

ANATOMICAL STUDY AND CLINICAL SIGNIFICANCE OF ARCUATE FORAMEN OF HUMAN ATLAS VERTEBRAE IN WESTERN MAHARASHTRA REGION

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ABSTRACT

Background: The atlas (C1) is the most superior (first) cervical vertebra of the spine. Atlas vertebra is one of the important bony components of craniovertebral junction. In human atlas vertebra, immediately behind each superior articular process of posterior arch is a groove (sulcus arteriae vertebralis), transmitting the 3rd part of vertebral artery and the suboccipital (first cervical spinal) nerve. This is sometimes converted into a foramen called as Arcuate foramen also known as Ponticuli or Tunnel by a delicate bony speculum which arches backward from the posterior end of the superior articular process. The importance of the Arcuate foramen lies in the external pressure it may cause on vertebral artery as it passes from foramen transversarium of first cervical vertebra to the foramen magnum of the skull.

Materials and Methods: The present study was carried out on 200 dried fully ossified adult human atlas vertebrae of unknown sex and age for evaluation of arcuate foramen. The sample was obtained from Department of Anatomy & Forensic Toxicology of Grant medical college & Sir J.J. group of hospital, Mumbai. India.

Results: In the present study one case (0.5/.) of bilateral presence of arcuate foramen or tunnel on atlas vertebra was detected for the passage of vertebral artery in Western Maharashtra region.

Conclusion: The study aims to evaluate the presence of Arcuate foramen in Western Maharashtra region. Neurologists, neurosurgeons and medical community in general should have knowledge about Arcuate foramen and requires careful radiological analysis while dealing with the patients complaining of symptoms of vertebrobasilar insufficiency like headache, vertigo, dizziness, shoulder and arm pain. Moreover C1 vertebra is also the target of stabilisation procedures, including transarticular C1-C2 screw fixation procedure. As the vertebral artery courses in the transverse foramen and on the vertebral artery groove of C1 lamina, this course of vertebral artery complicates surgical procedures in this area. So this also necessitates knowledge regarding C1 bony landmarks.

KEY WORDS: Arcuate Foramen, Craniovertebral Junction, Tunnels, Ponticuli, Atlas Vertebra.

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Access this Article online

Quick Response code



DOI: 10.16965/ijar.2016.351

Web site: International Journal of Anatomy and Research
ISSN 2321-4287
www.ijmhr.org/ijar.htm

Received: 03 Aug 2016 Accepted: 06 Sep 2016
Peer Review: 04 Aug 2016 Published (O): 30 Sep 2016
Revised: None Published (P): 30 Sep 2016

INTRODUCTION

The Atlas is the topmost vertebra of spine. It is named after the *Atlas* of mythology, because it supports the globe of head. It is one of the important bony component in cranio-vertebral junction along with Axis and Occipital bone. Atlas and Axis are important neurologically because the brainstem extends down to the axis. The chief peculiarity of the atlas vertebra is that it has no body, it is ring like and consists of anterior arch, posterior arch and two lateral masses. The anterior arch forms about one-fifth of the ring. Its anterior surface is convex and presents at its center the anterior tubercle for the attachment of the longus colli muscles and the anterior longitudinal ligament. Posteriorly it is concave and marked by a smooth, oval or circular facet (fovea dentis) for articulation with the odontoid process (dens) of the axis. The posterior arch forms about two-fifths of the circumference of the ring. It ends behind in the posterior tubercle which is the rudiment of a spinous process. The posterior part of the arch presents above and behind a rounded edge for the attachment of the posterior atlanto occipital membrane. Immediately behind each superior articular process is a groove (sulcus arteriae vertebralis), sometimes converted into a foramen called as Arcuate foramen or Ponticuli or Tunnels by a delicate bony spiculum which arches backward from the posterior end of the superior articular process. On the under surface of the posterior arch behind the articular facets, are two shallow grooves known as inferior vertebral notches. The lower border gives attachment to the posterior atlanto-axial ligament which connects it with the axis. The lateral masses are bulky, in order to support the weight of the head. Each carries two articular facets, a superior and an inferior. The transverse processes are large; they project laterally and downward from the lateral masses. They are long and their anterior and posterior tubercles are fused into one mass; the foramen transversarium is directed from below, upward and backward [1].

