ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCES

SCHOOL OF GRADUATE STUDIES DEPARTMENT OF RADIOLOGY

CROSS-SECTIONAL STUDY OF AORTIC ARCH BRANCHING, PATTERNS AND ANOMLIES,IN PEDIATRIC PATIENTS EVALUATED AT TIKUR ANBESSA SPECIALIZED HOSPITAL, ADDIS ABABA UNIVERSITY, ADDIS ABABA, ETHIOPIA, A TWO-YEAR RETROSPECTIVE STUDY

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

ADDIS ABABA, ETHIOPIA

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ACRONYMS

AAU – Addis Ababa University
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

Abstract

Background: The Development of the Aorta is a complex process which starts at the 3rd week of gestation. And this complex process can be susceptible to a variety of congenital variants and pathologic anomalies. knowledge of this anatomical variations may be significant when performing surgical and radiologist-interventionist procedures, raising the probability of mistakes, adverse effects, and even fatal outcomes

Objective:the objective of the study is to Evaluated the pattern of Aortic Arch anomalies seen in Pediatric Patientsat Black Lion Hospital.

Methods:A Retrospective cross-sectional study was conducted at TASH, college of health science in patients who had post contrast chest CT from January 2019 to January 2021.

Results:A Total of 448 children were included in the study and 270(60.3%) were male and 178 (39.7%) were female. And Ages of the participants ranged from 1 to 14 years of age with a mean of 6.4 ± 3.79 years. The most common aortic branching pattern that was seen in study was the Type A branching pattern with 320 (72.2 %), Followed by the Type B1 pattern with 80 (18.1%) patients.

Conclusion: Variation and anomalies of the aortic arch are common findings and knowledge about the different types of aortic arch anomalies is important for properpre surgical planning.

INTRODUCTION

The human Body can have a large variation in its morphology such as the shape and the dimensions of the structures. And in the presence of a substantial departure from the normal parameters, where the structures are only seen in a small portion of the population or are outside the normal reference range for the population it can be defined as a variant. (1) Another definition of a variant is the presence of an 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). In addition to the prevalence in the General population some also want to define anomalies based on their functional significance or a combination of both but there is no clear cut definition for the use of these terms.(3)

The incidence of Mediastinal vascular variants and anomalies are not well known and the data that is present about the prevalence of these variants is extrapolated from cadaver series or estimated based on series of children with congenital heart disease. (3) The Lack of data regarding the prevalence of these anomalies in the imaging literature may be due to the fact that these anatomical variations are present since birth and are taken as benign. But these anomalies may be significant when performing surgical and radiologist-interventionist procedures, raising the probability of mistakes, adverse effects, and even fatal outcomes. And there have been cases reported of perioperative ischemia by an incorrect shunt placement due to anatomic variations of the aortic arch during procedures (4). And additionally the presence of These anomalies have been associated with a higher incidence of some disease processes, such as the presence of aortic arch anomalies have been associated with a higher incidence of Aortic Dissections. (5)additionally, some anomalies are also associated with an increased incidence of injury following trauma such as the Traumatic injury of the innominate artery in people with a bovine arch. (6)therefore its very importance of being aware of mediastinal vascular anatomical variants and anomalies particular prior to surgical and interventional procedures involving the head, neck, thorax and/or upper limbs.

Mediastinal vascular anatomic variants are evaluated using Different imaging modalities which include Chest X-rays, Barium esophagograms, CT, MRI, and conventional angiography. With each imaging modalities used in diagnosing these anomalies and planning the possible Treatment plan. (7) Conventional radiology can detect the presence of anomalous compressions of the trachea and esophagus. By looking at any abnormal indentation in the air column which is not anatomical However, it lacks sensitivity, and in most cases it may not be sufficient to accurately diagnose the vascular abnormalities. (8) Conventional angiography is an invasive technique that has been a gold standard in the delineation of the vascular anatomy of a patient prior to the arrival of CT and MR Angiography but it has several disadvantages including long procedure time, need for sedation, arterial puncture and rare potential complications such as dissection and occlusion, Therefore Currently the conventional Angiography is mainly reserved for case where Treatment is planned as well.(8–10)

