Sudan University of Sciences and Technology

College of Graduate Studies

DIAGNOSIS OF CORONARY ARTERY DISEASES BY CT SCAN

تشخيص امراض الشرايين التاجية باستخدام الاشعة المقطعية

A thesis Submitted in partial fulfillment for the Award of Master Degree in Diagnostic Radiological Technology

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DEDICATION

I dedicate my research work to

My family ……

And many friends…..

A special feeling of gratitude to my loving parents, for their words of encouragement.

I also dedicate this research to my Wife who has supported me throughout the process.

I will always appreciate all they have done, helping me to master the leader dots.

I dedicate this work and give special thanks to my best friend I tidal for helping me.

AKNOWLEDGMENT

I wish to thank my committee members who were more than generous with their expertise and precious time. A special thanks to DR : Asma Ibrahim Ahmed Elamin , my committee chairman for his countless hours of reflecting, reading, encouraging, and most of all patience throughout the entire process.

I would like to acknowledge and thank my college for allowing me to conduct my research and providing any assistance requested. Special thanks go to the members of staff development and human resources department for their continued support.

Finally I would like to thank the group of this patch for encouraging and pushing to do our best to complete the master.

ABSTRACT

The aim of the study is to evaluate the accuracy t reveal advantage and disadvantages of CT chest angiography in diagnosis and treatment of coronary arteries diseases (CAD) in patients with suspected CAD.

Retrospectively this study carried out in 80 patients in UAE from 1/12014 to 1/6/2015.

Their ages running between (26-), 55 patients are male percentage (68.8%)

And 25 patients are female percentage (31.2%).

80 patients with suspected CAD underwent low-dose prospective electrocardio-gram gated coronary CTA, with images reconstructed using 256 slice CT scan of vessel and patient based levels. The patient data were divided into five groups (calcium scores of (0), (1-10), (11-100), (101-400) and 4000). The differences in diagnostic performance between the five groups were tested.

Most patients are within chest pain and the study found that the main affected age group (46 -55).

The study conclude that CT is accurate in diagnosing of coronary artery diseases low-dose prospective coronary CTA with 256 slices can acquire satisfactory image quality and show high diagnosis accuracy in patients with suspected CAD however, blooming continues to pose a challenge in severely calcified segments.

ملخص الدراسه

أجريت الدراسة على 80 مريضاً من مختلف الأعراق بدولة الإمارات العربية المتحدة في الفترة ما بين 2014/1/1 و حتى 2015/1/1.

وقد كان معظم المرضى من الرجال و عددهم 55 بنسبة مئوية تباغ 68.8% و الباقي نساء بعدد 25 حالة بنسبة بلغت 31.2%.

و قد خلصت الدراسة الى أن لفئة الاكثر تاثراً كانت للأعمار ما بين 46–55' و معظم النتائج كانت ضيق الشرايين التاجية.

عليه فإن الدراسة اكدت بأن التصوير بالأشعة المقطعية و عن طريق 256 slice يعتبر الأكثر فعالية و دقيق بنسبة عالية في تشخيص أمراض الشرايين التاجية للقلب.

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List of Abbreviations

BMI	Body Mass Index
CABG	Coronary Artery Bypass Graft
CAD	Coronary Artery Disease
CCA	Comprehensive Cardiac Analysis
CCA	Conventional Coronary Angiography
CFR	Coronary Flow Reserve
COPD	Chronic Obstructive Pulmonary Disease
CT	Computed Tomography
D1	First Diagonal
EBT	Electronic Beam Tomography
IVUS	Intravascular Ultrasound
LAD	Left Anterior Descending
LCX	Left Circumflex Coronary Artery
LDL	Low-Density Lipoprotein
LHL	High- Density Lipoprotein
LIMA	Left Internal Mammary Arterial
LM	Left Main Coronary Artery
MDCT	Multi Detector Computed Tomography
MPR	Multi Planar Reconstruction

NPV	Negative Predictive Value
NYHA	New York Heart Association
OM1	First Obtuse Marginal
OM2	Second Obtuse Marginal
PA	Pulmonary Artery
PCI	Percutaneous Coronary Interventional
PDA	Posterior Descending Artery
PET	Positron Emission Tomography
QCA	Quantitative Coronary Angiography
RCA	Right Coronary Artery
RVOT	Right Ventricular Outflow Tract
SCCT	Society of Cardiovascular Computed Tomography
US	Ultra Sound
XRA	X-ray Angiography

CHAPTER ONE

INTRODUCTION

Chapter One

Introduction

1.1 Introduction

For years, Coronary Artery Disease (CAD) has been a global health concern and is the leading cause of death in Americans. The National Heart Lung and Blood Institute (NHLBI). Reports that one in four deaths annually is directly caused by coronary artery diseases. CAD starts with fatty material and other substances forming plaque build-up on the walls of coronary arteries. Without proper blood flow to bring oxygen, cardiac muscle dies suffers and the heart will eventually stop contracting. Thus early screening for heart disease is crucial(husmann et al 2008).

Coronary artery disease is rapidly placing an enormous strain on health care economics. For patients with obvious symptoms of CAD, an early invasive strategy with cardiac catheterization is generally recommended. Many researchers agree that it is not helpful to perform noninvasive imaging prior to catheterization on high risk emergency patients because these tests could delay treatment. As an alternative to invasive and expensive percutaneous coronary intervention (PCI), non-invasive imaging techniques are used to detect asymptomatic CAD patients at an early stage and guide optimal patient management thereafter. Current research focuses on two types of studies: anatomical and functional imaging. For anatomical imaging, Multi-slice computed tomography (MSCT), electron beam computed tomography (EBCT) and magnetic resonance imaging (MRI) are used: whereas, for functional imaging, nuclear cardiology and/or stress echocardiography are used (Weustink et al., 2010).

1.2 Problem of Study

The main problem of study lies in identifying both advantage and disadvantages of CT chest angiography in diagnosis and treatment of coronary artery diseases.

1.3 Justification

CT Chest Angiography (CTA) has a large role in imaging anatomical strictures using iodinated contrast. Both MSCT and EBCT use a rotating source of radiation to capture images with different slice thicknesses. The difference between the two is EBCT uses electronic manipulation of the x-ray and has a shorter exposure time and the more commonly used MSCT uses traditional mechanical manipulation. CTA uses a calcium scoring system to determine heart attack risk of a patient. Coronary artery calcium (CAC) is defined as "a hyper attenuating lesion [above] 130 Hounsfield units with an area of greater than or equal to 3 pixels" and the risk associated is analyzed using "percentiles of calcification in a reference population that is stratified by [patient] age and sex" (Shah and Coulter, 2012, p. 240-241). A CAC score greater than one hundred is in the top 75th percentile for high risk of that set population. Many CT configurations also allow Positron Emission Tomography (PET) images to be laid on top of cardiac landmarks in a CT to compare it to the physiology of PET scans.

In the last decade, Computed Tomography (CT) has improved the 64 slice multi-scanner to diagnose anatomical CAD with less invasive risk to the patient and a lower-cost alternative to cardiac catheterization.

1.4 Research Question

1- What is the role of CT chest angiography in diagnosis and treatment of coronary artery diseases?

2- What is the effect of CT chest angiography on high risk emergency patient with CAD?

1.5 Objectives

a) General Objective

To reveal advantage and disadvantage of CT chest angiography in diagnosis and treatment of coronary arteries disease.

b) Specific Objective

To investigate the process of CT chest angiography in diagnosis and treatment of coronary arteries diseases.

1.6 Significant of Study

The significant of this study is based on knowing the role of CT chest angiography in diagnosis and lower cost and risk alternative to cardiac catheterization.

CHAPTER TWO

Chapter Two

Literature reviews

2.1 The Cardio Vascular System :

The cardiovascular system consists of the heart, which is an anatomical pump, with its intricate conduits (arteries, veins, and capillaries) that traverse the whole human body carrying blood. The blood contains oxygen, nutrients, wastes, and immune and other functional cells that help provide for homeostasis and basic functions of human cells and organs (chung CP et al 2005).

The pumping action of the heart usually maintains a balance between cardiac output and venous return. Cardiac output (CO) is the amount of blood pumped out by each ventricle in one minute. The normal adult blood volume is 5 liters (a little over 1 gallon) and it usually passes through the heart once a minute. Note that cardiac output varies with the demands of the body (husmann et al 2008).

The cardiac cycle refers to events that occur during one heart beat and is split into ventricular systole (contraction/ejection phase) and diastole (relaxation/filling phase). A normal heart rate is approximately 72 beats/minute, and the cardiac cycle spreads over 0.8 seconds. The heart sounds transmitted are due to closing of heart valves, and abnormal heart sounds, called murmurs, usually represent valve incompetency or abnormalities (husmann et al 2008).

Blood is transported through the whole body by a continuum of blood vessels. Arteries are blood vessels that transport blood away from the heart, and veins transport the blood back to the heart. Capillaries carry blood to tissue cells and are the exchange sites of nutrients, gases, wastes, etc (husmann et al 2008).

2.1.1Heart

The heart is a muscular organ weighing between 250-350 grams located obliquely in the mediastinum. It functions as a pump supplying blood to the body and accepting it in return for transmission to the pulmonary circuit for gas exchange.

The heart contains 4 chambers that essentially make up 2 sides of 2 chamber (atrium and ventricle) circuits; the left side chambers supply the systemic circulation, and the right side chambers supply the pulmonary circulation. The chambers of each side are separated by an atrioventricular valve (A-V valve). The left-sided chambers are separated by the mitral (bicuspid) valve, and right-sided chambers are divided by the tricuspid valve. Blood flows through the heart in only one direction enforced by a valvular system that regulates opening and closure of valves based on pressure gradients (choen R et al 2014).

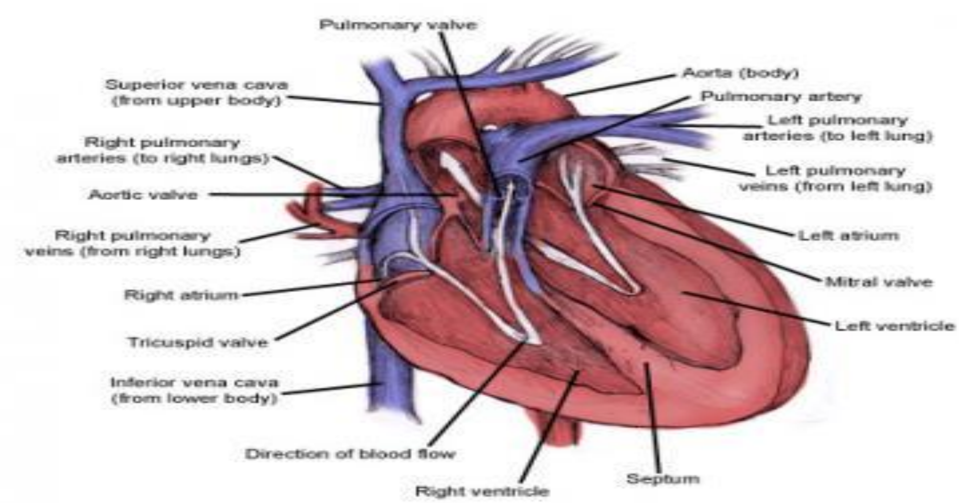

Figure (2.1). Heart anatomy (husmann et al 2008).

2.1.2 Unique properties of cardiac muscle

Cardiac muscle cells are branching striated, uninucleate (single nucleus) cells that contain myofibrils , Adjacent cardiac cells are connected by intercalated discs containing desmosomes and gap junctions. The myocardium behaves as a functional syncytium because of electrical coupling action provided by gap junctions.

Cardiac muscle has abundant mitochondria that depend on aerobic respiration primarily to generate adenosine tri-phosphate (ATP), the molecule that provides energy for cellular function (choen R et al 2014).

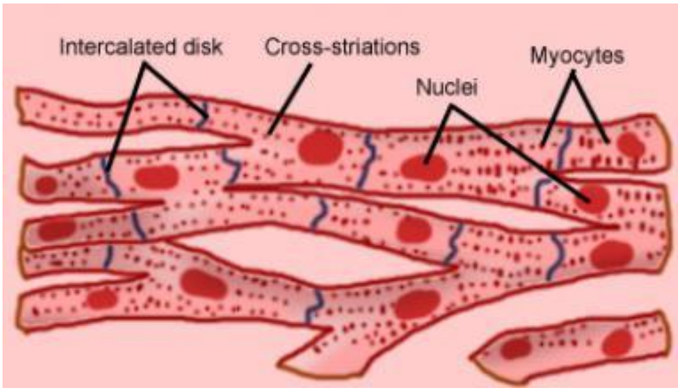

Figure (2.2). Cardiac muscle cells.

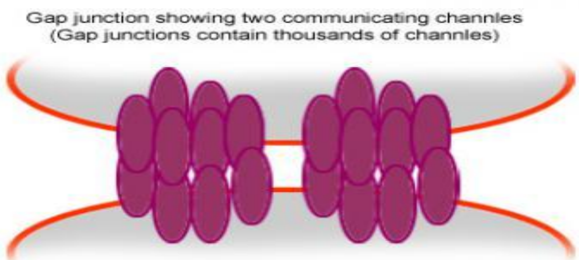

Figure (2.3). Myocardial gap junctions (husmann et al 2008).

2.1.3 Systemic Circulation

The systemic circuit originates in the left side of the heart and functions by receiving oxygen-laden blood into the left atrium from the lungs and flows one way down into the left ventricle via the mitral valve. From the left ventricle, oxygen rich blood is pumped to all organs of the human body through the aortic semilunar valve (choen R et al 2014).

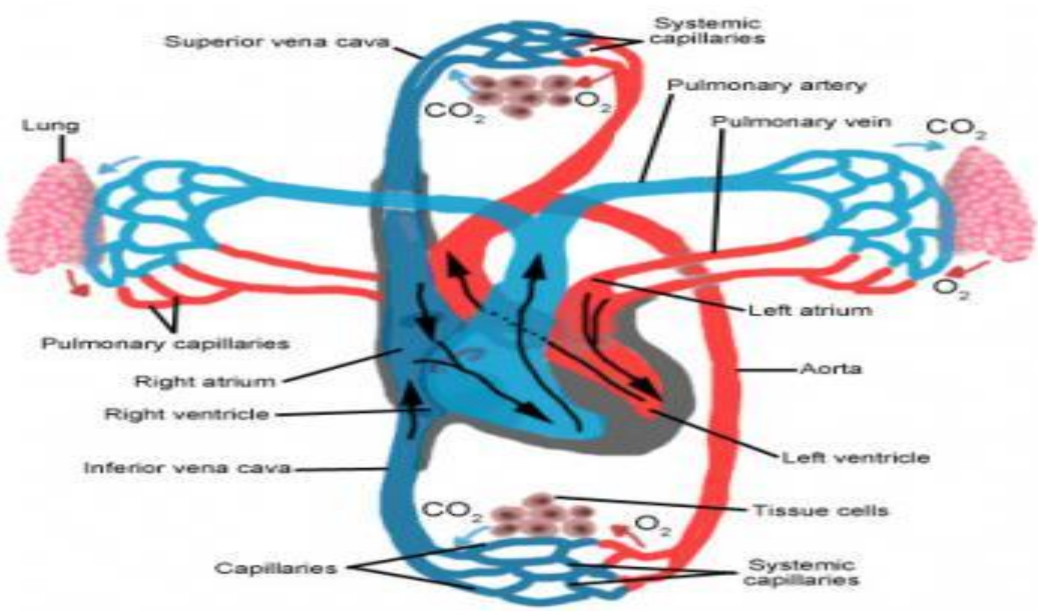

Figure (2.4). Systemic and Pulmonary Circulation

2.1.3.1 Pulmonary Circulation: The pulmonary circuit is on the right side of the heart and serves the function of gas exchange. Oxygen-poor systemic blood reaches the right atrium via 3 major venous structures: the superior vena cava, inferior vena cava, and coronary sinus (choen R et al 2014).

