

## **Anomalous “Mutilated Common Trunk” Aortic Arch Embryological Basis and its Clinical Significance**

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### **Abstract**

*Normally, the human Aortic arch branching into three vessels, the adult archetype of the Aortic arch and its branches are formed, due to the different growth pattern of the branchial arch arteries and their associated “migration” and “merging” of their branches. The anomalous branching patterns in the aortic arch are due to the deviations or disturbances the normal growth pattern of the aortic or branchial arch arteries during the embryonic period. The brachiocephalic trunk (BCT), the left common carotid artery (LCCA), the left vertebral artery (LVA), and the left subclavian artery (LSA) pattern was the most common four vessels arch branching pattern accounting up to 84.8%. The common trunk formation by these vessels is prevalence up to 16.1%, out of which 11% of the cases were the left vertebral artery originated with the left subclavian artery and form the “common vertebro-subclavian trunk - CVST”. The ontogenesis for these anomalous anatomical configurations and its clinical significance are still remaining unclarified. The implication of these common trunk arteries has not been properly signified in the literature till now. Till today the common vertebro-subclavian trunk Aortic arches are commonly regarded as a normal variant so, very little direct data are available. Generally, the patients with common vertebro-subclavian trunk Aortic arches are clinically normal and asymptomatic. Currently, the clinicians claimed the common vertebro-subclavian trunk Aortic arches are common in patients with atheromatic hypoperfusion and aneurysms. The present study aimed to through insight knowledge about this common trunk variant of the aortic arch. Recently, it is well identified that the suspicion exists with silent common vertebro-subclavian trunk Aortic arches, leads to sudden severe neurological complications due to the wide range of atheromatous plaques and congenital aneurysms, may cause fatal. Since the common vertebro-subclavian trunk Aortic arches are treated as “Mutilated Common Trunk –MCT” of the aortic arches.*

**Keywords:** *Mutilated Common Trunk, Common vertebro-subclavian trunk, Bovine trunk, Truncus bicaroticus.*

### **1. Introduction**

Arch of the aorta, is the upward continuation of the Ascending aorta and it is normally branching into three vessels patterns called, the brachiocephalic trunk (BCT) or innominate artery, the left common carotid artery (LCCA) and the left subclavian artery (LSA), incidence in 74.0% - 89.4% cases in radiological investigations [1,2,3] and 63.5% to 77.3% in cadaveric studies [4,5,6]. The adult archetype of the Aortic arch and its branches are formed, due to the different growth pattern of the aortic or branchial arch arteries and their associated “migration” and “merging” of their branches [7]. The most common variance of the aortic arch was observed as the anomalous aortic arch origin of the left vertebral artery (LVA). The anomalous branching patterns in the aortic arch are due to the deviations or disturbances the normal growth pattern of the aortic or branchial arch arteries during the embryonic period.

The brachiocephalic trunk (BCT), the left common carotid artery (LCCA), the left vertebral artery (LVA), and the left subclavian artery (LSA) pattern was the most common four vessels arch branching pattern accounting up to 84.8% [8]. The common trunk formation by these arteries in the arch of the aorta was prevalence up to 16.1%, out of which 11% of the

cases were the left vertebral artery originated with the left subclavian artery [8] and form a common trunk called “common vertebro-subclavian trunk - CVST”. The ontogenesis for this anomalous anatomical configurations and its clinical significance are still remaining unclarified.

