بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Study of Anatomic Variation of Coronary Arteries for Sudanese Using Cardiac CT Scan Angiography (CCA)

دراسة الاختلاف التشريحى للشرايين التاجيه للسودانيين بإستخدام الاشعه المقطعيه للقلب

A Proposal Submitted in Partial Fulfillment for Requirement of M.Sc Degree in Diagnostic Radiology

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الاية

بسم الله الرحمن الرحيم

قال تعالي:

(سَنُرِيهِمْ آيَاتِنَا فِي الافَاقِ وَ فِي

أَنْفُسِهِمْ حَتّيَ يتَبَيَّن لهُمْ أَنّهُ الْحَق أَولَمْ

يَكْفِ بِرَبِّكَ أَنّهُ علَى كُلِ شَئ شَهيد) صدق الله العظيم

سورة فصلت

الايه53

Dedication

To my parent who gives me hold forever

To my brothers who support and mind

To my best friends for their consecutive support

To all being who helps me to complete this study.

Acknowledgement

My acknowledgements and gratefulness at the beginning and at last is to God who gave us the gift of the mind.

My gratitude is extended to my supervisor **Dr. Ikhlas Abdelaziz** for her support and guidance, without her help this work could not have been accomplished.

My gratitude is also extended to my colleagues in Radiology Department at Alzaytouna Specialized Hospital for their continuous help and support.

Finally, my profound thanks and gratitude to everyone who encouraged me to complete this thesis.

Abstract

This descriptive analytic study aimed to study anatomic variation of coronary arteries among the Sudanese using cardiac CT angiography.

The study done for 87 patients of cardiac CTA examination, data were collect from 3D reconstruction at optimal phase, the number diagonals, obtuse marginal were account. The presence of ramus intermediate and origin of the RCA coronary artery were reported.

The study found the following results: 3 patients (3.4%) hadn't diagonal, 29 patients (33.3%) had one D, 41 patients (47.1%) had two D, 11 patients (12.6%) had three D, 3 patients (3.4) had more. 7 patients (8%) hadn't OM, 21 patients (24.1%) had one OM, 36 patients (41.4%) had two OMs, 22 patients (25.3%) had three OMs, one patient (1.1%) had more. 70 patients (80.5%) hadn't ramus and 17 patients (19.5%) had ramus intermediate. 82 patients (94.3%) had RCA originate from RCS and 5 patients (5.7%) had ectopic originate from LCA. Also the study found positive significant correlation between pathological findings and presence of ramus intermediate.

The study concluded that's wide variations on numbers of diagonals which arise from left anterior descending and obtuse marginal which arise from LCX of Sudanese. Ectopic originate of RCA was very rare. And the Sudanese con not different from other people.

The study recommended more studies about numbers coronary artery branches and it's relation to the heart size with large sample of Sudanese population.

ملخص البحث

هذه الدراسه وصفيه تحليليه هدفت الى دراسه الاختلاف التشريحى للشرايين التاجيه بين السودانيين بإستخدام الاشعه المقطعيه لشرايين للقلب.

اجريت هذه الدراسه على المرضى الذين خضعوا لفحص الاشعه المقطعيه لشرايين للقلب. جُمعت البيانات من الصوره ثلاثية الابعاد فى المرحله المثاليه، تم حساب الشريان القطرى و المنفرج الهامشى، كما تم تدوين وجود الشريان الفرعى المتوسط و تم تدوين موقع الشريان التاجي الايمن.

حصلت الدراسه على النتائج التاليه: ٣ مرضى (٣,٤ %) بدون الشريان قطريُ، ٢٩ مريض (٣٣,٣ %) كَانَ عِنْدَهُمْ واحد قطريُ ، ٤١ مريض (٤٧,١ %) كَانَ عِنْدَهُمْ إثنان قطريُ ، ١١ مريض (١٢,٦ %) كَانَ عِنْدَهُمْ ثلاثة قطريُ ، ٣ مرضى (٣,٤%) كَانَ عِنْدَهُمْ أكثرُ. ٧ مرضى (٨ %) بدون الشريان المنفرج الهامشى، ٢١ مريض (٢٤,١ %) كَانَ عِنْدَهُمْ واحد المنفرج الهامشى ، ٣٦ مريض (٤١,٤ %) كَانَ عِنْدَهُمْ إثنان المنفرجات الهامشيه، ٢٢ مريض (٢٥,٣ %) كَانَ عِنْدَهُمْ المنفرجات الهامشيه ، مريض واحد (١,١ %) كَانَ عِنْدَهُ أكثرُ. ٧٠ مريض (٨٠,٥ %) بدون الشريان الفرعى و١٧ مريض (١٩,٥ %) كَانَ عِنْدَهُمْ الفرعي المتوسّط. ٨٢ مريض (٩٤,٣ %) كَانَ عِنْدَهُمْ الوريد التاجي الايمن يَنْشأُ مِنْ الجيب التاجي الايمن و٥ مرضى (٥,٧ %) كَانَ عِنْدَهُ أصلُ منزاحُ من الوريد التاجي الايسر. كما اوجدت الدراسه علاقه قويه بين امراض الشرايين التاجيه و وجود الشريان الفرعى المتوسّط.

إستنتجتْ الدراسةُ تلك إختلافاتُ عريضةُ على عددِ الشريان القطرى و المنفرج الهامشى و الفرعى المتوسط بين السودانيينِ. الأصل المنزاح لآر سي أي مِنْ إل سي أي كَانَ نادرَ جداً. و السودانيينِ لا يختلفون عن باقى الشعوب.

أوصتْ الدراسةُ الى دِراساتَ أكثرَ حول فروعِ شريانِ التاجيةِ وعلاقتها إلى حجمِ القلبَ بعيّنةِ الكبيرةِ مِنْ السودانيين.

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List of abbreviations

AMI : Acute Myocardial infarction

AV : Atrioventricular

CCTA : Cardiac CT Angiography

CAC : Coronary artery calcification

CAD : Coronary artery diseases

CAI : Coronary Artery Imaging

CHD : Congenital Heart Defects

CM : Contrast media

CT : Computed Tomography

D : Diagonal

ECG : Electrocardiogram

IHD : Ischemic Heart Disease

LAD : left anterior descending artery

LCA : Left Coronary artery

LCS : Left coronary sinus

LCX : left Circumflex

LMT : Left mean trunk

LMCA : Left mean coronary artery

LMT : Left mean trunk

MDCT : Multidetectors computed tomography

msec : millisecond

MI : Myocardial infarction

MPR : Multiplanar reconstruction

OM : Obtuse marginal

PDA : Persistent ductus arteriosus

RCA : Right Coronary artery

RCS : Right coronary sinus

SA : Sinoatrial

Chapter one

Chapter One

1.1 Introduction

The arterial supply of the heart is provided by the right and left coronary arteries, which arise from the ascending aorta immediately above the aortic valve . The coronary arteries and their major branches are distributed over the surface of the heart, lying within subepicardial connective tissue.

Variations in the blood supply to the heart do occur, and the most common variations affect the blood supply to the diaphragmatic surface of both ventricles. Here the origin, size, and distribution of the posterior interventricular artery are variable. In right dominance, the posterior interventricular artery is a large branch of the right coronary artery. Right dominance is present in most individuals (90%). In left dominance, the posterior interventricular. (Snell 2012)

Cardiac CT has emerged as a less-invasive imaging modality for the diagnosis of coronary artery disease (CAD) and is often used to avoid coronary angiography in low- and intermediate risk patients, in particular. Continuous improvements in CT detector technology and in temporal (speed) and spatial (thin slices) resolution have resulted in clinical results with cardiac CT that are similar to those obtainable with conventional catheter coronary angiography.(Lois. 2011).

1.2 Problem statement

The widespread use of new image diagnosis techniques and development of non-aggressive treatments, the knowledge of normal coronary artery anatomy and its variation is essential.

The study attempt to explain what percentage of the prevalence of anatomic variation in Sudanese populations

1.3 Objective

3.1 General Objective

To study of anatomic variation of coronary arteries among the Sudanese.

3.2 Specific Objective

To identify the type of anatomic variation among Sudanese.

To correlate the anatomic variation with pathological findings.

1.4 Justifications

Coronary CT angiography (CTA) has become an increasingly important non-invasive modality in diagnosis of coronary artery diseases, correct interpret coronary angiography CTA require both radiologic technologist and radiologist to be familiar with normal anatomy and anatomic variants among different population.

1.5 Significant of Study

This study was reference index for anatomic variation of coronary artery for Sudanese population.

1.6 overview of study

Chapter one: is an introduction, statement of the problem, and study objectives.

Chapter two: include a comprehensive scholarly literature reviews concerning the previous studies.

Chapter three: deals with the methodology, where it provides an outline of material and methods used to acquire the data in this study as well as the method of analysis approach.

Chapter four: presenting the results

Chapter five: include discussion of results, conclusion and recommendation followed by references and appendices.

Chapter two

Literature reviews

Chapter Two

Literature reviews

2.1 Theoretical background

2.1.1 Anatomy of the heart

2.1.1.1 Superficial Landmarks

The heart is a hollow, four-chambered muscular organ located within the middle mediastinum. It is approximately the size of a large clenched fist and is situated obliquely in the chest with one third of its mass lying to the right of the median plane and two thirds to the left. The heart can be described as being roughly trapezoid shaped. The superficial relationships of the heart include the base, apex, three surfaces (sternocostal, diaphragmatic, pulmonary), and four borders (right, inferior, left, and superior). (Kelley, el. 2007)

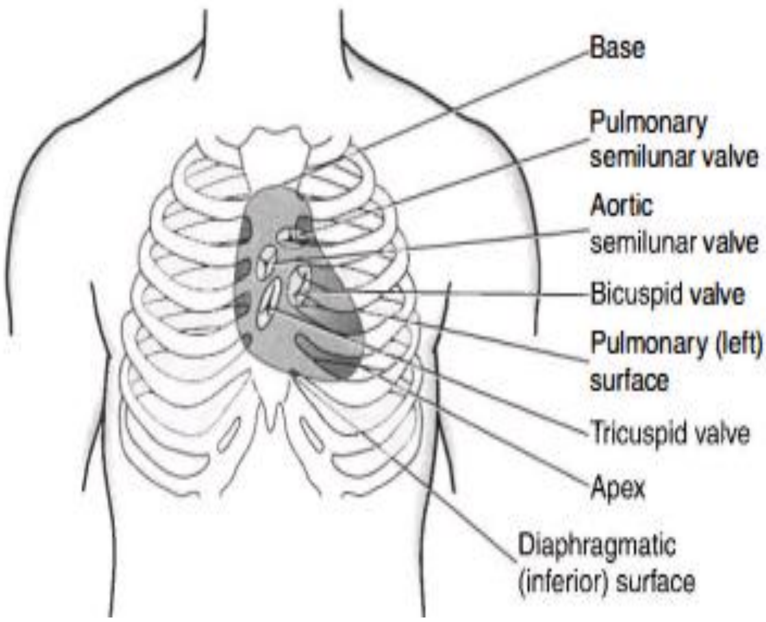


Fig (2.1): shows Superficial Landmarks

2.1.1.2 Heart Wall and chambers

The walls of the heart consist of three layers: epicardium, the thin outer layer that is in contact with the pericardium; myocardium, the thick middle layer consisting of strong cardiac muscle; and endocardium, the thin, endothelial layer lining the inner surface. The endothelial layer also lines the valves of the heart and is continuous with the inner lining of the blood vessels. (Kelley, el. 2007)

