Various Patterns of Accessory Foramen in the Sixth Cervical Vertebra- An Osteological Observation

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ABSTRACT

BACKGROUND
Variations of the foramen transversarium regarding its shape, size, number and location is reflected in the structure and functioning of the vertebral vessels which run inside the canal formed by FT of all cervical vertebrae. Variability of the foramen transversarium may be associated with very unpleasant symptoms like neurological disturbances, contributes to decrease in the quality of life. Morphological variations are affected by many factors i.e., mechanical, pathological and developmental factors. This study aimed to find the various pattern of accessory foramen in the sixth cervical vertebrae.

METHODS
A total of 97 dried human cervical vertebrae of unknown age and sex was studied in the Anatomy department of our institute. All the CV having variations in the FT were identified, photographed and documented.

RESULTS
22 out of a total of 97 cervical vertebrae studied presented variations in the FT. Variability of the FT of sixth cervical vertebrae showed higher frequency (9.27%). No extra foramina were observed in atlas and axis vertebrae.

CONCLUSIONS
This study revealed existence of various patterns of accessory foramen in the sixth cervical vertebrae. It is important to understand these variations and their relationship with vertebral vessels and nerves during surgical interventions in the cervical spine region. Knowledge of these variations will be helpful in the radiological interpretation for diagnostic purpose and for better surgical outcome.

KEYWORDS
Foramen Transversarium, Cervical Vertebrae, Accessory Foramen, Vertebral Vessels

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BACKGROUND

Traditionally there is one foramen transversarium of similar size present on each side of all cervical vertebrae which differentiates them from the vertebrae of other regions. The FT transmit the vertebra artery, veins and accompanying sympathetic plexus. However, variations of the foramen transversarium regarding its morphometric characteristics i.e. shape, size, number and location have been documented. The variety of these features is reflected in the structure and functioning of the vertebral vessels which run inside the canal formed by FT. Zibis A et al suggested that variations in FT (identified in cervical spine CT) are a good indicator of vertebral artery variations. Also variations in vertebral artery (found in USG) clearly points towards FT variations.[1] Many researchers observed that variations were more common in lower cervical vertebrae mostly in sixth cervical vertebrae.[2,3] The vertebral artery along with basilar artery contribute to the blood supply of brain and inner ear. The vertebral artery enters its vertebral course almost always through the foramen transversarium of sixth cervical vertebrae and C7 foramen transversarium is occupied only by the veins. The anterior tubercle of sixth vertebrae is longest and known as carotid tubercle of Chassaignac. Carotid artery can be compressed in the groove formed by the vertebral body and carotid tubercle.[4]

Variability of the foramen transversarium may be associated with very unpleasant symptoms, most of all neurological disturbances, contributes to decrease the quality of life. Morphological variations are affected by many factors i.e., mechanical, pathological and developmental factors. This study aimed to find the various pattern of accessory foramen in the sixth cervical vertebrae. The knowledge of these variations of the FT is of clinical significance and useful for clinicians during surgery to estimate the variations in course and vascular pattern of vertebral vessels and minimize the accidental intra-operative complications.

METHODS

This study was performed on 97 dried human cervical vertebrae of unknown age and sex, obtained from the Anatomy department of our institute CIMS, Bilaspur. Broken or damaged vertebrae were excluded. Typical and atypical cervical vertebrae were identified and separated. There were 78 typical and 19 atypical CV examined. All the typical and atypical cervical vertebrae having variations in the FT (total 22) were photographed and documented. The larger FT were taken as the main foramen while the smaller were accepted as the accessory foramen.[5] The position of the AF on each side and unusual side of the FT were also documented.

