Sudan University of Science and Technology

College of Graduate Studies

Measurement of Normal Thoracic Aorta in Sudanese using Computed Tomography

قياس الشريان الأبهر الصدري الطبيعي للسودانين بإستخدام الأشعة المقطعية المحوسبة

A Thesis Submitted for Partial Fulfillment for the Requirements of M.Sc. Degree in Diagnostic Radiologic Technology

By:

Mohammed Ali Hassan Mohammed Ahmed

Supervisor:

Dr. Afraa Siddig Hassan Omer

2022

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

الآية

قال تعالى:

(وتعالي الله الملك الحق ولا تعجل بالقران من قبل أن يقضي اليك وحيه وقل ربي زدني علما)

"سورة طه : الاية 114"

Dedication

To my lovely parents who have never failed to give me support for giving all my need during the time I developed my stem

To my big family

To my friends for their help and support

Acknowledgement

Firstly, I thank Allah whom enabling me to realize the meaning of success, ambitious, living my dreams come through giving me great peoples whose manipulating my life to a good way. With great deal of respect and grateful, I would like to thank my supervisor **Dr**. **Afraa Siddig Hassan Omer.**

My deeps gratitude and special appreciation extended to Sudan University of Science and Technology College of Radiological Sciences and my thanks to staff of Yastabshiroon hospital and Alraqi hospital.

Abstract

This was descriptive analytical study aimed to measurement the thoracic aorta diameter in Sudanese population by using CT scan conducted at radiology department emergency center Khartoum –department at Yastabshiroon hospital and Alraqi hospital during the period from august to December 2021, the sample of this study consisted of 50 subject with different gender 20 were female (40%) and 30 were male (60%), axial images will be obtained at the level of pulmonary artery bifurcation, ascending and descending thoracic aortic diameter measurements, analyzed using SPSS program version 16.

The results found mean of ascending aorta was (2.98±0.436cm), mean of descending aorta was (2.4460±0.32545cm), no significant relationship between ascending aorta and age, weight, height, BMI (p-value = 0.5567 0.544, 0.965, 0.934) respectively, no significant relationship between descending aorta and weight, height, BMI (p-value = 0.863, 0.126, 0.211), significant relationship between descending aorta and age (p-value = 0.013), ascending in male bigger than descending aorta, for female ascending bigger than descending aorta, no significant different age group with ascending aorta (positive relation) (p-value=0.76), significant different age group with descending aorta (negative relation) (p-value=0.01) and week relation the study found that can predict measure of the ascending aorta and descending aorta if the age.

The study concluded to there was significant relationship between descending aorta and age, significant different between age group with descending aorta.

المستخلص

دراسة تحليلية وصفية هدفت إلى قياس قطر الشريان الأورطي الصدري في السكان السودانيين باستخدام الأشعة المقطعية التي أجريت في قسم الأشعة بمراكز الطوارئ بالخرطوم – مستشفى يستبشيرون ومستشفى الراقي خلال الفترة من أغسطس إلى ديسمبر 2021، تتكون عينة هذه الدراسة من 50 موضوعا مختلف الجنس، 20 منهم من الإناث (40٪) و 30 من الذكور (60٪)، الصور المحورية تم الحصول عليها على مستوى تشعب الشريان الرئوي، قياسات قطر الأبهر الصدري الصاعد والهابط ، وتحليلها باستخدام برنامج (SPSS) الإصدار 16.

وجدت النتائج أن متوسط الشريان الأورطي الصاعد (2.98 ± 0.436 سم) ، متوسط الشريان الأبهر الهابط كان (2.4460 ± 0.32545 سم) ، لا توجد علاقة معنوية بين الأبهر الصاعد والعمر ، الوزن ، الطول ، مؤشر كتلة الجسم (القيمة الاحتمالية = 0.5567 0.544 ، 0.965 ، 0.934) على التوالي ، لا توجد علاقة ذات دلالة إحصائية بين الأبهر الهابط والوزن والطول ومؤشر كتلة الجسم (القيمة الاحتمالية = 0.863 ، 0.126 ، 0.211)، هناك علاقة ذات دلالة إحصائية بين الأبهر الهابط والعمر (القيمة الاحتمالية = 0.013)، الصاعد عند الذكور أكبر من الأبهر الهابط، للإناث الصاعد أكبر من الأبهر الهابط، هناك اختلاف غير معنوي في الأبهر الصاعد بين الاعمار (علاقة موجبة) (القيمة الاحتمالية = 0.76)، هناك اختلاف معنوي في الأبهر الهابط بين الاعمار (علاقة سلبية) (القيمة الاحتمالية = 0.01) وجدت الدراسة أن هنالك علاقة ضعيفة الأبهر الصاعد والشريان الأبهر النازل مع العمر يمكن التنبؤ بالقياسات.

وخلصت الدراسة إلى وجود علاقة معنوية بين الأبهر النازل والعمر، هناك اختلاف معنوي في الأبهر الهابط بين الاعمار.

List of contents

List of Figures

List of Tables

Chapter One

Introduction

Chapter One

Introduction

1.1 Introduction:

The aorta is the main artery in the human body. The aorta distributes oxygenated blood to all part of the body through the systemic circulation. It extends from the heart to about the fourth lumber vertebra and it divided into thoracic and abdominal sections. The thoracic section divided into four segments: aortic bulb (root), ascending aorta, aortic arch and descending aorta. The bulb or root portion is at the proximal end of the aorta and is the area from which the coronary arteries originate. Extending from the bulb is ascending portion of the aorta, which terminates at approximately second sternocostal joint and becomes the arch. The arch is unique from the other segments of the thoracic aorta because three arterial branches arise from it: the brachiocephalic artery, the left common carotid artery, and the left subclavian artery. The distal end of arch becomes descending aorta which extends from the isthmus to the level of twelfth dorsal vertebra. Numerous intercostal, bronchial, esophageal, and superior phrenic branches arise from the descending aorta. Then continues downward as the abdominal aorta which extends from diaphragm to the aortic bifurcation. It gives rise to lumbar and musculophrenic arteries, renal and middle suprarenal arteries, and visceral arteries (celiac trunk, the superior mesenteric artery and the inferior mesenteric artery). It ends in a bifurcation into the left and right common iliac arteries. (Kenneth, 2012)

Echocardiography better in measure aortic root diameter which provides prognostic information in aortic regurgitation and the Marfan syndrome. (Marco, 2016)

Computed tomography angiography uses an injection of iodine-rich contrast material and CT scanning to help diagnose and evaluate blood vessels disease or related condition such as aneurysm or blockage. (Richards et al., 2018)

Aortography is performed by x-ray with catheters, magnetic resonance imaging, and computed tomography which is usually the most useful technique in imagining of aorta and produce detailed image of vessels. (Tateishi et al., 2018)

1.2. Problem of the study

All anatomical organs differ according to race and ethnic groups. The structure may differ also due to diseases and abnormalities, age, gender, and BMI. There is no specific characterization of the measurements of the aortic diameter in normal Sudanese. So this study is an attempt to see the effectiveness of the age in the aortic diameter.

1.3. Objectives

1.3.1. General objective

To measure Thoracic Aorta in Sudanese Using Computed Tomography.

1.3.2. Specific objectives are

- To measure ascending thoracic aorta diameter.
- To measure descending thoracic aorta diameter.
- To correlate ascending and descending aortic measurement with patient gender.
- To correlate ascending and descending aortic measurement with patient age.
- To correlate ascending and descending aortic measurement with patient BMI.

1.4 Thesis Outline

This study will be built in five chapters. Chapter one will deal with introduction, problem of the study, objectives, and thesis outline. Chapter two will highlight the literature review. Chapter three will express the methodology of the study. Chapter four will include the presentation of results. Chapter five will concern with the discussion, conclusion, and recommendations.

Chapter two

Literature review and previous studies

Chapter two
Literature review and previous studies
2.1 Anatomy:

The aorta is the largest artery that carries oxygen rich blood from left ventricle of the heart to other part of the body(Cleveland clinic,2020).

The aorta begins at the top of the left ventricle, the heart's muscular pumping chamber pumps blood from the left ventricle into the aorta through the aortic valve. Three leaflets on the aortic valve open and close with each heartbeat to allow one-way flow of blood. (WebMD, 2016)

The aorta is a tube about a foot long and the size of the aorta is directly proportionate to the patient's height and weight. Its diameter may range from 3cm (more than an inch) to 1.2cm (half an inch). It is typically the largest in the aortic root and smallest in the abdominal aorta. (Cedars, 2016)

It commences at the upper part of the left ventricle, where it is about 3 cm in diameter, and after ascending for a short distance, arches backward and to the left side, over the root of the left lung; it then descends within the thorax on the left side of the vertebral column, passes into the abdominal cavity through the aortic hiatus in the diaphragm, and ends, considerably diminished in size (about 1.75 cm in diameter), opposite the lower border of the fourth lumbar vertebra, by dividing into the right and left common iliac arteries. Hence it is described in several portions, the ascending aorta, the arch of the aorta, and the descending aorta, which last is again divided into the thoracic and abdominal aorta. (Cedars, 2016)

Variation may occur in the location of the aorta, and the way in which arteries branch of the aorta. The aorta normally on the left side of the body, may be found on the right in dextrocardia, in which the heart is found on the right, or situs inversus, in which the location of all organs are flopped. Variations in the branching of individual arteries may also occur. For example, the left vertebral artery may arise from the aorta, instead of the left common carotid artery. (Drake, et al 2016)

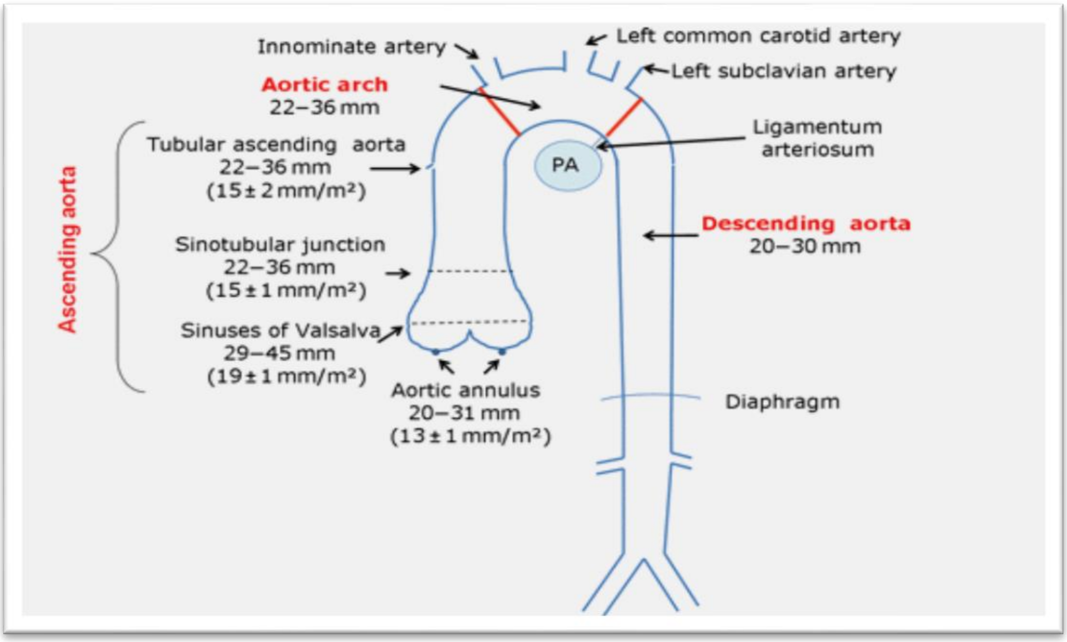

Fig (2.1): Ascending and descending aorta (Erbel et al, 2016)

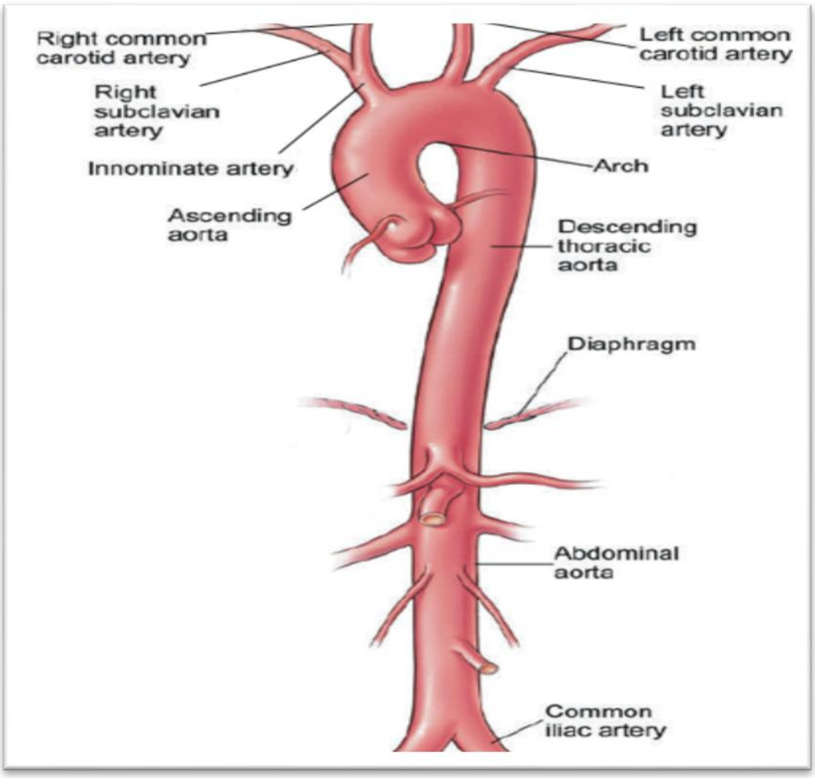

Fig (2.2) The portion of the aorta. (Cleveland Clinic, 2016)

2.1.1 Development of the aorta

Development of the aorta takes place during the third week of gestation. It is a jcomplex process associated with the formation of the endocardial tube (day 21), which lends itself to a variety of congenital variants. Each primitive aorta consists of a ventral and a dorsal segment that are continuous through the first aortic arch. The two ventral aorta fuse to form the aortic sac. The dorsal aorta fuse to form the midline descending aorta. Six paired aortic arches, the so-called branchial arch arteries, develop between the ventral and dorsal aorta. In addition, the dorsal aorta gives off several intersegmental arteries. The vessels derived from each arch are as follows: The first pair contributes to formation of the maxillary and external carotid arteries. The second pair contributes to formation of the stapedial arteries. (Thomas et al, 2017)

The third aortic arch constitutes the commencement of the internal carotid artery and is therefore named the carotid arch. Proximal segments of the third pair form the common carotid arteries. Together with segments of the dorsal aorta, the distal portions contribute to formation of the internal carotid arteries. The left arch of the fourth pair forms the segment of normal left aortic arch between the left common carotid and subclavian arteries. The right fourth arch forms the proximal right subclavian artery. The distal right subclavian artery is derived from a portion of the right dorsal aorta and the right seventh intersegmental artery. Rudimentary vessels that regress early develop out of the fifth pair. The left arch of the sixth pair contributes to the formation of the main and left pulmonary arteries and ductus arteriosus; this duct obliterates a few days after birth. The right sixth arch contributes to formation of the right pulmonary artery. With the caudad migration of the heart in the second fetal month, the seventh intersegmental arteries enlarge and migrate cephalad to form the distal subclavian arteries. The left subclavian artery is derived entirely from the left seventh intersegmental artery, whereas the portions of the right are derived from the right fourth arch and the right dorsal aorta. Malformations of the aortic arch system can be explained by persistence of segments of the aortic arches that normally regress or disappearance of segments that normally remain, or both. Regression of the right dorsal aortic root (between the right subclavian artery and the descending aorta) and the right ductus arteriosus leaves the normal left aortic arch. The classic left aortic arch and descending thoracic aorta are seen in ~70% of individuals. The three main branches of the aortic arch are the brachiocephalic (innominate) artery (dividing into the right subclavian and common carotid arteries), the left common carotid artery, and the left subclavian artery. (Thomas et al, 2017)

