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Original Research Article - Vertebral artery groove converted into a foramen by the ossified posterior atlantooccipital membrane in atlas bone

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Abstract
Atlas is the first cervical bone. It's an atypical cervical vertebra.It has no body, no spinous process, it is ring like consists of anterior and posterior arches and two lateral masses. The anterior and posterior arches provide attachment for a broad, dense fibrous anterior atlanto-occipital membrane and a broad but relatively thin posterior atlanto-occipital membrane. The posterior arch of atlas has a groove for passing of 3rd part of vertebral artery.
In the present study 80 dry atlas bones were studied out of which in 2 atlas vertebrae the lateral tendinuous part of the posterior atlanto-occipital membrane had been ossified and converted the groove into a foramen. This is one of the sites where the vertebral artery can get compressed leading to ischaemia in the regions supplied by it. Also in old age due to the reduced elasticity of the arteries can play a role in symptom of giddiness and syncope?
The knowledge of such type of variation is important for anatomists, neurosurgeons, orthopedicians and interventional radiologists who operate in this region. Significance of study in the clinical practice has been discussed here.

Keywords: Vertebral artery, Posterior arch of atlas, Posterior atlanto occipital membrane

1. Introduction

Atlas is the first cervical vertebra. It's named after Greek warrior atlas who carries the globe over his head, similarly atlas bone carries the head over it.

First the peculiarities of atlas bone.

- It has no body, no spinous process,
- It is ring like, consists of anterior and posterior arches and two lateral masses.
- Posterior arch of atlas has groove for passing of 3rd part of vertebral artery.
- The anterior a posterior arches provide attachment for a broad, dense fibrous anterior atlanto-occipital membrane and a broad but relatively thin posterior atlanto-occipital membrane [1].

Posterior atlanto-occipital membrane is made up of medial membranous part and a lateral tendinous part.Immediately behind the lateral mass there is a groove which transmits third part of vertebral artery and first spinal nerve. Sometimes the tendinous part of the membrane is ossified forming a bony spicule converting the groove into a foramen [1]. A three dimensional understanding of the anatomy of the cervical region is crucially important for any kind of surgery in craniovertebral region [2].

Last [3] 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[3]. Davies F[4] 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.

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 [5].

Susan Standring [6] 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 [6].

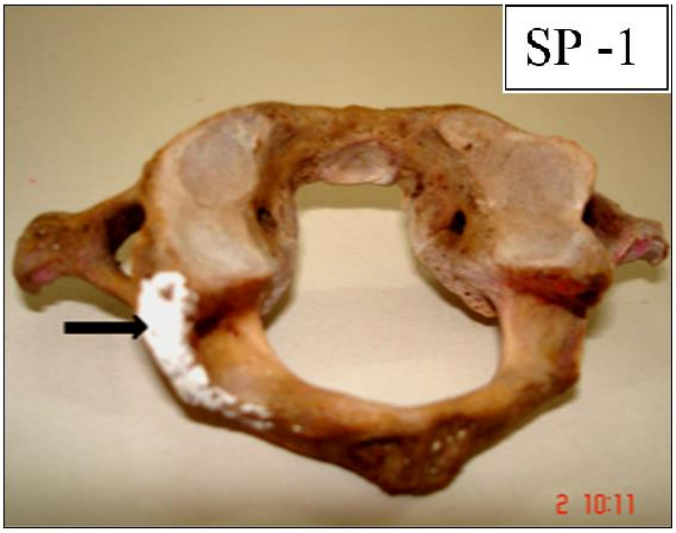
Various authors have reported the incidence of vertebral artery injury during the transoral surgery, lateral mass of atlas and transarticular screw implantation for atlantoaxial fixation and during lateral approaches to the foramen nagnum region [7, 8]. Significance of study in the clinical practice has been discussed here.

2. Materials and Methods

The study was conducted in department of Anatomy, JJMMC [2008-2012] S.I.M.S. & R.C. [2012- 2014] which included 80 atlas bones of unknown sex. In our study we found in 2 atlas vertebra the vertebral artery groove was converted into a foramen. The bones were checked for other variations if any, broken or damaged bones were excluded. The findings were tabulated photographs were taken accordingly.

