Chi-Square Tests
		Mixed Plaque		Total	Linear-by-Linear Association
		None	Yes		
Total Calcium Score	0-200	27	5	32	
	201-401	6	7	13	
	402-602	0	1	1	
	603-803	1	4	5	
	>803	2	0	2	
Total		36	17	53	.047

Table (4.17) Shows the Range of the Detected Total Calcium Scoring Values Cross Tabulated with Smoking

Cross Tabulation					Chi-Square Tests
		Smoking		Total	Linear-by-Linear Association
		No	Yes		
Total Calcium Score	0-200	26	6	32	
	201-401	9	4	13	
	402-602	1	0	1	
	603-803	5	0	5	
	>803	0	2	2	
Total		41	12	53	.199

Table (4.18) Shows the Range of the Detected Total Calcium Scoring Values Cross Tabulated with Hypertension

Cross Tabulation					Chi-Square Tests
		Blood Pressure		Total	Linear-by-Linear Association
		No	Yes		
Total Calcium Score	0-200	20	12	32	
	201-401	5	8	13	
	402-602	1	0	1	
	603-803	0	5	5	
	>803	0	2	2	
Total		26	27	53	.008

Table (4.19) Shows the Range of the Detected Total Calcium Scoring Values Cross Tabulated with Diabetes

Cross Tabulation					Chi-Square Tests
		Diabetes		Total	Linear-by-Linear Association
		No	Yes		
Total Calcium Score	0-200	20	12	32	
	201-401	11	2	13	
	402-602	1	0	1	
	603-803	3	2	5	
	>803	2	0	2	
Total		37	16	53	.738

Table (4.20) Shows the Range of the Detected Total Calcium Scoring Values Cross Tabulated with Weight

Total Calcium Score	Cross Tabulation					Total	Chi-Square Tests
	Weight Class						Linear-by-Linear Association
	63-73	74-84	85-95	96-106	>107		
0-200	8	10	8	2	4	32	
201-401	5	4	4	1	0	14	
402-602	0	0	0	0	0	0	
603-803	0	1	4	0	0	5	
>803	0	0	0	2	0	2	
Total	13	15	16	5	4	53	.066

5. Discussion, Conclusion and Recommendation

5.1. Discussion:

Coronary calcium scans Computed Tomography is method to check the buildup of calcium plaque on the walls of the coronary arteries. This test is used to check for heart disease in an early stage and to determine how severe it is (WEBMED-2014).

Our study was designed to evaluate the Coronary Arteries in Patients with Chest Pain Using Computerized Tomography .The study was obtained in 53 subjects complained of chest pain , female 24 (45.3%) and male 29 (54.7%) as presented in table (4-1). Their mean age was 41-51years (32.20%), this was presented in table (4-2). The mean Wight was from63-73 (24.60%) as presented in table (4-3). 27(50.9%) of them were hypertension as in table(4-4), 16(30.2%) diabetic as in table (4-5) and 12(22.6%) smokers as presented in table (4-6). 10 patient Patients Affected with Calcifications in Aorta, 5 in Left Circumflex Coronary Artery (LCFX) ,12 in Left Anterior Descending Artery (LAD) and 9 in Right Coronary Artery (RCA) as presented in table (4-8).

The number Affected patient with Soft Plaque was 12(22.7%), mixed plaque17 (67.9%) and hard plaque 4(7.5%) presented in table (4-9),(4-10) and (4-11). Total Calcium Scoring was classified in rang of 200 unite for each calcium scoring group this was presented in table (4-12).We tested the correlation between the total calcium score and all the variable in our study. No correlation was found between Total Calcium Scoring Values and Patient’s Age and Weight, it wasn’t significance in both, age = 0.819 > 0.005 , weight = 0.065> 0.005 this was presented in table (4-13).

By studying the Correlation Between Total Calcium Scoring Values, Patient Clinical History and Plaque Types which was presented in table(4-14) , there was significant correlation between blood pressure and total calcium score =0.006 , Thus, high blood pressure and in particular its duration rather than its value promotes the presence and overall extent of coronary calcium[Megnien et all-1996].

There was no relationship between diabetic 0.742>0.05 and total calcium scoring ,Patients with diabetes have higher CAC and semi quantitative coronary plaque scores compared to the age, gender and ethnicity matched controls without diabetes after adjustment for cardiovascular risk factors[Khazai et.all-2015].Also the relation between smoking=0.202 >0.05 and total calcium scoring wasn't significant ,Significant association was observed between current smokers, smokeless tobacco users and Coronary artery disease. Strong associations were also observed between frequency and duration of smoking with CAD [Ram and Trivedi-2012], the relation was significant with total score value and mixed plaque=0.046.

