Sudan University for Sciences and Technology

College of Graduate Studies

A Study of Cardiac Diseases using Multi-slice (MSCT) computed tomography

دراسه أمراض القلب بإستخدام الأشعة المقطعية المحوسبة متعددة الطبقات

A Thesis Submitted for Ph.D. in Diagnostic Radiological Technology

By:

Sarra Hassan Khalifa Ali

Supervisor:

Dr. Mohamed Mohamed Omer Mohamed Yousef

Co Supervisor:

Dr.Iklas Abdelaziz Hasssan Mohammed

2018

الآيـــــة

بسم الله الرحمن الرحيم

قَالَ تَعَالَىٰ:

﴿ أَفَلَمۡ يَسِيرُواْ فِى ٱلۡأَرۡضِ فَتَكُونَ لَهُمۡ قُلُوبٞ يَعۡقِلُونَ بِهَآ أَوۡ ءَاذَانٞ
يَسۡمَعُونَ بِهَاۖ فَإِنَّهَا لَا تَعۡمَى ٱلۡأَبۡصَٰرُ وَلَٰكِن تَعۡمَى ٱلۡقُلُوبُ ٱلَّتِى فِى
ٱلصُّدُورِ ٤٦ ﴾

صدق الله العظيم

سورة الحج ايه 46

Dedication

To my parents

My husband

My children

My teachers

My friends

For giving me never gifts of encouragement, love and patience

Acknowledgment

I would like to express my sincere gratitude to Professor.Dr. Mohammed Mohammed Omar and Dr.Iklas Abdelazeez whom have given me great advice and help in the whole process of my thesis for his fruitful day to day supervision, guidance, endless help and encouragement that built confidence in my work for their valuable and continuous help, their patience through all the years that made this work possible for giving this opportunity of study, and for endless encouragement and unlimited support.

My thanks extend also to colleagues in Omar Sawi complex Alrebat hospital, Royal scan, Royal care and colleagues in College Medical Radiological Science and all Library staff of Medical Radiological College. Mr. Ata alla Mr. Mohamed Abdelwahab, Mr. Mohamed ALI, Mrs. Shemma for contributing in the sample collections.

Thanks are also extended to Dr. Jumaa Tamboul and Dr.Awadia.

I would like to thank everyone who assisted by one way or another to bring this study to the light.

Abstract

The aim of this study was to study the cardiac diseases using Multi slice computed tomography (MSCT) and to determine the diagnostic value of (MSCT). Patient underwent MS CT study for coronary artery angiography and calcium scoring test by using axial and 3D image.135 Sudanese patients (73 males and 62females) their ages ranged (16-80) years were enrolled in the study in National Rebat Hospital Omer Sawi complex and Royal diagnosis center in the period from (2016-2018). Exclusion criteria were patient with unstable angina, allergic to iodinated contrast material, renal Insufficiency, severe respiratory function impairment, heart failure and pregnant women. The demographic parameters including age, sex, and weight. All patients had undergone a contrast material– enhanced, retrospectively electrocardiographically gated coronary CT angiographic examination, which was performed by using a MSCT scanner with Injection rate 3-5mL .Patient take beta blocker one day before the exam. Patient fasting at least 6 hours before the examined .Two views were taken anterioposterior and lateral localize the area of the study then we done calcium scoring test firstly then coronary computed tomography the amount of contrast (ominupaque)are about 70-100 ml. The image evaluated and the data was collected using data sheet which contained the patient name age weight sex then the images were diagnosis by radiologist. All the data were analyzed using SPSS program. Categorical data were presented as frequencies and percentages .Normally distributed continuous data were presented as means ± standard deviations. The result are displayed as tables and

graphs. The result are the male are more affected (69%)by cardiac diseases than women(64%).The cardiac diseases is more affected in old age patient mean age (56.6) the age group 50_70 represent (67.4 %) and opacity persons the mean weight (73.5).The common diseases are the atherosclerosis (6%) by its three type calcified and non-calcified and mixed. The calcium high score in multiple degree (20.7%).The coronary stenosis (24.4%) and the left branch is more affected (15%(than the right one (9%). The stenosis which affect (one 16- two 16 and three 1). There are several diseases like infarction (3.7%) aortic aneurysm (4.4%) ventricular aneurysm (3.7%) and aortic calcification (1.5%) pericardial effusion (3.7%).The study concluded that MSCT has great value in measuring cardiac diseases and is a reliable, non-invasive, appropriate tool for diagnosing patients with cardiac and coronary arteries diseases and has a great value in clinical settings.

ملخص الدراسه

الهدف من البحث دراسه امراض القلب باستخدام الاشعه المقطعيه متعددة الطبقات واظهار القيمه التشخيصيه للاشعه المقطعيه . تم اجراء فحص الشرايين التاجيه وقياس معدل الكالسيوم باجراء صور محوريه وثلاثيه الابعاد.اجريت الدراسه على(135 مريض)(73 ذكر -62 انثى). تتراوح اعمارهم بين(18 -80) الرباط الوطني مجمع عمر ساوي ومركز رويال اسكان التشخيصي في الفتره الزمنيه من (2016-2018). تم استبعاد المرضى المصابين بذبحه غير مستقرة وحساسيه الماده الملونه ومرضى الفشل الكلوي ومشاكل التنفس الحاده و فشل القلب والنساء الحوامل.

اخذت في الاعتبار العوامل الاتيه النوع والعمر والوزن و تم حقن جميع المرضى بوسيط التباين وتركيب جهاز رسم القلب الموصل مع جهاز الاشعه المقطعيه .اخذ جميع المرضى حبه من البيتا بلوك قبل يوم من اجراء الفحص و يكون المريض صائما مالا يقل عن 6 ساعات قبل الفحص . اخذت اوضاع التصوير الاماميه و الجانبيه وتم تحديد المنطقه المراد تصويرها ثم اخذت قراءه مدى التكلس في الشرايين التاجيه وبعدها تم تصوير القلب والشرايين بعد حقن من 70-100 مل من وسيط التباين بمعدل حقن 3-5 مللتر في الثانيه . اخذت من المرضى كل من الاسم النوع العمر الوزن كما تم تشخيص الصوربواسطه اخصائيين وتحديد شكل ودرجه ظهور المرض.تم تحليل البيانات عن طريق برنامج الحزمه الاحصائيه للعلوم الاجتماعيه في شكل ترددات ومتوسط وانحراف معياري. كما تم عرض النتائج في جداول ورسوم بيانيه وكانت النتائج يتعرض الذكور(69%) للاصابه بامراض القلب اكثر من الاناث(64%)وكبار السن اكثر تعرضا لامراض القلب حيث كان متوسط اعمار المرض المرضى(56%) سنه و تركز(67%) من اعمار المرضي في الفئه العمريه من(50-70) وكذلك كان المرضي ذوي الاوزان العاليه اكثر عرضه لامراض القلب (متوسط الاوزان 73 كيلو).

كانت الامراض الاكثرظهورا تصلب الشرايين (6%) بانواعه الثلاثه (متكلس ,غير متكلس ومختلط) كما كان ارتفاع معدل الكالسيوم من الامراض الاكثر شيوعا بدرجات متفاوته (20%) وضيق الشرايين (24%) كان الاكثر تعرضا للاصابه بضيق الشرايين (الشريان التاجي الايسر

15%)(من الشريان الايمن 6%) حيث كان هناك ضيق في ثلاثه شرايين (حاله واحده)شريانان (16 حاله) شريان واحد(16 حاله).كما تم تشخيص عده امراض مثل الذبحه الصدريه(3.7%) انبعاج الشريان الابهر(4.4%) انبعاج البطين (3.7%) تكلس الابهر(1.5%) وتجمع السوائل في غشاء القلب(3.7%) .

من الدراسه يتضح اهميه الاشعه المقطعيه في انها دقيقه وغير تداخليه ولها قيمه تشخيصيه عاليه في تشخيص امراض القلب والشرايين التاجيه .

List of Tables

List of Figures

List of Abbreviation

CVDs	**Cardio Vascular Diseases**
ACS	**Acute Coronary Syndrome**
MI	**Myocardial Infarctions**
CAD	**coronary artery disease**
WHO	**World Health Organization**
CCT	**Cardiac Computed Tomography**
MPI	**Myocardial Perfusion Imaging**
ECG	**The Electro Cardiogram**
AV	**Atrio Ventricular**
SVC	**Superior Vena Cava**
IVC	**Inferior Vena Cava**
RCA	**Right Coronary Artery**
ACS	**acute coronary syndrome**
MI	**myocardial infarctions**
MSCT	**multi-slice computed tomography**
LAD	**Left anterior descending artery**
LCX	**Left Circumference Artery**
SPSS	**Statistical Package for Social Science**
DM	**Diabetes Mellitus**
LMA	**Left Main Artery**
RCA	**Right Coronary Artery**
MPI	**Myocardial Perfusion Imaging**
DSCT	**dual-source computed tomography**
PDA	**patent ductus arteriosus**
ASD	**atrial septal defect**
QCA	**quantitative coronary angiography**
AHA	**American Heart Association**
FRS	**Framingham Risk Score**

EBCT	**electron beam CT**
CAC	**calcium score**
RR	**relative risk**
CHD	**Coronary heart disease**
3-D	**three-dimensional**
2-D	**two-dimensional**
PACS	**picture archiving and communication system**
MIP	**Maximum Intensity Projection**
RA	**right atrium**
RV	**right ventricle**
LA	**left atrium**
PA	**pulmonary artery**
SNP	**single nucleotide polymorphisms**

Table of contents

CHAPTER ONE

Chapter one

1.1 Introduction

Cardiovascular diseases are the most common causes of premature death in developed countries and the main cause of morbidity and mortality in 2015 according to a WHO report. A major fraction is attributable to coronary artery disease which may result in sudden cardiac death [Stary 1990]. In approximately 50%of patient's myocardial infarction is the first sign of coronary Atherosclerosis and more than 50% of patients suffering an acute myocardial event die within the first month after onset of the acute phase [Fuster et al 2011]. Such fact is related to the long-time delay between the incidence of atherosclerosis in young adults [Stary 1990, Fuster et al 2011]. Despite a recent decline in a CVD mortality in men and women, the main problem is related to the acute manifestation as the acute coronary syndrome (ACS), which leads 30 – 50% of subjects to sudden and fatal outcomes [Roger et al 2011,ErbelR et al 2010] . In addition, about 20% of first and recurrent acute myocardial infarctions (MI) are silent [Thom et al 2001, Boland et al 2002].The life time risk of coronary artery disease (CAD) after the age of 40 years is 49% for men and 32% for women [Lloyd 1999]. This data is confirmed for Europe despite a strong decline in hospital deaths[Lowel et al 2006,Dudas et al2006]. Coronary heart disease is the most common cause of death in the general population [Mirghany et al 2013].

A reduction of mortality caused by myocardial infarction may be achieved if coronary atherosclerosis can be detected at an early stage of the disease before symptoms occur; therefore, there is need for an effective tool that allows identification of patients at increased risk for future cardiac events [Fuster et al 2011].

Rapid advances in multi-slice computed tomography (MSCT) imaging technology have facilitated increasingly accurate noninvasive coronary artery imaging. Current generation 64-128 slices MSCT scanners have demonstrated highly accurate qualitative identification of significant coronary artery lesions (50% stenosis) in vessels larger than 1.5 to 2mm, with reported sensitivities and specificities ranging from 82% to 95% and 82% to 98%, respectively.

1.2 Problem of the study

Heart and coronary diseases is usually degenerative diseases is uncommon as clinical problem before the age of 30 and common by the age 60.One in four people will have heart attack. The first recognized symptom may be death. CAD long asymptomatic latent period and that early targeted preventive measure scan reduce mortality and morbidity .MSCT is low radiation dose, low cost and low invasive than catheterization and high spatial resolution than MRI. MSCT has high diagnostic accuracy in the CAD.

1.3 objectives

1.3.1 General objective

The aim of this research is to study cardiac diseases using (MSCT) Multi slice computed tomography.

1.3.2 Specific objectives

- To determine the diagnostic value of MSCT in the cardiac diseases.
- To provides a rapid and accurate diagnosis while avoiding unnecessary invasive cardiac diseases procedures.
- To present the correlation between cardiac diseases and the sex age and weight.
- To provides a rapid and accurate diagnosis while avoiding unnecessary invasive cardiac diseases procedures.

1.4 Over view of the study

This is described through the chapters of the study in a sequential manner.

In chapter one a summarized introduction including prelude about cardiac diseases, the study problem, objectives, and over view of chapter‘s contents were present.

In chapter two an over view of the literature including anatomy, physiology and pathology of heart and blood vessels were included. Over view of MSCT and cardiac imaging methods also took place as well as the previous studies and theoretical back ground as it is an important point of this research.

Chapter three dealt with the material used in the practical study including different machines, Also the methodology of the practical setup was discussed in details.

Chapter four dealt with the results of the study. The results interpretations are giving in this chapter. Also given in chapter five are the discussion, conclusions of the study performed as well as future work and recommendations.

CHAPTER TWO

THEAORATICAL BACK GROUND AND LITRUE REVIE

Chapter two

Theoretical background and literature review

2.1 Theoretical background

2.1.1 Anatomy

2.1.1.1 The Heart

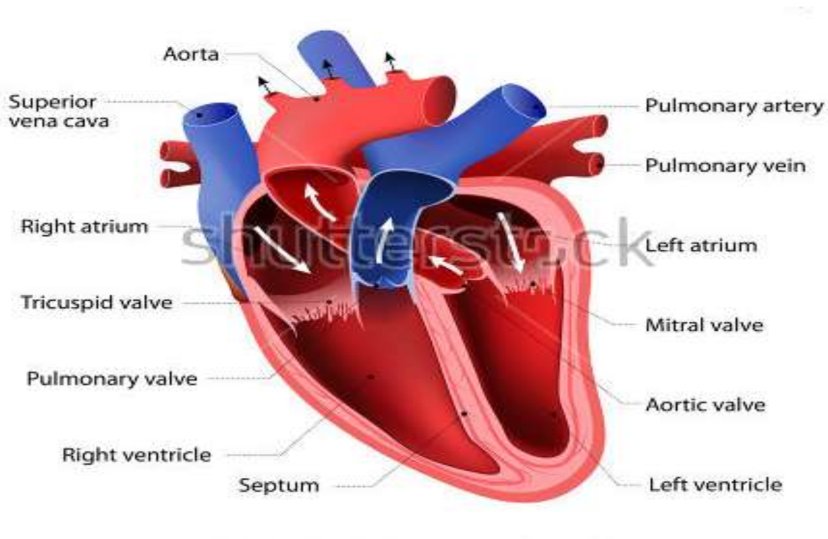


Figure 2.1: The passage of blood through the heart (www.shtterstock.com).

A basic understanding of cardiac anatomy allows for correlation of physical exam finding with the unseen anatomy of the heart. The adult heart is about the size of a closed fist and sits in the thorax on the left side of the chest in front of the lungs. The heart is designed as a pump with four chambers - right atrium (RA), right ventricle (RV), left atrium (LA), and left ventricle (LV). The two atria are the smaller, upper chambers of the heart and the two ventricles are the larger, lower chambers of the heart. The heart is oriented in the chest rotated about 30 degrees to the left lateral side such the right ventricle is the most anterior structure of the heart. The left ventricle is generally about twice as thick as the right ventricle because it needs to generate enough force to push blood through the entire body while the right ventricle only needs to generate enough force to push blood through the lungs [Hoffmann 2006].

The heart also has four valves. The tricuspid valve is between the right atrium and right ventricles. The pulmonary valve is between the right ventricle and the pulmonary artery. The mitral valve is between the left atrium and the left ventricle and the aortic valve is between the left ventricle and the aorta. The valves, under normal conditions, insure that blood only flows in one direction in the heart. In order to pump blood through the body, the heart is connecting to the vascular system of the body. This cardiovascular system is designed to transport oxygen and nutrients to the cells of the body and remove carbon dioxide and metabolic waste products from the body. The cardiovascular system is actually made up of two major circulatory systems, acting together. The right side of the heart pumps blood to the lungs through the pulmonary artery (PA), pulmonary capillaries, and then returns blood to the left atrium through the pulmonary veins (PV). The left side of the heart pumps blood to the rest of the body through the aorta, arteries, arterioles, systemic capillaries, and then returns blood to the right atrium through the venules and great veins [Hudsmith et al 2007].

2.1.1.2 Coronary arteries

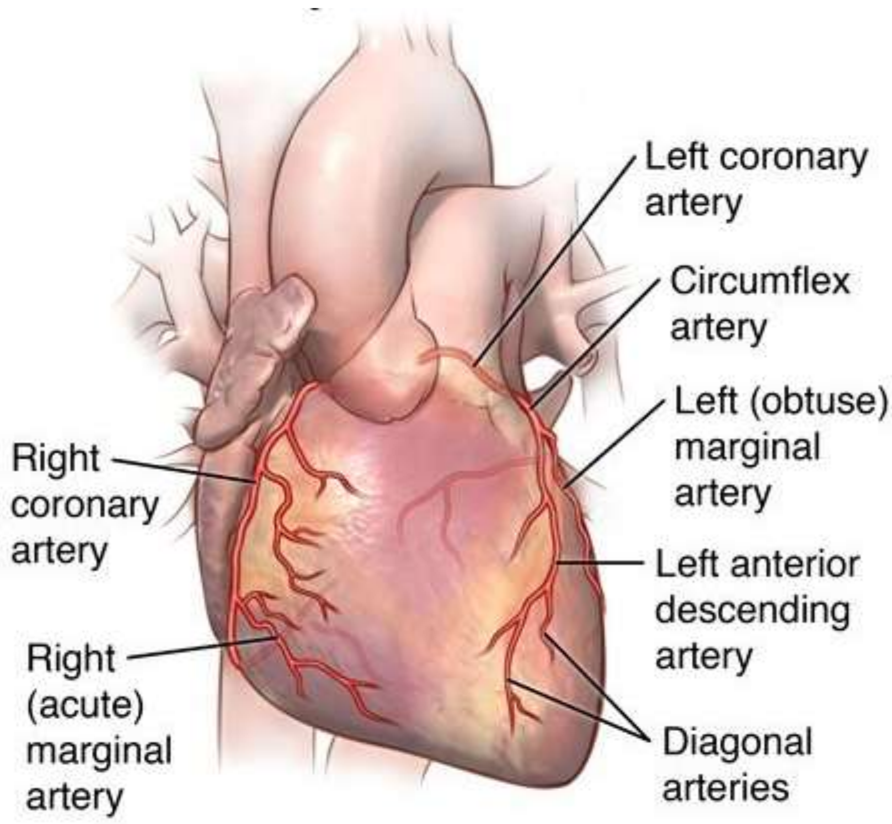


Figure 2.2 Coronary arteries (www.shtterstock.com).

Coronary arteries supply blood to the heart muscle. Like all other tissues in the body, the heart muscle needs oxygen-rich blood to function. Also, oxygen-depleted blood must be carried away. The coronary arteries wrap around the outside of the heart.

Small branches dive into the heart muscle to bring it blood [Hudsmith et al 2007]. The 2 main coronary arteries are the left main and right coronary arteries.

Left main coronary artery (LMCA). The left main coronary artery supplies blood to the left side of the heart muscle (the left ventricle and left atrium). The left main coronary divides into branches:

The left anterior descending artery branches off the left coronary artery and supplies blood to the front of the left side of the heart.

The circumflex artery branches off the left coronary artery and encircles the heart. This artery supplies blood to the outer side and back of the heart.

