A MORPHOMETRIC STUDY ON ANATOMICAL VARIATIONS OF TRANSVERSE FORAMINA IN DRIED TYPICAL CERVICAL VERTEBRAE C3-C6

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Abstract

Background and Objective: Foramen Transversarium is a cardinal feature of cervical vertebrae, transmitting the vertebral artery along with other contents. Variations in the size and shape of foramen transversarium are associated with the development or course of the vertebral artery, with its compartmentalization potentially causing compression on the vascular structure, leading to vertebrobasilar insufficiency. The study identifies morphometric variations in cervical vertebrae transverse foramina, aiding CT and MRI interpretation by neurosurgeons and radiologists.

Methods: 170 intact cervical vertebrae (C3-C6) of unknown gender and age were used after approval of Ethical Review Board. They were scrutinized for the presence of any accessory foramina, as well as for the morphology and dimensions of the foramen transversaria on both sides. The transverse and anteroposterior diameters of the foramen transversarium were measured and documented using a digital vernier calliper. Statistical analysis was done using SPSS.

Results: The average anteroposterior diameter was found to be 3.70 ± 0.989mm on the right side and 3.97 ± 0.985mm on the left side. There was a statistically significant difference in the anteroposterior diameters between the two sides. About 19(11.2%) vertebrae on the left side and 15(8.8%) vertebrae on the right side showed notched or incomplete transverse foramina. Additionally, around 10% of cases featured accessory foramina, with five instances being bilateral.

Conclusion: Considerable variations were present in the vertebrae transverse foramina. Vertebral artery injury is uncommon but may be a disastrous complication during cervical spinal surgery. Therefore, proper preoperative investigations and planning is essential for the surgeons.

Key words: cervical vertebrae, foramen transversarium, vertebral artery

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Cervical vertebrae are distinguished from all other vertebrae as there is a foramen present in the transverse processes called as foramen transversarium. This distinct feature of all cervical vertebrae becomes their point of identification.[1] In fact, their transverse processes are the morphological bony composite around these foramina. Each foramen is bounded anteriorly by rudimentary costal process and posteriorly by the actual transverse process which terminates as anterior and posterior tubercles respectively. Laterally, a bone, costotransverse bar joins the two tubercles to complete the foramen.[1] In upper six vertebrae, ascending part of vertebral artery, vertebral vein and a branch from cervicothoracic sympathetic ganglion (vertebral nerve) pass through these foramina.[2] Vertebral artery being the most important content is the key point for the importance of transverse foramina in these vertebrae. It passes antigravity over here to supply the brain. It arises from the first part of subclavian artery, arises at root of neck then enters foramen transversarium of 6th cervical vertebra, courses all above foramina and grooves over posterior arch of atlas to enter the foramen magnum thus contributes along with internal carotid artery into the blood supply of brain.[3] The compression of verte-

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bral artery at any site in its course can result in brain ischemia due to vertebrobasilar insufficiency. Vertigo, cervical myelopathy and even Alzheimer's disease also seems to be associated with its variations.[4] Throughout its course, the artery faces the maximum risk of being compressed is in the foramen transversarium.

These foramina are known to exhibit variations in their shape, size and in number. Etiology of these variations may be related to the variation in the development or course of vertebral artery.[5] Developmentally, each of this artery originates at the end of the seventh intersegmental artery; dorsal branches of dorsal aortae, which typically form the subclavian arteries.[6] The remaining part of each vertebral artery is formed from the longitudinal anastomoses of the 1st-6th intersegmental arteries bilaterally.[6] Absence or compartmentalization of the foramen might modify the course of these structures, leading to different pathological conditions. To identify variations and provide data of morphometric variations in transverse foramina of cervical vertebrae to the neurosurgeons and radiologists for interpretation of the computed topogram (CT) & magnetic resonance image (MRI) scans is very important, as the variations during vertebral artery are commonly disrupted in all such conditions. For example, in cases of cervical spondylosis, where degenerative changes in the cervical spine can affect the morphology of the transverse foramina, and in instances of cervical disc herniation, which may cause compression or displacement of the vertebral artery.

This study is designed for the identification and osteometry of the probable variations present in the foramen transversarium of typical cervical vertebrae in view, for both structural and clinical significance and to compare its findings with other studies.

METHODS

It is a descriptive cross-sectional study conducted at the department of Anatomy, FJMU, Lahore. Sample size was calculated using Cochran formula by taking 0.05 margin of error (e), (50%) an estimated proportion of population (p), population of 300 & Z score from Z table at 95% confidence of interval. Final sample size was based on limited population & was calculated as 170 typical cervical vertebrae C3-C6 of unknown sex and age. Intact typical cervical vertebrae C3-C6 were included in the study while damaged & deformed typical cervical vertebrae were excluded. Ethical clearance was taken from the Ethical Review Board by a letter no. 48/Research Proposal Anatomy FJ/ERC. All the vertebrae were numbered and later selected by simple random sampling using computer generated random number. The selected vertebrae were observed for any morphological change i.e., accessory foramen or osteophytes in their transverse processes. Measurements of transverse foramina were taken using digital vernier caliper. Anteroposterior and transverse dia-meters of both sided transverse foramen of every vertebrae were measured from farthest points. In case of accessory foramen, its measurements were also taken accordingly. Intra-observer variations were avoided by measuring each parameter 3 times and mean of the reading were recorded.

