

STUDY OF ARCUATE FORAMEN OF ATLAS VERTEBRAE

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ABSTRACT

Background: Variations in bone are common. Atlas vertebrae are especially subject to variation and are of clinical importance because of its close relation to vertebral artery. Bony spur can arise from the posterior margin for the groove of vertebral artery and form bridges known as ponticles. The bridges can be posterior, lateral or posterolateral. If the bridge is complete it is known as arcuate foramen. These variations can predispose to vertebrobasilar insufficiency.

Aim: To study the incidence of arcuate foramen and its various dimensions in the atlas vertebrae.

Materials and Methods: 58 human dry atlas vertebrae from Dept. of Anatomy, Govt. Thoothukudi Medical College, Tamilnadu were studied for the presence of arcuate foramen and ponticles and its dimensions were measured using digital vernier caliper.

Results: Arcuate foramen was found in 5 atlas vertebra (8.6%), one was bilateral and others were unilateral with equal incidence in right and left side. The mean length of the arcuate foramen was 6.09mm and the mean height of the arcuate foramen was 5.44mm. Ponticulus posterior was observed in 4 sides (3.45%) of atlas with higher incidence on left side (2.59%) and projection from superior articular facet posteriorly was found in 31.03% and also showed left side preponderance (17.24%). Exostosis from superior articular facet posterolaterally forming supratransverse foramen was observed in 4.31%.

Conclusion: Arcuate foramen can cause compression of vertebral artery during rotatory movements of neck and can result in vertebrobasilar insufficiency. It can also be a cause for vertigo. Having knowledge about this variation will be beneficial for the radiologist in interpreting and for neurosurgeons operating along the posterior arch.

KEY WORDS: Arcuate foramen, atlas, compression, ponticles, vertebrobasilar insufficiency.

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INTRODUCTION

Atlas, the first cervical vertebra which supports the head is unique in that it fails to incorporate the centrum. Atlas consists of two lateral masses connected by a short anterior and

posterior arch. The superior surface of the posterior arch bears a wide groove for the vertebral artery and is variably overhung by the lateral mass [1].

Frequently bony spurs arise from the anterior

and posterior margins of the groove for the vertebral artery and form bridges. The bridges can be posterior, lateral or posterolateral. Ponticulus posthicus or Kimmerle's anomaly (posterior bridge) is an osseous bridge that is formed between superior articular facet and the posterior arch of atlas and when it is complete forms the retroarticular canal or arcuate foramen. Lateral bridge is the lateral outgrowth of the bone that bridges the lateral margin of the superior articular facet to the posterior root of transverse processes of the atlas and may exist as supratransverse foramen. Ponticulus posterolateralis, a wide bone fragment extending from the lateral margin of posterior 1/3rd of superior articular facet to the transverse process and dorsal edge of the vertebral groove of atlas and they can cause external pressure on the vertebral artery when it passes from foramen transversarium to foramen magnum and can predispose to vertebrobasilar insufficiency and cervicogenic syndrome especially in neck movements [2].

The arcuate foramen is known by many names, foramen sagittale, foramen atlantoideum posterior, kimmerles variant, canalis vertebralis, retroarticular canal, retrocondylar vertebral artery ring [3]. This study is done to find the incidence of the arcuate foramen, ponticles and their various dimensions.

MATERIALS AND METHODS

58 dry human atlas vertebrae of unknown age and sex were studied from department of Anatomy, Govt. Thoothukudi Medical College, Tamilnadu. The vertebrae were observed for the presence of arcuate foramen and Ponticulus. Length (ventro dorsal dimension) and height (rostro caudal dimension) of the arcuate foramen were measured by using digital vernier caliper. The height and width of the Ponticulus were measured and photographed. Mean and standard deviation were calculated.

RESULTS

On detailed observation of 58 atlas vertebrae, arcuate foramen was found in 5 atlas vertebra, one vertebra showed bilateral incidence [Fig.1] and the remaining were unilateral [Fig.2] with equal occurrence in right and left side. Among

these, one vertebra showed arcuate foramen on right side and ponticulus posterior on left side [Fig.3]. The mean length of the arcuate foramen was 6.09mm and the mean height of the arcuate foramen was 5.44mm. Ponticulus posterior was observed in 4 sides (3.45%) of atlas with higher incidence on left side (2.59%) [Fig.4] and projection from superior articular facet posteriorly was found in 31.03% and also showed left side preponderance (17.24%). Exostosis from superior articular facet posterolaterally forming supratransverse foramen was observed in 0.86% [Fig.5 & 6].

Fig.1: Atlas Vertebra with arrow showing bilateral posterior arcuate foramen.

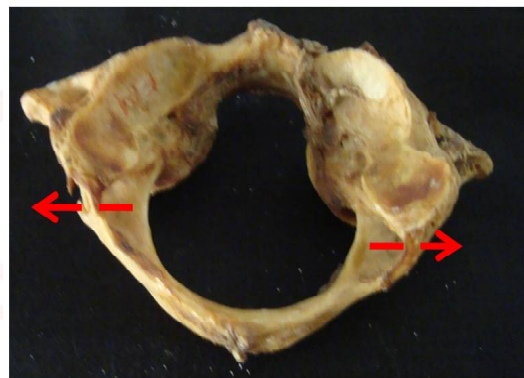


Fig. 2: Atlas with left posterior arcuate foramen. FT- foramen transversarium and AF- arcuate foramen.