The left coronary artery (left main coronary artery) emerges from the aorta through the Ostia of the left aortic cusp, within the sinus of Valsalva. The plane of muscle the semilunar valve is tilted so that the ostium of the left coronary artery is superior and posterior to the right coronary ostium. The left coronary artery travels from the aorta, and passes between the pulmonary trunk and the left atrial appendage. Under the appendage, the artery divides (and is thus a very short vessel) into the anterior interventricular (left anterior descending artery) and the left circumflex artery. This bifurcation can often be seen when looking into the left coronary artery Ostia with a video scope. Note that the left coronary artery may be completely absent, i.e., the anterior interventricular and circumflex arteries arise independently from the left aortic sinus [Raman et al2007].

In general, the LAD artery and its branches supply most of the interventricular septum; the anterior, lateral, and apical wall of the left ventricle, most of the right and left bundle branches, and the anterior papillary muscle of the bicuspid valve (left ventricle). It also provides collateral circulation to the anterior right ventricle, the posterior part of the interventricular septum, and the posterior descending artery.

The LAD artery is the most commonly occluded of the coronary arteries. It provides the major blood supply to the interventricular septum, and thus bundle branches of the conducting system. Hence, blockage of this artery due to coronary artery disease can lead to impairment or death (infarction) of the conducting system. The result is a "block" of impulse conduction between the atria and the ventricles known as "right/left bundle branch block."

The circumflex artery branches off of the left coronary artery and supplies most of the left atrium: the posterior and lateral free walls of the left ventricle, and part of the anterior papillary muscle. The circumflex artery may give off a variable number of left marginal branches to supply the left ventricle. The terminal branch is usually the largest of these branches. More likely, the circumflex artery may continue through the AV sulcus to supply the posterior wall of the left atrium and the left ventricle.

In 40-50% of hearts the circumflex artery supplies the artery to the SA node [Malouf et al 2005].

Right coronary artery (RCA). The right coronary artery supplies blood to the right ventricle, the right atrium, and the SA (sinoatrial) and AV (atrioventricular) nodes, which regulate the heart rhythm. The right coronary artery divides into smaller branches, including the right posterior descending artery and the acute marginal artery. Together with the left anterior descending artery, the right coronary artery helps supply blood to the middle or septum of the heart [Malouf et al 2005].

2.1.1.3 Coronary flow

During contraction of the ventricular myocardium (systole), the subendocardinal corollary Vessels (the vessels that enter the myocardium) are compressed due to the high intra ventricular pressures. However, the epicedial coronary vessels (the vessels that run along the outer surface of the heart) remain patent. Because of this, blood flow in the sub endocardium stops. As a result most myocardial perfusion occurs during heart relaxation (diastole) when the subendocardial coronary vessels are patent and under low pressure. This contributes to the filling difficulties of the coronary arteries. Compression remains the same.' Failure of oxygen delivery caused by a decrease in blood flow in front of increased oxygen demand of the heart results in tissue ischemia, a condition of oxygen debt. Brief ischemia is associated with intense chest pain, known as angina. Severe ischemia can cause the heart muscle to die from hypoxia, such as during a myocardial infarction. Chronic moderate ischemia causes contraction of the heart to weaken, known as myocardial hibernation. In addition to metabolism. Diepharmacologic unique possesses circulation coronary characteristics [Mozaffarian et al 2013].

2.1.1.4 The coronary veins

A complex network of veins drains the coronary circulation. An extensive degree of collateralization amongst these veins and the coronary arteries, and the paucity of valves within coronary veins, enables the use of retrograde coronary sinus cardioplegia for intraoperative myocardial protection. The venous circulation can he divided into three systems: the coronary sinus and its tributaries, the anterior right ventricular veins, and the basin veins [Mozaffarian et al 2013].

2.1.1.5 Coronary Sinus and its Tributaries

The coronary sinus predominantly drains the left ventricle and receives approximately 85% of coronary venous blood. It lies within the posterior atrioventricular groove and empties into the right atrium at the lateral border of the triangle of Koch .The orifice of the coronary shuts is guarded by the crescent shaped the besian valve. The named tributaries of the coronary sinus include the anterior inter ventricular vein, which courses parallel to the left anterior descending coronary artery. Adjacent to the bifurcation of the left main .stem, the anterior inter ventricular vein courses leftward in the inter-ventricular groove, where it is referred to as the great cardiac vein. It receives blood from the marginal and posterior left ventricular branches before becoming the Coronary sinus at the origin of the oblique vein (of Marshall) at the posterior margin of the left atrium. The posterior inter ventricular vein, or middle cardiac Vein, arises at the apex, courses parallel to the posterior descending coronary TA. Artery, and extends proximally to the crux. Here, this vein drains either directly into the right atrium or into the coronary sinus just prior to its orifice. The small cardiac vein runs posteriorly through the right atrio-ventricular groove [Mozaffarian et al 2013].

2.1.1.6 Anterior Right Ventricular Veins

The anterior right ventricular veins travel across the right ventricular surface to the right atrio-ventricular groove, where they either enter directly into the right atrium or coalesce to form the small cardiac vein. As indicated, this vein travels.

Down the right atrio-ventricular groove, around the acute margin, and enters into the right atrium directly or joins the coronary sinus just proximal to its orifice.

2.1.1.7 The besian Veins

The besian veins are small venous tributaries that drain directly into the cardiac chambers. They exist primarily in the right atrium and right ventricle [Mozaffarian et al 2013*]*.

2.1.2 Basic Cardiac Physiology

A basic understanding of cardiac physiology is also essential to interpreting the physical finding during a cardiac exam. Each pump or beat of the heart consists of two parts or phases - diastole and systole. During diastole the ventricles are filling and the atria contract. Then during systole, the ventricles contract while the atria are relaxed and filling. A more detailed understanding of the of cardiac physiology can be obtained by examining in detail the simultaneous pressure characteristics in the aorta, left atrium (atrium) and left ventricle (ventricle) through one cardiac cycle.

For the purposes for this study of cardiac physiology, we will focus on the physiology associated with the heart first sounds S1, S2, S3, and S4. S1 occurs near the beginning of (ventricular) systole with the closing of the tricuspid and mitral valves. The closing of these two valves with increasing pressure in the ventricles as they begin to contract should be simultaneous. Any splitting in which the closing of the two valves are heard separately should be considered pathological. S2 occurs near the end of (ventricular) systole with the closing of the pulmonary and aortic valves. The closing of these two valves occurs with beginning of backward flow in the pulmonary artery and aorta respectively as the ventricles relax. The two valves can occur simultaneously or with slight gap between them under normal physiologic circumstances. S3 occurs at the end of the rapid filling period of the ventricle during the beginning of (ventricular) diastole. An S3, if heard should occur 120-170 msec after S2. S4 occurs, if heard coincides with atrial contraction at the end of (ventricular) diastole.

The pressure created in the arteries by the contraction of the left ventricle is the systolic blood pressure. Once the left ventricle has fully contracted it begins to relax and refill with blood from the left atria. The pressure in the arteries falls whilst the ventricle refills. This is the diastolic blood pressure**.**

The atrio-ventricular septum completely separates the 2 sides of the heart. Unless there is a septal defect, the 2 sides of the heart never directly communicate. Blood travels from right side to left side via the lungs only. However the chambers themselves work together. The 2 atria contract simultaneously, and the 2 ventricles contract simultaneously [ShanthiMendis; PekkaPuska et al 2014].

2.1.3 Basic Cardiac Pathology

Cardiovascular disease (CVD) is a class of diseases that involve the heart or blood vessels. Cardiovascular disease includes coronary artery diseases (CAD) such as angina and myocardial infarction (commonly known as a heart attack). Other CVDs include stroke, heart failure, hypertensive heart disease, rheumatic heart disease, cardiomyopathy, heart arrhythmia, congenital heart disease, valvular heart disease, carditis, aortic aneurysms, peripheral artery disease, thromboembolic disease, and venous thrombosis [GBD 2014, GBD 2015].

2.1.3.1 Atherosclerosis

Heart and blood vessel disease also called heart disease includes numerous problems, many of which are related to a process called atherosclerosis. Atherosclerosis is a condition that develops when a substance called plaque builds up in the walls of the arteries. This buildup narrows the arteries, making it harder for blood to flow through. If a blood clot forms, it can stop the blood flow. This can cause a heart attack or stroke.

Coronary artery disease, stroke, and peripheral artery disease involve atherosclerosis. This may be caused by high blood pressure, smoking, diabetes, lack of exercise, obesity, high blood cholesterol, poor diet, and excessive alcohol consumption, among others. High blood pressure results in 13% of CVD deaths, while tobacco results in 9%, diabetes 6%, lack of exercise 6% and obesity 5%. Rheumatic heart disease may follow untreated strep throat [GBD 2015 Mortality and Causes of Death].

It is estimated that 90% of CVD is preventable. Prevention of atherosclerosis involves improving risk factors through: healthy eating, exercise, avoidance of tobacco smoke and limiting alcohol intake. Treating risk factors, such as high blood pressure, blood lipids and diabetes is also beneficial. Treating people who have strep throat with antibiotics can decrease the risk of rheumatic heart disease. The effect of the use of aspirin in people who are otherwise healthy is of unclear benefit [McGill et al 2008, Spinks et al 2013, and Sutcliffe et al 2013]. Cardiovascular diseases are the leading cause of death globally. This is true in all areas of the world except Africa. Together they resulted in 17.9 million deaths (32.1%) in 2015, up from 12.3 million (25.8%) in 1990. Deaths, at a given age, from CVD are more common and have been increasing in much of the developing world, while rates have declined in most of the developed world since the 1970s. Coronary artery disease and stroke account for 80% of CVD deaths in males and 75% of CVD deaths in females. Most cardiovascular disease affects older adults. In the United States 11% of people between 20 and 40 have CVD, while 37% between 40 and 60, 71% of people between 60 and 80, and 85% of people over 80 have CVD. The average age of death from coronary artery disease in the developed world is around 80 while it is around 68 in the developing world. Disease onset is typically seven to ten years earlier in men as compared to women .There are many cardiovascular diseases involving the blood vessels. They are known as vascular diseases [McGill HC et al 2008, Spinks, A et al 2013, and Sutcliffe et al 2013].

2.1.3.2 Coronary stenosis

It is an abnormal narrowing in a blood vessel or other tubular organ or structure. It is also sometimes called a stricture. Stricture as a term is usually used when narrowing is caused by contraction of smooth muscle; stenosis is usually used when narrowing is caused by lesion that reduces the space of lumen. The term coarctation is another synonym, but is commonly used only in the context of aortic artery becomes tapered and backed coronary is a condition in which a coarctation. A stenosis is a blood vessel located up with materials like fat or cholesterol.

2.1.3.3 A heart attack

Occurs when the blood flow to a part of the heart is blocked by a blood clot. If this clot cuts off the blood flow completely, the part of the heart muscle supplied by that artery begins to die. Most people survive their first heart attack and return to their normal lives to enjoy many more years of productive activity.

2.1.3.4 Aortic aneurysm

An enlargement (dilatation) of the aorta to greater than 1.5 times normal size [Shanthi 2011].

2.1.3.5 Cardiomyopathy

Diseases of cardiac muscle [Shanthi 2011].

2.1.3.6 Hypertensive heart disease

Diseases of the heart secondary to high blood pressure or hypertension [Shanthi 2011].

2.1.3.7 Heart failure

This doesn't mean that the heart stops beating. Heart failure, sometimes called congestive heart failure, means the heart isn't pumping blood as well as it should. The heart keeps working, but the body's need for blood and oxygen isn't being met. Heart failure can get worse if it's not treated. A clinical syndrome caused by the inability of the heart to supply sufficient blood to the tissues to meet their metabolic requirements [Shanthi 2011].

2.1.3.8 Pulmonary heart disease

A failure at the right side of the heart with respiratory system involvement [Shanthi 2011].

2.1.3.9 Inflammatory heart disease

Endocarditis inflammation of the inner layer of the heart, the endocardium. The structures most commonly involved are the heart valves. Inflammatory cardiomegaly −Myocarditis – inflammation of the myocardium, the muscular part of the heart [Shanthi 2011].

2.1.3.10 Valvular heart disease

When heart valves don't open enough to allow the blood to flow through as it should, it's called stenosis. When the heart valves don't close properly and allow blood to leak through, it's called regurgitation. When the valve leaflets bulge or prolapse back into the upper chamber, it‘s a condition called mitral valve prolapse. When this happens, they may not close properly. This allows blood to flow backward through them [Shanthi 2011].

2.1.3.11Congenital heart disease

Heart structure malformations existing at birth [Shanthi 2011].

2.1.3.12 Rheumatic heart disease – Arrhythmia

This is an abnormal rhythm of the heart. There are various types of arrhythmias. The heart can beat too slowly, too fast or irregularly.

Bradycardia is when the heart rate is less than 60 beats per minute. Tachycardia is when the heart rate is more than 100 beats per minute. An arrhythmia can affect how well the heart works. The heart may not be able to pump enough blood to meet the body's needs. Heart muscles and valves damage due to rheumatic fever caused by Streptococcus pyogenic a group A streptococcal infection [Shanthi 2011].

2.1.4 Risk factors

There are many risk factors for heart diseases: age, gender, tobacco use, physical inactivity, excessive alcohol consumption, unhealthy diet, obesity, genetic predisposition and family history of cardiovascular disease, raised blood pressure (hypertension), raised blood sugar (diabetes mellitus), raised blood cholesterol (hyperlipidemia), psychosocial factors, poverty and low educational status, and air pollution. While the individual contribution of each risk factor varies between different communities or ethnic groups the overall contribution of these risk factors is very consistent. Some of these risk factors, such as age, gender or family history/genetic predisposition, are immutable; however, many important cardiovascular risk factors are modifiable by lifestyle change, social change, drug treatment (for example prevention of hypertension, hyperlipidemia, and diabetes) . People with obesity are at increased risk of atherosclerosis of the coronary arteries

[Shanthi 2011, Hawken 2004, McPhee, Stephen 2012]

2.1.4.1 Genetics

Genetic factors influence the development of cardiovascular disease in men who are less than 55 years-old and in women who are less than 65 years old [Hawken 2004]. Cardiovascular disease in a person's parents increases their risk by 3 fold.

2.1.4.2 Age

It is by far the most important risk factor in developing cardiovascular or heart diseases, with approximately a tripling of risk with each decade of life. Coronary fatty streaks can begin to form in adolescence. It is estimated that 82 percent of people who die of coronary heart disease are 65 and older. At the same time, the risk of stroke doubles every decade after age 55[Eckel 2017, Kathiresan2012, Nikpay 2016 and MacRae,et al 2016].

Multiple explanations have been proposed to explain why age increases the risk of cardiovascular/heart diseases. One of them is related to serum cholesterol level. In most populations, the serum total cholesterol level increases as age increases. In men, this increase levels off around age 45 to 50 years. In women, the increase continues sharply until age 60 to 65 years [Finegold et al 2012].

Aging is also associated with changes in the mechanical and structural properties of the vascular wall, which leads to the loss of arterial elasticity and reduced arterial compliance and may subsequently lead to coronary artery disease [Finegold et al 2012].

2.1.4.3 Sex

Men are at greater risk of heart disease than pre-menopausal women. Once past menopause, it has been argued that a woman's risk is similar to a man's although more recent data from the WHO and UN disputes this. If a female has diabetes, she is more likely to develop heart disease than a male with diabetes [D'Adamo et al 2015].

Coronary heart diseases are 2 to 5 times more common among middle-aged men than women. In a study done by the World Health Organization, sex contributes to approximately 40% of the variation in sex ratios of coronary heart disease mortality. Another study reports similar results finding that gender differences explains nearly half the risk associated with cardiovascular diseases. One of the proposed explanations for gender differences in cardiovascular diseases is hormonal difference. Among women, estrogen is the predominant sex hormone. Estrogen may have protective effects on glucose metabolism and hemostatic system, and may have direct effect in improving endothelial cell function. The production of estrogen decreases after menopause, and this may change the female lipid metabolism toward a more atherogenic form by decreasing the HDL cholesterol level while increasing LDL and total cholesterol levels [Mackay et al 2004].

Among men and women, there are notable differences in body weight, height, body fat distribution, heart rate, stroke volume, and arterial compliance. In the very elderly, age-related large artery pulsatility and stiffness is more pronounced among women than men. This may be caused by the women's smaller body size.

2.1.4.4Tobacco

Cigarettes are the major form of smoked tobacco. Risks to health from tobacco use result not only from direct consumption of tobacco, but also from exposure to second-hand smoke. Approximately 10% of cardiovascular disease is attributed to smoking; however, people who quit smoking by age 30 have almost as low a risk of death as never smokers [GBD 2015*]*.

2.1.4.5 Physical inactivity

Insufficient physical activity (defined as less than 5 x 30 minutes of moderate activity per week, or less than 3 x 20 minutes of vigorous activity per week) is currently the fourth leading risk factor for mortality worldwide. In 2008, 31.3% of adults aged 15 or older (28.2% men and 34.4% women) were insufficiently physically active. The risk of ischemic heart disease and diabetes mellitus is reduced by almost a third in adults who participate in 150 minutes of moderate physical activity each week (or equivalent). In addition, physical activity assists weight loss and improves blood glucose control, blood pressure, and lipid profile and insulin sensitivity. These effects may, at least in part, explain its cardiovascular benefits [GBD 2015*]*.

2.1.4.6 Diet

High dietary intakes of saturated fat, trans-fats and salt, and low intake of fruits, vegetables and fish are linked to cardiovascular risk, although whether all these associations are a cause is disputed. The World Health Organization attributes approximately 1.7 million deaths worldwide to low fruit and vegetable consumption.

The amount of dietary salt consumed is also an important determinant of blood pressure levels and overall cardiovascular risk.

[GBD 2015*]*.

2.1.4.7 Socioeconomic disadvantage

Cardiovascular disease affects low- and middle-income countries even more than high-income countries. There is relatively little information regarding social patterns of cardiovascular disease within low- and middle-income countries, but within high income countries low income and low educational status are consistently associated with greater risk of cardiovascular disease. [Morenga 2014, Micha, Renata 2012, Kenneth 2010*]*.

2.1.4.8 Air pollution

Particulate matter has been studied for its short- and long-term exposure effects on cardiovascular disease. Currently, $PM_{2.5}$ is the major focus, in which gradients are used to determine CVD risk. For every 10 μg/m^3 of $PM_{2.5}$ long-term exposure, there was an estimated 8–18% CVD mortality risk. [World Health Organization (2011, Mariachiara 2013, Mackenbach 2000*]*.

2.1.4.9 Occupational exposure

Little is known about the relationship between work and cardiovascular disease, but links have been established between certain toxins, extreme heat and cold, exposure to tobacco smoke, and mental health concerns such as stress and depression [World Health Organization 2008].

2.1.4.10 Chemical risk factors

The risk of stroke was also increased by exposure to ionizing radiation. Hypertension develops more often in those who experience job strain and who have shiftwork. Differences between women and men in risk are small, however men risk suffering and dying of heart attacks or stroke twice as often as women during working life [World Health Organization 2008].

2.1.4.11 Non-chemical risk factors

A 2017 SBU report found evidence that workplace exposure to silica dust, engine exhaust or welding fumes is associated with heart disease. Associations also exist for exposure to arsenic, benzopyrenes, lead, dynamite, carbon disulphide, carbon monoxide, metalworking fluids and occupational exposure to tobacco smoke. Working with the electrolytic production of aluminium or the production of paper when the sulphate pulping process is used is associated with heart disease. An association was also found between heart disease and exposure to compounds which are no longer permitted in certain work environments, such as phenoxy acids containing TCDD (dioxin) or asbestos

[World Health Organization 2011, Mariachiara 2013*]*.

2.1.4.12 Somatic mutations

As of 2017, evidence suggests that certain leukemia-associated mutations in blood cells may also lead to increased risk of cardiovascular disease. Several large-scale research projects looking at human genetic data have found a robust link between the presence of these mutations, a condition known as clonal hematopoiesis, and cardiovascular disease-related incidents and mortality. Population-based studies show that atherosclerosis, the major precursor of cardiovascular disease, begins in childhood [Mukamal 2010].