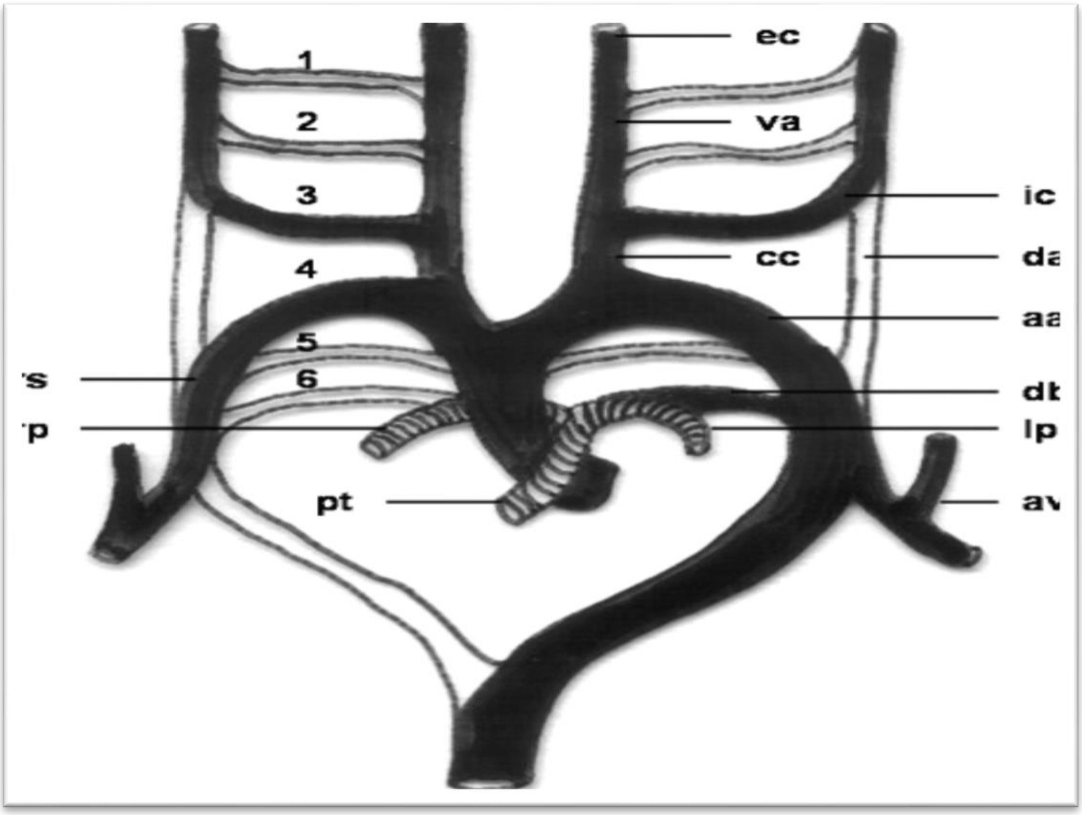

Fig (2.3) Schematic drawing of the development of the aortic arch and its branches. 1, first aortic arch; 2, second aortic arch; 3, third aortic arch; 4, fourth aortic arch; 5, fifth aortic arch; 6, sixth aortic arch; aa, aortic arch; va, ventral aorta; da, dorsal. (Thomas et al, 2017)

2.1.2 Histology of the aorta

The aorta is an elastic artery, and as such is quite distensible. The aorta consists of a heterogeneous mixture of smooth muscle, nervkes, intimal cells, endothelial cells, fibroblast-like cells, and a complex extracellular matrix. The vascular wall consists of several layers known as the tunica externa, tunica media, and tunica intima. The thickness of the aorta requires an extensive network of tiny blood vessels called vasa vasorum, which feed the tunica externa and tunica media outer layers of the aorta. The aortic arch contains bar receptors and chemoreceptors that relay information concerning blood pressure and blood pH and carbon dioxide levels to the medulla oblongata of the brain. This information is processed by the brain and the autonomic nervous system mediates the homeostatic responses. (Thomas et al, 2017)

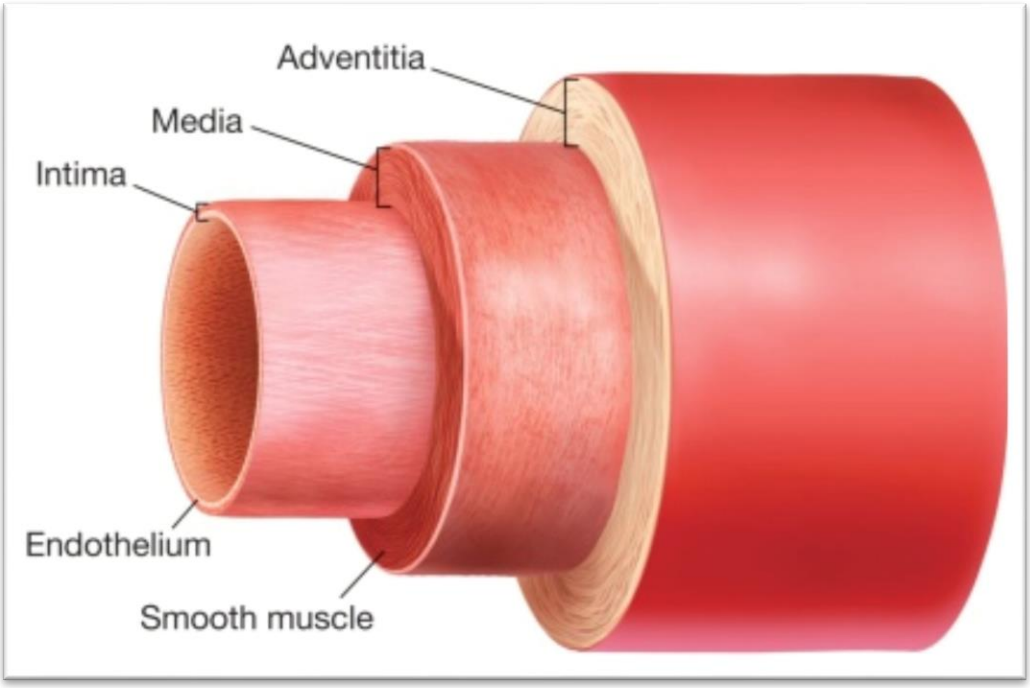

Fig (2.4): The aortic layers. (Aric et al, 2016)

2.1.3: Ascending Aorta

Is about 5 cm in length. It commences at the upper part of the base of the left ventricle, on a level with the lower border of the third costal cartilage behind the left half of the sternum; it passes obliquely upward, forward, and to the right, in the direction of the heart's axis, as high as the upper border of the second right costal cartilage, describing a slight curve in its course, and being situated, about 6 cm. behind the posterior surface of the sternum. At its origin it presents, opposite the segments of the aortic valve, three small dilatations called the aortic sinuses**.** At the union of the ascending aorta with the aortic arch the caliber of the vessel is increased, owing to a bulging of its right wall. This dilatation is termed the bulb of the aorta**,** and on transverse section presents a somewhat oval figure. The ascending aorta is contained within the pericardium, and is enclosed in a tube of the serous pericardium, common to it and the pulmonary artery. (Henry, 2018)

2.1.3.1 Relations

The ascending aorta is covered at its commencement by the trunk of the pulmonary artery and the right auricula, and, higher up, is separated from the sternum by the pericardium, the right pleura, the anterior margin of the right lung, some loose areolar tissue, and the remains of the thymus; posteriorly, it rests upon the left atrium and right pulmonary artery. On the right side, it is in relation with the superior vena cava and right atrium, the former lying partly behind it; on the left side, with the pulmonary artery. (Henry, 2018)

2.1.3.2 Branches

The only branches of the ascending aorta are the two coronary arteries which supply the heart; they arise near the commencement of the aorta immediately above the attached margins of the semilunar valves. The coronary arteries divided into right coronary artery and left coronary artery. (Henry, 2018)

2.1.4: The Arch of the Aorta

The arch of the aorta begins at the level of the upper border of the second sternocostal articulation of the right side, and runs at first upward, backward, and to the left in front of the trachea; it is then directed backward on the left side of the trachea and finally passes downward on the left side of the body of the fourth thoracic vertebra, at the lower border of which it becomes continuous with the descending aorta. It thus forms two curvatures: one with its convexity upward, the other with its convexity forward and to the left. Its upper border is usually about 2.5 cm. below the superior border to the manubrium sterni. (Henry, 2018)

2.1.4.1 Relations

The arch of the aorta is covered anteriorly by the pleura and anterior margins of the lungs, and by the remains of the thymus. As the vessel runs backward its left side is in contact with the left lung and pleura. Passing downward on the left side of this part of the arch are four nerves; in order from before backward these are, the left phrenic, the lower of the superior cardiac branches of the left vagus, the superior cardiac branch of the left sympathetic, and the trunk of the left vagus. As the last nerve crosses the arch it gives off its recurrent branch, which hooks around below the vessel and then passes upward on its right side. The highest left intercostal vein runs obliquely upward and forward on the left side of the arch, between the phrenic and vagus nerves. On the right are the deep part of the cardiac plexus, the left recurrent nerve, the esophagus, and the thoracic duct; the trachea lies behind and to the right of the vessel. Above are the innominate, left common carotid, and left subclavian arteries, which arise from the convexity of the arch and are crossed close to their origins by the left innominate vein. Below are the bifurcation of the pulmonary artery, the left bronchus, the ligamentum arteriosum, the superficial part of the cardiac plexus, and the left recurrent nerve. As already stated, the ligamentum arteriosum connects the commencement of the left pulmonary artery to the aortic arch. (Henry, 2018)

2.1.4.2 Branches

The branches given off from the arch of the aorta are three in number: the innominate, the left common carotid, and the left subclavian. These vessels supply blood to the head, neck, thorax and upper limbs. (Henry, 2018)

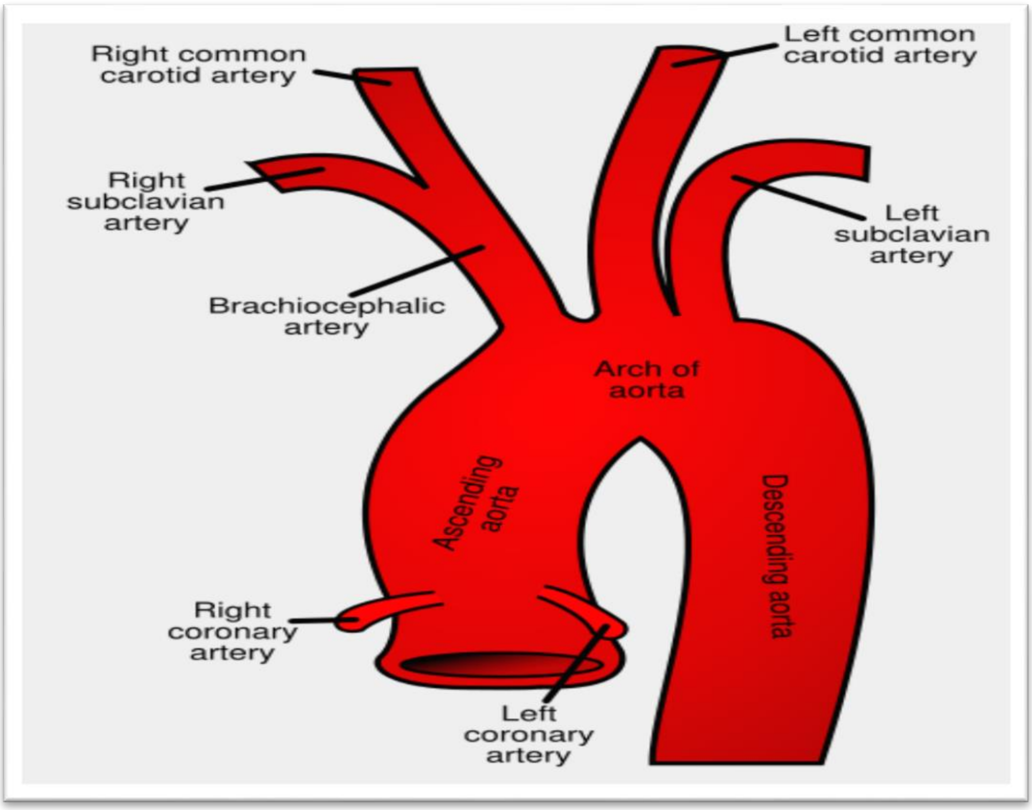

Fig (2.5) The aortic arch and its branches. (Cedars, 2016)

The branches, instead of arising from the highest part of the arch, may spring from the commencement of the arch or upper part of the ascending aorta; or the distance between them at their origins may be increased or diminished, the most frequent change in this respect being the approximation of the left carotid toward the innominate artery. The number of the primary branches may be reduced to one, or more commonly two; the left carotid arising from the innominate artery; or (more rarely) the carotid and subclavian arteries of the left side arising from a left innominate artery. But the number may be increased to four, from the right carotid and subclavian arteries arising directly from the aorta, the innominate being absent. In most of these latter cases the right subclavian has been found to arise from the left end of the arch; in other cases it is the second or third branch given off, instead of the first. Another common form in which there are four primary branches is that in which the left vertebral artery arises from the arch of the aorta between the left carotid and subclavian arteries. Lastly, the number of trunks from the arch may be increased to five or six; in these instances, the external and internal carotids arise separately from the arch, the common carotid being absent on one or both sides. In some few cases six branches have been found, and this condition is associated with the origin of both vertebral arteries from the arch. (Henry, 2018)

2.1.4.2.1 The Innominate Artery (Brachiocephalic Artery)

The innominate artery is the largest branch of the arch of the aorta, and is from 4 to 5cm in length. It arises, on a level with the upper border of the second right costal cartilage, from the commencement of the arch of the aorta, on a plane anterior to the origin of the left carotid; it ascends obliquely upward, backward, and to the right to the level of the upper border of the right sternoclavicular articulation, where it divides into the right common carotid and right subclavian arteries. The innominate artery sometimes divides above the level of the sternoclavicular joint, less frequently below it. The position of innominate artery when the aortic arch is on the right side, the innominate is supplies the right side of the head and neck as well as the right arm and chest wall. (Henry, 2018)

2.1.4.2.2: The left Common Carotid Artery

The left common carotid artery supply the head and neck, springs from the highest part of the arch of the aorta to the left of, and on a plane posterior to the innominate artery, and therefore consists of a thoracic and a cervical portion. The thoracic portion of the left common carotid artery ascends from the arch of the aorta through the superior mediastinum to the level of the left sternoclavicular joint, where it is continuous with the cervical portion. The cervical portions of the common carotids resemble each other so closely that one description will apply to both. Each vessel passes obliquely upward, from behind the sternoclavicular articulation, to the level of the upper border of the thyroid cartilage, where it divides into the external and internal carotid arteries. (Henry, 2018)

2.1.4.2.3 The left Subclavian Artery

The left subclavian artery arises from the arch of the aorta, behind the left common carotid, and at the level of the fourth thoracic vertebra; it ascends in the superior mediastinal cavity to the root of the neck and then arches lateral ward to the medial border of the scalenus anterior. The left subclavian artery supplies blood to the left arm (Henry, 2018)

