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Original Research Paper

Neurosurgery

ANATOMICAL VARIATIONS OF VERTEBRAL ARTERY AND ITS IMPLICATIONS IN CRANIOVERTEBRAL JUNCTION ANOMALIES.

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ABSTRACT

Observations & Results: In this study, 40 patients were enrolled. Mean age of cohort was 33 years with a sex ratio of 2.5: 1 (Male: Female). Most common CV Jn. anomaly observed was Atlanto – Axial subluxation seen in 35%. Entry at C6 transverse foramina seen in 86.25% (n = 69), with C4 level of entry seen in a case of Kleippel Feil syndrome. Left dominant VA were seen in 45%. Mean diameter of VA was found to be 4.94 mm (right = 5.05 mm, left = 4.82 mm). Mean distance from C1 lateral mass to vertebral artery was 12.26 mm on right side and 12.30 mm on left side. Mean distance of vertebral artery from C2 body was 10.62 mm on right and 10.76 mm on left. Mean distance of the VA from the C2 lateral mass was 5.40 mm on right and 5.54 mm on left.

Conclusion: Surgical exposure at CV junction demands meticulous skills and apt knowledge of relevant anatomy. Pre-operative relevant information must be obtained in individual patients to ensure surgical safety. So far various cadaveric studies have been done to gain knowledge of the two serpents; This study is an attempt to evaluate the variations of vertebral artery and their implications in CV – Jn anomalies.

KEYWORDS : CV Junction, Vertebral artery, VA, Cervical spine, Craniovertebral, Vertebral artery anatomy

INTRODUCTION:

The risk of vertebral artery injury during surgical procedures around the cranio-vertebral junction is about 4.1% [1] [2]. Anterior approaches to the cranio – vertebral junction carry albeit a lower risk of injury (0.3%) compared with 3.9 – 5.6% risk of injury seen in posterior approaches such as Lateral mass screws, Pedicle screws, Trans articular screws, Far lateral approach to foramen magnum [3][4]. Injuries that are diagnosed during surgery have mostly been managed with either hemostatic agents or direct ligation of the affected vessel [5]. Neurodeficit has been reported in 17.9% of patients who underwent Vertebral artery ligation due to injury, while delayed complications such as pseudoaneurysm formation have been reported in the range of 30 – 45% [6]. Variations in the anatomy of vertebral artery impose a higher risk of injury. The vertebral artery adopts a serpentine course in relationship to the craniovertebral region. The artery has multiple loops and an intimate relationship with the Atlas and axis bones [7]. Imaging studies to evaluate vascular anatomy in relation with the multiple bony landmarks is vital to prevent iatrogenic injuries. 3D CT angiography facilitates this with excellent details in terms of identifying the various anatomical features and variations of Vertebral artery in relation with C_{0-1-2} [8]. Current standards in neurosurgical practice, dictate the use of 3D reconstructed images of Computed tomographic angiography of vertebral arteries with Cranio – vertebral junction prior to surgical intervention in individuals with structural anomalies of the concerned region [9].

AIMS & OBJECTIVES:

(1) To delineate the anatomy of vertebral artery in patients with Cervical spine pathologies,
(2) To identify individuals at high risk of vascular injuries during surgical intervention.

MATERIALS & METHODS:

The current prospective study was carried out in the Department of Neurosurgery, at BANGUR INSTITUTE OF NEUROSCIENCES & SSKM HOSPITAL, IPGME & R, Kolkata, India, from 2016 – 2019. A total of 40 patients were enrolled in this study. All patients with CV Jn anomalies (congenital / acquired) who consented for CTA were enrolled. All evaluations were done by the same surgeon and radiologist.

OBSERVATIONS:

In this observational study, a total of 40 patients were enrolled and analyzed based on various Demographic, Clinical, and Radiological data.

It was observed that amongst 40 patients enrolled for the study, 37.5% (n = 15) were in the age group of (31 to 40). The mean age of the study group was 33 years.

A sex wise distribution of the cases was analyzed, and the observation was drawn that 70% (n = 28) of patients enrolled were males. This suggests the tendency of males to be at a higher risk of Cranio – Vertebral Junction anomalies.