The heart is divided into four chambers the right and left atria and the right and left ventricles. The two superior collecting chambers called atria are divided by the interatrial septum. During embryonic development an oval opening exists within the interatrial septum called the foramen ovale. This opening allows blood flow between the right and left atria during fetal lung development. At birth, the foramen ovale closes, leaving a small depression in the septal wall called the fossa ovalis in the adult heart. The two inferior pumping chambers called ventricles are divided by the interventricular septum. (Kelley, el. 2007)

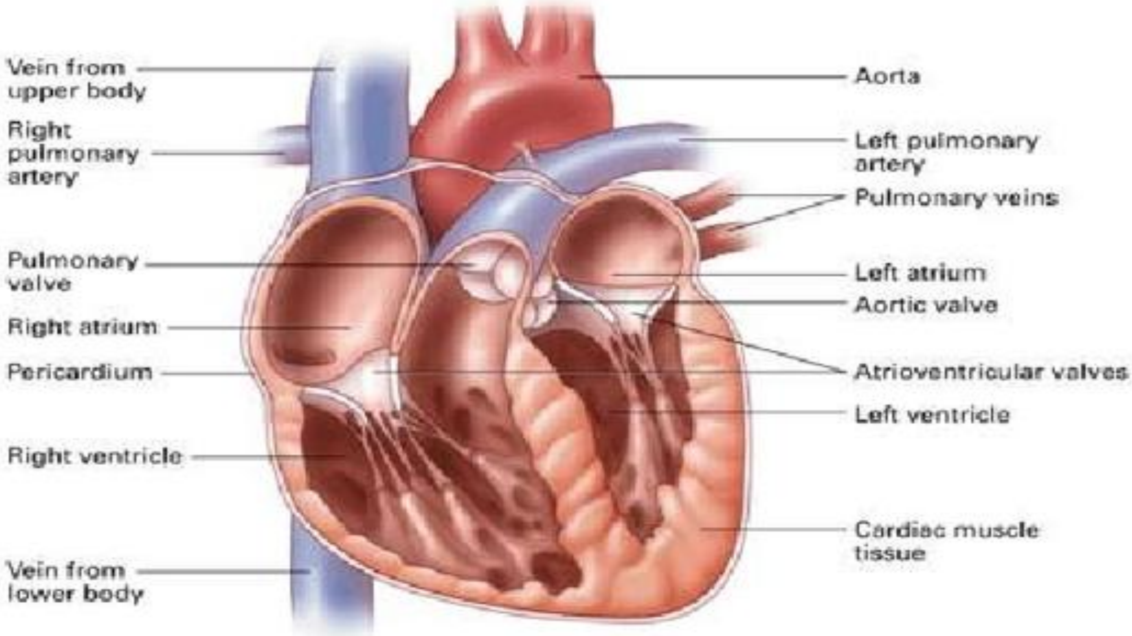


Fig 2.2 shows cardiac champers and it's wall (husmann et al 2008)

2.1.1.3 Arterial Supply of the Heart

The arterial supply of the heart is provided by the right and left coronary arteries, which arise from the ascending aorta immediately above the aortic valve. The coronary arteries and their major branches are distributed over the surface of the heart, lying within subepicardial connective tissue. (Snell 2012)

The right coronary artery arises from the base or root of the aorta (right aortic sinus) and passes anteriorly between the pulmonary trunk and right atrium to descend in the coronary (atrioventricular) groove. As it reaches the diaphragmatic surface, it gives off a right marginal branch that runs toward the apex of the heart. The right coronary artery then turns to the left and enters the posterior interventricular groove, where it gives off the posterior interventricular branch (posterior descending artery). The posterior interventricular branch continues to descend along the interventricular groove toward the apex, where it anastomoses with the left anterior descending artery of the left coronary artery. The right coronary artery and its branches supply the right atrium, right ventricle, interventricular septum, and the sinoatrial (SA) and atrioventricular (AV) nodes. It also supplies a portion of the left atrium and ventricle. (Snell 2012)

The left coronary artery arises from the left aortic sinus and passes to the left between the pulmonary trunk and left atrium to reach the coronary groove. Soon after reaching the coronary

groove, the left coronary artery divides into the circumflex and left anterior descending (interventricular) arteries. The circumflex artery winds around the left border of the heart to the posterior surface, where it gives off the left marginal artery. The left anterior descending artery (LAD) descends in the anterior interventricular groove toward the apex of the heart, where it reaches the diaphragmatic surface to anastomose with the posterior descending artery. The left coronary artery and its branches supply the interventricular septum, including the AV bundles, and most of the left ventricle and atrium. (Snell 2012)

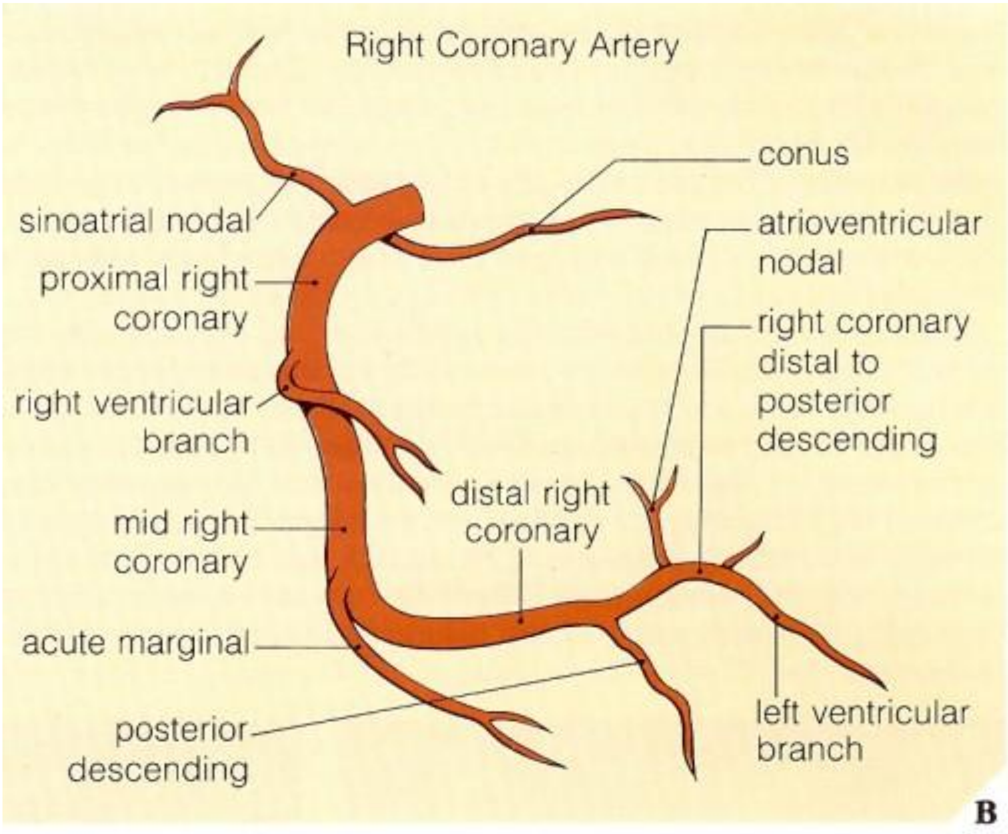


Fig (2.3) shows right coronary artery (choen R et al 2014).

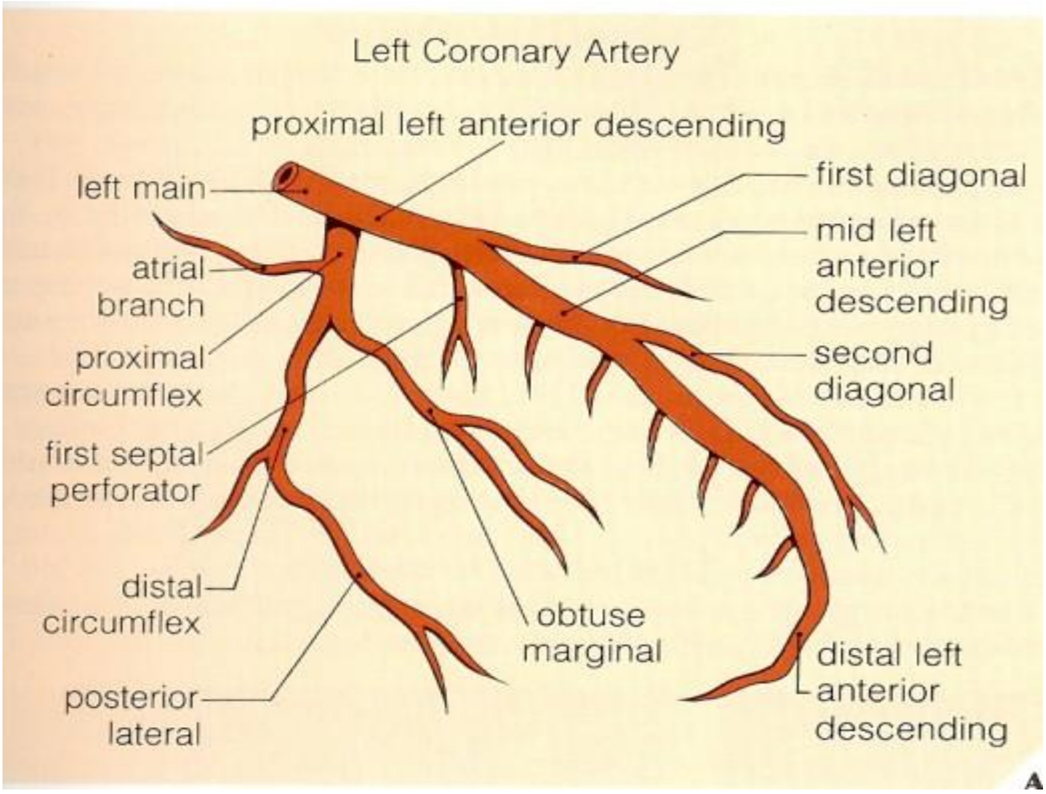
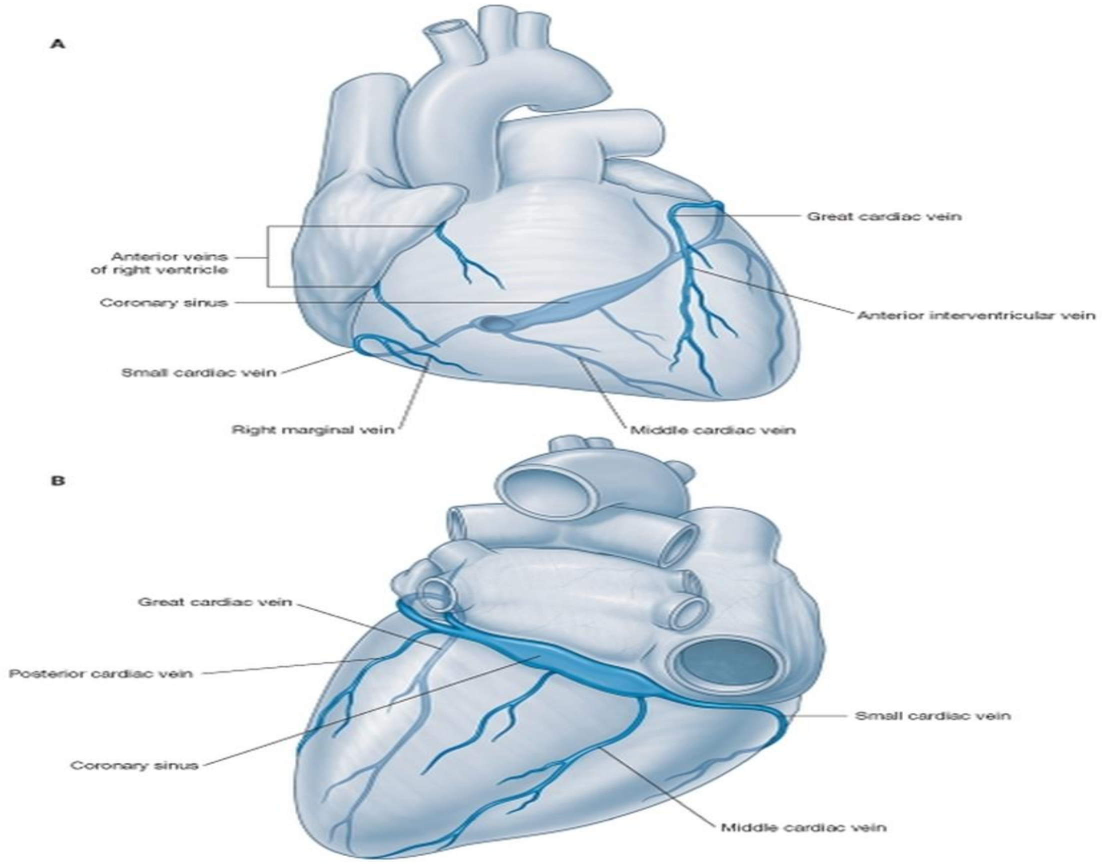


Fig (2.4) shows left coronary artery (choen R et al 2014).