Arcuate foramen is the frequently encountered normal variant of atlas. It develops by calcification of the oblique atlanto-occipital ligaments.

Following are the alternate names for this foramen: Ponticulus posticus, foramen atlantoideum posterius vertebrae, canalis arteriae vertebralis, foramen sagitale, retroarticular VA ring, foramen retroarticular superior, retrocondylar bony foramen, posterior atlantoid foramen and atlas bridging [3].

MATERIALS AND METHODS

The present study was carried out on 200 dried fully ossified adult human atlas vertebrae of unknown sex and age for evaluation of Arcuate foramen. The samples were obtained from the Department of Anatomy and Forensic Toxicology of Grant Medical College and Sir J.J. Group of Hospitals, Mumbai, India.

All the samples were inspected to ensure that they were free from osteophytes or metastatic tumours and that they were intact. Then each atlas vertebra was inspected carefully for the presence or absence of Arcuate foramen on superior surface of posterior arch and also noted whether this foramen is unilateral or bilateral, complete or incomplete.

RESULTS

In the present study conducted in the Western Maharashtra region one case (0.5/.) of bilateral presence of Arcuate foramen on superior surface of posterior arch of atlas vertebra was detected for the passage of 3rd part of vertebral artery and 1st cervical spinal nerve. There was a complete tunnel on the right side and incomplete tunnel on the left side.

Statistical analysis was done using Graph Pad Prism 5 software.

Fig. 1: Photograph of superior aspect of atlas vertebra showing bilateral presence of tunnel for the passage of vertebral artery. Complete tunnel on the right side and incomplete tunnel on the left side are seen.



DISCUSSION

This study aims to evaluate the presence or absence of Arcuate foramen in the population of western region of Maharashtra irrespective of age and sex. The importance of the arcuate foramen lies in the external pressure it may cause on the vertebral artery as it passes from the foramen transversarium of the 1st cervical vertebra to the foramen magnum of the skull.

The arcuate foramen is an underestimated structure and clinicians should be alerted to a possible arcuate foramen with patients complaining of vertigo, headache, shoulder-arm, and neck pain [2].

The incidence of Arcuate foramen was first reported by Macalister in 1869. Then further Macalister and Le Double studied in detail about this foramen which draws attention of the anatomist [10]. Taitz and Nathan [4] put forth the hypothesis that the formation of this arcuate foramen may be due to external mechanical factors like carrying heavy objects on the head which was further supported by Paraskevas G. et al [5]. He reported presence of bony ponticuli was more common in labourers as compared to non labourers. Presence of ponticulus posticus is associated with cervical pain and cerebrovascular disorder. The presence of the ponticulus posticus has been linked to migraine development (Wight et al, 1999) [9].

According to Miki et al, radiographically the ponticulus posticus can be classified into three types [9]:

Full type: complete bony ring.

Incomplete type: some portions of the bony ring are defective.

Calcified type: linear or amorphous calcification are present.

Mahdi Hasan & Sanjeev Shukla [6] recorded 34 posterolateral tunnels examined out of 350 dry atlas vertebrae out of which 11 were noted as a partial posterior ponticulus, a bony spicule extending from the superior articular facet overhanging the dorsal arch and the remaining in the form of complete tunnels. They classified tunnels for the passage of vertebral artery into six types,

Class I: Impression for the vertebral artery was

noticeable on the posterior arch.

Class II: Impression for the artery was deeper than the former class.

Class III: Partial posterior ponticulus was noted as a bony spicule extending from the superior articular facet overhanging the dorsal arch.

Class IV: Complete posterior ponticulus is seen.

Class V: Lateral bridge extended from lateral mass to transverse process present.

Class VI: Extensive posterolateral tunnel made its appearance as a combination of complete posterior (class IV) and lateral (class V) bridges.