The implication of these common trunk arteries has not been properly signified in the literature till now. Till today, the CVST Aortic arches are commonly regarded as a normal variant so, very little direct data are available. Generally, the patients with common vertebro-subclavian trunk Aortic arches are clinically normal and asymptomatic. Currently, the clinicians claimed the common vertebro-subclavian trunk Aortic arches are common in patients with atheromatic hypoperfusion and aneurysms. The present study aimed to through insight knowledge about this common trunk variant of the aortic arch. The normal diameter of LVA was identified as 3-5mm, in LSA was in 10 -12mm. The vertebral artery diameter was significantly more on the left side than the opposite [9, 10, 11]. The average diameter of this common vertebro-subclavian trunk (CVST) was reported as ~ 20mm. The large diameter CVST receives the high-pressure blood from the ascending and arch of the aorta, results in the increased blood pressure in the LVA and LSA. The increased pressure in the CVST causes dilatations of LVA and LSA vessels, it may be extended up to one and a half to two times that of a normal diameter, so called as ectasia, if the dilatations occur more than the twice of the normal diameter, results in an aneurysm [12]. These aneurysms (LVA and LSA aneurysms) should be repaired to avoid possible limb and life-threatening tribulations. The increased pressure in the CVST results in the asymmetric vertebral blood flow might influence the disturbances in the cerebral arterial system, cause infarcts in the areas before or after the vertebrobasilar junction.

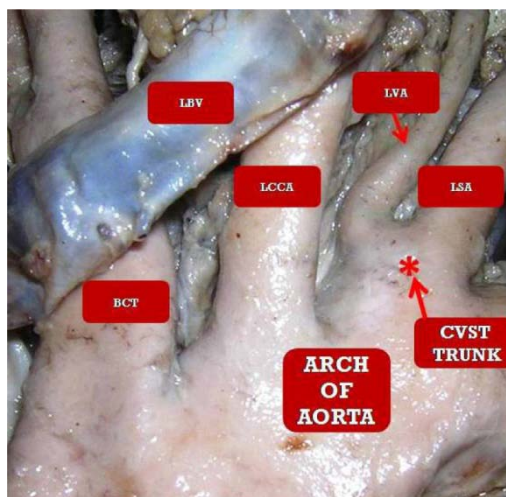
Recently, it is well identified that the suspicion exists with silent common vertebro-subclavian trunk Aortic arches, leads to sudden severe neurological complications due to the wide range of atheromatous plaques and congenital aneurysms, may cause fatal. Since the common vertebro-subclavian trunk Aortic arches are treated as “Mutilated Common Trunk – MCT” of the aortic arch.

## **2. Incidence**

The brachiocephalic trunk, the left common carotid artery, the left VA and the left subclavian artery pattern was the most common four vessels arch branching pattern accounting up to 84.8%. The common trunk formation by these arteries in the arch of the aorta was prevalence up to 16.1%, out of which 11% of the cases were the left VA arose with the left subclavian artery [8] from a common trunk called “common vertebro-subclavian trunk - CVST”.

