Original Research Article

Distance between Midline and Vertebral Artery Groove of Atlas – A Real Aid to the Neurosurgeon

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Abstract

The knowledge of the relationship of the vertebral artery with the atlas is very important, in order to avoid any injury to the vertebral artery, during surgeries in the craniovertebral region. Different researchers have measured the distance of the vertebral artery from the midline along the posterior arch of atlas (oblique distance), but some authors have measured the perpendicular distance of vertebral artery from the midline. Usually, it is the perpendicular distance along which the surgeons are exploring in this region. Hence, the present study was planned to study and compare both oblique and perpendicular distances of the vertebral artery from the midline and find out statistical differences between these two parameters. It was carried out on 30 atlas vertebrae of Indian origin. The oblique and perpendicular distances of vertebral artery groove from midline and the thickness of vertebral artery groove were measured. The results suggest that dissection on the posterior aspect of the arch of atlas should remain 17.00 mm lateral to the midline and dissection on the superior aspect of the arch of atlas should remain 8.00 mm from the midline to prevent injury to the vertebral artery. It was also observed that "oblique distances of vertebral artery groove from the midline to the medial margin of inner and outer cortex are larger than the corresponding perpendicular distances from the midline". Although, the differences of oblique and perpendicular distances are not statistically significant but it may be clinically significant for the surgeons operating in the craniovertebral region. Hence, it is concluded that the surgeon should be aware of both the distances while operating in the craniovertebral region to avoid any iatrogenic injury to the vertebral artery.

Keywords: Vertebral artery, atlas, perpendicular distance, oblique distance, vertebral artery groove

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Introduction

The vertebral artery has a serpentine course in relationship to atlas and axis vertebrae. This artery is present in the vertebral artery groove, lying on the superior aspect of the posterior arch of the atlas (1). This vertebral artery groove represents the location of the vertebral artery. A thorough knowledge of anatomical relations of the vertebral artery is foremost requirement for any kind of surgery in the craniovertebral region, especially during posterior midline approach over the posterior arch of atlas. The knowledge of vertebral artery distance from the midline is very important important, in order to avoid any inadvertent injury. Many researchers have reported the incidence of vertebral artery injury during posterior midline approach of atlas during various surgeries in this region (2,3). In their study, different authors have reported that the injury to the vertebral artery can be prevented if the surgical exposure of the posterior arch of atlas remains medial to the vertebral artery groove (4). Different workers have measured the distance of the vertebral artery from the midline along the posterior arch of atlas oblique distance), but

few authors (5) have measured the perpendicular distance of vertebral artery from the midline. Usually, it is the perpendicular distance along which the surgeons are exploring in this region. From Figure 1, it is obvious that oblique distance OD>OA the perpendicular distance. If the oblique distance is taken into consideration (which seems to be larger than the perpendicular), there is high probability of injury to vertebral artery. Hence, the present study was planned to study and compare both oblique and perpendicular distance of the vertebral artery from the midline and find out statistical difference between these two parameters.

Materials and Methods

The present study was carried out on 30 atlas vertebrae, of Indian origin. These atlases were harvested from the cadavers of adult individuals, received from the different regions of India. All the vertebrae were examined to be free from any bony abnormalities. In the present study, following measurements were taken:

1. Oblique distance (D1 = OD) from midline (posterior tubercle of atlas) to the medial margin of the vertebral artery groove lying on outer cortex of posterior arch of atlas, (Fig. 1). This distance was measured both on right and left side of vertebrae.

2. Oblique distance (D2 = OC) from midline (posterior tubercle of atlas) to the medial margin of the vertebral artery groove present on inner cortex of posterior arch of atlas (Fig. 1). This distance was measured both on right and left side of vertebrae.

3. Perpendicular distance (D3 = OB) from midline (posterior tubercle of atlas) to the medial margin of the vertebral artery groove lying on outer cortex of posterior arch of atlas (Fig. 1). This distance was measured both on right and left side of vertebrae.

4. Perpendicular distance (D4 = OA) from midline (posterior tubercle of atlas) to the medial margin of the vertebral artery groove present on inner cortex of posterior arch of atlas (Fig. 1). This distance was measured both on right and left side of vertebrae.

5. Thickness of posterior arch of atlas at vertebral artery groove.

Distances 1, 2 and 5 were measured by digital vernier calliper accurate to 0.1 mm for linear measurements. OB and OA were measured with the help of graph paper (Fig. 1). We kept atlas on graph paper in a such a way that posterior tip of the posterior tubercle lay on the intersection of the X and Y axis (0) and marked a point on the graph paper for medial most edge of vertebral artery groove on inner and outer cortices, both on right and left side from the midline (Fig. 1).