One vital parameter assessed was the radiological diagnosis of patients enrolled in the study. Amongst 40 patients enrolled, most common diagnosis was found to be ATLANTO – AXIAL DISLOCATION, seen in 35% (n = 14). Also, there were 2 cases of Kleippel Feil Syndrome.

An important complex parameter evaluated radiologically in the study was the level of entry of Vertebral arteries in the patients. Amongst 40 patients, a total of 80 vertebral arteries were assessed and the observation was drawn that 86.25% (n = 69) vertebral arteries entered the C6 transverse foramina. A rare observation was made in a 15-year-old female of Kleippel Feil Syndrome whose Right vertebral artery entered the osseous route at C4.

Radiological studies used to evaluate these patients also facilitated the determination of Dominance of vertebral artery. An important parameter considering the risk of injury during surgeries in cranio-vertebral junction anomalies. Amongst the 40 patients, 45% (n = 18) had a dominant Left vertebral artery, whilst Co-dominance was seen in 25% (n = 10) of the study population.

CT angiography was used to delineate Vertebral arteries in this study. Authors assessed a total of 40 patients and 80 vertebral arteries were measured. It was found that on the right side, mean diameter was 5.05 mm ranging from 3.3 – 7.2 mm. An interesting observation was made that despite the left vertebral artery being dominant in majority, the mean diameter was 4.82 mm with a range from 2.3 – 6.8 mm.

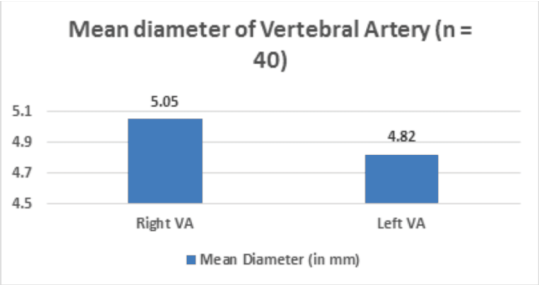


Table 1

Another variable assessed during the course of this study was the distance of vertebral arteries from C2 body. Amongst 40 patients, it was observed that the mean distance was 10.69 mm. For the right vertebral artery, it was 10.62 mm with a range from 6.70 – 14.30 mm. On the left side, the vertebral artery was found to have a mean distance of 10.76 mm from the midpoint of C2 body with a range from 8.69 to 17.63 mm.

The distance of vertebral artery from C2 lateral mass measured on 3-D reconstructed images of CT angiography of vertebral arteries was done by the authors. Mean distance amongst the cohort (n = 40) was found to be 5.47 mm. On the right side, the vertebral artery was having a mean distance of 5.40 mm with a range from 3.4 – 8.2 mm. Whilst on the left side, it was observed that the vertebral artery had a mean distance of 5.54 mm with a range varying from 3.5 – 8.1 mm.

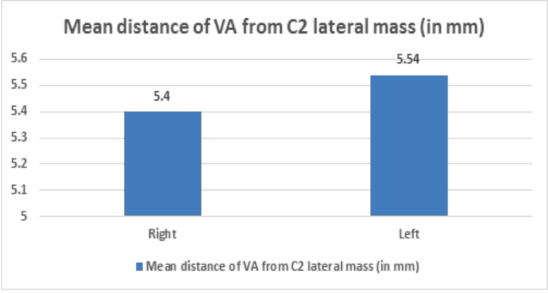
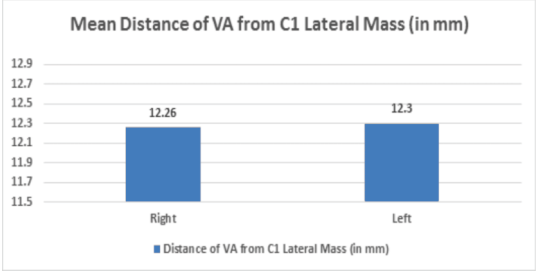


Table 2

The authors also measured the distance of Vertebral artery from C1 Lateral mass. Amongst 40 patients, a mean distance of 12.28 mm was seen. On the right side, the vertebral artery was found to be at a mean distance of 12.26 mm with a range varying from 8.69 – 17.63 mm. On the other hand, the left vertebral artery amongst 40 individuals showed a range from 7.58 – 17.25 mm with a mean distance of 12.30 mm.



