Original Article

Morphometric study of vertebral artery groove in dry human cervical vertebra in Pakistani population

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Abstract

Introduction: Vertebral artery passes through vertebral artery groove present on the posterior arch of atlas; free movement of which is required during rotation of the neck. This artery can be compressed if the vertebral groove is converted into arcuate foramina due to the projection of bony ponticuli over the grove. This compression can cause vertebra-basilar insufficiency, headache, or neck-shoulder pain of unknown origin.

Objective: This study aims to provide data regarding vertebral artery groove and its morphology to help surgeons and clinicians in the local Pakistani population as no data is available in this population.

Materials and Methods: A total of sixty adult dry human atlas vertebrae were taken from the Anatomy museum of King Edward medical university. Quantitative and qualitative data were taken for analysis. Quantitative data include the distance of medial and lateral edges of vertebral artery groove from the midline of the posterior arch, the distance of the medial edge of foramen transversarium from the midline, the thickness of vertebral artery groove and its dimensions at medial and lateral entrance points. Qualitative data includes the type of bridging over the vertebral artery groove. Data were analyzed and the mean was taken.

Results: Mean distance of the medial edge of vertebral artery groove from midline was found to be 13.32 ± 3.25 and 13.72 ± 2.82 mm on right and left sides respectively while the mean distance of the lateral edge of vertebral artery groove from midline was 22.31 ± 3.47 on the right side and 22.29 ± 2.98 on the left side. The mean of total thickness found was 3.84 ± 0.66 mm on right and 3.57 ± 1.14 mm on left. Morphology showed that 3.33% of the Pakistani population has complete arcuate foramina, 40% partial bridging, and 56.67% absent bridging.

Conclusion: Findings of this study can be helpful for neurosurgeons during procedures requiring exposure of the posterior arch of the atlas so that damage to a vertebral artery can be prevented.

Keywords: Atlas vertebra, arcuate foramen, vertebral artery groove, posterior bridging, posterior arch of the atlas.

Introduction

The vertebral artery passes through the vertebral artery groove present on the posterior arch of the 1st cervical vertebrae. Knowledge about the morphology of this groove is essential for various surgical procedures during cervical spine surgeries. This groove lies posterior to the superior articular process that transmits the third part of the vertebral artery along with the sub-occipital nerve.[1] Change in morphometry of this groove can complicate surgical procedures involving lateral mass screw fixation for various reasons.[2] Morphometric analysis shows that this groove can be shallow, deep, or even can be converted into a canal due to the extension of bony bridges from lateral mass and posterior arch. When converted into the canal, this can compress the vertebral artery grove causing neck-shoulder pain, vertebrobasilar insufficiency, and vertigo of unknown origin. This may require surgical intervention for which morphometric data is required to prevent damage to the vertebral artery while passing through the posterior arch. The posterior atlanto-occipital membrane is attached at the superior border of the posterior arch of the atlas, the lateral border of which is deficient to allow passage of the neurovascular bundle. Sometimes this lateral border can be ossified to convert vertebral artery groove into a canal.[3] This canal is named "retro articular canal or retro articular vertebral artery ring" by Sylvia.[4] Other names used for this foramen include "foramen atlantoideum posterior, foramen sagittale atlantis, canalis arteriae vertebralis and more commonly arcuate foramen",[5] that can lead to compression of vertebral artery and can cause vertebro-basilar insufficiency, vertigo, musculoskeletal pain, and posterior circulation stroke.[6]

Literature showed a higher incidence of arcuate foramen in laborers carrying heavy objects overhead[7], in black population as compared to white8 and more in males as compared to females.[9]

Most of the literature about the morphology of vertebral artery groove has been studied radiologically.[10,11,12] Present study focused on its anatomical study on dry human atlas vertebrae in the local Pakistani population as very little data is available about it.

Materials and Methods

It is a non-experimental observational study. Total sixty dry human atlas vertebrae of unknown age and sex were studied from Anatomy museums of King Edward Medical University, Lahore. All vertebrae with intact posterior arch and lateral mass were included while vertebrae with a damaged or defective posterior arch or any gross abnormality were excluded from this study. Data was collected for quantitative and qualitative analysis.