Results

The results obtained from the different measurements of this study, were tabulated (Table1). The mean oblique distance (D-1) and perpendicular distance (D-3) from midline to medial most edge of vertebral artery groove on the outer cortex of posterior arch of atlas were found to be 21.98±2.98 mm (D-1) and 20.40±1.82 mm (D-3) respectively, on right side and these distances were 20.40±1.85 and 18.86±1.58 mm respectively, on left side. Similarly the mean oblique distance (D-2) and perpendicular distance (D-4) from midline to medial most edge of vertebral artery groove on the inner cortex of posterior arch of atlas were found to be 12.42±1.82 mm and 10.73±2.9 mm, respectively on right side and these distances were 10.58±1.57 mm and 9.72±2.56 mm, respectively on left side. In all cases the oblique distance was found to be larger than corresponding perpendicular distance. The differences between mean values of oblique and perpendicular distances were calculated. The difference between the mean oblique distance (D-1) and perpendicular distance (D-3) from midline to medial most edge of vertebral artery groove on the outer cortex of posterior arch of atlas were found to

Figure 1: Showing the oblique (OD and OC) and perpendicular (OA and OB) distances from the midline to the medial most edge on the outer and inner cortex. OD= D1, OC= D2, OB= D3, OA = D4.

Table 1: Table showing the measured parameters of Atlas

Serial No.	Parameters	Side	Range	Mean	SD
1.	D1	Right	18.2-26.3	21.98	±2.98
		Left	17.6-22.6	20.40	±1.85
2.	D2	Right	9.8-13.8	12.42	±1.82
		Left	8.84-12.6	10.58	±1.57
3.	D3	Right	17.6-22.4	20.4	±1.82
		Left	16.9-21.0	18.86	±1.58
4.	D4	Right	7.8-20	10.73	±2.9
		Left	6.0-17.8	9.72	±2.56
5.	Thickness of vertebral Arches	Right	1.7-7.58	3.79	±1.08
		Left	2.7-6.92	4.05	±0.86

be 1.58 mm and 1.54 mm respectively on right and left side. Similarly, the differences between the mean oblique distance (D-2) and perpendicular distance (D-4) from midline to medial most edge of vertebral artery groove on the inner cortex of posterior arch of atlas were found to be 1.69 mm and 0.76 mm respectively. T test was applied to find out the statistical significance of the differences of the corresponding oblique and perpendicular distances. The difference between oblique and perpendicular distance was statistically insignificant. The different parameters of right and left side of the vertebrae also did not show any statistically significant difference. The mean thickness of posterior arch of atlas at vertebral artery groove on right and left sides, was found to be 3.79±1.08 mm and 4.05±0.86 mm, respectively.

Discussion

The atlas and axis vertebrae have unique anatomical features and significant anatomical relation with the vertebral artery. Vertebral artery is prone to injury during surgical exploration in the craniovertebral region as reported by many authors (6, 7, 8, 9,). These authors have observed that one should be aware of the fact that during surgery he should remain medial to the vertebral artery groove lying on the posterior arch of atlas to avoid any iatrogenic injury to the vertebral artery. Many researchers observed the significance of the site of the vertebral artery groove while performing operations in upper cervical region. In present study, we measured the oblique distance and perpendicular distance between the midline and the medial margins on inner and outer cortex of the vertebral artery groove. The data derived from the present study showed that minimum oblique distance (D-1) and perpendicular distance (D-3) from midline to medial most edge of vertebral artery groove on the outer cortex of posterior arch of atlas was 17.6mm and 16.9 mm, respectively (Table 1). This result suggests that dissection on the posterior aspect of the arch of atlas should remain 16.9 mm lateral to the midline. Similarly the minimum oblique distance (D-2) and perpendicular distance (D-4) from midline to medial most edge of vertebral artery groove on the inner cortex of posterior arch of atlas were found to be 8.84 mm and 7.89 mm, respectively (Table 1). This result suggests that dissection on the superior aspect of the arch of atlas should remain 7.89 mm from the midline. Stauffer recommended that the surgical exploration of posterior arch of atlas should not be more than 1 cm lateral to the midline (10). An HS and Simpson found that during exploration of atlas through posterior approach, surgeons should restrict themselves up to 1.5 cm from midline. (11). Ebraheim et al found that distance from midline to the medial margin of the vertebral artery groove present on inner margin and outer margin of posterior arch of atlas to be 10.4 mm and 19.2 mm in males, 8.9 mm and 16.5 mm in females, respectively (4). They suggested that the surgical exploration on the inner and outer cortex of posterior arch of atlas should remain between 8 and 12 mm. Naderi et al. studied atlas vertebra by both anatomical and radiological (CT Scan) method, and concluded that there was statistically significant difference between these two methods as far as the distance between the midline and vertebral artery groove on the outer margin of posterior arch of atlas is concerned (12). Awadalla and Fetouh showed in their study that the distance from the midline to the medial most edge of the vertebral artery groove on the inner cortex of the posterior arch of the atlas was 8.8 mm with a minimum of 5 mm (13). These data suggested that dissection of the posterior aspect of the posterior arch should remain within 5 mm form the midline. Also in this study, the distance from the midline to the medial edge of vertebral artery groove on the outer