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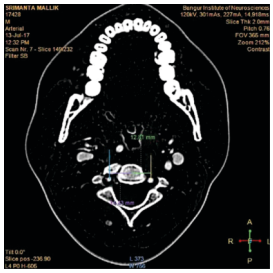

Fig 1 – Vertebral artery in relation with C2 body on axial sequence CT angiogram

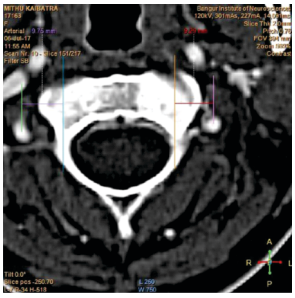

Fig 2 – Vertebral artery in relation with C2 lateral mass in axial sequence CT angiogram

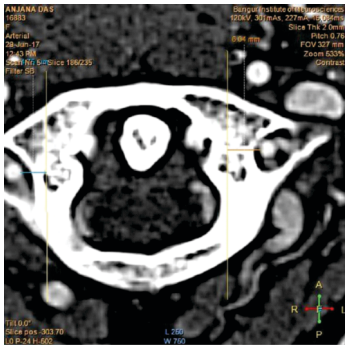

Fig 3 – Vertebral artery in relation with C1 lateral mass in axial sequence CT angiogram

DISCUSSION:

The study conducted by the authors consisted of a cohort of 40 patients with variable demographic profiles. The mean age of the cohort was found to be 33 years. Majority of the study population viz. 37.5% (n = 15) were found to be in their 3rd decade of life. JAYESH SARDHARA et al in their research regarding risk stratification of vertebral artery vulnerability during surgery for congenital atlanto – axial dislocation with or without occipitalized atlas, evaluated a total of 104 patients and their patients had a range of 3 – 76 years of age; and a mean age of 35 years [10].

This study assessed the sex wise distribution of pathologies amongst the cohort. With a 70% share in the population, (n = 28) males dominated the study cohort. The ratio of males: females was found to be 2.5: 1. RAMEN TALUKDAR et al, in their study of Imaging in cranio – vertebral abnormalities; mentioned that their cohort consisted of 46 patients with a male preponderance and a ration of male: female = 3: 1 [11].

Authors categorized the cohort based on the radiological diagnosis established. Atlanto – axial dislocation was seen in (n = 14) 35% of the cohort. Other diagnosis included Chiari 1 malformation (n = 8), Basilar invagination (n = 6), C2 # (n = 60, Os odontoideum (n = 4) and Kleippel Feil syndrome was seen amongst (n = 2) 5% of the cohorts. MENEZES et al published a record of Atlanto – axial dislocation to be the most common cranio – vertebral junction anomaly observed amongst 54% cases [12].

In this study, a total of 80 vertebral arteries were visualized on the angiogram and 86.25% (n = 69) of these entered the C6 transverse foramina to ascend up further. An entry through the C5 vertebra was found in 5% (n = 4) vertebral arteries while a C7 entry level was seen in 7.5% (n = 6) arteries on the right side and 2.5% (n = 2) on the left side. One rare anomaly observed during the study by the authors was in a case of Kleippel Feil syndrome where the right vertebral artery originated from a high rising subclavian artery and entered the transverse foramina on right side at C4 vertebra. RAWAL JITENDRA D et al delineated the variations of vertebral artery anatomy in 25 embalmed cadavers, showed a 92% entry through C6 vertebra and 8% through C7 vertebra [13]. CHANAPA P et al studied 181 cervical spines in cadavers to evaluate the V2 segment of vertebral arteries. They published their results showing an 89% entry at C6 transverse foramina, 1.1% (n = 4) entering from C4, 4.4% (n = 16) entering from C5 vertebra and 5.5% (n = 20) arteries entering from C7 vertebra [14]. **The difference is not significant as p-value is 0.71.**

The authors in their cohort of 40 found that 45% (n = 18) were left dominant while 30% (n = 12) had right dominant artery. Co-dominance was seen in 25% (n = 10) patients. HONG JM et al established the role of vertebral artery dominance in basilar artery curvature and posterior circulation vascular events. They showed that 58% had a dominant left vertebral artery and a co-dominant vertebral artery was seen in 19% of their population [15]. **The difference is not significant as the p-value is 0.203**.