With the introduction of the multi detector row CT (MDCT) CT is being used more and more in the evaluation of vascular and airway diseases. And some of the advantages of MDCT compared with single detector row CT, include improved temporal and spatial resolution, greater anatomic coverage, more consistent contrast material enhancement, faster scan speed and higher quality three-dimensional (3D) reconstructions. These allow excellent display of vascular anomalies that can be used as a vascular road map by surgeons.(11–13)

The Development of the Aorta is a complex process which starts at the 3rd week of gestation. Each primitive aorta consists of a ventral and a dorsal segment and the ventral aortae fuse to form the aortic sac and the tow dorsal aortae fuse to form the midline descending aorta.Six paired primitive, oropharyngeal, aortic arches develop between the ventral and dorsal aortae. The dorsal aortae also give rise to several intersegmental arteries. The primitive arches appear and regress one after another in a cranial-to-caudal order and are not all present at the same time. The mature aortic arch system is formed as some of the primitive arch's regress, whereas others persist and develop. And this complex process can be susceptible to a variety of congenital variants and pathologic anomalies. (Figure 1)(14)

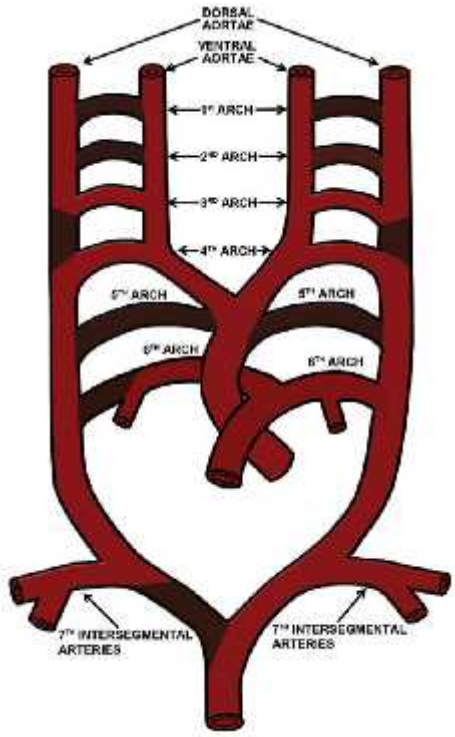

Figure 1 Schematic figure of the embryonic aortic arches and branches. (Hanneman K, Newman B, Chan F Radiographics. 2017;37(1):34)

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 to the 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 arch were 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)(1)