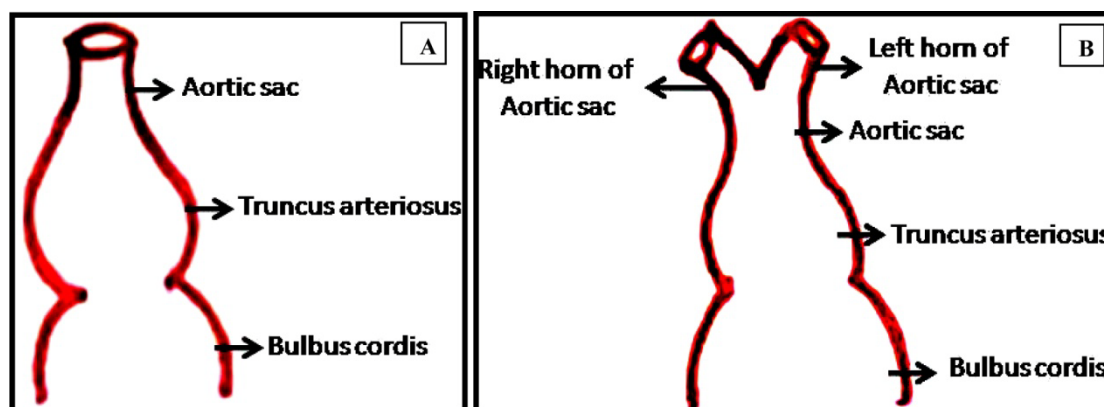
## **3. Observations**

On the dissected human heart specimens with the aortic arch branches, we observed most prevalence common trunk four vessels arch branching pattern called the “common vertebro-subclavian trunk – CVST” aortic arch. The arch of the aorta shows the branching pattern like the brachiocephalic trunk, the left common carotid artery, the left vertebral artery and the left subclavian artery. The Anomalous Aortic arch origin of the left vertebral artery (LVA) with the common trunk origin of the left subclavian artery (LSA) formed the “common vertebro-subclavian trunk – CVST” (Fig-1).



**Fig-1:** The Anomalous Aortic arch origin of the left vertebral artery (LVA) forming the “common vertebro-subclavian trunk – CVST” with the origin of the left subclavian artery (LSA). (BCT- Brachiocephalic Trunk, LCCA- Left common carotid artery and LBV-Left Brachiocephalic vein)

After its origin, the Left subclavian artery and the first part of the left subclavian artery followed its normal course to enter the foramen transversarium of the sixth cervical vertebra. On the other hand, the right subclavian and vertebral arteries are branched out normally.



**Fig-2:** The development of Aortic sacs A. schematics showing the proximal part of the developing heart tube and B. During the later period, the Aortic sac shows its terminal branches called Right and Left horns.

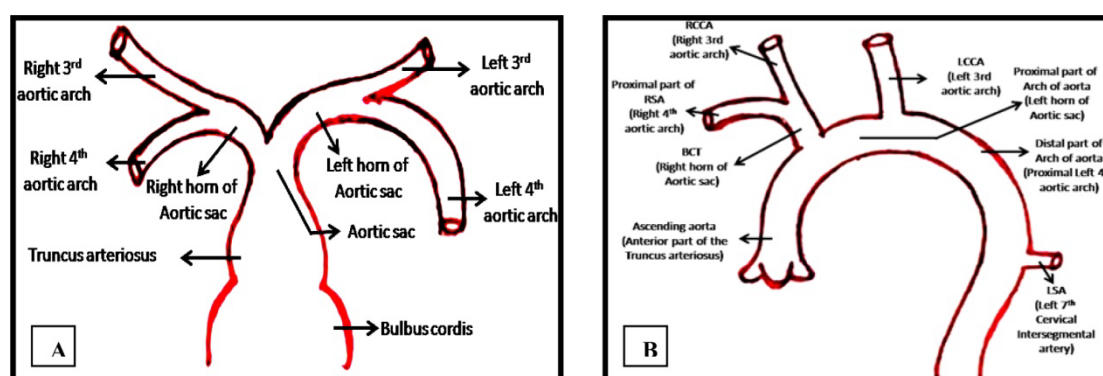
### 3.1 Ontogenesis for the normal aortic arch branching pattern:

During development, in the primitive heart tube, the Truncus arteriosus (aortic sac) receives six sets (right and left) of Aortic or branchial arterial arch [13]. These arterial arches undergo selective apoptosis, and the residual branch vessels constitute the formation of Aortic arch and its great vessels. Any deviations in this normal process will result in the anatomical variance.

The first and second sets (right and left) arterial arches (I and II) are usually gets regressed. The third pair (right and left) arterial arches (III), forms the proximal part of the common carotid arteries bilaterally. The proximal part of the right fourth arterial arch (IV) persists as the right subclavian artery up to the origin of the internal thoracic (mammary) artery, whereas the distal part of the right fourth arterial arch gets regressed. The distal part of the left fourth arterial arch (IV) regresses and its proximal part forms a small segment of the adult Aortic arch between the origin of the left common carotid artery and the left subclavian arteries. The right and left, fifth arterial arch (V) either regresses or incompletely formed. The proximal part of the right and left sixth arterial arch (VI) forms the pulmonary arteries. The distal part

of the right side sixth arch (VI), becomes ductus arteriosus, whereas in the left side distal part will regress completely [14]. The right horn of the Aortic sac forms the brachiocephalic trunk (BCT) or innominate artery and the left horn of the Aortic sac, normally forms the part of the Aortic arch intervenes between the origins of the brachiocephalic trunk (BCT) or innominate artery and the left common carotid (LCCA) arteries.