2.1.1.4 Venous Drainage of the Heart

Most blood from the heart wall drains into the right atrium through the coronary sinus, which lies in the posterior part of the atrioventricular groove and is a continuation of the great cardiac vein. It opens into the right atrium to the left of the inferior vena cava. The small and middle cardiac veins are tributaries of the coronary sinus. The remainder of the blood is returned to the right atrium by the anterior cardiac vein and by small veins that open directly into the heart chambers. (Snell 2012)



fig(2.5) shows venous drainage the heart

2.1.2 Physiology of the heart

2.1.2.1 Nerve Supply of the Heart

The heart is innervated by sympathetic and parasympathetic fibers of the autonomic nervous system via the cardiac plexuses situated below the arch of the aorta. The sympathetic supply arises from the cervical and upper thoracic portions of the sympathetic trunks, and the parasympathetic supply comes from the vagus nerves. (Stanfield, et al .2009)

The postganglionic sympathetic fibers terminate on the sinuatrial and atrioventricular nodes, on cardiac muscle fibers, and on the coronary arteries. Activation of these nerves results in cardiac acceleration, increased force of contraction of the cardiac muscle, and dilatation of the coronary arteries.

The postganglionic parasympathetic fibers terminate on the sinuatrial and atrioventricular nodes and on the coronary arteries. Activation of the parasympathetic nerves results in a reduction in the rate and force of contraction of the heart and a constriction of the coronary arteries. (Stanfield, et al .2009)

Afferent fibers running with the sympathetic nerves carry nervous impulses that normally do not reach consciousness. However, should the blood supply to the myocardium become impaired, pain impulses reach consciousness via this pathway. Afferent fibers running with the vagus nerves take part in cardiovascular reflexes. (Stanfield, el .2009)

2.1.2.2 Action of the Heart

The heart is a muscular pump. The series of changes that take place within it as it fills with blood and empties is referred to as the cardiac cycle. The normal heart beats 70 to 90 times per minute in the resting adult and 130 to 150 times per minute in the newborn child. (Stanfield, et al .2009)

Blood is continuously returning to the heart; during ventricular systole (contraction), when the atrioventricular valves are closed, the blood is temporarily accommodated in the large veins and atria. Once ventricular diastole (relaxation) occurs, the atrioventricular valves open, and blood passively flows from the atria to the ventricles. When the ventricles are nearly full, atrial systole occurs and forces the remainder of the blood in the atria into the ventricles. The sinuatrial node initiates the wave of contraction in the atria, which commences around the openings of the large veins and milks the blood toward the ventricles. By this means, blood does not reflux into the veins.

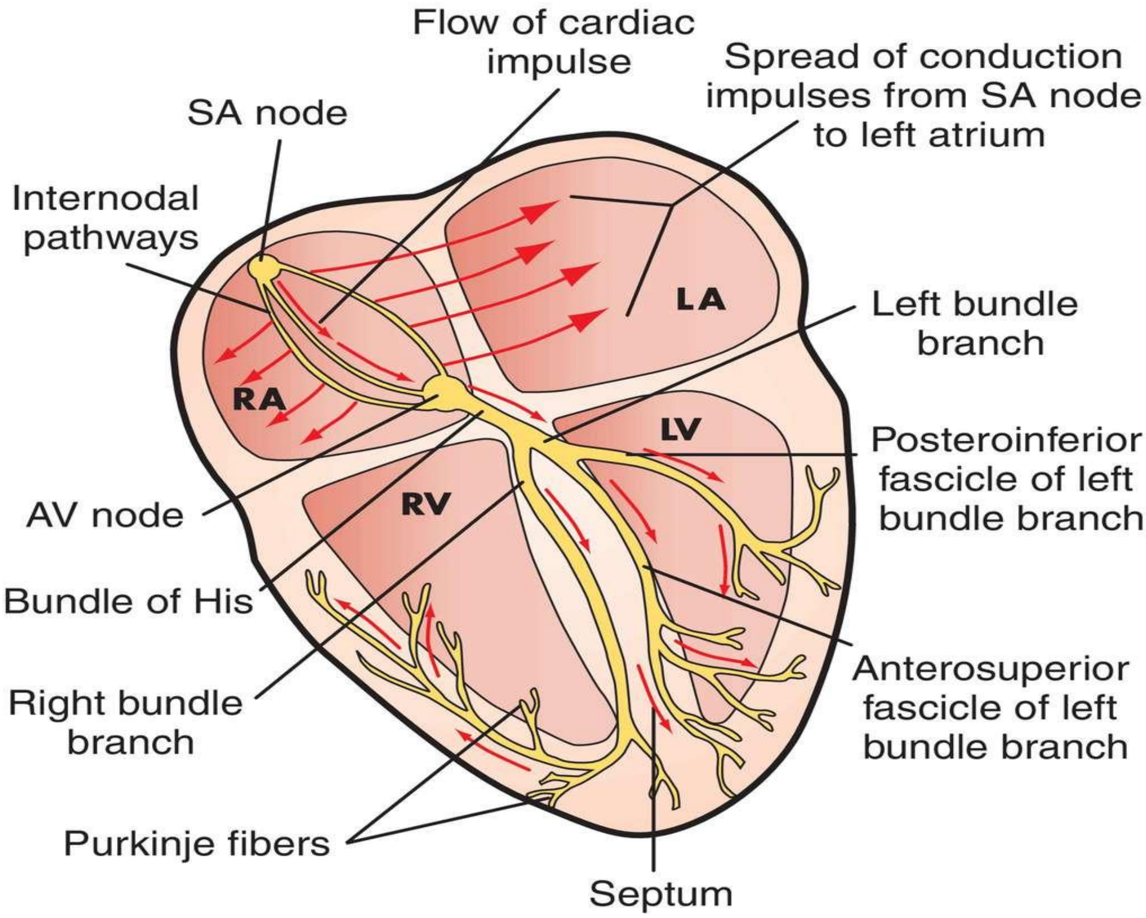
The cardiac impulse, having reached the atrioventricular node, is conducted to the papillary muscles by the atrioventricular bundle and its branches. The papillary muscles then begin to contract and take up the slack of the chordae tendineae. Meanwhile, the ventricles start contracting and the atrioventricular valves close. The spread of the cardiac impulse along the atrioventricular bundle and its terminal branches, including the Purkinje fibers, ensures that myocardial contraction occurs at almost the same time throughout the ventricles. (Stanfield, et al .2009)

Once the intraventricular blood pressure exceeds that present in the large arteries (aorta and pulmonary trunk), the semilunar valve cusps are pushed aside, and the blood is ejected from the heart. At the conclusion of ventricular systole, blood begins to move back toward the ventricles and immediately fills the pockets of the semilunar valves. The cusps float into apposition and completely close the aortic and pulmonary orifices. (Stanfield, et al .2009)

2.1.2.3 Conducting System of the Heart

The normal heart contracts rhythmically at about 70 to 90 beats per minute in the resting adult. The rhythmic contractile process originates spontaneously in the conducting system and the impulse travels to different regions of the heart, so the atria contract first and together, to be followed later by the contractions of both ventricles together. The slight delay in the passage of the impulse from the atria to the ventricles allows time for the atria to empty their blood into the ventricles before the ventricles contract. (Stanfield, et al .2009)

The conducting system of the heart consists of specialized cardiac muscle present in the sinuatrial node, the atrioventricular node, the atrioventricular bundle and its right and left terminal branches, and the subendocardial plexus of Purkinje fibers (specialized cardiac muscle fibers that form the conducting system of the heart).(Stanfield, et al .2009)



fig(2.6) shows nerve conducting the heart (Aeboah , et al 2014)

2.1.3 Pathology of the heart

2.1.3.1Congenital abnormalities of the heart and great vessels

The complex development of the heart and major arteries accounts for the multitude of congenital abnormalities which may affect these structures, either alone or in combination. (Huxley RR et al , 2011).

Dextro-rotation of the heart means that this organ and its emerging vessels lie as a mirror-image to the normal anatomy. It may be associated with reversal of all the intra-abdominal organs. (Huxley RR et al , 2011).

Septal defects At birth, the septum primum and septum secundum are forced together, closing the flap valve of the foramen ovale. Fusion usually takes place about 3 months after birth. In about 10% of subjects, this fusion may be incomplete.

Congenital pulmonary stenosis may affect the trunk of the pulmonary artery, its valve or the infundibulum of the right ventricle. If stenosis occurs in conjunction with a septal defect, the compensatory hypertrophy of the right ventricle (developed to force blood through the pulmonary obstruction) develops a sufficiently high pressure to shunt blood through the defect into the left heart; this mixing of the deoxygenated right heart blood with the oxygenated left-sided blood results in the child being cyanosed at birth. (Huxley RR et al , 2011).

Persistent ductus arteriosus is a relatively common congenital defect. If left uncorrected, it causes progressive work hypertrophy of the left heart and pulmonary hypertension. (Huxley RR et al , 2011).

Aortic coarctation is thought to be due to an abnormality of the obliterative process which normally occludes the ductus arteriosus. There may be an extensive obstruction of the aorta from the left subclavian artery to the ductus, which is widely patent and maintains the circulation to the lower parts of the body; often there are multiple other defects and frequently infants so afflicted die at an early age. More commonly there is a short segment involved in the region of the ligamentum arteriosum or still patent ductus. Fig (2.7) (Huxley RR et al , 2011).