According to table (4-15) the Detected Total Calcium Scoring Values

With Soft Plaque Vessels=12, it was approved with Chi squire test Linear Association=0.886maybe due to pathology or simple data size significant was missed.

Although the simple number of Mixed Plaque=17in sample But, the relation was significant and it was approved by the Linear Association=0.047 tabulated in table (4-16).

Asymptomatic persons with diabetes were shown to have significantly higher calcium score than non-diabetics even after controlling for other risk factors [George and Matthew-2012].

In our study the correlation wasn’t significant for diabetic=16, Linear Association=0.199.According to the cross tabulating smoking=12, Linear Association=0.783don’t effect total calcium score, may be due to small data sample, tabulated in table (4-17) and (4-19).

Blood pressure effect total calcium score, Bothe test confirm that, 27 had blood pressure and the Linear Association=0,008.tabulated in table (4-18)

In the study Wight doesn't affect Calcium Scoring Values, the mean of wight**85-95**at the highest calcium score the no of patient was 0, tabulated in table (4-20).

5.2. Conclusion:

This study was designed to define the role of computed tomography coronary angiography (CTA) in the diagnosis of patients with chest pain by measuring the calcium scoring in the coronary arteries (CAC) and correlate the results with the clinical history and plaque type. A 53 patients Hypertensive, diabetic and smoker underwent (CTA). Quantitative coronary angiography calcium scoring (Agatston) was measured in right coronary artery (RCA), left anterior descending artery (LAD), left circumflex coronary artery (LCFX) and aorta.

5.3. Recommendation:

- Finally (CAC) offers identifying the patients intended to have cardiac events, diagnosis of coronary arteries lesions and characterizing the plaque pattern .It is believable that measurements of calcium score will provide an acknowledged analytical radiological tool for the diagnoses of (CAD).
- For future and upcoming research it’s important to increase the number of the patient of more finding.

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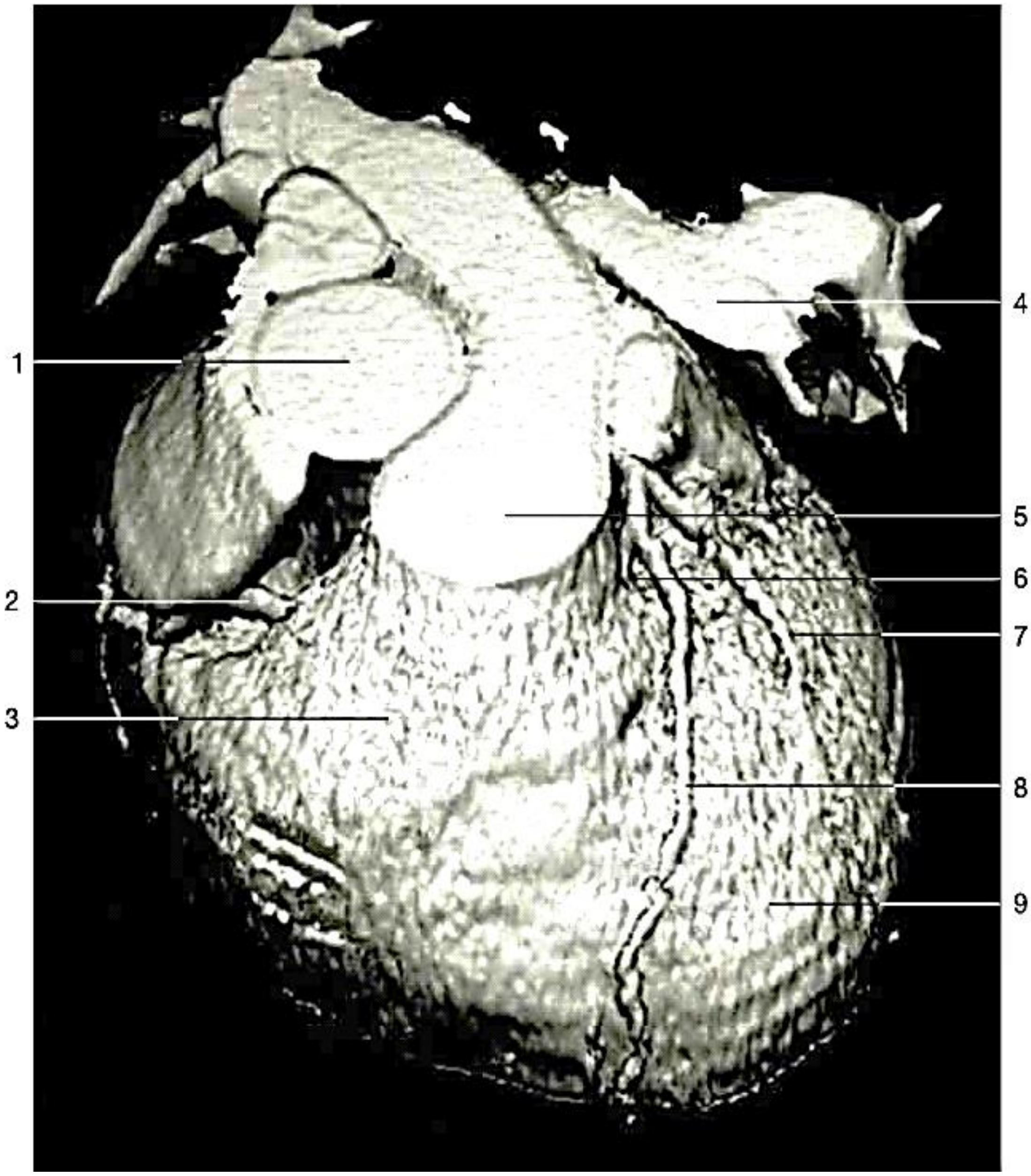
Appendix A