RESULTS

Out of 78 typical cervical vertebrae studied 19 vertebrae were found to have variations in the foramen transversarium. Total 19.5% incidence was noted out of which C3 (1.03%), C4 (4.1%), C5 (5.1%) and C6 (9.27%). In comparison to C3 - C5 vertebrae, C6 showed the highest frequency of variations in the FT (Table 1). We observed different variations in total nine C6 vertebrae, among them, 3 vertebrae had bilateral incomplete accessory foramen joined posterior to the main foramen (Figure 1). Two C6 vertebrae had bilateral complete double foramen of similar size and situated posterior to the main foramen. The accessory foramen was separated from the main foramen by a thin bar of bone (Figure 2). One C6 vertebrae showed bilateral accessory foramen, on the right which the AF was complete, smaller in size located posterior to the MF and on the left side the AF was incomplete, smaller and joined posterior to the MF (Figure 3). Only one C6 vertebrae had double FT on the right side. AF was smaller and located posterior to the large main foramen (Figure 4). In two C6 vertebrae had unilateral incomplete AF, one on the right and one on the left side. Out of 19 Atypical cervical vertebrae, accessory foramen was seen in only three C7 vertebrae (3.09%). Two C7 vertebrae had unilateral incomplete AF on the right side and one had bilateral complete AF (Figure 5). No AF was observed in atlas and axis vertebrae.

Type of Vertebrae	No. of Vertebrae Showing Variations	Total Incidence (%)
C3	01	1.03%
C4	04	4.1%
C5	05	5.1%
C6	09	9. 27%
C7	03	3.09%

Table 1. Frequency of Variation in the FT of Lower Cervical Vertebrae

*No incidence of variations was found in C1 and C2 vertebrae

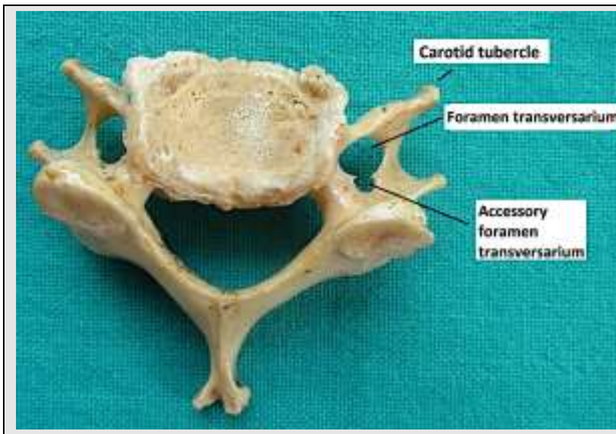

Figure 1. Bilateral Incomplete Accessory Foramen in the C6 Vertebra

DISCUSSION

The system of vertebral-basal arteries supplies blood directly to the brain. The FT of cervical vertebrae gives passage to vertebral vessels and sympathetic fibers from inferior cervical ganglion. The vertebral artery usually enters into FT of sixth cervical vertebrae while C7 vertebrae transmits only vein. An important factor which affects the normal function of the vertebral basal system is the place of origin of the vertebral artery. Most frequently it is a branch from subclavian artery and enter the FT at the level of C6. In nearly 90% of cases vertebral artery usually enters into FT of C6 cervical vertebrae. But it may also enter cervical vertebral column through C3 (1%), C4 (2%), C5 (5%) or C7 (2%).[4] Any deformities and variation in the FT may affect the vertebral vessels. This may cause vascular insufficiency, which leads to common symptoms like Migraines, Shoulder pain, Neck pain, hearing disturbances and severity of cerebro-vascular incidents.[6] It is commonly accepted that there is one FT on each side of transverse process of all cervical vertebrae and are usually of a similar shape and size to each other.[7] However variations in the FT with respect to size, shape, multiplicity or absence of foramina are not uncommon. The exact aetiology of variations was uncertain. It may be multi-factorial i.e. anatomical, morphological, pathological, embryological consideration should be given. Taitz C et al; conducted a study on 480 cervical vertebrae and found 34 vertebrae with double FT. Among that, accessory FT of six vertebrae (C6 & C7) were of equal size while in other vertebrae, the accompanying foramen were smaller in size. They also observed four vertebrae with no FT and one vertebrae with triple FT.[2] Roh et al (2004) studied an extra FT appeared in as many as 74% of the examined vertebrae. According to him accessory foramen appeared most often at the lower level (C5, C6).[8] They pointed out that the presence of extra foramina in the transverse processes may indicate multiplication of the number of structures running through them. Kaya et al (2011) reported that the shape and size of the FT varies from different vertebrae and individuals.[9] The studies on the 12th /13th c. material from the environs of Kielce (Wysocki et al. 2003b) confirmed the most frequent occurrence of double foramina in C6, and the least frequent in C3.[10] Jaffar's (2004) results were similar: double foramina were the most frequent at the level of C6 (70%), while C2 had no extra foramina. The greatest variation in the number of foramina appeared in vertebrae at lower levels (C7-C6), which may be associated with the nerves running there.[11]