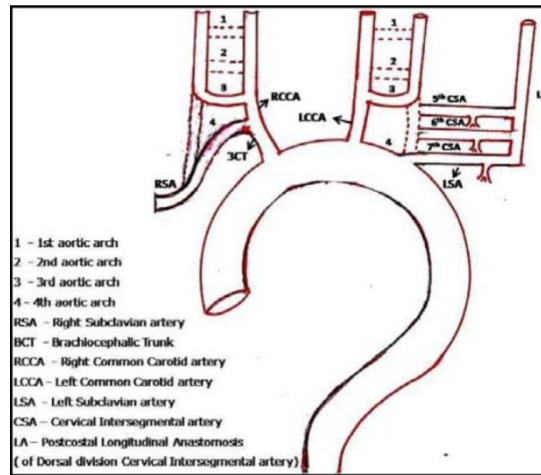
Normally, the anterior part of the Truncus arteriosus receives the third (III) and fourth (IV) sets (right and left) of arterial arches; eventually, it opens into the right and left horns of the Aortic sac. The posterior part of the Truncus arteriosus receives the sixth (VI) sets (right and left) of arterial arches, and forms the right and left pulmonary arteries. The formation of the spiral or Conotruncal septum divides the Truncus arteriosus into the anterior ascending aorta and the posterior pulmonary trunk. The anterior part of the Truncus arteriosus continuous above as the Aortic sac, where it connects with the third (III) and fourth (IV) sets (right and left) of Aortic or branchial arch arteries. Ultimately, the aortic sac and its horns receive, all the derivatives of third (III) and fourth (IV) sets (right and left) of Aortic or branchial arches (Fig-2 & 3).



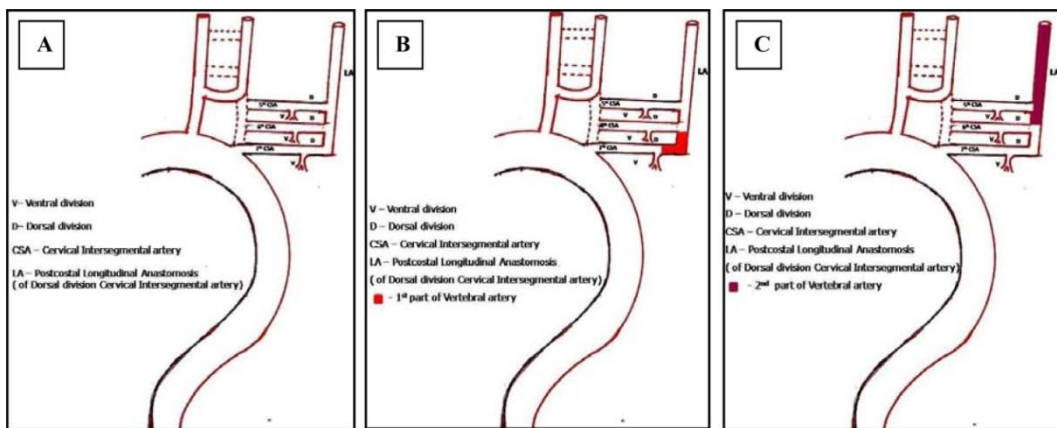
**Fig-3:** The derivatives of aortic arch arteries A. schematics showing the Truncus arteriosus receives the third (III) and fourth (IV) sets (right and left) of Aortic arch arteries, ultimately it is opens into the right and left horns of the Aortic sac and B. Derivatives of the Aortic sac horns and third (III) and fourth (IV) sets (right and left) of Aortic arch arteries.(BCT-Brachiocephalic trunk, RSA- Right subclavian artery, RCCA- Right Common carotid artery, LCCA- Left Common carotid artery and LSA-Right subclavian artery)

