

ANATOMICAL VARIATIONS IN CONDUIT OF VERTEBRAL ARTERY IN ATLAS

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ABSTRACT: BACKGROUND: The 1st cervical vertebra is named as atlas. It differs from all the other vertebrae in having no body and no spine. The atlas consists of two bulky lateral masses, connected to each other in front by a short anterior arch, and behind by a long curved posterior arch it thus forms a ring of bone. The posterior arch forms three-fifths of the atlantal ring. At the root of the arch the superior surface of posterior arch bears a wide groove for the vertebral artery, venous plexus and the C1 nerve immediately behind the lateral mass. In few cases this groove is converted into the completely or partially posterior/lateral vertebral artery foramen. **AIM:** This study was carried out to know the variations in posterior vertebral artery groove in atlas vertebra for clinical and surgical purpose. **MATERIALS AND METHODS:** The present study is based on the observation of the 300 macerated Human atlas vertebrae of North Indian present in the Anthropology Museum of Department of Anatomy, GSVM Medical College, Kanpur. The atlases were randomly selected the age and sex were not taken into consideration. **RESULTS:** We observed the complete posterior vertebral artery foramen in 8% specimen (2.33% bilateral and 5.67% unilateral). In 3.33% it was found on left side and 2.33% on right side. Incidence of incomplete posterior vertebral artery foramen was observed in 9.33% (1.33% bilateral and 8% unilateral). In 5% it was found on left side and 3% on right side. The bilateral presence of complete or incomplete lateral vertebral artery foramen was nil. The unilateral presence of complete or incomplete lateral vertebral artery foramen was found equal in frequency i.e. 0.67%. The unilateral presence of complete lateral vertebral artery foramen on either side was found in 0.33% specimen whereas the incomplete lateral vertebral artery foramen was found only on left side (0.67%). **CONCLUSION:** The presence of complete/incomplete posterior or lateral vertebral artery foramen may reduce the area of the space for the vertebral artery passing through the vertebral artery groove and may compress the vertebral artery which may result into various types of neurological symptomatology.

KEY WORDS: Atlas, Posterior arch, vertebral artery groove, vertebral artery.

INTRODUCTION: Vertebrae are named by regions. Cervical vertebrae of neck region can range from a single vertebra in amphibians to seven in most mammals. The 1st cervical vertebra is named as atlas, because it supports the globe of the head. The name of the atlas is derived from a deity of Greek mythology called atlas. It differs from all the other vertebrae in having no body and this is due to the fact that the centrum of the atlas has been occupied with the centrum of the 2nd cervical vertebra i.e. axis. In addition, it has no spine. The atlas consists of two bulky lateral masses, connected to each other in front by a short anterior arch, and behind by a long curved posterior arch it thus forms a ring of bone. The lateral mass carries the weight bearing articular facets. These facets serves to distinguish upper from lower surfaces. In contrast to the deep concavity of the upper kidney shaped surfaces the lower facets are circular and flat. The lateral mass is projected laterally

into the transverse process, which is perforated by the transverse foramen. Gardner E¹ and Davies F² suggested that the posterior arch of atlas vertebra which corresponds to the laminae of other vertebrae, presents a wide groove for the vertebral artery on its upper surface. The first cervical nerve is also present in this groove. A spicule of bone sometimes projects backwards from the lateral mass and may convert the groove into a foramen for the vertebral artery and first cervical nerve. Davies F² also explained that behind the groove, on each side, the upper border of the posterior arch gives attachment to the posterior atlanto – occipital membrane; its lower border gives attachment to the highest pair of ligament flava. Last³ observed that the free border of the posterior atlanto-occipital membrane, arching over the artery and nerve is sometimes ossified and converted the groove for the vertebral artery; into a foramen. The vertebral artery arises from the upper and posterior part of the first part of the subclavian artery. It ascends through the transverse foramina of the upper six cervical vertebrae, with a large branch derived from the cervico-thoracic cervical ganglion and a plexus of vein. It lies in front of the ventral rami of cervical nerve (C2-C6) and pursues an almost vertical course as far as the transverse process of the axis, through which it runs upwards and laterally to the transverse foramen of atlas. After passing through the transverse foramen it runs on the medial side and curves backwards behind the lateral mass of atlas, the ventral ramus of the first cervical nerve being on its medial side; It then lies in the groove on the upper surface of the posterior arch of atlas and enters the Vertebral canal by passing below the lower, arched border of the posterior atlanto occipital membrane. Susan Standring⁴ suggested that the movements of atlanto-occipital joints allow mainly for flexion and extension, which has a total range of about 15 degree, and the lateral flexion on either side, has not been measured in living subjects. In the event of presence of posterior or lateral vertebral artery foramen whether it is complete or incomplete may be unilateral or bilateral, the vertebral artery becomes unprotective and exposed to be pressed on either sided lateral flexion which may result into various types of neurological symptomatology depending upon the severity of pressure hence a clinician needs to pay the special attention to keep these variations in mind to explore the cause of neurological symptoms specially when the symptomatology enhances on lateral flexion.