2.1.5 Cardiovascular risk assessment

Existing cardiovascular disease or a previous cardiovascular event, such as a heart attack or stroke, is the strongest predictor of a future cardiovascular event. Age, sex, smoking, blood pressure, blood lipids and diabetes are important predictors of future cardiovascular disease in people who are not known to have cardiovascular disease. These measures, and sometimes others, may be combined into composite risk scores to estimate an individual's future risk of cardiovascular disease. They include family history, coronary artery calcification score, high sensitivity C-reactive protein (hsCRP), ankle–brachial pressure index, lipoprotein subclasses and particle concentration, lipoprotein(a), apolipoproteins A-I and B, fibrinogen, white blood cell count, homocysteine, N-terminal pro B-type natriuretic peptide (NT-proBNP), and markers of kidney function. High blood phosphorus is also linked to an increased risk [Mukamal, Kenneth 2010].

2.1.6 Overview of X-ray Computed Tomography

The development of computed tomography (MSCT), resulting in widespread clinical use of CT scanning by the early1980s, was a major breakthrough in clinical diagnosis. The primary advantage of(MSCT) was the ability to obtain thin cross-sectional axial images, with improved spatial resolution over echocardiography, nuclear medicine, and magnetic resonance imaging. This imaging avoided super position of three-dimensional (3-D) structures onto a planar 2-D representation, as is the problem with conventional projection X-ray (fluoroscopy). The increased contrast resolution of (MSCT) is the reason for its increase insensitivity for atherosclerosis and coronary artery disease (CAD). Localization of structures (in any plane) is more accurate and easier with tomography than with projection imaging like fluoroscopy. Furthermore, the images, which are inherently digital and thus quite robust, are amen able to 3D computer reconstruction, allowing for ultimately nearly an infinite number of projections [Metin et al 2013].

The basic principle of (MSCT) is that a fan-shaped, thin x ray beam passes through the body at many angles to allow for cross-sectional images. The corresponding X-ray transmission measurements are collected by a detector array. Information entering the detector array and X ray beam itself is collimated to produce thin sections while avoiding unnecessary photon scatter (to keep radiation exposure and image noise to a minimum). The data recorded by the detectors are digitized into picture elements (pixels) with known dimensions. The gray-scale information contained in each individual pixel is reconstructed according to the attenuation of the X-ray beam along its path using a standardized technique termed filtered back projection. Gray-scale values for pixels within the reconstructed tomogram are defined with reference to the value for invention of the (MSCT) scanner in the late 1960s. Since (MS CT) uses X-ray absorption to create images, the differences in the image brightness at any point will depend on physical density and the presence of atoms with a high difference in anatomic number like calcium, and soft tissue and water. The absorption of the X-ray beam by different atoms will cause differences in (MSCT) brightness on the resulting image. Blood and soft tissue (in the absence of vascular contrast enhancement) have similar density and consist of similar proportions of the same atoms (hydrogen, oxygen, carbon).

Bone has an abundance of calcium. Fat has an abundance of hydrogen. Lung contains air which is of extremely low physical density. The higher the density, the brighter the structure on (MSCT). Calcium is bright white, air is black, and muscle or blood is gray. Computed tomography, therefore, can distinguish blood from air, fat and bone but not readily from muscle or other soft tissue. The densities of blood, myocardium, thrombus, and fibrous tissues are so similar in their (MS CT) number, that non-enhanced (MSCT) cannot distinguish these structures. Thus, the ventricles and other cardiac chambers can be seen on non-enhanced (MSCT), but delineating the wall from the blood pool is not possible. Due to the thin wall which does not contribute significantly to the total measured volume, the left and right atrial volumes can be accurately measured on noncontrast (MSCT) [Matthew et al].

The higher spatial resolution of (MSCT) allows visualization of coronary arteries both with and without contrast enhancement. The ability to see the coronary arteries on anon-contrast study depends upon the fat surrounding the artery (of lower density, thus more black on images), providing a natural contrast between the myocardium and the pericardial artery. Usually, the entire course of each coronary artery is visible on non-enhanced scans. The major exception is bridging, when the coronary artery delves into the myocardium and cannot bed is distinguished without contrast. The distinction of blood and soft tissue (such as the left ventricle, where there is no air or fat to act as a natural contrast agent) requires injection MSCT is a highly accurate diagnostic modality for congenital heart diseases, obviating the need for invasive modalities. Beside its noninvasive nature, the advantage of (MSCT) over the angiography is its ability to provide detailed anatomical information about the heart, vessels, lungs and intra-abdominal organs.

2.1.6.1 Cardiac CT

Cardiac computed tomography (MSCT) provides image slices or tomograms of the heart. (MSCT) technology has significantly improved since its introduction into clinical practice in 1972. Current conventional scanners used for cardiac and cardiovascular imaging now employ either a rotating X-ray source with a circular, stationary detector array (spiral or helical CT) or a rotating electron beam (EBCT).The biggest issue with cardiac imaging is the need for both spatial and temporal resolution. Cardiac magnetic resonance (MR) has been an emerging technique for almost two decades, making little progress toward widespread utilization over this time. Temporal resolution (how long it takes to obtain an image) is inversely related to spatial resolution with cardiac MR. Improving the MR spatial resolution requires prolonging the imaging time. This greatly limits the ability to focus with precision on moving objects, as the viewer needs to settle for either a high resolution image plagued by cardiac motion, or a low resolution image with no motion artifacts. Cardiac CT does not suffer from this inverse relationship, and allows for both high spatial and temporal resolution. Electron beam CT (EBCT – described in detail below) allows for high resolution imaging at 50–100 milliseconds (ms). Multidetector (MDCT), with improved spatial resolution, allows for rotation speeds now on the order of 330–400ms. Thus, EBCT has the best temporal resolution, (MDCT) the best spatial resolution, and cardiac MR is generally the worst in each category (although in nonmoving structures such as the spine, MR, which is inherently a 3-D method, is capable of spatial resolution on the order of microns). The most distinct advantage of cardiac (MSCT) over cardiac MR is the improved spatial resolution. The best resolution reported by a cardiac MR study (using the strongest magnet -3 teslas) demonstrated resolution in the *x*-, *y*- and *z*-axes of 0.6 ¥ 0.6 ¥ 3 mm [BudoffM et al 1999]. The best resolution offered by cardiac CT is 0.35 ¥ 0.35 ¥ 0.5mm, which is almost a factor of 10 better spatial resolution and approaching the ultimate for 3D tomography of nearly cubic (isentropic) ―voxels‖ – or volume elements. As we consider non-invasive angiography with either (MSCT) or MR, we need to remember that both spatial and temporal resolution is much higher with traditional invasive angiography.

Reconstruction algorithms and multi-―head‖ detectors common to both current electron beam and spiral/helical (MSCT) have been implemented enabling volumetric imaging, and multiple highquality reconstructions of various volumes of interest can be done either prospectively or retrospectively, depending on the method. The details of each type of scanner and principles of use will be described in detail [StuberMet al 2002].

2.1.6.2 (MSCT) Methods

Sub-second (MSCT) scanners use a rapidly rotating X-ray tube and several rows of detectors, also rotating. The tube and detectors are fitted with slip rings that allow them to continuously move through multiple 360° rotations. The "helical" or "spiral" mode is possible secondary to the development of this slip-ring interconnect. This allows the X-ray tube and detectors to rotate continuously during image acquisition since no wires directly connect the rotating and stationary components of the system (i.e. no need to unwind the wires). This slip-ring technology was a fund a mental breakthrough in conventional (MSCT) performing continuously move through multiple 360° rotations. The "helical" or "spiral" mode is possible secondary to the development of this slip-ring interconnect. This allows the X-ray tube and detectors to rotate continuously during image acquisition since no wires directly connect the rotating and stationary components of the system. This slip-ring technology was a fundamental breakthrough in conventional (MSCT) performing single slice scanning in the 1980s to rapid multislice scanning in the 21st century. With gantry continuously rotating, the table moves the patient through the imaging plane at a predetermined speed. The relative speed of the gantry rotation table motion is the scan pitch. Pitch is calculated as table speed divided by collimator width. Thus, moving the table faster will lead to wider slices and vice versa. A low pitch (low table speed or wide slices) allows for overlapping data from adjacent detectors. Most commonly, physicians use a low table speed and thin imaging, leading to a lot of images, each very thin axial slices which are of great value for imaging the heart with high resolution. The downside is that the slower the table movement the higher the radiation exposure. [Carr et al2005].

The smooth rapid table motion or pitch in helical scanning allows complete coverage of the cardiac anatomy in 5 to 25 seconds, depending on the actual number of multirow detectors. The current generation of (MSCT) systems complete a 360° rotation in about 3–4 tenths of a second and are capable of acquiring 4–64 sections of the heart simultaneously with electrocardiographic (ECG) gating in either a prospective or retrospective mode. (MSCT) differs from single detector-row helical or spiral (MSCT) systems principally by the design of the detector arrays and data acquisition systems, which allow the detector arrays to be configured electronically to acquire multiple adjacent sections simultaneously. For example, in 16-row MDCT systems, 16 sections can be acquired at either 0.5–0.75 or 1–1.5mm section widths or 8 sections 2.5mm thick.

In MDCT systems, like the preceding generation of single-detector-row helical scanners, the X-ray photons are generated within a specialized X-ray tube mounted on a rotating gantry. The patient is centered within the bore of the gantry such that the array of detectors is positioned to record incident photons after traversing the patient. Within the X-ray tube, a tungsten filament allows the tube current to be increased (mA), which proportionately increases the number of X-ray photons for producing an image. Thus, heavier patients can have increased mA, allowing for better tissue penetration and decreased image noise. One of the advantages of MDCT over EBCT is the variability of the mA settings, thus increasing the versatility for general diagnostic (MSCT) in nearly all patients and nearly all body segments.

For example, the calcium scanning protocol employed in the National Institutes of Health (NIH) Multi-Ethnic Study of Atherosclerosis is complex. Scans were performed using prospective ECG gating at 50% of the cardiac cycle, 120kV, 106mAs, 2.5mm slice collimation, 0.5s gantry rotation, and a partial scan reconstruction resulting in a temporal resolution of 300ms. Images were reconstructed using the standard algorithm into a 35cm display field of view. For participants weighing 100kg (220lb) or greater, the milliampere (mA) setting was increased by 25%. [Nieman et al.2008].

2.1.6.3 Post processing Technique

The interpretation of cardiac CT angiographic studies performed with multidetector scanners requires real-time interaction with the volumetric data set that is generated. Consequently, radiologists must become proficient with workstation applications and post processing techniques [Nieman et al.2008].

2.1.6.3.1 Multiplanar Reformation

MPR is the basic tool used to interpret cardiac CT angiographic studies. With use of retrospective electrocardiographic gating, data from specific phases of the cardiac cycle are retrospectively referenced to the electrocardiogram for reconstruction. Once the reconstruction is complete, the data are transferred directly to the workstation. The radiologist then interfaces with the reconstructed series in real time at the workstation. Because of variations in the orientation of the heart in the thorax, it is often useful to evaluate cardiac structures along the cardiac planes. The multiplanar capabilities of the workstation allow images of the heart and coronary arteries to be manually rotated for optimal evaluation of the cardiac anatomy. Most workstations with cardiac analysis capabilities can automatically orient volumetric image data sets along the cardiac axes and into the traditionally used cardiac planes (ie, short-axis, horizontal long-axis, vertical long-axis) with the click of a button. This feature is especially useful for evaluating the cardiac chambers and left ventricular (LV) function. Selected reformatted images are sent to the picture archiving and communication system (PACS) for review by the referring clinicians and for long-term storage [Ropers et al.2003].

2.1.6.3.2 Maximum Intensity Projection

MIP is a post processing technique that takes the highest-attenuation voxel in a predetermined slab of data and projects it from the user toward the viewing screen, resulting in a two dimensional image. MIP images are similar to traditional angiograms, which display intraluminal opacity values [Baum al.2003].

Only the highest attenuation objects, typically contrast material and bone, are preferentially displayed and retained in the image. The limitation of MIP images is that they lack depth and spatial information regarding relationships to adjacent structures. However, they can allow quick assessment for significant coronary artery stenosis [Lawler 2005].

2.1.6.3.3 Volume Rendering

VR is a 3D technique in which the CT attenuation values for each voxel can be assigned a specific color [Lawler 2005], thereby producing an overall image of the heart. VR is the only true 3D technique and provides the depth and spatial information that is lacking with MIP. VR techniques facilitate surface evaluation of the heart and coronary arteries. With respect to diagnosis, we have found this technique to be the most useful for evaluating complex anatomy, including coronary artery anomalies, bypass grafts, and fistulas [Lawler 2005].

2.1.6.3.4 Curved Reformation

Because normal coronary arteries are often tortuous, accurate evaluation requires assessment of the entire vessel along its center line. Curved reformatted images provide this capability by sampling a given volume (ie, artery) along a predefined curved anatomic plane. Most cardiac workstations have software capable of automatically determining the center line of each coronary artery and display the entire length of the artery on a single curved reformatted image [Cody 2002]. This type of reformation is especially helpful in patients with bypass grafts and highly tortuous coronary arteries [Gruden 2005].

2.2 Literature review and previous studies

Shema et-al 2011 studied assessment of coronary arteries appearance with MSCT and cardiac catheterization and said the aim of this study was to assess the appearance of the coronary artery (appearance, pathological change and the most coronary artery effect by pathology) by using multi-slice angio (CT scan 64 slice) and cardiac catheterization and to know the best way to do this exam and to know the importance, characteristic and limited from the other exam witch evaluate the risk factor in coronary artery.

Study was done in Royal scan center in Khartoum and retrospective data front King Fahad cardiac center in Kingdom of Saudi Arabia "Riyadh". The study sample was 50 patients, 30 of them underwent to CCTA and 20 of them underwent to cardiac catheterization by vein.

In the study the positive patient who diagnosed by CCTA were 17(56.6%) from CCTA group 11(64.7%) of them have Ca deposits, 4(23.5%) have coronary artery stenosis and 2(11.7%) have congenital anomalies. the rest of the CCTA group are Normal in configuration. The positive patient who diagnosed by cardiac catheterization 6(30%) from this group have Ca stenosis, the rest of the group are normal. Also the capable to dispose many type of pathology by use CCTA like calculate Ca scoring in any coronary artery witch that difficult to detect by cardiac catheterization and other exams specifically and that cannot complete the CCTA if it‘s in high level because there are more risk factor and guaranty the image quality.

The study showed that the most affected branches were as follows LAD have the most risk factor by any why that risk in percentage 43.50%, RCA 30.40%, LCX 21.7%, WA 4.4% the lasted one is PDA in percentage near to zero. Both technique (CCTA and cardiac catheterization) perform good visualized of larger coronary arteries branches, but cardiac catheterization visualized smaller branches better than CCTA.

Wafa et-al 2010 said that this is a descriptive hospital-based study conducted to evaluate the cardiac Imaging examinations for patients undergo cardiac catheterization in fluoroscopy examination in Sudan Heart Center.

Patients subjected to cardiac catheterization in Sudan Heart Center, done mainly on adults (Males or Females), 50 patients were studied, the data obtained was analyzed by using the Statistical Package for Social Science (SPSS), and then results were presented as tables and graphs of 50 patients male to female ratio was 1.8: 1.0, The most frequent complain recorded among patients done cardiac catheterization is chest pain 25(50%), distribution of diabetes mellitus and to gender showed that, they are more common among hypertension according females 33(66%) and 40(80%) for males. Complication represented 26(52%), while 20(40%) showed no complications. Findings showed Chest X-ray only has no value to confirm the diagnosis of heart disease while ECG and Echocardiography have similar value in the diagnosis of heart disease. Positive family history of DM and HTN were very common and indicates their effectiveness. The most Troponin value rest were positive in patients who suffer from unstable angina.Cardiac Catheterization should be done for patients after the assessment more than one imaging modalities.

Mirghany et al 2013 found that Coronary heart disease is the most common cause of death in the general population. Multi detector Computed Tomography (MDCT) is noninvasive technique and can study the entire coronary artery tree during a single imaging session. The aims of this study were to characterize coronary arteries in patients who were clinically diagnosed to have coronary artery disease (CAD) using (MDCT) 256 slices, and to compare the findings with other cardiac examinations outcome. The study was done at King Fahad

Specialist Hospital-Alqaseem- KSA during the period from January to May 2013 .A total of 102 patients, 63(61.76%) males, and 39 (38.24 %) females were included. All patients with pre-test probability of CAD underwent coronary CT angiography with beta-blockers were administered prior to the scan, and other cardiac investigations were obtained. Patient's age, gender, BMI, weight, Cholesterol level, Hypertension, Diabetes Mellitus, chest pain types, Calcium scoring, were evaluated and correlated with the CT findings and other cardiac investigation results. The evaluated arteries were Left Main Artery (LMA), Left Anterior Descending artery (LAD), Right Coronary Artery (RCA), and Left Circumference Artery **(**LCA) and were observed for plaques characterization, occlusion or stenosis. A significant association was detected between the CT plaques morphology and BMI, Hyper tension and calcium score at P-value < 0.05. Patients with normal findings in ECG 53 (57.6%) Echocardiography 58.0(76.3%) and Myocardial Perfusion Imaging (MPI) 2(25.0%) were found to have positive cardiac disease in CTA. Echocardiography is able to characterize atrial filibration, Heart failure, Ventricle diseases, and Valve stenosis and has significant association with gender *P*-value 0.022 and BMI *P*-value 0.042.Myocardial Perfusion Imaging results showed the cardiac function and ejection fraction. No significant association was found between CT findings in coronary arteries and MPI results at P-value 0.789. Coronary CTA disclose diseases in arteries (98.5%), heart anomalies or valve disease 3(3%), plaques with significant stenosis 4(4%), plaque without significant stenosis 11(10.9%), stenosis without plaques 14 (14%) and total occlusion 1(1%). In relation to other cardiac tests; cardiac ischemic changes can be detected in ECG, MPI and Echo cardiography. Association between CT Plaque Characteristics and Invasive Coronary Arteries results were significant for LAD and RCA at P-value 0.05. Coronary CTA is a promising non-invasive technique and is highly recommended for characterization of Coronary Arteries and diagnosis the CAD; it could be of great value prior to invasive coronary angiography, although ECG, Echocardiography and MPI (SPECT) are better in studying function.

Sedaghat et-al said that Cardiac dual-source computed tomography (DSCT) is primarily used for coronary arteries. There are limited studies about the application of DSCT for congenital heart diseases. The aim of this study was to determine the diagnostic value of DSCT in the cardiac anomalies. The Material and Methods are the images of DSCTs and conventional angiographies of 36 patients (21 male; mean age: 8.5 month) with congenital heart diseases were reviewed and the parameters of diagnostic value of these methods were compared. Cardiac surgery was the gold standard. The Results was a total of 105 cardiac anomalies were diagnosed at surgery. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of DSCT were 98.25%, 97.9%, 98.1%, 99.07%, and 98.2%, respectively. The corresponding values of angiography were 95.04%, 98.7%, 97.8%, 98.1%, and 98%, respectively. Only one atrial septal defect (ASD) and two patent ductus arteriosus (PDA) were missed by DSCT. Angiography missed two ASD and two PDA. DSCT also provided important additional findings (n=35) about the intrathoracic or intra-abdominal organs.