2.1.5: The descending aorta

Is the largest artery in the body; it runs from the heart down the length of the chest and abdomen. It is divided into two portions, the thoracic and abdominal, in correspondence with the two great cavities of the trunk in which it sits. Within the abdomen, the descending aorta branches into the two common iliac arteries that provide blood to the pelvis and, eventually, the legs. (David, 2016)

2.1.5.1 The thoracic aorta

Is contained in the posterior mediastinal cavity, begins at the 4th thoracic vertebra where it is continuous with the aortic arch, and ends in front of the lower border of the twelfth thoracic vertebra, , at the aortic hiatus in the diaphragm where it becomes the abdominal aorta. Branches from the thoracic aorta include the bronchial arteries, the mediastinal arteries, the esophageal arteries, the pericardial arteries, the superior phrenic artery which supply the diaphragm, and the subcostal arteries for the twelfth ribs. The thoracic aorta and the esophagus run parallel for most of its length, with the esophagus lying on the right side of the aorta, but at the lower part of the thorax, it is placed in front of the aorta, and, close to the diaphragm, is situated on its left side. (David, 2016)

The thoracic aorta's relation, from above downward, is as follows: anteriorly with the root of the left lung, the pericardium, the esophagus and the diaphragm; posteriorly with the vertebral column; on the right side with the hemiazygos veins and thoracic duct; and on the left side with the left pleura and lung. The esophagus lies on the right side of the aorta for most of its length, but at the lower part of the thorax is placed in front of the aorta and close to the diaphragm, situated on its left side. As it descends in the thorax, the aorta gives off several paired branches. In descending order these are: the bronchial arteries, the mediastinal arteries, the esophageal arteries, the pericardial arteries, and the superior phrenic artery. The posterior intercostal arteries are branches that originate throughout the length of the posterior aspect of the thoracic aorta. (Drake, et al.2016)

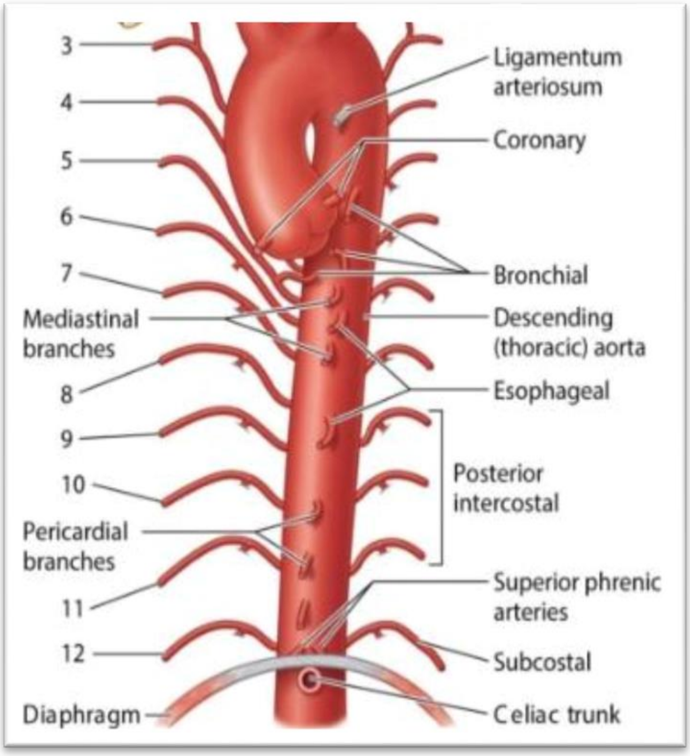

Fig (2.6) Anterior view of thoracic aorta and its branches (Mo, 2016)

2.1.5.2: The abdominal aorta:

Is the largest artery in the abdominal cavity and supplies blood to most of the abdominal organs. It is a direct continuation of the descending aorta. It begins at the level of the diaphragm, crossing it via the aortic hiatus, a hole in the diaphragm that allows the passage of the great vessels, at the vertebral level of T12. It travels down the posterior wall of the abdomen, anterior to the vertebral column, following the curvature of the lumbar vertebrae. The abdominal aorta runs parallel to the inferior vena cava, which is located just to the right of the abdominal aorta. (Drake, et al.2016)

The abdominal aorta lies slightly to the left of the midline of the body. It is covered, anteriorly, by the lesser omentum and stomach. Posteriorly, it is separated from the lumbar vertebrae by the anterior longitudinal ligament and left lumbar veins. (Drake, et al.2016)

The abdominal aorta gives rise to lumbar and musculophrenic arteries, renal and middle suprarenal arteries, and visceral arteries (the celiac trunk, the superior mesenteric artery and the inferior mesenteric artery). It ends in a bifurcation into the left and right common iliac arteries. At the point of the bifurcation, there also springs a smaller branch, the median sacral artery. (Drake, et al.2016)

2.1.5.2 .1 Relationship with inferior vena cava

The abdominal aorta's venous counterpart, the inferior vena cava (IVC), travels parallel to it on its right side. Above the level of the umbilicus, the aorta is somewhat posterior to the IVC, sending the right renal artery travelling behind it. The IVC likewise sends its opposite side counterpart, the left renal vein, crossing in front of the aorta. Below the level of the umbilicus, the situation is generally reversed, with the aorta sending its right common iliac artery to cross its opposite side counterpart (the left common iliac vein) anteriorly. (Susan, 2016)

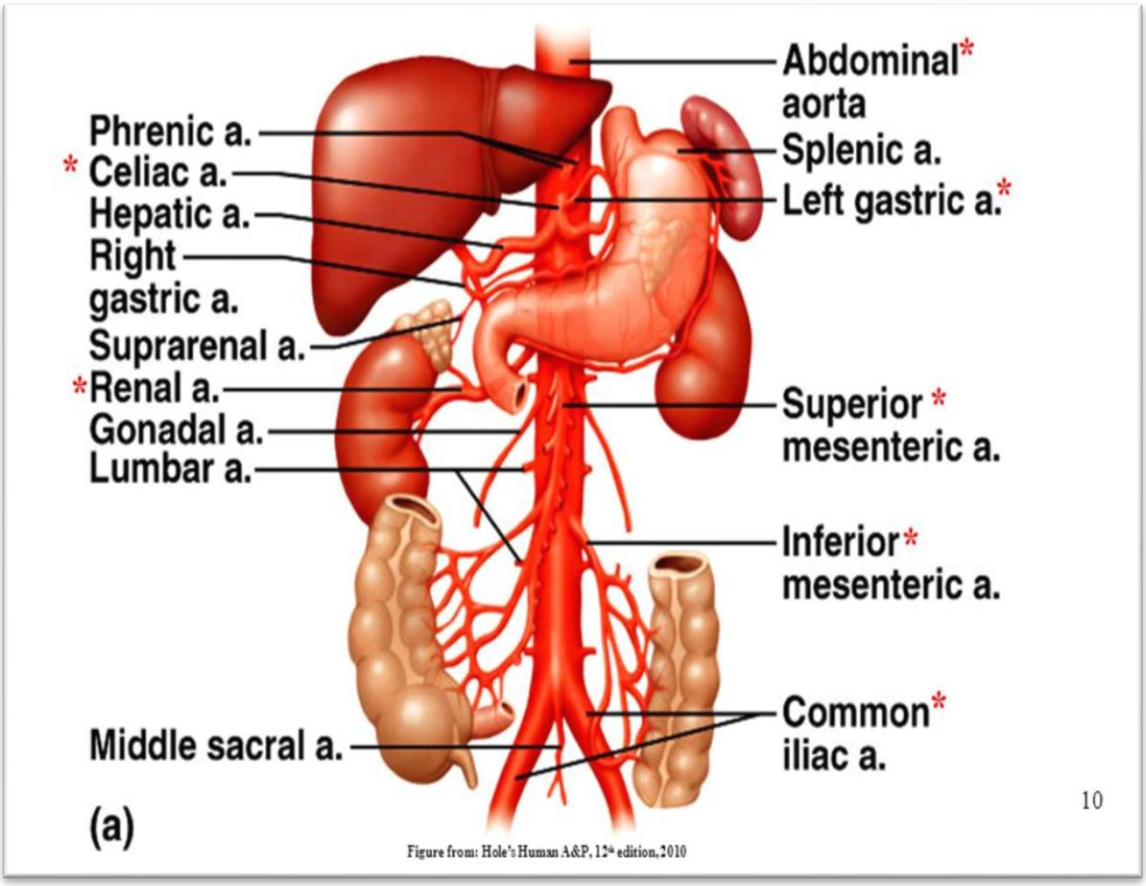

Fig (2.7): Abdominal aorta and its major branches. (David et al, 2016)

2.2 Physiology of Aorta

The aorta is the most proximal artery connected directly to the heart and acts both as a conduit and an elastic chamber. In its latter role, the aorta's elasticity serves to convert the heart's pulsatile flow to nearly steady flow in peripheral vessels. Stephen Hales (1733) reported his observations that the aorta expands to accommodate a large fraction of the stroke volume. Hales reasoned that the aorta serves as an elastic reservoir, which distends with blood during the heart's contraction and discharges blood through the peripheral resistance by elastic recoil while the heart refills. His explanation accounts for the smoothing action of the aorta in converting the pulsatile flow of the heart to smooth flow in blood vessels. An analogy was made with a hand-pump fire engine which smoothes a pump's pulsatile flow of water. In 1899, Otto Frank used this analogy to formulate the well known Windkessel theory**.** (**J** R Soc Interface**. 2016)**

2.3: Pathology of the aorta

2.3.1: Patent ductus arteriosus (PDA)

Is a congenital heart defect wherein the ductus arteriosus fails to close after birth. Early symptoms are uncommon, but in the first year of life include increased 'work of breathing' and poor weight gain. An uncorrected PDA may lead to congestive heart failure with increasing age. The ductus arteriosus is a fetal blood vessel that closes soon after birth. In a PDA, the vessel does not close and remains "patent" (open), resulting in irregular transmission of blood between the aorta and the pulmonary artery. PDA is common in newborns with persistent respiratory problems such as hypoxia, and has a high occurrence in premature newborns. Premature newborns are more likely to be hypoxic and have PDA due to underdevelopment of the heart and lungs. A PDA allows a portion of the oxygenated blood from the left heart to flow back to the lungs by flowing from the aorta (which has higher pressure) to the pulmonary artery. If this shunt is substantial, the neonate becomes short of breath: the additional fluid returning to the lungs increases lung pressure, which in turn increases the energy required to inflate the lungs. This uses more calories than normal and often interferes with feeding in infancy. This condition, as a constellation of findings, is called congestive heart failure. In some congenital heart defects (such as in transposition of the great vessels) a PDA may need to remain open, as it is the only way that oxygenated blood can mix with deoxygenated blood. (Tsamis et al, 2016)

2.3.2: Coarctation of the aorta (CoA or CoAo)

Also called aortic narrowing, is a congenital condition whereby the aorta is narrow, usually in the area where the ductus arteriosus (ligamentum arteriosum after regression) inserts. The word “coarctation” means narrowing. Coarctations are most common where the aorta—the major artery leading away from the heart—arches toward the abdomen and legs (the aortic arch). The arch may be small in babies with coarctations. Other heart defects may also occur when coarctation is present, typically occurring on the left side of the heart. When a patient has a coarctation, the left ventricle has to work harder. Since the aorta is narrowed, the left ventricle must generate a much higher pressure than normal in order to force enough blood through the aorta to deliver blood to the lower part of the body. If the narrowing is severe enough, the left ventricle may not be strong enough to push blood through the coarctation, thus resulting in lack of blood to the lower half of the body. Physiologically its complete form is manifested as interrupted aortic arch. (Groenemeijer et al, 2016)

There are three types of aortic coarctations: Preductal, Ductal and Postductal coarctation. (Valdes, et al, 2016)

2.3.3: An aortic aneurysm

Is enlargement (dilation) of the aorta to greater than 1.5 times normal size. They usually cause no symptoms except when ruptured. Occasionally there may be abdominal, back or leg pain. They are most commonly located in the abdominal aorta, but can also be located in the thoracic aorta. Aortic aneurysms cause weakness in the wall of the aorta and increase the risk of aortic rupture. When rupture occurs, massive internal bleeding results and, unless treated immediately, shock and death can occur. Screening with ultrasound is indicated in those at high risk. Prevention is by decreasing risk factors such as smoking. Treatment is either by open or endovascular surgery. (Kent, 2016)

Aortic aneurysms resulted in about 152,000 deaths in 2013, up from 100,000 in 1990. (G B D, 2016)

Ascending aortic aneurysms are the most common subtype of thoracic aortic aneurysms, and may be true or false injuries. Aneurysmal dilatation is considered with the ascending aorta measures >4.0 cm in diameter. (Aditya et al, 2015)

2.3.4 Aortic dissection

Occurs when a tear in the tunica intima of the aorta causes blood to flow between the layers of the wall of the aorta, forcing the layers apart. In most cases this is associated with severe characteristic chest or abdominal pain described as "tearing" in character, and often with other symptoms that result from decreased blood supply to other organs. Aortic dissection is a medical emergency and can quickly lead to death, even with optimal treatment, as a result of decreased blood supply to other organs, heart failure, and sometimes rupture of the aorta. Aortic dissection is more common in those with a history of high blood pressure, a known thoracic aortic aneurysm, and in a number of connective tissue diseases that affect blood vessel wall integrity such as Marfan syndrome and the vascular subtype of Ehlers– Danlos syndrome. The diagnosis is made with medical imaging (computed tomography, magnetic resonance imaging or echocardiography). (Kamalakannan et al, 2017*)*

2.3.5 Aortic regurgitation (AR)

Another name of aortic insufficiency. Blood regurgitates backward through the incompletely closed aortic valve and into the heart's left ventricle. Valvular abnormalities that may result in AR can be caused by the congenital causes - Bicuspid aortic valve is the most common congenital cause, and acquired causes: Rheumatic fever Infective endocarditis Collagen vascular diseases Degenerative aortic valve disease Traumatic Postsurgical (including post-transcatheter aortic valve replacement).(Freeman et al, 2018)

2.3.6 Aortic stenosis (AS or AoS)

Is the narrowing of the exit of the left ventricle of the heart, such that problems result. It may occur at the aortic valve as well as above and below this level. It typically gets worse over time. Symptoms often come on gradually with a decreased ability to exercise often occurring first. If heart failure, loss of consciousness, or heart related chest pain occurs due to AS the outcomes are worse. Loss of consciousness typically occurs with standing or exercise. *(Czarny* et al, 2016)

2.3.7 Atherosclerosis

Also known as arteriosclerotic vascular disease or ASVD is a specific form of arteriosclerosis in which an artery -wall thickens as a result of invasion and accumulation of white blood cells (foam cell) and proliferation of intimal-smooth-muscle cell creating a fibrofatty plaque.(*Maton* et al, 2016)

2.3.8 Ehlers–Danlos syndrome (EDS)

Is an inherited connective tissue disorder with presentations that have been classified into several primary types. EDS is caused by a defect in the structure, production, or processing of collagen or proteins that interact with collagen, such as mutations in the COL5A or COL3A genes. This is the collagen of granulation tissue, and is produced quickly by young fibroblasts before the tougher type I collagen is synthesized. Commonly associated with keloid formation, reticular fiber, and found in artery walls, skin, intestines and the uterus. (Voermans et al, 2016)

2.3.9 Marfan syndrome

Is a genetic disorder of connective tissue. It has a variable clinical presentation, ranging from mild to severe systemic disease. The most serious manifestations involve defects of the heart valves and aorta, which may lead to early death if not properly managed. The syndrome also may affect the lungs, eyes, dural sac surrounding the spinal cord, the skeleton, and the hard palate. People with Marfan syndrome tend to be unusually tall, due to the disorder causing people with the condition to have long limbs and long, thin fingers and toes. (Dietz et al, 2016)