The significance of the findings was determined using statistical analysis conducted with SPSS version 23.0. Quantitative data were analyzed using mean ± SD, and statistical significance was assessed with a threshold of $p \leq 0.05$.

RESULTS

During this study, 170 intact typical cervical vertebrae were observed for size and shapes of their transverse foramina.

The sizes of both sided foramen transversaria of all vertebrae were determined by measuring their anteroposterior and transverse diameters. The average anteroposterior diameter was found to be 3.70 ± 0.989 mm on the right side and 3.97 ± 0.985mm on the left side. Independent t test was applied to compare these findings and resulted in a highly significant difference between the two-sided AP diameters. However, a non-significant difference was observed in the means of transverse diameters of these foramina on right and left sides (Table1).

The observed variations in the sample included

Table 1: Anteroposterior and transverse diameters of foramen transversaria of typical cervical vertebrae

Foramen transversarium	Side	N	Mean	Std. Deviation	P-value
Anteroposterior Diameters	Right Side	170	3.70	.989	0.008 *
	Left Side	170	3.98	.985	
Tranverse Diameters	Right Side	170	4.71	1.005	0.157
	Left Side	170	4.87	1.038	

19 vertebrae on the left side (11.2%) and 15 vertebrae on the right side (8.8%) showing notched or incomplete transverse foramina. Additionally, about 10% of the vertebrae (18 out of 170) had accessory foramina on the right side, and 8% (12 out of 170) on the left side, with 2.9% (5 out of 170) of the sample having bilateral accessory foramina. These percentages reflect the diversity in the shape and presence of accessory foramina within the vertebrae studied.

Table 2: Presence of Accessory Foramina by Side

Presence of Accessory Foramina	Right Side	Left Side	Total	p value
Present	18	12	30	
Absent	152	158	310	> 0.05
Total	170	170	340	

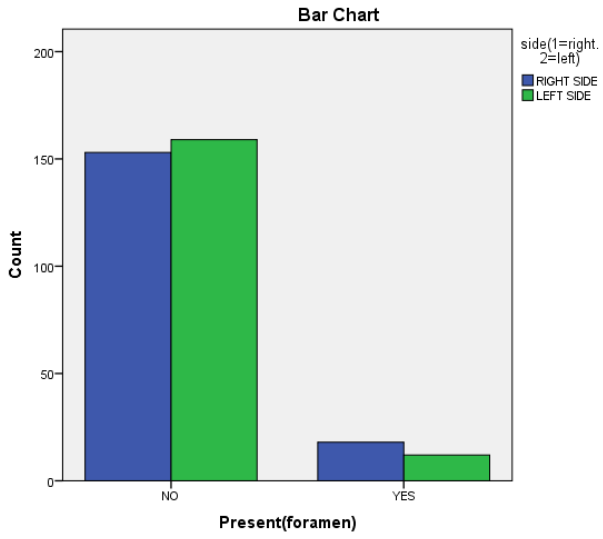

Figure 1: *Bar chart showing number of vertebrae with and without accessary foramina along their foramen transversarium*

These vertebrae were also observed for presence of any accessary foramina transversaria (Table 2, Figure1). In this study, the Chi-square test showed no significant association (p-value > 0.05), suggesting that the presence of accessory foramina is not dependent on the side of the vertebrae. These accessary foramina are present unilaterally in most of the observed vertebrae but 5 vertebrae have bilateral accessary foramina in their transverse processes.

DISCUSSION

Foramen transversarium of cervical vertebrae have always been the topic of interest for researchers because of its vitally important content; vertebral artery. Variation in the shape and sizes of these foramina are somewhat associated with either the development or course of its contents. Foramina of typical cervical vertebrae observed in recent study have similarity in shape with the outcomes of a research by Patra A et al.[7] in which they found round shape of foramen in majority of dried typical cervical vertebrae. However the presence of notch/incomplete foramina in 8-10% of vertebrae portrays the variations of development/ placement of contents in these foramina. Another finding of recent study of presence of accessory foramina in 8-10% of vertebrae is similar to observations of Agarwal B et.al.[8] who found 7 bilateral accessory foramina and 4 unilateral foramina out of 176 typical cervical vertebrae. Manjunath et al[9] also found 20% of accessory foramina in the transverse processes of cervical vertebrae of both typical and atypical variety with preponderance in typical as compared to atypical cervical vertebrae. The underlying cause for the presence of these accessory foramina can be either embryogenic or vascular. It could be the double costal component on the same side merging with the original transverse process of developing vertebrae giving an unusual number of foramina in the transverse processes or a variable number of vertebral vessels be the cause of multiple foramina. Bifid or duplicate origin of vertebral artery has been described by Mugge et al.[10] Absence of vertebral artery (Unilateral & bilateral) has also been reported.[11] Variations in the foramen transversarium, which includes duplication of foramen; there may be triple or open foramen and hypoplastic foramen. This might lead to narrowing of the size of real transverse process and

might cause pressure on vertebral vessels and sympathetic plexus coursing through it.[11]

CONCLUSION

Variations of the shape and size of foramen transversarium present in typical cervical vertebrae were witnessed during this study to report the data to the Neurosurgeon & Radiologists for interpretation of CT & MRI scans, as variations during the course of vertebral artery are generally disrupted in all such conditions. Therefore, it is recommended to have CT Angiogram prior to the surgery.

Ethical Approval:
The ethical Approval was obtained vide letter no. 48/Research Proposal Anatomy FJ/ERC

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