THE TABLE OF DATA COLLECTED DURING THE STUDY

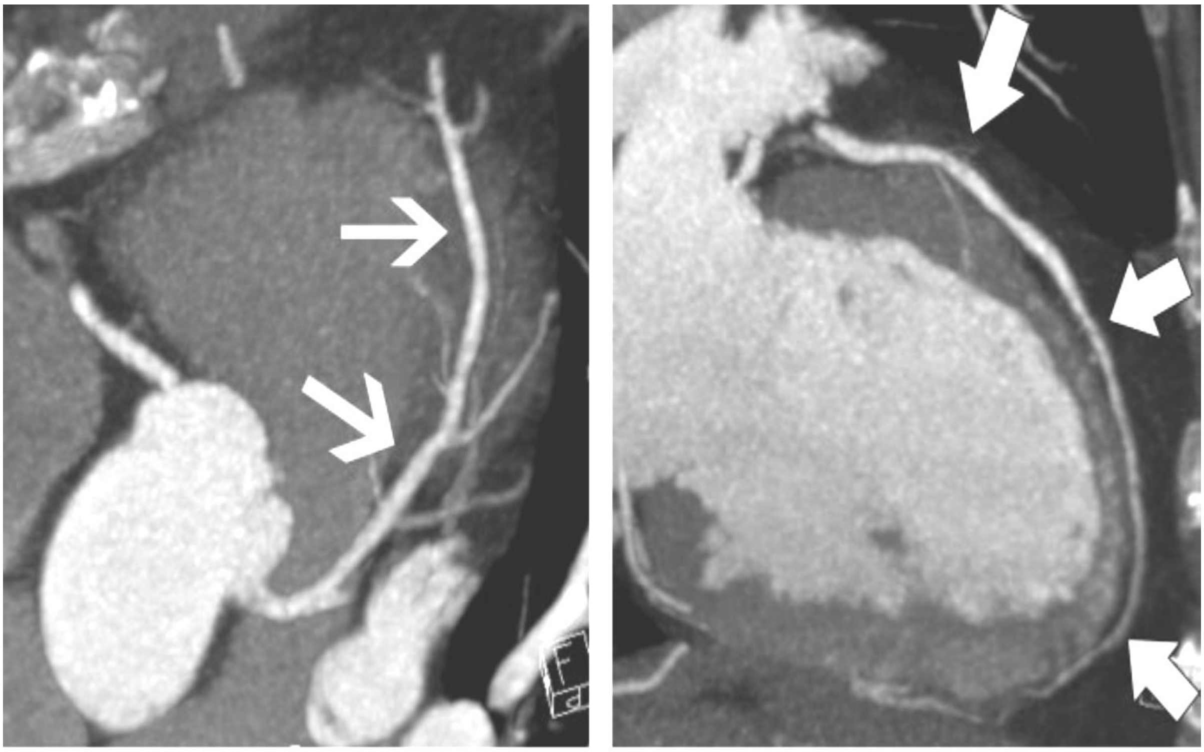
No.	Gender	Age	Weight	Clinical History and Habits			Duration	Normal "CCS = 0"	Heart Vessels "CCS"				Total CCS	Plaque Type 3		
				BP	Diabetic	Smoking			RCA	LAD	LCX	Aorta		Hard	Soft	Mixed
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																