Quantitative analysis: following important parameters were measured on the posterior arch of C1 vertebrae on both right and left sides with the help of a digital vernier caliper.[13]

L1: Distance from the midline to the medial edge of vertebral artery groove. (Figure 1)

L2: Distance from the midline to the lateral edge of vertebral artery groove. (Figure 1)

L3: Distance from the midline to the medial edge of foramen transversarium (Figure 1)

T: Thickness of vertebral artery groove from its thinnest part. (Figure 2)

LD: Lateral depth of vertebral artery groove at its entrance. (Figure 3)

MD: Medial depth of vertebral artery groove at its medial end. (Figure 4)

Qualitative analysis: This analysis includes the projection of lateral or posterior ponticuli to form arcuate foramen.[14] This morphology was divided into three stages by Taitz and Nathan[15] as under:

Complete bridging where the groove is converted into a canal by bony ponticuli. (Figure 5)

Partial bridging where only bony projections are present but they do not unite to form a complete bridge. (Figure 6)

Absent bridging where bony spicules or projections are completely absent.

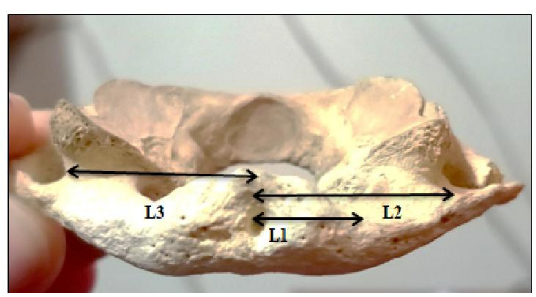

Figure 1: Demonstration of measurement of L1, L2, and L3

Figure 2: Measurement of thickness of vertebral artery grove

Figure 3: Measurement of lateral depth of vertebral artery groove

Figure 4: Measurement of medial depth of vertebral artery groove

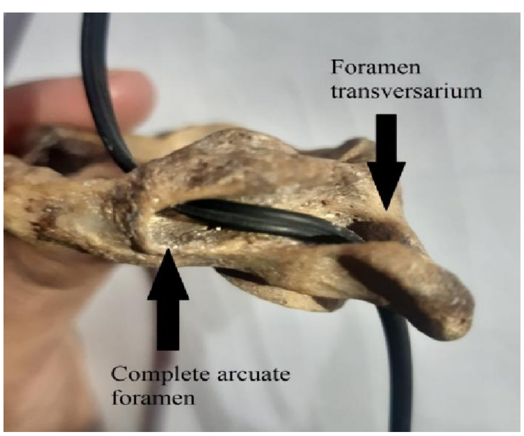

Figure 5: Complete bridging to form arcuate foramen

Figure 6: Partial bridging

Results

The quantitative parameters for the vertebral artery groove are depicted in table 1. The mean distance of the midline to the medial edge of the vertebral groove (L1) was found to be 13.32± 3.25 mm on the right side and 13.72 ± 2.82 mm on the left side. In addition, the mean distance of the vertebral artery groove's lateral edge to midline (L2) was found to be 22.31 ± 3.47 on the right side and 22.29± 2.98 on the left side. While there was no statistically significant difference on the right and left sides amid measuring L1 and L2, L3-the distance from the midline to the medial edge of transverse foramen showed a significant difference in measurements on the left and right sides with mean distance at right being 32.55 ± 2.57 mm and on left being 33.92 ± 2.59 mm. The thickness which was taken by measuring the thinnest part of the groove was found to be 3.84 ± 0.66 mm on right with a range of 2.93-5.09 mm and 3.57 ± 1.14 mm on left with a range of 2.12-5.68 mm. The mean lateral depth of the groove on the right side was 6.50± 2.01mm and on left it was 6.43± 2.13 mm with a range of 4.05-7.89 mm. The mean medial depth of the groove on right was found to be 10.75 ± 2.20 mm and on left was found to be 9.86 ± 2.12 mm with a range of 6.20-14.76 mm.

