STUDY OF PONTICULI IN HUMAN ATLAS VERTEBRAE
Rekha B S¹, Rajeshwari T²

ABSTRACT: It would be presumptuous to attach pathological significance to atlas bridging by examination of dried specimens alone, but by drawing attention to the many anatomical variations of atlas bridging this study might facilitate interpretation radiological findings, may guide certain neurological interventions and perhaps sound a note of caution when cranio-vertebral manipulation are carried out. 200 dried macerated atlas vertebrae were examined for presence of ponticuli, 80 vertebrae showed ponticuli. Posterior ponticuli were found in 62(31%), lateral in 13(6.5%) and posterolateral in 5(2.5%). Complete ponticuli in 9(4.5%), incomplete in 69(34.5%) and bilateral 34(17%), unilateral in 46(28%). Right sided in 24(12%) and left sided in 22(11%). Incidences of posterior incomplete unilateral ponticuli were higher in present study. Posterior complete ponticuli were more compared lateral ponticuli. Right sided ponticuli were almost equal to left sided ponticuli. There has been relatively high incidence ponticuli in the present study.

INTRODUCTION: The first cervical vertebra supports the skull and is therefore called Atlas after the mythical Greek God who supported the globe.

The atlas is unique in that it lacks a body.¹ The vertebral arch has become modified to form a thick lateral mass on each side, joined at the front by a short anterior arch and longer posterior arch at the back.²

The bony bridge extends from the lateral mass to the postero-medial margin of the groove. This is termed as the posterior bridge of the atlas. It has been variously described as ponticulus posticus, Kimmerle’s anomaly. The foramen formed by the bridge is called the foramen arcuate or the foramen retroarticulare superior.

In some cases another bony bridge extends laterally from the lateral mass to the posterior root of the transverse process, thus forming an additional foramen for the vertebral artery, above and behind the transverse foramen. This is the ponticulus lateralis.³

Sometimes both posterior and lateral ponticuli are present resulting in formation of posterolateral ponticuli.

In the atlas vertebra, the retroarticular canal and the lateral bridge are examples of bony outgrowth or exostosis which may cause external pressure on the vertebral artery as it passes from the foramen transversarium of the atlas vertebra to the foramen magnum of the skull. If this pressure is severe enough, as may occur during the extreme rotatory movements carried out during therapeutic manipulation of cervical spine,⁴ during yoga exercise⁵ or chiropractic cervical manipulation, the vertebral artery may be compressed reducing its cross sectional area and compromising its blood flow resulting in vertebro-basilar insufficiency. Thus, these anatomical factors should be taken into account in the manipulation of the cervical spine.⁴
Knowledge of this anatomical landmark is a clue in radiological diagnosis of lesions in the posterior cranial fossa and has been associated with headache, Barri Lieou syndrome, photophobia and migraine.

**MATERIALS AND METHODS:** The present study was carried out on a total of 200 dried macerated atlas vertebrae belonging to the population of south India.

The vertebrae were observed with naked eye for the presence of various ponticuli.

The findings were recorded and incidences were calculated.
RESULTS: Out of 200 vertebrae examined, 80 vertebrae showed ponticuli(graph 1) were classified.(table 1)

I. Posterior, lateral and posterolateral ponticuli (Table 1) (Graph 2)
   Atlas vertebrae with posterior ponticuli - 62 (Figure 1)
   Atlas vertebrae with lateral ponticuli -13 (Figure 2)
   Atlas vertebrae with posterolateral ponticuli - 5 (Figure 3)

II. Complete, incomplete and complete and incomplete ponticuli
   1. Atlas vertebrae with complete ponticuli - 9
      Out of these atlas vertebrae
      a) Atlas vertebrae with complete posterior ponticuli- 6 (Figure 4)
      b) Atlas vertebrae with complete lateral ponticuli- 2 (Figure 5)
      c) Atlas vertebrae with complete posterolateral ponticuli-1 (Figure 6)
   2. Atlas vertebrae with incomplete ponticuli – 69

III. Unilateral & bilateral ponticuli
   1. Atlas vertebrae with unilateral ponticuli- 46
   2. Atlas vertebrae with bilateral ponticuli -34