Figure 2. Bilateral Complete Accessory Foramen in the C6 Vertebra

The FT is formed by the vestigial costal element fused to the body and true transverse process of the cervical vertebrae. It is closed laterally by the costo-transverse bar. The vertebral vessels outline one of the important factor in the formation of FT. The different variants of these vessels and their course will lead to changes in the size and shape of the FT. In other words; changes or variations of FT may be helpful for estimating changes or variations of the vessels and accompanying nerve structures. Although the clinical significance of the fact is not completely clear, exact identification of accessory FT may prevent damaging such structures during surgery. An absence of FT could means absence of vertebral artery. A narrowing of the FT indicates narrowness of the vessels and so on. Double FT could means duplication of VA. There are cases where the artery runs along the transverse process and not through the FT. This is particularly frequent in the lower cervical vertebrae. Instead of entering the sixth FT, the artery may start to enter the FT at higher level. Other cases were described where the vertebral artery splits, one branch running through the FT and other outside, to merge again in one simple trunk at upper level. Babin and Haller (1973) describe two vessels of unequal calibre arising separately from the subclavian artery and joining at the C6 vertebral level to form a vertebral artery of normal caliber.[12]

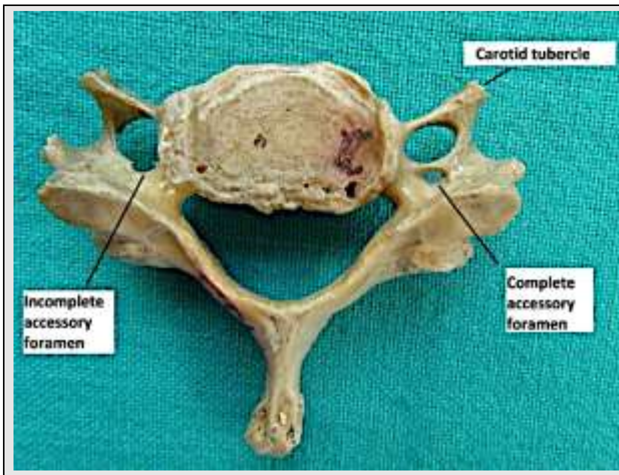

Figure 3. Complete Accessory Foramen on the Right Side and Incomplete Foramen on the Left Side of C6

Our study showed that accessory foramen more common in lower cervical vertebrae mostly in C6. The accessory FT may be present to compartmentalize the contents of FT. Anatomically the FT is described to be divided by a fibrous or bony bridge separating the artery and the vein. The smaller posterior part that encloses the vertebral vein and a branch of vertebral nerve is called accessory vertebral foramen. The vertebral nerve ascends from the stellate ganglion up to the level of C3, two branches from this nerve are formed running towards the sixth spinal nerve, and one of these branches passes through the accessory foramen.[13] Double FT indicates duplication of vertebral artery. The vertebral artery is developed from the fusion of the longitudinal anastomosis that link the cervical inter segmental arteries which branch off from the dorsal division of somatic inter segmental artery in neck region. These inter segmental arteries eventually regress except for the seventh artery which forms the proximal portion of the subclavian artery and beginning of the vertebral arteries.[14] Sim et al described that sometimes there occurs failure of the controlled regression of this portion of the primitive dorsal aorta along with the two inter segmental arteries which lead to the double origin and duplication of the vertebral arteries. The bilateral occurrence of these failures is the reason behind the bilateral duplication of the vertebral arteries.[15]

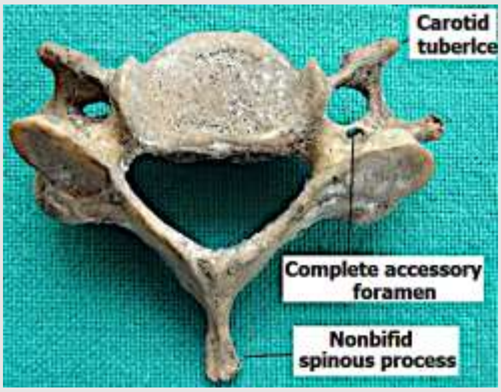

Figure 4. Unilateral Complete Accessory Foramen on the Right Side of C6 Vertebrae

Incomplete FT occur when the bone does not completely enclose the FT. This can be present as single or double incomplete FT. Kovacs et al reported the VA pressure cause bony excavation in the superior process and the configurations and pressure changes of the vessels passing through the foramen may cause appearance of a sulcus.[16] Our speculations about the development of sulcus formation include that it may be incomplete duplication of a FT. We detected an incomplete accessory foramen in total 8 CV in our study.