MATERIALS AND METHODS: The present study is based on the observation of 300 atlas Vertebrae, randomly selected from stock of vertebrae belonging to north India present in the Anthropology museum of Department of Anatomy, GSVM Medical College, Kanpur. The macerated atlas vertebrae were randomly selected. The age and sex of the vertebrae were not taken into consideration. The vertebrae were cleaned properly and examined non metric variants.

The posterior arch of atlas and vertebral artery grooves over it was observed carefully.

1. The vertebral artery groove was examined for any bony outgrowth or spicule over it and it was noted that whether these bony growth forms a complete or incomplete foramen over the vertebral artery groove and whether these conversions are unilateral or bilateral.
2. It was also found that in some atlas vertebrae a bony spicule arises from a posterior side of superior articular surface or the lateral side of superior articular surface.
3. The bony outgrowth or spicule, bridges partially or completely over the vertebral artery groove and converted it into posterior or lateral incomplete/complete vertebral artery foramen.

RESULT:

1. The study revealed that 24 atlases out of 300 were having the complete posterior vertebral artery foramen (8%). In which 17 atlases showed unilateral presence of complete posterior vertebral artery foramen (5.67%). Out of these 17 atlases the complete posterior vertebral artery foramen was found in 10 specimens on left side (3.33%), (fig. 1) and 7 on right side (2.33%), fig. (2). Seven atlases shown the bilateral presence of complete posterior vertebral artery foramen (2.33%), fig. (3). Refer to table number (1).
2. Twenty eight atlases showed the presence of incomplete posterior vertebral artery foramen out of 300 (9.3%). In which the unilateral presence of incomplete posterior vertebral artery foramen was seen in 24 atlases (8.0%) and out of these the incomplete posterior vertebral artery foramen was seen 15 on left side (5.0%), fig. (4) and 9 on right side (3.0%), fig. (5) and 4 atlases shown the bilateral presence of incomplete posterior vertebral artery foramen (1.33%), fig. (6). Refer to table number (2).
3. Our study revealed that the presence of incomplete posterior vertebral artery foramen was more as compare to complete posterior vertebral artery foramen i.e. 9.3%: 8.0%.
4. The unilateral presence of incomplete posterior vertebral artery foramen was more as compare to complete posterior vertebral artery foramen i.e. (8.0%: 5.67%).
5. The unilateral presence on left side of incomplete posterior vertebral artery foramen (5%) was found more as compare to the complete posterior vertebral artery foramen (3.33%).
6. The unilateral presence on right side of incomplete posterior vertebral artery foramen (3%) were found more as compare to complete posterior vertebral artery foramen (2.33%).
7. Therefore the frequency of left sided incomplete posterior vertebral artery foramen and the complete posterior vertebral artery foramen is more as compare to right side.
8. The bilateral presences of complete posterior vertebral artery foramen were more as compare to the incomplete posterior vertebral artery foramen (2.33%:1.33%). Refer to table number (1&2).
9. Our study revealed that the bilateral presence of complete **or** incomplete lateral vertebral artery foramen was nil (0.0%). However the unilateral presence of complete lateral vertebral artery foramen and incomplete lateral vertebral artery foramen was found equal in frequency i.e. 0.67%. The presence of complete lateral vertebral artery foramen was found equally on both sides (0.33% on left and 0.33% on right) [table number (3), fig. - 7 & 8], whereas the presence of incomplete lateral vertebral artery foramen was found on left side only i.e. 0.67% [table number (4), fig. - 9].

DISCUSSION: Our study revealed 8% presence of complete posterior vertebral artery foramen Poipier⁵ also reported the same percentage of presence of complete posterior vertebral artery. Taitz and Nathan⁶ and Loth-Niemirycz⁷ reported 7.9% and 7.4% presence of complete posterior vertebral artery respectively, which is almost same percentage as our study revealed.