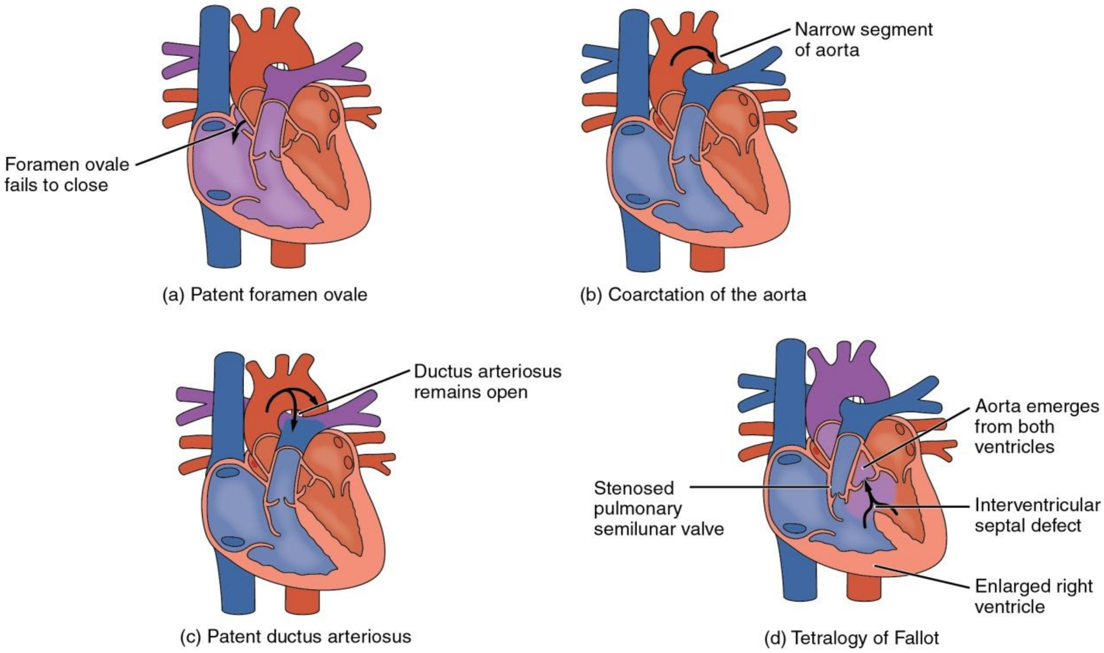


Fig (2.7) shows Congenital Heart Defects (Huxley RR et al , 2011).

2.1.3.2 Coronary artery diseases (CAD)

Coronary artery disease (CAD), also known as ischemic heart disease (IHD), is a group of diseases that includes: stable angina, unstable angina, myocardial infarction, and sudden cardiac death. It is within the group of cardiovascular diseases of which it is the most common type. A common symptom is chest pain or discomfort which may travel into the shoulder, arm, back, neck, or jaw. Occasionally it may feel like heartburn. Usually symptoms occur with exercise or emotional stress, last less than a few minutes, and get better with rest. Shortness of breath may also occur and sometimes no symptoms are present. The first sign is occasionally a heart attack. Other complications include heart failure or an irregular heartbeat. (HuxleyRR et al,2011).

Angina pectoris, commonly known as angina, is the sensation of chest pain, pressure, or squeezing, often due to not enough blood flow to the heart muscle as a result of obstruction or spasm of the coronary arteries. While angina pectoris can occur due to anemia, abnormal heart rhythms and heart failure, its main cause is coronary artery disease, an atherosclerotic process affecting the arteries feeding the heart. (HuxleyRR et al,2011).

Myocardial infarction (MI) or acute myocardial infarction (AMI), commonly known as a heart attack, occurs when blood flow stops to a part of the heart causing damage to the heart muscle. The mechanism of an MI often involves the complete blockage of a coronary artery caused by a rupture of an atherosclerotic plaque.

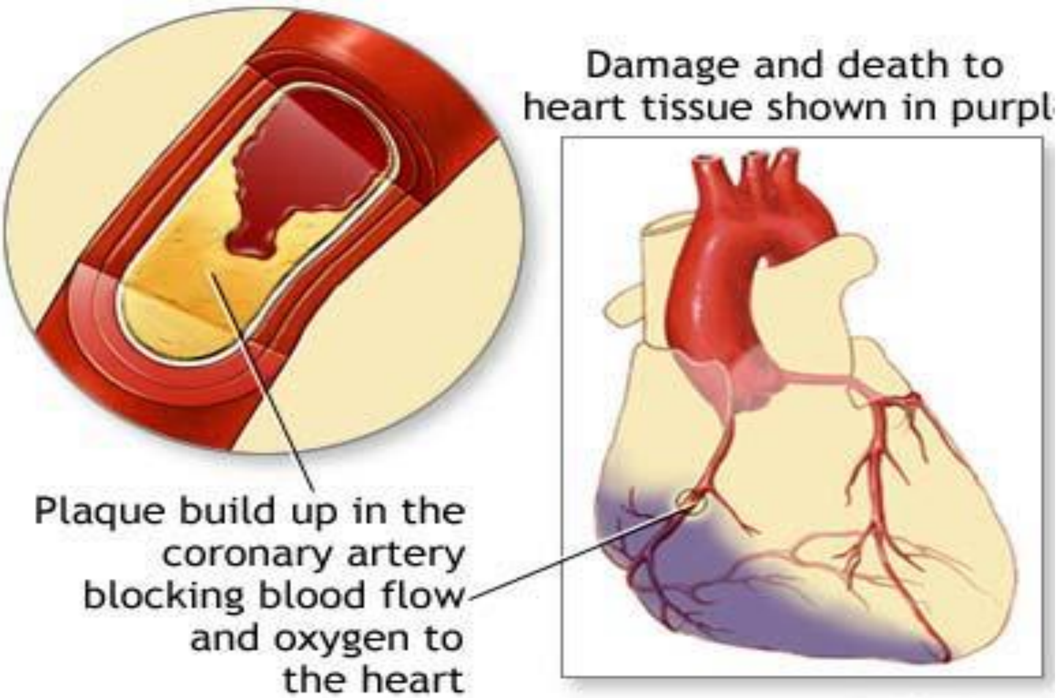


Fig (2.8) shows myocardiac infarction

2.1.4 Cardiac CT scans angiography (CCTA)

There are two general types of cardiac applications: coronary artery calcification and coronary artery imaging. Strictly, coronary artery calcification exams belong to the category of screening, since they generally involve the scanning of asymptomatic patients. (Hsieh. 2009)

2.1.4.1 Coronary artery calcification (CAC)

The amount of calcium present in the arteries may be an important indicator of coronary artery disease and therefore one's risk of a heart attack. In recent studies, the negative predictive ability of CAC has been shown to be valuable—that is, the lack of artery calcification is a good predictor of a low probability of a coronary event. The presence of calcium is the nature of atherosclerosis: a chronic process of injury and healing of the blood vessel walls. Part of the healing process involves calcium deposition to the injured area. (Hsieh. 2009).

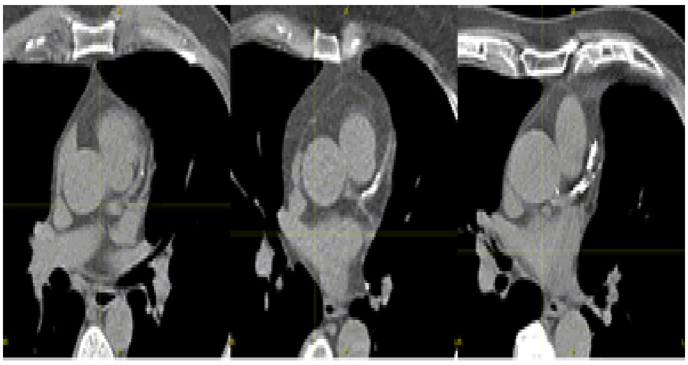


Fig (2.9) shows degree of calcification within LAD

2.1.4.2 Coronary Artery Imaging (CAI)

The objective of CAI is to visualize the vascular structure of the heart, which allows physicians to detect stenosis (narrowing of a vessel) and plaque. It may also enable physicians to examine the dynamic motion of the muscles and detect abnormalities. This type of examination is typically conducted with contrast

injection. From a purely technological point of view, the scanner's performance requirements for CAI are higher than those for CAC for two reasons. To visualize the narrowing of a small vessel, CT scans must not only freeze the cardiac motion (which requires a higher temporal resolution) but also accurately depict the size of the vessel (which requires a higher spatial resolution). For calcification screening, the scanner's ability to freeze cardiac motion is less important because the scores are averaged over a small region. (Hsieh. 2009)

2.1.4.3 Data acquisition and reconstruction

2.1.4.3.1 ECG Gating

To reduce the impact of cardiac motion in CAI, the data acquisition typically relies on ECG signals to indicate the phase of the heart, A cardiac cycle has two phases in which the heart motion is relatively small: the end-systolic and end-diastolic phases. During these phases, the heart undergoes quiescent periods of cardiac motion when the related artifacts and degradation can be minimized. On an ECG trace, the mid-diastolic phase generally corresponds to a region between 70 and 75% of the R-R interval, and the end systolic phase is between 30 to 35% of the R-R interval. (Loise 2011)

The two techniques that attempt to minimize cardiac motion in the study by selecting (or acquiring) images during cardiac segments with relatively slow cardiac motion are called prospective ECG triggering and retrospective ECG gating. Prospective ECG gating, also known as sequential or cine-mode scanning, seeks to identify the areas of lowest cardiac motion and acquire images only in those portions of the cardiac cycle, which minimizes radiation exposure. Retrospective gating methods acquire images throughout the cardiac cycle while the patient's ECG is recorded. Images are later reconstructed to create image sets at any desired phase of the cardiac cycle. (Loise 2011) Fig (2.10)

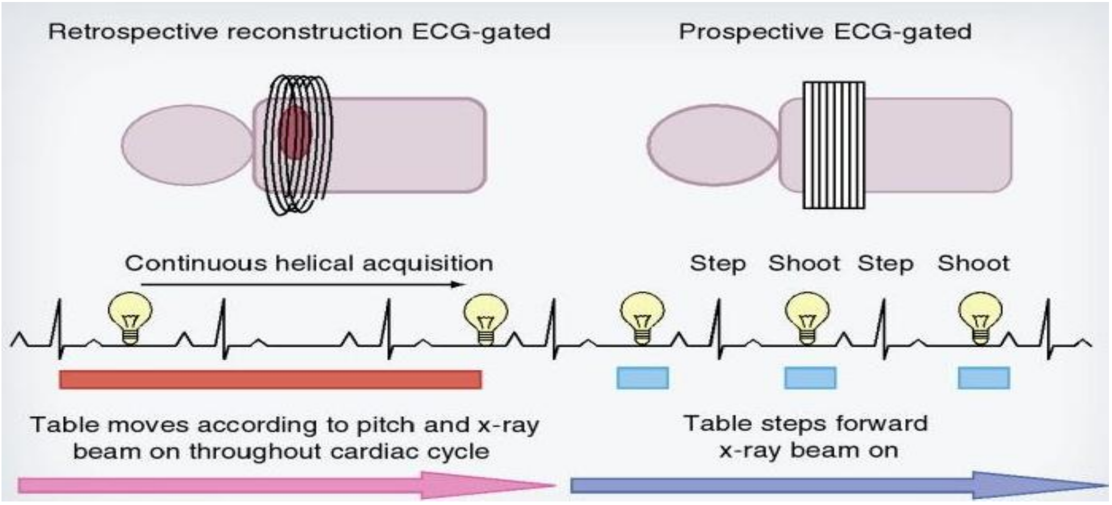


Fig (2.10) shows type of ECG Gated

2.1.4.3.2 Temporal resolution improvement

Temporal resolution is defined as the length of time required to image an object. In order to image a moving structure with a high degree of temporal resolution, i.e., without motion artifacts, one must acquire the image faster than that structure is moving. In imaging, the gold standard for temporal resolution has been set by conventional angiography which has temporal resolution of about 20 msec. When considering MDCT scanners, the parameters which affect temporal resolution are speed of gantry rotation, pitch, the ability to acquire image data in a segmented fashion. Current technology allows gantry rotation times as low as 0.33 sec. Speed of gantry rotation is limited by the g forces produced by the rotating gantry upon the x-ray tube; for example at a rotation speed of .5 sec exceeds 10 g. (Loise 2011)

It is not necessary to use the data acquired in a full 360 degree rotation in order to reconstruct an image of the heart. Therefore, in a method referred to as segmenting the scan, single source MDCT scanners use the data acquired in 180 degrees of rotation (½ scan). Using a ½ scan technique, twice the image data is acquired during a full rotation or 360 degrees. This method allows faster scanning, improving the temporal resolution to 165 msec for a single source scanner When the scanner gantry rotates 360 degrees in 0.33 sec, the temporal resolution of the scan is 330 msec which is decreased to 33 msec when ECG gating reconstruction divides the cardiac cycle into 10 segments of the R-R interval, approaching the temporal resolution of conventional angiography. (Loise .2011)

2.1.4.3.3 Spatial resolution improvement

Although much attention has been paid to the temporal resolution aspect of cardiac imaging, spatial resolution plays an equally important role in CAI. Many applications require estimations of the percentage stenosis on relatively small vessels of 2 mm or less diameter. To differentiate between a 25%, 50%, and 75% stenosis, the system must be capable of resolving structures smaller than 0.5 mm. Spatial resolution plays an important role in reducing blooming artifacts when high-contrast objects are imaged. (Hsieh. 2009)

2.1.4.4 Artifact

2.1.4.4.1 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. Beta blockers are helpful in reducing heart rate variability and avoiding stairstep artifacts. Fig (2.11) (Kitagawa k , et al 2009).