Gross examination of vertebral artery groove showed that it was well defined in some cases while in others a spicule or a bridging was present over the groove. Out of 60 atlas vertebra, bridging was seen in 26 (43.33%) while 34 (56.67%) showed no signs of bridging. This bridging was either partial or complete turning the groove completely into a canal. 24 vertebrae (40%) showed partial and 2 vertebrae (3.33%) showed complete bridging (Figure. 5).

Table 1: Measurements of quantitative parameters of vertebral artery groove

Measurements	*Side*	*Mean (mm)*	*SD (mm)*	*Range (mm)*	*P value*
L1	Right	13.32	± 3.25	9.79-19.55	0.71
	Left	13.72	± 2.82	10.38-18.22	
L2	Right	22.31	± 3.47	18.46-27.98	0.99
	Left	22.29	± 2.98	19.85-27.30	
L3	Right	32.55	± 2.57	29.18-36.85	0.01
	Left	33.92	± 2.59	30.4-37.8	
Thickness	Right	3.84	± 0.66	2.93-5.09	0.52
	Left	3.57	± 1.14	2.12-5.68	
Lateral Depth	Right	6.50	± 2.01	4.05-7.72	0.19
	Left	6.43	± 2.13	4.77-7.89	
Medial Depth	Right	10.76	± 2.20	6.52-14.76	0.21
	Left	9.86	± 2.12	6.20-13.24	

P-value <0.05 is statistically significant

Table 2: Qualitative parameters

Parameter	*Absent bridging*	*Partial bridging*	*Complete bridging*
Percentage	56.67% (34)	40% (24)	3.33% (2)

Discussion

A curved course of the vertebral artery makes its position very critical during surgery requiring exposure of the posterior arch of the atlas. Damage to the vertebral artery can be prevented if dissection remains confined to the medial side of the posterior arch away from the vertebral artery groove.[16] Present study provides data that the mean distance of the medial edge of the vertebral artery groove from the midline of the posterior arch is 13.32 ± 3.25 and 13.72 ± 2.82 on right and left sides respectively. Thus during dissection, these measurements should be kept in mind to avoid damage to the vertebral artery. A similar study was done by Awadalla et al.[17] who suggested that this distance should be a minimum of 5 mm to keep the vertebral artery safe. Our results also coincide with Naderi et al.[18] who reported a distance of 15 mm between the midline of the posterior arch and vertebral artery groove. Little data was available regarding other measurements that can be beneficial for surgeons.

The present study reveals that the incidence of arcuate foramen formation is 3.33% in the Pakistani population. Awadalla et al.[17] studied the occurrence of this foramen in the Egyptian population and compared it with others. He found the highest incidence rate in Negros and Middle East population as compared to Indians and Egyptians. This study showed that the Pakistani population has a higher incidence as compared to Egyptians (Table 3).

Table 3: Distribution of bridging in different population groups

Population group	*No. of specimens*	*Absent bridge*		*Partial bridge*		*Complete bridge*	
		n	%	n	%	n	%
Negros	67	49	73.2	7	10.4	11	16.4
Middle east	187	70	37.4	103	55.2	14	7.4
Pakistani (present study)	60	34	56.67	24	40	2	3.3
Indian	139	84	60.4	52	37.4	3	2.2
Egyptian	76	32	42.1	42	55.26	2	2.6

The vertebral artery passes through the vertebral artery groove after emerging from the transverse foramen and passes medially to enter into the foramen magnum. Vertebral artery groove allows stretching and free movement of an artery during rotation of neck but if complete bridging is present its movements are restricted due to narrowing of the canal. This external pressure due to bridging causes clinical symptoms of headache, vertigo, and neck-shoulder pain.

Conclusion

The present study provides data related to underestimated arcuate foramen in the Pakistani population that can help clinicians and neurosurgeons to diagnose and treat patients with unknown vertebro-basilar insufficiency, vertigo, headache, and neck-shoulder pain. Narrowing of vertebral artery groove can be the cause of such symptoms.

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