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Original Research Article

Histo-Morphometric Assessment of the Various Segments of Vertebral Artery

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Abstract

Aim: To study histomorphometric variations in four segments of vertebral artery.

Material & Methods: Present study was done on 40 human cadavers of unknown age and sex which were available in department of anatomy. Meticulous dissection of the VA throughout its length was done on both sides.

Results: Present study observed that outer diameter of vertebral artery on left side is 3.563 mm ± 0.31 and on right side is 3.264 mm ± 0.34. unpaired t-test (t=3.549) shows that mean difference in outer diameter of left and right side of vertebral artery is 0.3153, 95% CI lower limit of which is 0.1382 and upper limit is 0.4903 and p value is 0.0005 which is less than 0.05 and hence difference is significant. Present study observed the variability in the thickness of the VAs and V4 has the thinnest wall. Conclusion: Left vertebral artery was found to be dominant than the right. Internal elastic lamina was main elastic constituent of 4th part of vertebral artery, so damage to it may cause vascular pathologies like atherosclerosis, aneurysm etc.

Keywords: Vertebral artery, Inner diameter, Outer diameter, Internal elastic membrane, External elastic membrane.

Introduction

Vertebral artery shows multiple variations in its origin and course. The vertebral arteries originate from the posterior superior aspect of the first part of the subclavian artery. [1] The vessels take a vertical posterior course to enter into the foramen transversarium of the sixth cervical vertebra. The segment of the artery from its origin at the subclavian artery to its respective transverse foramen is termed as pre-transverse or prevertebral segment. [2] The second part passes through foramen transversarium of sixth cervical vertebra (C6) to the first cervical vertebra (C1). The third part curves medially behind the lateral mass of the atlas. It passes through foramen magnum as fourth part and at the lower border of pons; two vertebral systems unite to form the basilar artery. The vertebral arteries form the vertebrobasilar vascular system and supply blood to the upper spinal cord, cerebellum, and posterior part of the brain stem. Topographically, the vertebral artery is divided into four parts: cervical or prevertebral, vertebral, sub-occipital, and intracranial part. [3]

The initial segment of the vertebral artery (V1) ascends to enter the transverse foramen (TF) of the six cervical vertebrae (V2). Then, it ascends through the transverse foramina of C6-C1, which runs posterolaterally around the atlas (V3). Finally, it penetrates the dura mater and passes through the foramen magnum to become the intracranial segment of the vertebral artery (V4) [4-5]. Both the VA unites together to form the basilar artery, which forms the caudal part of the circle of Willis to supply the hindbrain, which has the centers that control the respiratory and cardiac functions [6]. The vertebral artery is highly protected by bony and muscular structures in the neck, which makes it difficult to approach during surgical procedures. During cervical spine movements, VA undergoes large shear and tensile forces, elongated during lateral flexion, with kinking occurring during the rotation of the neck [7].

VA may be compressed from outside due to exostoses of the cervical vertebrae and atherosclerotic plaques in the wall of the artery can be an internal cause of compromised blood flow in the artery. Also, full range rotation of cervical spine may cause mechanical stretching of the VA and it will decrease the blood flow through it. Initial size of the artery play important role in decreased blood flow [8-9]. VA tears after blows to the head and neck are usually associated with basal subarachnoid hemorrhage with a rapidly fatal outcome [10]. Precise knowledge of anatomy and variations of VA is mandatory while performing angiography and various surgical procedures to prevent serious complications [11].

Hence, this study aims to study histomorphometric variations in four segments of vertebral artery.

Material & Methods:

Present study was done in Department of Anatomy, Anugrah Narayan Magadh Medical College, Gaya, Bihar, India, 40 human cadavers of unknown age and sex which were available in department of anatomy. These cadavers were used by undergraduate students for routine dissection. Meticulous dissection of the VA throughout its length was done on both sides. All four segments of VA, each having 0.5 cm lengths were taken. Outer and inner diameters were measured by Verniercalliper in mm and kept in separate containers in 10% formalin. Each of the containers was properly labeled and tissue stored till it was processed.

Four different sites of VA from where the sample was taken:

- 1^{st} part (V1) – 1cm above its origin from subclavian artery.
- 2^{nd} part (V2) - in between the transverse process of C_3 to C_5 vertebra. • 3^{rd} part (V3) –in sub occipital triangle.
- 4^{th} part (V4) – 1cm proximal to formation of basilar artery.

Tissues were processed through routine procedure and blocks prepared. Five to seven micro meters thick sections were cut and were stained with Verhoeff's Van Geison, and Masson Trichrome [10]. Stained slides were scanned by IS capture software under 10 X magnification.

Normal structure and variations in histology of the various parts of VA were observed, recorded and where needed photomicrography was done.