Appendix B

Computed Tomography Images

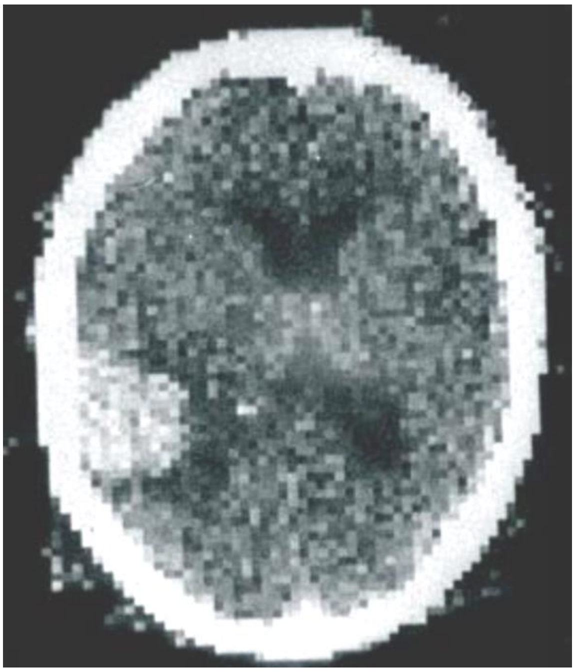


B1 *Human Heart (3-D reconstruction of electron beam CT scans as Shaded Surface Display).*