Zhong et al 2009 studied the Multi-slice computed tomography angiography in the diagnosis of coronary artery disease and said that Multi-slice CT angiography represents one of the most exciting technological revolutions in cardiac imaging and it has been increasingly used in the diagnosis of coronary artery disease. Rapid improvements in multi-slice CT scanners over the last decade have allowed this technique to become a potentially effective alternative to invasive coronary angiography in patients with suspected coronary artery disease. High diagnostic value has been achieved with multi-slice CT angiography with use of

64- and more slice CT scanners. In addition, multi-slice CT angiography shows accurate detection and analysis of coronary calcium, characterization of coronary plaques, as well as prediction of the disease progression and major cardiac events. Thus, patients can benefit from multi-slice CT angiography that provides a rapid and accurate diagnosis while avoiding unnecessary invasive coronary angiography procedures. The aim of this article is present an overview of the clinical applications of multi-slice CT angiography in coronary artery disease with a focus on the diagnostic accuracy of coronary artery disease; prognostic value of coronary artery disease with regard to the prediction of major cardiac events; detection and quantification of coronary calcium and characterization of coronary plaques. Limitations of multi-slice CT angiography in coronary artery disease are also briefly discussed, and future directions are highlighted.

Gilbert et-al studied the Diagnostic Accuracy of Noninvasive Coronary Angiography Using 64-Slice Spiral Computed Tomography their objectives was to evaluate the diagnostic accuracy of multi-slice computed tomography (MSCT) coronary angiography using a new 64-slice scanner. The new 64-slice MSCT scanner has improved spatial resolution of 0.4 mm and a faster rotation time (330 ms) compared to prior MSCT scanners. They studied 70 consecutive patients undergoing elective invasive coronary angiography. Patients were excluded for atrial fibrillation, but not for high heart rate, coronary calcification, or obesity. All vessels were analyzed, including those 1.5 mm in diameter; MSCT lesions were analyzed quantitatively as well as by a qualitative scale and compared to quantitative coronary angiography (QCA). Results were also analyzed for significant coronary stenosis (over 50% luminal narrowing) by segment, by artery, and by patient.

The result was all scans showed diagnostic image quality. Of 1,065 segments, 935 (88%) could be evaluated, and 773 of 935 (83%) could be assessed quantitatively by both MSCT and QCA. The Spearman correlation coefficient between MSCT and QCA was 0.76 (p _ 0.0001).

Bland 2012 analysis demonstrated a mean difference in percent stenosis of 1.3 - 14.2%.A total of 26% of patients had calcium scores above 400 Agatston U, 25% had heart rates 70beats/min, and 50% were obese. Specificity, sensitivity, and positive and negative predictive values for the presence of significant stenosis were: by segment (n - 935), 86%, 95%, 66%, and 98%, respectively; by artery (n - 279), 91%, 92%, 80%, and 97%, respectively; by patient (n - 70), 95%, 90%, 93%, and 93%, respectively. The results indicate high quantitative and qualitative diagnostic accuracy of 64-slice.

Sebastian et-al studied MSCT coronary angiography with 64-slice. The aim of the study was to investigate the accuracy of 64-slice computed tomography (CT) for assessing hemodynamically significant stenosis of coronary arteries.

CT angiography was performed in 67 patients (50 male, 17 female; mean age60.1+10.5 years) with suspected coronary artery disease and compared with invasive coronary angiography. All vessels -1.5 mm were considered for the assessment of significant coronary artery stenosis (diameter reduction .50%). Forty-seven patients were identified as having significant coronary stenosis on invasive angiography with 18% (176/1005) affected segments. None of the coronary segments needed to be excluded from analysis. CT correctly identified all 20 patients having no significant stenosis on invasive angiography. Overall sensitivity for classifying stenosis was 94%, specificity was 97%, positive predictive value was 87%, and negative predictive value was 99%.Conclusion Sixty-four-slice CT provides a high diagnostic accuracy in assessing coronary artery stenosis.

Wang et-al 2013 studied the Characterization of the cardiac venous system in heart failure patients using 256-slice CT the objective was to review the histopathologic classification of coronary atherosclerotic plaques and describe the possibilities and limitations of CT regarding the evaluation of coronary artery plaques.

The composition of atherosclerotic plaques in the coronary arteries displays substantial variability and is associated with the likelihood for rupture and downstream ischemic events. Accurate identification and quantification of coronary plaque components on CT is challenging because of the limited temporal, spatial, and contrast resolutions of current scanners. Nonetheless, CT may provide valuable information that has potential for characterization of coronary plaques. For example, the extent of calcification can be determined, lipid-rich lesions can be separated from more fibrous ones, and positive remodeling can be identified.

John W. Nance e-al studied Coronary Atherosclerosis in African American and White Patients with acute Chest Pain: Characterization with Coronary CT Angiography

Result-based studies indicate higher prevalence of cardiovascular disease and coronary artery disease (CAD) and higher disease-specific mortality rates among African Americans than among white individuals. Yet the coronary artery calcium level, which is considered a marker of atherosclerosis, consistently has been shown to be lower in African American patients than in white patients.

Histopathologic studies have revealed that atherosclerosis is less characterized by calcium deposition and vascular remodeling in African Americans than in white individuals, suggesting that there are path genetic differences between these populations that are insufficiently reflected by the coronary artery calcium burden. Plaque composition is an important determinant of lesion vulnerability.

Accordingly, a more comprehensive comparison of the atherosclerotic burden according to race is warranted.

Coronary computed tomographic (CT) angiography enables the detection of obstructive and nonobstructive atherosclerotic lesions and the differentiation of calcified versus noncalcified plaque components. Thus, the purpose of this study was to use coronary CT angiography to compare the prevalence, extent, and composition of coronary atherosclerotic lesions in African American and white patients with acute chest pain in summary, our findings indicate a similar overall atherosclerotic burden between symptomatic African American and white patients but differences in plaque composition. The prevalence of noncalcified plaque, which may be more unstable, was higher among the African Americans after corrections for baseline differences; however, the prevalence of calcified plaque, which may represent more stable disease, was lower in this group. Population-based outcome studies are necessary to determine the prognostic value of these findings.

Matthew Jet-al studied the assessment of Coronary Artery Disease by Cardiac Computed Tomography. This scientific statement reviews the scientific data for cardiac computed tomography (CT) related to imaging of coronary artery disease (CAD) and atherosclerosis. Cardiac CT is a CT imaging technique that accounts for cardiac motion, typically through the use of ECG gating. Compared with other imaging modalities, cardiac CT has undergone an accelerated progression in imaging capabilities over the past decade, and this is expected to continue for the foreseeable future. As a result, the diagnostic capabilities at times have preceded the critical evaluation of clinical application. In this statement, the American Heart Association (AHA) Writing Group evaluates the availabledata for the application of cardiac CT for CAD.

The majority of published studies have reported that the total amount of coronary calcium (usually expressed as the ―Agosto score‖) predicts coronary disease events beyond standard risk factors. Although some registries used self-reported risk factor data, data from EBCT reports using measured risk factors demonstrate incremental risk stratification beyond the Framingham Risk Score (FRS). These studies demonstrate that CACP is both independent of and incremental with respect to traditional risk factors in the prediction of cardiac events These studies may have been subject to referral bias, as a positive test may have been the rationale for subjecting the patient to the invasive angiogram. More comparison work between modalities is clearly needed. A positive cardiac CT examination in which any CACP is identified is nearly 100% specific for athermanous coronary plaque. CACP can develop early in the course of subclinical atherosclerosis and can be identified histologically after fatty streak formation. CACP is present in the intima of both obstructive and nonobstructive lesions, and thus, the presence of calcified plaque on cardiac CT is not specific to an obstructive lesion. Studies using intracoronary ultrasound have documented a strong association between patterns of CACP and culprit lesions in the setting of acute coronary syndromes.

Cardiac CT studies correlating calcified plaque using EBCT technology and various methods of coronary angiography in more than 7600 symptomatic patients demonstrate negative predictive values of 96% to 100%, providing physicians with a high level of confidence that an individual without CACP (total calcium score=0) does not have obstructive angiographic CAD. The presence of CACP is extremely sensitive, albeit with reduced specificity, for diagnosing obstructive CAD (95% to 99%) in patients >40 years of age. A recent study of 1195 patients who underwent CACP measurement with EBCT and myocardial perfusion single photon emission CT (SPECT) assessment demonstrated that CACP was often present in the absence of myocardial perfusion scintigraphy

(MPS) abnormalities (normal nuclear test) and that <2% of all patients with CACP <100 had positive MPS studies. This is supported by other published reports and is synthesized in a recent appropriateness criteria statement from the American Society of Nuclear Cardiology and the American College of Cardiology. CACP measured by cardiac CT has a high sensitivity and negative predictive power for obstructive CAD but markedly limited specificity. Because calcified plaque may be present in nonobstructive lesions, the presence of CACP in asymptomatic persons does not provide a rationale for revascularization but rather for risk factor modification and possible further functional assessment. Clinicians must understand that a positive calcium scan indicates atherosclerosis but most often no significant stenosis. With exceptions, high-risk calcium scores (such as an Agatston score ≥400) are associated with an increased frequency of perfusion ischemia and obstructive CAD. The absence of coronary calcium is most often associated with a normal nuclear test in summary, cardiac CT has been demonstrated to provide quantitative measures of CACP and NCP. CACP, as determined by cardiac CT, documents the presence of coronary atherosclerosis, identifies individuals at elevated risk for myocardial infarction (MI) and CVD death, and adds significant predictive ability to the Framingham Score (an index of traditional CVD risk factors). Data suggest that cardiac CT may improve risk prediction, especially in individuals determined to be at intermediate risk. Data from Greenland et al demonstrated that intermediate-risk patients with an elevated coronary artery calcium (CAC) score (intermediate FRS and CAC score >300) had an annual hard event rate of 2.8%, or a 10-year rate of 28%, and thus would be considered high risk. The best estimates of the relative risk (RR) from this study indicated that a CAC score >300 had a hazard ratio (HR) of about 4 compared with a score of 0. This would mean that the estimated risk in the intermediate-risk patient with a CAC score of 0 might be reduced by at least 2-fold while the risk of a person with a CAC score of 300+ would be increased by about 2-fold.

Thus, the person with a high CAC score and intermediate FRS is now reclassified as high risk.

Yaw 2013 et-al demonstrated the Coronary heart disease (CHD) is the most prevalent cause of death worldwide. Atherosclerosis which is the condition of plaque buildup on the inside of the coronary artery wall is the main cause Of CHD. Rupture of unstable atherosclerotic coronary plaque is known to be the cause of acute coronary syndrome. The composition of plaque is important for detection of plaque vulnerability. Due to prognostic importance of early stage identification, non-invasive assessment of plaque characterization is necessary. Computed tomography (CT) has emerged as a non-invasive alternative to coronary angiography. Recently, dual energy CT (DECT) coronary angiography has been performed clinically. DECT scanners use two different X-ray energies in order to determine the energy dependency of tissue attenuation values for each voxel. They generate virtual monochromatic energy images, as well as material basis pair images. The characterization of plaque components by DECT is still an active research topic since overlap between the CT attenuations measured in Plaque components and contrast material shows that the single mean density might not be an appropriate measure for characterization. This dissertation proposes feature extraction, feature selection and learning strategies for supervised characterization of coronary atherosclerotic plaques. In my first study, I proposed an approach for calcium quantification in contrast-enhanced examinations of the coronary arteries, potentially eliminating the need for an extra non-contrast X-ray acquisition.

The ambiguity of separation of calcium from contrast material was solved by using virtual noncontract images. Additional attenuation data provided by DECT provides valuable information for separation of lipid from fibrous plaque since the change of their attenuation as the energy level changes is different. My second study proposed these as the input to supervised learners for a more precise classification of lipid and fibrous plaques. My last study aimed at automatic segmentation of coronary arteries characterizing plaque components and lumen on contrast enhanced monochromatic X-ray images. This required extraction of features from regions of interests. This study I proposed feature extraction strategies and selection of important ones. The results show that supervised learning on the proposed features provides promising results for automatic characterization of coronary atherosclerotic plaques by DECT.

CHAPTER THREE

MATERIALS AND METHODS

Chapter three

Materials and methods

3.1 Materials

3.1.1 Patient

This study was done at the National Ribat hospital- Omer Sawi complex Royal scan Diagnostic Centers- Khartoum Sudan) during the period from 2016 to 2018. The Sample included Sudanese patients with different clinical symptoms. The patient under went to multi slices CT study for coronary artery angiography and calcium scoring test by using axial and 3D image.

135 Sudanese patients (73 males and 62females) their ages ranged (16-80) years were enrolled in the study. Exclusion criteria were patient with unstable angina, allergic to iodinated contrast material, renal Insufficiency, severe respiratory function impairment, heart failure and pregnant women.

All patients gave formal written consent approved by the department of radiology ethics. The demographic parameters including age, sex, and weight. Patients were categorized into groups of males and females. Ethical clearance was sought from the Research and Publications Committee of the Sudan University Khartoum Sudan and permission to conduct the study was obtained from the Ethics committee department of Radiology. Patients were enrolled after informed verbal and written consent.

3.1.2 Equipment

CT machines images were conducted using 64-128 slice .All patients had undergone a contrast material–enhanced, retrospectively electrocardiographically gated coronary CT angiographic examination, which was performed by using a CT scanner with the following parameters: (0.5mm, 120 KV, 300-500 MA). Image type original \primary \axial .scan option helical ct. Body part examined Chest .Patient position supine scout view AP\LAT. Slice thickness 0.5 mm. Injection rate 3-5. Protocol name coronary cardiac CT. No gantry detector tilt. X ray tube current 430 focal sot 1.6\1.4 group pixel spacing. The coronary CT angiographic examinations were enhanced with 70-100 ml followed by 30 mL of saline solution, both of which were injected at 6 mL/sec.

Figure 3.1 show the CT machine

Figure 3.2 show the automatic injector

3.2 Methods

3.2.1 CT Technique

Patient take one capsule of beta blocker one day before the exam one at night and the last one in the day of the exam morning. Patient fasting at least 6 hours before the examined patient must to stop smoking and drinking tea and coffee before the exam we must to see the RFT test and blood pressure. Insure that the cannula is in vein and also the ECG tools in right side give good instruction to the patient. The patient is in supine position feet first. Two views were taken AP and LAT localize the area of the study by laser alignment then the calcium scoring test was done firstly then CCTA the amount of contrast are about 70-100 ml.

There were CT calcium scoring systems widely used it was the original Agatston method. The Agatston score method involves multiplication of the calcium area by a number related to CT density and, in the presence of partial volume artifacts, can be variable. Also, the Agatston system was designed and is properly used only when the slice thickness of the scan is 3 mm. A calcium score is reported for a given coronary artery and for the entire coronary system. ominoopaque contrast agent was used because they are better tolerated by patients and extravasation of non-ionic contrast agents tends to cause less serious complications .Compared with dynamic incremental CT, smaller amounts of contrast agent were required . Due to cost issues, as well as possible decreased nephrotoxicity with lower contrast amounts, a double power injector was used to facilitate the examination procedure and to avoid mixing contrast material with the saline solution. The use of dual-headed injectors (with one filled with contrast and one filled with saline) allows for reduced contrast requirements and improved uniform opacification of the coronary tree. When blood flows through a vessel, there is a higher velocity in the center of the vessel as compared to the lumen wall. Due to the loss of venous pressure after injection, as well as the issue of wasted contrast media present in the tubing and arm vein of the patient during imaging, most centers now utilize a saline injection to maximize distal contrast opacification without increasing contrast dose to the patient. Injection of contrast material followed by a saline solution bolus using a double power injector when performing cardiac CT allows for more uniform opacification of the cardiac study (more uniform HU from top of aorta to base of heart) as well as a 20% reduction of contrast material volume to 60mL with a similar degree of enhancement. In addition, perivenous artifacts in the superior vena cava (SVC) were significantly reduced.

The patients were asked to good breath-hold during the study because it is most important, regardless of equipment. The patient were at end-inspiration by the time the scan begins, and a 1–2-second delay was inherent in the scanner from when the technologist started the scan and the first images were obtained.

3.2.2 Images interpretation

Well training and experienced CT technician‘s physician knowledgeable in CT and radiation exposure and cardiac anatomy and pathology experienced investigators, reading image quality to be excellent, diagnostic, or nondiagnostic. Excellent image quality was defined as low image noise, with motion-free delineation of a well contrast-enhanced coronary artery tree. The images were considered to be nondiagnostic in the presence of severe motion artifacts, excessive image noise due to morbid obesity, or contrast enhancement that was insufficient for the reliable delineation of noncalcified plaque components.

All patient image were evaluated by expert radiologist reporting on calcium scoring and other pathology.

3.2.3 Data collection and analyzed

The data was collected using data sheet which contained the patient name age weight sex then we take the images to the radiologist for diagnosis. All the data were analyzed using SPSS program. Categorical data were presented as frequencies and percentages .Normally distributed continuous data were presented as means ± standard deviations.

The result were displayed as tables and graphs.

CHAPTER FOUR

THE RESULT

Chapter Four

Results

The following tables and figures presented the results of the study.

Male candidates made up 37 number of the sampled population while the females made up the rest 62. Age ranged from 62 to 48 years with age 56.28 as the mean age of the distribution. Table (4. 1) and figure (4.1) gives the summary of the frequency distribution of sex , while Table (4. 2) figure (4.2)gives the mean values of the frequency distribution of age.

Because there are many risk factors for heart diseases such as age, gender and obesity the tables (4.1-4.2-4.3) and figures (4.1-4.2-4.3) shown that.

Table (4. 3) figure (4.3) shows mean values of the frequency distribution of weight

Table (4.1) frequency distribution of sex

Sex	Frequency	Percent	Valid Percent	Cumulative Percent
Female	62	45.9	45.9	45.9
Male	73	54.1	54.1	100.0
Total	135	100.0	100.0	

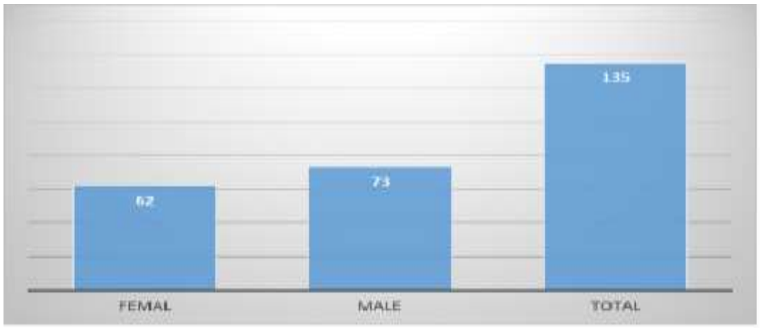


Figure (4.1) frequency distribution of sex

Age group	Frequency	Percent	Valid Percent	Cumulative Percent
16-26 years	2	1.5	1.5	1.5
27-37 years	9	6.7	6.7	8.1
38-48 years	19	14.1	14.1	22.2
49-59 years	48	35.6	35.6	57.8
60-70 years	43	31.9	31.9	89.6
71-80 years	14	10.4	10.4	100.0
Total	135	100.0	100.0	
Min=18, max=80, mean= 56.60, std. Deviation =11.66				

Table (4.2) frequency distribution of age group

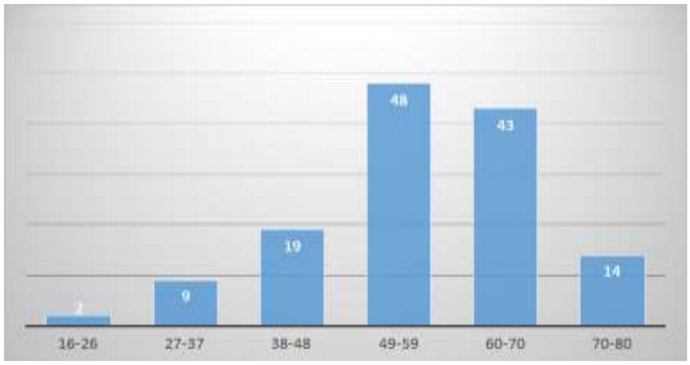


Figure (4.2) frequency distribution of age group

The cardiac diseases related with age. The mean age was 56.60 .most of the patient in the range of 60-70.