2.3.10 Major trauma

Is any injury that has the potential to cause prolonged disability or death. There are many causes of major trauma, blunt and penetrating, including falls, motor vehicle collisions, and gunshot wounds. Depending on the severity of injury, quick management and transport to an appropriate medical facility may be necessary to prevent loss of life. (Yuranga et al, 2016)

2.4 Imaging modality of Aorta

2.4.1 Aortogram (angiogram)

An angiogram is an X-ray test that uses a special dye and camera (fluoroscopy) to take pictures of the blood flow in an artery (such as the aorta) or a vein (such as the vena cava). An angiogram can be used to look at the arteries or veins in the head, arms, legs, chest, back, or belly. Common angiograms can look at the arteries near the heart (coronary angiogram), lungs (pulmonary angiogram), brain (cerebral angiogram), head and neck (carotid angiogram), legs or arms (peripheral), and the aorta (aortogram). During an angiogram, a thin tube called a catheter is placed into a blood vessel in the groin (femoral artery or vein) or just above the elbow (brachial artery or vein). The catheter is guided to the area to be studied. Then an iodine dye (contrast material) is injected into the vessel to make the area show clearly on the X-ray pictures. This method is known as conventional or catheter angiogram. The angiogram pictures can be made into regular X-ray films or stored as digital pictures in a computer. (WebMD, 2014)

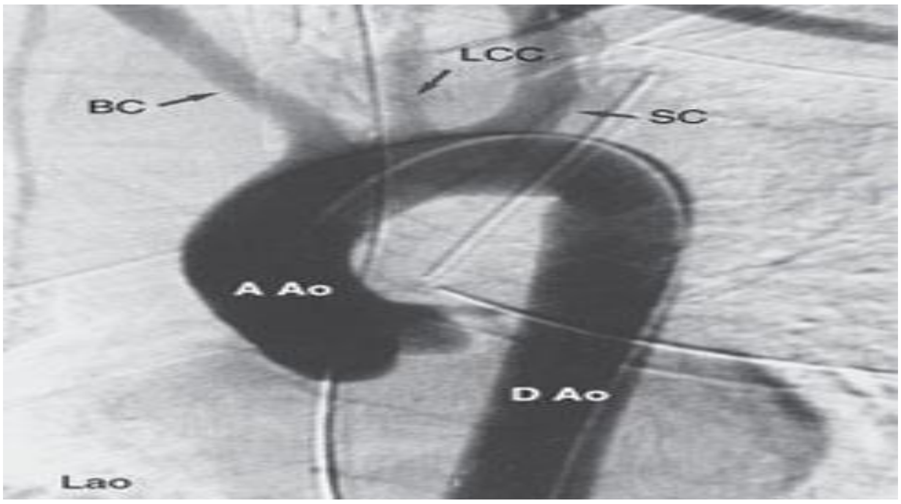

Fig (2.8) angiography of the arch of the aorta. (medicine.academic.ru, 2016)

2.4.2 Computed tomography angiography (CTA)

Is a computed tomography technique used to visualize arterial and venous vessels throughout the body**.** CTA can be used to examine blood vessels in many key areas of the body, including the brain, kidneys, pelvis, and the lungs. Under some circumstances the coronary arteries may be examined by CTA, but CTA has not replaced invasive catheter coronary angiography. The procedure is able to detect narrowing of blood vessels in time for corrective therapy to be done. This method displays the anatomical detail of blood vessels more precisely than magnetic (MRI) or ultrasound. Today, many patients can undergo CTA in place of a conventional catheter angiogram. CTA is a useful way of screening for arterial disease because it is safer and much less time-consuming than catheter angiography and is a cost-effective procedure. There is also less discomfort because contrast material is injected into an arm vein rather than into a large artery in the groin. (American College of Chest Physicians and American Thoracic Society, 2016**)**

Fig (2.9) 3-D image of the aorta in the CT chest **(**RadiologyInfo.org, 2016**)**

2.4.3 Magnetic resonance angiography (MRA)

Is a group of techniques based on magnetic resonance imaging (MRI) to image blood vessels. Magnetic resonance angiography is used to generate images of arteries (and less commonly veins) in order to evaluate them for stenosis (abnormal narrowing), occlusions, aneurysms (vessel wall dilatations, at risk of rupture) or other abnormalities. MRA is often used to evaluate the arteries of the neck and brain, the thoracic and abdominal aorta, the renal arteries, and the legs. A variety of techniques can be used to generate the pictures of blood vessels, both arteries and veins, based on flow effects or on contrast (inherent or pharmacologically generated). The most frequently applied MRA methods involve the use intravenous contrast agents, particularly those containing gadolinium to shorten the T_1 of blood to about 250 ms, shorter than the T_1 of all other tissues (except fat). Short-TR sequences produce bright images of the blood. However, many other techniques for performing MRA exist, and can be classified into two general groups: 'flow-dependent' methods and 'flow-independent' methods. Flow-dependent angiography is based on blood flow. They take advantage of the fact that the blood within vessels is flowing to distinguish the vessels from other static tissue. That way, images of the vasculature can be produced. Flow dependent MRA can be divided into different categories: There is phase-contrast MRA (PC-MRA) which utilizes phase differences to distinguish blood from static tissue and time-of-flight MRA (TOF MRA) which exploits that moving spins of the blood experience fewer excitation pulses than static tissue. (Eur Radiol, 2018)

Fig (2.10) Contrast-enhanced (CE-MRA) of the aorta. (Matthias et al, 2016)

2.4.2 Echocardiography

Is a sonogram of the heart, uses standard two-dimensional, three-dimensional, and Doppler ultrasound to create images of the heart. A standard echocardiogram is also known as a transthoracic echocardiogram (TTE), or cardiac ultrasound. In this case, the echocardiography transducer (or probe) is placed on the chest wall (or thorax) of the subject, and images are taken through the chest wall. This is a non-invasive, highly accurate and quick assessment of the overall health of the heart. The alternative way to perform an echocardiogram is a transesophageal echocardiogram, or TOE. A specialized probe containing an ultrasound transducer at its tip is passed into the patient's esophagus. This allows image and Doppler evaluation from a location directly behind the heart. Transesophageal echocardiograms are most often utilized when transthoracic images are suboptimal and when a more clear and precise image is needed for assessment. This test is performed in the presence of a cardiologist, registered nurse, and ultrasound technician. Conscious sedation and/or localized numbing medication may or may not be used in order to make the patient more comfortable during the procedure. (Journal of American College of Cardiology, etrieved August 17, 2016)

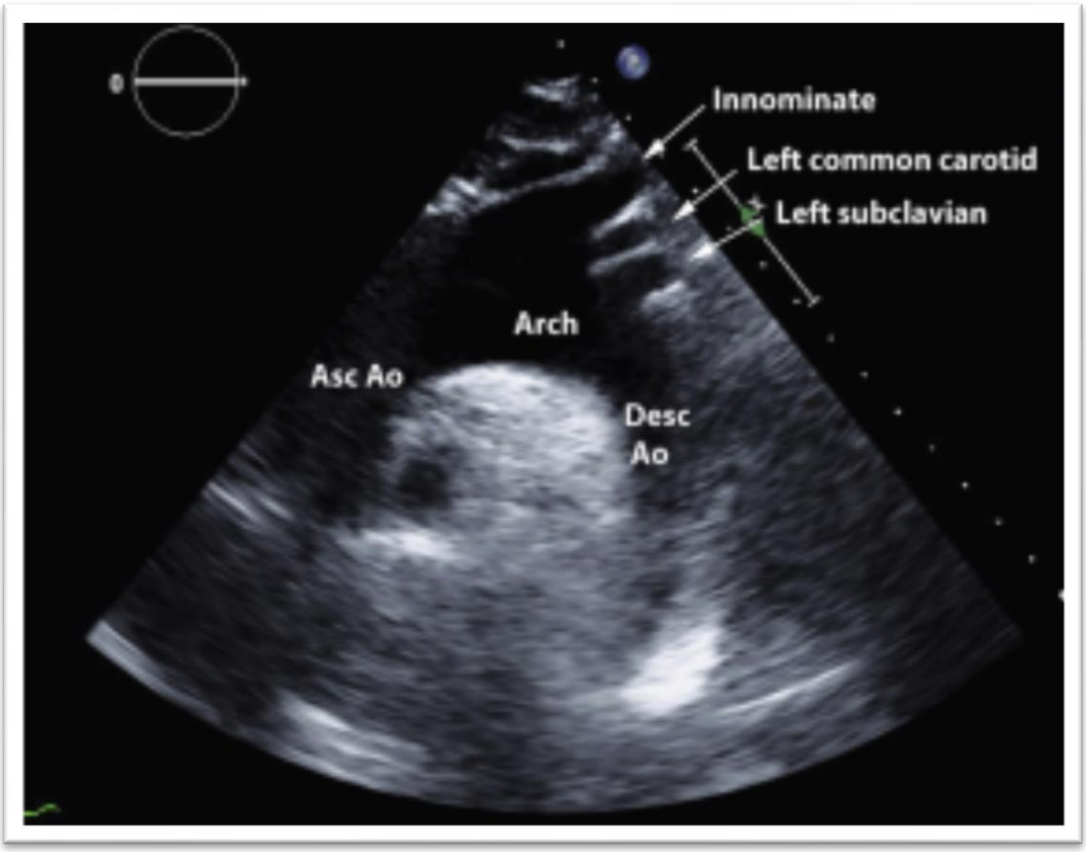

Fig (2.11) Transthoracic echocardiographic suprasternal notch view of the distal ascending aorta (Asc Ao), aortic arch, supraaortic vessels (arrows), and proximal descending thoracic aorta (Desc Ao). (Journal of the American Society of Echocardiography February 2016)

2.5 Computerized Tomography Scanning

Computed tomography (CT scan or CAT scan) is a noninvasive diagnostic imaging procedure that uses a combination of X-rays and computer technology to produce horizontal, or axial, images (often called slices) of the body. A CT scan shows detailed images of any part of the body, including the bones, muscles, fat, and organs. CT scans are more detailed than standard X-rays. In standard X-rays, a beam of energy is aimed at the body part being studied. A plate behind the body part captures the variations of the energy beam after it passes through skin, bone, muscle, and other tissue. While much information can be obtained from a standard X-ray, a lot of detail about internal organs and other structures is not available. In computed tomography, the X-ray beam moves in a circle around the body. This allows many different views of the same organ or structure. The X-ray information is sent to a computer that interprets the X-ray data and displays it in a two- dimensional (2D) form on a monitor. CT scans may be done with or without "contrast." Contrast refers to a substance taken by mouth or injected into an intravenous (IV) line that causes the particular organ or tissue under study to be seen more clearly. Contrast examinations may require you to fast for a certain period of time before the procedure. (Jiang, 2016)

2.5.1 Basic principle of CT

CT is based on the fundamental principle that the density of the tissue passed by the X-ray beam can be measured from the calculation of the attenuation coefficient. So, CT allows the reconstruction of the density of the body, by two dimensional section perpendiculars to the axis of the acquisition system. The emitter of X-rays (typically with energy levels between 20 and 150 keV), emits photons per unit of time. The beam passes through the layer of biological material thickness. A detector placed at the exit of the sample, measures photons, number of photons smaller than 0. So, the X-rays interacted with the object and the beam has been attenuated. There are basically two processes of the absorption: the photoelectric effect and the Compton. This phenomenon is represented by a single coefficient. In the specific case of the CT, the emitter of X-rays rotates around the patient and the detector, placed in diametrically opposite side, picks up the image of a body section (beam and detector move in synchrony). Unlike X-ray radiography, the detector of the CT scanner does not produce an image. They measure the transmission of a thin beam (1-10mm) of X-rays through a full scan of the body. The image of that section is taken from different angles and this allows retrieving the information on the depth (in the third dimension). In order to obtain tomographic images of the patient from the data in "raw" scan, the computer uses complex mathematical algorithms for image reconstruction. (Goldman, 2008)

If the X-ray at the exit of the tube is made monochromatic or quasi-monochromatic with the proper filter, one can calculate the attenuation coefficient corresponding to the volume of irradiated tissue by the application of the general formula of absorption of the X-rays in the field. The outgoing intensity of the beam of photons measured will depend on the location. In fact, the intensity is smaller where the body is more radioopaque. (Goldman, 2018)

The image of the section of the object irradiated by the X-ray is reconstructed from a large number of measurements of attenuation coefficient. It gathers together all the data coming from the elementary volumes of material through the detectors. Using the computer, it presents the elementary surfaces of the reconstructed image from projection of the data matrix reconstruction, the tone depending on the attenuation coefficients. The image by the CT scanner is a digital image and consists of square matrix of elements (pixel), each of which represents a voxel (volume element) of the tissue of the patient. In conclusion, a measurement made by a detector CT is proportional to the sum of the attenuation coefficients. (Lukáš et al, 2016)

The typical CT image is composed of 512 rows, each of 512 pixels, i.e., a square matrix of 512 x 512 = 262144 pixels (one for each voxel). In the process of image, the value of attenuated coefficient for each voxel corresponding to these pixels needs to be calculated. Each image point is surrounded by a halo-shaped star that degrades the contrast and blurs the boundary of the object. To avoid this, the method of filtered back projection is used. The action of the filter function is such that the negative value created is the filtered projection, when projected backwards, is removed and an image is produced, which is the accurate representation of the original object. (Lukáš et al, 2016)

Before the data are presented on the screen, the conventional rescaling was made into CT numbers, expressed in Hounsfield Units (HU), which define as a quantity commonly used in computed tomography (CT) scanning to express CT numbers in a standardized and convenient form. Hounsfield units, created by and named after Sir Godfrey Hounsfield, are obtained from a linear transformation of the measured attenuation coefficients. The radiodensity of distilled water at standard temperature and pressure (STP) 0 HU, and the radiodensity of air at STP -1000 HU. So, the signal transmitted by the detector is processed by the PC in the form of the digital information, the CT image reconstruction. (Lukáš et al, 2016)

2.5.2 The pitch

Is a term used in helical CT. It has two terminologies depending on whether single slice or multislice CT scanners are used. Is defined as table distance traveled in one 360° gantry rotation divided by beam collimation. For example, if the table traveled 5 mm in one rotation and the beam collimation was 5 mm then pitch equals 5 mm / 5 mm = 1.0. (Silverman et al, 2016)

2.5.3 The field of view (FOV)

The parameter that determines how much anatomy is scanned. The FOV should exceed the dimensions of the anatomy. Its value can be selected by the operator and generally lies in the range between 12 and 50 cm. The choice of a small FOV allows increased spatial resolution in the image, because the whole reconstruction matrix is used for a smaller region than is the case with a larger FOV; this results in reduction of the pixel size. In any case, the selection of the FOV must take into account not only the opportunity for increasing the spatial resolution but also the need for examining all the areas of possible disease. If the FOV is too small, relevant areas may be excluded from the visible image. If raw data are available the FOV can be changed by post-processing**.** (Willi, 2016)