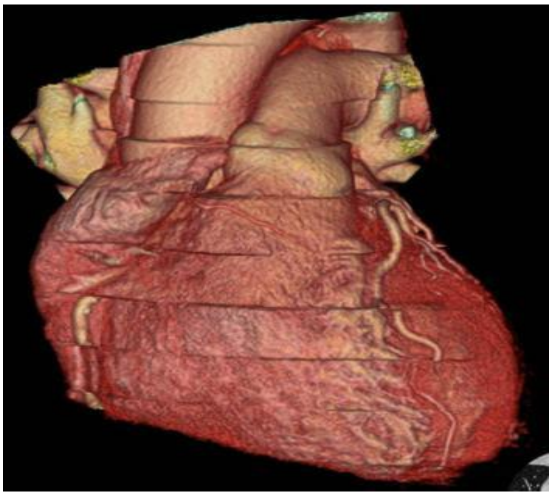


Fig (2.11) shows Stairstep artifact

2.1.4.4.2 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. Motion can be minimized by reconstructing the data during a phase where there is minimal motion. (Kitagawa k , et al 2009).

2.1.4.4.3 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).

2.1.4.4.4 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).

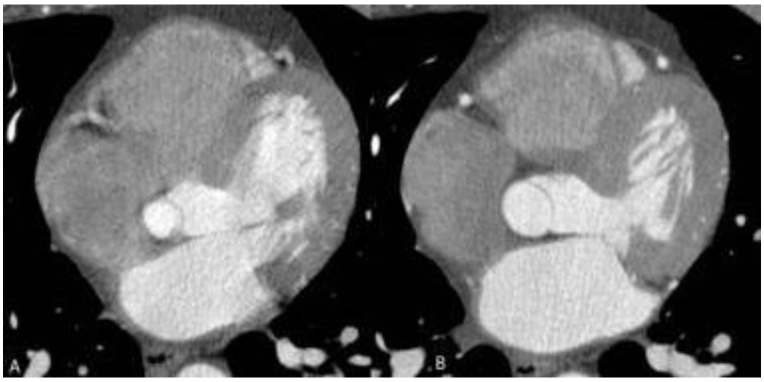


Fig (2.12) shows coronary motion artifact

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).

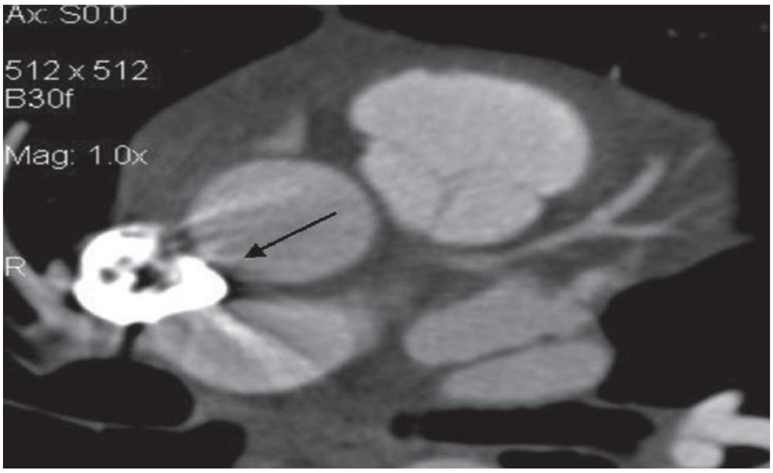


Fig (2.13) shows streak artifact

Multiplanar reconstruction (MPR) CT image demonstrates streak artifact in superior vena cava as result of administration of CM without NS cleanup(Kitagawa k , et al 2009).

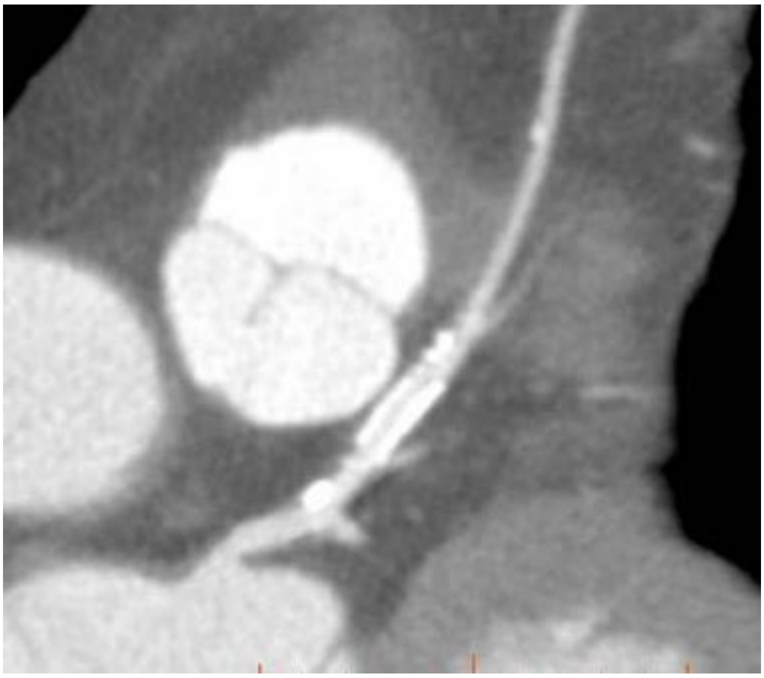


Fig (2.14) shows blooming artifact

Curve 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).

2.2 Previous studies

Sherif Fathy Abdelrahman, Mohamed Ali Salem …et al. Coronary arteries variants & congenital anomalies; using MDCT in 100 of the Egyptian population. At 2015 they found 31% had one diagonal arising from the LAD, 47.3% had two diagonals, 17.3% had three diagonal branches, 4.3% had four diagonals and 0.1% had five diagonal branches arising from the LAD.

3.1% of the cases had no OM branch, 59.9% had one OM branch, 31.7% had two OM branches, 5.1% had three OMs, and 0.2% had four OM branches arising from the LCX. 70.1% had no ramus branch, 30.3% had one ramus branch while 0.9% had two rami arising from the LMT.

Anomalous coronary artery origin from an improper sinus was seen in 4 patients (0.4%) with anomalous RCA from the left coronary sinus anterior to the origin of the LMT.

Cengiz Erol, Mustafa Koplay, Yahya Paksoy. Evaluation of anatomy, variation and anomalies of the coronary arteries with coronary computed tomography angiography for Turkish population. At 2013 they found: The LMCA originates from the RCS in 0.09-0.2% of patients and the RCA originates from the LCS in 0.03-0.5% of patients.

Chapter Three

Chapter three

Materials & methods

3.1 Material

3.1.1 Machine

All CT examinations were perform by a 64-slice CT scanner (Aquillon 64, Toshiba Medical Systems, Tochigi, Japan) with retrospective ECG gating.

3.1.2 Populations of study

Population of this study were normal patient that undergo coronary angiography.

3.1.3 Sample size

87 patients were performed CT scan coronary angiography.

3.2 Method

3.2.1 Techniques

80–85 mL of contrast media with high iodine concentration was injected with a flow rate of 5 mL/s, followed by a 20 mL saline. The scan timing will determine with automated bolus tracking technique by placing the region of interest over the proximal descending aorta and setting the trigger threshold to 180 HU. Images were reconstructed at the optimal phase and transfer to another workstation. 3D was performed with high resolution and multiple views were taken in order to account the number diagonals, obtuse marginal. The presence of ramus intermediate and origin of the RCA coronary arteries were reported.

3.2.2 Images interpretations

Images were interpreted by consultant radiologist and images with surgical bypass and stents were excluded.

3.2.3 Data collection

Data were collect randomly according to age by data collection sheets.

Chapter four

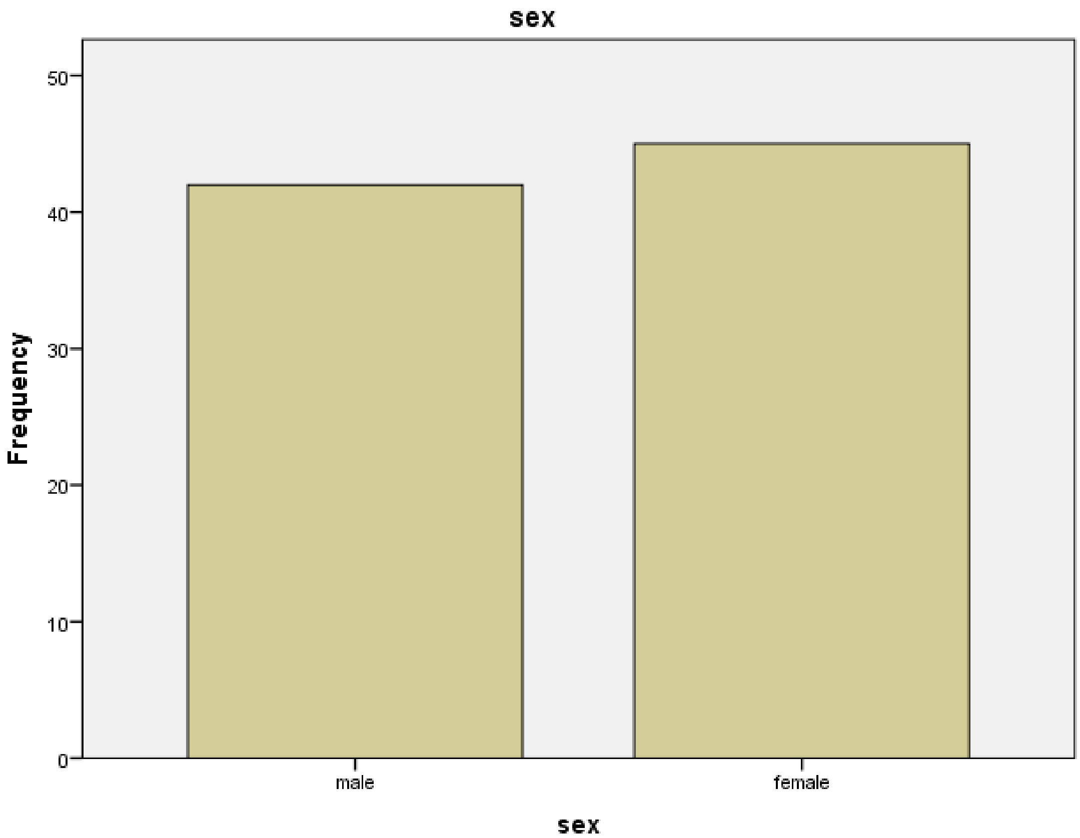
Results

Chapter four

Results

Table (4.1): Represents frequency distribution and percent of sex

Sex	Frequency	Percent
Male	42	48.3%
Female	45	51.7%
Total	87	100.0%



Fig(4.15) Shows sex distribution

Table 4.2 Represents frequency distribution and percent of age groups

Age	Frequency	Percent
40-50	19	21.8%
50-59	31	35.6%
more than 60	37	42.5%
Total	87	100.0%