This blood is pumped down to the right ventricle via the tricuspid valve and eventually through the pulmonic valve, leading to the pulmonary trunk that takes the oxygen deprived blood to the lungs for gas exchange. Once gas exchange occurs in the lung tissue, the oxygen-laden blood is carried to the left atrium via the pulmonary veins, hence completing the pulmonary circuit.

2.1.5 Coronary Circulation

Coronary circulation is the circulation to the heart organ itself. The right and left coronary arteries branch from the ascending aorta and, through their branches (anterior and posterior interventricular, marginal and circumflex arteries), supply the heart muscle (myocardial) tissue. Venous blood collected by the cardiac veins (great, middle, small, and anterior) flows into the coronary sinus. Delivery of oxygen-rich blood to the myocardial tissue occurs during the heart relaxation phase (choen R et al 2014).

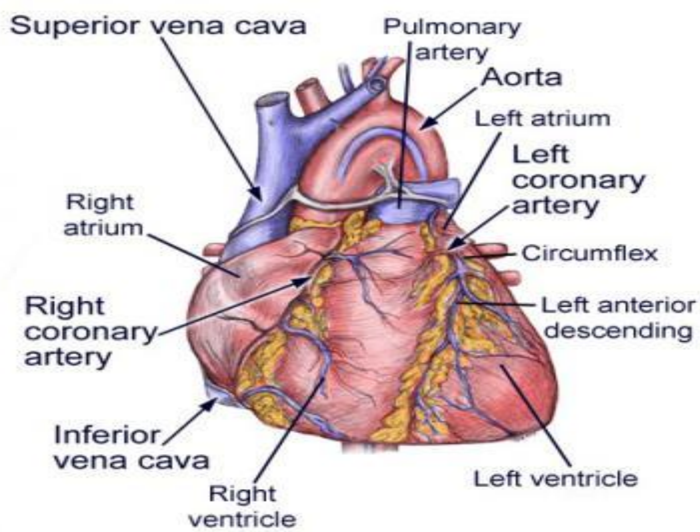

Figure (2.5) Coronary Circulation (choen R et al 2014).

2.1.6 Vessel Anatomy

An artery is a blood vessel that carries blood away from the heart to peripheral organs. They are subdivided into larger conducting arteries, smaller distributing arteries, and the smallest arteries, known as arterioles, that supply the capillary bed (the site of active tissue cells gas exchange).

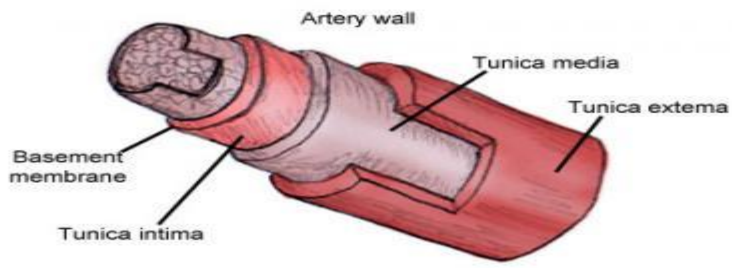

Figure (2.6) Arterial Cross-section (choen R et al 2014).

Capillaries are vessels that are microscopic in size and provide a site of gas, ion, nutrient, and cellular exchange between blood and interstitial fluid. They have fenestrations that allow for and enhance permeability for exchange of gas, ion, nutrient, and cellular elements (choen R et al 2014).

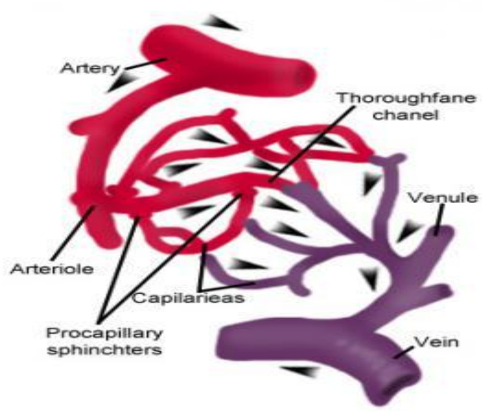

Figure (2-7). Capillary structure.

A vein is a blood vessel that has a larger lumen, and sometimes veins serve as blood reservoirs or capacitance vessels, containing valves that prevent backflow. This system of vessels in general returns blood to the heart from the periphery.

Figure (2.8). Veins: Blood Flow and Valve Structure (choen R et al 2014).

Natural Variants : Congenital heart anomaliescongenital heart defects cause structural problems of the heart and lead to abnormal or incomplete development of its major chambers and valves, resulting in poor flow and circulation.

Atrial septal defect is a hole in the wall between the right and left atria that promotes mixing of oxygenated and unoxygenated blood (choen R et al 2014).

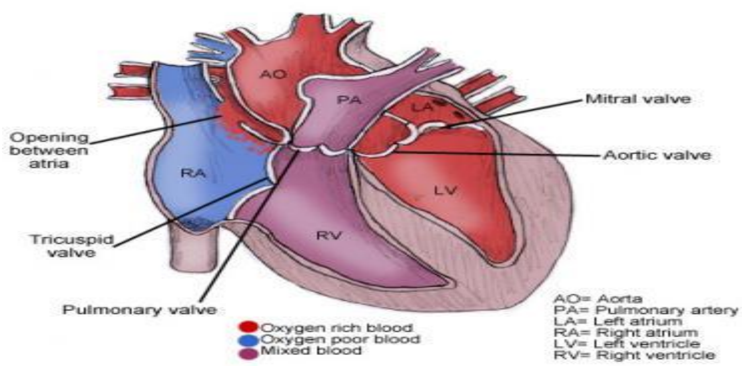

Figure (2.9) Atrial Septal Defect (choen R et al 2014).

Coarctation of the aorta is a narrowing of the aorta that causes the heart to need to pump harder to force blood through the narrow part of the aorta . Hypo plastic left heart syndrome is when the left side of the heart does not develop completely, leading to a defective and underdeveloped left ventricle, mitral valve, aortic valve, and aorta (Huxley RR et al , 2011).

Atrioventricular canal defect is also known as a endocardial cushion defect and occurs when a hole exists between the chambers of the heart and irregularities with the valves of the heart exist; hence, defects in flow and blood circulation.

Ventricular septal defect is a hole in the septal wall between the right and left ventricles that contributes to the mixing of oxygenated and unoxygenated blood.

Patent ductus arteriosus is a defect in which the connection between the aorta and the pulmonary trunk remains open. Tetralogy of Fallot is a rare and very serious congenital heart defect involving the heart that includes a stenotic pulmonary valve, an aorta that arises from both ventricles, an interventricular septal opening (ie, ventricular septal defect), and enlarged right ventricle. Babies born with this defect are cyanotic within minutes of birth and require immediate surgical repair.

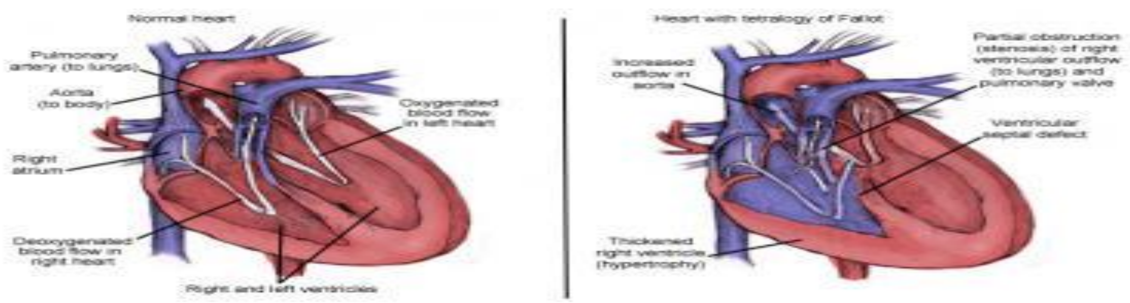

Figure (2.10)Tetralogy of Fallot (Huxley RR et al , 2011).

2.2Pathophysiological Variants

2.2.1Congestive Heart Failure

This is a clinical syndrome that results from the inability of the heart to pump effectively to achieve the cardiac output capable of supplying sufficient oxygen to the peripheral organs for basic metabolic function as well as metabolic demand. Heart failure may be further classified into right ventricular failure, left ventricular failure, or biventricular failure.

2.2.2 Cardiomyopathy

2.2.2.1Dilated cardiomyopathy (congestive)

The main characteristic of this condition is a decreased heart contractile function with biventricular dilatation.

The causes may be idiopathic, inflammatory-infectious etiology that may have been caused by postviral myocarditis (coxsackie B or Echo virus), noninfectious etiologies (collagen vascular disease [Lupus, rheumatoid arthritis, polyarteritis]), peripartum, or sarcoidosis (Aeboah , et al 2014).

Toxin induced Alcohol, chemotherapy agents such as doxorubicin and Adriamycin, drugs such as cocaine, heroin, or organic solvents can cause cardiomyopathy (Huxley RR et al , 2011).

2.2.2.3 Metabolic reasons

Metabolic reasons include hypothyroidism, chronic hypocalcaemia, or hypophosphatemia.

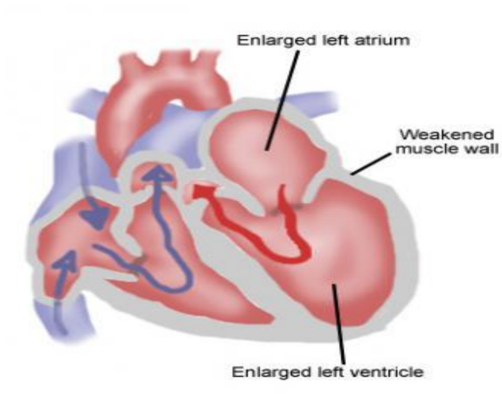

Figure (2.11). Dilated Cardiomyopathy (Huxley RR et al , 2011).

2.2.3 Hypertrophic cardiomyopathy

This condition is caused by a familial autosomal dominant trait resulting in marked hypertrophy of the myocardium and a disproportionate greater thickening of the interventricular septum. This hypertrophied septum can cause narrowing of the sub aortic area due to its opposition to the anterior mitral leaflet resulting in left ventricular outflow obstruction during mid-systole (Aeboah , et al 2014).

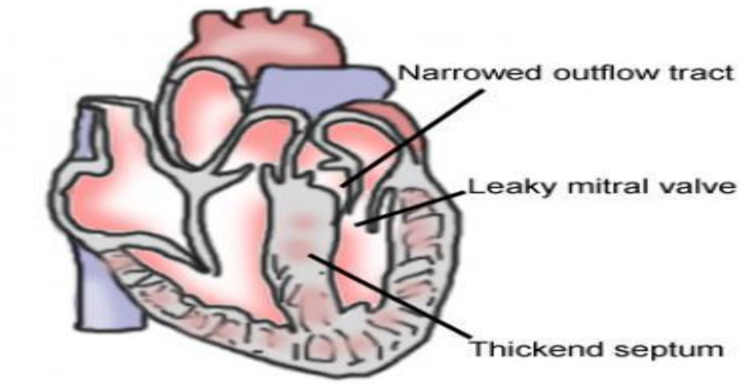

Figure (2.12). Hypertrophic Cardiomyopathy (Aeboah , et al 2014)

2.2.3.1Restrictive cardiomyopathy

This is characterized by abnormally rigid ventricles that impair diastolic heart filling but the heart retains a normal size and a normal systolic function. A reduced ventricular compliance due to fibrosis or infiltration results in an abnormal high diastolic pressure leading to high systemic and pulmonary venous pressures (Aeboah , et al 2014).

2.2.3.2 Myocardial fibrosis

Myocardial fibrosis is caused by scarring or infiltration caused by amyloidosis or sarcoidosis; non infiltrative myocardial fibrosis is caused by scleroderma. Other storage diseases such as glycogen storage disease or hemochromatosis may cause this condition (Aeboah , et al 2014).

2.2.3.3Endomyocardial fibrosis

Endomyocardial fibrosis is caused by scarring or infiltration caused by hypereosinophilic syndrome and radiation therapy; metastatic tumors may also be considered as other etiologies (Aeboah , et al 2014).

2.2.3.4Rheumatic heart disease

Rheumatic heart disease is a serious complication of rheumatic fever. Acute rheumatic fever follows 0.3% of cases of group-A beta-hemolytic streptococcal pharyngitis (a throat infection) in children. Patients with acute rheumatic fever may develop varying degrees of associated valve insufficiency, heart failure, pericarditis, and even death. With chronic rheumatic heart disease, patients develop valve stenosis with varying degrees of regurgitation, atrial dilation, arrhythmias, and ventricular dysfunction. Chronic rheumatic heart disease remains the leading cause of mitral valve stenosis and valve replacement in adults in the United States.

Acute rheumatic fever and rheumatic heart disease are thought to result from an autoimmune response, but the exact pathogenesis remains unclear (Manzi S et al , 1997).

2.2.4 Valve conditions

Alterations in the normal functioning of heart valves lead to alterations in the normal cardiovascular physiology. A valve defect may be stenotic or regurgitant. When it is stenotic it represents a valvular opening that is narrowed, thus restricting blood flow through the valve. A regurgitant valve is usually incompetent resulting in back flow through a partially open valve. The atrioventricular valves, mitral valve, and tricuspid valve, prevent backflow into the atria when the ventricles are contracting. The pulmonary and aortic semilunar valves prevent backflow into the ventricles during the relaxation phase (Aeboah , et al 2014).

2.2.4.1. Mitral stenosis

Mitral stenosis is usually a consequence of rheumatic heart disease. Approximately 50% of those with mitral stenosis usually have a history of rheumatic fever. This can be distinguished by a murmur that is localized near the apex of the heart.

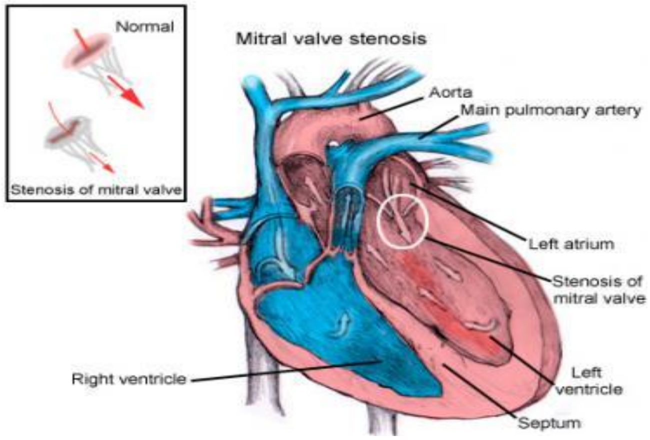

Figure (2.13)Mitral Valve Stenosis (Manzi S et al , 2003).

2.2.4.2. Mitral regurgitation

Mitral regurgitation may result from rheumatic heart disease, mitral prolapse, or ruptured chordae tendineae or papillary muscle dysfunction after a myocardial infarction (Manzi S et al , 1997).