Table (4.3) frequency distribution of weight

Weight	Frequency	Percent	Valid Percent	Cumulative Percent
40-55 kg	3	2.2	2.2	2.2
56-70 kg	58	43.0	43.0	45.2
71-85kg	55	40.7	40.7	85.9
86-100 kg	19	14.1	14.1	100.0
Total	135	100.0	100.0	
Min=40, max=100, means=73.50, Std. Deviation =10.18				

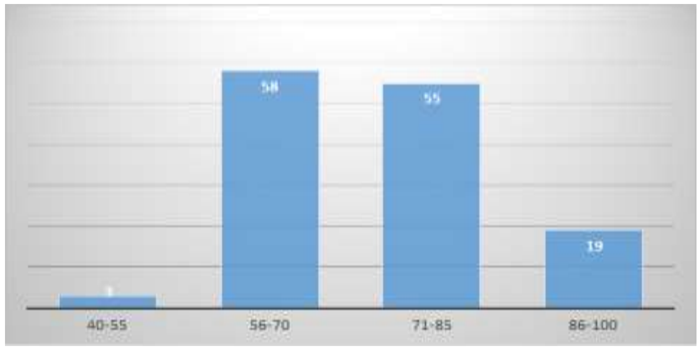


Figure (4.3) frequency distribution of weight

Table (4.4) frequency distribution of diagnosis

Total	normal	Percent	Diagnosis up normal	Percent
135	39	28.8%	96	71.1%

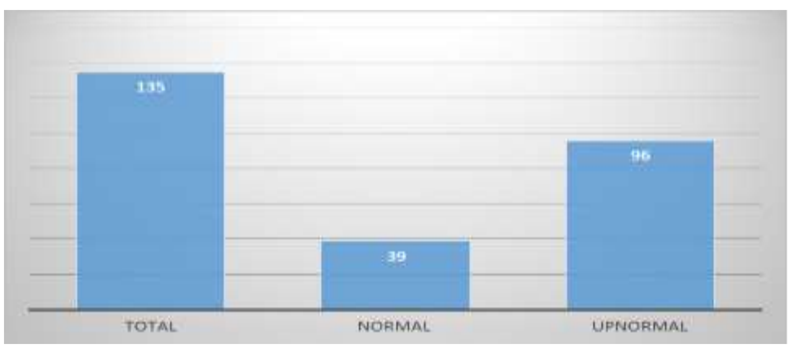


Figure (4.4) frequency distribution of diagnosis

Table (4.5) frequency distribution of diagnosis (calcium score)

Diagnosis	Frequency	Percent	Valid Percent	Cumulative Percent
Ca score 0 normal	5	3.7	3.7	15.6
Extensive evidence ca score 1500	1	.7	.7	40.7
Extensive evidence ca score 1900	1	.7	.7	41.5
Extensive evidence ca score 2000	2	1.5	1.5	43.0
Extensive evidence Ca score 450	2	1.5	1.5	44.4
Extensive evidence Ca score 470	2	1.5	1.5	45.9
Extensive evidence Ca score 480	1	.7	.7	46.7
Mild evidence ca score 28	1	.7	.7	51.1
Mild evidence ca score 70	1	.7	.7	51.9
Minimal evidence ca score 4	1	.7	.7	52.6
Moderate evidence ca score 178	1	.7	.7	53.3
Moderate evidence ca score 196	3	2.2	2.2	55.6
Moderate evidence ca score 200	2	1.5	1.5	57.0
Moderate evidence ca score 232	1	.7	.7	57.8
Moderate evidence ca score 243	6	4.4	4.4	62.2
Moderate evidence ca score 253	2	1.5	1.5	63.7
Total	32		23.7%	

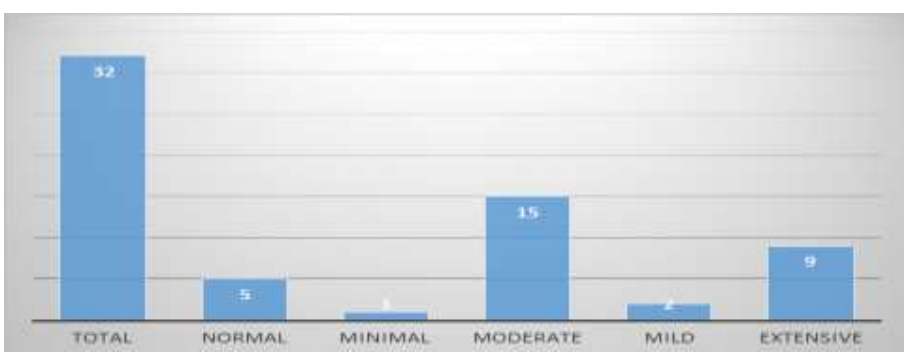


Figure (4.5) frequency distribution of diagnosis (calcium score)

Table (4.6) frequency distribution of diagnosis (Atherosclerosis)

Diagnosis	Frequency	calcified	noncalcified	mixed	Percent	Valid Percent	Cumulative Percent
Atherosclerosis	8				5.9	5.9	11.9
		5	2	1		6%	

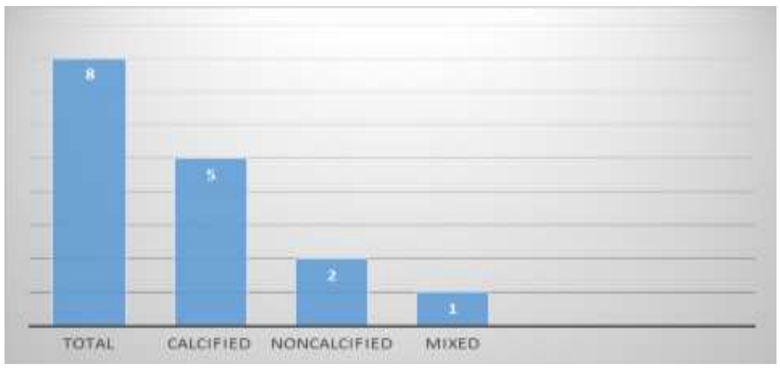


Figure (4.6) frequency distribution of diagnosis (Atherosclerosis)

Table (4.7) frequency distribution of diagnosis (Coronary stenosis)

Diagnosis	Frequency	Percent	Valid Percent	Cumulative Percent
Coronary stenosis	30	22.2	22.2	37.8
Coronary stenosis and rupture	3	2.2	2.2	40.0
		24.4%		

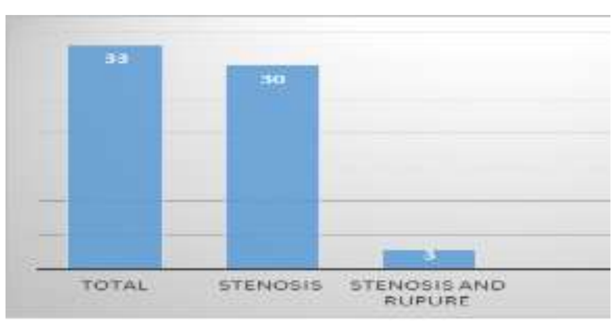


Figure (4.7) frequency distribution of diagnosis (Coronary stenosis)

Table (4.8) frequency distribution of side of coronary stenosis

Side of coronary stenosis	Frequency	Percent	Valid Percent	Cumulative Percent
Right	13	9.6	39.4	39.4
Left	20	14.8	60.6	100.0
Total	33	24.4	100.0	

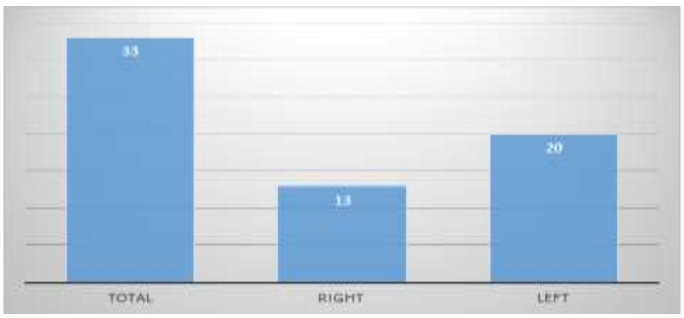


Figure (4.8) frequency distribution of side of coronary stenosis

Table (4.9) frequency distribution of diagnosis (other diseases)

Diagnosis	Frequency	Percent	Valid Percent	Cumulative Percent
Aorta calcification	2	1.5	1.5	1.5
Aortic aneurysm	6	4.4	4.4	5.9
Infarction	5	3.7	3.7	50.4
Pericardial effusion	5	3.7	3.7	67.4
Ventricular aneurysm	5	3.7	3.7	71.1
TOTAL	23		17%	

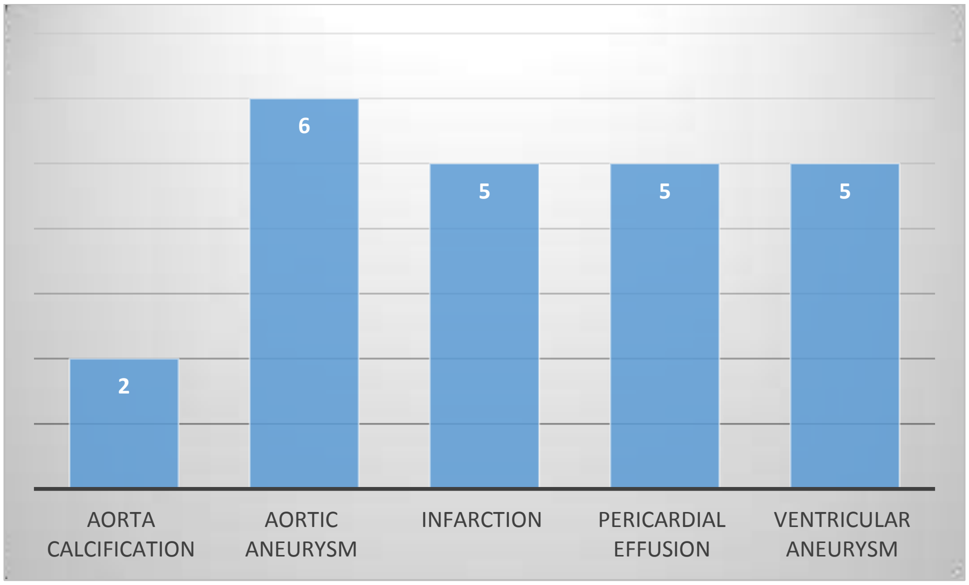


Figure (4.9) frequency distribution of diagnosis (other diseases)

135 patients successfully underwent the MSCT (73 Males, 62 Females, aged 18-80 years, average age 56.60 years) Table (4.2).shows demographic characteristics and clinical data of patients. 33 segments were stenosis and 27 were calcium score positive (Table 4-5 4-7).

Table (4.10) frequency distribution of features

Feature	Frequency	Percent	Valid Percent	Cumulative Percent
Calcified Atherosclerosis	5	3.7	3.7	3.7
Non calcified Atherosclerosis	2	1.5	1.5	62.2
Mixed Atherosclerosis	1	.7	.7	32.6
Dilation of aorta more than 1.5 times (Aortic aneurysm)	5	3.7	3.7	7.4
Excessive	2	1.5	1.5	8.9
Extensive calcium	9	6.7	6.7	15.6
Mild calcium	2	1.5	1.5	27.4
Minimal calcium	1	.7	.7	31.9
Moderate calcium	15	11.1	11.1	60.7
Normal calcium	5	3.7	3.7	94.8
Mild	14	10.4	10.4	25.9
Minimal	5	3.7	3.7	31.1
Moderate	23	17.0	17.0	49.6
Severe	7	5.2	5.2	100.0
Normal	39	28.9	28.9	91.1
Total	135	100.0	100.0	

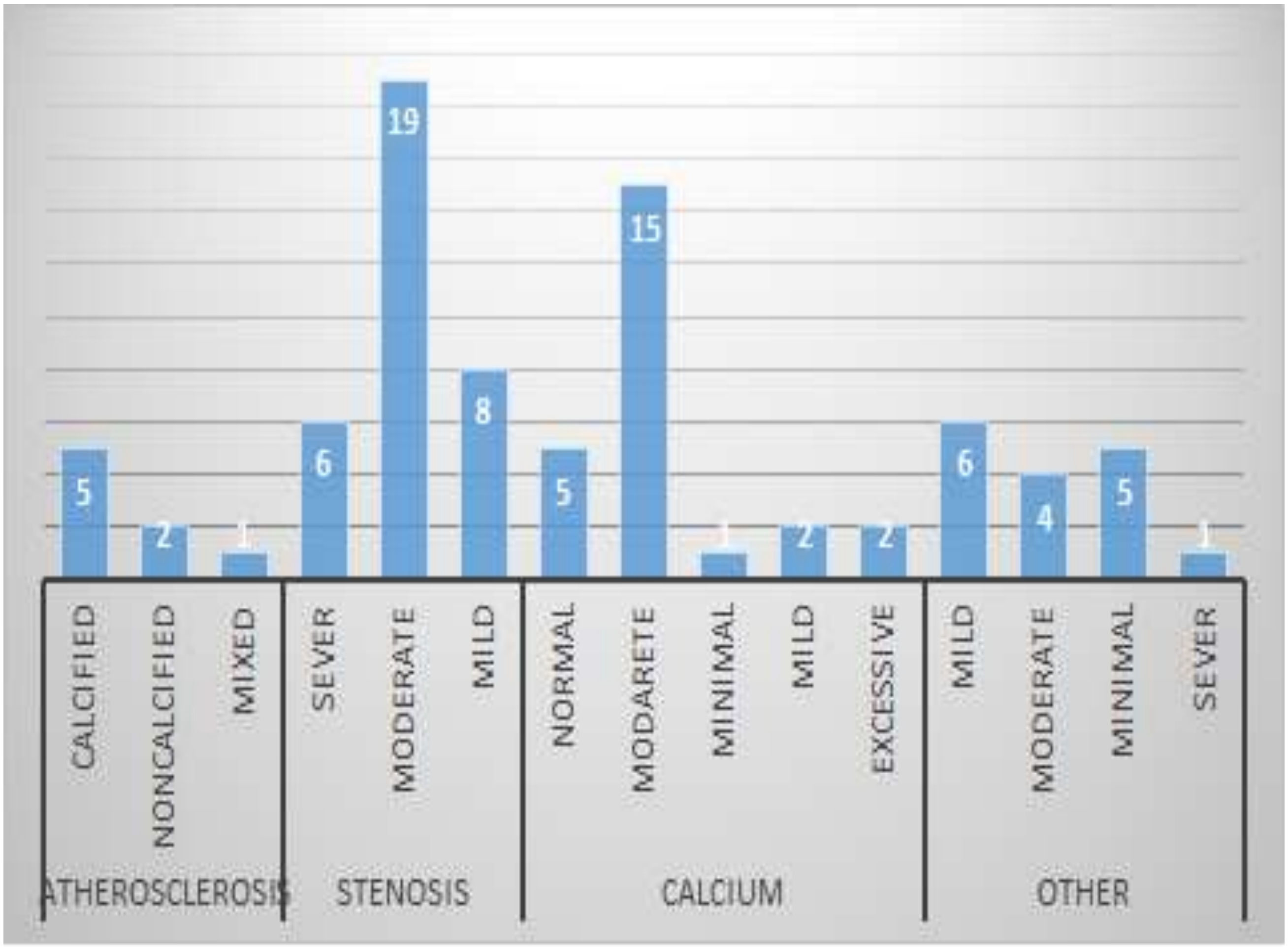


Figure (4.10) frequency distribution of features

Table (4.11) cross tabulation sex and diagnosis

Diagnosis	Sex		Total
	Female	Male	
Aorta calcification	1	1	2
Aortic aneurysm	1	5	6
Atherosclerosis	4	4	8
Ca score 0 normal	2	3	5
Coronary stenosis	12	18	30
Coronary stenosis and rupture	3	0	3
Extensive evidence Ca score 450	2	0	2
Extensive evidence Ca score 470	0	2	2
Extensive evidence Ca score 480	0	1	1
Extensive evidence ca score 1500	0	1	1
Extensive evidence ca score 1900	1	0	1
Extensive evidence ca score 2000	0	2	2
Infarction	2	3	5
Mild evidence ca score 28	1	0	1
Mild evidence ca score 70	0	1	1
Minimal evidence ca score 4	0	1	1
Moderate evidence ca score 178	1	0	1
Moderate evidence ca score 196	1	2	3
Moderate evidence ca score 200	1	1	2
Moderate evidence ca score 232	0	1	1
Moderate evidence ca score 243	3	3	6
Moderate evidence ca score 253	1	1	2
Normal	20	19	39
Pericardial effusion	2	3	5
Ventricular aneurysm	4	1	5
Total	62	73	135
P value = 0.527			

Table (4.12) cross tabulation age and diagnosis

Diagnosis	Age						Total
	16-26 years	27-37 years	38-48 years	49-59 years	60-70 years	71-80 years	
Aorta calcification	0	0	1	1	0	0	2
Aortic aneurysm	0	1	0	1	3	1	6
Atherosclerosis	0	1	1	5	1	0	8
Ca score 0 normal	0	0	0	1	3	1	5
Coronary stenosis	0	1	5	9	11	4	30
Coronary stenosis and rupture	0	0	0	1	2	0	3
Extensive evidence Ca score 450	0	0	0	1	1	0	2
Extensive evidence Ca score 470	0	0	0	0	2	0	2
Extensive evidence Ca score 480	0	0	1	0	0	0	1
Extensive evidence ca score 1500	0	0	0	1	0	0	1
Extensive evidence ca score 1900	0	0	0	1	0	0	1
Extensive evidence ca score 2000	0	0	1	1	0	0	2
Infarction	0	0	0	2	2	1	5
Mild evidence ca score 28	0	0	0	1	0	0	1
Mild evidence ca score 70	0	0	0	1	0	0	1
Minimal evidence ca score 4	0	0	1	0	0	0	1
Moderate evidence ca score 178	0	0	0	1	0	0	1
Moderate evidence ca score 196	0	0	1	1	1	0	3
Moderate evidence ca score 200	0	0	0	1	0	1	2
Moderate evidence ca score 232	0	0	0	1	0	0	1
Moderate evidence ca score 243	0	0	0	4	0	2	6
Moderate evidence ca score 253	0	1	0	0	1	0	2
Normal	2	5	8	9	13	2	39
Pericardial effusion	0	0	0	2	2	1	5
Ventricular aneurysm	0	0	0	3	1	1	5
Total	2	9	19	48	43	14	135
P value = 0.994							

Table (4.13) cross tabulation weight and diagnosis

Diagnosis	Weight				Total
	40-55 kg	56-70 kg	71-85kg	86-100 kg	
Aorta calcification	0	2	0	0	2
Aortic aneurysm	0	2	3	1	6
Atherosclerosis	0	4	2	2	8
Ca score 0 normal	0	1	4	0	5
Coronary stenosis	0	15	12	3	30
Coronary stenosis and rupture	0	1	1	1	3
Extensive evidence Ca score 450	0	0	2	0	2
Extensive evidence Ca score 470	0	0	2	0	2
Extensive evidence Ca score 480	0	0	1	0	1
Extensive evidence ca score 1500	0	0	0	1	1
Extensive evidence ca score 1900	0	0	1	0	1
Extensive evidence ca score 2000	0	1	1	0	2
Infarction	0	3	2	0	5
Mild evidence ca score 28	0	0	0	1	1
Mild evidence ca score 70	0	0	0	1	1
Minimal evidence ca score 4	0	1	0	0	1
Moderate evidence ca score 178	0	0	1	0	1
Moderate evidence ca score 196	0	0	3	0	3
Moderate evidence ca score 200	0	1	1	0	2
Moderate evidence ca score 232	0	0	1	0	1
Moderate evidence ca score 243	0	2	4	0	6
Moderate evidence ca score 253	0	2	0	0	2
Normal	3	21	10	5	39
Pericardial effusion	0	2	1	2	5
Ventricular aneurysm	0	0	3	2	5
Total	3	58	55	19	135
P value = 0.572					