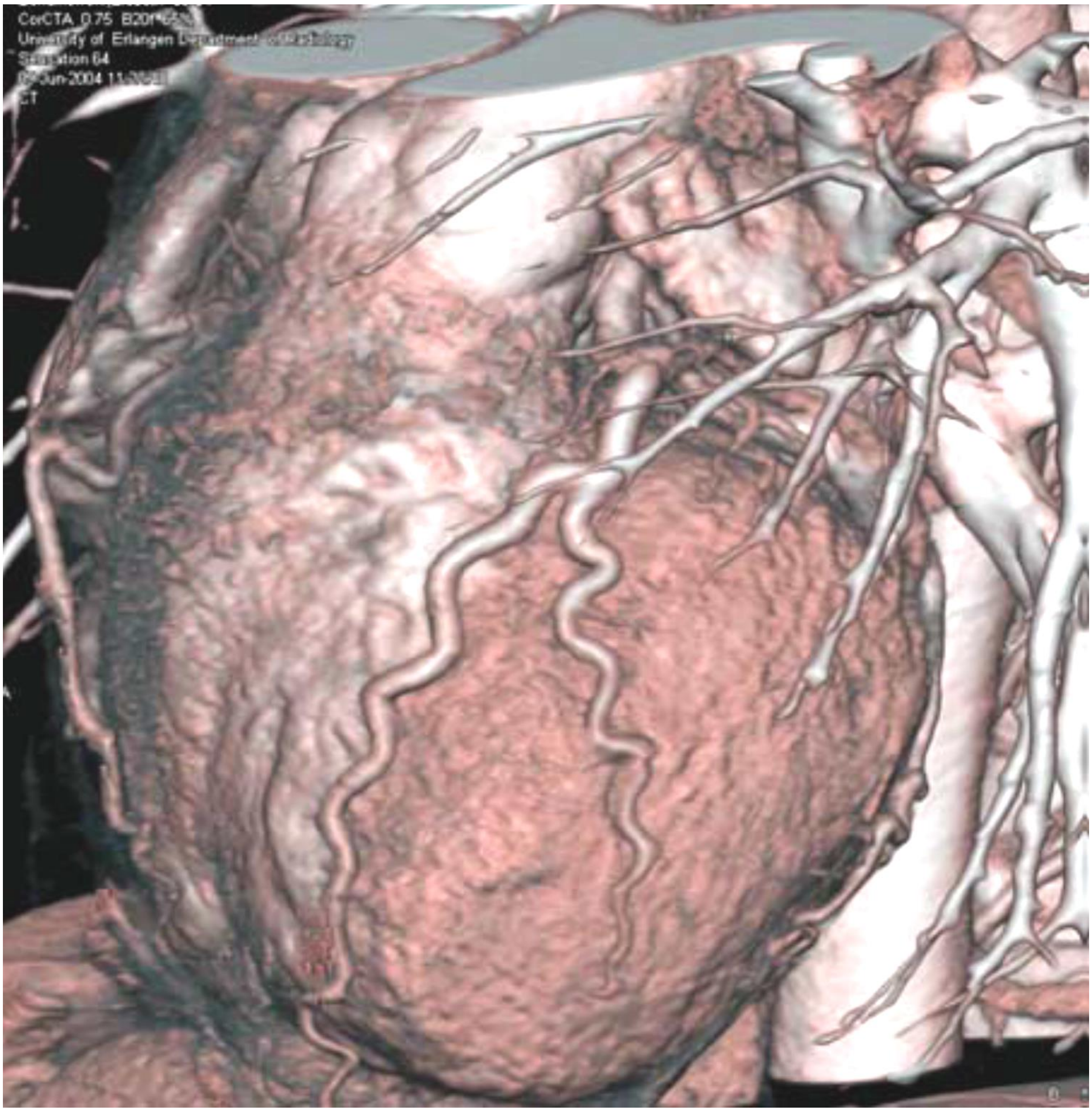


a. b.

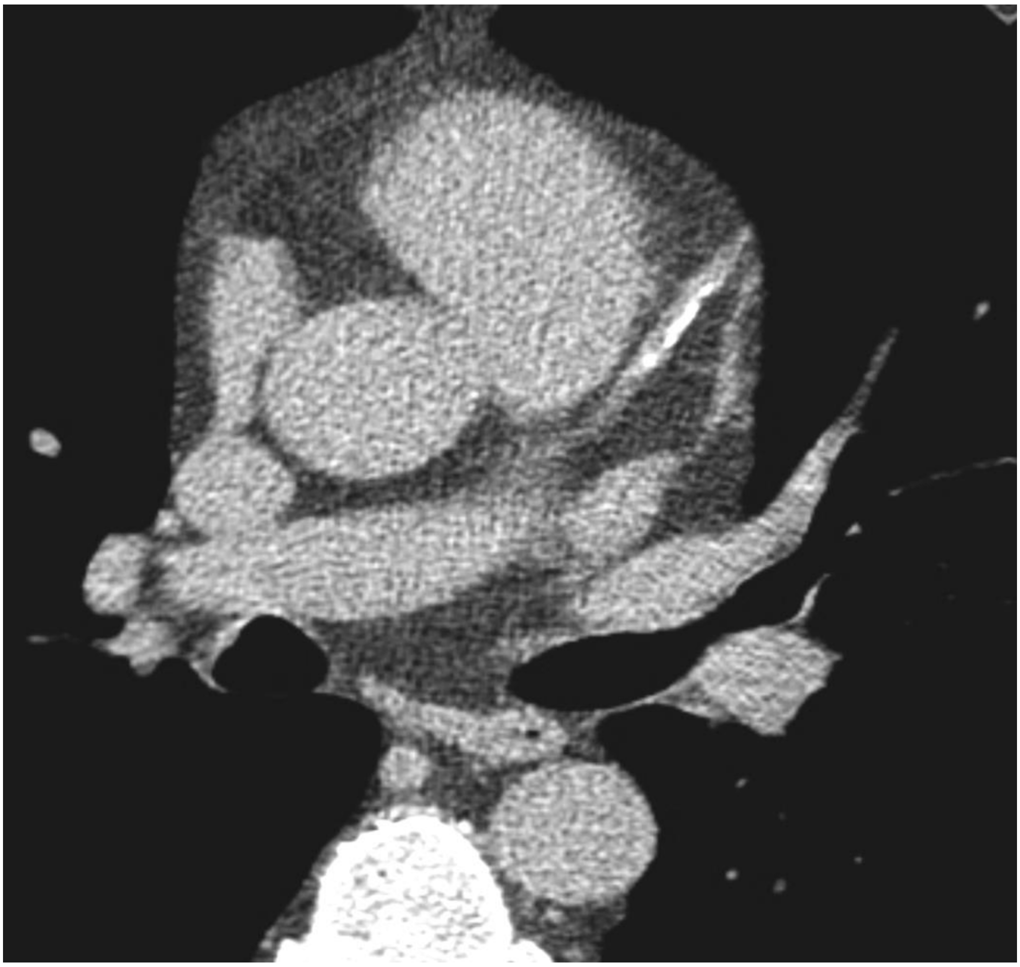
B2 *Oblique axial (a) and vertical long-axis (b) MPR images show the normal LAD artery (arrows) coursing in the epicardial fat of the interventricular groove toward the LV apex.*



B3 *the first commercial CT scanner brain image*.



B4 *3D volume rendering of a coronary CT angiography Examination using the latest 64-slice CT generation*



B5*Transaxial image display of coronary calcification in LAD using ECG-triggered acquisition with subsecond singleslice mechanical CT*