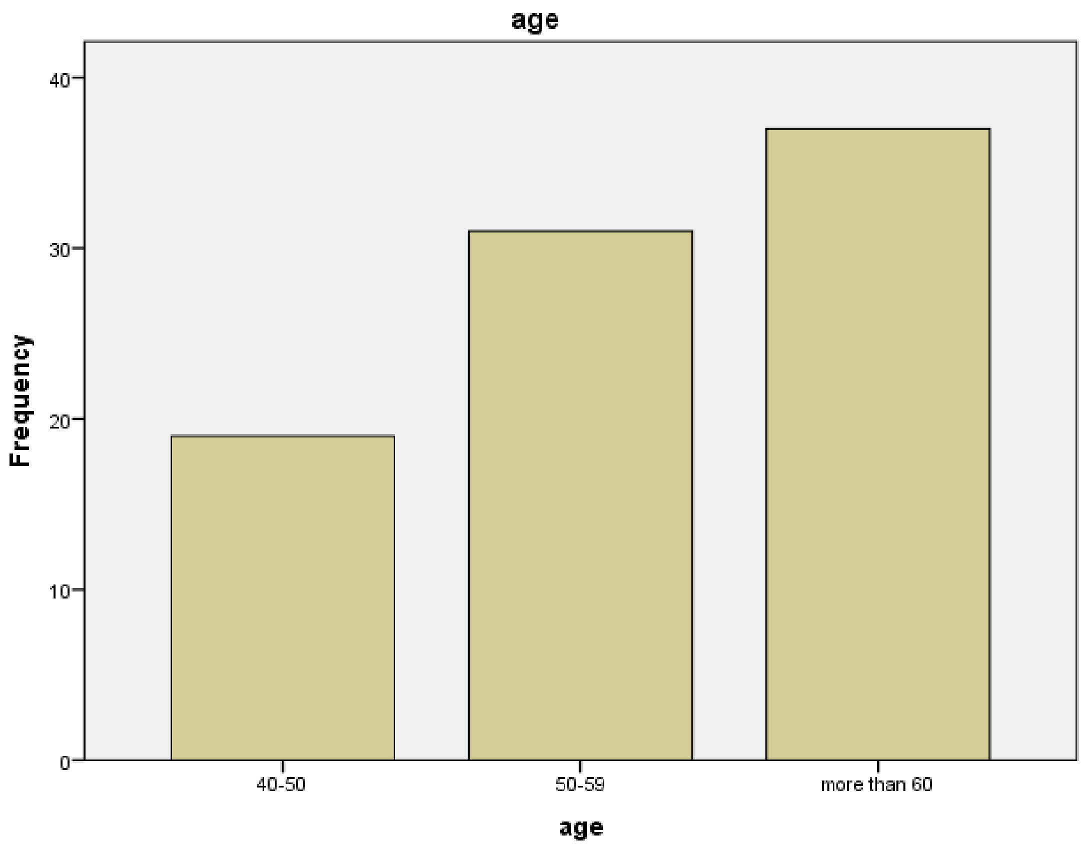


Fig 4.16 Shows age groups distribution

Table (4.3) Represents frequency distribution of diagonal numbers

	Frequency	Percent
Absent	3	3.4%
One	29	33.3%
Two	41	47.1%
Three	11	12.6%
More	3	3.4%
Total	87	100.0%

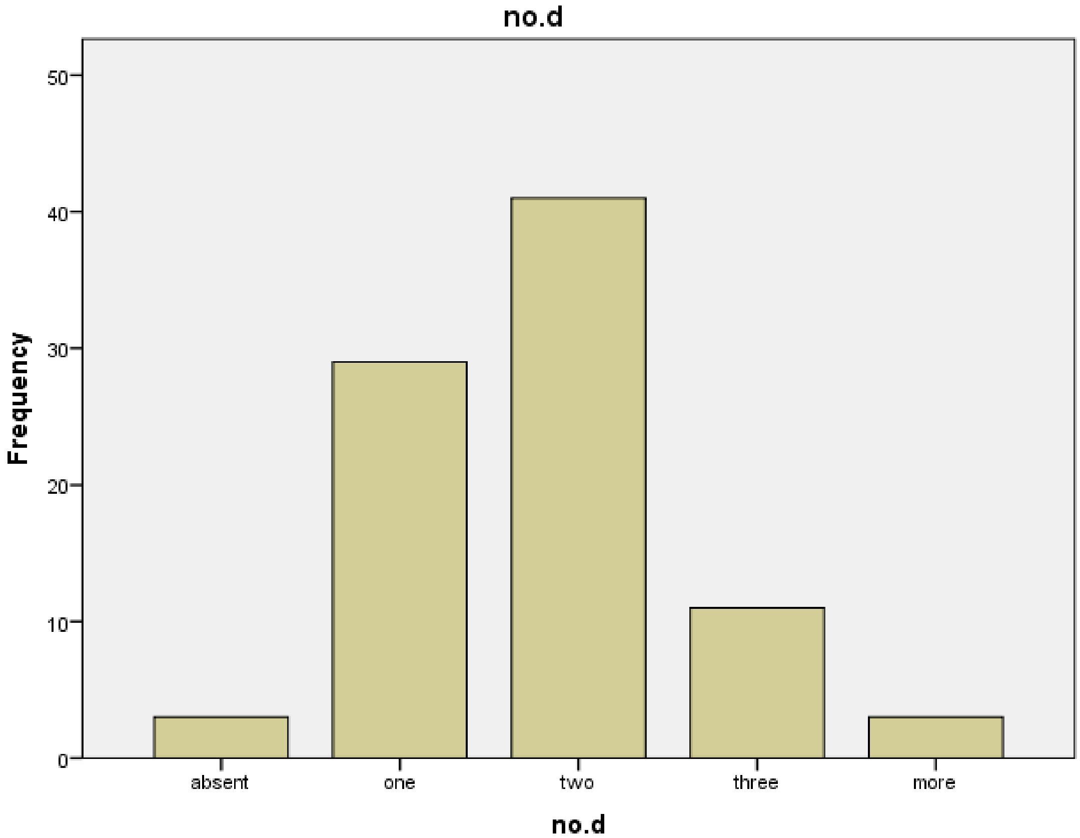


Fig (4.17) Shows distribution of diagonal numbers

Table (4.4) Represents frequency distribution of OMs numbers

		Frequency	Percent
Valid	absent	7	8.0%
	one	21	24.1%
	two	36	41.4%
	three	22	25.3%
	more	1	1.1%
	Total	87	100.0%

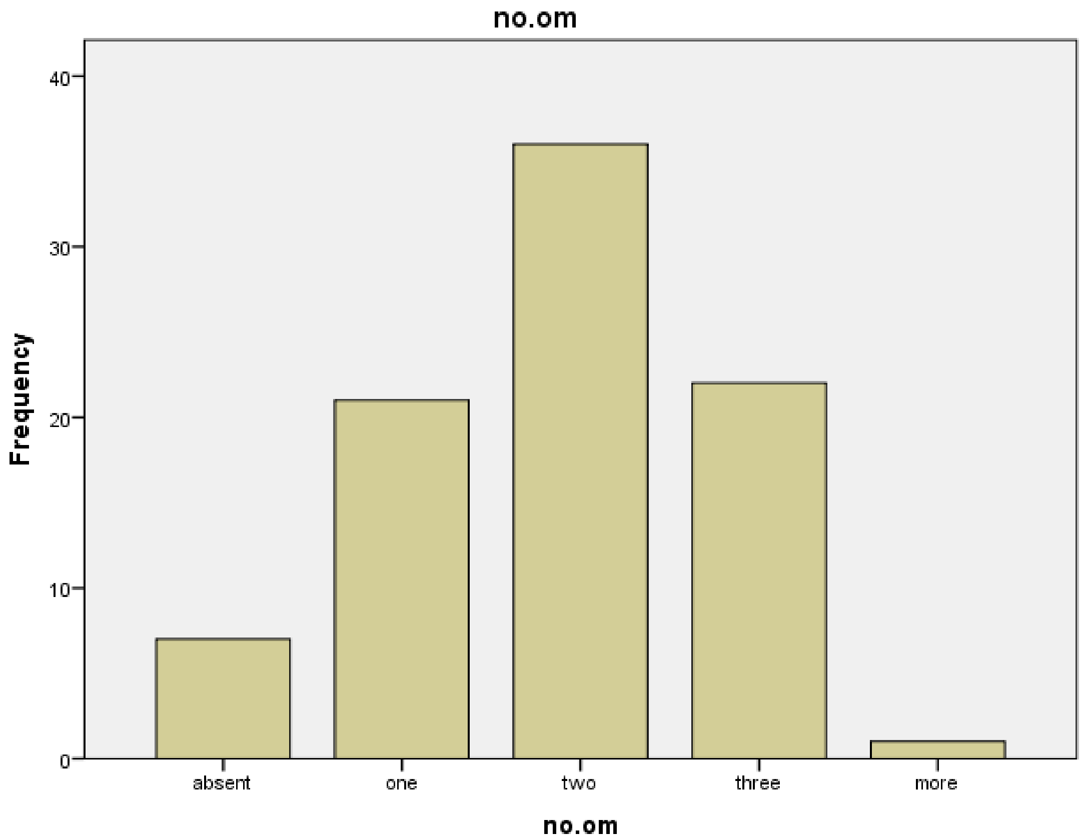


Fig (4.18) Shows distribution of OMs numbers

Table (4.5) Represents frequency distribution of presence of ramus

		Frequency	Percent
Valid	No	70	80.5%
	Yes	17	19.5%
	Total	87	100.0%

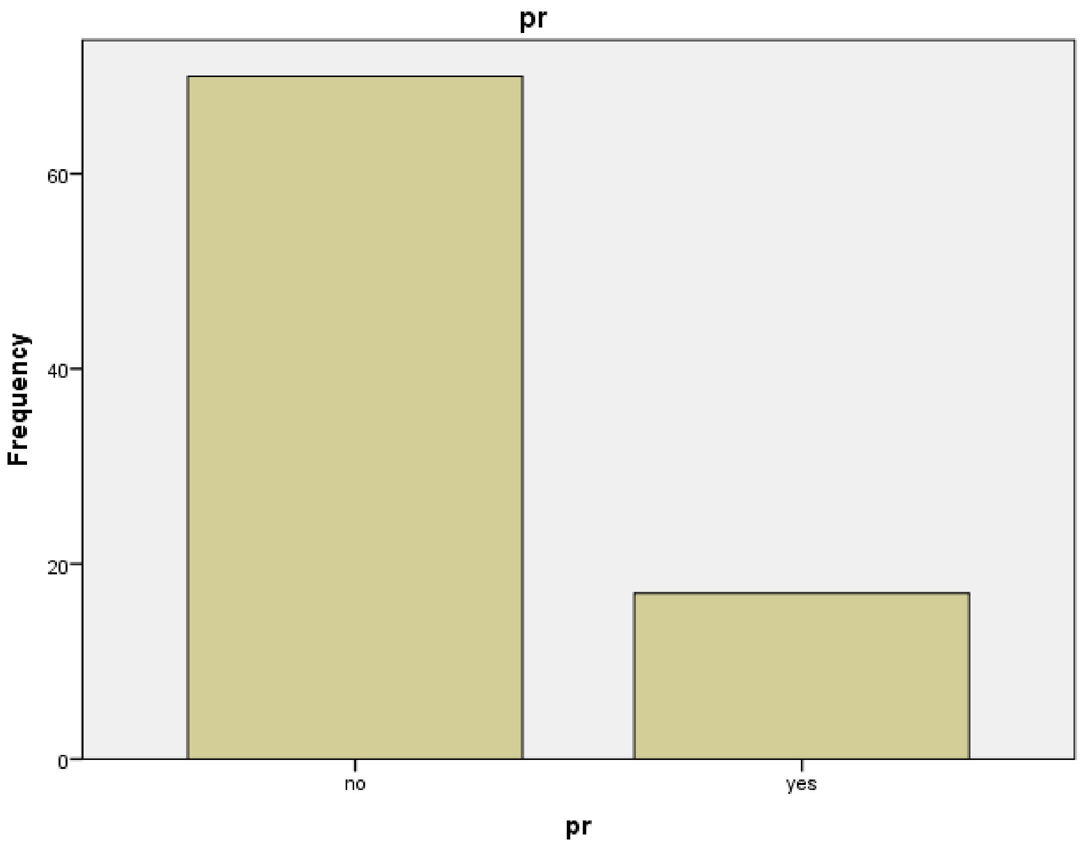


Fig (4.19) shows distribution of patients with ramus "yes" and without "no"

