ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCES

SCHOOL OF GRADUATE STUDIES DEPARTMENT OF RADIOLOGY

CROSS-SECTIONAL STUDY OF SYSTEMIC MEDIASTINAL VASCULAR ANOMALIES AND VARIATIONS IN PATIENTS EVALUATED AT TIKUR ANBESSA SPECIALIZED HOSPITAL, ADDIS ABABA UNIVERSITY, ADDIS ABABA, ETHIOPIA FROM SEPTEMBER 2019-NOVEMBER 2019.

INVESTIGATOR: DR. TEWOROS MELKAMU (MD, RADIOLOGY RESIDENT)

A THESIS FOR PREPARATION OF SENIOR PAPER TO BE SUBMITTED TO THE RADIOLOGY DEPARTMENT, COLLEGE OF HEALTH SCIENCE, ADDIS ABABA UNIVERSITY IN PREPARATION FOR PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE POSTGRADUATE STUDY IN RADIOLOGY.

ADDIS ABABA, ETHIOPIA

DECEMBER, 2020

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ADDIS ABABA, ETHIOPIA

OCTOBER, 2020

Contents

Abstract

Objective: This study is designed to assess the magnitude of common incidental variants and anomalies of the systemic mediastinal vasculatures

Method: The study was conducted at TASH from September 2019- Nov2019. A hospital-based retrospective cross-sectional study was conducted at TASH to address the specific objective during the study period. The study was conducted among patients being evaluated at Tikur Anbessa Specialized Hospital who had post-contrast chest CT during the study period. The source population were all adult patients with post-contrast chest CT during the data collection period.

Data was collected by evaluating chest CT scans from PACS. The data was checked for clarity and completeness. Computerized data analysis was conducted by using SPSS version 25.0 software

Result: A total of 422 (N = 422) patients were included in the study out of which aortic branching anatomy was evaluated in 384 patients out of which 220 (57.3%) had normal classic anatomy and 164(42.7%) cases had variant anatomy with a common origin of brachiocephalic trunk and left common carotid artery contributing to the majority of these variants (37.3%) and left vertebral artery arising from the aortic arch making up 3.1%. An aberrant right subclavian artery was seen in 2%. There was one case of a right vertebral artery arising directly from the aortic arch constituting 0.3% of the sample. A total of 384(N=384) patients were evaluated for right-sided aortic arch and there were no cases found suggesting a prevalence <0.3%. A total of 384 (N=384) patients were evaluated the for Azygos lobe out of which 3 (0.8%) had Azygos lobe. A total number of 384 (N=384) cases were evaluated for left-sided superior vena cava and there were no cases found suggesting a prevalence <0.3%.

Conclusion: Variants of systemic mediastinal vasculature are common .An understanding and anticipation of these entities on post-contrast chest CT enables precise reporting and is essential in pre-procedure planning.

Acknowledgments

I would like to forward my appreciation to the department of radiology, CHS, Addis Ababa University for allowing me to undertake this research.

I would like to express my deepest gratitude to my advisor Dr. Azmera Gissila and Dr. Amir Alwan for their invaluable and constructive comments during the development of this paper.

I am grateful to my colleagues who helped me in searching and providing necessary literature and volunteering to undertake this paper together.

List of abbreviations

- AA –Aortic arch
- VA- Vertebral artery
- ARSA – Aberrant right subclavian artery
- BT –Brachiocephalic trunk
- CT-Computed tomography
- CTA - Computed tomography Angiography
- LCCA – Left common carotid artery
- LSA –Left subclavian artery
- LVA- Left vertebral artery
- RSA –Right subclavian artery
- RCCA- Right common carotid artery
- DSA- Digital Subtraction angiography
- RAA-Right sided Aortic arch
- ALSA-Aberrant left subclavian artery
- LSVC – Left side superior vena cava

CHAPTER ONE: INTRODUCTION

1.1 Background

The terms variant and anomaly are commonly used in the description of anatomy. (1)The word anomaly is from the Greek ανωμαλος (an-omalos), translated as "not normal."(2) which is defined as an anatomic (microscopic and macroscopic) phenotype that represents a substantial departure from the appropriate reference population. (2) "Substantial departure" here is used to imply that a particular anomaly is found in a small fraction (typically <2.5%) of the population or, in the case of measurable anomalies, the measured sign falls outside the normal reference range for the population (> or <2 SD from the mean).A variant is defined as a mild anatomic phenotype that represents a small departure (typically between 2.5% and 10%) from the appropriate reference population justifying it to be an error of development. (2)A more conservative threshold suggested variations that occur in less than 1% of the population should be considered anomalies regardless of functional significance (1) while others advocate the use of higher threshold (<4%)to consider a variant as an anomaly. (3)The definition of these terms may be based on prevalence in the general population but also on functional significance, or a combination of the two; however, there is no consensus regarding the use of these terms. (1)Furthermore; Some earlier descriptions differentiated between major and minor anomalies defining major anomaly as having "an adverse effect on either the function or social acceptability of the individual" and minor anomalies as "neither of medical nor cosmetic consequence to the patient."(4)