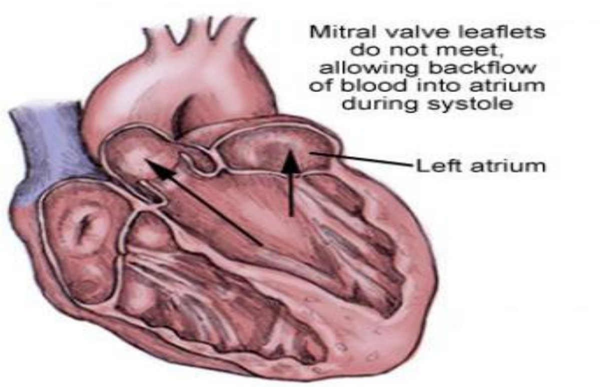

Figure (2.14). Mitral Regurgitation. (Manzi S et al , 2003).

Aortic stenosis : This condition may result from congenital lesions, such as bicuspid aortic valve, rheumatic heart disease, and calcified aortic valve. This can be distinguished by a systolic ejection murmur.

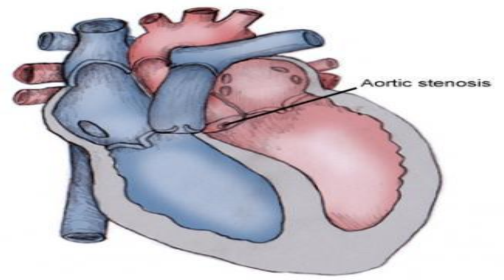

Figure (2.15) Aortic Stenosis (Manzi S et al , 2003).

2.2.4.4. Aortic regurgitation

This condition may be a result of rheumatic heart disease, endocarditis, valvular congenital structural heart defects, syphilis or aneurysms. Aortic valve defects may be seen clinically presenting with signs or symptoms of congestive heart failure, angina, syncope or decreases in exercise tolerance.

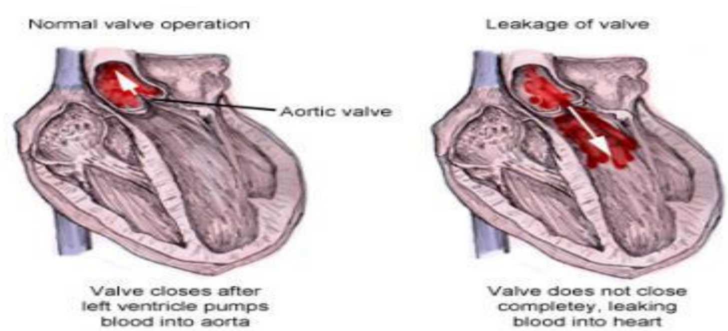

Figure (2.16)Aortic Regurgitation (Larosa JC , et al 2005)

2.2.4.5. Pericarditis

The heart is surrounded by a sack of tissue known as the pericardium that functions as a protective layer to the heart and also reduces friction with adjacent organs.

Inflammation of this layer is known as pericarditis. The clinical manifestations of acute pericarditis are due to the inflammation of the pericardium; treatment is targeted with anti-inflammatories such as aspirin or NSAIDs, while the clinical manifestations of chronic pericarditis are usually due to the constriction of pericardium around the myocardium. Because the right ventricle operates under lower pressures than the left ventricle, the right ventricle is primarily affected by the constricted pericardium. Constrictive pericarditis usually presents with right-sided symptoms because the right ventricle does not fill with normal capacity due to the anatomic bottleneck caused by the constricted pericardium, hence causing venous congestion, preload reduction, and a reduction in cardiac output.

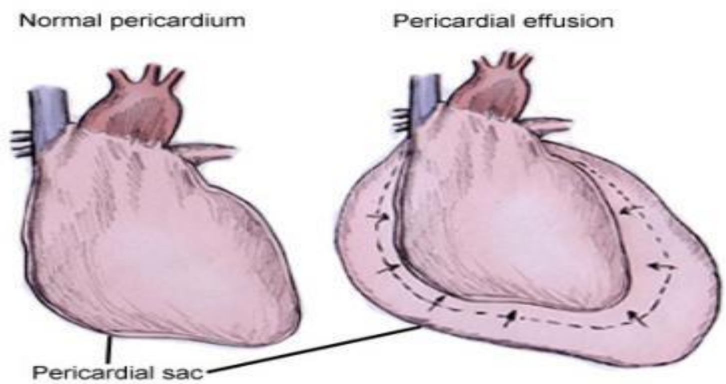

Figure (2.17). Pericardial Effusion (Larosa JC , et al 2005)

2.2.4.6. Systemic Hypertension

Blood pressure is influenced by cardiac output, peripheral resistance of vessels, and blood volume. Vessel diameter is the most important of these factors, and small changes in vessel diameter significantly affect blood pressure. Blood pressure varies directly with both cardiac output and blood volume; it varies inversely with vessel diameter. Blood pressure is regulated by autonomic neural reflexes involving baroreceptors, chemoreceptors, the vasomotor center, and vasomotor fibers acting on vascular smooth muscle inputs from higher central nervous system centers, chemicals such as hormones and renal compensatory pathways. Blood pressure above the normal ranges of 120 mmHg systolic and 80 mmHg diastolic are considered prehypertensive (120-139/80-89) mmHg. Stage 1 hypertension is defined as blood pressure of 140-159/90-99 mmHg. Stage 2 hypertension is defined as blood pressure greater than 160/greater than 100 mmHg. The most common type of hypertension isessentialhypertension ,for which the cause is unknown. This accounts for up to 98% of patients. The remaining 2% have secondary causes, such as renal disease, pheochromocytoma, mineralocorticoid excess, aortic coarctation, or pre-eclampsia during pregnancy. Malignant hypertension is when the blood pressure is greater than 200 systolic and 140 diastolic with evidence of papilledema. This is a medical emergency, and the blood pressure must be controlled adequately and promptly (Rixe J , et al 2009).

2.2.5. Other Common Abnormal Cardiovascular Conditions

2.2.5.1. Angina pectoris

This is the clinical syndrome that occurs when heart oxygen demand exceeds blood supply resulting in pain or discomfort in the chest and adjacent areas. Angina may be classified as stable or unstable. This condition may result from myocardial ischemia that is a result of a reduction in coronary blood flow caused by a fixed or dynamic coronary artery blockage, an abnormal constriction or decreased relaxation of the coronary microcirculation, or a reduction in the oxygen-carrying capacity of the blood (Larosa JC , et al 2005).

2.2.5.2 Myocardial infarction

Myocardial infarction is a condition in which the heart muscle is damaged due to lack of blood supply or ischemia in the coronary vessels and, thus, the heart is unable to pump blood effectively to the peripheral organs. Atherosclerosis is the most common cause of coronary artery stenosis resulting in myocardial ischemia.

The infarction area or area of ischemia is isolated to the muscular area of blood supply resulting in poor or lack of function of that regional area of heart muscle. For example, a blockage in the left circumflex artery may result in damage to the left ventricular muscle; likewise, a right coronary artery defect or ischemia may result in right heart ventricular dysfunction. See the image below and the area of heart blood supply versus regional infarcted area (Rixe J , et al 2009).

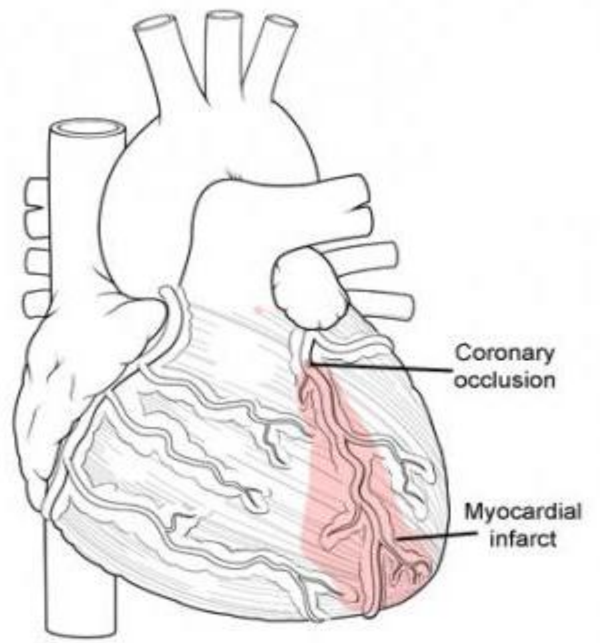

Figure (2.18). Myocardial Infarction and Regional Affected Cardiac Area (Larosa JC , et al 2005).

2.2.5.3.Cardiac CT Angiography

Contrast-enhanced cardiac CT angiography (CTA) involves the use of multi-slice CT and intravenously administered contrast material to obtain detailed images of the blood vessels of the heart. It has been used as an alternative to conventional invasive coronary angiography for evaluating coronary artery disease and coronary artery anomalies , The performance of cardiac CTA has been improved by increasing the number of slices that can be acquired simultaneously by increasing the number of detector rows (AHTA, 2006). As the number of slices that can be acquired simultaneously increases, the scanning time is shortened and the spatial resolution is increased. Initial cardiac CT imaging was conducted with 4-slice detector CT. Scanning times were reduced from 40 seconds down to 20 seconds with 16-slice detector CT and with the advent of 64-slice detector CT, scanning times have been reduced to a 10 second breath-hold (Larosa JC , et al 2005).

Cardiac CTA using 64-slices has been shown in studies to have a high negative predictive value (93 to 100 %), using conventional coronary angiography as the reference standard. Given its high negative predictive value, cardiac CTA has been shown to be most useful for evaluating persons at low to intermediate risk of coronary artery disease. This would include evaluation of asymptomatic low- to intermediate-risk persons with an equivocal exercise or pharmacologic stress test, and evaluation of low- to intermediate-risk persons with chest pain who have a contraindication to exercise and pharmacological stress testing. Cardiac CTA is also a useful alternative to invasive coronary angiography for pre-operative evaluation of persons undergoing non-coronary cardiac surgery or high-risk noncardiac surgery, where invasive coronary angiography would otherwise be indicated , Substantial controversy over the appropriate indications for cardiac CTA is due, in part, to the relatively poor quality of available evidence (Rixe J , et al 2009).

The net re-classification improvement resulting from the addition of CCTA to a model based on standard risk factors and CACS was negligible. The authors concluded that although the prognosis for individuals without CPS is stratified by CCTA, the additional risk-predictive advantage by CCTA is not clinically meaningful compared with a risk model based on CACS. Therefore, at present, the application of CCTA for risk assessment of individuals without CPS should not be justified (Larosa JC , et al 2005).

The American College of Radiology Expert Panel on Cardiac Imaging's clinical guideline on "Chronic chest pain - low to intermediate probability of coronary artery disease" (Woodard et al, 2012) rendered a "3" rating for CT coronary calcium (a "3" rating denotes the procedure is usually not appropriate).

Table (2.1) can be used to assess if a person has a low or very low pre-test probability of CAD. Alternatively, pre-test probability of CAD can be assessed using the Framingham Risk Scoring Tool available at the following website, with low risk defined as a 10-year risk of less than 10 % , No data exist for patients less than 30 years or greater than 69 years, but it can be assumed that prevalence of CAD increases with age. In a few cases, patients with ages at the extremes of the decades listed may have probabilities slightly outside the high or low range (Hendel et al, 2006.).

2.3. Typical angina (definite):

Substernal chest discomfort with a characteristic quality and duration that is provoked by exertion or emotional stress and relieved by rest ornitroglycerin.

2.3.1.Atypical angina (probable):

Meets 2 of the above criteria.

2.3.2Non-cardiac chest pain:

Meets 1 or none of the above criteria ***(Snow et al, 2004)*** , In addition, exercise stress testing is not useful in persons who are unable to exercise, persons on digoxin, persons who have a cardiac conduction abnormality that prevents achievement of an adequate heart rate response, persons on a medication (e.g., beta blockers, other negative chronotropic agents) that can not be stopped which prevent achievement of an adequate heart rate response, and persons with an uninterpretable electrocardiogram. The American College of Cardiology defines an uninterpretable electrocardiogram as a ventricular paced rhythm, complete left bundle branch block, ventricular preexcitation arrhythmia (Wolfe Parkinson White syndrome), or greater than 1 mm ST segment depression at rest (Woodard et al, 2012).

The following are contraindications to adenosine or dipyridamole (Persantine) stress testing:

Active bronchospasm or reactive airway disease , Patients taking Persantine (contraindication to adenosine stress testing) , Patients using methylxanthines (e.g., caffeine and aminophylline) (In general, patients should refrain from ingesting caffeine for at least 24 hours prior to adenosineor dipyridamole administration),

Coronary computed tomography angiography (CCTA) has recently emerged as an effective noninvasive method to image the coronary arteries. The purpose of this article is to provide an overview of clinical applications, technology, anatomy, and interpretation, and it includes material of interest to radiologists, cardiologists, physicians in training, and referring physicians. Physicians interpreting CCTA studies should be aware of the American College of Cardiologyand American College of Radiologyguidelines for training (Choen R , et al 2014).

2.4. Clinical Applications: Coronary Artery Disease

2.4.1 Calcium score

Calcium scoring and coronary CT angiography (CCTA) have different clinical indications. Calcium scoring is primarily used for risk stratification of asymptomatic patients, while CCTA is primarily used in patients with acute or chronic chest pain. One potential use of performing a nonenhanced calcium scoring study before a CCTA is to decide whether to proceed with CCTA in patients with extensive coronary calcium. There is no established calcium score cutoff value above which CCTA will not be diagnostic, but a score of 1000 is often used (Woodard et al, 2012).

In the multicenter Assessment by Coronary Computed Tomographic Angiography of Individuals Undergoing Invasive Coronary Angiography (ACCURACY) trialthe specificity of CCTA was significantly reduced (from 86% to 53%) in patients with calcium scores greater than 400. However, in a meta-analysis of 51 studiespublished in 2012, the accuracy of CCTA for significant stenoses was high, even in cases of severe coronary calcification, as long as 64-slice or new CT systems were used (Choen R , et al 2014).

In symptomatic patients with low-to-intermediate pretest probability of coronary artery disease (CAD) (the categories for which coronary CT angiography [CTA[has been endorsed), a negative coronary CTA shows a very high negative predictive value, independent of the coronary calcium score. In addition, the calcium score does not influence the result of the CCTA when it is considered positive for obstructive CAD (Woodard et al, 2012).

2.4.2. Coronary CTA

Figure (2.19) CT angiography and catheterization ***Multiplanar reconstruction (MPR) CT image (A) demonstrates a severe proximal left anterior descending (LAD) artery stenosis (arrow), also demonstrated on cardiac catheterization (B) (arrow). Injection of the LAD after angioplasty and stenting (C) demonstrates no residual stenosis*** (Woodard et al, 2012)**.**

2.4.3. Indications

A ***(2008 scientific statement from the American Heart Association (AHA))***indicates that the potential benefit of noninvasive coronary angiography is likely to be the greatest for symptomatic patients who are at intermediate risk for coronary artery disease (CAD) after initial risk stratification, including patients with equivocal stress tests. CCTA is recommended over coronary magnetic resonance angiography (MRA) because of superior diagnostic accuracy.

Neither coronary CTA nor MR angiography (MRA) is recommended to screen for CAD in patients who have no signs or symptoms suggestive of CAD. In 7590 individuals without chest pain syndrome or history of CAD in the CONFIRM registry, the additional risk-predictive advantage of CCTA was not clinically meaningful compared with a risk model based on coronary calcium score alone.

Results from the multicenter CONFIRM registry support that CCTA can be used effectively as a gatekeeper to invasive coronary angiography.

Appropriateness criteria were published in 2010 from the combined efforts of 9 specialty societies.The following indications (Woodard et al, 2012).