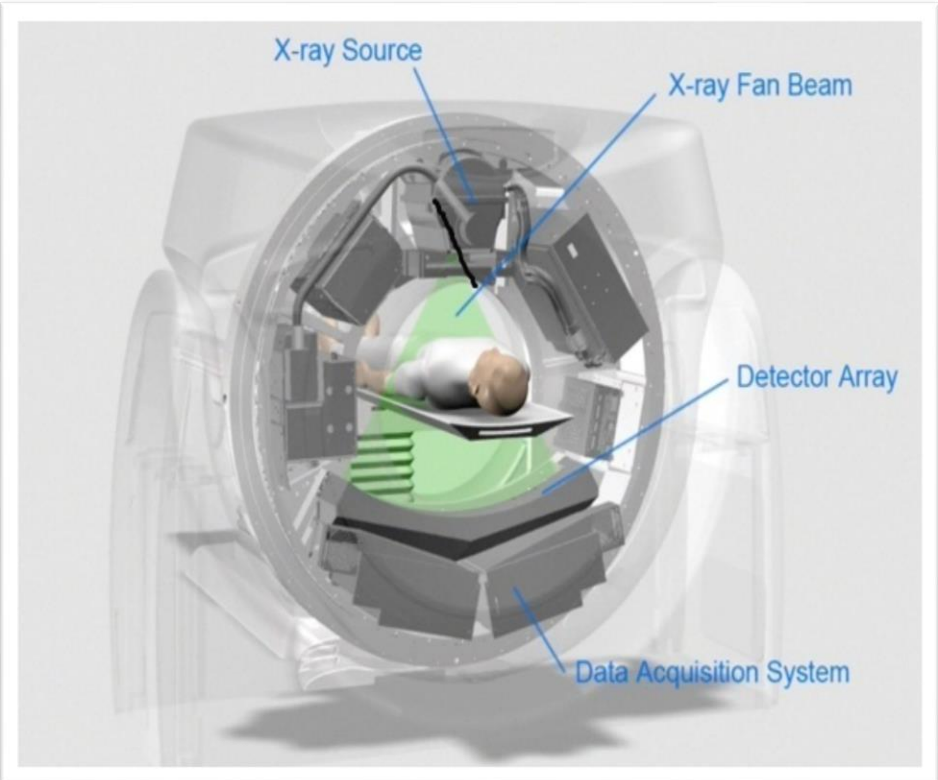

Fig (2.12): CT scan unit. (Lukáš et al, 2016)

2.5.4 CT chest

CT chest (computed tomography) is an imaging method that uses x-rays to create cross-sectional pictures of the chest and upper abdomen. (Gerald et al, 2017)

Chest CT scans are used for a multitude of reasons. They may be done to check for certain cancers in various different ways including to detect abnormal tumors, can also be ordered after a mammogram exam, Some chest CT scans are tailored to look for heart disease, aneurysms of the aorta or pulmonary emboli, can be used to guide doctors or surgeons during a procedure, such as a biopsy, can be used to detect cysts or infections in the body, They can also identify the bone structures within the body and can accurately measure the density of bone, and is often used to quickly inspect a patient after an accident in order to identify traumatic internal injuries. (Gerald et al, 2017)

The technologist begins by positioning patient on the CT examination table, usually lying flat on his back. Straps and pillows may be used to help you maintain the correct position and to help you remain still during the exam. Many scanners are fast enough that children can be scanned without sedation. In special cases, sedation may be needed for children who cannot hold still. Motion will cause blurring of the images and degrade the quality of the examination the same way that it affects photographs. If a contrast material is used, it will be injected into a vein shortly before scanning begins. Next, the table will move quickly through the scanner to determine the correct starting position for the scans. Then, the table will move slowly through the machine as the actual CT scanning is performed. Depending on the type of CT scan, the machine may make several passes. You may be asked to hold his breath during the scanning. Any motion, whether breathing or body movements, can lead to artifacts on the images. This loss of image quality can resemble the blurring seen on a photograph taken of a moving object. When the examination is completed, you will be asked to wait until the technologist verifies that the images are of high enough quality for accurate interpretation. The actual CT scanning takes less than 30 seconds and the entire process is usually completed within 30 minutes. (Gerald et al, 2017)

Certain CT scans require a special dye, called contrast, to be delivered into the body before the test starts. Contrast highlights specific areas inside the body and creates a clearer image. If your doctor requests a CT scan with intravenous contrast, you will be given it through a vein (IV) in your arm or hand. A blood test to measure your kidney function may be done before the test. This test is to make sure your kidneys are healthy enough to filter the contrast. Some people have allergies to IV contrast and may need to take medications before their test to safely receive this substance. Contrast can be given in several ways, depending on the type of CT being performed. It may be delivered through a vein (IV) in your hand or forearm, it may be given through the rectum using an enema, and you might drink the contrast before your scan. When you actually drink the contrast depends on the type of exam being done. The contrast liquid may taste chalky, although some are flavored to make them taste a little better. The contrast eventually passes out of your body through your stool. If contrast is used, you may also be asked not to eat or drink anything for 4 to 6 hours before the test. (Gerald et al, 2017)

2.5.5 The benefits vs. risks of CT

Benefits; CT is fast, which is important for patients who have trouble holding their breath. CT scanning is painless, noninvasive and accurate. A major advantage of CT is its ability to image bone, soft tissue and blood vessels all at the same time. Unlike conventional x-rays, CT scanning provides very detailed images of many types of tissue as well as the lungs, bones, and blood vessels. CT examinations are fast and simple; in emergency cases, they can reveal internal injuries and bleeding quickly enough to help save lives. CT has been shown to be a cost-effective imaging tool for a wide range of clinical problems. CT is less sensitive to patient movement than MRI. CT can be performed if you have an implanted medical device of any kind, unlike MRI. CT imaging provides real-time imaging, making it a good tool for guiding minimally invasive procedures such as needle biopsies and needle aspirations of many areas of the body, particularly the lungs, abdomen, pelvis and bones. A diagnosis determined by CT scanning may eliminate the need for exploratory surgery and surgical biopsy. No radiation remains in a patient's body after a CT examination. X-rays used in CT scans should have no immediate side effects. Low-dose CT scans of the chest use a lower dose of radiation than conventional chest CT.(RadiologyInfo.org,2016)

Risks; There is always a slight chance of cancer from excessive exposure to radiation. However, the benefit of an accurate diagnosis far outweighs the risk. The effective radiation dose for this procedure varies. See the Safety page for more information about radiation dose. Women should always inform their physician and x-ray or CT technologist if there is any possibility that they are pregnant. See the Safety page for more information about pregnancy and x-rays. CT scanning is, in general, not recommended for pregnant women unless medically necessary because of potential risk to the baby in the womb. The risk of serious allergic reaction to contrast materials that contain iodine is extremely rare, and radiology departments are well-equipped to deal with them. In some patients with reduced kidney function, the dye used in CT scanning may worsen kidney function. Because children are more sensitive to radiation, they should have a CT exam only if it is essential for making a diagnosis and should not have repeated CT exams unless absolutely necessary. CT scans in children should always be done with low-dose technique.(RadiologyInfo.org,2016)

2.7 Previous Studies

- Ahmed M.tawfik et 2019 had done statistical study about the effect of the age and gender on tortuosity of descending thoracic aorta , their method was done by contrast enhancement CT scan on 182 patiant were analaized by an experienced radiologist using routine3D imaging software. The descending aorta was defined by proximal and distal endpoints. The software generated centerline length, and straight line distance between the 2 endpoints were measured. TI was calculated as: [centerline length / straight line distance -1] * 100. Impact of age on TI of the descending aorta was assessed using linear regression in both genders. To assess inter-observer agreement; TI measurements of 50 cases were repeated by 3 other independent readers, and he found Tortuosity of the descending aorta increases with age in both genders. TI has acceptable inter-observer agreement and was better correlated to age than centerline length measurements

- Arik, et al 2008 had done statistical study about aortic size assessment by noncontrast cardiac computed tomography to determine normal limits for ascending and descending thoracic aorta diameters in a large population of asymptomatic, low risk adult subjects. Their methods were done in 4,039 adult patients undergoing coronary artery calcium (CAC) scanning during the period from July 2004 to March 2007, systematic measurements of the ascending and descending thoracic aorta diameters were made at the level of the pulmonary artery bifurcation. The final analysis groups for ascending and descending thoracic aorta included 2,952 and 1,931 subjects, respectively. Subjects were then regrouped by gender, age, and body surface area (BSA) for ascending and descending aorta, separately. The mean diameters for the final analysis group were 33 ± 4 mm for the ascending and 24 ± 3 mm for the descending thoracic aorta.

- Mao, et al 2008 had done study about normal thoracic aorta diameter on cardiac computed tomography in healthy asymptomatic adult to establish the normal criterion of ascending aortic diameter (AAOD) measured by 64 Multi-Detector Computed Tomography and Electron Beam Computed Tomography based on gender and age. 1442 consecutive subjects who were referred for evaluation of possible coronary artery disease underwent coronary CT angiography and coronary artery calcium scanning (55+11 years, 65% male) without known coronary heart disease, hypertension, chronic pulmonary and renal disease, diabetes and severe aortic calcification. The ascending aortic diameter, descending aortic diameter, pulmonary artery and chest anterioposterior diameter, posterior border of sternal bone to anterior border of spine, were measured at the slice level of mid right pulmonary artery. The linear correlation analysis was done between AAOD and all parameters.Thier result AAOD had significant linear association with age, gender, descending aortic diameter and pulmonary artery diameter. The mean Intra-luminal AAOD was 31.1 ± 3.9mm and 33.6 ± 4.1 mm in females and males respectively. Their concluded with the ascending aortic diameter increases with age and male gender.

- FY, et al 2018 had done study to establish reference values for thoracic aortic diameters MDCT in adults without evident cardiovascular disease. There method were done in 103 (43% women, age 51 +/- 14 years) adults free of cardiac or aortic structural disease underwent MDCT examination to determine aortic dimensions. There results were at the end-diastolic diameter 95% confidence intervals were 2.5-3.7 cm for the aortic root, 2.1-3.5 cm for the ascending aorta, and 1.7-2.6 cm for the descending thoracic aorta. Aortic diameters were significantly greater at end systole than end diastole, Aortic root and ascending aortic diameter increased significantly with age and body surface area.

- Alfred, et al 2016 their aim is the use of helical computed tomography is well established in the evaluation of the thoracic aorta. They planned to set up normal diameters for the thoracic aorta of adults obtained by helical computed tomography. Their study was done on seventy adults, 17 to 89 years old, without any signs of cardiovascular disease were investigated with helical computed tomography. Aortic diameters were measured at seven predefined thoracic levels, There result are Aortic diameters (mean ± SD) were 2.98 ± 0.46 cm at the aortic valve sinus, 3.09 ± 0.41 cm at the ascending aorta, 2.94 ± 0.42 cm proximal to the innominate artery, 2.77 ± 0.37 cm at the proximal transverse arch, 2.61 ± 0.41 cm at the distal transverse arch, 2.47 ± 0.40 cm at the isthmus, and 2.43 ± 0.35 cm at the diaphragm. Men had slightly longer diameters than did women. All diameters increased with age.

- Garcier et al, 2017 they were done study to determine the evolution of the diameter of the thoracic aorta with age in order to detect dilatation more reliably by imaging. They performed a retrospective analysis of the MRI examinations of the normal thoracic aorta of 66 subjects aged 44.1±19.1 years (range 19.1–82.4 years) obtained between 1991 and 2000 used T1-weighted spin echo sequences. Sixteen measurements were made in the axial plane, the oblique sagittal plane in the axis of the aortic arch, and the oblique frontal plane perpendicular to the latter at the level of the ascending aorta, the arch and the descending thoracic aorta. They found an increase in the thoracic aorta diameter and a significant relationship between this diameter and the age of their subjects, wherever the measure was performed.

- Anthony et al, 1994 they used transesophageal echocardiography to assessment the effects of age, gender, and hypertension on thoracic aortic wall size, thickness, and stiffness. In 83 patients undergoing transesophageal echocardiography for clinical indications, recordings of the descending thoracic aorta were made. There were 53 normotensive subjects (33 men and 20 women, mean age 46 years, range 14 to 79 years) and 25 hypertensive subjects (8 men and 17 women, mean age 67 years, range 50 to 80 years). Their result is aging significantly increases aortic thickness and stiffness. Women have significantly higher relative aortic wall thickness than men but a similar stiffness. Hypertension increases aortic thickness and stiffness.

- Anne et al, 2019study was done on 484 subjects (230 male, 254 female), age 19-70 years without identifiable cardiac risk factors underwent MRI to determine aortic diameter at three levels namely; the ascending aorta, proximal descending aorta (pulmonary artery level), and the abdominal aorta. In addition, 208 of the subjects had aortic root measurements performed at the aortic valve annulus, aortic sinuses and sino-tubular junction. Their results are with increasing BSA, aortic root diameter increased at all levels measured, No gender difference in the degree of dilatation with increasing BSA was seen and aortic diameters at the more distal aortic levels also increased with increasing BSA.

Chapter Three
Material and Methods

Chapter Three
Materials and Methods

3.1 Materials:

3.1.1 Study design

This was descriptive analytical study.

3.1.2 Duration and Area of the study:

The study was conducted at radiology department at Yastabshiroon hospital and Alraqi hospital during the period from August to December 2021.

3.1.3 Patient:

The research will be conducted on 50 adult patients (24-85 years).

3.1.4 Inclusion Criteria:

A total of fifty patients were included in this study, their age from 24 to 85 years old.

3.1.5 Exclusion criteria

Patients having pathological changes such as pulmonary embolism, aortic aneurysm, aortic atherosclerosis, aortic regurgitation, aortic dissection, aortic stenosis and aortitis.

3.1.6 Equipment:

Will be using different type of CT machine :

- Toshiba 16 slice .

-Siemens 16 slice.

3.2 Method

3.2.1 Scanning Protocol

CT scans will be obtained with the patient in supine position during full inspiration. The scan range from 1 cm above lung apices to the diaphragm. The exposure parameters 120 kVp, 50-300 mA and 5 mm slice.

3.2.2 Method of Thoracic Aorta Measurement

The measurements will be taken from the operator council of the CT machine; the axial images will be obtained at the level of pulmonary artery bifurcation, ascending and descending thoracic aortic diameter measurements perpendicular to the axis of rotation of aorta made in (mm), and used as a reference applied by Arik, et al 2008. The diameter of ascending aorta and descending aorta were measured at the same slice images.

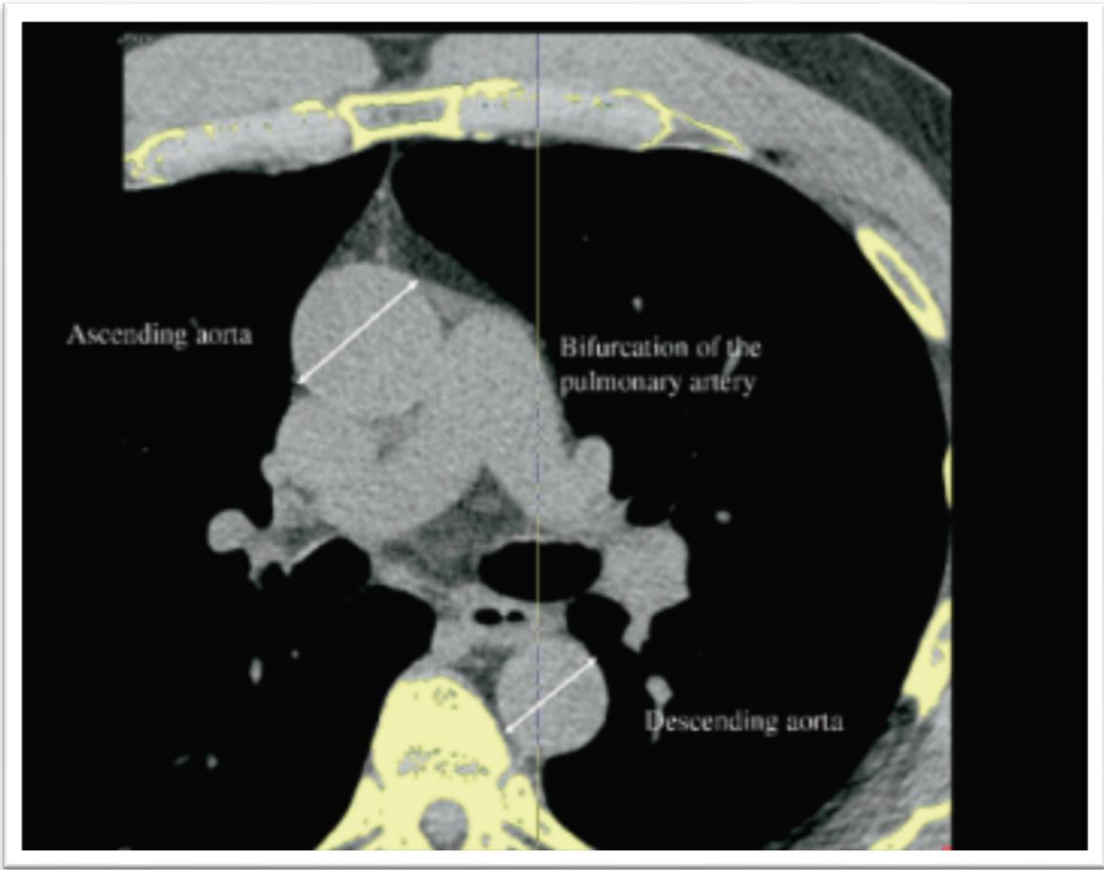

Fig (3.1) Show the method of aorta measurement. (Arik et al, 2008)

3.2.3. Statistical Analysis

The data collected in master data sheet and were analyzed using SPSS program version 16. Data were presented as mean and standard deviation (SD) for all of variables. The results were significant at $p < 0.05$. Detailed results are shown in the tables and figures.