IV. Right side, left side and both right and left side ponticuli
   1. Atlas vertebrae with right side ponticuli were- 24
   2. Atlas vertebrae with left side ponticuli - 22
   3. Bilateral (Both Right side & Left side) ponticuli were -34

<table>
<thead>
<tr>
<th>Incidence of Ponticuli</th>
<th>Number (n=200)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior (fig 1)</td>
<td>62</td>
<td>31.00%</td>
</tr>
<tr>
<td>Lateral (fig 2)</td>
<td>13</td>
<td>6.50%</td>
</tr>
<tr>
<td>Posterolateral(fig 3)</td>
<td>5</td>
<td>2.50%</td>
</tr>
<tr>
<td>Complete (fig 4,fig5, fig 6)</td>
<td>9</td>
<td>4.50%</td>
</tr>
<tr>
<td>Incomplete</td>
<td>69</td>
<td>34.50%</td>
</tr>
<tr>
<td>Compete/Incomplete</td>
<td>2</td>
<td>1.00%</td>
</tr>
<tr>
<td>Unilateral</td>
<td>46</td>
<td>23.00%</td>
</tr>
<tr>
<td>Bilateral</td>
<td>34</td>
<td>17.00%</td>
</tr>
<tr>
<td>Right side</td>
<td>24</td>
<td>12.00%</td>
</tr>
<tr>
<td>Left side</td>
<td>22</td>
<td>11.00%</td>
</tr>
</tbody>
</table>

TABLE 1: INCIDENCE OF VARI AUS PONTICULI
Master chart

Posterior - 62
- Complete - 6
  - Unilateral - 4
    - Right - 2
    - Left - 2
  - Bilateral - 2
- Incomplete - 56
  - Unilateral - 31
    - Right - 14
    - Left - 17
  - Bilateral - 25

Lateral - 13
- Complete - 2
  - Unilateral - 2
    - Right - 2
    - Left - 0
  - Bilateral - 0
- Incomplete - 11
  - Unilateral - 7
    - Right - 4
    - Left - 3
  - Bilateral - 4

Posterolateral - 5
- Complete - 1
  - Bilateral - 1
  - Right - 2
  - Left - 0
- Incomplete - 2
  - Unilateral - 2
- Complete / Incomplete - 2
  - Bilateral - 2

Graph 1: Incidence of Ponticuli
TABLE 2: SHOWING COMPARATIVE STUDY OF VARIOUS PONTICULI

<table>
<thead>
<tr>
<th>SL. NO</th>
<th>Authors</th>
<th>Year</th>
<th>Vertebrae studied</th>
<th>Posterior ponticuli</th>
<th>%</th>
<th>Lateral ponticuli</th>
<th>%</th>
<th>Posterolateral ponticuli</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Radojevic S. and Negovanovic B.</td>
<td>1963</td>
<td>280</td>
<td>64</td>
<td>23%</td>
<td>7</td>
<td>2.50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Taitz C. and Nathan H.</td>
<td>1986</td>
<td>672</td>
<td>227</td>
<td>33.70%</td>
<td>26</td>
<td>3.80%</td>
<td>9</td>
<td>1.32%</td>
</tr>
<tr>
<td>3</td>
<td>Dhall U.et al.</td>
<td>1993</td>
<td>148</td>
<td>41</td>
<td>27.70%</td>
<td>5</td>
<td>3.37%</td>
<td>15</td>
<td>11.80%</td>
</tr>
<tr>
<td>4</td>
<td>Hassan et al.</td>
<td>2001</td>
<td>350</td>
<td>23</td>
<td>6.57%</td>
<td>7</td>
<td>2%</td>
<td>4</td>
<td>1.14%</td>
</tr>
<tr>
<td>5</td>
<td>Present Study</td>
<td>2006</td>
<td>200</td>
<td>62</td>
<td>31%</td>
<td>13</td>
<td>6.50%</td>
<td>5</td>
<td>2.50%</td>
</tr>
</tbody>
</table>

DISCUSSION: In the present study ponticuli were present in 80 (40%). The posterior ponticuli in 62 (31%). The values are close to those of the studies conducted by Taitz C and Nathan H (33.70%) and Dhall U et al (41.22%).