### 3.2 Normal ontogenesis of left vertebral and subclavian arteries:

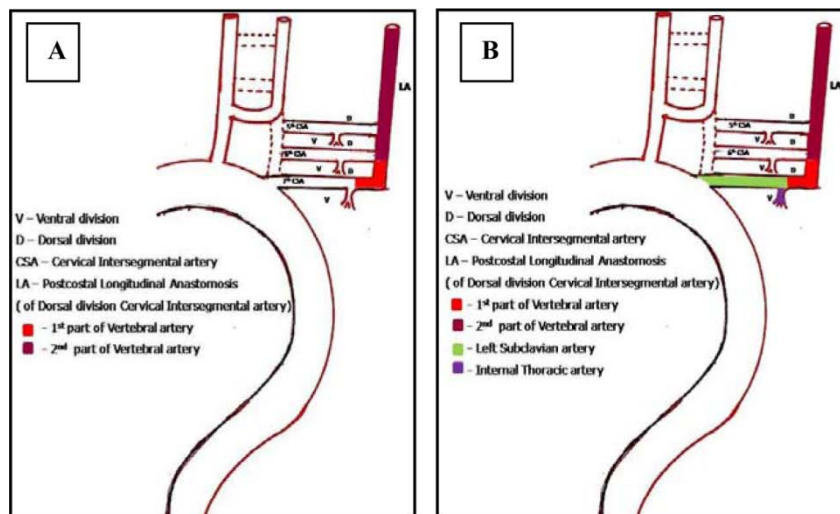
The small intersegmental branches arise from the dorsal aorta, extends from the cranial (cervical) to the caudal (sacral) region, to vascularize the somites of the developing embryo. In the cervical region, these intersegmental arteries are named as C1 to C7. The vertebral artery normally developed from the cervical intersegmental arteries. The dorsal branches (distal part) from the cervical intersegmental arteries from C1 to C7 are fused to form the postcostal longitudinal anastomosis. Normally, the first part of vertebral artery developed from the distal part of the seventh cervical intersegmental artery and its (proximal part) dorsal branch (proximal to postcostal anastomosis). The sixth cervical intersegmental artery and its dorsal division are usually disappeared. The second part is derived from postcostal longitudinal anastomosis between the C6 to C1 (Fig-4 - 6). The left subclavian artery commonly developed form the proximal part of the seventh cervical intersegmental artery (Fig-4 green shaded).



**Fig-4:** Ontogenesis of normal development Aortic arch and its branches.



**Fig-5:** The schematic representation shows the Ontogenesis of: A. connections of 5th to 7th cervical intersegmental arteries with the Dorsal aorta, B. development of 1st part of left vertebral artery from the dorsal branch of 7th cervical intersegmental artery alone, and C. the 2nd part of left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) 6th and above cervical intersegmental arteries.