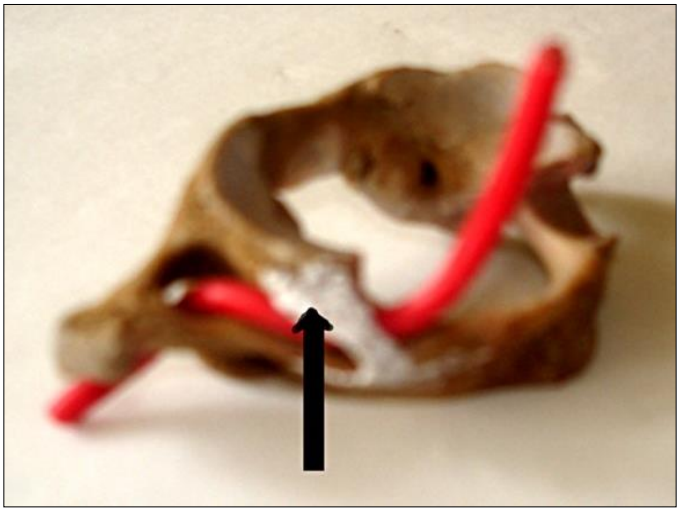
3. Results

Specimen 1: on the left side a bony spicule was present converting the groove into a foramen.



Arrow showing the ossified part of bone.

Fig 1



- Arrow showing the bony spicule,
- The red wire depicting the normal course of 3rd part of vertebral artery.

Fig 2

Specimen 2: on the left side a bony spicule was present converting the groove into a foramen

Fig 3: The metal probe depicting the normal course of 3rd part of vertebral artery.

4. Discussion

Anatomic and morphological variations of the vertebral artery is of immense importance in surgery and other non-invasive procedures [9] of the 80 atlas bone studied we found 2 [two] atlas bones where vertebral artery groove was converted into foramen by bony spicule. So in our study occurrence of such a variation is 2 out of 80, that is 2.5 %.

In a study conducted by Malhotra *et al.* [10] the presence of posterior vertebral artery foramen was seen in 5.4 % of cases which is closer to the observations made in our study. A study conducted by Manjunath *et al.* [11] the incidence of the vertebral artery groove foramen in atlas bone was 1.65%. Krishna Gopal and workers on 300 atalas bones found the vertebral artery groove converted into a foramen 8% of the cases [5]. Paramore *et al.* [12] suggested that approximately 20% of the cases are not suitable for lateral mass screw implantation. It was observed that the screw implantation of the superior articular facet of C2 vertebra has to be sharply medial and to be directed towards the anterior tubercle of C1 for transarticular fixation [12].

It was observed by Krishna Gopal and workers that the frequency of complete vertebral artery foramen was observed in 5.67%, in that left sided vertebral artery foramen was seen in 3.33% & right sided foramen was seen in 2.33%[5]. In their study the left sided incomplete posterior vertebral artery foramen and the complete posterior vertebral artery foramen is more as compared to right side vertebral artery foramen[5].

The vertebral artery takes a loop after its exit from the foramen transversarium of C1 vertebra. It then occupies the vertebral artery groove over the superior surface of posterior arch of atlas. Vertebral artery in its location over the lateral aspect of posterior arch of atlas is vulnerable to injury during a posterior midline approach [2].

Ebraheim *et al.* [13] observed that the dissection on the posterior aspect of posterior ring during surgeries should remain within 12mm lateral to the midline and dissection on the superior aspect of the posterior ring should remain within 8mm of the midline [13]. The study conducted by Shilpa and workers [14] concluded that thickness of the vertebral artery groove was

3.72 mm on the right side and 3.70 mm on the left side based on the measurements taken on dry atlas vertebrae. This again will show that there is difference in growth of the bone depending on the use of atlantooccipital joint.

Thus the purpose of the study is to help physicians and surgeons know such type of variation in the course of vertebral artery. Here in the vertebral artery groove it can be stenosed and compressed leading to the vertebral artery stenosis. Such stenotic lesions can be potentially treated by endovascular techniques. This site is one of the most common sites for extracranial vertebral artery stenosis and is also a reason for posterior circulation strokes. Any how the gold standard investigation for external vertebral artery stenosis is digital substraction imaging. In such cases helical or spiral CT angiography (C.T.A.) is used without the risks associated with catheter angiography [9].

5. Conclusion

The study was carried out on 80 atlas bones in Karnataka region and the incidence of vertebral artery groove converted into a foramen was 2.5 % in our study, which was accordance with the study conducted by various workers as discussed above. There is however difference in the incidence of it in different regions, nature of work done by the indivisuals and also can be linked to the strain on the posterior atlanto-occipital membrane which could be the factor for lateral tendinous portion of the membrane becoming calcified and converting the groove it a foramen.

Secondary to the bony spicule in the posterior arch of the atlas the reduced elasticity of the arteries makes them vulnarable for compression and trauma leading to ischaemia of the regions of the brain supplied by the vertebral artery and other serious implications. The knowledge of such type of variation is important for anatomists, neurosurgeons, orthopedicians and interventional radiologists who operate in this region.

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