Table (4.6) Represents frequency distribution of RCA origination

		Frequency	Percent
Valid	normal	82	94.3%
	from LCA	5	5.7%
	Total	87	100.0%

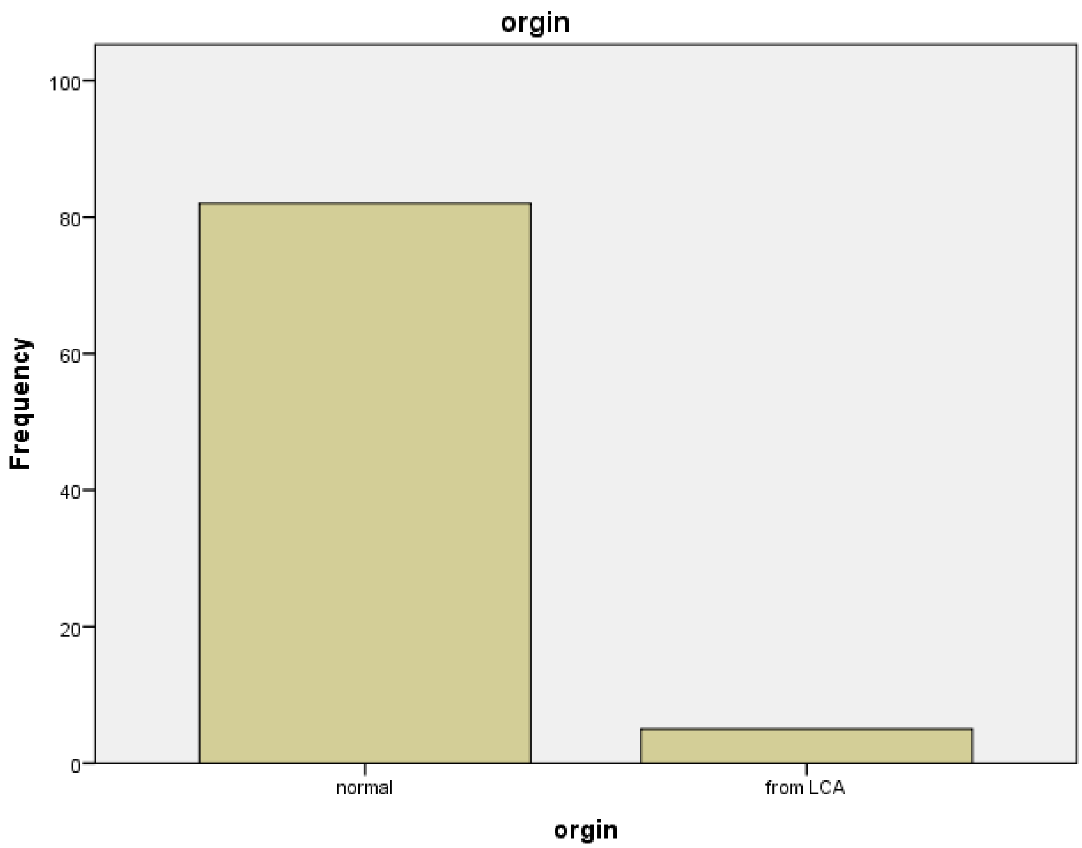


Fig (4.20) Shows distribution of RCA origination from "LCA" or "normal origin"

Table (4.7) Represents frequency distribution of pathological findings

		Frequency	Percent
Valid	No	64	73.6
	Yes	23	26.4
	Total	87	100.0

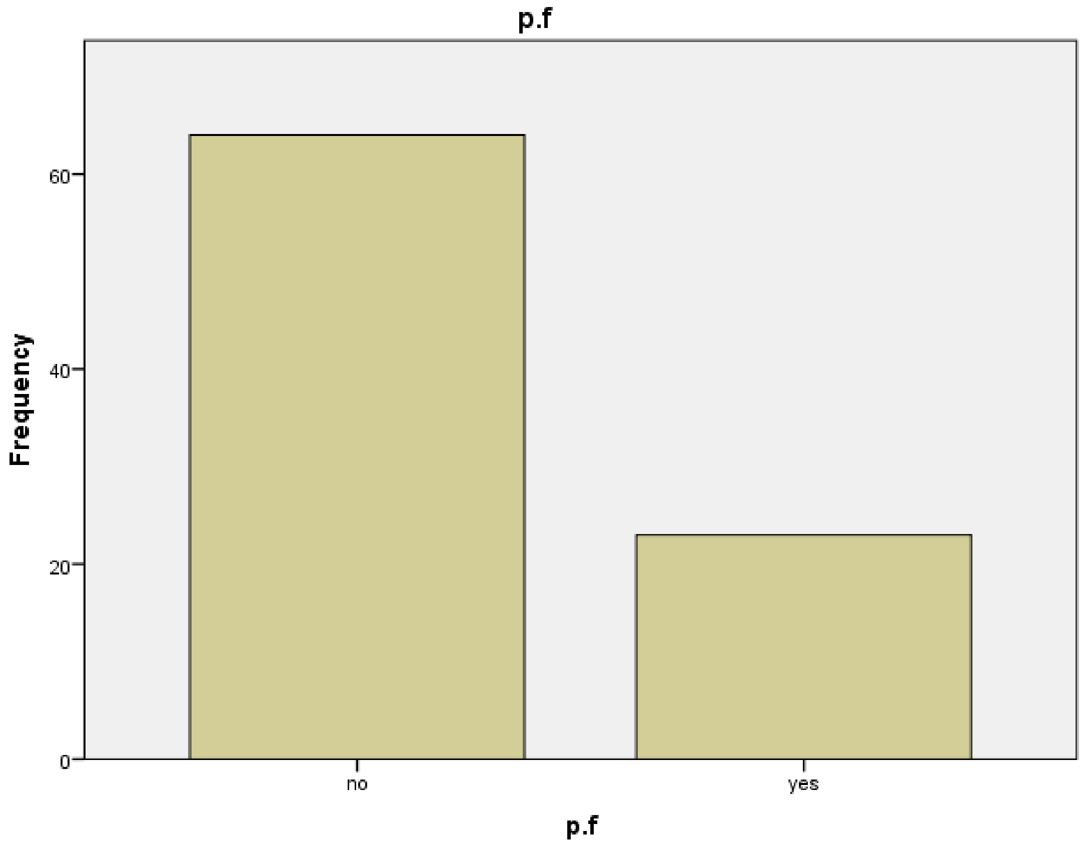


Fig (4.20) Shows distribution of patients with pathological findings "yes" and without "no"

Table (4.8) represents correlations of pathological findings with presences of ramus

		Pr	p.f
Pr	Pearson Correlation	1	.296**
	Sig. (2-tailed)		.005
	N	87	87
p.f	Pearson Correlation	.296**	1
	Sig. (2-tailed)	.005	
	N	87	87

**. Correlation is significant at the 0.01 level (2-tailed).

Chapter five

Discussion, Conclusions and Recommendations

Chapter five

Discussions, Conclusions and Recommendations

5.1 Discussions

Table (4.1) and (4.2) 87 subjects were studied. Their age ranged from 40 to 90 years. 42 males which represent 48% and 45 females which represent 51%. However, the mean age was not statistically different between the two groups. Ages grouped for both male and female, study found the group 40-50 years had minimally frequent to perform CCTA which presented 21%, on other hand the age of more than 60 years had higher percent 42.5% that due increase of risk of CAD with age as reported in literature reveiw.

Table 4.3 shown wide variable of diagonal numbers but most of subjects had one and two diagonals artery represent 33.3% and 47.1% respectively, whereas 3.4% had absent of diagonal, 12.6% had three and 3.4% had more than three D branch arising from LAD. This results similar to Sherif Fathy Abdelrahman, Mohamed Ali Salem …et al. at 2015 as it mentioned on previous studies.

Table 4.4 shown 8% had absent of OM branch, most of subjects had one, two, three branches of OMs arising from LCX represent 24.1%, 41.4 and 25.3 respectively; whereas one subject had more than three OMs branch. The study results not similar to Sherif Fathy Abdelrahman, Mohamed Ali Salem …et al. which they found most of their study groups had one OM branch by percent of 59.9 %; these incompatibility due to their large groups under study.

Table 4.5 the study shown 80.5% of Sudanese population that studied had no ramus intermediate arising from LMCA. These results near to results of Egyptians population was 70.1% .

Table 4.6 shown 94.3% had RCA originate from RCS whereas 5.7% had ectopic origin from LCA; these similar to Sherif Fathy Abdelrahman, Mohamed Ali Salem …et al. at 2015 and Cengiz Erol, Mustafa Koplay, Yahya Paksoy. At 2013

Also the study found significant correlation of pathological findings with presences of ramus intermediate this due to increase risk of CAD with any findings of anomalies and variations as mentioned in literature review. Table (4.8).

5.2 Conclusion

The study concluded that's wide variations on numbers of diagonals which arise from left anterior descending and obtuse marginal which arise from LCX of Sudanese. Ectopic originate of RCA was very rare. Although the Sudanese con not different from other people.

5.3 Recommendations

Further studies in anatomic variation of coronary artery with large sample of Sudanese population.

Further studies about numbers coronary artery branches and it's relation to the heart size.