The present study describes the prevalence of mediastinal systemic vascular variants and anomalies in a consecutive series of adults using post-contrast chest CT. This topic has received scant attention in the imaging literature(1). As seen in the numbers frequently quoted in the largest consecutive imaging series describing the prevalence of these variants and anomalies in the general adult population extrapolated from cadaver series or estimated based on series of children with congenital heart disease. (1)The anatomical variations are present since birth and are taken as benign, but they may represent a challenge on the performance of surgical and radiologist-interventionist procedures, raising the probability of mistakes, adverse effects, and even fatal outcomes. Recognition of variants and anomalies of the branching of the aortic arch has diagnostic and therapeutic implications.(1)There are cases of perioperative ischemia by an incorrect shunt placement due to anatomic variations of the aortic arch during carotid endarterectomy (5). A study on arch anomalies in patients with thoracic aortic dissections showed a higher relevance of arch branching anomalies in patients with thoracic aortic dissections when compared with controls. (6) Additionally, there is an association of innominate artery injury in blunt trauma and bovine aortic arch. (7)Hence, the importance of being aware of them and to perform proper assessments of anatomical features of the aortic arch before surgical and interventional procedures involving the head, neck, thorax and/or upper limbs(8)Further, they may be accompanied by congenital malformations of the cardiovascular system. It is not all doom and gloom; in some instances, these variations have been seen to confer some protection against the spread of infections as in the case of the azygos lobe. (9)

1.2 Statement of the problem and Significance of the study

The prevalence of chest vascular anomalies and variations is very common with some variations involving as high as 40% of the general population. (8)

Although the variations in question are usually asymptomatic, they may cause dyspnea, dysphagia, intermittent claudication, misinterpretation of radiological examinations. An appreciation of the appearance of anomalies and common variants of the thoracic vasculature is useful in pre-procedure planning. Especially to minimize complications during neck and thorax surgery like vascular injuries, shock, possible thoracotomy, and even the possibility of pulmonary torsion. Furthermore, these variations may be accompanied by other congenital abnormalities. (1, 10, 11)

Although many of these conditions were discussed many years ago there is a paucity of imaging literature describing the prevalence of central venous anomalies in the general adult population(1)

There have been few African studies of the chest vascular variants and anomalies from South-Africa, Kenya, and Sudan (12-15) but there are no figures for Ethiopia. The purpose of this study is to report the prevalence variations and anomalies of systemic mediastinal vessels specifically aortic branching pattern, azygos lobe, right-sided aortic arch, and left-sided SVC in a sample Ethiopian population with the intention of providing useful data to anatomists, radiologists, vascular, neck and thoracic surgeons

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CHAPTER TWO: LITERATURE REVIEW

2.1 Azygos lobe

Galen for the first time utilized the term "ἄζυγος φλέψ" (Azygos vein)(16) The Greek root Zyg refers to a pair. 'A-' means not. Thus, azygos means unpaired. The azygos vein is unpaired in that there is only one in the body(17). The first mention of the existence of an accessory lobe in the right apex was found to have been made by Wrisberg in 1778 from anatomical studies, the structure is therefore sometimes designated the Lobus Wrisbergi. (18)The azygos lobe forms when the posterior cardinal vein, the precursor of the upper thoracic segment of the azygos vein, fails to migrate over the apex of the right lung to its normal medial position in the mediastinum. (9) The reason for its occurrence during the development is unknown(10) the abnormally located vessel indents the lung and its overlying parietal and visceral layers of pleura. Thus, two folds of parietal and two layers of visceral pleura form a mesentery-like structure, the mesoazygos which provides a barrier to the spread of disease, just as the other inter-lobar septa do(9) However if the azygos lobe is deflated (such as by pneumothorax or during a thoracic surgical procedure), the azygos vein can dislodge from the azygos fissure and migrate to its usual para-mediastinal position, adjacent to the right tracheal border, leaving behind an ''empty'' azygos fissure. (19)Despite many published reports regarding an azygos lobe, a limited number of studies have examined its prevalence The azygos lobe is a normal variant that is found in 1% of anatomic specimens, on about 0.4% of chest radiographs. (20) and a prevalence of 1.2% a high-resolution CT images. (21) Azygos lobe may also be associated with the presence of intrapulmonary right brachiocephalic vein(22) or esophageal stricture (23). In a cadaveric study done in South Africa Out of the 704 specimens, only four (prevalence 0.57%) were identified as having an azygos lobe. The azygos lobe was identified in one white cadaver and three black cadavers.. (10) in a large consecutive series of adults using CT angiography done by *Berko et al,* An azygos lobe was present in 0.3% of patients in this series (1). A retrospective analysis of 2,775 thoracic CT images in Cyprus stated a prevalence of 1.54% (24)