3.2.4 Ethical consideration:

Permission is taken from ministry of health, hospitals and ultrasound departments. The patients were aware of the nature of the study and to willingly, consent verbally to have a data for the study.

Chapter Four

Results

Chapter Four
Results

Table (4.1) frequency distribution of gender

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Female	20	40.0	40.0	40.0
Male	30	60.0	60.0	100.0
Total	50	100.0	100.0	

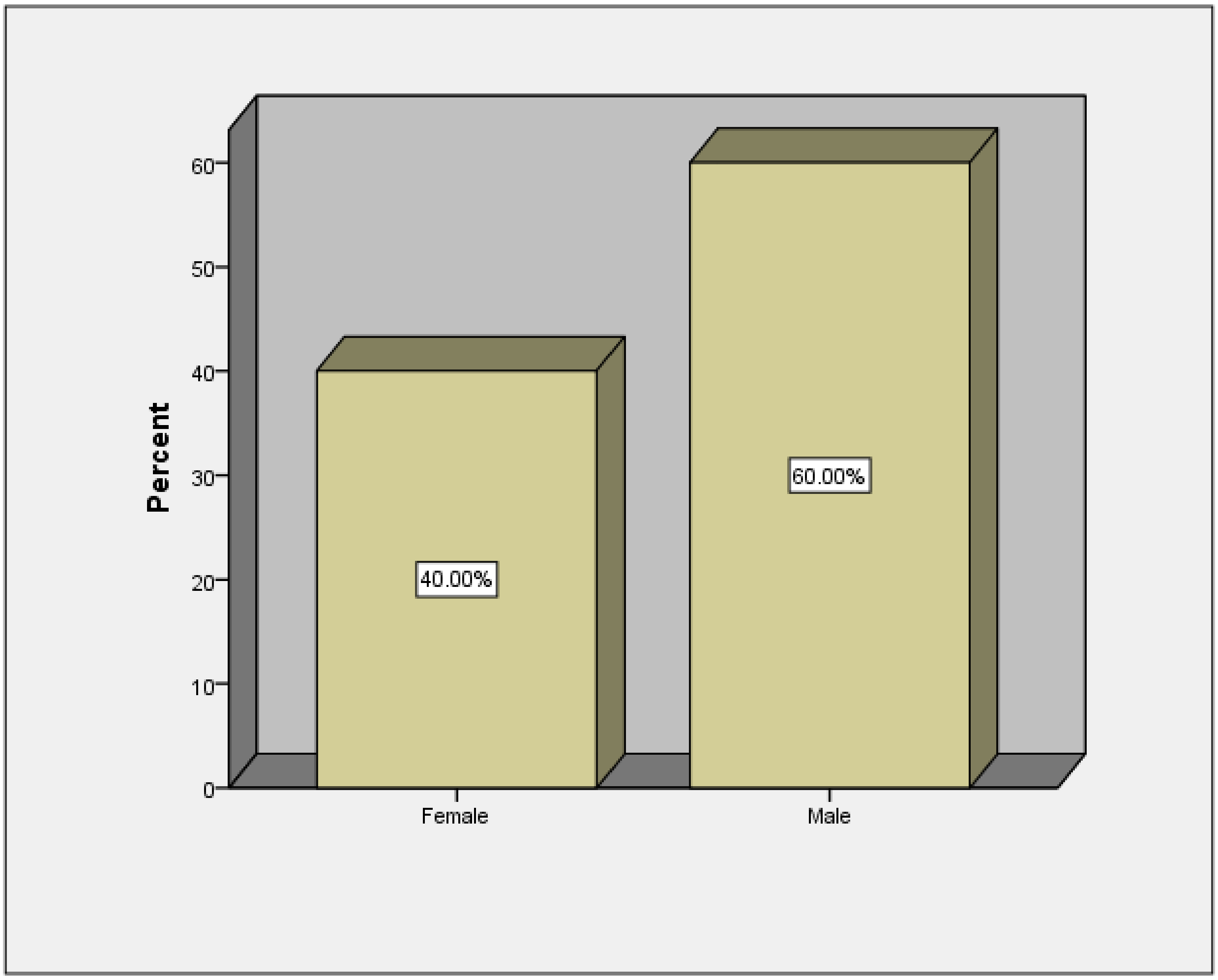

Figure (4.1) frequency distribution of gender

Table (4.2) frequency distribution of age group

Age group	Frequency	Percent	Valid Percent	Cumulative Percent
31-45	8	16.0	16.0	16.0
46-60	19	38.0	38.0	54.0
61-75	16	32.0	32.0	86.0
more than 75	7	14.0	14.0	100.0
Total	50	100.0	100.0	

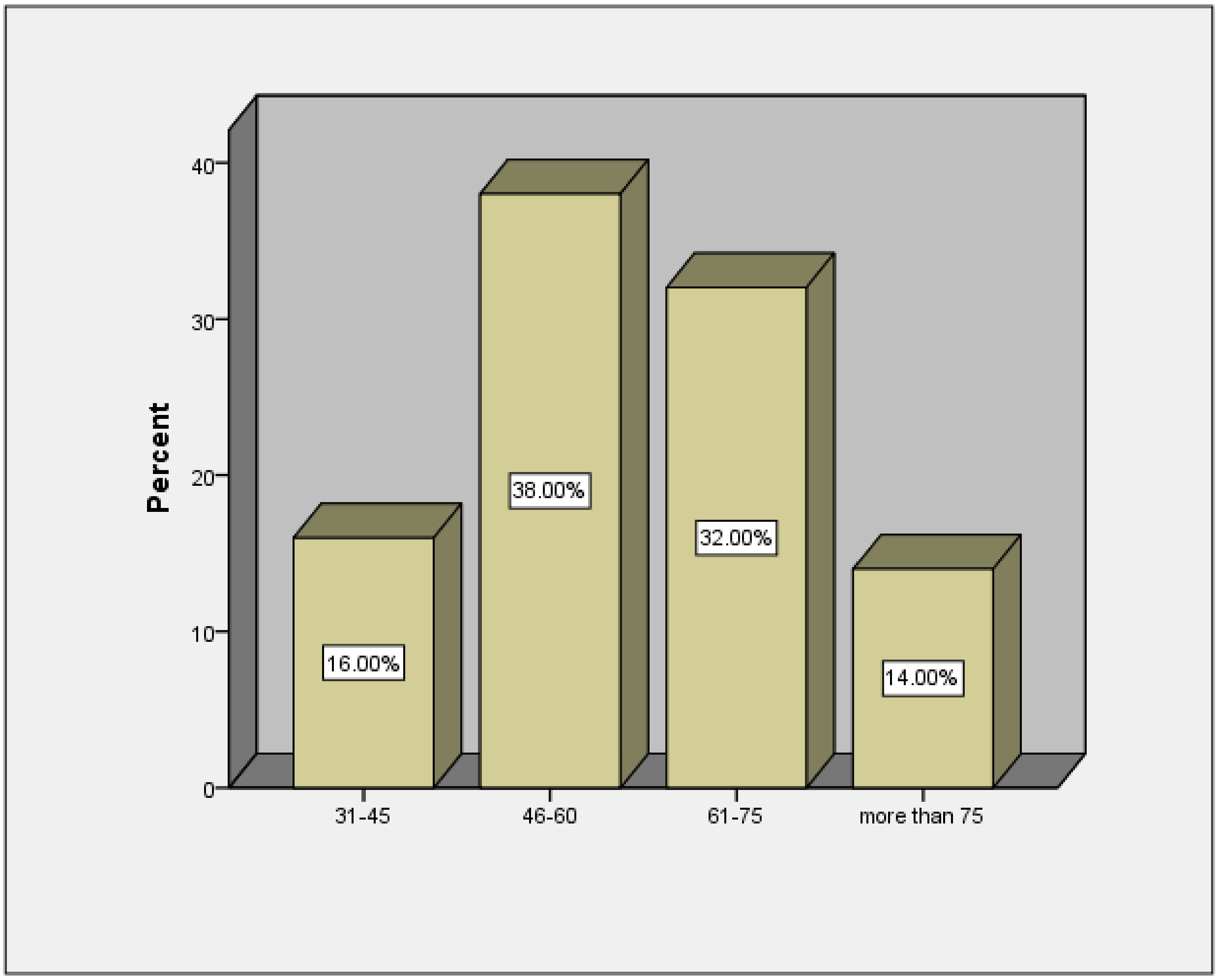

Figure (4.2) frequency distribution of age group

Table (4.3) descriptive statistic for age, weight, height, BMI and ascending and descending measurement (minimum, maximum, mean ± Std. Deviation)

Variables	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Age	50	31	81	59.06	13.117
Weight	50	44	75	58.96	7.094
Height	50	139	180	156.60	9.158
BMI	50	19.5	31.1	24.740	3.4131
Ascending measurement	50	2.25	4.07	2.9830	0.43654
Descending measurement	50	1.60	3.07	2.4460	0.32545
Valid N (listwise)	50				

Table (4.4) correlation between age, weight, height, BMI and ascending and descending measurement

		Age	Weight	Height	BMI
Ascending measurement	Pearson Correlation	0.083	-0.088	-0.006	-0.012
	Sig. (2-tailed)	0.567	0.544	.965	0.934
	N	50	50	50	50
Descending measurement	Pearson Correlation	0.350*	-0.025	-0.219	0.180
	Sig. (2-tailed)	0.013	0.863	0.126	0.211
	N	50	50	50	50

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

*. Correlation is significant at the 0.05 level (2-tailed).

Table (4.5) independent sample t-test for compare mean measurement in both gender :

a. Compare mean

Variables	Gender	N	Mean	Std. Deviation	Std. Error Mean
Age	Male	30	57.43	13.469	2.459
	Female	20	61.50	12.505	2.796
Weight	Male	30	59.47	6.431	1.174
	Female	20	58.20	8.102	1.812
Height	Male	30	156.30	10.616	1.938
	Female	20	157.05	6.629	1.482
BMI	Male	30	24.443	3.5729	0.6523
	Female	20	25.185	3.1954	0.7145
Ascending measurement	Male	30	3.0047	0.47493	0.08671
	Female	20	2.9505	0.38122	0.08524
Descending measurement	Male	30	2.4497	0.33888	0.06187
	Female	20	2.4405	0.31277	0.06994

b. Independent sample t- test for compares mean

Variables	t-test for Equality of Means						
		df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Age	-1.076	48	.287	-4.067	3.781	-11.668	3.535
	-1.092	42.932	.281	-4.067	3.724	-11.577	3.443
Weight	.615	48	.542	1.267	2.061	-2.877	5.411
	.587	34.345	.561	1.267	2.159	-3.119	5.652
Height	-.281	48	.780	-.750	2.669	-6.116	4.616
	-.307	47.856	.760	-.750	2.440	-5.656	4.156
BMI	-.749	48	.457	-.7417	.9897	-2.7316	1.2483
	-.767	43.893	.447	-.7417	.9675	-2.6917	1.2083
Ascending measurement	.426	48	.672	.05417	.12708	-.20135	.30968
	.445	46.232	.658	.05417	.12159	-.19056	.29889
Descending measurement	.097	48	.923	.00917	.09491	-.18167	.20000
	.098	43.086	.922	.00917	.09338	-.17913	.19747

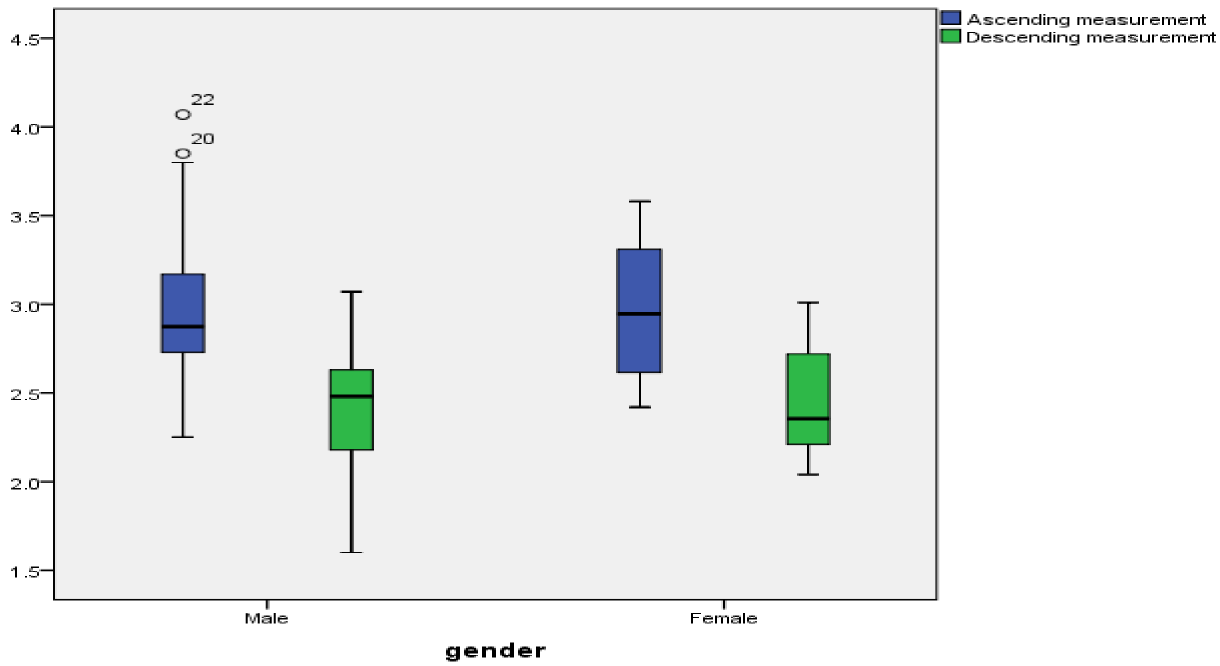

Figure (4.3) plot box shows mean measurement in both gender

Table (4.6) compares mean measurement of ascending and descending in different age groups (One way a nova test)