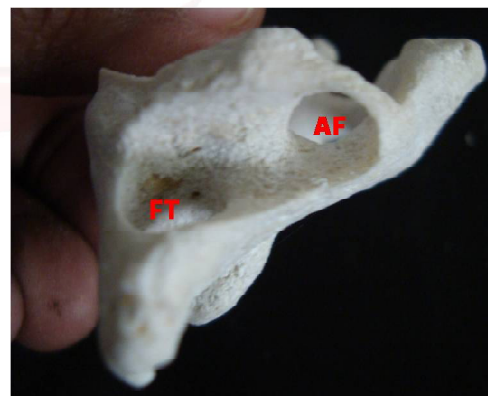


Fig. 3: Atlas Vertebra with left Ponticulus posthicus (red arrow) and right posterolateral arcuate foramen (white arrow).



Fig. 4: Atlas Vertebra with left Ponticulus posthicus (red arrow).



Fig. 5: Atlas Vertebra with right lateral arcuate foramen (red arrow).



Fig. 6: Atlas Vertebra with arrow showing right Posterolateral arcuate foramen.



DISCUSSION

Atlas is especially subjected to variation. The sulcus arteria vertebralis is in 10% of cases bridged over by a bar of bone extending from the inferior articular processes and a bridge may also be developed between the transverse and superior articular processes. These varieties represent normal conditions in the lower primates [4].

Many authors have reported the incidence of partial and complete arcuate foramen. [Table: 1] Hasan et al described six classes of the groove for vertebral artery. Class I - only the impression

of vertebral artery on posterior arch of atlas, Class II - the impression is deeper and becomes groove, Class III - partial posterior ponticulus as a bony spicule extending from superior articular facet overhanging the dorsal arch. Class IV- complete posterior ponticulus, Class V- lateral bridge extending from lateral mass to the transverse process, Class VI - relatively more extensive posterolateral tunnel [3]. On comparing with Hasan et al, incidence of class I was found to be lower and class III was found to be higher which was significant [Table:2].

Table 1: Incidence of partial and complete arcuate foramen reported by various authors.

Sl.No.	Author	Arcuate foramen	Partial arcuate foramen
1	Krishnamurthy A et al 2007 [6]	8.33%	5.50%
2	Tubbs RS et al 2007 [10]	5%	-
3	Baeesa SS et al 2012 [8]	16.10%	31.80%
4	Sun JY 1990 [9]	7.40%	-
5	Cakmak O et al 2005 [12]	11.70%	3.30%
6	Paraskevas G et al 2005 [20]	10.23%	24.43%
7	Present study	8.60%	3.45%

Table 2: Incidence of various classes of atlas vertebra based on the features of the vertebral artery groove.

Class	Hasan et al 2001 [3]	Present Study
I	47.40%	18.97%
II	42.90%	41.38%
III	3.14%	33.62%
IV	3.42%	4.31%
V	2.00%	0.86%
VI	1.14%	0.86%

Various reasons were proposed by many authors for the presence of arcuate foramen. Lateral margin of posterior atlanto occipital membrane sometimes ossifies and converts the groove for vertebral artery into a foramen [5]. It can be congenital or may be a result of ossification of ageing. External mechanical factors such as carrying heavy objects on the head could play a role in the development of the bridges of atlas [6] or can be due to acquired ossification of ligaments induced by pulsation of the vertebral artery [7].

This anomaly showed male predilection in left side and these had propensity for bilaterality [8]. Hasan et al too observed that posterior, lateral and posterolateral bridging were more common on left side.

Foramen arcuale complete or incomplete may

restrict or compress the vertebral artery passing through [9]. Intraluminal part of V3 segment was grossly compressed on measuring the diameter of vertebral artery proximal, within and distal to arcuate foramen [10]. Foramen arcuale of vertebral artery is one of the causes for vertigo [11].

Patients with complete arcuate foramen had significant complaints of shoulder arm pain, neck pain and vertigo compared to patients with incomplete arcuate foramen [12]. Arcuate foramen can cause compression on the artery during extreme rotator movements of the neck or manipulation of the cervical spine during surgeries, in physiotherapy or exercises and can cause vertebrobasilar ischaemia [7].

Kimmerle's anomaly can be a cause for manifestation of chronic tension type headaches and neurosensory type hearing loss [13] and also for acute cerebrovascular disorders in vertebral basilar field [14] and can be an extravasal factor in respect of the vertebral artery causing a compression-stenosing – irritative effect. [15] Cushing KE et al have reported that presence of an arcuate foramen can cause tethering of the vertebral artery in the foramen and dissection can occur from repetitive trauma with movement of the neck [16].

It may have functional significance in protecting the tortuous vertebral artery in an area of high mobility. The foramen can be easily identified on preoperative x-rays or parasagittal CT slices [17].

A broad dorsal arch of the atlas is the best indication for modified screw trajectory. Ponticulus posticus and arcuate foramen carrying vertebral artery can be mistaken for a broad dorsal arch and the surgeon may insert the screw into the ponticulus posticus. This can result in an injury to the vertebral artery, and lead to stroke or even death by thrombosis, embolism, or arterial dissection. Preoperative lateral radiograph showing the anomaly should alert the surgeon to avoid using Ponticulus posticus as a starting point for a lateral mass screw in order not to injure the vertebral artery [18].

3-D CT scan should be taken when a ponticulus posticus is suspected or observed on radiographs of a patient who is about to undergo lateral mass

screw placement in the posterior arch of the atlas. [19].

CONCLUSION

These observations may be helpful for neurosurgeons and spine surgeons who operate along the posterior arch near the groove for vertebral artery. Knowing about this will be beneficial for the radiologists while interpreting. More radiological and clinical studies are needed to stress upon the importance of arcuate foramen and its clinical significance.

Conflicts of Interests: None

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