2.2 Left Superior vena cava

Persistent left superior vena cava (PLSVC) is an uncommon vascular anomaly; however, it is the most common congenital anomaly of the thoracic venous system affecting approximately 0.5% to 2% of the general population. (25, 26) Most of the reported frequency studies are of cadaveric. Abbott 1936 studied 1000 cadavers and found 36 examples of left-sided superior vena cava making up 3.6% (27)whereas Campbell and Deuchar 1954 found 3% prevalence after a study of 1500 cadavers. (28)The persistence of the left superior vena cava is caused by the persistence of the left anterior cardinal vein. (1) The PLSVC generally drains into the right atrium via the coronary sinus. The most common type of this venous anomaly, comprising 90% of PLSVC reports, is the presence of both right and left superior vena cava. A bridging innominate vein is observed in approximately 30% of these cases. (25)Patients with left SVC are usually asymptomatic, and the condition is often found unexpectedly during pacemaker implantation when this finding creates significant procedural challenges. (29)

2.3 Aortic Branching pattern variants and anomalies

The normal or standard anatomic configuration described as branches arising from the AA, from proximal to distal with respect to the heart, in this order: brachiocephalic trunk (BT), left common carotid artery (LCCA), and left subclavian artery (LSA)(8)is present in approximately 80% of individuals. This figure, and the prevalence of anatomical variations of arch anatomy, have previously been gleaned from post-mortem studies (30)The first of which was reported in small post-mortem series in 1893 by Thompson(31). Isolated variations in the anatomy of the aortic arch and its branches are commonly asymptomatic. However, certain anomalies may cause clinically significant symptoms, which often arise from compression or pressure effects on the trachea or esophagus. (30)Increasing activity in the fields of cardiac and vascular surgery has served to revive interest in the developmental and adult anatomy of the aortic arch and its great vessels.(32)A variant of origin and course of a great vessel arising from the aortic arch is of great clinical value, because lack of knowledge of these variations may lead to serious surgical complications during procedures occurring in the superior mediastinum and the root of the neck.(32) The definitive aortic arch and its branches develop in the first few weeks of fetal life.(33)Truncus arteriosus, A common arterial trunk emerges from the primitive heart and divides into six paired arches which fuse on either side of the pharynx to form bilateral dorsal aortae. (34)The Bilateral dorsal aortae merge to form one descending aorta in the 3rd week of fetal development. .The left fourth arch gives rise to the left subclavian artery and the aortic arch which joins the descending aorta while the third arches form the carotid arteries. The rest of the arches disappear.(35)*Wang L. and colleagues* identified 12 types of aortic arch branching patterns in the patients. The prevalence and general morphology of the aortic arch was used to divide the branching pattern into types A to E .Type A based on a classic configuration in which the aortic arch gives rise to three branches: the brachiocephalic trunk (BT), the LCCA, and the left subclavian artery .Type B was based on the most frequent variation, a common origin of the BT and LCCA, without other variations were classified as type B1; the common origin of the BT and LCCA combined with the left VA arising between the LCCA and LSA were categorized as type B2.Type B3, which indicates a common origin of the BT and LCCA combined with the left VA arising from the arch distal to the origin of the LSA. The right subclavian artery (RSA), right CCA (RCCA), and LCCA shared a short common trunk was classified as type B4.Type C indicated an additional branch originating directly from the aortic arch. The left VA directly arising from the arch between the LCCA and LSA was classified as type C1.left VA arising from the arch distal tothe origin of the LSA were classified as type C2.The thyroid ima artery from the arch was regarded as type C3.Type D was defined based on an aberrant RSA as the last branch of the aortic arch. A single variation of an aberrant RSA was classified as type D1 An aberrant RSA with a common origin of the RCCA and LCCA was defined as type D2 .Type D3 was defined as the combined variations of an aberrant RSA and type C1.right-sided aortic archwere recorded as type E, and both of them were associated with an aberrant LSA (type E1), a right aortic arch with mirror-image (type E2)(36).To simplify the classification, *Granados Sanches and Gabriel Prada et al(2016)* proposed a new classification: type 1 or "Normal branching": BT, LCCA, LSA, in this order; type 2 or "Bovine arch": BT and LCCA arising from the AA in a common trunk; type 3: LCCA originating separately from the BT; type 4: left vertebral artery originating separately from the AA and after studying study CTA of 444 subjects with a mean age of 57 years (18-96 years) found: type 1 or "Normal": 59.9% (266/444 subjects); type 2 or "Bovine arch": 27.9% (124/444 subjects); type 3: 9.9% (44/444 subjects); type 4: 2.2% (10/444 subjects). (8).According to *Jakanani et al*, the aortic arch had a conventional configuration in 643 patients (74%). The most frequent anatomical variant was a common origin to the brachiocephalic and left common carotid artery origin (bovine arch), which occurred in 176 (20%) patients.In 53 patients (6%) the left vertebral artery arose directly from the aortic arch, with further variations in anatomy also observed in this group: 17 occurred in conjunction with a bovine arch, four (0.5%) occurred in conjunction with both a bovine arch and an aberrant retro-esophageal right subclavian artery(30).A study was done in South Africa in 2004 on 60 patients using aortograms demonstrated a prevalence Bovine arch of 28.3%(37)(which may be *Granados Sanches* type 2 or type 3 as this study did not differentiate between the two).Furthermore, there was no aberrant left vertebral and right subclavian artery seen.(37) A paper published from Aristotle University of Thessaloniki by *Natsis et al (2008)* found type of the aortic arch is described as the "normal" aortic arch had an incidence of 83% the second most common pattern with an incidence of 15% called "bovine aortic arch" a common stem which is divided into the right Subclavian(RSA), right Common Carotid(RCCA) and LCCA and a second direct aortic branch the LSA(11), although it does not absolutely resemble the aortic arch of the cattle(38).Nevertheless, the branching pattern is found in other animals, including cats, dogs, and rabbits, leading to the recommendation that this variation should appropriately be named as a "feline" ,"canine", or "lapine" arch(39).The Third common branching pattern in the paper by *Natsis et al(2008)*was Left vertebral arising directly from the arch and not from the left subclavian, providing an aortic arch pattern with four branches with an incidence of 0.79% (11). One hundred and thirteen aortic arches of adult black Kenyans were exposed during cadaver dissection in a study by *Ogeng'o, JA., Olabu, BO et al (2010)* 67.3% of the aortic arches showed the classical branching pattern of brachiocephalic, left common carotid and left subclavian arteries. Of the remaining 32.7%, there were 6 different types of variations noted The most common (25.7%) was two branches namely the left subclavian artery and a common stem that gave rise to the brachiocephalic trunk and left common carotid artery. In four cases (3.5%) the aortic arch gave rise to four branches namely brachiocephalic trunk, left common carotid, left subclavian and left vertebral artery. The vertebral was proximal to left subclavian in three cases and distal in one.(14)The study by *Ogeng et al* also doesn't differentiate between LCCA arising from the AA in a common trunk and LCCA originating separately from the BT. Eventhough The most common vertebral artery variant is the left vertebral artery arising directly from the aortic arch between the left common carotid artery and left subclavian artery with a large sample showing a 3.7%to 7.7% incidence of the left VA arising directly from the aortic arch;(1, 30, 40-44)anomalies of the right vertebral artery are also encountered albeit less frequently(45)In such instances, the RVA generally arises distal to the supra-aortic trunks(46)Origin of the right vertebral artery directly from the aortic arch distal to the left subclavian artery is a much more rare entity, with only 18 cases reported in the literature to date(45, 47-54)