2.4.4. Emergency department use

In a multicenter trialof 1000 patients presenting to the emergency department (ED) with symptoms suggestive of acute coronary syndromes, incorporation of CCTA into the triage strategy improved the efficiency of clinical decision making (significantly higher rates of discharge from the ED and reduced mean length of hospital stay) compared with standard evaluation. However, incorporation of CCTA resulted in an increase in downstream testing and radiation exposure with no decrease in overall costs of care. In a meta-analysis of 4 randomized controlled trials,the use of CCTA in the ED was associated with decreased ED cost and length of stay but a 2% increase in invasive coronary angiography and revascularization (whether the increased rate of invasive procedures leads to improved patient outcomes is unknown) (Choen R , et al 2014).

2.4.5. Cost-effectiveness

Data as to the cost-effectiveness of CCTA are limited. Two analysesand one multicenter trialsuggest that CCTA may be a more cost-effective alternative to myocardial perfusion scintigraphy. CCTA may be a cost-effective method of avoiding unnecessary conventional coronary angiography in patients with a pretest probability of disease 50% or lower (Choen R , et al 2014).

2.4.6. Accuracy

The majority of studies (with the exception of the Coronary Evaluation Using Multidetector Spiral Computed Tomography Angiography using 64 Detectors [CORE 64] study) indicate that a negative CCTA can effectively rule out (Choen R , et al 2014).

obstructive coronary artery disease. In a 2008 meta-analysis,64-slice CCTA had a sensitivity of 99% and negative predictive value (NPV) of 100% for patient-based detection of significant CAD. However the specificity has been lower than the sensitivity in most studies, and false-positive results are possible, particularly in patients with high calcium scores (Johnson TR , et al 2007).

In the ACCURACY prospective multicenter trial of patients with chest pain without known CAD and intermediate disease prevalence, 64-slice CCTA had a patient-based sensitivity of 94% and a specificity of 83% in detecting stenosis of

70% or greater (comparable values were seen at a 50% stenosis level). Patients with high calcium scores were not excluded from the study. Calcium scores greater than 400 reduced specificity significantly. The NPV of CCTA was 99% , In the CORE 64 prospective multicenter trial of patients with suspected symptomatic CAD referred for conventional coronary angiography, 64-slice CCTA had a patient–based sensitivity of 85% and specificity of 90% (excluding patients with a calcium score greater than 600) for detecting stenoses 50% or greater. However, the NPV of 83% in this study was lower than in other studies , In a 2008 meta-analysis, the sensitivity was highest in the left main artery and lowest (85%) in the circumflex artery (Johnson TR , et al 2007).

The ACCURACY trial suggested that, compared with other noninvasive modalities such as stress echocardiography and stress nuclear testing, CCTA has comparable specificity but superior sensitivity and NPV (Johnson TR , et al 2007).

2.5. Clinical Applications: Coronary Artery Stents

2.5.1. Indications

In appropriateness criteria published in 2010 from 9 specialty societies,the use of coronary CT angiography (CCTA) in patients with a history of percutaneous revascularization with stents greater than or equal to 3 mm and chest pain syndrome was rated as uncertain, and it was rated as appropriate in asymptomatic patients. A ***2010 consensus statementstates*** that in patients known to have larger stents and whose clinical presentation suggests low-to-intermediate probability for restenosis, 64-slice CCTA may be a reasonable alternative to invasive angiography to rule out significant in-stent restenosis.

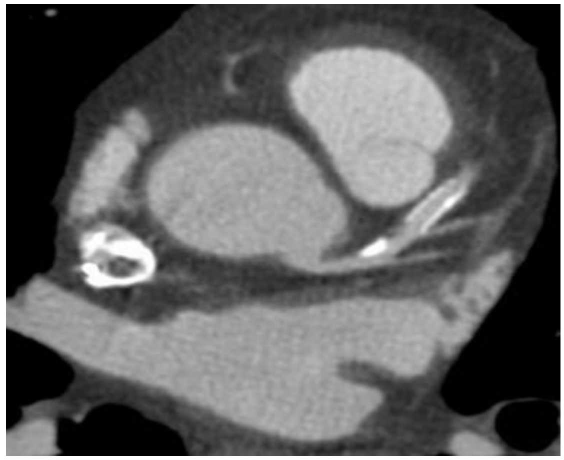

Figure (2.20) Coronary artery stent

Axial CT image demonstrates a left anterior descending (LAD) artery stent. The stent lumen is well-visualized in this case (Johnson TR , et al 2007).

2.5.2 Accuracy

Visualization of the stent lumen by CCTA is variable.

In a meta-analysis, the sensitivity and specificity of 64-slice CCTA for the detection of coronary in-stent restenosis (>50%) were 90% and 91%, respectively, not including nonassessable stents; 89% of stents were assessable.

Stent size and material can affect evaluability by CCTA. Stents under 3 mm are often nonassessable.Magnesium is the most favorable stent material for imaging.Stainless-steel and cobalt stents are also favorable.Other factors that can potentially limit stent evaluability include overlapping positioning, strut thickness, and large patient size (Johnson TR , et al 2007).

2.6. Clinical Applications: Coronary Bypass Grafts

2.6.1. Indications

According to appropriateness criteria published in 2010 from 9 specialty societies, the use of coronary CT angiography (CCTA) in patients to evaluate bypass graft patency in patients with chest pain syndrome was rated as appropriate, and it was rated as inappropriate in asymptomatic patients less than 5 years after surgery, and it was rated uncertain in asymptomatic patients more than 5 years after surgery (Johnson TR , et al 2007).

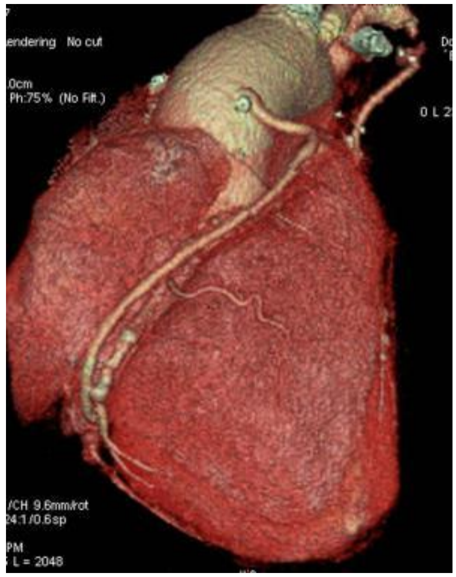

Figure (2.21) Saphenous vein graft

Volume-rendered CT image of a saphenous vein graft to the right coronary artery (Johnson TR , et al 2007).

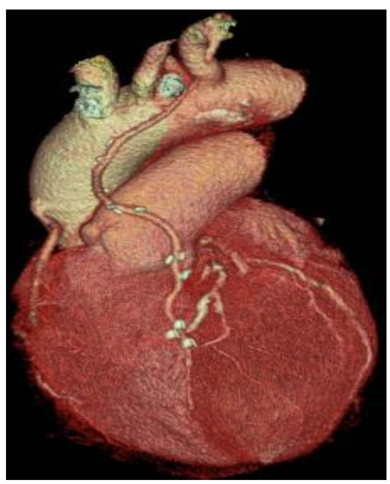

Figure (2.22) Left internal mammary artery (LIMA) graft

Volume-rendered CT image of a LIMA to left anterior descending (LAD) artery graft(Johnson TR , et al 2007).

In a ***2007 consensus statement*** from the Society of Cardiovascular Computed Tomography and the North American Society for Cardiac Imaging, stress nuclear testing or echocardiography was suggested as the first method of evaluation rather than CCTA, as the question of graft patency is not as important as the functional significance of the grafts and bypass vessels. CCTA was suggested for reoperation bypass mapping of the previous bypass grafts, the setting of aortic dissection, difficult catheterization, or high risk of catheterization (eg, Marfan syndrome).

2.6.2. Accuracy

Bypass grafts are well visualized by CCTA. In a meta-analysis,16- and 64-slice CCTA had a sensitivity of 98% and specificity of 97% for coronary artery bypass graft stenosis or occlusion; 92% of bypass grafts were evaluable. However, the accuracy for evaluating the coronary artery bypass graft (CABG) anastomosesis less than that for other CABG segments (Johnson TR , et al 2007).

2.6.3. Imaging pearls

See the list below:

Artifact from surgical clips can limit graft evaluation by CCTA. The distal anastomosis in particular can be difficult to assess due to motion and/or clip artifacts , The most challenging aspect of CCTA in post-CABG patients is often evaluation of the native vessels. In one study, 29% of native vessel segments could not be evaluated in CABG patients.

Proximity of the graft(s) to the sternum should be described to avoid damage during a redo sternotomy. If the graft abuts the sternum, the position of the graft relative to the sternal notch should be reported , In patients with internal mammary grafts, the scan should extend superiorly to the level of the clavicle so that subclavian stenosis can be ruled out (Johnson TR , et al 2007).

2.6.4. Recent Technology

A full discussion of multidetector CT technology is beyond the scope of this article, but is well addressed in other literature.The 2 major recent advancements in multidetector CT technology are dual-source 64-slice CT and single-source 256- and 320-slice CT. Both of these techniques offer the possibility of reduced radiation dose compared with single-source 64-slice CT. Dual-source CT allows coronary CT angiography (CCTA) to be performed at higher heart rates. Currently, there is little published literature on 256- or 320-slice CCTA (Johnson TR , et al 2007).

2.6.5. Dual-source CT

The primary advantage of dual-source CT is greater temporal resolution.

A dual-source CT contains 2 tube/detector sets, arranged at 90º angles to each other. In CCTA, the data are typically reconstructed from a 180º rotation (partial scan reconstruction) to maximize temporal resolution. If the gantry rotation time is 330 msec, a single-source CT performing CCTA with partial scan reconstruction has a temporal resolution of 165 msec. With 2 tubes, only a quarter rotation is needed for data collection, and the temporal resolution is 83 msec (Ropers D et al, 2006) , The higher temporal resolution of dual-source CT allows CCTA to be performed at higher heart rates without the use of beta blockers , Although the tube current is doubled with 2 tubes, the scan time is halved, and the tube current-time product (mAs) is unchanged as compared with single-source CT.However, radiation dose can usually be lower than that with single-source CT. Because of higher temporal resolution, the pitch can be increased at higher heart rates, which will decrease dose (see Radiation Dose). In addition, other dose-reduction techniques, such as ECG-dependent tube current modulation and prospectively triggered sequential scanning (see Radiation Dose), can be optimally used with the increased temporal resolution of a dual-source scanner , In addition, simultaneous data acquisition can be performed with the tubes operating at different voltages (80 kV and 140 kV).This offers the possibility of improved tissue differentiation, but it is unclear what impact this will have on CCTA (Ropers D et al, 2006).

In a meta-analysis of 25 studies,dual-source CT had a per-patient sensitivity of 99% and specificity of 89%. Accuracy remained high in a systematic review of the use of dual-source CT in difficult-to-image patient groups (Ropers D et al, 2006).

2.6.6. 256-slice CT and 320-slice CT

The primary advantage of 256- and 320-slice CT is the increased craniocaudal coverage , The 256- and 320-slice CT scanners have a craniocaudal coverage of approximately 12 and 16 cm, respectively. This potentially allows the heart to be scanned in one tube rotation and one heartbeat, without table movement. This technique is ideal for the prospectively triggered sequential scan technique,which substantially reduces radiation dose compared with retrospectively gated helical techniques. If the prospectively triggered technique is used, heart rate control is useful, as a slower heart rate allows a narrower phase window to be used,further decreasing radiation dose. Another advantage is that if the data can be acquired in one heartbeat, phase misregistration artifacts arising from irregular heartbeats are not an issue , In a comparison of prospectively gated 64- and 256-slice CT, 256-slice CT provided significantly improved and more stable image quality compared with 64-slice CT, at equivalent effective radiation dose (Ropers D et al, 2006).

2.6.7. Radiation Dose

Attention has been drawn to the risk of cancer from computed tomography. In these discussions, coronary CT angiography (CCTA) is often cited for its high radiation dose. For example, in a review by ***(Smith-Bindman et al,)***it was estimated that 1 in 270 women, and 1 in 600 men, who underwent CCTA at age 40 would develop cancer from that scan. However, these figures do not take into account recent technological developments that can greatly decrease the radiation dose from CCTA (Ropers D et al, 2006).

There are several things that are important to note. First, the radiation dose from CCTA is highly variable and is largely dependent upon the specific equipment and techniques used. For example, one study suggests that use of a prospectively triggered technique reduced the risk of cancer by 87%, compared to a retrospectively gated technique.Therefore, it is very important for the practitioner to understand ways of reducing the radiation dose to the patient. Other examinations that might be used instead of CCTA, such as cardiac nuclear medicine studies, have relatively high radiation doses. In addition, noninvasive examinations such as CCTA have the potential to reduce the use of coronary catheterization, which is invasive and involves relatively high radiation doses. In a study of 398,978 patients who underwent elective coronary catheterization,only 37.6% had obstructive coronary disease (Ropers D et al, 2006).

Examinations that do not utilize ionizing radiation, such as stress echocardiography, could also be considered. A decision analytic model suggests that stress echocardiography followed by CCTA if needed is most appropriate for evaluation of patients with a pretest probability for coronary artery disease of less than 20%, while CCTA alone is more appropriate for intermediate-risk patients.

Radiation doses for CCTA studies, if performed with retrospective gating in helical mode, are typically relatively high. Radiation doses are high because data are acquired throughout the cardiac cycle, and with the fast gantry rotation required for high temporal resolution in CCTA, a low pitch (table travel per gantry rotation/collimation) is required in order to avoid gaps in the data. If data are acquired throughout the cardiac cycle, the table should not move more than the beam width during one cardiac cycle. In particular, slow movement is required with fast gantry rotation; otherwise, all phases of the heart at a specific location will not be seen by the detector. As pitch is inversely related to radiation dose, a low pitch results in a high radiation dose (hsieh et al 2006).

The reported radiation doses for CCTA vary depending on the specific technology and techniques employed. With retrospectively gated single-source 64-slice CT, the reported effective radiation doses have ranged from 9.5 to 21.4 mSv.However, using many of the technologies and techniques discussed below, it is possible to lower the dose to less than 5 mSv, and doses less than 1 mSv are currently possible in some patients. For comparison, the average yearly background radiation dose is around 3 mSv, and a chest x-ray dose is 0.05 mSv. Depending on the technique, CCTA may have a higher or lower effective dose than conventional coronary angiography (3.1-9.4 mSv). However, the dose from a cardiac single-photon emission computed tomography (SPECT) scan performed using technetium-99m is typically high (8 -17.5 mSv) (hsieh et al 2006).

A variety of methods exist for decreasing radiation dose from cardiac CT.In general, radiation dose from a CT scan can be reduced by reducing tube current, reducing tube voltage, or increasing pitch (hsieh et al 2006).

2.6.8. ECG-dependent tube current modulation

Anatomic-based tube current modulation can be performed where the tube current is adjusted for patient size and shape. However, a more effective method of dose reduction is ECG-dependent tube current modulation. As the best image quality for CCTA is typically obtained at the specific phase of the R-R interval (usually mid- to end-diastole), the tube current (and thus dose) can be reduced in the phases where image quality is not optimal.This is the most common method to reduce radiation dose. The primary disadvantage of this technique is that optimal functional imaging is not possible because of poor image quality in the portions of the cardiac cycle where lower tube current was used. The use of ECG-dependent dose modulation can result in a 20-50% decrease in radiation dose.This technique can be optimally used with dual-source CT, as the time requiring the highest tube current is shorter (Kitagawa k , et al 2009).