Table (4.14) frequency distribution of branches which affected by coronary stenosis

Branches of CA affected	Frequency	Percent	Valid Percent	Cumulative Percent
One	16	11.9	48.5	48.5
Two	16	11.9	48.5	97.0
Three	1	.7	3.0	100.0
Total	33	24.4	100.0	

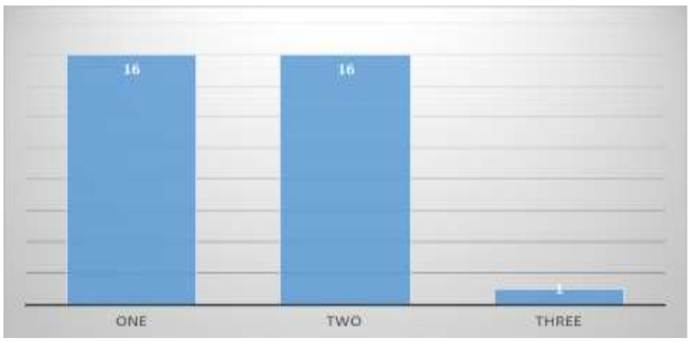


Figure (4.11) frequency distribution of branches which affected by coronary stenosis

Table (4.15) cross tabulation features and diagnosis

Diagnosis	Feature															Total
	Calcified	Dialation of aorta more than 1.5 times	Excessive	Extensive calcium	Mild	Mild calcium	Minimal	Minimal calcium	Mixed	Moderate	Moderate calcium	Non calcified	Norma l	Normal calcium	Severe	
Aorta calcification	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Aortic aneurysm	0	5	0	0	0	0	0	0	0	0	0	0	0	0	1	6
Atherosclerosis	5	0	0	0	0	0	0	0	1	0	0	2	0	0	0	8
Ca score 0 normal	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5
Coronary stenosis	0	0	0	0	10	0	0	0	0	18	0	0	0	0	2	30
Coronary stenosis and rupture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
Extensive evidence Ca score 450	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Extensive evidence Ca score 470	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Extensive evidence Ca score 480	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Extensive evidence ca score 1500	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Extensive evidence ca score 1900	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Extensive evidence ca score 2000	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Infarction	0	0	0	0	2	0	2	0	0	1	0	0	0	0	0	5
Mild evidence ca score 28	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Mild evidence ca score 70	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Minimal evidence ca score 4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Moderate evidence ca score 178	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Moderate evidence ca score 196	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3
Moderate evidence ca score 200	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Moderate evidence ca score 232	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Moderate evidence ca score 243	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	6
Moderate evidence ca score 253	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Normal	0	0	0	0	0	0	0	0	0	0	0	0	39	0	0	39
Pericardial effusion	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	5
Ventricular aneurysm	0	0	0	0	2	0	1	0	0	1	0	0	0	0	1	5
Total	5	5	2	9	14	2	5	1	1	23	15	2	39	5	7	135
P value =0.000																

CHAPTER FIVE

DISSCUTION CONCLUSION AND RECOMMENDATIEN

Chapter five

Discussion, conclusion and recommendation

5.1 Discussion

Multi-slice CT angiography represents one of the most exciting technological revolutions in cardiac imaging and it has been increasingly used in the diagnosis of coronary artery disease. Rapid improvements in multi-slice CT scanners over the last decade have allowed this technique to become a potentially effective alternative to invasive coronary angiography in patients with suspected coronary artery disease.

There are many risk factors for heart diseases: age, gender, obesity and family history of cardiovascular disease .While the individual contribution of each risk factor varies between different communities or ethnic groups the overall contribution of these risk factors is very consistent. Some of these risk factors, such as age, gender or family history/genetic predisposition, are immutable; however, many important cardiovascular risk factors are modifiable by lifestyle change, social change, drug treatment (for example prevention of hypertension, hyperlipidemia, and diabetes) .People with obesity are at increased risk of atherosclerosis of the coronary arteries [Shanthi et al 2011].

Genetic factors influence the development of cardiovascular disease in men who are less than 55 years-old and in women who are less than 65 years old [Yusuf et al. 2004]. Cardiovascular disease in a person's parents increases their risk by 3 fold. Multiple single nucleotide polymorphisms (SNP) have been found to be associated with cardiovascular disease in genetic association studies, but usually their individual influence is small, and genetic contributions to cardiovascular disease are poorly understood. Age is by far the most important risk factor in developing cardiovascular or heart diseases, with approximately a tripling of risk with each decade of life. Coronary fatty streaks can begin to form in adolescence. It is estimated that 82 percent of people who die of coronary heart disease are 65 and older. At the same time, the risk of stroke doubles every decade after age 55[McPhee2012].

Multiple explanations have been proposed to explain why age increases the risk of cardiovascular/heart diseases. One of them is related to serum cholesterol level. In most populations, the serum total cholesterol level increases as age increases. In men, this increase levels off around age 45 to 50 years. In women, the increase continues sharply until age 60 to 65 years [Finegold et al 2012].

Aging is also associated with changes in the mechanical and structural properties of the vascular wall, which leads to the loss of arterial elasticity and reduced arterial compliance and may subsequently lead to coronary artery disease [Finegold, et al 2012].

Men are at greater risk of heart disease than pre-menopausal women. Once past menopause, it has been argued that a woman's risk is similar to a man's although more recent data from the WHO and UN disputes this. If a female has diabetes, she is more likely to develop heart disease than a male with diabetes [D'Adamo, 2015].

Coronary heart diseases are 2 to 5 times more common among middle-aged men than women. In a study done by the World Health Organization, sex contributes to approximately 40% of the variation in sex ratios of coronary heart disease mortality. Another study reports similar results finding that gender differences explains nearly half the risk associated with cardiovascular diseases. One of the proposed explanations for gender differences in cardiovascular diseases is hormonal difference. Among women, estrogen is the predominant sex hormone. Estrogen may have protective effects on glucose metabolism and hemostatic system, and may have direct effect in improving endothelial cell function. The production of estrogen decreases after menopause, and this may change the female lipid metabolism toward a more atherogenic form by decreasing the HDL cholesterol level while increasing LDL and total cholesterol levels [Mackay et al 2004].

Among men and women, there are notable differences in body weight, height, body fat distribution, heart rate, stroke volume, and arterial compliance. In the very elderly, age-related large artery pulsatility and stiffness is more pronounced among women than men. This may be caused by the women's smaller body size.

The present study is agree with the above studies and with (Abdalrahim et al2010) and (Mirghany et al-2013) the Male to female ratio was 54:46 as shown in (table 4-1) and the ratio of diseases was 53:42 as shown in (table 4-11).The male were more affected by cardiac diseases.

High diagnostic value has been achieved with multi-slice CT angiography with use of 64- and more slice CT scanners. In addition, multi-slice CT angiography shows accurate detection and analysis of coronary calcium, characterization of coronary plaques, as well as prediction of the disease progression and major cardiac events. Thus, patients can benefit from multi-slice CT angiography that provides a rapid and accurate diagnosis while avoiding unnecessary invasive coronary angiography procedures. Data from Greenland et al demonstrated that intermediate-risk patients with an elevated coronary artery calcium (CA) score (intermediate FRS and CA score >300) had an annual hard event rate of 2.9 %, or a 10-year rate of 28%, and thus would be considered high risk. The best estimate of the relative risk (RR) from this study indicated that a CA score >300 had a hazard ratio (HR) of about 4 compared with a score of 0. This would mean that the estimated risk in the intermediate-risk patient with a CA score of 0 might be reduced by at least 2-fold while the risk of a person with a CA score of 300+ would be increased by about 2fold. Thus, the person with a high CA score and intermediate is now reclassified as high risk [.Matthew et al 2004]. In this study total of 32 patient had done calcium score examination 5 of them show normal score , 9 show excessive score and the remaining were divided to minimal mild and moderate according to CA score and shown in table(4-5) and figure(4-5) this was agree with Shema et al-2011

The composition of atherosclerotic plaques in the coronary arteries displays substantial variability and is associated with the likelihood for rupture and downstream ischemic events. Accurate identification and quantification of coronary plaque components on CT is challenging because of the limited temporal, spatial, and contrast resolutions of current scanners. Nonetheless, CT may provide valuable information that has potential for characterization of coronary plaques. For example, the extent of calcification can be determined, lipid-rich lesions can be separated from more fibrous ones, and positive remodeling can be identified. Didem Yaw 2013 et-al demonstrated the Coronary heart disease (CHD) is the most prevalent cause of death worldwide. Atherosclerosis which is the condition of plaque buildup on the inside of the coronary artery wall is the main cause Of CHD. Rupture of unstable atherosclerotic coronary plaque is known to be the cause of acute coronary syndrome. The composition of plaque is important for detection of plaque vulnerability. Due to prognostic importance of early stage identification, non-invasive assessment of plaque characterization is necessary

We found that there was 8(5%) of them suffer from atherosclerotic plaques as shown in table and figure (4-6). The characterization of coronary plaques divided into three type Calcified 5(3.7%) non calcified 2(1.5%) and mixed 1(.7%) as shown in table and figure (4-10).The result also agree with Mohammed Yousif et al -2013.

Detection of CAD along with the complex anatomic relations with adjacent structures is excellent with MDCT (Hurlock et al., 2009; Kacmaz et al., 2008).

All vessels -1.5 mm were considered for the assessment of significant coronary artery stenosis (diameter reduction .50%) patient complain from coronary stenosis [Wang et al 20013].In the present study the prevalence of the coronary artery stenosis was 33 (24.4%) of patients with suspected coronary artery diseases which shown in table and figure(4-7).

Our result is slightly lower than that of Mohammed Yousif et al -2013 and Shema et al-2013 .In the present study left coronary artery diseases were more common than right coronary artery anomalies. This is in agreement with the results of Shema et al2011, Mohammed Yousif et al -2013 and Datta et al 2005and in disagreement with results of other studies (Yang et al., 2010; Knickelbine et al, 2009) and shown in table and figure (4-8).

Extensively calcified lesion most likely represent atherosclerosis at later stages of remodeling and may reflect more stable lesions (Hong et al., 2005). Therefore, in the presence of coronary plaques, especially calcified plaques, coronary artery undergoes dimensional changes due to alternation process, resulting in corresponding diameter differences between the normal and diseased coronary arteries. Results from this study are consistent with other reports regarding the distribution and morphology of coronary plaques (Rodriguez et al., 2007; Rodriguez\ et al., 2006; Kaazempur et al., 2004; Kimura et al., 1996). Atherosclerotic plaques were commonly located at the LAD, particularly close to the ostium of LAD, whereas the left main stem and the LCx were less frequently affected. This could be used as guidance for analysis of possible effects of the hemodynamic on the local characteristics and distribution of plaques (Cademartiri et al., 2009). The present study shown that one branches of CA affected by stenosis 16(48.9%) and two branches 16(48.9%) three branches only one (.7%).that result was shown in table (4–14)figure (4-11).

This study confirms the visualization of lesions of coronary arteries, cardiac morphology revolution, as well as classification of plaques type in those diagnostic methods which was achieved in all patients, comparable to other studies done (Achenbach et al., 2006; Johnson et al., 2006; Scheffel et al., 2006). Images concern with the presentation of CAD and calcium score values were presented in (figure 4-11).

The higher spatial resolution of CT allows visualization of coronary arteries both with and without contrast enhancement. The ability to see the coronary arteries on anon-contrast study depends upon the fat surrounding the artery (of lower density, thus more black on images), providing a natural contrast between the myocardium and the pericardial artery. Usually, the entire course of each coronary artery is visible on non-enhanced scans. The major exception is bridging, when the coronary artery delves into the myocardium and cannot be distinguished without contrast. The distinction of blood and soft tissue (such as the left ventricle, where there is no air or fat to act as a natural contrast agent) requires injection MSCT is a highly accurate diagnostic modality for congenital heart diseases, obviating the need for invasive modalities. Beside its noninvasive nature, the advantage of MSCT over the angiography is its ability to provide detailed anatomical information about the heart, vessels, lungs and intra-abdominal organs.[Brent Vernon et al 2013] .

In the present study there was Aorta calcification 2(1.5%) Aortic aneurysm 6 (4.4%) Pericardial effusion 5(4.7%) is shown in table and figure (4-9).

The LAD artery it‘s the most commonly occluded of the coronary arteries. It provides the major blood supply to the interventricular septum, and thus bundle branches of the conducting system. Hence, blockage of this artery due to coronary artery disease can lead to impairment or death (infarction) of the conducting system. The result is a "block" of impulse conduction between the atria and the ventricles known as "right/left bundle branch block."[Malouf JF, Edwards WD et al 2005]. In the present study there was Infarction 5 (4.7%) is shown in table (4–14) figure (4-11).

5.2 conclusion

This study concluded**:**

- With the development of new modalities, such as multi detector ECG gated cardiac MSCT, noninvasive imaging of small mobile structures, such as coronary arteries, has become possible. Because of the high prevalence, morbidity, mortality, and enormous socioeconomic burden of coronary artery disease, noninvasive detection of significant coronary artery stenosis has been the driving force behind the development of this technology.
- The present study results showed relationship between cardiac diseases and weight.
- Stenosis calcium score atherosclerosis were more common CVD. The research noted higher values of cardiac diseases in males than in females.
- Age and cardiac diseases showed strong, positive statistically significant relationships.
- The non-invasive cardiovascular imaging modalities, are playing an increasing role in both clinical and research settings.
- Multi-detector cardiac computed tomography (MDCT) has become the preeminent modalities for the assessment of coronary artery atherosclerosis.

. As the technology evolves, cardiac CT will become readily available, making interpretation a necessary clinical ability. In the future diagnostic non- invasive anatomic and functional imaging need to be evaluated in large patient populations to establish their efficacy, safety, and cost effectiveness.

5.3 Recommendations

From the results of this study the researcher recommended that:

This study is small study consisting of randomized populations of people in Khartoum state and the study population cannot be the representation of whole population. Relatively the sample size was also small.

Importantly, these investigations should result in the development of comprehensive guidelines on the use of CTA in clinical practice as well. Moreover, the combined use of these techniques may enhance the assessment of the presence and extent of CAD.

Although further work is required to determine the prognostic utility of MSCT and to clarify its precise clinical role, the currently available data suggest that it will play an increasing role in the evaluation of patients with known or suspected CAD.

5.4 Future work

Characterize every disease individual study using MSCT.

5.5 Study limitations

This study is small study consisting of randomized populations and the study population cannot be the representation of whole population.

This study was designed to highlight the diagnostic role of MSCT in the diagnosing the CVD, and this was done by collecting randomly the data and then assess the findings of each imaging

. There were problem in collecting more important patient data like hypertension diabetes cholesterol level which were important in relationship between them and cardiac diseases.

References

- Assessment of Coronary Artery Disease by Cardiac Computed Tomography A Scientific Statement From the American Heart Association Committee on Cardiovascular Imaging and
  Intervention, Council on Cardiovascular Radiology and Intervention, and Committee on Cardiac Imaging, Council on Clinical Cardiology
- Brent Vernon ARIZONA STATE UNIVERSITY May 2013 Characterization of Coronary Atherosclerotic Plaques by Dual Energy Compute Tomography.
- Budoff MJ, Mao SS, Wang S, Bakhsheshi H, Brundage BH. A Simple single slice method for measurement of left and right atrial volume by electron beam computed tomography. Acad Radiol 1999;6:481– 486
- BolandLL ,FolsomAR, SorliePD, TaylorHA, RosamondWD, ChamblessLE, Cooper LS. Occurrence of unrecognized myocardial infarction in subjects' aged45–65years (the ARIC study).AmJ Cardiol2002; 90:927–931.
- Carr JJ, Nelson JC, Wong ND, et al. Calcified coronary artery plaque measurement with cardiac CT in population-based studies: standardized protocol of Multi-Ethnic Study of Atherosclerosis (MESA) and Coronary Artery Risk Development in Young Adults (CARDIA) study. Radiology 2005; 234:35–43.
- Cody DD. AAPM/RSNA physics tutorial for residents: topics in CT—image processing in CT. Radio Graphics 2002; 22(5):1255–1268Stary HC. These quence of cell and matrix changes in atherosclerotic lesions of coronary arteries in the first forty years of life .Eur Heart J 1990; 11(Suppl.E 3–19.
- D'Adamo, E; Guardamagna, O; Chiarelli, F; Bartuli, A; Liccardo, D; Ferrari, F; Nobili, V (2015). "Atherogenic dyslipidemia and cardiovascular risk factors in obese children". International Journal of Endocrinology. 2015: 912047.

- . Didem Yamak A Dissertation Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy Approved April 2013 by the Graduate Supervisory Committee
- DudasK, LappasG, StewartS, RosengrenA. Trendsinout-of-hospital deaths due to coronary heart disease in Sweden(1991–2006).Circulation2011;123: 46–52.
  - Eckel, Robert H. (November 4, 1997). "Obesity and Heart Disease: A Statement for Healthcare Professionals From the Nutrition Committee, American Heart Association". ahajournals.org. Archived from the original on 2017-07-01.
- ErbelR,Mo¨hlenkampS, MoebusS, SchmermundA,LehmannN, StangA, DraganoN, Gro¨nemeyerD, SeibelR, Ka¨lschH,Bro¨cker-PreussM, MannK, SiegristJ,Jo¨ckelKH; Heinz Nixd or fRecall Study Investigative Group. Coronary risks tratification, discrimination, and reclassification improvement based on quantification of sub clinical coronary atherosclerosis: the HeinzNixdorfRecall study .J AmCollCardiol2010; 56:1397–1406.
- Eckel, Robert H. (November 4, 1997). "Obesity and Heart Disease: A Statement for Healthcare Professionals From the Nutrition Committee, American Heart Association". ahajournals.org. Archived from the original on 2017-07-01.
- Fariborz Sedaghat,1,A,BHamidreza Pouraliakbar,1,A,BMarzieh Motevalli,1,A,BMohammad Ali Karimi,2,A,C,D,E,F and Sandbad Armand2,B,F are studied the Comparison of diagnostic accuracy of dual-source CT and conventional angiography in detecting congenital heart diseases
- Finegold, JA; Asaria, P; Francis, DP (Dec 4, 2012). "Mortality from ischaemic heart disease by country, region, and age: Statistics from World Health Organisation and United Nations". International Journal of Cardiology. 168 (2): 934–945. doi:10.1016/j.ijcard.2012.10.046.
  PMC 3819990 . PMID 23218570.

- Fuster V, Cohen M, Halperin J.Aspirinin the prevention of coronary disease .Engl J Med1989; 321:183–185.
- GBD 2015 Mortality and Causes of Death, Collaborators. (8 October 2016). "Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015". Lancet. 388 (10053): 1459–1544. doi:10.1016/S0140-6736(16)31012-1. PMID 27733281
- GBD 2013 Mortality and Causes of Death, Collaborators (17 December 2014). "Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013". Lancet. 385 (9963): 117–71. doi:10.1016/S0140-6736(14)61682-2. PMC 4340604. PMID 25530442.
- Gilbert L. Raff, MD, FACC, Michael J. Gallagher, MD, William W. O'Neill, MD, FACC, James A. Goldstein, MD, FACC Royal Oak, Michigan studied the Diagnostic Accuracy of Noninvasive Coronary Angiography Using 64-Slice Spiral Computed Tomography
- Gruden JF. Thoracic CT performance and interpretation in the multi-detector era. J Thorac Imaging 2005;20(4):253–264.
- Go, AS; Mozaffarian, D; Roger, VL; Benjamin, EJ; Berry, JD; Borden, WB; Bravata, DM; Dai, S; Ford, ES; Fox, CS; Franco, S; Fullerton, HJ; Gillespie, C; Hailpern, SM; Heit, JA; Howard, VJ; Huffman, MD; Kissela, BM; Kittner, SJ; Lackland, DT; Lichtman, JH; Lisabeth, LD; Magid, D; Marcus, GM; Marelli, A; Matchar, DB; McGuire, DK; Mohler, ER; Moy, CS; Mussolino, ME; Nichol, G; Paynter, NP; Schreiner, PJ; Sorlie, PD; Stein, J; Turan, TN; Virani, SS; Wong, ND; Woo, D; Turner, MB; American Heart Association Statistics Committee and Stroke Statistics, Subcommittee (1 January 2013). "Heart disease and stroke

statistics--2013 update: a report from the American Heart Association". Circulation. 127 (1): e6–e245. doi:10.1161/cir.0b013e31828124ad. PMID 23239837.