Described first by Hunauld in 1735 (55)the clinical entity of "Dysphagia lusoria" however was first described by Bayford in 1787 in a woman with a long history of Dysphagia who was found to have an aberrant right subclavian artery at autopsy (56)Hence, it is also known as Bayford-Autenrieth dysphagia. An aberrant right subclavian artery is the most common aortic arch anomaly. This anomaly results from the interruption of the embryological right fourth aortic arch between the carotid and subclavian arteries.(1)when aberrant right subclavian artery variant is present, the brachiocephalic trunk is absent and four large arteries arise from the arch of the aorta: the right common carotid artery, the left common carotid artery, the left subclavian artery, and the final one with the most distal left-sided origin, the right subclavian artery, also called the Arteria lusoria.(57)The course of the aberrant right subclavian artery is usually retro-esophageal thus Prior recognition of an aberrant right subclavian artery is important in planning esophageal and vascular surgical and angiographic procedures. (1) After defining "anatomical variant" as an anatomical situation different from what is observed in most subjects but not associated with clinically relevant symptoms, and as "anomaly" a marked deviation from normality, resulting from congenital or hereditary defects and susceptible to cause symptoms *Rea et al* reported aberrant right subclavian artery as the most common anomalies (4/1359, 0.5%)(10).An Imaging series of 1000 CTAs by *Berko et al(2009)*reported a prevalence of 1.2% and a retro-esophageal course was seen in every case in this series.(1)*Natsis et(2008)* reported a 1.4% prevalence in an imaging series with 633 DSAs(11) in 2016 this same investigator carried out a cadaveric series and ARSA was detected in six cadavers (2.2%).The ARSA followed a retro esophageal course in 83%, while in 16.7% the vessel coursed between trachea and esophagus.The occurrence of arteria lusoria and was seen to be more common in female than male subjects (55.3% versus 44.7%)(58)

Studies (first author)	Wang(36)	Müller(41)	Berko(1)	Jakanani(30)	Ergun(40)	Celikyay(43)	Karacan(44)	Vučurević(42)
Sample size, No.	2370	2033	1000	861	1001	1136	1000	1266
Country	China	Germany	USA	UK	Turkey	Turkey	Turkey	Serbia
Classification of aortic arch branching patterns								
Type A (classic branching pattern), %	83.8	86.7	66.5	74.4	85.2	74.4	79.2	74.7
Type B (common origin of BT and LCCA), %								
Type B1 (combined with no other variation)	9.6	8	25.8	18.5	7.8	21.1	14.1	15.56
Type B2 (combined with left VA arising between LCCA and LSA)	0.6	0	1.6	2	0	0.4	1.2	0
Type B3 (combined with left VA arising distal to the origin of LSA)	0.04	0	0	0	0	0.2	0	0
Type B4 (common origin of RSA, RCCA, and LCCA)	0.04	0	0	0	0	0	0	0
Type C (additional branch originating directly from the aortic arch), %								
Type C1 (left VA arising between LCCA and LSA)	4.7	4.2	6.1	4.2	5.1	2.9	4.1	3.6
Type C2 (left VA arising distal to the origin of LSA)	0.17	0.05	0	0	0	0.1	0	0.08