Following histological parameters were measured:

i. Whole thickness of arterial wall in micrometre
ii. Thickness of tunica media (TM) in micrometre
iii. Appearance of internal and external elastic lamina (IEL and EEL)
iv. Disposition of elastic and muscle fibres in TM
v. Disposition of elastic and collagen fibres in tunica adventitia (TA)

Results:

Present study observed that outer diameter of vertebral artery on left side is 3.563 mm ± 0.31 and on right side is 3.264 mm ± 0.34. unpaired t-test (t=3.549) shows that mean difference in outer diameter of left and right side of vertebral artery is 0.3153, 95% CI lower limit of which is 0.1382 and upper limit is 0.4903 and p value is 0.0005 which is less than 0.05 and hence difference is significant. [Table 1]. Present study observed that inner diameter of vertebral artery on left side is 3.172 mm ± 0.31 and on right side is 2.879 mm ± 0.28. Unpaired t-test (t=4.483) shows that mean difference in inner diameter of left and right side of vertebral artery is 0.3740, 95% CI lower limit of which is 0.1840 and upper limit is 0.4659 and p value is 0.0001 which is less than 0.05 and hence difference is significant. [Table 1]

Present study observed the variability in the thickness of the VAs and V4 has the thinnest wall [Table 2].

In V1 part of VA: we observed that the endothelium was seen to be discontinuous in some specimens; sub endothelial tissue (SET) show variable thickness. Internal elastic lamina (IEL) was prominent and wavy. Tunica media (TM) was thick and comprise of smooth muscle, collagen and elastic fiber. Rest part is of muscle and collagen fibres.External elastic lamina (EEL) shows single lamina of circularly arranged elastic fibres and it was surrounded by many layers of longitudinally arranged elastic fibres.In tunica adventitia (TA) concentration of elastic fibres are more as compared to collagen and mostly longitudinally arranged with few circularly arranged. [Fig.1].

In V2 part of VA: the endothelium and SET were well appreciated with variable thickness. Thin TI was observed compared V1 and V3. IEL was prominent. TM was less thick as compared to 1st part of VA and was muscular. Numbers of elastic fibres were less as compared to V1.EEL shows 3 to 5 layers of circularly arranged elastic fibres. TA shows circularly arranged bundles of collagen fibres prominently with very few elastic fibres [Figure 2].

In V3 part of VA: the endothelium and SET were distorted at places and well appreciated with variable thickness at some places. IEL was prominent and wavy. TM was thick than rest of the parts of VA and mainly consist of smooth muscle interspersed in between are elastic fibrils. At some places it also showed fragmented elastic fibres. EEL is prominent with inner circular and outer longitudinally arranged elastic fibres.TA shows more elastic fibres as compared to V2 and V4 segments. [Figure 3]

In V4 part of VA: IEL was very prominent, thick and less wavy as compared to other three parts of VA. TM is thin as compared to other segments. It contains comparatively more number of muscle fibres than elastic fibres. EEL was either absent or it was represented by sparse single elastic fibrils only at some places. TA was thin and shows mainly collagen fibres. We observed thick tunica media in third part of vertebral artery. [Figure 4]

Table 1: Segment wise mean diameter of vertebral artery (mm).

Diameter	V1		V2		V3		V4		Mean of all 4	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Outer	3.743	4.112	3.303	3.590	3.389	3.654	2.615	2.986	3.264	3.563
Inner	3.220	3.702	2.973	3.293	2.937	3.192	2.330	2.538	2.879	3.172

Table 2: Segment wise thickness of arterial wall of vertebral artery in micrometer.

V1		V2		V3		V4		Mean of all 4 segments	
Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
424.21	433.62	352.33	350.74	425.62	429.65	222.41	250.55	353.79	368.52

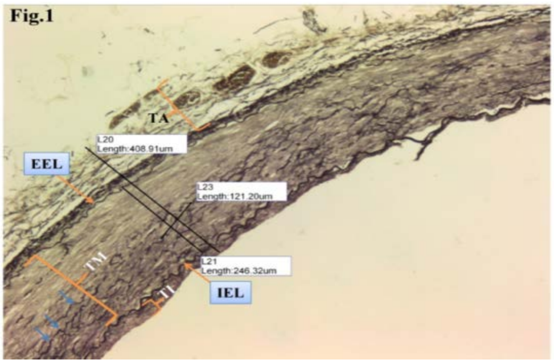

Figure: 1: Photomicrograph of first part of vertebral artery showing Tunica Intima (TI), Internal Elastic Lamina, Tunica Media (TM), External Elastic Lamina (EEL), and Tunica Adventitia (TA). Blue arrows showing elastic fibres in TM which are close to IEL (under 10 X magnification)

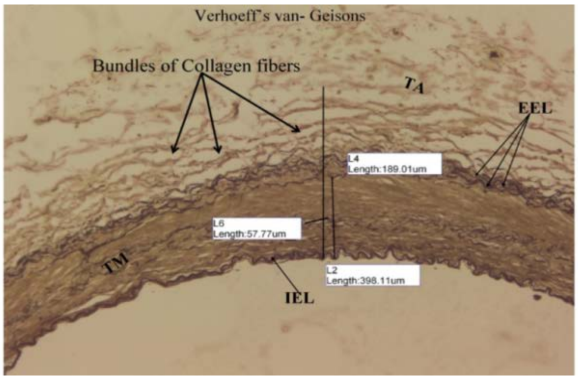

Figure: 2: Photomicrograph of second part of vertebral artery showing Tunica Intima (TI), Internal Elastic Lamina, Tunica Media (TM), External Elastic Lamina (EEL), Tunica Adventitia (TA) [Verhoeff's van- Grisons stain]. (Under 10X magnification)