As for as percentage of presence of complete posterior vertebral artery foramen is concerned, J.wysocki⁸ has reported the range of presence as 1.14 to 29.2% on the basis of the work of other workers but he has witnessed 13.8% presence of complete posterior vertebral artery foramen. The other workers like Cacciola F⁹, et al, George P. et al ¹⁰, Cakmak et al¹¹ reported 10%, 10.23% and 11.7% presence of the complete posterior vertebral artery foramen respectively which

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are very near to our finding. Whereas Dubreuil-Chambardel¹² and Lamberthy and Zivancovic¹³ reported the higher percentage as 30% and 15% respectively and Malhotra et al have reported as low percentage of presence of complete posterior vertebral artery foramen as 5.14%, which are almost in the range of presence of the complete posterior vertebral artery foramen as already reported by J.wysocki et al⁸. Our study also revealed the bilateral presence of complete posterior vertebral artery foramen in 2.33% of specimen. Manjunath et al¹⁴ and Lamberthy and Zivancovic¹³ reported 1.65% and 3.33% presence of bilateral complete posterior vertebral artery foramen which is almost near to our observation whereas Radojevic and Negovanovic¹⁵ reported the presence of bilateral complete posterior vertebral artery foramen as high as 7%. Malhotra et al¹⁶ reported it as low as 1.42% of specimens. Our study also revealed the bilateral presence of complete posterior vertebral artery foramen in 2.33% of the specimen that clearly showed that our finding is within the range of the presence of bilateral complete posterior vertebral artery foramen reported by the other workers.

Our study revealed the unilateral presence of complete posterior vertebral artery foramen as 5.67% in which 3.33% was on left side and 2.33% was on right side. Malhotra et al¹⁶ reported unilateral presence of complete posterior vertebral artery foramen as 3.71% (1.42% on right and 0.28% on left side), these reports are very near to our observation.

Our study revealed 9.3% presence of incomplete posterior vertebral artery foramen. Radojevic and Negovanovic¹⁵ reported 2%, Lamberthy and Zivancovic¹³ reported 21.66% presence, Malhotra et al¹⁶ in 7.71%, Taiz C et al⁶ in 25.90%, Cakmak¹¹ in 3.3%, and George P et al¹⁰ in 24.43% and that showed the presence of incomplete posterior vertebral artery foramen varies from 2.0% to 25.90% and our observation is within the range. Our study revealed the bilateral presence of incomplete posterior vertebral artery foramen was found 1.33% Malhotra et al¹⁶ reported it to be 0.85% which is also very near to our study. Our study revealed the unilateral presence of incomplete posterior vertebral artery foramen was found in 8% of specimen (5% on left and 3% on right side). Malhotra et al¹⁶ reported 6.85% presence of unilateral incomplete posterior vertebral artery foramen (3.71% on left and 3.14% on right side). Our study revealed that the presence of incomplete posterior vertebral artery foramen was more as compare to complete posterior vertebral artery foramen i.e. 9.3%: 8.0%. The unilateral presence of incomplete posterior vertebral artery foramen was more as compare to complete posterior vertebral artery foramen i.e. 8.0%: 5.67%. The unilateral presence on left side of incomplete posterior vertebral artery foramen (5%) was found more as compare to the left side of complete posterior vertebral artery foramen (3.33%). The unilateral presence on right side of incomplete posterior vertebral artery foramen (3%) were found more as compare to right side of complete posterior vertebral artery foramen (2.33%). Therefore the frequency of left sided incomplete posterior vertebral artery foramen and the complete posterior vertebral artery foramen is more as compare to right side.

The bilateral presence of complete posterior vertebral artery foramen was more as compare to the incomplete posterior vertebral artery foramen (2.33%:1.33%) [Refer to table number (1&2)]. These finding cannot be compared with the other workers as they have not thrown the light on these aspects. Breathnach¹⁷ and Hasan M et al¹⁸ described the lateral vertebral artery foramen. Hasan M et al¹⁸ also explained that the lateral vertebral artery foramen on the atlas is of normal occurrence in lower animals and reported it in 1.14% of specimen. Our study revealed the bilateral presence of complete or incomplete lateral vertebral artery foramen was nil. Our study revealed that the

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unilateral presence of complete or incomplete lateral vertebral artery foramen was found equal in frequency i.e. 0.67%. Malhotra et al¹⁶ reported this frequency as 0.85%. He has also reported that the frequency of complete and incomplete lateral vertebral artery foramen were 0.57% and 0.28% respectively. Our study revealed the unilateral presence of complete lateral vertebral artery foramen on either side in 0.33% whereas the incomplete lateral vertebral artery foramen was found on left side only in 0.67%. Our observation is close to that of Malhotra et al¹⁶.