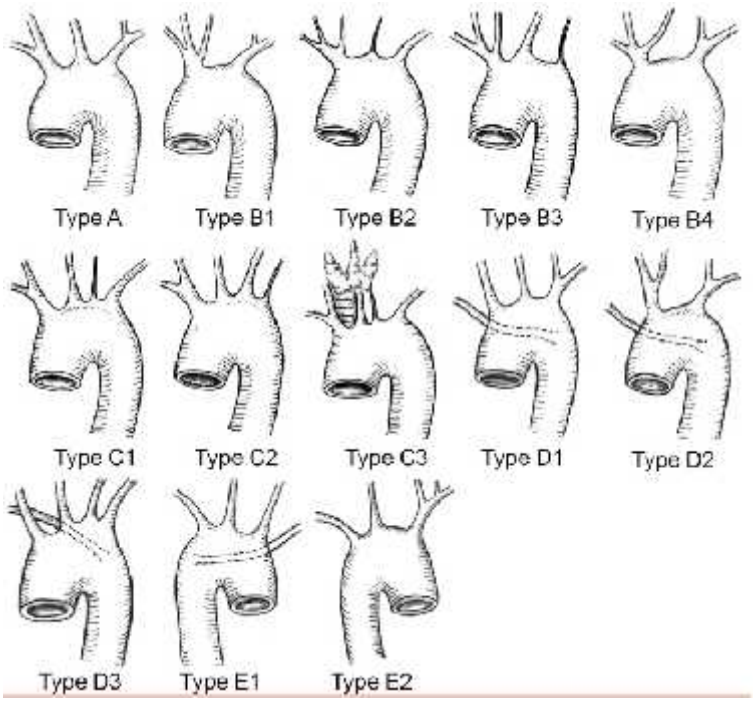

Figure 2: Morphologic features of the aortic arch and its branches Reffernced from (Wang L, Zhang J, Xin S. 2016;64(6):1608.e1.

Methods and Materials

Study Design, Study area and Study Period

A Retrospective cross-sectional study was conducted at TASH, college of health science, Addis Ababa University, Addis Ababa Ethiopia. The only hospital with dedicated pediatric radiologists in Ethiopia .The hospital delivers tertiary hospital-level care for more than 900 inpatients. The study was conducted from 1/1/2019 – 1/1/2021.

Source population, Study population and Sampling Methods

Source population

- The source population was all patients who had CT scan done at Black Lion Hospital during the study period.

Study population.

- All pediatric patients who had a post contrast Chest CT at Black lion Hospital during the Study Period

Inclusion and exclusion criteria

Inclusion criteria

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

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

Sampling Method

Convenience nonprobabilitysampling was performed with all pediatric patients with chest CT that fulfilled the Inclusion criteria during the study period were included in the study.

Data collection, quality control, analysis, and interpretation

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 and anomalies , and each parameter were assessed, and a finding was recorded in the questionnaires. 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. The data was checked for clarity and completeness.

Data was analyzed using statistical methods with the help of the SPSS version 26 software package. Then a comparison of the data with the previous study was done.

Ethical consideration

The study was approved by the Radiology Department Research and Ethics Committee. The names and other unique identifiers of the participants were not taken for the sake of confidentiality

Results

Background information

A Total of 448 children were included in the study and 270(60.3%) were male and 178 (39.7%) were female. And Ages of the participants ranged from 1 to 14 years of age with a mean of 6.4 ± 3.79 years. (Table 1)

Aortic Arching pattern

Based on Mayer's classification the most common aortic branching pattern that was seen in study was the Type A branching pattern with 320(72.2 %), Followed by the Type B1 pattern with 80 (18.1%) patient's, Type C1 with 26 (5.9%), Type B3 with 4(0.9%), Type D2 with 4(0.9%), Type D1 with 3(0.7%), Type D3 with 2 (0.5%), Type B2 with 2 (0.5%), Type E1and E2 4(1%). In the study the B4 and C2 branching patterns were not seen. (Table 2)

Table 1: Background information in pediatric patient who had a post contrast chest CT From 1/1/2019 to 1/1/2021

Variables	Categories	Frequency	Percentage (%)
Sex	Male	270	60.3 %
	Female	178	39.7 %
	Total	448	100 %
Age Range	0 - 2	80	17.9 %
	3 – 5	142	31.7%
	6 – 10	138	30.8 %
	11- 14	88	19.6%
	Total	448	100 %

Table 2 : Aortic branching patterns of children who underwent post contras Chest CT at Black Lion hospital from 1/1/2019- 1/1/2021