margin of the posterior arch was found to be 20 ± 2.3 mm with a minimum of 15 mm (12). The thickness of vertebral artery groove should be satisfactory for applying some fixation techniques as clamps and hook plating. The mean thickness of this parameter was 3.79 mm and 4.05 mm on right and left side respectively. Ebraheim et al. found this parameter in the range of 3-5 mm (4).

Conclusion

The results of the present study suggests that the surgical exploration on the posterior arch of atlas should not be more than 17 mm lateral to the midline and this distance should not be more than 8 mm from the midline on the superior surface of posterior arch of atlas to prevent any iatrogenic injury to the vertebral artery. From the results, it is concluded that "oblique distances of vertebral artery groove from the midline to the medial margin of inner and outer cortex are larger than the corresponding perpendicular distances from the midline". Although, the differences of oblique and perpendicular distances are not statistically significant but it may be clinically significant for the surgeon operating in the craniovertebral region. Few authors have measured oblique distances, while other authors have measured perpendicular distances of vertebral artery groove from midline. Hence, surgeon should be aware of both the distances while operating in the craniovertebral region to avoid any iatrogenic injury to the vertebral artery.

References

1. Cacciola F, Phalke U, Goel A. Vertebral artery in relationship to C1-C2 vertebrae: An anatomical study. Neurol India 2004; 52(2): 178-84.

2. Goel A, Desai KI, Muzumdar DP. Atlantoaxial fixation using plate and screw method. A report of 160 treated patients. Neurosurgery 2002; 51(6): 1351-7.

3. Gupta S, Goel A. Quantitative anatomy of the lateral masses of the atlas and axis vertebrae. Neurol India 2000; 48(2): 120-5.

4. Ebraheim NA, Xu R, Ahmad M, Heck B. The quantitative anatomy of the vertebral artery groove of the atlas and its relation to the posterior atlantoaxial approach. Spine 1998; 23(3): 320-3.

5. Ravichandran D,Shanthi KC,Srinivasan V. Vertebral artery groove in the atlas and its clinical significance. J Clin Diagn Res 2011; 5(3): 542-5.

6. Doherty BJ, Heggeness MH. The quantitative anatomy of the atlas. Spine (Phila Pa 1976) 1994; 19(22): 2497-2500.

7. Xu R, Nadaud MC, Ebraheim NA, Yeasting RA. Morphology of the second cervical vertebra and the posterior projection of the C2 pedicle axis. Spine 1995; 20(3): 259-63.

8. Doherty BJ, Heggeness MH. Quantitative anatomy of the second cervical vertebra. Spine 1995; 20(5): 513-7.

9. Huggare J, Houghton P. Asymmetry in the human skeleton. A study on prehistoric Polynesian and Thais. Eur J Morphol 1995; 33(1): 3-14.

10. Stauffer ES. Posterior atlanto-axial arthrodesis: The Gallie and Brooks techniques and their modifications. Tech Orthop 1994; 9: 43-8.

11. An HS, Simpson JM. Spinal instrumentation of the cervical spine. In: An HS, Simpson JM, eds. Surgery of the Cervical Spine. London: Martin Dunitz 1994, pp- 379-400.

12. Naderi S, Cakmakci H, Acar F, Arman C, Mertol T, Arda MN. Anatomical and computed tomographic analysis of C1 vertebra. Clin Neurol Neurosurg 2003; 105(4): 245-8.

13. Awadalla AM, Fetouh FA. Morphometric analysis of vertebral artery groove of the first cervical vertebra (atlas). The Pan Arab Journal of Neurosurgery 2009; 13(1): 66-71.