Type C3 (thyroid ima artery arising directly from the aortic arch)	0.08	0	0	0	0	0	0.1	2.2
Type D (aberrant RSA), %		1						
Type D1 (combined with no other variation)	0.5	NA	0.8	0	0.7	0.4	0.6	0.4
Type D2 (combined with common origin of RCCA and LCCA)	0.2	NA	0.4	0.5	0	0.3	0.7	0
Type D3 (combined with left VA arising between LCCA and LSA)	0.08	NA	0	0	0	0.1	0	0
Type E (right aortic arch), %				0.2				
Type E1 (right aortic arch with aberrant LSA)	0.08	0.05	0.1	NA	0.1	0.1	0	0.3
Type E2 (right aortic arch with mirror-image type)	0	0	0	NA	0	0.1	0	0
Examination methods	CT	CT	CTA	CT/CTA	CTA	CT/CTA	CTA	CT/DSA

2.4 Right-sided aortic arch

Anomalies of the aortic arch have been recognized at autopsy as far back as the 1700s. With the advent of Roentgenology it became possible to demonstrate these anomalies during life; first with radiography and fluoroscopy, and then with Arteriography, CT, and two-dimensional echocardiography in the 1970s, and MRI in the 1980s. (59) Several anomalies of the aortic arch may occur depending on the site of the involution of the embryonic aortic arches. These result from abnormal or incomplete regression of 1 of the 6 embryonic brachial arches. (60, 61) Studies have stated right-sided aortic arch occurs in approximately 0.05% - to 0.3% of the population. (36, 40, 41, 44, 62) RAAs have been classified into three types according to the branching pattern of the arch vessels: an RAA with an ALSA, an RAA with mirror image branching and an RAA with the isolation of the LSA.(63)RAA with mirror image being the most common accounting for 59% followed by RAA with an ALSA making up 39.5% & most rare type contributing 0.8% is RAA with the isolation of the LSA (64)

CHAPTER THREE: OBJECTIVE

3.1 General objective

- To assess the prevalence and patterns of systemic mediastinal vasculature variants

3.2 Specific objectives

- To assess the incidence of azygos lobe
- To assess the incidence of aortic arch branching pattern variants
- To assess the incidence of right-sided aortic arch
- To assess the incidence of persistent left-sided superior vena cava

CHAPTER FOUR: METHODS AND MATERIALS

4.1 Study area and period

The study was conducted at TASH, college of health science, Addis Ababa university, Addis Ababa Ethiopia. The hospital delivers tertiary hospital-level care for more than 900 inpatients. The study was conducted from Sep 2019-Nov 2019 G.C.The study period was chosen as it was one of the periods in which the CT scan service was uninterrupted.

4.2 Study design

A Retrospective cross-sectional study was employed

4.3 Population

4.3.1 Source population

The source population was all adult patients who had post-contrast chest CT during the study period.

4.3.2 Study population

This cross-sectional study included a total number of 384 patients that were referred to the radiology department Tikur Anbessa Hospital to do post-contrast chest CT during the period from Sep 2019-Nov 2019 G.C

4.3.3 Inclusion and exclusion criteria

4.3.3.1 Inclusion criteria

- All adult patients who were evaluated with post-contrast chest CT during the study period.

4.3.3.2 Exclusion criteria

- Patients who had large mediastinal, lung parenchymal, pleural, or neck mass that distorted arterial or venous anatomy
- Patients who had poor enhancement of the venous and arterial structures due to different reasons
- Vascular injuries of the AA, azygos Vein, LCCA, RCCA, BT, LVA and

4.4 Sampling technique and sample size

The sample size was calculated with a 5% margin of error and a 95% confidence interval. To the best of our knowledge, there were no local researches on the topic studied under this thesis. Therefore, The population variability is unknown and taken to be 50%. The sample size is calculated by Cochran's formula giving the sample size number 384. 10% of the sample size was added for non response with final sample size number being 422

All patients with chest CT that has fulfilled the Inclusion criteria during the study period were included in the study until the sample size was reached

4.5 Data collection

Data was collected using a structured questionnaire from the picture archive communication system (PACS). The patient's images were reviewed for the presence of aortic branching pattern variants, persistent left side SVC, azygos lobe, and right-sided aortic arch, and each parameter were assessed and a finding was recorded in the questionnaires.

4.6 Data quality control

In order to evaluate the clarity of the questionnaire and validity of the instruments a pre-test was done and the findings and observations obtained were used to modify the questionnaire and the data collection process. A simplified questionnaire was used and difficult cases were re-evaluated by another resident independently as well as by cardiothoracic radiology subspecialists and results were be obtained by consensus.

4.7 Data analysis and interpretation

The data was checked for clarity and completeness. Data was analyzed using statistical methods with the help of the SPSS version 25 software package. Then a comparison of the data with the previous study was done.

4.8 Ethical considerations

This study was conducted after the approval of the proposal at TASH, college of health science, Addis Ababa university. Information was recorded anonymously and confidentiality was assured throughout the study period.

