Hypoplasia of Fourth Part of Vertebral Artery and Its Clinical Significance

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Abstract

Introduction: The anatomical and morphological variation of vertebral artery has clinical importance not only to the performance of interventional or surgical procedure itself but also to ensure circulation to the hindbrain. Aim of the Study: To analyze the morphological and morphometric variations of the fourth part of vertebral arteries. Materials and Methods: The present study was conducted in the Department of Anatomy, Vinayaka Mission’s Kirupananda Varriyar Medical College and Hospitals, Salem, Tamil Nadu, India. Fifteen adult human brains’ specimens acquired from embalmed human cadavers were utilized for the study. Morphology and morphometric analysis of the fourth part of vertebral arteries were done to demonstrate the variations. Vernier caliper was used for morphometric analysis. Results: The mean diameter of the fourth part of the left vertebral artery has been larger in size than the right vertebral artery with a mean of 2.55 mm ± 0.30 mm. In one specimen, the fourth part of the left vertebral artery was very narrow with a diameter of 0.1 mm and the right vertebral artery measured 0.4 mm. Conclusion: Hypoplasia of the fourth part of the vertebral artery is a contributing factor in acute ischemia of the brain. Morphological variations of the vertebral artery are considered as an etiological factor for conditions such as atherosclerosis, infarction, vascular malformations, transient ischemic attack and syndromes such as Wallenberg’s and Medial Medullary syndrome. Vascular variations usually subject for controversy, and detailed knowledge of such variations serves as a key role in procedures such as magnetic resonance imaging, computed tomography, and neurovascular surgeries. The study will be done extensively to support the anatomical and morphological variations of vertebral arteries to make fruitful clinical implications.

Keywords: Cranial part, diameter, hypoplasia, variation, vertebral artery

INTRODUCTION

Vertebral artery is the largest branch of the first part of the subclavian artery. It has a long course from its origin to the cranial cavity, where its contribution to the brain begins. Anatomically, vertebral artery is subdivided into four parts. First part commences from its origin to the foramen transversarium of the sixth cervical vertebrae. The second part of the artery passes through the foramen transversarium of the sixth cervical vertebra to the axis vertebrae. It then passes superiorly and reaches the foramen transversarium of the atlas vertebrae. The artery then comes out from the foramen transversarium of Atlas vertebra and then winds around the vertebral groove of posterior arch of Atlas to reach the suboccipital triangle. The fourth part of the artery extends from the posterior atlantooccipital membrane to enter through the foramen magnum and reach in the posterior cranial fossa; it ascends medially to reach the medulla oblongata and then finally reach to the lower border of the pons.[1] Both vertebral arteries further join to form a basilar artery that lies in the basilar sulcus of ventral part of the pons[2] [Figure 1]. The infratentorial part of the brain will get main source of blood supply from the branches of vertebrobasilar artery system that controls main functions of blood pressure, body movements, coordination, reflexes, breathing, and many other essential functions. Hence, if any complications have been occurred, it causes vertebrobasilar insufficiency.

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Vertebral artery variation are commonly encountered as abnormal origin, anomalies, and hypoplasia is found to be one of the common factors of acute ischemic stroke, especially involving the brain structures present in the posterior cranial fossa.\[3\]

The knowledge on variations of the vertebral artery was clinically very important to neurosurgeons, for operating endovascular procedures such as vertebroplasty, for treating vertebral artery stenosis and aneurysms, and for interpreting the imaging techniques of this region. Hypoplastic vertebral artery is commonly associated with regional hypoperfusion and further causing neurovascular complications such as ischemic stroke.\[4\]

Hypoplastic vertebral artery is also found to be a causal factor of acute ischemic stroke in predominantly hindbrain structures.\[5\] Even though basilar artery is an essential component of cerebral circulation, the interference of blood supply due to any cause, even for a short interval (7–8 min), would cause severe and permanent damage to brain tissue. Morphological variation of the vertebral arteries is considered to be an etiological factor for many pathological conditions such as atherosclerosis, infarcts, arteriovenous malformations, transient ischemic attacks, and certain syndromes, including Wallenberg’s syndrome and Medial Medullary syndrome.\[6\]

Hence, this study focused to identify and measure to morphological and anatomical variations in the intracranial part of vertebral arteries.

**Aim of the study**

The study was done to demonstrate morphological and morphometric variations of the fourth part of the vertebral arteries.

**Need of the study**

The anatomical and morphological variations of vertebral artery has clinical importance not only for the performance of interventional or surgical procedure itself but also to ensure the hind brain circulation. Hence, the comprehension of anatomical variations of the vertebral artery in the head and neck and neuroanatomy region is of enormous importance.

**Materials and Methods**

The descriptive study was conducted in the Department of Anatomy, Vinayaka Mission’s Kirupananda Variyar Medical College and Hospitals, Salem, Tamil Nadu, India, after obtaining necessary clearances from the Institutional Review Board and Ethical Committee for conducting the study. Out of 15 specimens, 10 brain specimens were procured from male cadaver while 5 brain specimens were procured from female cadaver. The age of cadaver ranges between 65 and 70 years. The brain specimens procured from the cadavers were fixed in 10% formalin solution and observed carefully to analyze the morphological variations in the right and left vertebral arteries, and their diameters were measured to demonstrate morphometric variations [Figure 2]. The diameters of the vertebral arteries were measured using the digital Vernier caliper. Digital photographic equipment and red coloring materials were also used to demonstrate the variations [Figure 3].

**Statistical analysis**

The measurements were subjected to statistical analysis using SPSS (Statistical Package Social Service) software version 16.0.0.247 (spss Inc.). The mean, range, and standard deviation were calculated. “Paired t-test” was done to compare the variables.