- Heart diseases. J Med Assoc Thai 2000; 83:111-117.
- Hoffmann U, Pena AJ, Cury RC, et al. CardiacCT in emergency department patients with acute chest pain. RadioGraphics 2006;26(4):963–980.
- Hudsmith LE, Petersen SE, Francis JM, RobsonMD, Neubauer S. Normal human left and right ventricular and left atrial dimensions using steady state free precession magnetic resonance imaging. J Cardiovasc Magn Reson 2005;7(5):775–782.
- Jani B, Rajkumar C (2006). "Ageing and vascular ageing". Postgrad Med J. 82 (968): 357– 362. doi:10.1136/pgmj.2005.036053.
- Jousilahti Vartiainen; Tuomilehto Puska (1999). "Sex, Age, Cardiovascular Risk Factors, and coronary heart disease". Circulation. 99 (9): 1165–1172. doi:10.1161/01.cir.99.9.1165
- John W. Nance, Jr, MD, Fabian Bamberg, MD, MPH, U. Joseph Schoepf, MD, Doo Kyoung Kang, MD, J. Michael Barraza, Jr, BS,
- Joseph A. Abro, MA, Gorka Bastarrika, MD, PhD, Gary F. Headden, MD, Philip Costello, MD, and Christian Thilo, MD Coronary Atherosclerosis in African American and White Patients with Acute Chest Pain: Characterization with Coronary CT Angiography
- J. P. Mackenbach; A. E. Cavelaars; A. E. Kunst; F. Groenhof (July 2000). "Socioeconomic inequalities in cardiovascular disease mortality; an international study". European Heart Journal. 21 (14): 1141–1151. doi:10.1053/euhj.1999.1990. PMID 10924297. Alexander M. Clark; Marie DesMeules; Wei Luo; Amanda S. Duncan; Andy Wielgosz (November 2009). "Socioeconomic status and

cardiovascular disease: risks and implications for care". Nature Reviews Cardiology. 6 (11): 712–722. doi:10.1038/nrcardio.2009.163. PMID 19770848.

- Kathiresan, S; Srivastava, D (16 March 2012). "Genetics of human cardiovascular disease".
  Cell. 148 (6): 1242–57. doi:10.1016/j.cell.2012.03.001. PMC 3319439 . PMID 22424232.

  - Lawler LP, Pannu HK, Fishman EK. MDCT evaluation of the coronary arteries, 2004: how we do it—data acquisition, postprocessing, display, and interpretation. AJR Am J Roentgenol 2005; 184(5):1402–1412.

- Lloyd-JonesDM, LarsonMG, BeiserA, LevyD. Life time risk of developing coronary heart disease.Lancet1999;353:89–92.
- Lo¨welH, MeisingerC, HeierM, HymerH, AlteD, Vo¨lzkeH. Epidemiology of hypertension in Germany. Selected results of population-representative cross
- Mackay, Mensah, Mendis, et al. The Atlas of Heart Disease and Stroke. World Health Organization. January 2004.
- Mariachiara Di Cesare; Young-Ho Khang; Perviz Asaria; Tony Blakely; Melanie J. Cowan; Farshad Farzadfar; Ramiro Guerrero; Nayu Ikeda; Catherine Kyobutungi; Kelias P. Msyamboza; Sophal Oum; John W. Lynch; Michael G. Marmot; Majid Ezzati (February 2013). "Inequalities in non-communicable diseases and effective responses". Lancet. 381 (9866): 585–597. doi:10.1016/S0140-6736(12)61851-0. PMID 23410608.
- Matthew J. Budoff, Stephan Achenbach, Roger S. Blumenthal, J. Jeffrey Carr, Jonathan G. Goldin, Philip Greenland, Alan D. Guerci, Joao A.C. Lima, Daniel J. Rader, Geoffrey D. Rubin, Leslee J. Shaw, Susan E. Wiegers https://doi.org/10.1161/CIRCULATIONAHA.106.178458 Circulation. 2006;114:1761- 1791Originally published October 16, 2006

MacRae, Calum A.; Vasan, Ramachandran S. (2016-06-21). "The Future of Genetics and Genomics: Closing the Phenotype Gap in Precision Medicine". Circulation. 133 (25): 2634– 2639. doi:10.1161/CIRCULATIONAHA.116.022547. ISSN 1524-4539. PMID 27324359.

- Maiming Correspondence information about theauthor Ximing Wang Email the author Ximing Wang, HaizhuXie,ChunjuanSun,ZhaoyingWen, Yong Wang, Yinghong Shi, Jing Liu, Jun Yang Correspondence information about the author JunYang Characterization of the cardiac venous system in heart failure patients using 256-slice CT
- Malouf JF, Edwards WD, Tajik AJ, Seward JB.Functional anatomy of the heart. In: Fuster V, Alexander RW, O'Rourke RA, Roberts R, King SB, Wellens HJJ, eds. Hurst's the heart. 11th ed. New York, NY: McGraw-Hill, 2005; 45–82
- McGill HC, McMahan CA, Gidding SS (March 2008). "Preventing heart disease in the 21st century: implications of the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) study". Circulation. 117 (9): 1216–27. doi:10.1161/CIRCULATIONAHA.107.717033. PMID 18316498.
- McPhee, Stephen (2012). Current medical diagnosis & treatment 2012. New York: McGrawHill Medical. p. 430. ISBN 9780071763721.
- Metin Akay, Co-chair Jit Muthuswamy, Co-chair Yasemin Akay William Pavlicek

  23. Matthew J. Budoff and Jerold S. Shinbane Editors Associate EditorsStephan Achenbach, Paolo Raggi, and John A. Rumberger Cardiac CT Imaging Diagnosis of Cardiovascular Disease with 299 Figures including 168 Color Plates

- .Micha, Renata; Michas, Georgios; Mozaffarian, Dariush (2012). "Unprocessed Red and Processed Meats and Risk of Coronary Artery Disease and Type 2

Diabetes – An Updated Review of the Evidence". Current Atherosclerosis Reports. 14 (6): 515–524. doi:10.1007/s11883-012-0282-8. ISSN 1523-3804. PMC 3483430 . PMID 23001745

- Mukamal, Kenneth J.; Chen, Chiung M.; Rao, Sowmya R.; Breslow, Rosalind A. (2010). "Alcohol Consumption and Cardiovascular Mortality among U.S. Adults, 1987 to 2002". Journal of the American College of Cardiology. 55 (13): 1328–1335. doi:10.1016/j.jacc.2009.10.056. ISSN 0735-1097. PMC 3865979 . PMID 20338493.
- Mohamed Yousef 2013 et-al Diagnoses of coronary artery diseases using 64-Slice computed tomography angiography PHD research.
  - Nieman K, Rensing BJ, van Geuns RJ, et al. Non-invasive coronary angiography with multislice spiral computed tomography: impact of heart rate. Heart 200;88(5):470–474.
- Nikpay, Majid; Goel, Anuj; Won, Hong-Hee; Hall, Leanne M; Willenborg, Christina; Kanoni, Stavroula; Saleheen, Danish; Kyriakou, Theodosios; Nelson, Christopher P. "A comprehensive 1000 Genomes–based genome-wide association meta-analysis of coronary artery disease". Nature Genetics. 47 (10): 1121–1130. doi:10.1038/ng.3396. PMC 4589895. PMID 26343387.
- Raman SV, Shah M, McCarthy B, Garcia A, Ferketich AK. Multi-detector row cardiac computed tomography accurately quantifies right and left ventricular size and function compared with cardiac magnetic resonance. Am Heart J 2006;151(3): 736–744. Roger VL, GoAS, Lloyd-JonesDM, Adams RJ, Berry JD, Brown TM, CarnethonMR,Dai S, de Simone G, Ford ES, Fox CS, Fullerton HJ, Gillespie C, GreenlundKJ, HailpernSM,HeitJA, Ho PM,Howard VJ, Kissela BM,KittnerSJ, LacklandDT ,LichtmanJH, LisabethLD, MakucDM, MarcusGM, MarelliA, MatcharDB ,McDermott MM ,Meigs JB, MoyCS, Mozaffarian D,

Mussolino ME,Nichol G, Paynter NP, Rosamond WD, SorliePD ,StaffordRS ,TuranTN ,Turner MB, Wong ND, Wylie-RosettJ; American Heart Association Statistics Committee and Stroke Statistics Subcom-mittee .Heart disease and stroke statistics—2011update:areport from the American HeartAssociation.Circulation2011;123:e18–e209.

- Richard Doll; Richard Peto; Jillian Boreham & Isabelle Sutherland (June 2004). "Mortality in relation to smoking: 50 years' observations on male British doctors". BMJ. 328 (7455): 1519. doi:10.1136/bmj.38142.554479.AE. PMC 437139 . PMID 15213107.
- Ropers D,Baum U,Pohle K,et al.Detection of coronary artery stenosis with thin-slice multidetector row spiral computed tomography and multiplanar reconstruction. Circulation 2003;107:664–666.
- **.**Salma Mohamed Mirghany Abdelmageed1, Caroline Edward Ayad2, Hanaa Mohamed Alsaqaa1, Hythum Salah Mohamed1, Elsafi Ahmed Abdalla2 studied the Characterization of coronary artery diseases using 256 multi detectors CT scanners
  - Sebastian Leschka1, Hatem Alkadhi1, Andre´ Plass2, Lotus Desbiolles1, Ju¨rg Gru¨nenfelder2,Borut Marincek1, and Simon Wildermuth11Department of Medical Radiology, Institute of Diagnostic Radiology, University Hospital Zurich, Ra¨mistrasse 100, 8091Zurich, Switzerland; and 2 Clinic for Cardiovascular Surgery, University Hospital Zurich, Switzerland Received 17 December 2004; revised 7 March 2005; accepted 15 March 2005; online publish-ahead-of-print 19 April 2005Accuracy of MSCT coronary angiography with 64-slice. sectionalstudies.DtschMedWochenschr2006; 131:2586–2591.

- Shema Mohammed Dr Husain Ahmed Sudan University 2011 assessment of coronary arteries appearance with MSCT and cardiac catheterization Master research.
- Spinks, A; Glasziou, PP; Del Mar, CB (5 November 2013). "Antibiotics for sore throat". The Cochrane Database of Systematic Reviews. 11: CD000023. doi:10.1002/14651858.CD000023.pub4. PMID 24190439.
- Shanthi Mendis; Pekka Puska; Bo Norrving; World Health Organization (2011). Global Atlas on Cardiovascular Disease Prevention and Control (PDF). World Health Organization in collaboration with the World Heart Federation and the World Stroke Organization. pp. 3–18. ISBN 978-92-4-156437-3. Archived (PDF) from the original on 2014-08-17.
- Shanthi Mendis; Pekka Puska; Bo Norrving (2011). Global Atlas on Cardiovascular Disease Prevention and Control. World Health Organization in collaboration with the World Heart Federation and the World Stroke Organization. ISBN 978-92-4-156437-3. Archived from the original on 2016-05-06.
- Soongswang J, Nana A, LaohaprasitipornD,Durongpisitkul K, Kangkagate C, Rochanasiri W, andKovitcharoentrakul T. Limitation of transthoracicechocardiography in the diagnosis of congenital heartdiseases. J Med Assoc Thai 2000; 83:111-117.
- Stuber M, Botnar RM, Fischer SE, et al. Preliminary report of in-vivo coronary MRA at 3 Tesla in humans. Magn Reson Med 2002;48:425– 428.
- Sutcliffe, P; Connock, M; Gurung, T; Freeman, K; Johnson, S; Ngianga-Bakwin, K; Grove, A; Gurung, B; Morrow, S; Stranges, S; Clarke, A (2013). "Aspirin in primary prevention of cardiovascular disease and cancer: a systematic review of the balance of evidence from reviews of randomized trials". PLOS ONE. 8 (12): e81970. doi:10.1371/journal.pone.0081970. PMC 3855368 . PMID 24339983.

- Sutcliffe, P; Connock, M; Gurung, T; Freeman, K; Johnson, S; Kandala, NB; Grove, A; Gurung, B; Morrow, S; Clarke, A (September 2013). "Aspirin for prophylactic use in the primary prevention of cardiovascular disease and cancer: a systematic review and overview of reviews". Health Technology Assessment. 17 (43): 1–253. doi:10.3310/hta17430. PMC 4781046 . PMID 24074752. Fuster, Board on Global Health; Valentin; Academies, Bridget B. Kelly (2010). Institute
- ThomTJ,KannelWB,SilberhatzD ,DA´gostinoRBSr. Cardiovascular diseases in the United States andprevention approaches. InFusterV, AlexanderRW, Schlant RC,O_Rourke RA, Roberts R, SonnenblickEH,(eds), Hurst_s the Heart.10thed.NewYork,NY:McGrawHill;2001.p3–7.
- Te Morenga, L. A.; Howatson, A. J.; Jones, R. M.; Mann, J. (2014). "Dietary sugars and cardiometabolic risk: systematic review and meta-analyses of randomized controlled trials of the effects on blood pressure and lipids". American Journal of Clinical Nutrition. 100 (1): 65–79. doi:10.3945/ajcn.113.081521. ISSN 0002-9165. PMID 24808490.
- Understand Your Risk of Heart Attack". American Heart Association.http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRis kofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp#
- Wafa Galaleldin Abdalrahim Dr Carolin Edward Ayad Sudan University evaluation of cardiac disease examination to cardiac Catheterization
- World Health Organization; UNAIDS (1 January 2007). Prevention of Cardiovascular Disease. World Health Organization. pp. 3–. ISBN 978-92-4-154726-0. Archived from the original on 27 April 2016..

- World Health Organization (2011). Global Status Report on Alcohol and Health. World Health Organization. ISBN 978-92-4-156415-1. Archived from the original on 2016-05-07.
- World Health Organization (2008). Closing the Gap in a Generation: Health Equity Through Action on the Social Determinants of Health : Commission on Social Determinants of Health Final Report. World Health Organization. pp. 26–. ISBN 978-92-4-156370-3. Archived from the original on 2016-05-01.
- Yusuf S, Hawken S, Ounpuu S, et al. (2004). "Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): casecontrol study". Lancet. 364 (9438): 937–52. doi:10.1016/S0140-6736(04)17018-9. PMID 15364185.
- Zhong-Hua Sun1, Yan Cao2, Hua-Feng Li21 Discipline of Medical Imaging, Department of Imaging and Applied Physics, Curtin University of Technology, Perth, Western Australia 6845, Australia 2 Department of Medical Imaging, Shandong Medical College, Jinan 250012, Shandong Province, China studied the Multi-slice computed tomography angiography in the diagnosis of coronary artery disease .

Appendix 1

Data sheet

No	Pt name	sex	age	weight	diagnosis	feature

Appendix 2

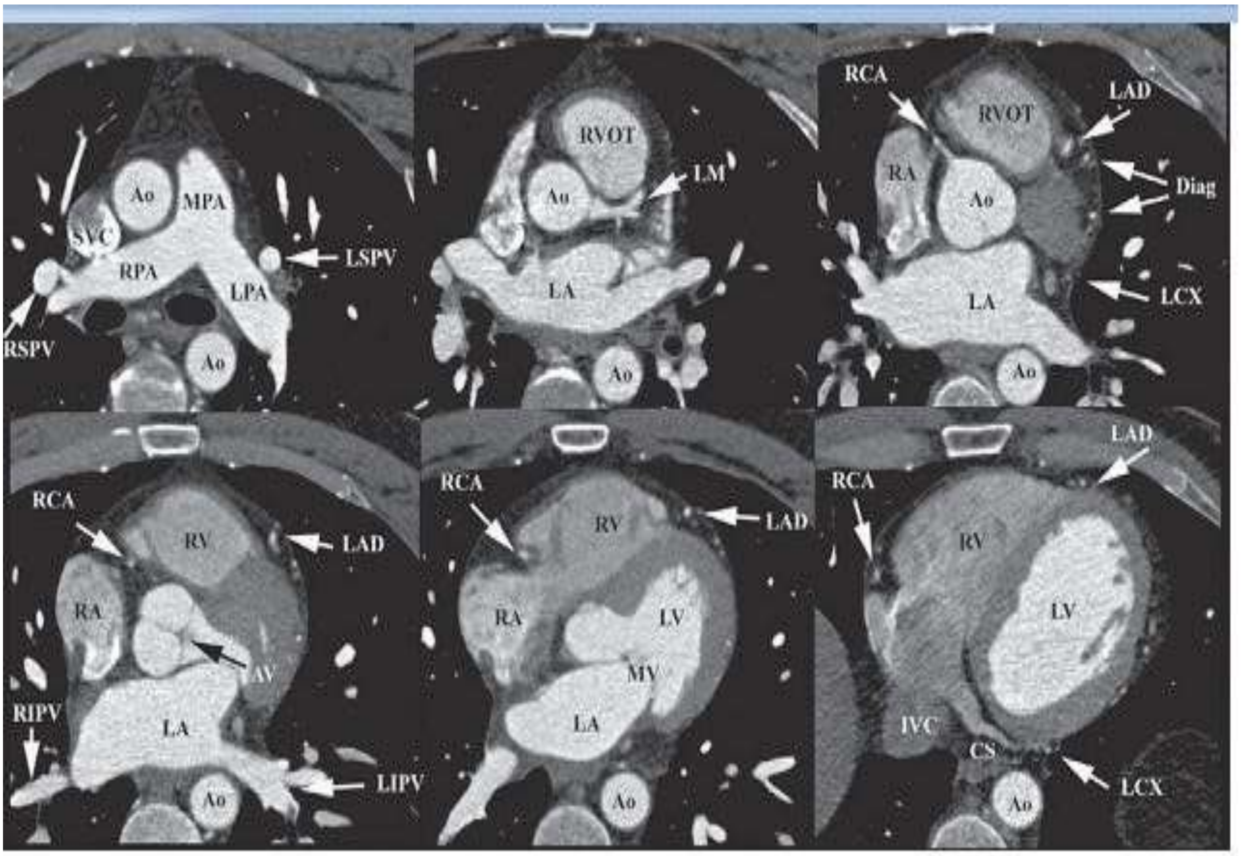


Figure (1) Normal anatomy at cardiac CT angiography. Axial composite image Ao, aorta; AV, aortic valve; CS, coronary sinus; diagonal branch; IVC, inferior vena cava; LA, left atrium; LAA, left atrial appendage; LAD, left anterior descending artery; LCX, left circumflex artery; LM, left main coronary artery; LIPV, left inferior pulmonary vein; LPA, left pulmonary artery; LSPV, left superior pulmonary vein; LV, left ventricle; MV, mitral valve; MPA, main pulmonary artery; RA, right atrium; RCA, right coronary artery; RIPV, right inferior pulmonary vein; RPA, right pulmonary artery; RSPV, right superior pulmonary vein; RV, right ventricle; RVOT, right ventricular outflow tract; SVC, superior vena cava.