4.8 The Limitations Encountered

- Poorly timed post-contrast studies of chest CT scan
- Minimal administration of IV contrast which led to a poor enhancement of vessels
- Incomplete inclusion of vessels
- Predominance of previous litratures of cadveric study in the topic of this study

4.9 Plan of disseminating study finding

Study results were presented TASH, college of health science, Addis Ababa university, and a written document was submitted to the department of radiology and the library

CHAPTER FIVE: RESULT

I retrospectively reviewed 422 post-contrast chest CT of adult patients from Sep 2019-Nov 2019 G.C. I excluded patients 38 patients who had either a mediastinal mass that had distorted the venous and arterial anatomy, had poor visualization of the mediastinal vessels due to poor contrast or had vascular injuries of mediastinal vessels

Azygos Vein

Out of 422 patients, 384 had a post-contrast chest CT of adequate quality for azygos vein study. Of these patients 55.6 % were within the age range of 15-45, 36.8% are 46-65 with the rest being above 65. There were 189 men (49.2%) and 195 women (50.7 %). The frequency of the azygos lobe was determined to be 0.8%.

is azygos lobe present		
	Frequency	Percent
No	381	99.2
yes	3	0.8
Total	384	100.0

Left-sided Superior vena cava

384 patients had sufficient quality post-contrast chest CT for left-sided superior vena cava evaluation from 422 patients reviewed in this study. It was found 55.3% were within the age range of 15-45, 37.1% are 46-65 with the rest being above 65. There were 187 men (48.7%) and 197 women (51.3 %). There were no cases of left-sided Superior Vena cava.

Aortic Branching Pattern

From the total 422 post contrast chest CT of patients reviewed, 384 patients had post-contrast chest CTs of proper quality for the study of aortic arch branching pattern. In these patients, 55.3% were within the age range of 15-45,37.1% are 46-65 with the rest being above 65. There were 190 men (49.5%) and 194 women (50.5%). The 164 (42.7%) had variation in the aortic branching pattern and 220   (57.3%) showed normal branching pattern. Branching variations detected in this series had a frequency of Bovine trunk (Common origin of right BC & LCCA with separate LSA origin)143 cases (37.3%); Bovine trunk combined with left VA arising between the LCCA and LSA 2 cases (0.5%). There were no type B3 (BT combined with left VA arising distal to the origin of LSA) and type B4 (common origin of RSA, RCCA, and LCCA) cases. There were 9 cases of type C1 (left VA arising between LCCA and LSA)

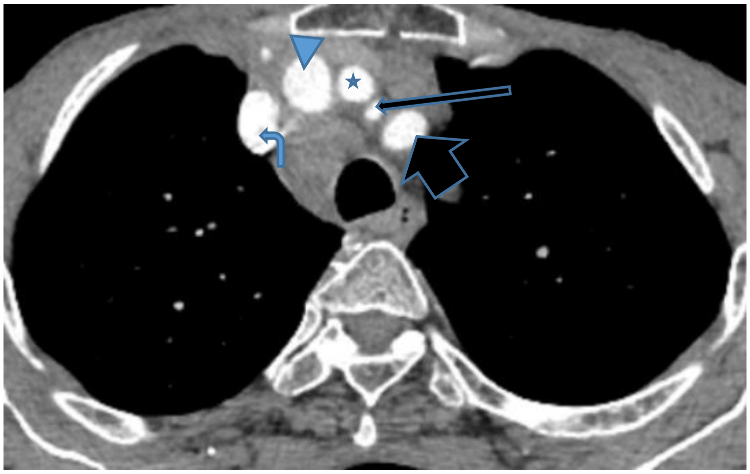

Fig 1: (curved arrow) SVC,(Arrow head) BT,(star) LCC, (long arrow)left vertebral artery arising from the aortic arch,(short arrow) left subclavian artery

constituting 2.3% and 1 case (0.3%) of type C2 (left VA arising distal to the origin of LSA) but there was no type C3 (thyroid ima artery arising directly from the aortic arch). type D1 [Aberrant RSA arising distal to the left subclavian artery (RCCA, LCCA, LSA & RSA from right to left)] were seen in 4 cases(1%) also type D2 [An aberrant RSA with a common origin of the RCCA and LCCA] were seen in 4 cases (1%). There were no cases of type D3 (combined with left VA arising between LCCA and LSA), type E1 (right aortic arch with aberrant LSA), and type E2 (right aortic arch with mirror-image type).

There was one case where the right vertebral artery was seen arising from the aortic arch distal to the LSA which makes the prevalence 0.3 %.