Slow and steady heart rates are necessary for effective ECG-dependent dose modulation. At high heart rates, the period of reduced tube output (diastolic duration) becomes shorter relative to the cardiac cycle. With irregular heart rates, the optimal time point in the cardiac cycle to apply the full tube current is less predictable (hsieh et al 2006).

Society of Cardiovascular Computed Tomography (SCCT) guidelinesrecommend ECG-based, tube-current modification in retrospective gated studies, except in patients with highly irregular heart rhythms (Kitagawa k , et al 2009).

2.6.9. Reduced tube voltage

Reducing the tube voltage (from 120 kV to 100 or 80 kV) will reduce the radiation dose. Another advantage is that opacification of the blood vessels may increase at lower kV because of an increase in the photoelectric effect.The primary disadvantage is increased image noise. SCCT guidelinesrecommend a tube potential of 100 kV for patients weighing no more than 90 kg or with a body mass index of no more than 30 kg/m^2. A tube potential of 120 kV is indicated for larger patients, and even higher tube potentials may be indicated for severely obese patients (hsieh et al 2006).

2.6.1. Increased pitch

With dual-source scanners, the pitch can be increased at high heart rates to reduce radiation dose , Increasing the pitch will decrease the radiation dose, as the patient is exposed to radiation for a shorter period of time. The pitch can be increased at higher heart rates, because the time necessary to collect data throughout the cardiac cycle is decreased when the R-R interval is shorter , However, single-source scanners typically do not allow pitch to be increased at high heart rates. Single-source scanners usually need to utilize multisegment reconstruction to increase temporal resolution at high heart rates, and multisegment reconstruction requires a low pitch. In this technique, the data required for image reconstruction are selected from multiple sequential heart cycles. This technique requires retrospective gating and a regular heart rate.For data from several cardiac cycles to be used for image reconstruction, the same position has to be covered by the detector during consecutive cardiac cycles. Thus, the pitch must be lowered, which will increase radiation dose. Multisegment reconstruction is effective in improving temporal resolution only at specific heart rates (the heart rate and gantry rotation time need to be desynchronized) (hsieh et al 2006).

A dual-source scanner has greater temporal resolution, and multisegment reconstruction is not necessary at high heart rates. This allows the pitch to be increased, and dose decreased, at higher heart rates (hsieh et al 2006).

2.7. Prospective ECG triggering and sequential scanning

Coronary CT angiography is usually performed with retrospective ECG gating, where scanning occurs throughout the cardiac cycle and simultaneously acquired ECG data are used retrospectively during image reconstruction. The acquisition of data throughout the cardiac cycle increases radiation dose. In addition, the scan is performed helically with a low pitch, resulting in substantial tissue overlap during scanning, as well as increasing radiation dose (Kitagawa k , et al 2009).

With prospective ECG triggering, the data are acquired at a specific point in the R-R interval. The scanner acquires data sequentially ("step and shoot") rather than in helical mode. Radiation dose is decreased, as data are not acquired throughout the cardiac cycle, and there is minimal tissue overlap with a sequential scan technique. This technique is standard for coronary artery calcium scoring but can be used to reduce radiation dose substantially during CCTA. Using a prospectively triggered sequential scan technique, Earls et al achieved an 83% reduction in dose as compared to the retrospective gated technique (hsieh et al 2006).

The primary disadvantage of this technique is the lack of functional data. In addition, as data are only available from predefined phases of the R-R interval, reconstructions from additional phases to improve image quality are not possible.

This technique is optimal in patients with a low and stable heart rate. High heart rates are not optimal for this technique, as reconstructions at multiple phases during the R-R cycle are sometimes needed. With irregular heart rates, the acquisitions may be triggered at different points in the R-R interval.

Prospective ECG triggering is optimal for 256- or 320-slice CT, where the entire heart could potentially be scanned in one tube rotation and one heartbeat. This obviates the issue of phase misregistration in patients with irregular heart rates. In one study, the median effective radiation dose of 320-slice CT was 4.2 mSv,which was lower than an 8.5 mSv median dose from catheter angiography performed in the same patients. Prospective ECG triggering is also well suited for use with dual-source CT, as the increased temporal resolution may allow the technique to be used at a higher heart rate threshold (Kitagawa k , et al 2009).

In a meta-analysis of 20 studiesin patients with CAD and without tachyarrhythmia, prospectively triggered CCTA provided image quality and diagnostic accuracy comparable to retrospectively gated CTA, but at a much lower radiation dose (3.5 mSv average compared with 12.3 mSv) (Kitagawa k , et al 2009).

SCCT guidelinesstate that prospective ECG triggering should be used in patients who have stable sinus rhythm and low heart rates (typically < 60-65 beats per minute). The width of the data acquisition window should be kept to a minimum. Retrospective gating is recommended for patients who do not qualify for prospective scanning due to irregular rhythms or high heart rates (Kitagawa k , et al 2009).

2.7.1.Iterative reconstruction

Iterative reconstruction is a new CT reconstruction technique that reduces image noise, which then allows radiation dose to be decreased. Interactive reconstruction has been shown to both reduce image noise and improve image quality(Kitagawa k , et al 2009).

2.7.2. How low can radiation dose be?

In one study, 320-slice CT, prospective gating, iterative reconstruction and automated exposure control were used in conjunction with lower radiation dose in 107 consecutive patients.The dosage was less than 4 mSv for 96% of the patients and less than 1 mSv for 54% of the patients. For comparison, the average yearly background radiation dose is around 3 mSv (Kitagawa k , et al 2009).

2.7.3. Patient Preparation

At our institution, patients are instructed to avoid caffeine and smoking 12 hours prior to the procedure to avoid cardiac stimulation. They are also instructed to avoid eating solid food 4 hours before the study and to increase fluid intake prior to the study. Standard precautions with regard to contrast allergy history and renal function are taken (Kitagawa k , et al 2009).

2.7.4. Beta blockers

Beta-blocker administration is often helpful in cardiac CT to lower the heart rate and decrease motion artifact. The level to which the heart rate should be lowered depends on the temporal resolution of the scan. With single-source CT scanners, it is usually helpful to lower heart rate below 65 beats per minute (bpm), and ideally below 60 bpm. Dual-source CT scanners have higher temporal resolution and can be performed at heart rates of up to 90 bpm, obviating the need for beta blockers in many cases. Cardiac MRI has higher temporal resolution than CT and can be performed without beta blockers , However, heart rate variability may be a more important determinant of image quality than absolute heart rate.Beta blockers are also helpful in patients with irregular heart rates, supraventricular tachycardias, and arrhythmias. For example, in atrial fibrillation, the negative chronotropic and dromotropic effects can lengthen diastole (Kitagawa k , et al 2009).

Possible contraindications to beta-blocker administration include the following: Heart rate < 60 bpm , Systolic blood pressure < 100 mm Hg , Asthma or chronic obstructive pulmonary disease (COPD) on beta $_2$ -agonist inhaler.

There are many different protocols for metoprolol administration. An oral dose of 50-100 mg can be administered 60-90 minutes before the study.If this does not lower the heart rate to the desired level, 5-mg doses of IV metoprolol can be administered at 3- to 5-minute intervals, up to a total dose of 15-30 mg.

Atenololand esmololhave also been successfully used.

Diltiazem or verapamil can also be used in patients in whom beta blockade is contraindicated, although these are less effective and result in more hypotension.These drugs can also be used in combination with a very low dose of metoprolol (Kitagawa k , et al 2009).

2.7.5. Nitroglycerin

The administration of sublingual nitroglycerin dilates the coronary arteries and increases side branch visualization.Nitroglycerin is contraindicated in patients who are allergic to it and in patients who are taking phosphodiesterase inhibitors for erectile dysfunction.Patients should not have taken a phosphodiesterase inhibitor for at least 48 hours before the exam. The concomitant use of phosphodiesterase inhibitors can cause severe hypotension. Nitroglycerin can cause orthostatic hypotension and should be used with caution in patients who have low systolic blood pressure (eg, < 90 mm Hg) and who are volume depleted from diuretic therapy. Angina caused by hypertrophic cardiomyopathy can also be aggravated.

2.7.6. Artifacts

2.7.6.1. Stairstep artifacts

Stairstep artifacts are associated with heart rate variability.With irregular heart rates, phase misregistration can occur when data from different cardiac phases are used for reconstruction. A stairstep appearance results from the data reconstructed from different cardiac phases (Kitagawa k , et al 2009).

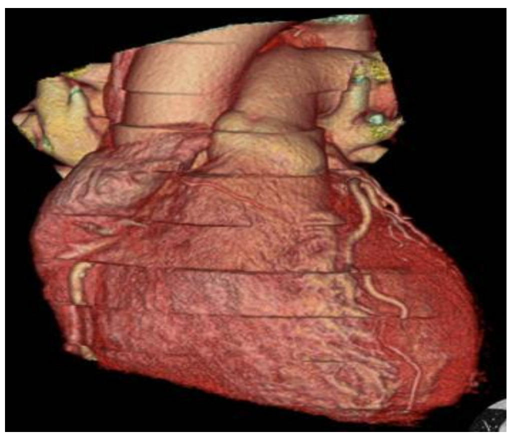

Figure (2.23) Stairstep artifact

Volume-rendered CT image demonstrates "stairstep" artifact. This is a phase-misregistration artifact that is typically secondary to an irregular heartbeat (Kitagawa k , et al 2009).

Beta blockers are helpful in reducing heart rate variability and avoiding stairstep artifacts. Manual ECG editing can also be helpful. With 256- and 320-slice CT, stairstep artifacts should not be seen if the heart is scanned in one heartbeat (Kitagawa k , et al 2009).

2.7.6.2. Coronary artery motion artifacts

Artifacts from motion of the coronary arteries result in image blurring. The right coronary artery is often most affected by motion artifact.

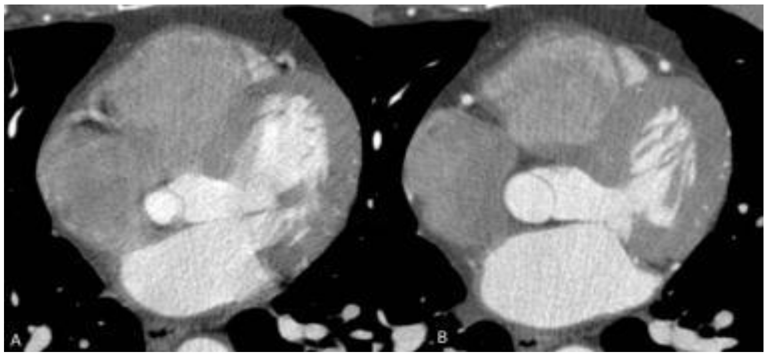

Figure (2.24) Coronary artery motion

Axial CT images reconstructed at 90% (A) and 70% (B) of the R-R interval demonstrate the importance of imaging during the phase of least cardiac motion (Kitagawa k , et al 2009).

General strategies to decrease motion artifact are to increase the time during the cardiac cycle where there is the least motion and to image as quickly as possible.

Motion can be minimized by reconstructing the data during a phase where there is minimal motion. Choosing the optimal phase of the R-R cycle to reconstruct the data is discussed in the image reconstruction section, below. Decreasing the heart rate with beta blockers has the advantages of decreasing the motion velocity of the coronary arteriesand increasing the relative and absolute duration of the diastolic rest period in the cardiac cycle (Kitagawa k , et al 2009).

Temporal resolution can be increased in 2 ways. Dual-source CT scanners have substantially higher temporal resolution. With a single-source scanner, one way to increase temporal resolution, typically used in patients with higher heart rates, is to use a multiple-segment reconstruction technique. In this technique, the data required for image reconstruction are selected from multiple sequential heart cycles. This technique requires retrospective gating and a regular heart rate.For data from several cardiac cycles to be used for image reconstruction, the same position has to be covered by the detector during consecutive cardiac cycles. Thus, the pitch must be lowered, which will increase radiation dose. Multi-segment reconstruction is only effective in improving temporal resolution at specific heart rates (the heart rate and gantry rotation time need to be desynchronized) (Kitagawa k , et al 2009).

2.7.6.3. Arrhythmias

Arrhythmias present a challenge for CCTA because of both high and irregular heart rates, and both stairstep and motion artifacts can be seen. CCTA has been successfully performed in patients with atrial fibrillation by using dual-source CT and end-systolic reconstruction and by using single-source 64-slice CT with ECG-editingand middiastolic reconstruction (Kitagawa k , et al 2009).

2.7.6.4. Respiratory motion artifacts

Most patients can breath-hold for the time necessary to complete a CCTA study. A Valsalva maneuver should be avoided, as this can decrease inflow into the right atrium and decrease contrast enhancement (Kitagawa k , et al 2009).

2.7.6.5. Streak artifacts

Streak artifacts from beam hardening can be seen secondary to metal clips. Streak artifact in the superior vena cava and right atrium from dense contrast can limit evaluation of the right coronary artery. This can be mitigated by the use of a saline bolus chaser. However, a saline bolus chaser can result in poor contrast opacification of the right heart lumen, which may limit morphologic and functional evaluation. Protocols that utilize an admixture of saline and contrast are helpful in maintaining right heart opacification without streak artifact (Chobanian CP , et al 2003).

2.7.6.6. Blooming artifacts

Blooming artifacts can cause small high-contrast structures such as stents and calcium to appear larger than they are.Edge-enhancing kernel filters can decrease blooming artifacts and may be helpful for evaluating a stent lumen, although image noise is increased (Kitagawa k , et al 2009).

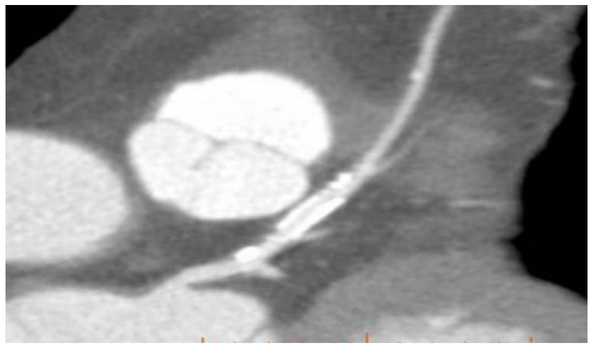

Figure (2.25) Blooming artifact

Multiplanar reconstruction (MPR) CT image demonstrates blooming artifact from a left anterior descending (LAD) artery stent. The stent lumen is poorly visualized secondary to this artifact (Kitagawa k , et al 2009).

2.7.7. Image Reconstruction

2.7.7. 1. Reconstruction Window

The coronary arteries are optimally imaged when there is the least cardiac motion. This occurs during so-called rest periods, which is typically in middiastole (diastasis). Coronary motion is also minimal during end-systole (isovolumic relaxation), but this is of shorter duration than diastolic diastasis at low heart rates.

With dual-source CT at low heart rates, the optimal reconstruction window is often 70–75% of the R-R interval (diastolic) for all of the coronary arteries. A 30-35% systolic window may occasionally be helpful for the right coronary artery.As heart rate increases, diastole shortens relative to systole, and diastasis shortens dramatically. The optimal reconstruction window transitions from diastole to systole around 75-85 bpm.At high heart rates, the optimal reconstruction windows are 85-90% (diastole) and 40-45% (systole).End-systolic reconstruction windowsmay be helpful in patients with atrial fibrillation, as the systolic rest period will be less variable than the diastolic rest period (Chobanian CP , et al 2003).

Use of a fixed reconstruction window,such as 50 msec rather than a percentage of the R-R interval, is helpful in patients with atrial fibrillation and variable R-R intervals (Chobanian CP , et al 2003).