Pathological changes of the movements could be expressed in changes of the FT. Taitzs et al found that tortuosity of the VA may cause bone destruction thus it may be a factor in producing the variations of FT. Duplication of FT as a result of degenerative changes of the vertebrae, osteophytes. They can cause compression of the VV or irritation of the surrounding sympathetic nerve plexus. The most frequently affected FT were those of C5 and C6. In our observation, the incidence of double FT either complete or incomplete were most commonly detected at C6 vertebral level. We found incomplete double FT in total 3 C6 vertebrae and complete double FT in two C6 vertebrae.

Taitz et al (1978) and Wysocki et al (2003b) pointed also to the rare occurrence of triple foramina.[2,10] Such foramina not appeared in our study.

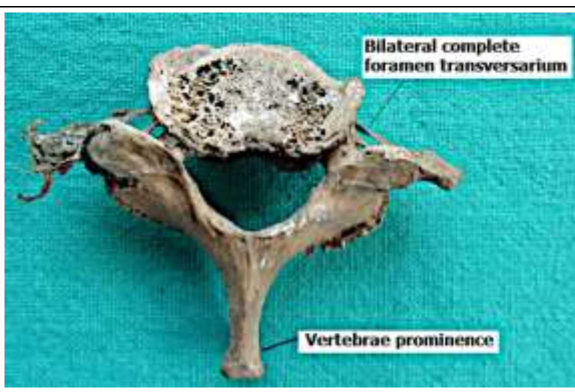

Figure 5. Bilateral Complete Accessory Foramen in the C7 Vertebra

A bifid spinous process is a feature of C3-C6 cervical vertebrae. The presence of non-bifid spinous process of the third, fourth and sixth cervical vertebra is an extremely rare variation and these findings may be of clinical interest to radiologists, neurologists, orthopaedic surgeons, anthropologists and forensic personnel.[17] Mishra GP et al[18] reported a sixth cervical vertebra with bilateral double foramen transversarium and non-bifid spine while Akhtar M J et al[19] reported unilateral double foramen transversarium with non-bifid spine in one sixth cervical vertebra. We also observed the same. In one C6 vertebrae, we observed a bilateral double FT with non-bifid spinous process. The accessory foramen of right side was complete and smaller then main FT while accessory foramen on the left side was incomplete and showed double bubble appearance (Figure 3). We observed unilateral complete accessory foramen on right side with non-bifid spine in one C6 vertebrae also (Figure 4).

Difference in shape may be related to the mechanical stresses. Cavdar et al showed that normal VA did not have a constant caliber during its course within the FT. It is reduced in caliber from C6 to C3; above C3 it began to re-increase its caliber; and its largest caliber at the level of C1 could be considered as a mechanical factor responsible for the larger size of the foramen in C1 as is observed in our study. Erbil et al. found 4% asymmetric TFs in their study evaluating adult cervical vertebrae. On the other hand, Taitz et al. did not evaluate variations; however, they divided TFs into groups according to their shape. The most frequent morphological variations were found at the C6 level.[20] In the current study, asymmetric appearance was detected in one C6 cervical vertebrae (Figure 4), which can be accepted as morphological variation. The left FT was detected as small as compare to right FT.

CONCLUSIONS

This study revealed existence of various patterns of accessory foramen in the sixth cervical vertebrae. It is important to understand these variations and their relationship with vertebral vessels and nerves during surgical interventions in the cervical spine region. Maintaining the vertebral artery intact constitutes an important concern during cervical spine surgeries since minor lesions will lead to severe haemorrhage, neurological symptoms and hearing disturbances. Knowledge of these variations will be helpful in the radiological interpretation for diagnostic purpose and for better surgical outcome.