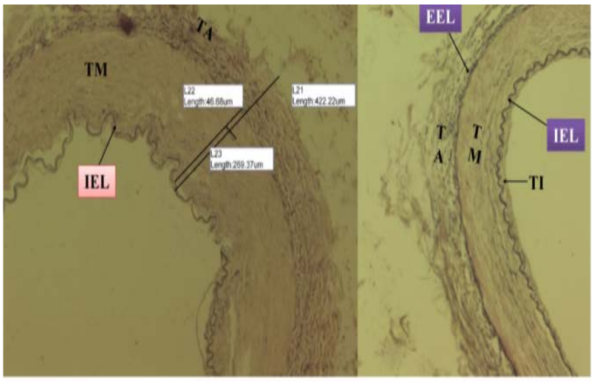

Figure. 3: Photomicrograph of third part of vertebral artery showing Tunica Intima (TI), Internal Elastic Lamina, Tunica Media (TM), External Elastic Lamina (EEL),Tunica Adventitia (TA) [Verhoeff's van- Grisons stain].(under 10X magnification)

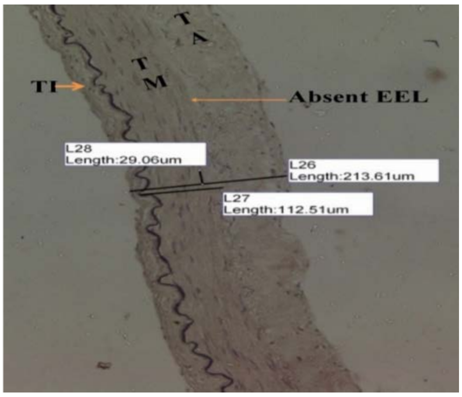

Figure 4: : Photomicrograph of fourth part of vertebral artery showing Internal Elastic Lamina, Tunica Media (TM), External Elastic Lamina (EEL) represented by sparse single elastic fibrils, Tunica Adventitia (TA) [Verhoeff's van- Geisons stain](under 10X magnification)

Discussion:

In international literature, the incidence of vertebral artery passing through C& transverse foramen is seen in approximately 6-7% of the studied population [12-13] In a recent study conducted in France [14] , 500 vertebral arteries' paths were studied by means of 200 magnetic resonance and 50 computed tomography images with angiographic contrast. With this large case series, the authors found anatomical variations in 7% of the cases studied, similar data to those observed in the present anatomical study. Among unusual paths, we found the vertebral artery entering the foramen at C3, C4, C5 or C& in incidences of 0.2%, 1%, 5% and 0.8%, respectively.

The significant part of the VA is the V4 segment, where aneurysms are common. Knowledge concerning anomalies and variations in the vertebrobasilar complex can be useful to radiologists in the diagnosis of associated aneurysms and in preventing complications during endovascular procedures. Hypo perfusion of brain tissues and hemodynamic insufficiency due to hypoplasia or stenosis of the VA is the basis for transient ischaemic stroke [15].

The length and diameter of the V4 were observed in the present study. There were no statistically significant differences in gender, however, the left artery was longer in both sexes, which was in concordance with a study done by Hong JM et al. [16]. However, a study done by Sureka B et al. showed a difference in the diameter of the male and female vertebral artery, where the female artery showed a smaller diameter as compared to male subjects [17].

Earlier studies have reported numerous variations in the origin of the vertebral artery. The origin of the left vertebral artery directly from the aortic arch between the left subclavian artery and the left common carotid artery is the most common variation with a distribution of (2.4-5.8%). In such cases, the left vertebral artery generally enters the transverse foramen of C4-C5 rather than C6. [18]

TM wall thickness is related to the flow dynamics. S. Cavdar et al. stated that TM of V3 segment of vertebral artery comparatively dominated by smooth muscle and relatively less number of elastic fiber when compared with I and II part of VA. TM of V4 segment had abundant of smooth muscle fibres. This pattern was contradictory to finding of Bhadkaria et al. [19].

Johnson et al. found elastic count in TM gradually decreases along the course of artery. Wilkinson mentioned that medial thickness of intradural segment is noticeably less than extradural part [20]. Our findings are in correlation with these findings. In the present study tunica media of Ist part of VA showed more of elastic fiber in inner segment than its outer segment. This finding may be the just the gradual change with reduction of elastic fiber from outer segment of TM in a process towards the muscular artery as it moves away from heart [21]. Chopard et.al also noted similarly that elastic fiber is found to be more in the internal portion of tunica media [22,23].

Conclusion:

Left vertebral artery was found to be dominant than the right. Internal elastic lamina was main elastic constituent of 4th part of vertebral artery, so damage to it may cause vascular pathologies like atherosclerosis, aneurysm etc.

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