Age group		Ascending measurement	Descending measurements
31-45	Mean	2.8475	2.1225
	N	8	8
	Std. D	0.18866	0.23741
46-60	Mean	3.0468	2.5179
	N	19	19
	Std. D	0.40898	0.26233
61-75	Mean	2.9656	2.4500
	N	16	16
	Std. D	0.51964	0.34587
more than 75	Mean	3.0043	2.6114
	N	7	7
	Std. D	0.54696	0.32534
Total	Mean	2.9830	2.4460
	N	50	50
	Std. D	0.43654	0.32545
P values		0.760	0.010*

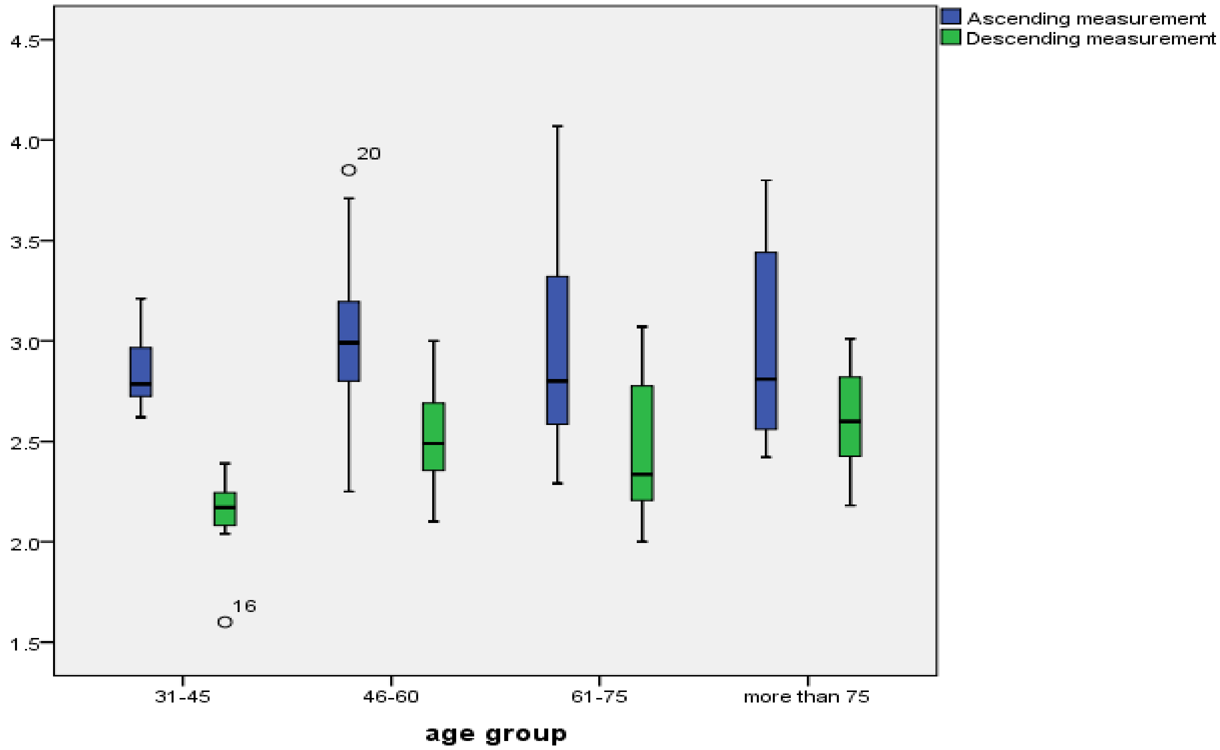

Figure (4.4) plot box shows mean measurement in different age group

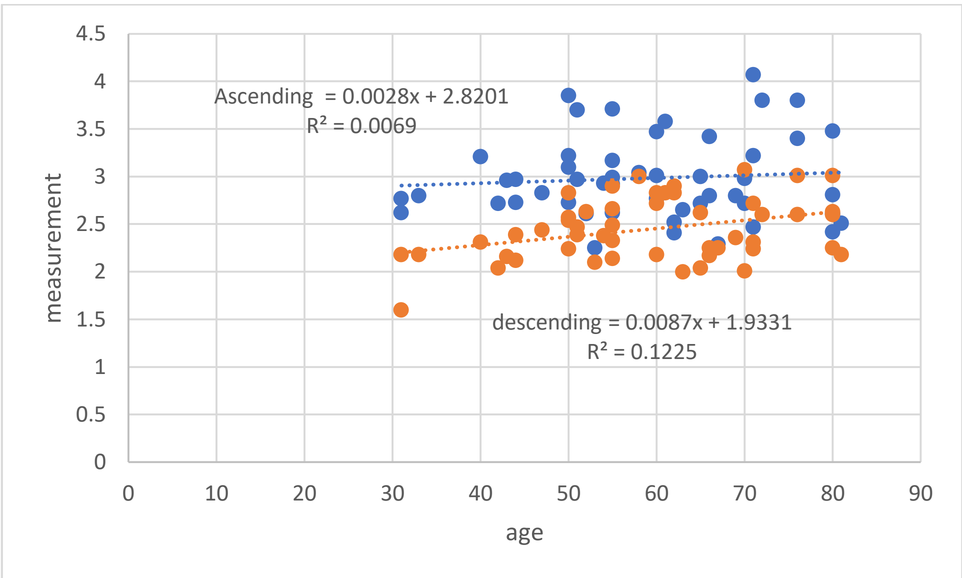

Figure (4.5) scatterplot to assess the relationship between age and measurements

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion and Recommendations

5.1 Discussion:

The objectives of this descriptive study were to measurement the thoracic aorta diameter in Sudanese population by using CT scan and to evaluate the aorta diameter regarding to age and gender and BMI. Descriptive statistics mean and SD of the variables which includes age, weight, height, BMI, descending thoracic aorta diameter, and ascending aorta diameter. show frequency distraction for gender. this study consists of 50 subject with different gender, 20 were female was (40%) and were male was (60%) the number of male is more especially the adults. the study agrees the study Alfred, et al 2016 and Mao, et al 2008 Table (4.1) figure (4.1).

Group statistic for distribution of age group to divide to 4 group. first group 31-45 years with 8 patients was (16%). and second group 46-60 years with 19 patients was (19%). and third group 61-75 years with 16 patients was (7%) .And fourth group more than 75 years with 7 patients was (14%) frequency distribution of age group between 46-60 more patients then another group. the study agrees with this point Anthony, et al 1994.table (4.2) figure (4.2).

Show group statistic for age, weight, height, BMI, ascending aorta and descending measurement. For age mean ± SD was (59.06±13.117 cm) and minimum 31 and maximum 81.

And weight to mean ± SD was (58.96±7.1cm) and minimum 44, maximum 75.

And height to mean± SD was (156.6±9.2cm), minimum 139, and maximum 180.

And BMI to mean ± SD was (24.7±3.4cm) minimum 19.5, maximum 31.

And ascending aorta to mean± SD was (2.98±.436cm), minimum 2.25, and maximum 4.07.

And descending aorta to mean± SD was (2.4460± .32545cm), minimum 1.60, and maximum 3.07. And we found the minimum between variables is descending aorta (1.60) and maximum between variables is height (180), table (4.3).

Show correlation between ascending aorta measurement with age, weight, height, BMI was p-value respectively.5567m.544, .965, .934 is no significant relationship between ascending aorta and age, weight, height, BMI (positive relation).

Show correlation between descending aorta measurement with weight, height, BMI, was p-value respectively .863, .126 ,0211 is no significant relationship between descending aorta and weight, height, BMI (positive relation) and correlation between descending aorta measurement with patient age was p-value .013 significant relationship between descending aorta and age, weight, height, BMI (negative relation).Table (4.4).

indecent sample t-test for compare mean measurement in both gender compare mean for patient gender mean± SD for male was (57.43±134.69cm) and female was (61.50±12.505cm) and patient weight was (59.49±6.431cm) and female was (58.20±8.102cm) and patient height for male was (156.30±10.616cm) and female was (157.05±6.629cm) and patient BMI for male was (24.44±3.5729cm) and female was (25.185±3.195cm), and patient ascending aorta for male was (3.0047±.47493cm) and female was (2.9505±.32122cm),and descending aorta for male was (2.4405±.31277cm).Table (4.5).

Indecent sample t-test camper mean for age, plot shows mean between else with ascending and descending aorta, the ascending mean in male bigger descending aorta mean. For female mean ascending mean bigger descending aorta mean figure (4.3).

compares mean measurement of ascending and descending aorta and deferent group divide to 4 group : first group 31-45years was mean ± SD was (2.84±.1888cm) and number of patient 8 .second group 4-.60 was (3.0462

±..40892cm) and number of patient 19 ,third group 61-75 was(2.9656±.51964cm) and number of patient 16, fourth group more than 75 years was(3.00±0596cm) and number of patient 7, and descending aorta divide to 4 group , first group 31-45 years was mean± SD was (2.1225±23741cm), and number of patient 8, second group was(2.5179±.26233cm) and number of patient 19.third group 61-75 years was(2.455±.34587cm) and number of patient 16, fourth group was more than 75 years was (2.6114±.32534cm) and number of patient 7. And p-value with ascending measurement was 0.760 show there is no significant different age group with ascending aorta (positive relation).

And p-value with descending aorta measurement was0.010, show there is significant different age group with descending aorta (negative relation) table (4.6).

The highest group with ascending aorta was third group 61-75 and lowest group 40-60 and highest group descending aorta was 61-75 and lowest group 61-75 figure (4.4).

The correlation between ascending aorta and descending aorta with patient age the rate of change ascending aorta with patient age was 0.00 28x as for 8 years of the patient, and the R square value was 0.0069 is mean week relation.

Will the correlation the descending aorta with patient age. the rate of change descending aorta with patient age was 0.0087 for 80 years of the patient age and R square value was 0.1225 is mean week relation the study found that can predict measure of the ascending aorta and descending aorta if the age was known by the following equation: ascending aorta 0.0028x + 2.8201 and descending aorta 0.0087x + 1.9331, figure (4.5).

5.2 Conclusion:

Correlation between ascending aorta measurement with age, Wight, height, BMI was being no significant relationship between ascending aorta and age, weight, height, BMI (positive relation), no significant relationship between descending aorta and weight, height, BMI (positive relation) and was significant relationship between descending aorta and age, (negative relation), no significant different between age group with ascending aorta (positive relation) but on the other hand moderate significant correlation between age and descending measurement p value less than 0.05, significant different between age group with descending aorta (negative relation), there was significant different between age group with descending aorta (negative relation), descending aorta moderate correlation with age and week relative association between descending aorta and age.

5.3 Recommendations

1. Further descriptive analytic studies are needed using another imaging method as MRI or echocardiography to confirm these result that presented in the index so as to help in diagnosis of aortic problem which lead to enlargement or decreasing its size.
2. As the morphology differs regarding the race and ethnicity factor a similar local research is recommend in different Sudanese tribes.
3. Further study should be done with large sample size.

References

- Alfred Hager, MD Harald Kaemmerer, MD, VD, PhD Ulrike Rapp-Bernhardt, MD Sebastian Blücher, MD Karl Rapp Thomas M. Bernhardt, MD Michael Galanski, MD, PhD John Hess, MD, PhD. (2002),Diameters of the thoracic aorta throughout life as measured with helical computed tomography, Vol.123(6) :1060-1066.
- American College of Cardiology, (2012) retrieved August 17.
- American College of Chest Physicians and American Thoracic Society), retrieved 6 January (2013). Anatomic Approach. Philadelphia: Lippincott Williams & Wilkins.
- Anne Davis, Cameron Holloway, Adam J Lewandowski , Ntobeko Ntusi , Richard M Nethononda , Alex Pitcher , Jane M Francis , , Stefan Neubauer , Oliver J Ride,(2013) Diameters of the normal thoracic aorta measured by cardiovascular magnetic resonance imaging; correlation with gender, body surface area and body mass index, Paul Leeson2
- Anthony C. Pearson, MD , Ruiqiang Guo, MD, David A. Orsinelli, MD, Philip F. Binkley, MD, Tomasz J. Pasierski, MD,(1993) Transesophageal echocardiographic assessment of the effects of age, gender, and hypertension on thoracic aortic wall size, thickness, and stiffness, .
- Aric. Madisen J,Ema.Eseelle. Connere (2015), The Circulatory system.
- Arik Wolak, MD ; Heidi Gransar, MS ; Louise E.J. Thomson, MB ChB ; John D. Friedman, MD, FACC ; Rory Hachamovitch, MD, FACC ; ArielGutstein, MD ; Leslee J. Shaw, PhD, FACC ;Donna Polk, MD, MPH ; Nathan D. Wong, PhD ; Rola Saouaf, MD ; Sean W. Hayes, MD ; Alan Rozanski, MD, FACC ; Piotr J. Slomka, PhD ;Guido Germano, PhD, FACC ; Daniel S. Berman,MD, FACC(2008) 1(2):200-209 doi:10.1016/j.jcmg.2007.11.005Chapter Four
- Cedars Sinai, (2016) Anatomy of the aorta, 501(c) (3) .

- Czarny, MJ; Resar, JR, (2014) Diagnosis and management of valvular aortic stenosis, Vol 8(1):15-24.
- David Shier, Jackie Butler, and Ricki Lewis, (2015) Hole's Human Anatomy and Physiology, edition 14th
- Dietz HC, Loeys B, Carta L, Ramirez F; Loeys; Carta; Ramirez (2005). "Recent progress towards a molecular understanding of Marfan syndrome".
- Dr Yuranga Weerakkody and Dr Donna D'Souza, (2008) Thoracic aortic injury; 191 (5) 1564-9.
- Dr. Aditya Shetty and A.Prof Frank Gaillard, (2015) Ascending aortic aneurysm, Radiopaedia.Org
- Dr. MO,(2014) Superior and posterior mediastinum, 270(1): 15-24
- Drake, Richard L.; Vogl, Wayne; Tibbitts, Adam W.M. Mitchell, (2010,) Gray's anatomy for students, Philadelphia: Elsevier/Churchill Livingstone.
- Erbel R, Alfonso F, Boileau C,Dirsch O,Eber B,Haverich A.(2005) Diagnosis and management of aortic dissection.
- Erbel R, Alfonso F, Boileau C, Dirsch O, Eber B, Haverich A, (2001); Diagnosis and management of aortic dissection, Recommendations of the task force on aortic dissection. European Society of Cardiology. Eur Heart J 22:1642.
- Freeman LA, Young PM, Foley TA, Williamson EE, Bruce CJ, Greason KL, (2013),Volume 200, CT and MRI assessment of the aortic root and ascending aorta.
- Freeman RV, Otto CM, (2011) Aortic valve disease, 13th edition, vol 2 .
- GBD 2013 Mortality and Causes of Death, Collaborators (17 December 2014) "Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013
- Gerald N,Olsen M.D, Basic Chest Radiology, 2013.
- Goldman LW (2008). Principles of CT: Multislice CT. Journal of Nuclear Medicine Technology. Vol. 36, No.2

- Groenemeijer, BE; Bakker, A; Slis, HW;Waalewijn, RA; Heijmen, RH (2008). "An unexpected finding late after repair of coarctation of the aorta". Netherlands Heart Journal 16 (7-8): 260–3.
- Henry Gray, (1918). Anatomy of the Human Body
- J.M. Garcier , V. PetitcolinAffiliated withDepartment of Radiology, CHUG.Montpied,BP, M. Filaire, R. Mofid, K. Azarnouch, A. Ravel,G. Van neuville, L. Boyer,(2003) Normal diameter of the thoracic aorta in adults: a magnetic resoance imaging study,25 (3-4):322-9..
- Jiang Hsieh, (2009) Computed Tomography, Second Edition: Principles, Design, Artifacts, and Recent Advances.
- Journal of the American College of Cardiology(2012) 57 (9): 1126–1166.
- Journal of the American Society of Echocardiography February, 2015, Volume 29, Issue 6.
- Kamalakannan D, Rosman HS, Eagle KA,(2007) Acute aortic dissection.23(4): 779-800.
- Kenneth L. Bontrager, MA, RT(R) John P. Lampingnano, Med, R (CT),(2012) TEXT BOOK OF Radiographic positioning and Related Anatomy, Sixth Edition.
- Kent KC (27 November 2014)."Clinical practice. Abdominal aortic aneurysms." The New England Journal of Medicine 371 (22)
- Lin FY, Devereux RB, Roman MJ, Meng J, Jow VM, Jacobs A, Weinsaft JW, Shaw LJ, Berman DS, Gilmore A, Callister TQ, Min JK.(2008), Assessment of the thoracic aorta by multidetector computed tomography, Vol. 2(5): 298-303
- Lukáš Mikšík, KZM FN Moto (2014) Basic Principle of CT Scan.
- Magnetic resonance angiography. (2013) Eur Radiol
- Marco Spartera, Maurizio Galderisi, Donato Mele, Matteo Cameli, Antonell o D'Andrea, Andrea Rossi, Sergio Mondillo, Giuseppina Novo,Roberta Esp osito, Flavio D'Ascenzi, Roberta Montisci, Sabina Gallina, Alberto Margon

ato, Eustachio Agricola(2016) Echocardiographic Study Group of the Italian Society of Cardiology (SIC)Eur Heart J Cardiovascular Imaging 17 (5).