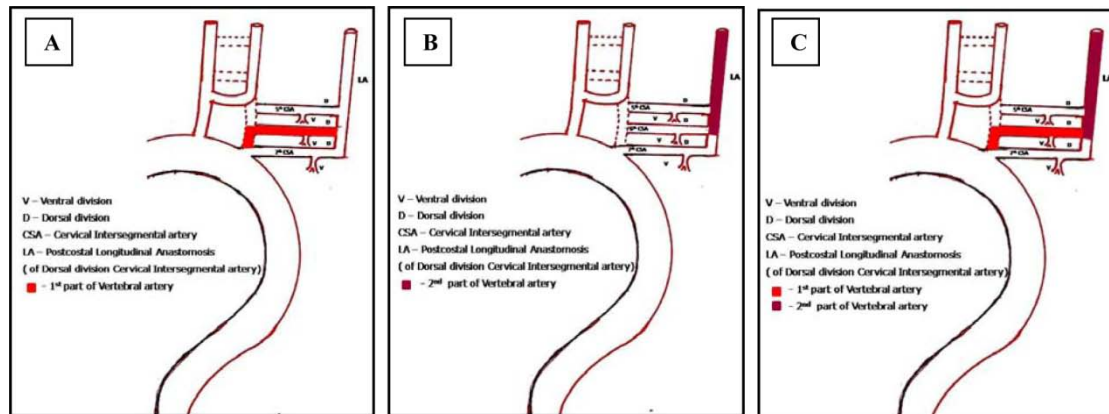


**Fig-6:** The schematic representation shows the Ontogenesis of: A. normal source of development of left vertebral artery (LVA). B. normal source of development of left subclavian artery (LSA) from the 7th cervical intersegmental artery and its branch called internal thoracic or internal mammary artery from the ventral branch of 7th cervical intersegmental artery.

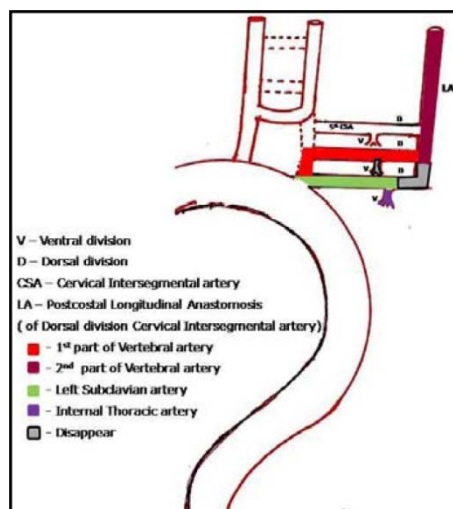
### 3.3 Embryological basis for the “common vertebro-subclavian trunk (CVST)”:

The left sixth intersegmental artery and its dorsal branch may fail to disappear. The blood from aortic arch directly flows to the persisting sixth cervical intersegmental artery forming the aortic arch origin of the left vertebral artery. This preferential blood flows through the persisting left sixth intersegmental channel, results in diminishes the normal flow through the seventh cervical intersegmental artery (to its dorsal branch), which ultimately disappear.

The first part of the left vertebral artery derived from the sixth intersegmental artery and also from the small proximal portion of its dorsal branch. The ventral branch of the sixth intersegmental artery was disappeared completely. The second part of the left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) sixth and above cervical intersegmental arteries. It gives the pattern of variance left vertebral artery arises from the common trunk origin with the LSA termed as “Common vertebro-subclavian trunk - CVST” (Fig- 7 and 8).



**Fig-7:** The schematic representation shows the Embryological basis of: A. variants origin of 1st part of left vertebral artery from the left sixth intersegmental artery and its dorsal branch, B. Normal development of the 2nd part of left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) 6th and above cervical intersegmental arteries, and C. the variants Aortic arch origin of left vertebral artery from the left sixth intersegmental artery.



**Fig-8:** The variance left vertebral artery (LVA) arises from the common trunk origin with the LSA (green shaded), termed as “Common vertebro-subclavian trunk - CVST”. The normal source of development of left subclavian artery (LSA) from the 7th cervical intersegmental artery and its branch called internal thoracic or internal mammary artery from the ventral branch of 7th cervical intersegmental artery.

#### 4. Discussion:

Arch of the aorta, is the upward continuation of the Ascending aorta and it is normally branching into three vessels patterns called, the brachiocephalic trunk (BCT) or innominate artery, the left common carotid artery (LCCA) and the left subclavian artery (LSA), incidence in 74.0% - 89.4% cases in radiological investigations [1,2,3] and 63.5% to 77.3% in cadaveric studies [4,5,6]. The adult archetype of the Aortic arch and its branches are formed, due to the different growth pattern of the aortic or branchial arch arteries and their associated "migration" and "merging" of their branches [7]. The most common variance of the aortic arch was observed as the anomalous aortic arch origin of the left vertebral artery (LVA). The anomalous branching patterns in the aortic arch are due to the deviations or disturbances the normal growth pattern of the aortic or branchial arch arteries during the embryonic period.