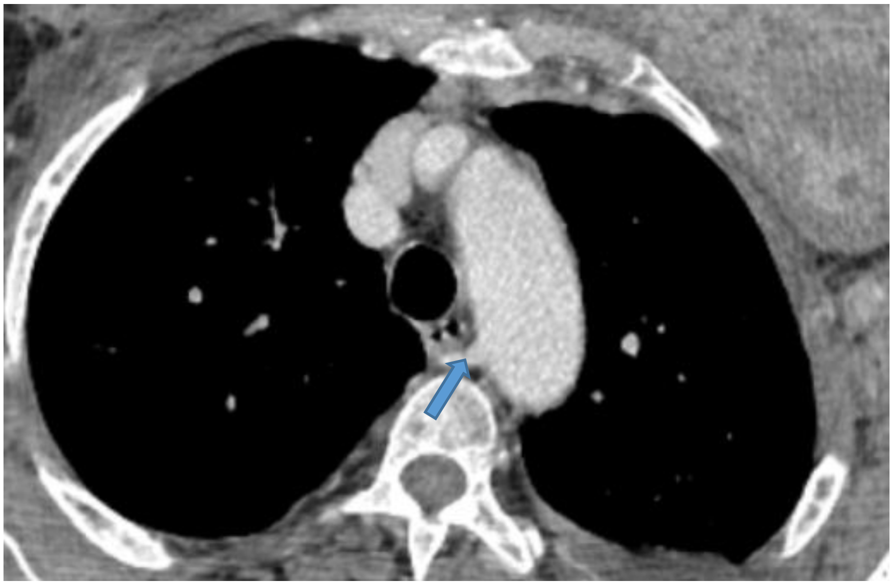

Fig 2: The arrow shows the right vertebral artery arising from the aorta and coursing behind the esophagus

Aortic Arch branching patterns			
	Frequency	Percent	Cumulative Percent
type A [(Normal branching pattern (BC ,LCCA& LSA from right to left)]	220	57.3%	57.3%
type B1 [Bovine trunk (Common origin of right BC & LCCA with separate LSA origin)]	143	37.3%	94.6%
type B2 [common origin of the BT and LCCA combined with the left VA arising between the LCCA and LSA]	2	0.5%	95.1%
type C1 [left VA directly arising from the arch between the LCCA and LSA]	9	2.3%	97.4%
type C2 [left VA arising from the arch distal to the origin of the LSA]	1	0.3%	97.7%
type D1 [Aberrant RSA arising distal to the left subclavian artery (RCCA,LCCA ,LSA & RSA from right to left)]	4	1%	98.7%
type D2 [An aberrant RSA with a common origin of the RCCA and LCCA]	4	1%	99.7%
Right vertebral artery arising distal to LSA otherwise normal aortic branching pattern	1	0.3%	100%
Total	384	100.0%	

Right-sided aortic arch

384 out of 422 patients had appropriate quality chest CTs for the evaluation of right-sided aorta. From these patients 55.3% were within the age range of 15-45, 37.1% are 46-65 with the rest being above 65. There were 187 men (48.7%) and 197 women (51.3 %). There were no cases of the right-sided aortic arch.

Studies (first author)	**Current study**	**Wang(36)**	**Müller(41)**	**Berko(1)**	**Jakanani(30)**	**Ergun(40)**	**Celikyay(43)**	**Karacan(44)**	**Vucˇurevic´(42)**
Sample size, No.	384	2370	2033	1000	861	1001	1136	1000	1266
Country	Ethiopia	China	Germany	USA	UK	Turkey	Turkey	Turkey	Serbia
Classification of aortic arch branching patterns									
Type A (classic branching pattern), %	57.3	83.8	86.7	66.5	74.4	85.2	74.4	79.2	74.7
Type B (common origin of BT and LCCA), %									
• Type B1 (combined with no other variation)	37.3	9.6	8	25.8	18.5	7.8	21.1	14.1	15.56
• Type B2 (combined with left VA arising between LCCA and LSA)	0.5	0.6	0	1.6	2	0	0.4	1.2	0
• Type B3 (combined with left VA arising distal to the origin of LSA)	0	0.04	0	0	0	0	0.2	0	0
• Type B4 (common origin of RSA, RCCA, and LCCA)	0	0.04	0	0	0	0	0	0	0
Type C (additional branch originating directly from the aortic arch), %									
• Type C1 (left VA arising between LCCA and LSA)	2.3	4.7	4.2	6.1	4.2	5.1	2.9	4.1	3.6
• Type C2 (left VA arising distal to the origin of LSA)	0.3	0.17	0.05	0	0	0	0.1	0	0.08

• Type C3 (thyroid ima artery arising directly from the aortic arch)	0	0.08	0	0	0	0	0	0.1	2.2
Type D (aberrant RSA), %			1						
• Type D1 (combined with no other variation)	1.0	0.5	NA	0.8	0	0.7	0.4	0.6	0.4
• Type D2 (combined with common origin of RCCA and LCCA)	1.0	0.2	NA	0.4	0.5	0	0.3	0.7	0
• Type D3 (combined with left VA arising between LCCA and LSA)	0	0.08	NA	0	0	0	0.1	0	0
Type E (right aortic arch), %					0.2				
Type E1 (right aortic arch with aberrant LSA)	0	0.08	0.05	0.1	NA	0.1	0.1	0	0.3
Type E2 (right aortic arch with mirror-image type)	0	0	0	0	NA	0	0.1	0	0
Examination methods	CT	CT	CT	CTA	CT/ CTA	CTA	CT/ CTA	CTA	CT/ DSA
BT, Brachiocephalic trunk; CT, computed tomography; CTA, computed tomography angiography; DSA, digital subtraction arteriography; LCCA, left common carotid artery; LSA, left subclavian artery; NA, not available; RCCA, right common carotid artery; RSA, right subclavian artery; UK, United Kingdom; USA, United States of America; VA, vertebral artery.									