2.7.7. 2.Postprocessing Techniques

A variety of postprocessing techniques are useful in CCTA.Many interpreting physicians will start with the axial source images and then utilize multiplanar reconstructions in at least 2 planes (Chobanian CP , et al 2003).

2.7.7. 3. Axial source images

Axial source images are often the initial images used to review the coronary arteries and are used to evaluate the extracardiac structures (Chobanian CP , et al 2003).

2.7.7.4 Multiplanar reconstruction (MPR)

MPRs can be performed at oblique planes to the body or the coronary arteries. For coronary artery imaging, a curved MPR technique is usually used where the reconstruction plane is locked onto the target vessel. for reasons such as motion artifact, poor contrast opacification, or dense calcifications (Chobanian CP , et al 2003).

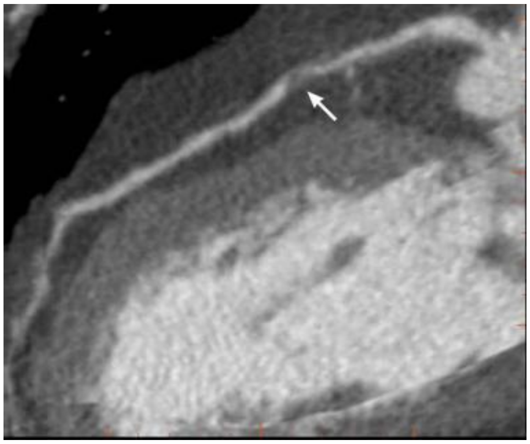

Figure (2.26) Curved MPR

Curved multiplanar reconstruction (MPR) image of a left anterior descending (LAD) artery stenosis (arrow) (Chobanian CP , et al 2003).

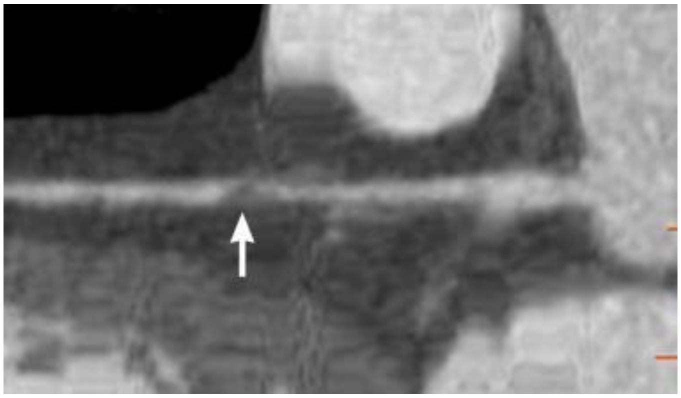

Figure (2.27) "Ribbon" multiplanar reconstruction (MPR)

"Ribbon" MPR image of a left anterior descending (LAD) artery stenosis (arrow) (Chobanian CP , et al 2003).

Maximum intensity projection (MIP)

2.7.7.5. Maximum intensity projection (MIP)

With the MIP technique, the highest voxel attenuation values from a volume of CT data are used to reconstruct the image. The MIP technique can be used to create "angiographic" images. However, as voxels with lower attenuation values are suppressed, noncalcified plaques can be masked by luminal contrast, and calcified plaque can mask less dense luminal contrast.The MIP technique tends to overestimate stenosis (Chobanian CP , et al 2003).

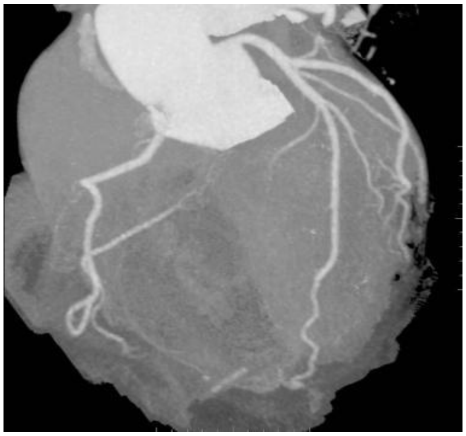

Figure (2.28) Maximum intensity projection (MIP)

"Angiographic" MIP image of the coronary arteries (Chobanian CP , et al 2003).

3D volume rendering : Volume-rendered images are visually appealing, but they usually play little role in primary interpretation. They are helpful for visualizing anomalous vessels and bypass grafts. Generation of volume-rendered images is computationally intensive and often requires manual editing.

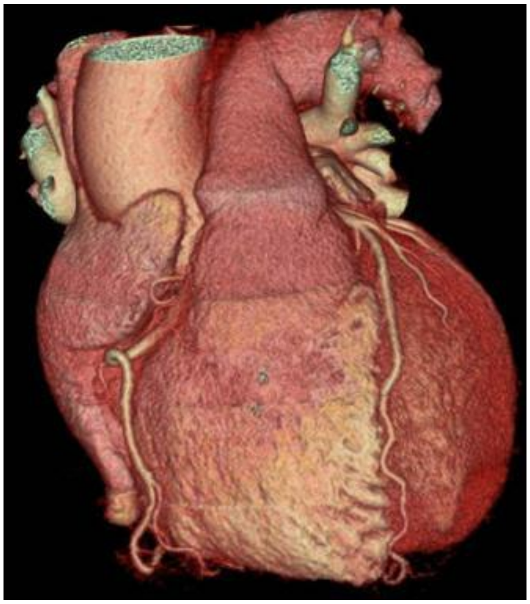

Figure (2.29) Volume-rendering

Volume-rendered image of the heart demonstrates both the right and left coronary arteries as well as the cardiac chambers.

2.7.7.7 Anatomy

The left anterior descending artery (LAD) and posterior descending artery (PDA) run in the interventricular groove, while the circumflex and right coronary arteries (RCA) run in the atrioventricular groove (Chobanian CP , et al 2003).

In general, hypoplasia of one vessel will be accompanied by prominence of another vessel. For example, if the LAD is small and does not extend to the apex, the PDA is typically prominent and extends to the apex. If the circumflex is small, there are typically prominent posterolateral branches arising from the RCA. If there is a large ramus intermedius, the diagonals may be small (Chobanian CP , et al 2003).

2.7.7.8 Dominance

Right dominant (80-85%): Both the PDA and the posterolateral (also called posterior ventricular) branches arise from the RCA (Chobanian CP , et al 2003).

Figure (2.30) Right coronary artery (RCA)

Volume-rendered CT image of the RCA demonstrates a right-dominant RCA with acute marginal, posterior descending artery, and posterior ventricular branches (Chobanian CP , et al 2003).

Left dominant (15-20%): Both the PDA and the posterolateral branches arise from the circumflex(Chobanian CP , et al 2003).

Figure (2.31) Left-dominant system

Volume-rendered CT image demonstrates a left-dominant system with the posterior descending artery (PDA) (arrowhead) and a posterolateral branch (white arrow) arising from the circumflex artery (black arrow).

Codominant (5%): The PDA arises from the RCA. The posterolateral branches arise from the circumflex.

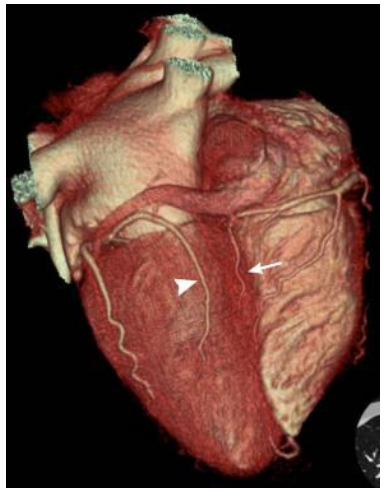

Figure (2.32) Codominant system

Volume-rendered CT image demonstrates a codominant system with the posterior descending artery (arrow) arising from the right coronary artery (RCA) and a posterior ventricular branch (arrowhead) arising from the circumflex.

Left main coronary artery: The left main coronary artery is variable in length, 11 mm ± 5 mm.If intervention in the left coronary artery system is a possibility, it may be helpful to report the length of the left main artery. The left main coronary artery will usually bifurcate into the LAD and the left circumflex artery. In approximately 30% of cases, the left main artery will trifurcate, with a ramus intermedius artery between the LAD and circumflex. The ramus intermedius artery will supply a lateral wall territory between the first diagonal and the first obtuse marginal branch territories , Rarely, the left main coronary artery will be absent and the LAD and circumflex artery will arise directly from the aorta (Chobanian CP , et al 2003).

Figure (2.33) Left coronary arteries

Volume-rendered (A) and multiplanar reconstruction (MPR) (B) CT images in 2 patients demonstrate the left anterior descending (LAD) artery (1), first septal perforator (2), first diagonal (3), ramus intermedius (4), circumflex artery (5), and first obtuse marginal (6).

2.7.7.9. Left anterior descending artery

The LAD is variable in length and can terminate before the apex, supply the apex, or supply the distal inferior wall , The LAD gives rise to diagonal branches supplying the anterolateral wall and to septal perforators supplying the interventricular septum. Compared with the diagonals, the septal perforators usually are less implicated in ischemia and are less often targets of intervention.

In 1% of cases, there can be dual LADs (Chobanian CP , et al 2003).

2.7.7.9. Left circumflex artery

The left circumflex artery gives off obtuse marginal branches that supply the posterolateral wall. In many cases, particularly in a right-dominant system, the first obtuse marginal branch will be larger than the circumflex. The circumflex artery is the vessel that remains in the atrioventricular groove , The left circumflex artery usually terminates in the atrioventricular groove. In a left dominant system, the PDA and posterolateral branches arise from the circumflex. In the codominant system, the posterolateral branches arise from the circumflex (Chobanian CP , et al 2003).

2.7.7.9.1.Right coronary artery

The branches from the RCA are called acute marginal or right ventricular marginal arteries. However, the acute marginal branch is also used to refer to the largest marginal artery, which arises at the inferior aspect of the right border of the heart, coursing towards the apex. The marginal arteries usually do not cause significant ischemia and are rarely targets for intervention , At the inferior aspect of the right atrioventricular groove, the RCA, if dominant, bifurcates into the PDA and posterolateral left ventricular branch. The PDA runs along the undersurface of the heart in the posterior interventricular groove and gives rise to septal perforators supplying the posterior third of the interventricular septum. The posterolateral branch has a hairpin curve (first cephalad, then caudad), and supplies the posterior and lateral left ventricular walls(Chobanian CP , et al 2003).

The first branch of the RCA is often the conus artery. In 50 % of cases, the conus artery arises from the RCA; in the order 50%, it arises from aorta (vasan RS , et al 2001)

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Figure (2.34) Conus artery

Axial maximum intensity projection (MIP) image demonstrates the conus artery (arrow) arising from the right coronary artery (RCA) (vasan RS , et al 2001)

The second branch off the RCA is often the sinoatrial (SA) nodal artery. In 55% of cases, the SA nodal artery arises from the RCA; in the other 45%, it arises from the circumflex. The SA nodal artery heads posteriorly toward the sinoatrial node (Chobanian CP , et al 2003).

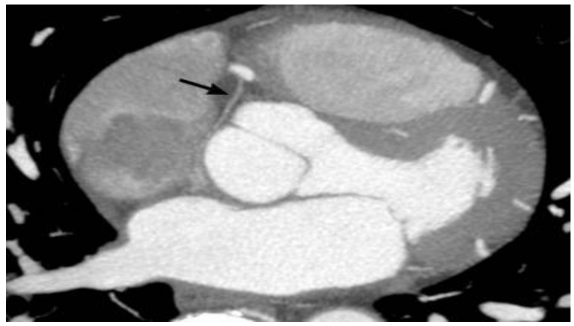

Figure (2.35) Sinoatrial node artery

Axial maximum intensity projection (MIP) image demonstrates the sinoatrial node artery (arrow) arising from the right coronary artery (RCA) (vasan RS , et al 2001)

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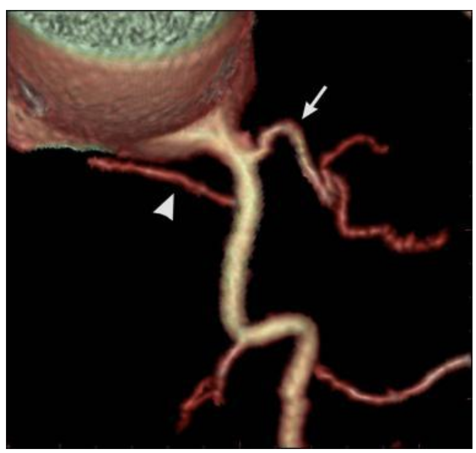

Figure (2.36) Conus and sinoatrial node arteries

Volume-rendered CT image of the right coronary artery demonstrates the conus artery (arrow) heading anteriorly and the sinoatrial node artery (arrowhead) heading posteriorly. (vasan RS , et al 2001)

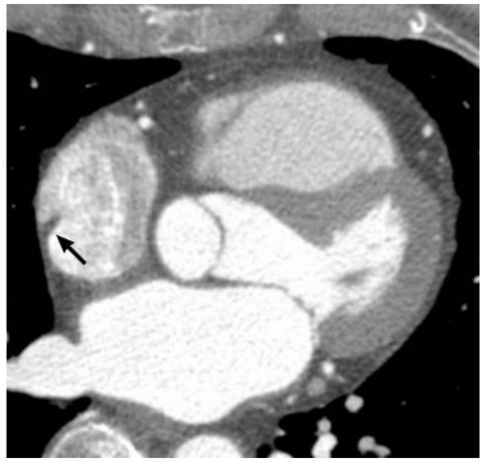

Figure (2.37) Crista terminalis

Axial CT image demonstrates the crista terminalis (arrow) in the superior right atrium(vasan RS , et al 2001)

The last named branch off the RCA is the atrioventricular (AV) nodal artery, which arises from the RCA in 80-87% of cases. It can also arise from the circumflex or from both the RCA and the circumflex. If it originates from the RCA, it typically arises from the proximal posterolateral branch. It heads superiorly through the septum to the AV node, which is in the inferior aspect of the interatrial septum (vasan RS , et al 2001)

2.7.7..9.2 Collateral pathways

Collateral pathways are typically better visualized on invasive coronary angiography than on CCTA (vasan RS , et al 2001).

2.7.7..9.3 Anomalies

Coronary artery anomalies can be broadly classified as anomalies of origin, anomalies of course, and anomalies of termination , In anomalous cases, the coronary arteries should be identified by their location rather than by their origin or specific branches. The right coronary artery lies in the right atrioventricular groove and supplies the right ventricular free wall. The LAD lies in the anterior interventricular groove and supplies the anterior interventricular septum (the LAD need not give rise to diagonal branches). The left circumflex artery lies in the left atrioventricular groove and supplies the left ventricular free wall , Most anomalies are incidental findings but may be important during surgical planning to avoid accidental vascular injury. Only a few anomalies are potentially malignant, with the potential to result in ischemia, infarction, or sudden death. These include origin of the artery from the opposite coronary sinus with interarterial course, pulmonary artery origin, and coronary artery fistulae. Patients with anomalous coronary artery origin from the pulmonary arteries show symptoms in infancy and early childhood. The left and right coronary arteries can arise from the noncoronary sinus or the opposite sinus. In these cases, the arteries can take 4 courses: retroaortic, prepulmonic, septal (beneath the right ventricular outflow tract), or interarterial (between the aorta and pulmonary artery). Patients with an interarterial course, particularly of the left coronary artery, are at risk for ischemia, infarction, and sudden cardiac death, particularly during exercise (vasan RS , et al 2001)

Figure (2.38) Anomalous right coronary artery (RCA)

Axial CT image of an anomalous RCA arising from the left coronary sinus, with an interarterial course between the aorta and pulmonary artery (vasan RS , et al 2001)

Figure (2.39) Anomalous left circumflex

Axial CT image of an anomalous circumflex artery (arrow) passing posterior to the aorta (vasan RS , et al 2001)

Myocardial bridging,also called tunneled artery, is a congenital anomaly where myocardium encases a segment of coronary artery. It is most common in the mid-LAD. The artery may be compressed in the systolic phase. Although it is usually a benign anomaly, it has been associated with myocardial ischemia. Myocardial bridging is well demonstrated by CCTA (vasan RS , et al 2001)

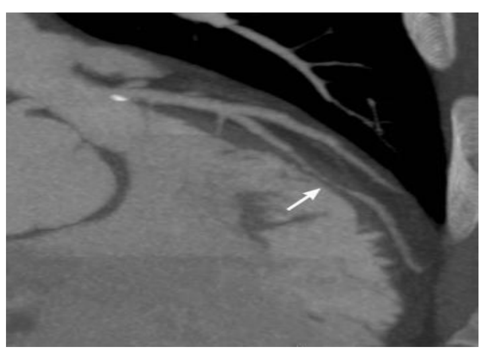

Figure (2.40) Myocardial bridging

Maximum intensity projection (MIP) image demonstrates a myocardial bridge (arrow) involving the mid-left anterior descending artery (LAD).