**Results**

One of the brain specimens showed hypoplasia of both the vertebral arteries and marked narrowing of the left vertebral artery was noted [Figure 4] with a diameter of 0.1 mm, and on the right side, the diameter was 0.4 mm [Table 1].

In the present study, the diameter of the fourth part of the right vertebral artery of the remaining 14 brain specimens ranged from 1.43 to 2.96 mm with a mean of 2.06 ± 0.42 mm [Table 2].

![Figure 1: Normal vertebral arteries](image1)

![Figure 2: Measuring diameter of left vertebral artery (hypoplasia) using Vernier caliper](image2)
The diameter of the fourth part of the left vertebral artery ranged from 2.05 to 2.96 mm with a mean of 2.55 ± 0.30 mm [Table 2].

In the present study, the mean diameter of the left fourth part of the vertebral artery was significantly higher when compared to the right fourth part of the vertebral artery (P > 0.017) [Table 3].

**DISCUSSION**

Congenital abnormality of vertebral arteries predominantly shows morphometric changes, tortuosity of both vertebral arteries, and hypoplastic HBV is defined as where lumen measures a diameter of <2 mm in a study stating no clear consensus in the definition.[4]

In the embryonic period, the cervical intersegmental arteries degenerate except the seventh intersegmental artery which persists and forms the proximal part of subclavian and vertebral arteries.[7]

Park *et al.* reported 3.4% of patents with ischemic stroke exhibited hypoplastic vertebral artery bilaterally as well as unilaterally causing posterior circulatory Stroke this explains the significance of anatomical variations of vertebral artery in causing ischemic stroke.[8]

Akar *et al.*, in their study on microsurgical anatomy of vertebral artery’s dimension, length, and branches in 11 cadaveric specimens, have noted that right vertebral arteries were bigger than the left vertebral arteries.[9,10] However, the current study shows larger diameter on the left vertebral artery than the right vertebral artery.

Katsanos *et al.* have reported that the significance of hypoplastic vertebral artery ranges from 1.9% to 11.6% and the incidence of HVA was 5%. In the present study, the diameter of the cranial part of the right vertebral arteries ranged from 1.43 to 2.96 mm and the left vertebral artery ranged from 2.05 to 2.96 mm [Table 2].

Although numerous studies have elaborated on cranial part of vertebral artery and its branches, length, and it variations are unequal in size in 60% and the left vertebral artery is often larger in size than the right vertebral artery.[13,14] Similar findings were found in the present study too.

Chuang *et al.* have described operational definitions of the vertebral artery hypoplasia which varies between diameters of 2–3 mm, otherwise the asymmetry value will be ≥1.7 mm.[15]

Blickenstaff *et al.* have established that the incidence of hypoplasia and congenital atresia was more common in the left vertebral artery, it is usually larger in size compared to the right, and it carries more amount of blood to the brain;[16,17] and the same was established in the current study too.

The radiological study stated that hypoplastice vertebral artery causes high risk of ischemia stroke and some neurological problems due to the reduction of the blood flow of posterior cranial fossa structures.[18]

Uzmsel *et al.* have quoted that the definition of vertebral artery hypoplasia has not been precisely stated. He conducted in living humans using ultrasonography and concluded that <2mm diameter of lumen of vertebral artery are considered as hypoplastic and in his study he reported that 1.9% of cases shown hypoplastic vertebral artery & 6% cases exhibited up to 3mm diameter of vertebral artery.[19]

The present study also emphasizes the same findings; hypoplasia of the vertebral artery was noted in one case. It was not associated with the hypoplasia of the basilar artery [Figure 4].

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**Table 1: Variation of vertebral artery diameter**

|            | Right vertebral artery | Left vertebral artery |
|------------|------------------------|-----------------------|
| Mean (mm)  | 0.4                    | 0.1                   |

|            | Right vertebral artery (mm) | Left vertebral artery (mm) |
|------------|------------------------------|-----------------------------|
| Mean       | 2.6                          | 2.55                        |
| Minimum    | 1.43                         | 2.5                         |
| Maximum    | 2.96                         | 2.96                        |
| SD         | 0.42                         | 0.30                        |
| Variance   | 0.18                         | 0.9                         |
The knowledge of these variations in the vertebral artery is helpful for the neurosurgeons to plan and execute surgeries for the treatment of stenosis, aneurysms, and arteriovenous malformations in the posterior cranial fossa.

**Conclusion**

Hypoplasia of the fourth part of the vertebral artery is a contributing factor in acute ischemia of the brain. Morphological variations of the vertebral artery are considered as an etiological factor for conditions such as atherosclerosis, infarction, vascular malformations, and transient ischemic attack and syndromes such as Wallenberg’s and Medial Medullary syndrome. Vascular variations are clinically significant; detailed knowledge of such variations serves as a key role in procedures such as magnetic resonance imaging, computed tomography, and neurovascular surgeries. The study will be done extensively to support the anatomical and morphological variations of vertebral arteries to make fruitful clinical implications.

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**Conflicts of interest**

There are no conflicts of interest.

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**Table 3: Statistically compared fourth part of right and left vertebral artery diameters – paired t-test**

| Paired differences | Mean±SD | SEM | 95% CI of the difference | t | DF | Significant |
|--------------------|---------|-----|--------------------------|---|----|------------|
|                    |         |     | Lower                    |   |    |            |
| Right vertebral artery diameter – left vertebral artery diameter | -0.4957±0.3335 | 0.08915 | -0.6831 | -0.30311 | -5.560 | 13 | 0.017 |

SD: Standard deviation, SEM: Standard error of mean, CI: Confidence interval, DF: Degree of freedom