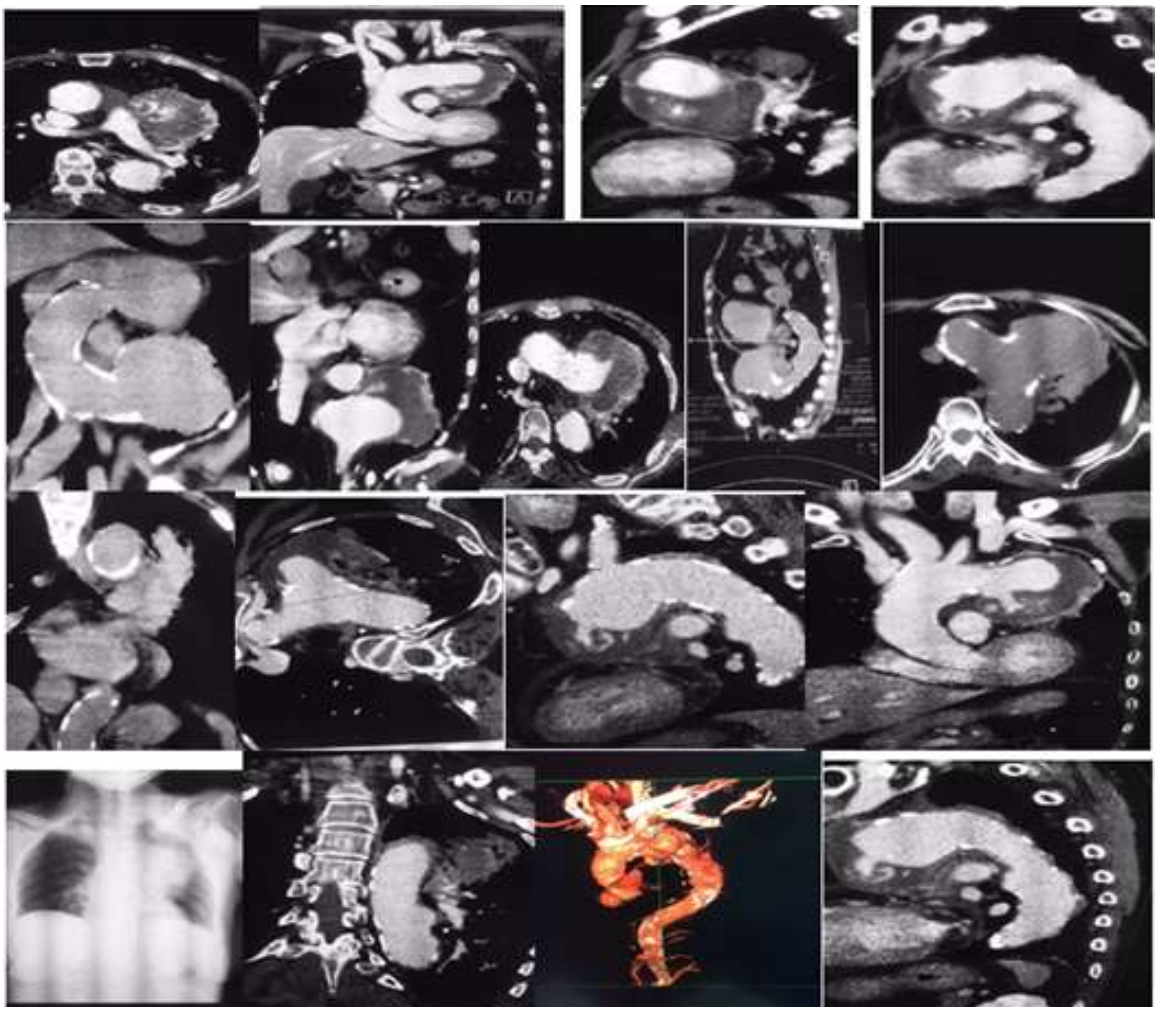


Figure (2) a contrast-enhanced CT of the coronary arteries, with excellent visualization of sever stenosis and rupture for Female 63 years old in the scout view there is clear aortic enlargement.

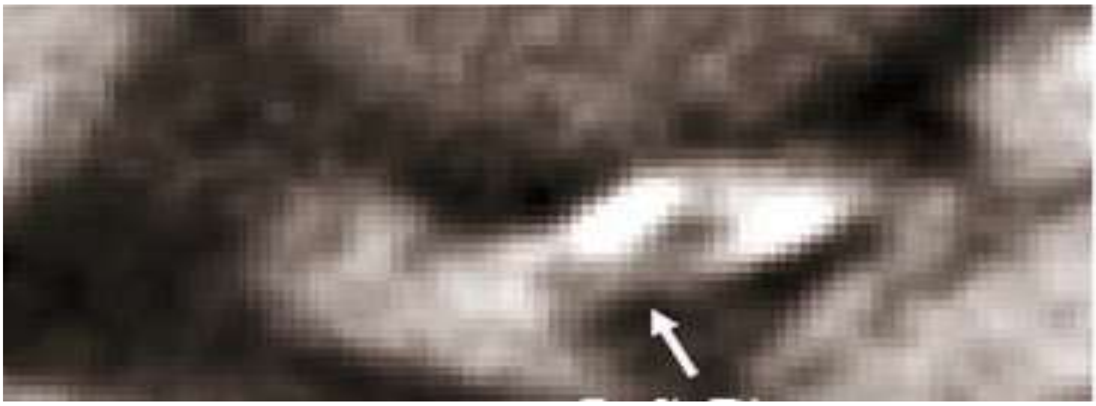


Figure (3) non-contrast study for male patient 54 years old of the left main and proximal left anterior descending. The soft plaque is visible **(**white arrow**)** (dark region, representing fat density) with calcified plaque (white regions).)This can theoretically quantitate the volume of soft plaque, fibrous plaque and calcified plaque in any given CT image.

,.

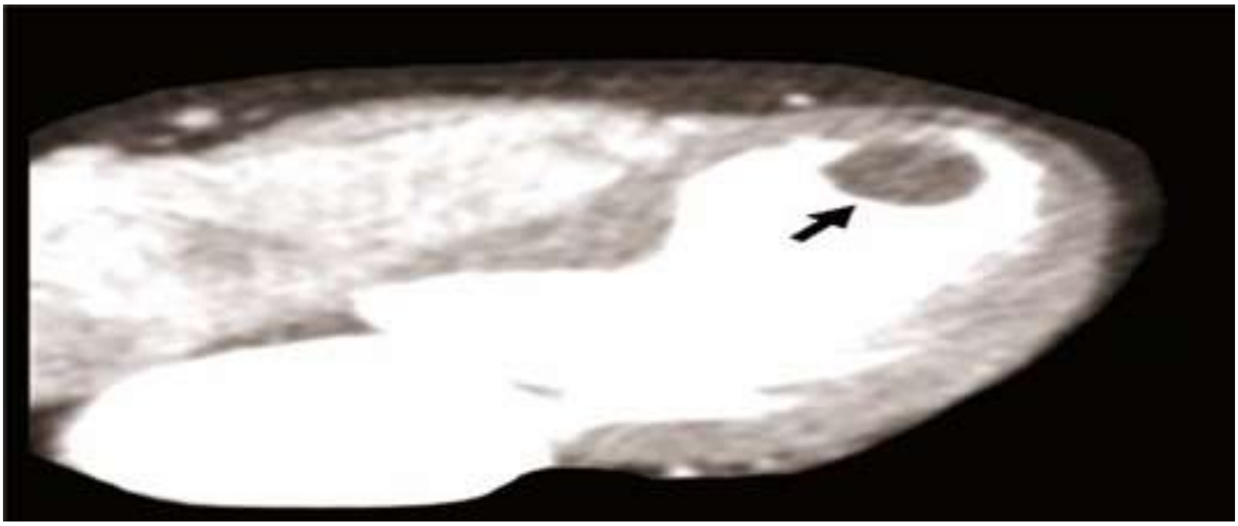
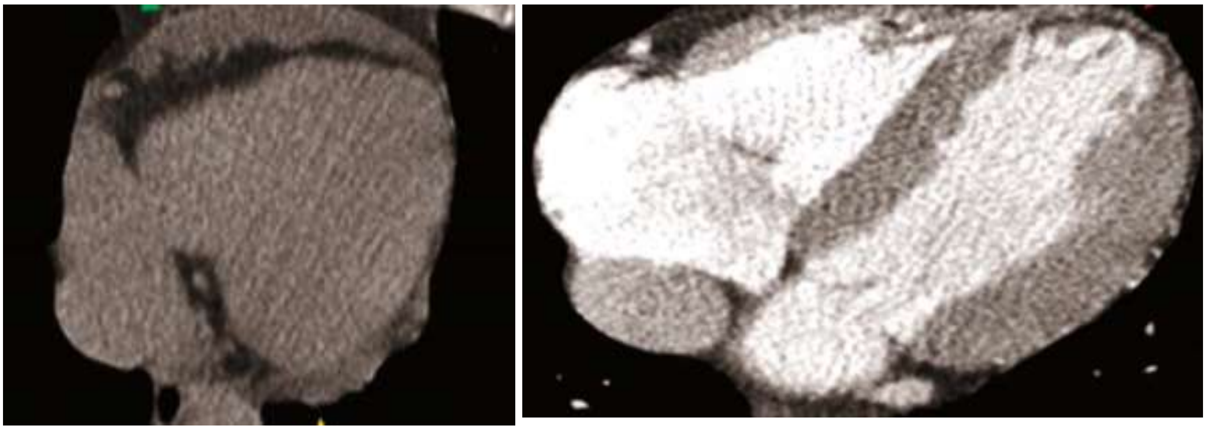


Figure (4) male 65 years old apical thrombus. This left ventricular thrombus (black arrow) demonstrates a large thrombus in the left ventricle appear rounded black area.



.Figure (5) female 72 years old pericardial effusion. Contrast and noncontract image the effusion appear black area.

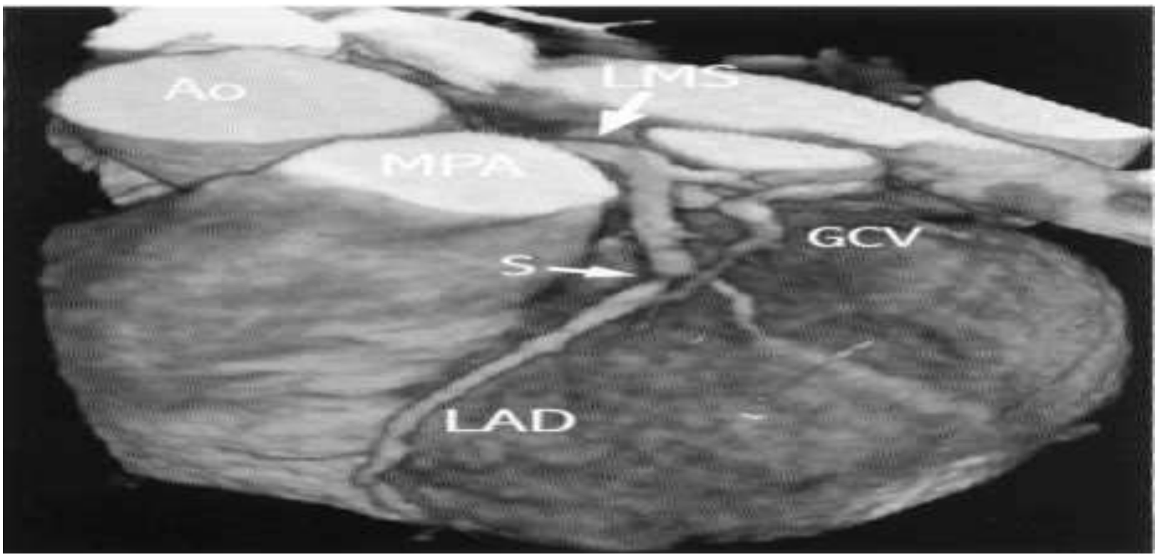


Figure (6) shows High-resolution multislice contrast CT demonstrating the left coronary artery with a stenosis (S) in the mid left anterior descending branch. Ao = aorta; MPA = main pulmonary artery; LMS = left main stem; LAD = left anterior descending artery; GCV = great cardiac vein.

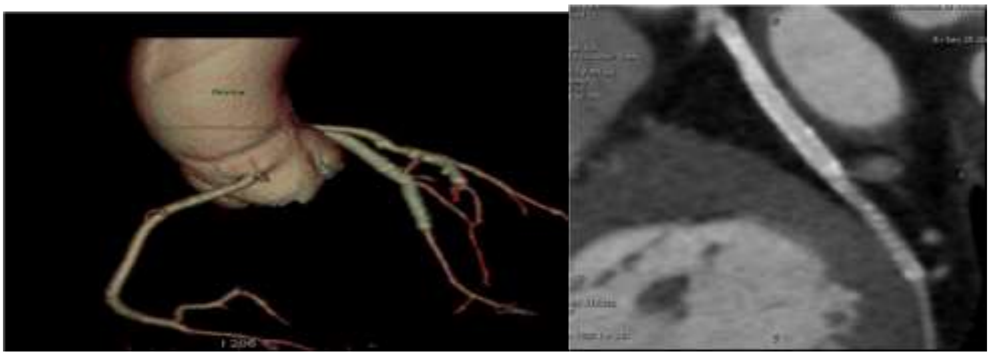


Figure (7.) Shows Coronary CT angiography male 54 year Rt 3D volume rendering image, and Lt curved multi planar reformatted (MPR), three stent placed in LAD and left circumflex.CAC score is 28.In the proximal part of the LAD showed athermanous plaque with stenosis of the distal part of the left circumflex

Figure (8) Shows Coronary CT angiography for male 54year with Rt 3D volume rendering image, and Lt curved multiplanar reformatted, (MPR) of CAC score is 2120.grafting of the LAD with LIMA with 3 vessel disease. Subtotal stenosis in the proximal part of the left circumflex artery.

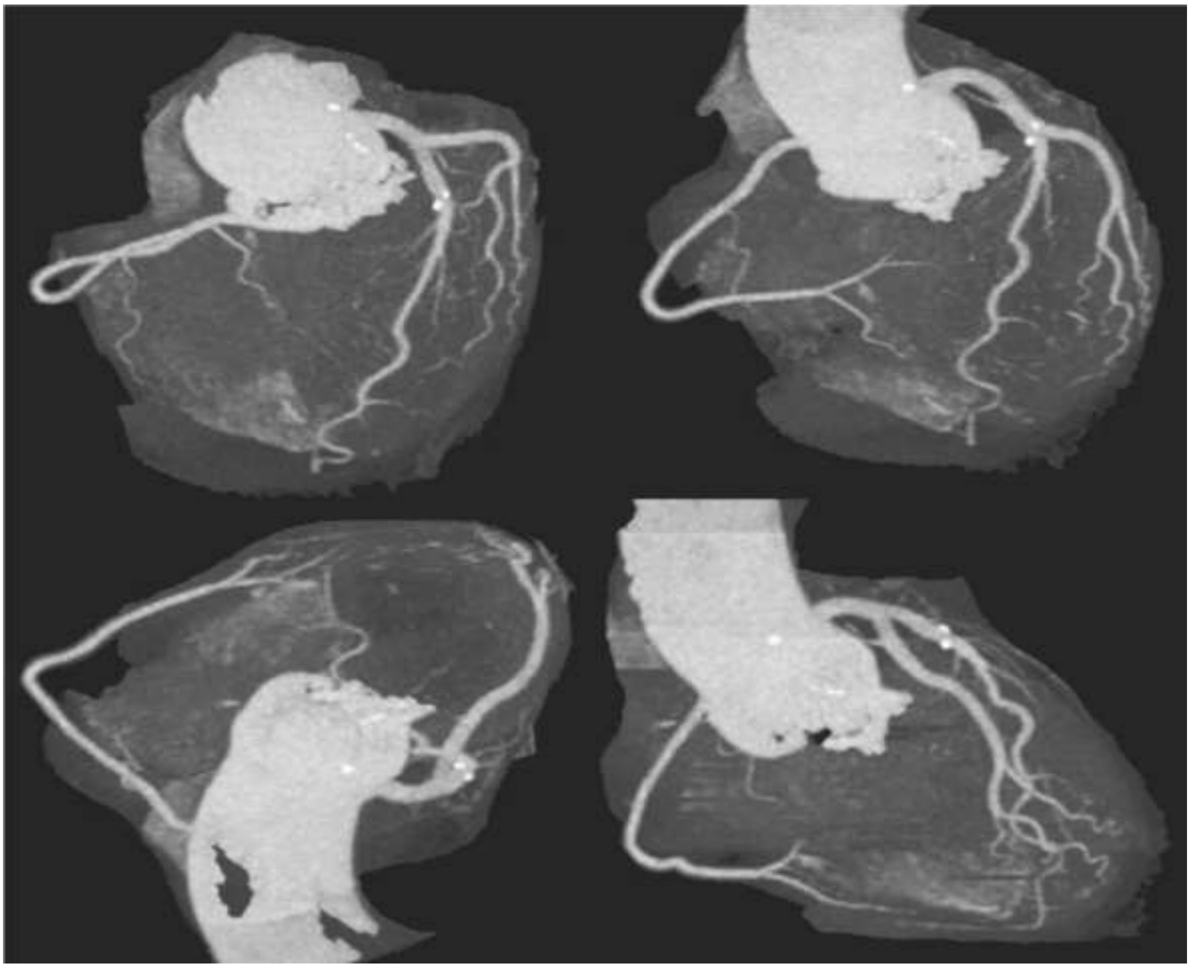


Figure (9). Multiple projections of a person with normal coronary arteries using the maximal intensity projection rendering technique. This allows for complete visualization of coronary tree .

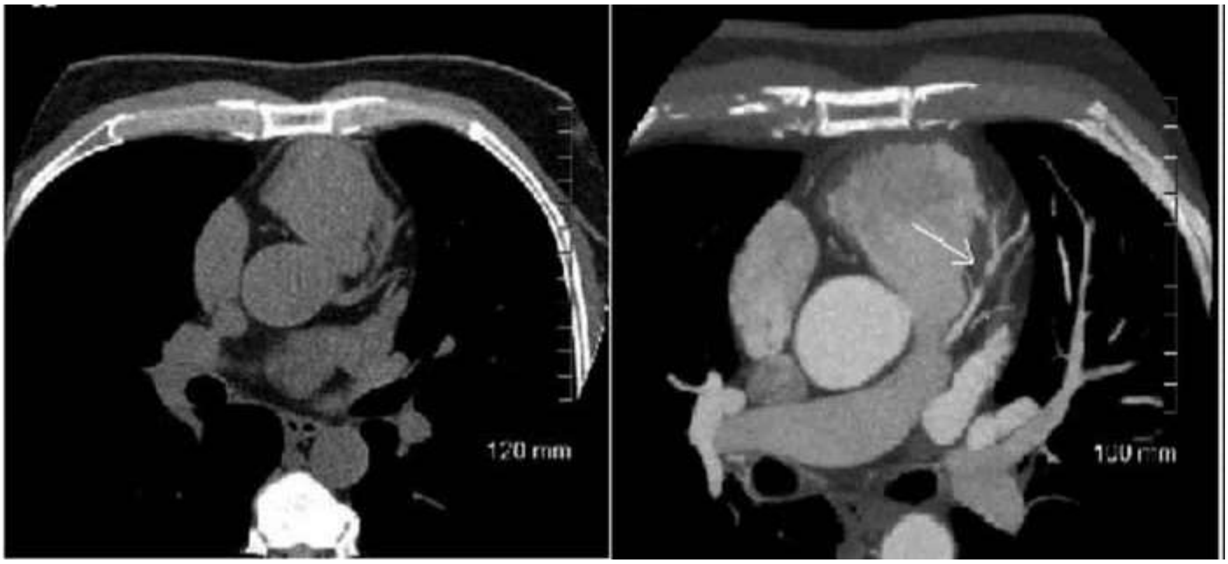


Figure (10) shows axial contrast CT demonstrating the left coronary artery with a stenosis (white arrow) for male patient 68 years.