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The significance of the common trunk of the arteries has not been properly indicated in the literature till now. Till today the common vertebro-subclavian trunk Aortic arches are commonly regarded as a normal variant so, very little direct data are available. Generally, the patients with common vertebro-subclavian trunk Aortic arches are clinically normal and asymptomatic. Currently, the clinicians claimed the common vertebro-subclavian trunk Aortic arches are common in patients with atheromatic hypoperfusion and aneurysms. The present study aimed to through insight knowledge about this common trunk variant of the aortic arch.

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vessels up to the one and a half to two times that of a normal diameter, so called as ectasia, if the dilatations occur more than the twice of the normal diameter, results in an aneurysm [12]. These aneurysms (LVA and LSA aneurysms) should be repaired to avoid possible limb and life-threatening tribulations. The pressure increases in the common vertebro-subclavian trunk resulting from asymmetric vertebral blood flow might influence the disturbances in the cerebral arterial system, cause infarcts in the areas before or after the vertebrobasilar junction.

An atherosclerotic lesion was the most common (60%) cause, for an aneurysm. The arterial bifurcations are the most common site for the atheromatous plaque formations. Atheromatous plaques are developed in the crucial regions with intricate blood flow patterns with fluctuation lateral pressure on the blood vessels as in the regions such as bifurcations, bends and junctions [15, 16, 17]. The patients with the common vertebro-subclavian trunk may be asymptomatic unless it involved with the atherosclerotic lesions [18]. Angiographic studies show the extracranial atheromatous plaques with the atherosclerotic lesions are very common in the first few centimeters of the CVST, often extension into the origins of LVA and LSA. The atherosclerotic lesion in the LVA causes transient hypoperfusion leads to ischemic attacks. According to the previous observations, only 20% of strokes are due to the hemorrhagic origin. Although the hemorrhagic strokes are less common than ischemic strokes, it causes more severe lesions than the ischemic type. The ischemia is often resulting from the high blood pressure or lateral wall pressure on the blood vessels which are before now damaged by the atherosclerotic lesions.

The ischemic strokes are the more common (80%) type of all strokes. Normally, the left vertebral artery (LVA) is often larger than the right vertebral artery (RVA) [19], and the dominant vertebral artery was most frequent on the left side (69.2%). The curvature of the Basilar artery (BA) was directly opposite side of the dominant vertebral artery. The aforementioned two reasons results in the Basilar artery (BA) curvature was mainly directed to the right side. The most frequent morphological change in the Basilar artery (BA) was a C-shaped bend, followed by S-shaped, J-shaped, and no bend or straight.

Conventionally, the clinicians regarded as, the congenital variant vertebral arteries are the clinically worthless findings unless it causes the vascular insufficiencies [20, 21]. On the other hand, the recent studies confirmed that the vertebral arteries insufficiencies are the major risk factors for the posterior circulation stroke [22, 23, 24, 25]. Now it is believed, the variations or anomalies in the aortic arch arteries will lead to the increased pressure in the blood across the vessels, which in turn increases the stress in the LVA, LSA and descending thoracic aorta, leading in the development of Vertebral, Subclavian, and Thoracic Aortic Aneurysms.

## 5. Conclusion:

Recently, it is well identified that the suspicion exists with silent common vertebro-subclavian trunk Aortic arches, leads to sudden severe neurological complications due to the wide range of atheromatous plaques and congenital aneurysms, may cause fatal. Since the common vertebro-subclavian trunk Aortic arches are treated as “Mutilated Common Trunk – MCT” of the aortic arches.

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