Specimen	Incidence	Vertebral artery foramen (No. of Atlases)					Total (Unilateral +bilateral)	%
		Left	%	Right	%	Total (left + Right)		
Atlas	Unilateral	10	3.33	7	2.33	17 (5.67%)	24	8
	Bilateral	7 (2.33)						

TABLE-1: COMPLETE POSTERIOR VERTEBRAL ARTEY FORAMEN

Specimen	Incidence	Vertebral artery foramen (No. of Atlases)					Total (Unilateral + bilateral)	%
		Left	%	Right	%	Total (left + Right)		
Atlas	Unilateral	15	5	9	3	24 (8.0%)	28	9.3
	Bilateral	4 (1.33)						

TABLE-2: INCOMPLETE POSTERIOR VERTEBRAE ARTEY FORAMEN

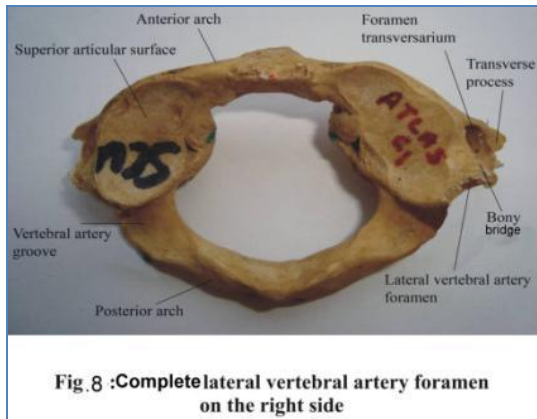
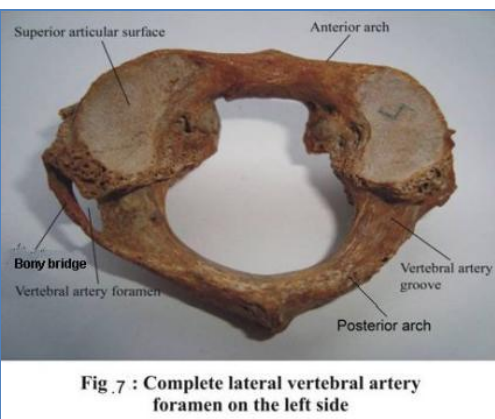
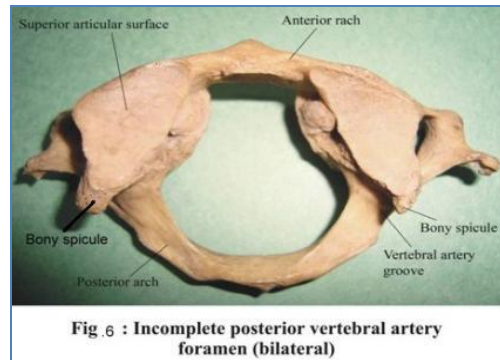
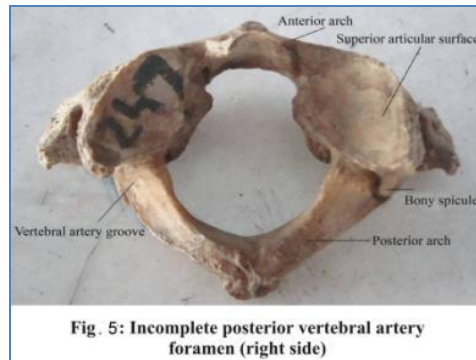
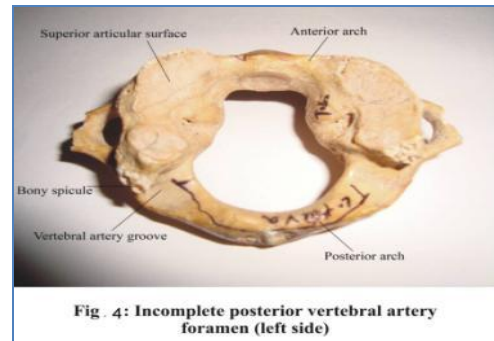
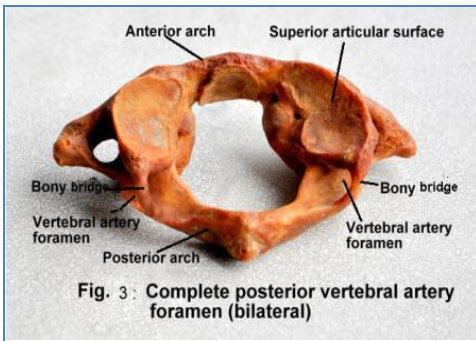
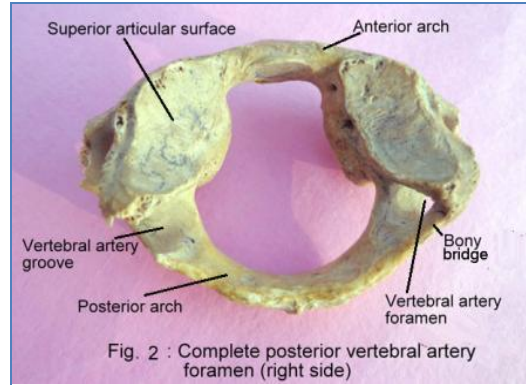
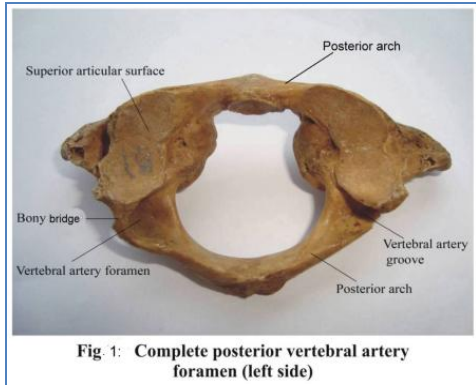
Specimen	Incidence	Vertebral artery foramen (No. of Atlases)				Total (Unilateral + Bilateral))	%
		Left	%	Right	%		
Atlas	Unilateral	1	0.33	1	0.33	2	0.67
	Bilateral	-					