This was attributed to an anomalous ossification center in the oblique ligament of atlas, which is actually the lower border of the lateral division of the posterior atlanto-occipital membrane that bridges the sulcus and converts it into a foramen for the vertebral artery. In addition, the complete or partial bridging occurred principally in the age group beyond forty.

It was stated that bony ring was a permanent structure in other vertebrates so bony ring in human atlas vertebra could not be a simple ossification of a ligament, but was regressive and disappearing morphological phenomenon. The bony ring was observed in the atlas vertebra of two skeletons aged two and four years and also in the x-ray of cervical spine of a 13 year old boy. Ossification of the ligament did not normally occur in such young persons.

The ponticulus posterior is a congenital variant and it occurs in approximately 15% of Caucasian subjects and appears to have no difference in distribution between the sexes or predominance to either side. Normal age distribution indicates that it is not an ageing phenomenon.

The posterior ponticuli is uniquely derived trait (autapomorphy) within primates which is restricted to some individuals in Homosapiens. Appearance of this foramen in human evolution
could be related to the acquisition of the erect posture and bipedal locomotion and consecutive modifications of the regional venous circulation.\textsuperscript{11}

It has been observed that both clinoid bridging and atlas bridging were more frequent in relatives of affected individuals than in the sample as a whole. Correlations between parents and offsprings and between sibs are highly significant for atlas bridging, less so for clinoid bridging. These traits should fit either a single gene or quasi-continues, polygenic model of inheritance.\textsuperscript{12}

In the present study the over all incidence of lateral ponticuli were 13 (6.5%). This incidence was higher than those reported by other workers.

The number of lateral bridges occurring with the retroarticular canal appeared to increase with age, after forty.\textsuperscript{4}

Posterolateral ponticuli were found in 5 (2.5%). But one vertebra showed dehiscence of the inferior part of the middle of posterolateral ponticulus

Hasan et al. noted dehiscence of the inferior part of the middle of posterolateral ponticus in 4 out of 350 atlas vertebrae, an extension of this gap rostrally could cause separation of lateral and posterior ponticuli. The bony roof of the posterolateral tunnel probably allows greater attachment of posterior atlanto-occipital membrane in quadrupeds where load of the head is supported by extensor muscles of neck, ligaments and posterior atlanto-occipital membrane, but in man weight of the head is borne by vertical loading of the superior articular facet of atlas the roof of the tunnel has disappeared. It is apparent that these ponticuli would in extreme cases further compromise the caliber of an already stretched vertebral artery. The cross-sectional areas of ponticuli have been found to be smaller than the areas of foramina transversaria. Based on these considerations, the posterolateral ponticuli might predispose to peripheral compression syndrome.\textsuperscript{12} The lateral ponticuli whose incidence was much lower, may be lost early in development, with the result that the posterior ponticuli persist in larger number. It is noteworthy that the posterior bridging regresses by disappearance its middle part first, thus explaining the occurrence of partial bridging.\textsuperscript{13}

The partial bridging formation is a characteristic of younger age group (10-30 years) and from 30 to 80 years complete bridging predominates, so the partial bridge might be precursor of a complete bridge.\textsuperscript{3}

The complete foramina were commoner in males with no difference in racial distribution; partial foramina had a significantly greater frequency in white females. Increasing age did not seem to increase the incidence of the two types of foramina.\textsuperscript{14}

The incidences of atlas bridges were more frequently seen on the left side \textsuperscript{4,8,13}. However in the present study the incidence was little more on the right side which is not of significance. The inclined posture of the head on one side favoured the formation of atlas bridges on that side which is probable contributory factor.\textsuperscript{8}

**CONCLUSION:** This regressive and disappearing phenomenon could be related to acquisition of erect posture and bipedalism. The relatively high incidence of its occurrence suggests that this condition may be of significance in the cause of vertebrobasilar insufficiency as it may cause external pressure on the vertebral artery as it passes from the foramen transversarium of the atlas vertebra to the foramen magnum of the skull reducing its cross sectional area and compromising its blood flow.
REFERENCES:

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