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Abbreviations

FT - Foramen transversarium
MF - Main foramen
AF - Accessory foramen

CV - Cervical vertebrae
VA - Vertebral artery
VV - Vertebral vessels

REFERENCES

[1] Zibis A, Mitrousias V, Galanakis N, et al. Variations of transverse foramina in cervical vertebrae: what happens to the vertebral artery? Eur Spine J 2018;27(6):1278-1285.

[2] Taitz C, Nathan H, Arensburg B. Anatomical observations of the foramina transversaria. J Neurol Neurosurg Psychiatry 1978;41(2):170-176.

[3] El Shaarawy EA, Sabry SM, El Gammaroy T, et al. Morphology and morphometry of the foramina transversaria of cervical vertebrae: a correlation with the position of the vertebral artery. Egyptian J Med Sci 2008;29:1133-1164.

[4] Newell RNM, Bogduk N. The Back. In: Standring S, Ellis H, Healy JC, eds. Gray's anatomy: the anatomical basis of clinical practices. 40th edn. New York: Churchill Livingstone 2008:718-720.

[5] Dofe MY, Kasote AP, Meshram MM. The study of cervical vertebrae showing variational presentation of foramen transversarium. Int J Anat Res 2015;3(2):1128-1132.

[6] Sultana Q, Avadhani R, Varalakshmi KL, et al. Variations of foramen transversarium in atlas vertebrae: a morphological study with its clinical significance. Nitte Univ J Health Sci 2015;5(2):80-83.

[7] Moore KL, Daly AF, Agur AMR. Clinically oriented anatomy. 6th edn. Baltimore: Lippincott Williams and Wilkins 2010.

[8] Roh J, Jessup C, Yoo J, et al. The prevalence of accessory foramen transversaria in the human cervical spine. Spine J 2004;4(5):S92.

[9] Kaya S, Yilmaz ND, Pusat S, et al. Double foramen transversarium variation in ancient Byzantine cervical vertebrae: preliminary report of an anthropological study. Turk Neurosurg 2011;21(4):534-538.

[10] Wysocki J, Bubrowski M, Reymond J, et al. Anatomical variants of the cervical vertebrae and first thoracic vertebra in man. Folia Morphol (Warsz) 2003;62(4):357-363.

[11] Jaffar A, Mobarak H, Najm S. Morphology of the foramen transversarium a correlation with causative factor. Al-Kindy College Medical Journal 2004;2(1):61-64.

[12] Babin E, Haller M. Correlation between bony radiological signs and dolichoarterial loops of the cervical vertebral artery. Neuroradiology 1974;7(1):15-17.

[13] Sharma A, Singh K, Gupta V. et al. Double foramen transversarium in cervical vertebra an osteological study. J Anat Soc India 2010;59(2):229-231.

[14] Ionete C, Omojola MF. MR angiographic demonstration of bilateral duplication of the extracranial vertebral artery: unusual course and review of the literature. AJNR Am J Neuroradiol 2006;27(6):1304-1306.

[15] Sim E, Vaccaro AR, Berzlanovich A, et al. Fenestration of the extracranial vertebral artery: review of the literature. Spine (Phila Pa 1976) 2001;26(6):E139-E142.

[16] Kovacs A. Subluxation and deformation of the cervical apophyseal joints; a contribution to the aetiology of headache. Acta Radiol 1955;43(1):1-16.

[17] Anas IY, Esomonu UG, Dimitrov ND, et al. Anatomical Variation of the spinous process in the Cervical vertebrae: a case study. Int J Biomed Health Sci 2010;6(1):63-67.

[18] Mishra GP, Kumari S, Bhatnagar S, et al. Sixth cervical vertebra with bilateral double foramen transversarium and non-bifid spine: a rare case. Int J Res Med Sci 2015;3(1):352-353.

[19] Akhtar MJ, Premjeet KM, Ahtasham A. Sixth cervical vertebra with unilateral double foramen transversarium and non-bifid spine: a rare case. Int J Sci R 2015;4(2):279-280.

[20] Erbil KM, Sargon MF, Celik HH, et al. A study of variations of transverse foramens of cervical vertebras in human: accessory foramina in shape and number. Morphologie 2001;85(269):23-24.