Myocardial loops refer to muscle bundles from the atrial myocardium surrounding three quarters of the circumference of an artery. These are of no clinical significance , Coronary artery fistulas are usually congenital and can be symptomatic if large. They are well visualized by CCTA. Coronary artery fistulas originate from the RCA in two thirds of cases and the left coronary system in a quarter of cases. More than 90% drain into the right atrium, coronary sinus, or right ventricle.On CCTA, contrast opacification of the receiving chamber/vessel (shunt sign)is useful for determining the exact site of entry of the fistula. However, this finding will be obscured if there is a significant amount of preexisting contrast in the receiving chamber/vessel (vasan RS , et al 2001)

Figure (2.41) Coronary artery fistula

Volume-rendered CT image (A) demonstrates a fistula from the left anterior descending (LAD) artery (arrow) to the right ventricular outflow tract (RVOT) (arrowhead). Coronal CT image (B) demonstrates a small jet of contrast in the region of the shunt entrance (arrow) into the RVOT (Chobanian CP , et al 2003).

Other anomalies are not hemodynamically significant but important to describe in detail if intervention is a possibility. For example, a dual LAD can result in diagnostic error during cardiac catheterization or in technical difficulty during revascularization (Chobanian CP , et al 2003).

2.7.7.9.4 Stenosis Grading

There are many different methods to grade the degree of stenosis, including visual assessment; manually determined diameter or cross-sectional area on multiplanar reformats perpendicular to the median centerline of the vessel ("end-on" view); diameter on maximum intensity projection (MIP) images parallel to the long axis of the vessel; and software calculationof diameter or area. Dodd et al found that the cross-sectional area technique had the highest correlation with quantitative coronary angiography, and MIP technique had the smallest interobserver variability.Grading is less accurate in calcified plaques and in distal coronary vessels (Chobanian CP , et al 2003).

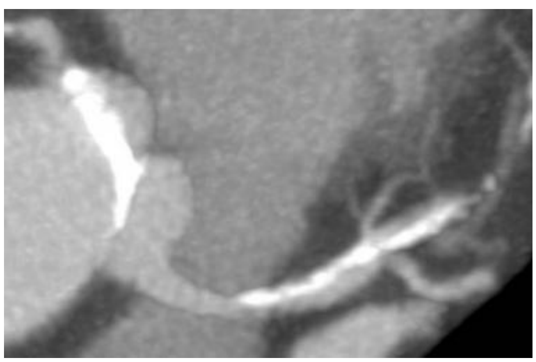

Figure (2.42) Maximum intensity projection (MIP)

MIP image of a left anterior descending (LAD) artery stenosis secondary to calcified plaque. MIP images parallel to the long axis of the vessel can be used to assess the degree of stenosis(Chobanian CP , et al 2003).

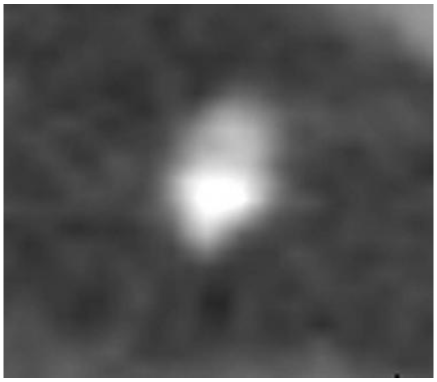

Figure (2.43) "End-on" multiplanar reformat (MPR)

"End-on" MPR view (perpendicular to the median centerline of the vessel) of a left anterior descending (LAD) artery stenosis secondary to calcified plaque. The degree of stenosis could be assessed on this view visually, or from manually or software-calculated diameter or cross-sectional area (Chobanian CP , et al 2003).

Cross-sectional images at the level of the most severe narrowing can be compared to a reference minimal lumen diameter averaging the segments proximal and distal to the stenosis. The diameter should be measured lumen to lumen rather than wall to wall. The distal reference vessel should not be distal to a bifurcation.

Because the spatial resolution is inadequate for precise grading, coronary stenoses are often graded with semiquantitative descriptors such as normal, mild (< 50%), moderate (50–70% stenosis), severe (>70% stenosis), and occluded.

Stenosis is typically overestimated in areas where heavily calcified plaques are present. In the presence of extensive calcification, reconstruction of a additional dataset using a sharper convolution kernel (as used for stents) and use of bone window setting can reduce blooming artifacts from calcification.Zhang et al offer the following suggestions to better assess the degree of stenosis when calcified plaques are present:

A significant luminal stenosis is unlikely if the plaque thickness measures 50% or less of the diameter of a nearby normal segment and if it is eccentrically positioned on a cross-sectional multiplanar reconstruction (MPR) view or there is visible lumen adjacent to the plaque on a long-axis MPR view, A significant stenosis is likely if calcified plaque fills the entire central portion of the lumen on a cross-sectional MPR image.

2.7.7..9.4 Pitfalls

Several areas may be difficult to evaluate due to curvature, and additional review of these regions using thick-slap MIP may be helpful, as follows:

Distal segment of the RCA and origin of the PDA , Origin of the first diagonal branch , Distal circumflex near the origin of the obtuse marginal . A stenosis should always have an associated visible plaque, calcified or noncalcified. This is helpful in differentiating stenosis from artifactual apparent narrowing (Johnson TR, et al 2007).

Chapter three

Materials & methods

3.1 material

3.1.1 machine : Brilliance ICT 256- slices

3.1.1.2 prepare the patient

In order to achiebe the best results possible. It is important that you prepare the apatient correctly.

3.1.1.3 pre-scan preparation

Ask the patient to refrain from stimulants (such as coffe) prior to scan don't give oral contrast. Cardiac scans are usually short scan time. Ask the patient not to takein a deep breath during the breathold. Review voice commands prior to examination. The patient should have good IV access (18 -21G) if possible. It is suggested that the IV be placed in a large vein such as the antecubital vein.

3.1.1.4 contrast parameters

Knowledge and the experience using Philips products. When you have registered at the site navigate to the CT forum and search through the area called exam "cards" for contributors information about contrast parameters on helical and step and shoot cardiac CT.

3.1.1.5 prepare patient for the scan

3.1.1.6 electrode placement

It is recommende that you properly pepare the skim of the patient before attaching the electrodes.

3.1.1.7. If body hair is presents. Shave the site to insure good electrode contact with the skin.

3.1.1.8. clean the contact sites with alcohol to remove exesss oils.

3.1.1.9. use ECG skin preparation tape to abrade the skin and remove the outer layer of dead skin cells.

3.1.1.10. Apply clean with gel electrodes to these locations:

Right pectoral , Left pectoral , Left mid abdomen right mid abdomen , Connect the four ECG leads to the electrode.

Make sure electrodes and leads are not in the foeld of view. Run the leads along eacj=h side of patients body. Make sure the leads are straight snd without loops. Tape the electrodes to the leads for better connection if needed.

3.1.1.1.1. cardiac scanning

This chapter describes how to perform cardiac scanning as well as the additional procedures rhat may be necessary to complete the desired cardiac scan.

A typical cariac scan procedures consist of these steps: enter patient information select and exam protocol perform scan

Note: prior toperform a scan you must set up ECG PIM and set up the patient.

Follow the procedures in this chapte t ocreat motion-free heart images.

For detailed information aboyt scanning, refe to scanner operation ND SCscan protocols chapte r in volume 1 of this documentation set.

3**.1.1.1.2. helical retrospective tagging**

3.1.1.1.3.helicalretrospective tagging Allows acquisition of a volume of data while the patient’s ECG is recorded.the acquired data aare tagged and reconstructed retrospectively at any desired phase of cardiac cycle. In general, images that are reconstructed at the mid-to end-diastolic phase of the cardiac cycle shoes the least cardiac motion and hoghes level od=f coronary artery flow. This phase is considered to be optimal for coronary artery evaluation. A special algorithm id spplied in the software to trackthe diastolic phase of the heart rate T variable heart rates. This is critical when performing advanced 3-D imaging of the heart for coronary CT angoiography, and crdiac functional analysis .

3.1.1.1.4 cadiac Dose Right

Cadiac DoseRight is a toolused during helical coronary CTA scanning toreduce the amount of radiation to the patient, while maintain good image quality, this technique is called ECG dose modulation. When cardiac DoseRight is enabled, the scanner uses the planned mAs during the phase(s)used for coronary artery evaluation.

In other areas of the heart cycle, such as those phases used for functional analysis, the mAs is reduced to level equal to 20% of planned mAs value.

Cardiac rates is optimal with low and steady heart rates. For example with heart rates of less or equal to 60 beats per minute (bpm) radiation dose saving can reach up to 40%.

3.1.1.1.5. handle irregularities on-line

Handle irreglaties on line is feature that can be used to step and shoot helical coronary CTA scanning.

Note: in order to use the feature which allows irregularities on-line, you must first set tha appropriate options in the cardiac scanning performances see preferences, on page 5-1 for more information.

The arrhythmia setting in cardiac performance allows you to define how the system applies the dose savings in the case of an arrhythemia during the coronary CTA scan.

3.1.1.1.6. cancel Dose saving for one beat only – when this option is selected, the systemturnd off dose saving for one heart cycle. On the next heart cycle, it resumes the dose savings.

3.1.1.1.6. cancel Dose saving henceforth – when this option is selctd, the dystem ends dose savings and completes the rest of the scan with the planned mAs

3.1.1.1.7. scan procedure

The complete helical respectively tagging process involves these scans: surview bolus tracking or test injection bolus timed scan.

Helical scan

These scans may already be include in the protocol you select however they can also be added during the scan set—up.

Use this procedure to conduct the process:

- Click **start study**. The patient data from opens.
- Enter patient information in patient data form
- Selsct patient position. Feet firdt id recommended
- Click **Exsm protocol Group.**
- In the exam protocol groups, click cardiac mini image. The list of cardiac protocols display.
- Select a restrospective (helical)protocol. The system displays the protocol parameters for the surview.
- If neede, edit the protocol parameters.

Note the scan should be from manubrial ntch to the iliac crest.

The system prompts you to press the auto botton to start the surview scan (with breath hold).

- Pressss the appropriate button on the scan control box. The system displays the Surview image.
- Plan on the Surview. Now that the Surview is complete, you can continue to the bolus tracking scan. If the locator and tracking scans are not included in your protocol, continue to **bolus tracking**, step **1,** on page 7-5.if the locator and tracking scans are included in the protocol continue to Bolus tracking, step 6,on page 7-6.

3.1.1.1.8. Bolus tracking

If your protocol did not include the bolus tracking option, you must addit before conducting a bolus tracking a bolus tracking procedure.

- Click the injector tab in the scan tool panel.
- Select Bolus tracking. The system displays locator and tracker scans in the series list and automatically closes the injector tab.
- Click locator in the scan series list. The system displays a loctor line on the image.
- Move the locator line.

Chapter Four

Results

Chapter Four

Results

1.Table (4.1): shows the Age distributions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	26-35	13	16.3	16.3	16.3
	36-45	18	22.5	22.5	38.8
	46-55	25	31.3	31.3	70.0
	56-65	15	18.8	18.8	88.8
	66-75	8	10.0	10.0	98.8
	76-85	1	1.3	1.3	100.0
	Total	**80**	**100.0**	**100.0**	

- The age in the study between (29 to 85).
- Most of age in group (46-55).

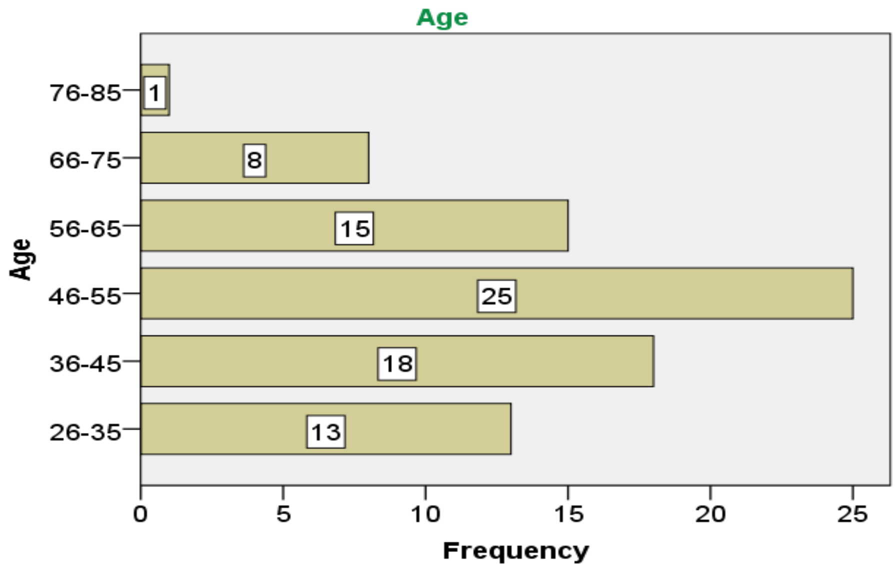

Figure (4.1) The Age group and Frequency

2. **Table (4.2): show the Sex distributions**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	55	68.8	68.8	68.8
	Female	25	31.3	31.3	100.0
	Total	**80**	**100.0**	**100.0**	

- The 80 patients are 55 Males and 25 Females.