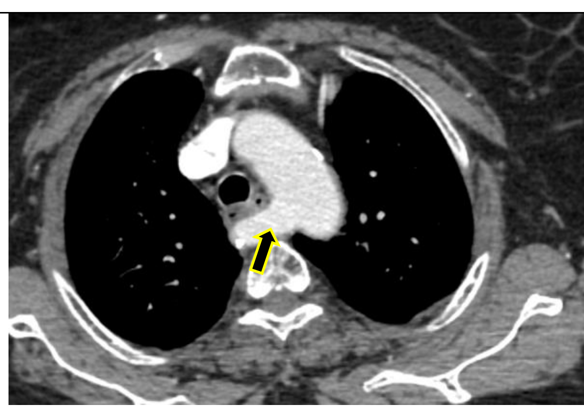

Fig 3.1 (Arrow)shows a right aberrant subclavian artery

Fig 3.2: (Arrow head)Common origin of LCC &RCC arteries ; (arrow)a separate LSA seen in the same patient from fig 3.1

CHAPTER SIX : DISCUSSION

The present study describes the prevalence of variants and anomalies of the systemic mediastinal arteries and veins in a consecutive series of adults using post-contrast chest CT. This is Important for thoracic operations, especially in vascular, cardiac, esophageal, and mediastinal surgery

Because post-contrast CT is the most common modality used to image the thoracic vasculature, the present large post-contrast CT series serves to elucidate the imaging appearance and significance of these variants and anomalies

The prevalence of venous anomalies described in the literature is not derived from studies devoted to the determination of the prevalence of these anomalies in the general adult population. The numbers frequently quoted in the literature are extrapolated from cadaver series(1)

Azygos lobe is a normal variant that is found in 1% of anatomic specimens, on about 0.4% of chest radiographs. (20) It has a prevalence of 1.2% on high-resolution CT (21)images with the present study result of 0.8% being comparable to the previous studies.

Persistent LSVC is venous anomaly of the thorax affecting approximately 0.5% to 2% of the general population. The persistent LSVC generally drains into the right atrium via the coronary sinus. (25)The persistence of the left superior vena cava is caused by the persistence of the left anterior cardinal vein. (1)The most common type of this venous anomaly, comprising 90% of persistent LSVC reports, is the presence of both right and left superior vena cava. A bridging innominate vein is observed in (25). This study found no cases of persistent LSVC suggesting a prevalence less than 0.3%

Variations of aortic arch branching patterns are not rare. Race appears to play an important role in variations of arch branches. (36) In the present study, (42.7%) of adult patients had variations of arch branches which compared to other studies that ranged from 13.3% to 40.1%(8, 41)is slightly higher.Previous studies found that a common origin of the BT and LCCA (type B) was the most common pattern with an incidence of 7.8% to 28.3%(37, 40)our study also showed this was the commonest pattern albeit it showed an increased frequency of 37.3% as compared to the other studies. An explanation to this high prevalence of variants was found in old litratures that have indicated a much higher rate of the type B pattern approaching 40% in African Americans. (65, 66)

The left VA arising directly from the aortic arch (types C1+C2+B2) occurred in 3.1% of patients in the present study. Other studies with a large sample showed a slightly higher result with 3.7% to 7.7 % incidence of the left VA arising directly from the aortic arch. (1, 30, 40-44)

The prevalence of type D variation with an aberrant RSA appears to be relatively similar among most studies with an incidence of approximately 1 %(0.4-1.3%) (3, 5-10) but this series showed a an elevated frequency of 8 patients making up 2% of the sample. Even though an investigation of

102 type D arches showed that the prevalence of a combined common carotid trunk (type D2) was 20.6%.(67)we found 4 patients (50% of ARSAs) had a common carotid trunk (type D2). The ARSA followed a retro esophageal course in 83%, while in 16.7% the vessel coursed between trachea and esophagus(58). All 8 (100% of ARSAs) aberrant RSAs in our series had a retro-esophageal course

There was one case where the right vertebral artery was seen arising from the aortic arch distal to the LSA which is not included in the classification forwarded by Wang and colleagues. This one case in this study makes the prevalence 0.3%. There are no frequency studies to compare to with regards to the aortic origin of RVA.

Multiple litratures have stated right-sided aortic arch occurs in approximately 0.05% - to 0.3% of the population. (36, 40, 41, 44, 62) .The current study found no cases of right-sided aorta suggesting a prevalence of less than 0.3%

CHAPTER SEVEN : CONCLUSION

It was concluded that a detailed understanding of mediastinal vascular anomalies and variants can be identified by post-contrast CT. Awareness of these variations and anomalies, as well as anticipation of their presence, is important in surgeries, interventional radiology, and minimally invasive procedures.

Peri-operative lack of awareness can result in injury, and knowledge of their presence can reduce the incidence of complications. Therefore, clinically important mediastinal vascular anatomic variants should be reported on CT

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