Reference

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Appendix 2

No	Age	Sex	NO. D	NO OM	Presence of ramus	RCA origin	Pathological finding
1.							
2.							
3.							
4.							
5.							
6.							
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Appendix 2

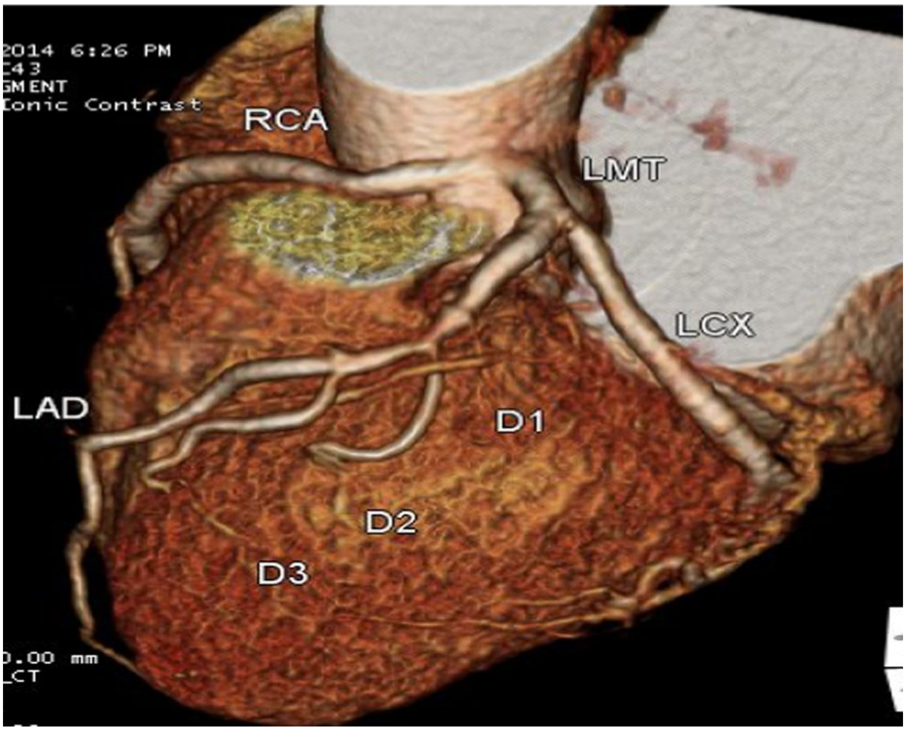

Fig : 55 years Female shows VR 3D that demonstrate ectopic RCA origin from LCA, threee diagonals arteries

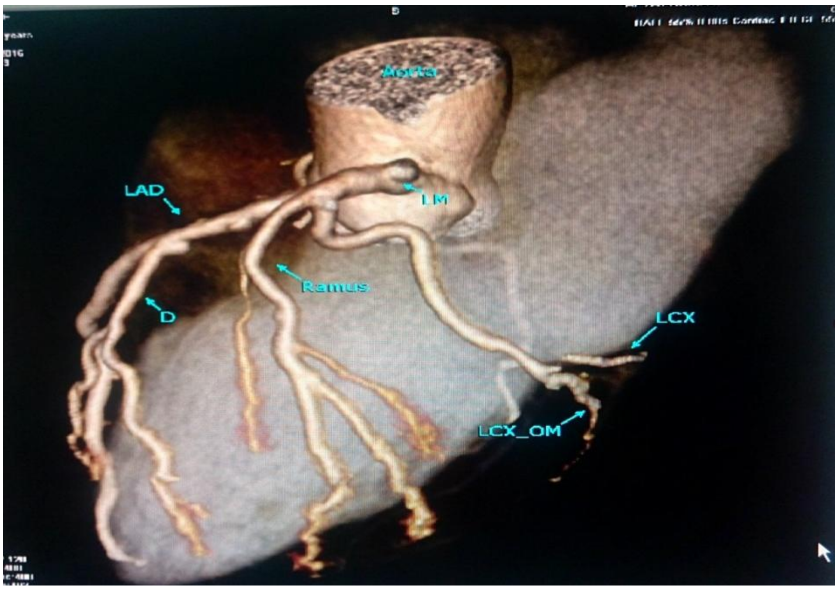

Fig : 48 years Male shows VR 3D that demonstrate the present of ramus intermediate

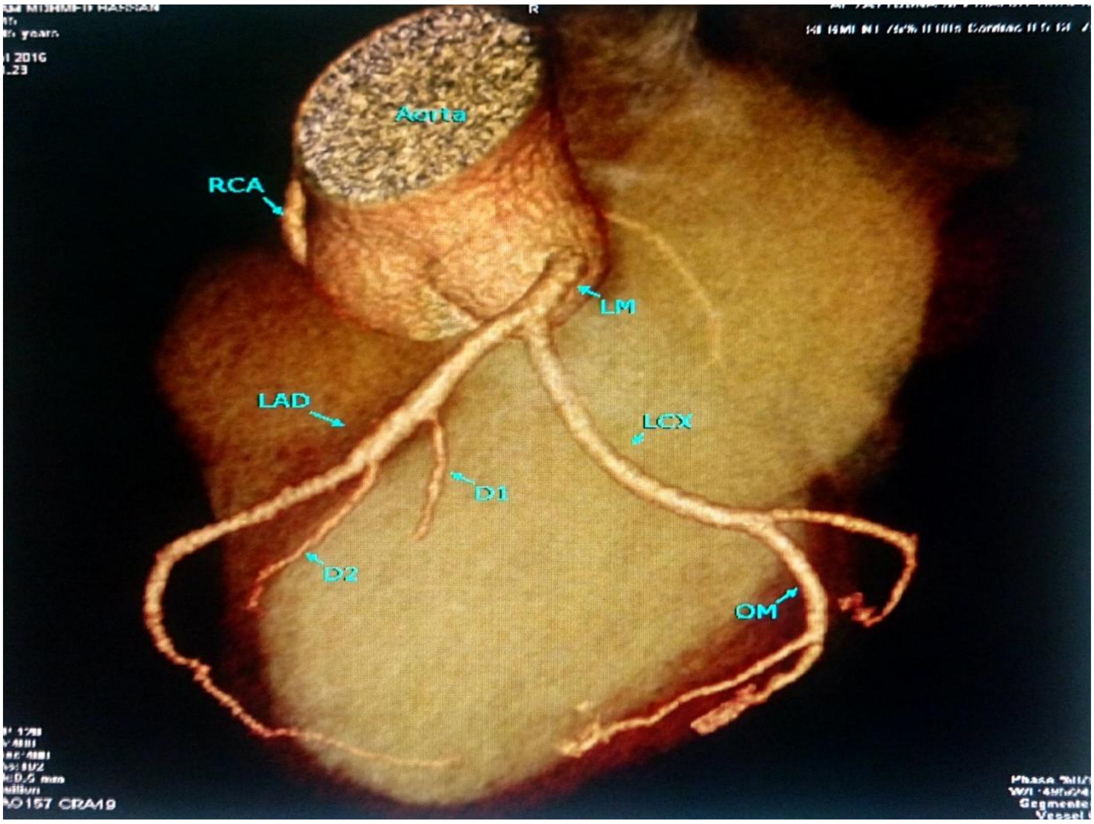

Fig : 50 years Female shows VR 3D that demonstrate two diagonals

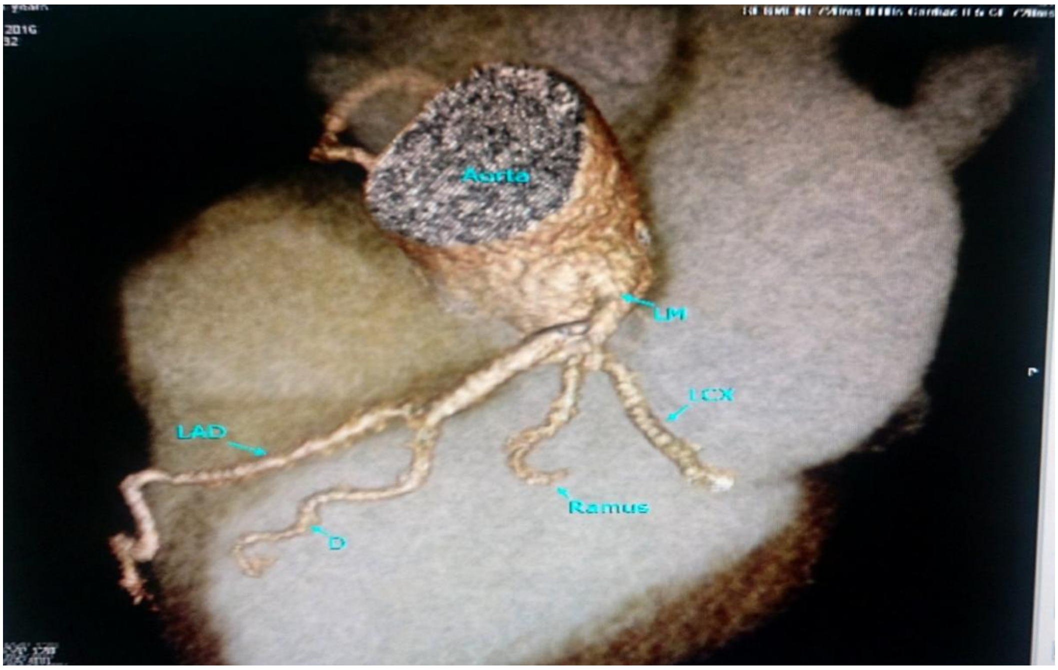

Fig : 63 years Female shows VR 3D that demonstrate ramus and LCX with absent of OM artery

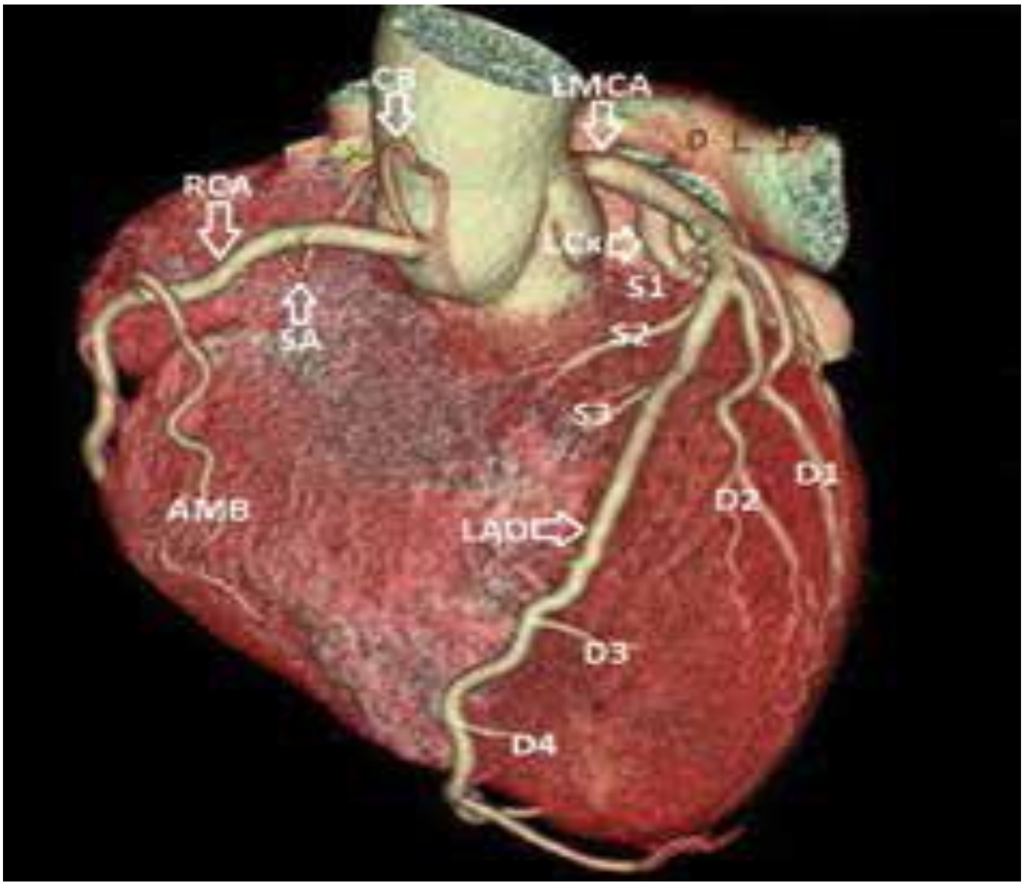

Fig : 63 years Female shows VR 3D that demonstrate Four diagonals arteries

~~end~~