- Maton, Anthea; Roshan L. Jean Hopkins; Charles William McLaughlin; Susan Johnson; Maryanna Quon Warner; David LaHart; Jill D. Wright,(1993). 128 (7):559 Human Biology and Health.
- Matthias Müller-Eschner, Tobias Müller, Andreas Biesdor, Stefan Wörz, Fabian Rengier, Dittmar Böckler, Hans-Ulrich Kauczor, Karl Rohr, Hendrik von Tengg-Kobligk, (2014), 4(2), 3D morphometry using automated aortic segmentation in native MR angiography
- Medicine.academic.ru, 2001
- RadiologyInfo.org, 2016
- Silverman PM, Kalender WA, Hazle JD. Common terminology for single and multislice helical CT. AJR Am J Roentgenol. (2001); 176 (5): 1135-6.doi:10.2214/ajr.176.5.1761135 - Pubmed citation
- Song Shou Mao, MD, Nasir Ahmadi, MPH, Birju Shah, M.B.B.S, Daniel Beckmann, BS, Annie Chen , BS, Luan Ngo, BS, Ferdinand R Flores, BS,Yan lin Gao, MD, and Matthew J Budoff, M.D,(2009) Normal Thoracic Aorta Diameter on Cardiac Computed Tomography in Healthy Asymptomatic Adult; Impact of Age and Gender,Vol, 15(7):827-834
- Susan Standring(2008) Gray's anatomy: the anatomical basis of clinical practice, 41st Edition.
- Thomas Kau, M.D., Marietta Sinzig, M.D., Johann Gasser, M.D., Gerald Lesnik, M.D., Egon Rabitsch, M.D., Stefan Celedin, M.D., Wolfgang Eicher, M.D., Herbert Illiasch, M.D and Klaus Armin Hausegger, M.D.(2007). Aortic Development and Anomalies.24 (2): 141-52.
- Tsamis, A.; Krawiec, J. T.; Vorp, D. A, (2013) Elastin and collagen fibre microstructure of the human aorta in ageing and disease a review". Journal of the Royal Society Interface 10 (83): 20121004–20121004.

- Valdes-Cruz, Lilliam M.; Cayre, Raul O, (1999) Echocardiographic Diagnosis of Congenital Heart Disease: An Embryologic and
- Voermans, Nicol C.; van Alfen, Nens; Pillen, Sigrid; Lammens, Martin; Schalkwijk, Joost; Zwarts, Machiel J.; van Rooij, Iris A.;Hamel, Ben C. J.; van Engelen, Baziel G.(2009). "Neuromuscular involvement in various types of Ehlers-Danlos syndrome". Annals of Neurology 65 (6)
- WebMD Medical Reference from Healthwise Last Updated: September 09, 2014
- Willi A Kalender, (2006) X-ray computed tomography, 51 (13): 29-43, Germany.

Appendices

Appendix [I]

Data collection sheet

No	Gender	Age	Weight	Height	BMI	Ascending Measurement	Descending measurement
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

Appendix [II]

CT Images

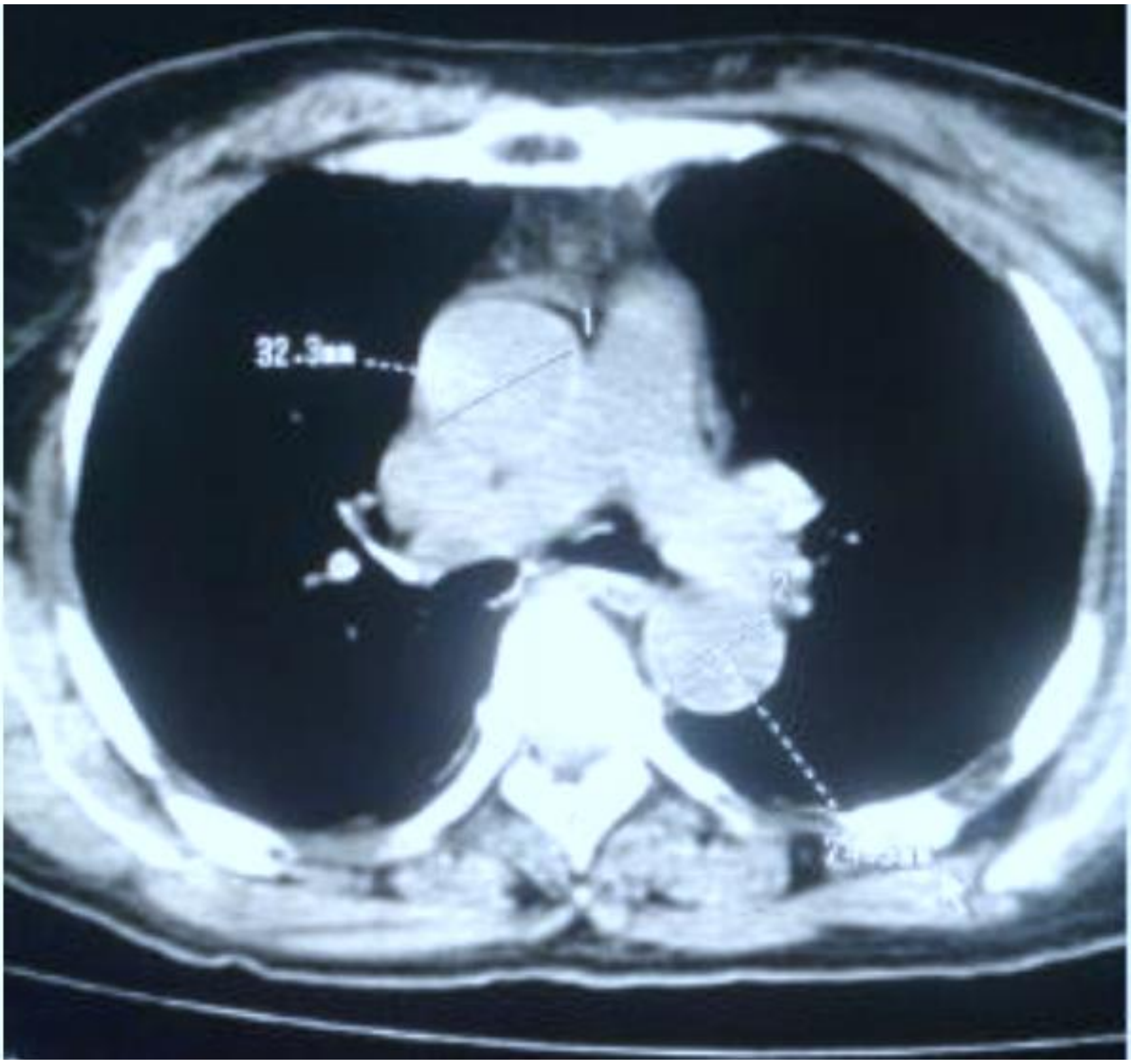

Image 1: 60 yrs. Male patient ascending aorta 32.3mm descending aorta 24.3mm

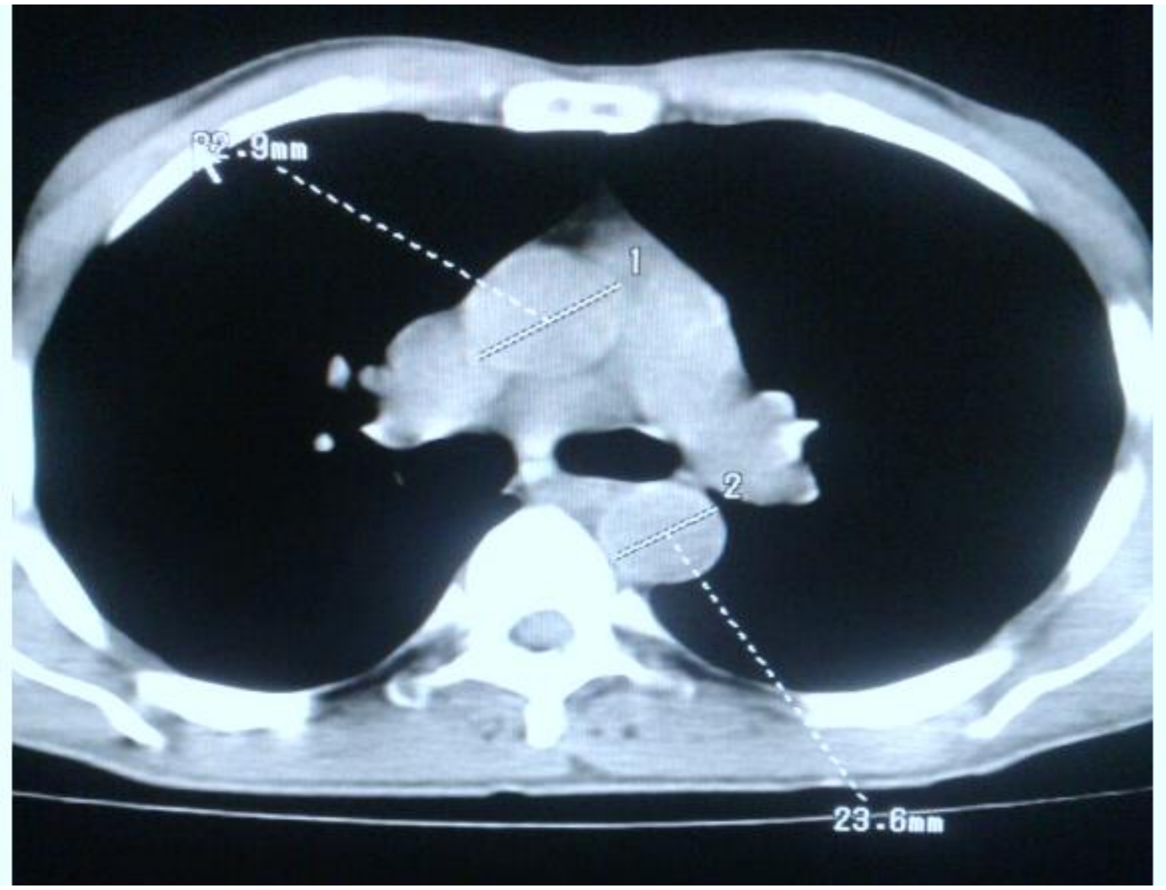

Image 2: 50 yrs. Male patient ascending aorta 32.9mm descending aorta 23.6mm

Image 3: 52 yrs. Male patient ascending aorta 38mm descending aorta 27.7mm

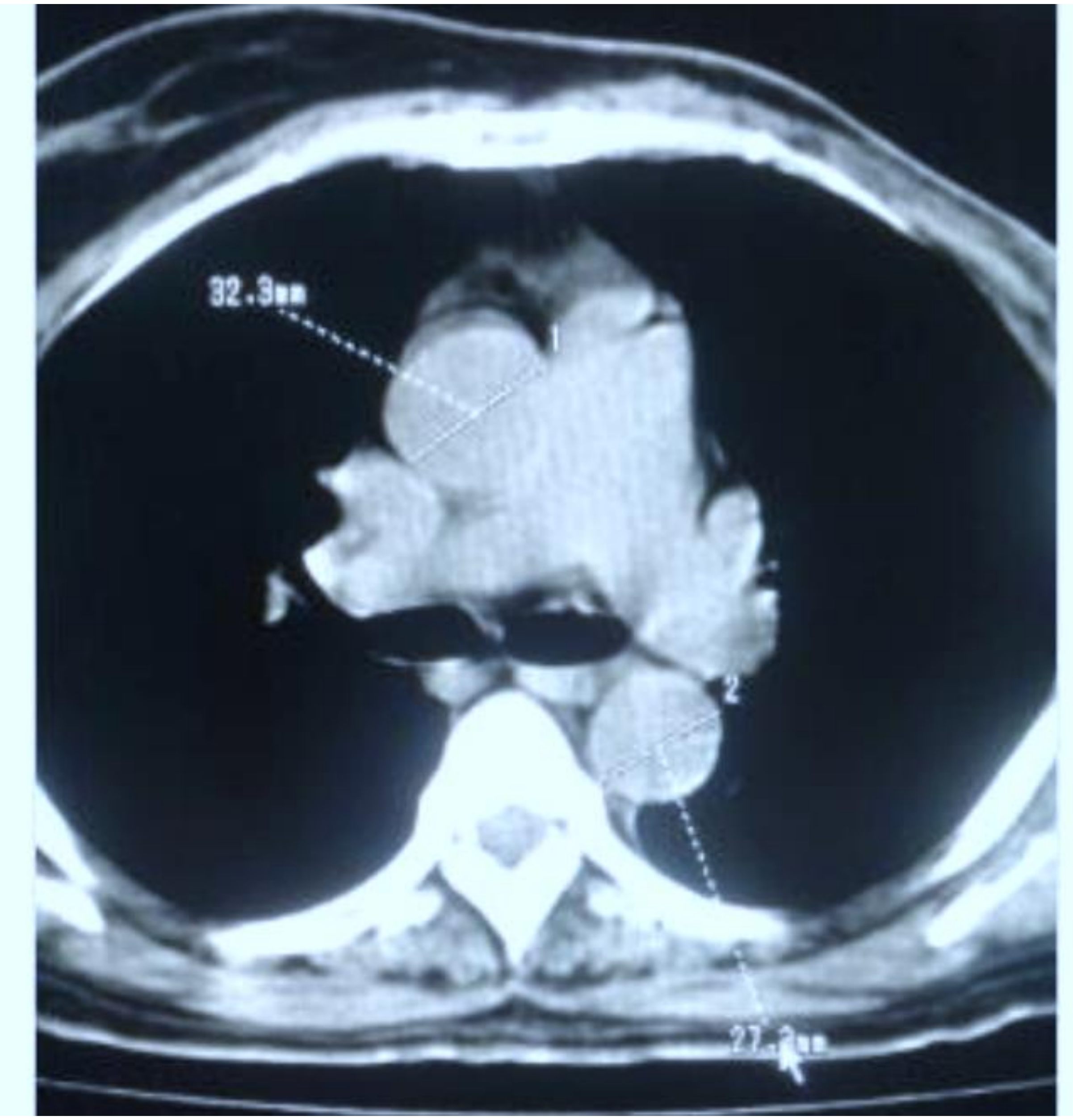

Image 4: 45 yrs. Female patient ascending aorta 32.3mm descending aorta 27.2mm