Dhanraj Singh [7] detected tunneling for the vertebral artery in 2 cases out of 253 atlas vertebrae. In the present study one case (0.5%) of bilateral presence of tunnels on atlas vertebrae was detected. On the right side, the tunnel was Class IV type and on the left side the tunnel was Class III type. Krishnamurthy A et al [2] further studied and had taken the measurements of the arcuate foramen. He observed mean length on right and left side was 9.99mm and 7.16mm respectively in bilateral cases and mean height on right and left side was 6.52mm and 6.57mm respectively in bilateral cases. R. Shane Tubess et al [8] performed a study in 60 cadavers (39 males, 21 females; mean age at the time of death was 73 years) to determine the incidence of the foramen arcuale.

All cadavers were placed in the prone position and the overlying muscle covering the posterior craniocervical junction was removed. If foramen arcuale was present in the cadaveric specimen the diameter of vertebral artery was measured just before, within and immediately after it transversed the foramen arcuale. All measurements including the length and thickness of the osseous strut were made with callipers. The cross-sectional area of these foramina was calculated in the formula for an ellipse: $area = \pi (D1/2 \times D2/2)$ where D1= horizontal length of foramen arcuale and D2= vertical length of foramen arcuale. The area of the ipsilateral transverse foramen of the atlas was then measured and compared with the area of the foramen arcuale. To compare the structures on the two sides statistical analysis was performed with student t-test. The authors identified foramen arcuale in 5% specimens. The

mean length and thickness of the osseous struts that converted the groove for the vertebral artery into the foramen arcuale were 7mm and 2mm respectively. The mean area of the identified foramina was 14.2 mm². The mean area of the ipsilateral atlas transverse foramina was 18mm² in specimens with foramen arcuale. The mean measurements of the proximal, intraforaminal (foramen arcuale) and distal diameter of the V3 segment of the vertebral artery at the level of the foramen arcuale were 6, 4 and 5 mm respectively. In all specimens the authors noted that the intraforaminal part of the V3 segment was grossly compressed. The authors found that the foramen arcuale may compress the V3 segment of the vertebral artery. However, they could not conclude that compression at this location results in symptomatic vertebral artery insufficiency. It seems that symptomatic compression of the vertebral artery at this location may be alleviated in some patients with some decompressive procedures.

CONCLUSION

In conclusion, as aimed at the beginning we could find that some of our observations are comparable with previous studies, as specified in our discussion. Study of the presence of arcuate foramen is done by many authors in the population of North India and Bihar region, and they found that the incidence of this foramen was high, but in the population of Western Maharashtra region it is a rare anomaly. However sweeping statements regarding the incidence needs further studies of larger sample size to conclusively prove that the incidence of Arcuate foramen is lower in western Maharashtra. This lower incidence could be related to the occupation of the people in North India where people may have to carry heavy loads for long distances when compared to people living in Western Maharashtra.

Preoperative diagnosis of Arcuate foramina using 3D CT is of paramount importance in avoiding neurovascular injury during surgery. They may even complicate specific diagnostic or surgical procedures. In addition, they may cause a great number of symptoms, ranging from headache and neck pain to loss of postural muscle tone and consciousness, due to close and

complex relationship of bone structures with nerve, Blood vessels, muscles and ligaments. As a result Radiologists, Neurologists, Neurosurgeons and Orthopaedicians should consider in their clinical reasoning that the possibility of atlas dysmorphism may occur.

ACKNOWLEDGEMENTS

Sincerely thanks to Dr. Annabelle Rajaseharan, Dean of VMMC, Karaikal, for giving her expert guidance.

Conflicts of Interests: None

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How to cite this article: Shaikh Jasmeen Vajir, Annabelle Rajaseharan, Shaikh Shirin Vajir. ANATOMICAL STUDY AND CLINICAL SIGNIFICANCE OF ARCUATE FORAMEN OF HUMAN ATLAS VERTEBRAE IN WESTERN MAHARASHTRA REGION. *Int J Anat Res* 2016;4(3):2838-2841. DOI: 10.16965/ijar.2016.351