Aortic Arch Branching Patterns	Frequency	Percentage
Type A [classic branching pattern)	**320**	**72.2 %**
Type B1 [Bovine trunk (Common origin of right BC & LCCA with separate LSA origin)]	**80**	**18.1 %**
Type B2 [common origin of the BT and LCCA combined with the left VA arising between the LCCA and LSA	**2**	**0.5%**
Type B3 [common origin of the BT and LCCA combined with the left VA arising from the arch distal to the origin of the LSA]	**4**	**0.9 %**
Type B4 [right subclavian artery (RSA), right CCA (RCCA), and LCCA shared a short common trunk]	**0**	**0**
Type C1 [left VA directly arising from the arch between the LCCA and LSA]	**26**	**5.9%**
Type C2 [left VA arising from the arch distal to the origin of the LSA]	**0**	**0**
Type C3(Thyroid ima artery arising directly from the aortic arch)	**2**	**0.5%**
Type D1 [Aberrant RSA arising distal to the left subclavian artery (RCCA, LCCA, LSA& RSA from right to left)	**3**	**0.7%**
Type D2 [An aberrant RSA with a common origin of the RCCA and LCCA]	**4**	**0.9%**
Type D3 [Aberrant RSA combined with Left VA arising between LCCA and LSA	**2**	**0.5%**
Type E1[Right Aortic Arch with Aberrant LSA	**2**	**0.5%**
Type E2 [Right aortic arch with a mirror image type]	**2**	**0.5%**

Discussion

The classic Branching pattern of the Aorta in which the aortic arch gives rise to three branches, the Brachiocephalic trunk, the Left common carotid artery, and the subclavian artery in that order remains the most common branching pattern of the aorta seen in the study with 320 (72.2%) of the patients having this branching pattern. This was relatively less common compared to other studies done China, Germany and turkey where those studies showed a higher prevalence of the Classic branching patterns of the Aorta with 83.6%, 86.7% and 85.2% respectively. (1)(15)(16)

Variations to the Classic Aortic Arch anomalies were also not uncommon in our study with 128(27.8 %) of the patient's having such a variant anatomical branching pattern. The common origin of the brachiocephalic truck and the Left common carotid artery (Type B) was the most common variant type with 86(19.5%) of the patients. This was much Higher than other studies conducted in china, Germany and Japan.(1,15,17) and it was smaller to other studies conducted in USA. And Race appears to be a significant factor in the variation of the Aortic arch anomalies as some studies have indicated that the Type B pattern was much more common in African Americans. (18,19)

Having the Left vertebral artery arise from directly from the aortic arch (Type C) variation occurred in 28 (6.4%) of the patients in the study and this was comparable to other studies conducted in other countries with much larger sample sizes.(16,20), the Type C arch anomalies is associated with an anomalies entry level of the vertebral artery into the Transverse foramen and has a higher risk of obstruction and dissection during neck rotation and care should be taken during surgery and interventional procedures. (21)This finding was supported by a study conducted in Japan where a higher incidence of arterial dissection was seen associated this Type C Aortic branching pattern. (22)

The Type D branching pattern of the aorta with an aberrant right Subclavian artery was seen in only 9(2.1%) of the patients in the current study and other studies in the UK, Turkey and Serbia also showed that this Branching pattern was rare accounting for less than 1% of the branching patterns.(23–26) The clinical significance of a Type D aortic arch patterns is that an aberrant RSA can be

responsible for causing dysphagia by causing compression of the Esophagus and additionally a Type D arching pattern may be associated with a non-recurrent inferior laryngeal nerve which is a rare variant where the nerve directly enters into the larynx without descending into the thorax and this can make it liable to injury during thyroid surgery. (27)

A right sided aortic arch (Type E) pattern was seen in around 1% of the cases in the current study which was higher than other studies where A Right sided Arch is believed to represent 0.05-0.3% of the population. And in the Current study there was equal amount of Right sided arch with an aberrant LSA (Type E1) and a right sided arch which was a mirror- image type (Type E2) which was not seen in the other studies were the Type E1 was significantly more common than the Type E2.(1,15–17,20,22,23)

Conclusion

Variation and anomalies of the aortic arch are common findings and knowledge about the different types of aortic arch anomalies is important for proper pre surgical planning to prevent any iatrogenic injuries during surgery and interventional procedures. some of these variations and anomalies are higher in our population than are in Caucasians therefore anticipation of their presence, as well as awareness of these, is even more important in our surgeries, interventional radiology, and minimally invasive procedure.

Recommendation

Standard and timely post contrast imaging are important for vascular study so the study should be done with automatic injector. Further study which includes large population is recommended.

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