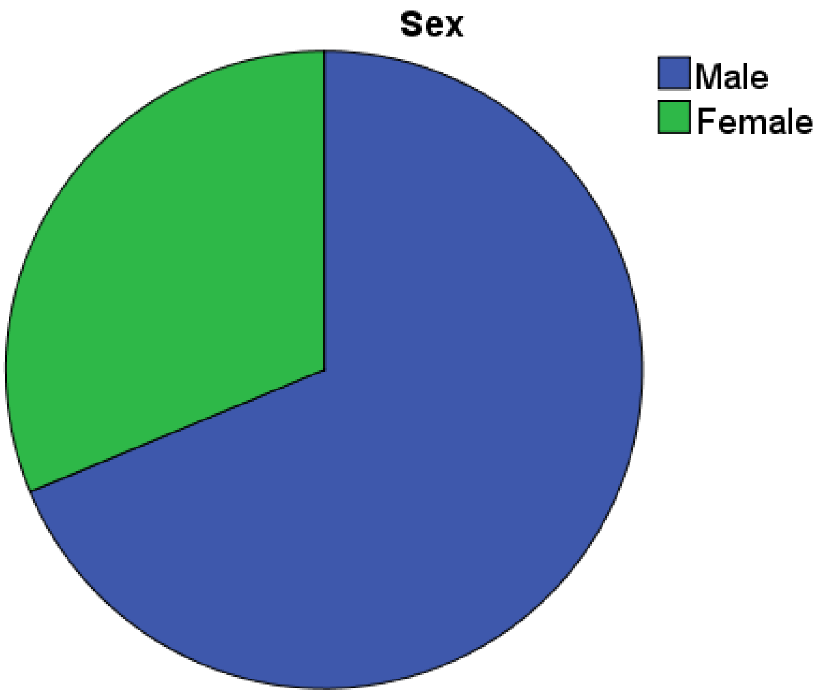

Figure (4.2): Sex distribution

3. Table (4.3) Calcium Score Range (CR)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-10	5	6.3	6.8	6.8
	11-100	7	8.8	9.5	16.2
	101-400	7	8.8	9.5	25.7
	Over 400	9	11.3	12.2	37.8
	Zero	46	57.5	62.2	100.0
	Total	74	92.5	100.0	
Missing	System	6	7.5		
Total		80	100.0		

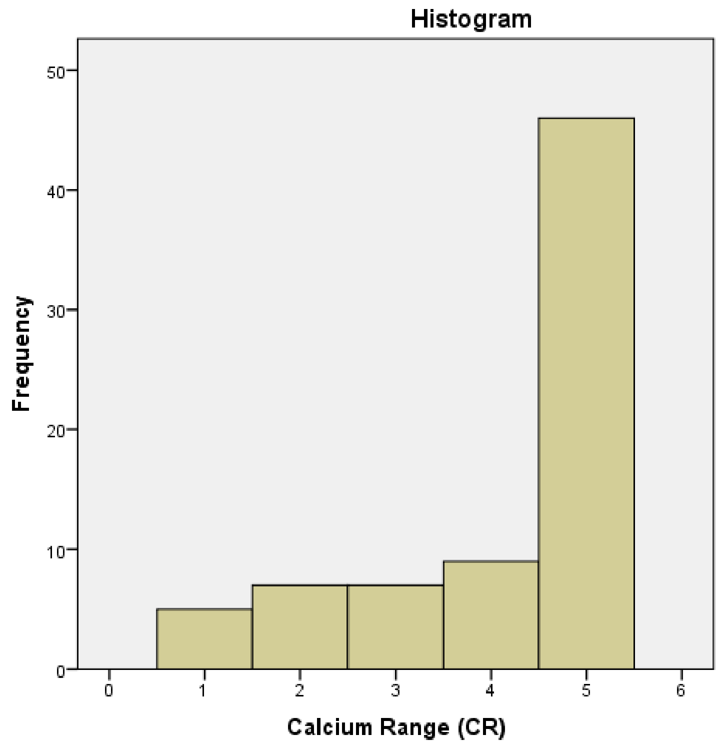

Figure (4.3) Calcium Score Range (CR)

4. Table (4.4) : cases processing summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Age * Right Coronary Artery (RCA)	76	95.0%	4	5.0%	80	100.0%
Age * LMs	74	92.5%	6	7.5%	80	100.0%
Age * Left Anterior Descending (LAD)	75	93.8%	5	6.3%	80	100.0%
Age * Left Main Coronary Artery (LM)	71	88.8%	9	11.3%	80	100.0%
Age * Left Circumflex (LCx)	75	93.8%	5	6.3%	80	100.0%
Age * Plaque	15	18.8%	0	81.3%	80	100.0%
Age * First Obtuse Marginal (OM1)	37	46.3%	43	53.8%	80	100.0%
Age * OM2	34	42.5%	46	57.5%	80	100.0%
Age * Coronary Artery Bypass Graft (CABG)	3	3.8%	77	96.3%	80	100.0%

5. Table (4.5): Cross tabulation for Age and Sex

			Sex		
			Male	Female	Total
Age	26-35	Count	12	1	13
		% within Sex	21.8%	4.0%	16.3%
	36-45	Count	14	4	18
		% within Sex	25.5%	16.0%	22.5%
	46-55	Count	12	13	25
		% within Sex	21.8%	52.0%	31.3%
	56-65	Count	9	6	15
		% within Sex	16.4%	24.0%	18.8%
	66-75	Count	7	1	8
		% within Sex	12.7%	4.0%	10.0%
	76-85	Count	1	0	1
		% within Sex	1.8%	0.0%	1.3%
Total		Count	55	25	80
		% within Sex	100.0%	100.0%	100.0%

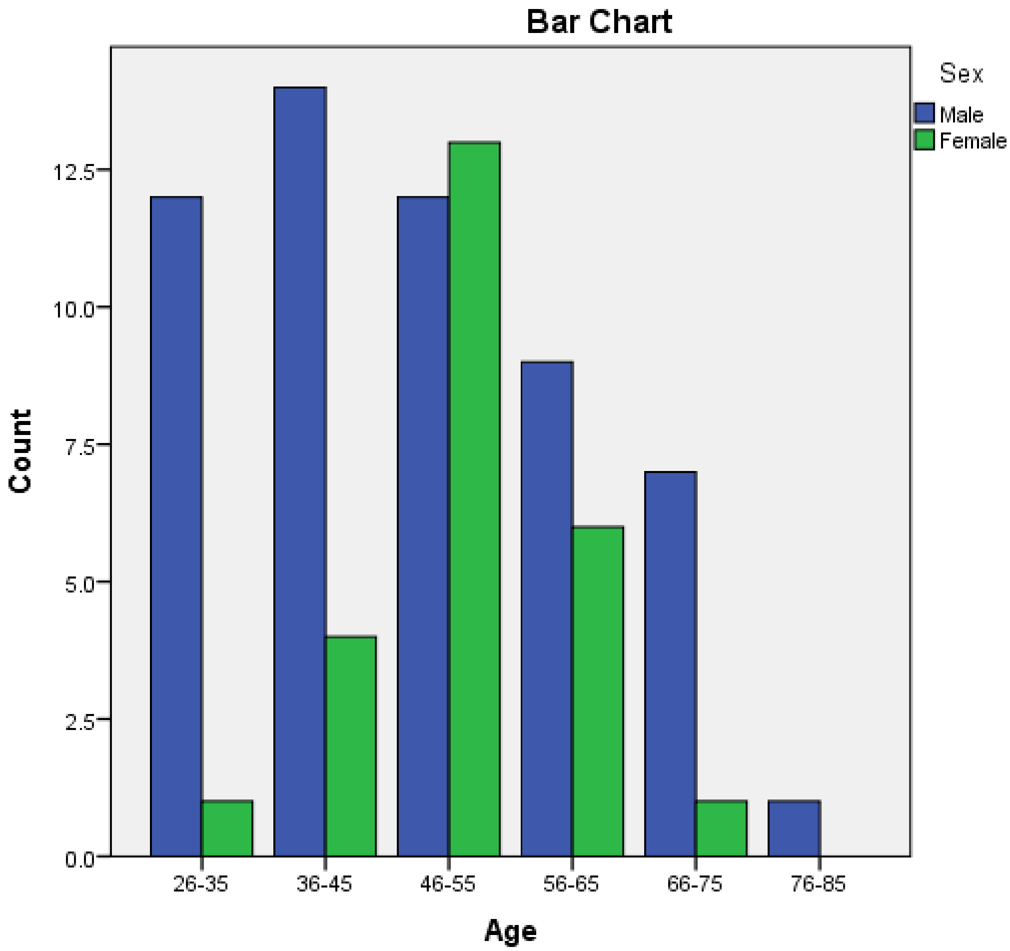

Figure (4.4) Cross tabulation for Age and Sex

7. **Table (4.5): age and Calcium Range**

			Total
Age	26-35	Count	13
		% within Calcium Range	16.3 %
	36-45	Count	18
		% within Calcium Range	22.5 %
	46-55	Count	25
		% within Calcium Range	31.3 %
	56-65	Count	15
		% within Calcium Range	18.8 %
	66-75	Count	8
		% within Calcium Range	10.0 %
	76-85	Count	1
		% within Calcium Range	1.3%
Total		Count	80
		% within Sex	100.0 %

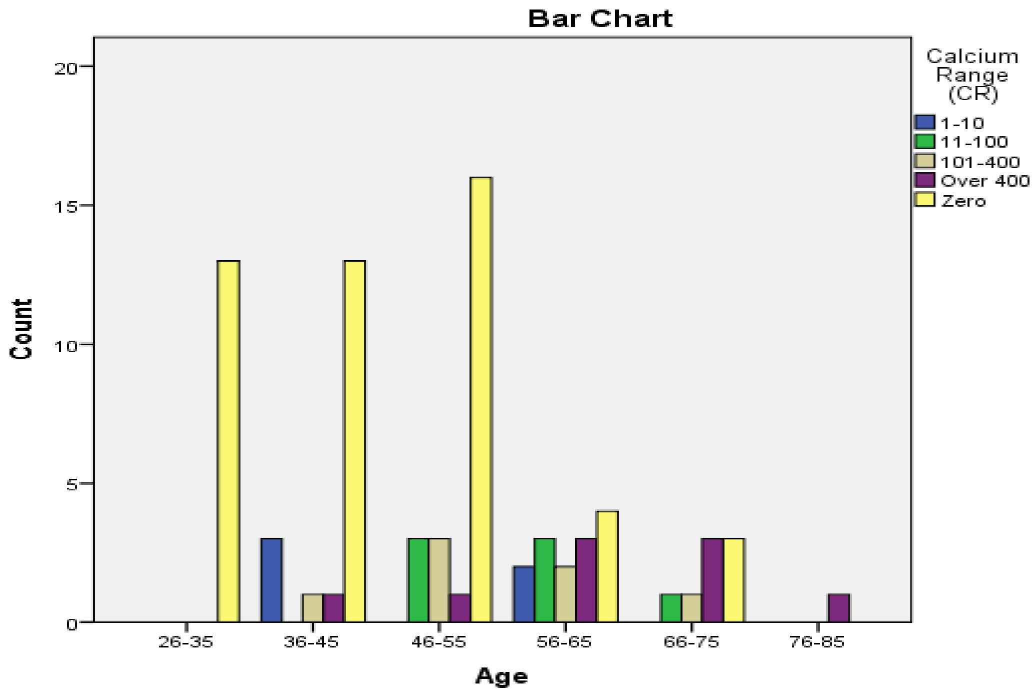

Figure (4.5) Age and Calcium Range

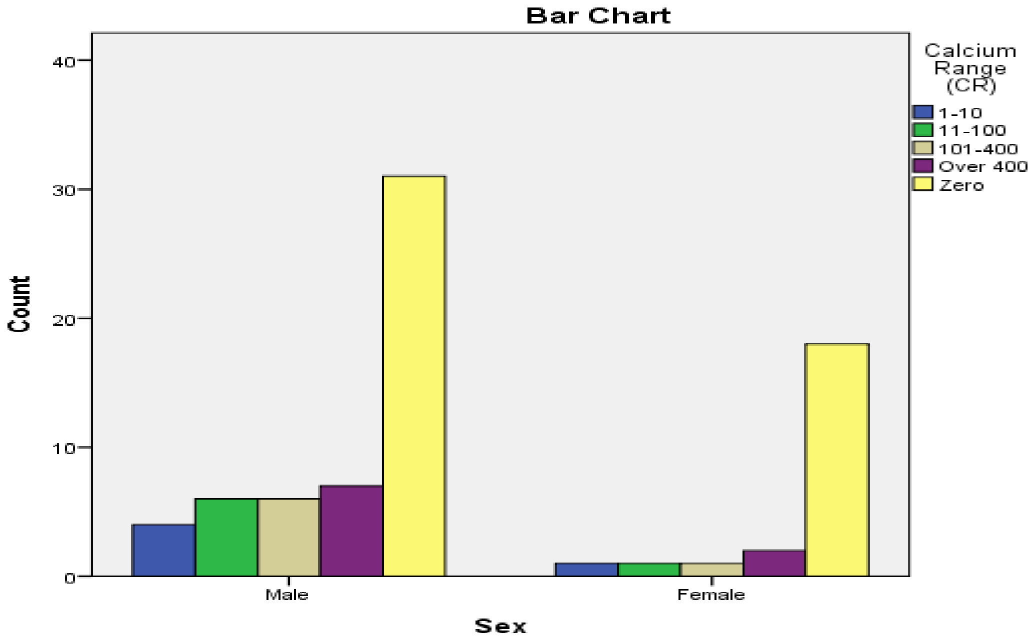

Figure (4.6) sex and calcium score range

7. Table (4.7) shows CT finding:

	Male	Female	Total
Normal	16	6	22
Stenosis	41	17	58

CHAPTER FIVE

DISCUSSION

CONCLUSIONS and RECOMMENDATIONS

Chapter five

Discussion , Conclusions and Recommendations

5.1 Discussion

As we shown in the table (4.1) above we estimate that the severity of CAD disease in male with the range of (26>=85) the greater exposed with taken consideration of the age and calcium levels, As we shown in the result table (4.1)of age and calcium levels range (cross tabulation) table show the higher range of percentage of calcium levels in male patient between the range of (46-55)with the percentage of 29.9% regarding less to the other variables that may affect to the patient stability or surgical procedures of disease or diagnosis accuracy of the device used to analyze the cases with the regard less of the minimum range of age between(76-85) ,the lower percentage of 1.3%, As the above results we conclude that the age of study including (29 to 85) and most of age are in group of (46-55), The frequency of the illustrated chart show the maximum of the severity of age (46-55).

As we shown in table (4.2) sex that we conclude that the column of cumulative percent of 80 patient are 55 Males and 25 are Females in in frequency 68.8% for males and 31.3 for females as shown in both table and graph.

According to the table (4.3) calcium score range (CR), the case processing summary we have age with regard to the right coronary artery RCA the study found that the valid percent of sample is 95.0% of the most cases with ignoring of the missing factors of the coronary artery rupture surgery which could not take in to consideration 5%.

Age with LMS which is 74 of cases has the percentage of 92.5% and the percentage of 7.5 of missing surgical procedures.

Age with left anterior descending LAD of 75 Sample with percentage of 92.5% and missing of 6.3%.

Age with left main coronary artery LM 71 cases of 93.8% with missing of 6.3%.sst pain cases The CT findings table (4.8) shows that most of the cases were stenosis as follow 41 male and 17 females and chest pain cases were 16 and 6 male and females respectively.

5.2 Conclusions

Among patients in whom a decision had already been made to obtain CCA, the study found that 64-slice CTCA was reliable for ruling out significant CAD in patients with stable and unstable anginal syndromes. A positive 64-slice CTCA scan often overestimates the severity of atherosclerotic obstructions and requires further testing to guide patient management.

All patients were examined 256- slice in cardiac imaging, prospective gating is recommended since it allows acquisition of dataset in one gantry rotation, thus providing both anatomical assessment and physiological evaluation.

Narrowing the phase window width in prospective gated protocol is recommended to reduce patient radiation dose in a single heartbeat CT angiography (256- or 320-slice CT).

The study concluded that CT is accurate in diagnosingof coronary artery diseases .

The main affected age in this study varieng between (46-55)and males were found more affected than females , Most CT findings were stenosis.

5.3 Recommendations

- I recommend that for the patients with symptoms of CAD in age between 20 to45 years avoid the risk of interventional procedures. And the high accuracy of coronary angiogram done by multi doctors (ICT Brilliance 2586 slices).
- Patients must be aware for their life style and try make it healthier.
- Patients who were smokes must quit smoking.
- Patients must increase their sport exercises and try let it daily program.

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