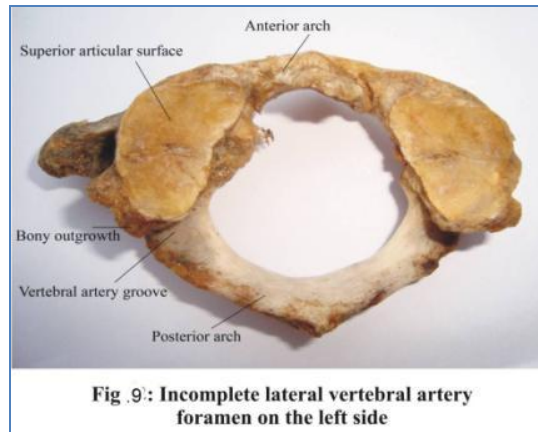
TABLE-3: COMPLETE LATERAL VERTEBRAL ARTERY FORAMEN

Specimen	Incidence	Vertebral artery foramen (No. of Atlases)				Total (Unilateral+ Bilateral)	%
		Left	%	Right	%		
Atlas	Unilateral	2	0.67	-	-	2	0.67
	Bilateral	-					

TABLE-4: INCOMPLETE LATERAL VERTEBRAL ARTERY FORAMEN

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CONCLUSION: In the study of 300 macerated human atlas vertebrae we observed the vertebral artery groove for its conversion into the foramen. We observed the complete posterior vertebral artery foramen in 8% specimen. In 2.33% it was found bilaterally and 5.67% unilaterally. In 3.33% it was found on left side and 2.33% on right side. In 9.33% of specimen incomplete posterior vertebral artery foramen was observed. It was found more on the left side than that of right side. In 0.67% of specimen complete lateral vertebral artery foramen was observed. The incomplete lateral vertebral artery foramen also observed in 0.67% of specimen. These variations can also be easily confused with enlarged atlas posterior arch. Surgeons should review cervical spine tomography images in order to check the presence of posterior vertebral artery foramen and to outline medial and lateral boundaries for surgical exposure to achieve safe procedure, preventing injuries to the vertebral artery and the related nerves.

The vertebral artery is vulnerable to compression in its course between foramen transversarium and the foramen magnum during extreme rotation of the head and neck. This situation may be aggravated by the presence of posterior or lateral bridges of atlas and result in compromised blood flow. The presence of bony bridging should also be taken into account by the orthopedic surgeons during a surgical manipulation of the cervical spine.

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