Authors evaluated 80 vertebral arteries and found that on the right side the size varied from 3.3 mm to 7.2 mm with a mean size of 5.5 mm, while on the left side was found to vary from 2.3 mm to 6.8 mm with a mean size of 4.82 mm. CACCIOLA F et al delineated the size of both vertebral arteries in the whole course. The mean size of vertebral artery was 3.4mm on left side with a range of 2.3 mm to 4.5 mm on left side and a mean size of 5.75mm on right side with a range of 4.1 mm to 7.4 mm on right side [7]. **The difference is significant for both right and left vertebral arteries. (p value < 0.00001 for left side and p value = 0.000418 for right side using a one tailed t-test)**

The authors evaluated the distance of vertebral arteries from C2 body and found that the right vertebral artery was at a mean distance of 10.62 mm (range = 6.70 to 14.30 mm) from the body of C2 whereas the left vertebral artery was found to be at a mean distance of 10.76 mm (range = 8.69 to 17.63 mm). CACCIOLA F et al also evaluated this parameter in their cadaveric study and reported a mean distance of 11.7 mm (range = 6.1to 16.2 mm) [7]. **The difference is significant using two sample t-test (p value = 0.029).**

The distance of vertebral artery from lateral mass of C2. The authors studied 80 vertebral arteries (40 right and 40 left). It was observed that a mean distance amongst the cohort was 5.47 mm. On the right side a mean distance of 5.40 mm (range = 3.4 to 8.2 mm) and on the left side mean distance of 5.54 mm (range = 3.5 to 8.1) was tabulated. CACCIOLA F et al observed a mean distance of 7.5 mm [7]. **The difference is significant using two sample t-test (p value < 0.0001).**

Authors studied 3-D reconstructed images of CT angiography of vertebral arteries to calculate the distance of the artery from C1 lateral masses. It was observed that amongst 40 patients, a mean distance of 12.28 mm was seen. On the right side, the vertebral artery was found to be at a mean distance of 12.26 mm (range = 8.69 – 17.63 mm). On the other hand, the left vertebral artery amongst 40 individuals had a mean distance of 12.30 mm (range 7.58 – 17.25 mm). BUTEERA et al studied 159 atlas specimens to determine the relationship between vertebral arteries and C1 lateral masses. They found a mean distance of 12.95 mm on the left side and 12.99 on the right side [16]**. The difference was not significant using two sample t-test (p value = 0.14).**

With such observations, the authors would like to summarize that in population with Cranio – vertebral junction anomalies, there is a significant difference of vertebral artery anatomy compared to a general population. Such differences were mostly seen in terms of Dominance of vertebral artery and location of vertebral artery with respect to bony land marks of C2 vertebra viz. mid-point of body and lateral mass. These variations are important to be known as surgical interventions at CV Jn involve manipulation of C1 – C2 complex with risk of injury to vertebral artery.

CONCLUSION:

Cranio – vertebral junction poses a myriad of surgical challenges. One of them being the anatomical variations of vertebral artery. Neurosurgeons need to be well versed with the structural variations in the region in different pathologies, to ensure a safe surgical intervention. So far various cadaveric studies have been done to gain knowledge of the two serpents; This study is an attempt to evaluate the variations of vertebral artery and their implications in CV – Jn anomalies. With significant differences in anatomy of vertebral artery and its dominance between general population and patients with CV Jn anomalies, it is vital for neurosurgeon to pre – operatively evaluate the vertebral artery to avoid any intra – operative catastrophe.

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