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Original Research Article

An Osteological Study of Anatomical Variations of Foramen Transversarium of Cervical Vertebrae and its Clinical Implications

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ABSTRACT

Background: In cervical vertebrae, the costal and transverse elements are connected to each other around the foramen transversarium of the transverse process. The adult cervical vertebrae are characterized by the presence of Foramen Transversarium (FT) in transverse process. These transverse foramina are found to have variations in size, shape and numbers and may be absent, incomplete or duplicate, which may lead to various symptoms.

Aim: To study the anatomical variations of cervical vertebrae.

Materials and methods: The present observational study was performed on 182 dry human cervical vertebrae of unknown sex and age. Intact cervical vertebrae without any degenerative or traumatic disorders were included in this study. Deformed and damaged vertebrae were excluded from the study

Results: Out of these 364 foramen transversarium, 98 (27%) foramen transversarium were of type-I. Type -I was the most common presentation in the present study. Type -II foramen transversarium were seen in 33 (09%) foramen transversarium. Out of 364 foramen transversarium 88 (24%) foramen transversarium were of type-III. Type-IV foramen transversarium were seen in 62 (17%) foramen transversarium. Type-V foramen transversarium were seen on 83 (23%) foramen transversarium. Out of 182 vertebrae 40 (22%) showed complete double foramen transversarium. Incomplete double foramen transversarium were seen in 24 (13%) of vertebrae. One side complete & other side incomplete foramen transversarium were seen in 04 (02%) vertebrae.

Conclusion: Knowledge of such variations is important for Physicians, Neurologists Otorhinolaryngologists, radiologists and Orthopedicians. Presence of accessory foramen transversarium especially of incomplete variety, the second part of vertebral artery may be dislodged and prone to get damaged easily during posterior cervical injuries. It helps in radiological imaging, neurological diagnosis and complex surgical procedures in the cervical area.

KEY WORDS: Cervical Vertebrae**,** Foramen transversarium, Accessory Foramen Transversarium.

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INTRODUCTION

The cervical spine is made up of first seven cervical vertebrae. It starts just below the skull and extends at the top of the thoracic spine. Approximately 8% of overall body length is accounted by the cervical spine [1], whereas for the cervical (neck) length, 80% is contributed by the cervical vertebral bodies

and about 20% is provided by the intervertebral discs [2]. In cervical vertebrae, the costal and transverse elements are connected to each other around the foramen transversarium of the transverse process. The costal element is represented by the anterior root, anterior tubercle, costotransverse bar and posterior tubercle. The transverse element is represented by the posterior root [3]. The adult cervical vertebrae are characterized by the presence of Foramen Transversarium (FT) in transverse process, which differentiates them from other vertebrae. The vertebral artery, vertebral vein and sympathetic nerves from inferior cervical ganglion pass though these foramina except the seventh. The vertebral artery enters in its vertebral course at the level of FT of sixth cervical vertebra. The FT of seventh cervical vertebra transmits only vein and is small or even sometimes absent [4]. Vertebrae develop from sclerotome portion of somites derived from paraxial mesoderm which is regulated by HOX genes. Foramen transversarium develops by vestigeal costal element anteriorly and true transverse process posteriorly [5].

These transverse foramina are found to have variations in size, shape and numbers and may be absent, incomplete or duplicate, which may lead to various symptoms. Vertebral vessels are responsible for formation of foramen transversarium. It can be assumed that variations in the course of the Vertebral vessels may cause variations in Foramen transversarium [6].

The variations in number and size of foramen transversarium results in headache, migraine, fainting attack due to compression of vertebral artery. The aetiology for variation may be embryological or may be related to the course of the vertebral artery [7]. Compartmentalization or absence of the foramen may alter the course of these structures, causing pathological conditions like vertebrobasilar insufficiency. Surgical anatomy and morphology are useful to the operating spine surgeons and radiologist while doing computed tomography and magnetic resonant imaging scans. Maintaining the vertebral artery is an important concern during cervical spine surgeries since even minor lesions will lead to serious haemorrhage or death. There are anatomical studies under taken to minimize such accidental intraoperative lesions of these arteries [8]. The objective of the present study was to analyse foramen transversarium macroscopically, to study the incidence of accessory foramen transversarium and types of foramen transversarium according to their shape.

MATERIALS AND METHODS

The present observational study was performed on 182 dry human cervical vertebrae of unknown sex and age, available in the Departments of Anatomy, Sri Siddhartha medical college, Tumkur, Karnataka.

Inclusion Criteria: Intact cervical vertebrae without any degenerative or traumatic disorders were included in this study.

Exclusion Criteria: Deformed and damaged vertebrae were excluded from the study.

Vertebrae having variations in transverse foramina were photographed. Variations in number and shape were observed, recorded with data compilation and analysis done using Microsoft Excel software.

Shape of Foramen transversarium was classified into five types using the criteria by Taitz.C et al [9]. According to the shape and direction of main diameter, transverse foramina were classified into five types:

Type 1 – Round

Type 2 – Elliptical with main diameter (length) anteroposterior

Type 3 – Elliptical with main diameter(breath) transverse

Type 4 – Elliptical with main diameter oblique from right to left

Type 5 – Elliptical with main diameter oblique from left to right

RESULTS

In the present study, all 182 cervical vertebrae had foramen transversarium. A total of 364 foramen transversarium were studied. Out of these 364 foramen transversarium 98 (27%) foramen transversarium were of type-I [Fig-1]. Among these 98 (27%) foramen transversarium, 56 (15%) were on right side

and 42 (12%) were on left side. Type -I was the most common presentation in the present study. Type -II [Fig-2] foramen transversarium were seen in 33 (09%) foramen transversarium and among these 11 (03%) were on right side and 22 (06%) were on left side. Out of 364 foramen transversarium 88 (24%) foramen transversarium were of type-III [Fig-3] and among these 45 (12%) were on right side and 43 (12%) were on left side. Type-IV [Fig-4] foramen transversarium were seen in 62 (17%) foramen transversarium and among these 29 (08%) were seen on right side and 33 (09%) were seen on left side. Type-V [Fig-5] foramen transversarium were seen on 83 (23%) foramen transversarium and among these 44 (12%) were seen on right side and 39 (11%) were seen on left side. [Table-1]. There were few cervical vertebrae with asymmetric foramen transversarium [Fig-6].

Present study showed accessory foramen transversarium which were bilateral, unilateral, complete and incomplete. Out of 182 vertebrae 40 (22%) showed complete double foramen transversarium [Fig-7] and among these 29 (16%) were unilateral and 11 (06%) were bilateral. Incomplete double foramen transversarium [Fig-8] were seen in 24 (13%) of vertebrae and among these 17 (09%) were seen on right side and 07 (04%) were seen on left side [Table-2]

Vertebrae with left sided complete unilateral accessary foramen transversarium [Fig-9] were seen in 13 vertebrae and Vertebrae with left sided incomplete unilateral accessary foramen transversarium [Fig-10] were seen in 10 vertebrae. [Table-3] Vertebrae with right sided complete unilateral accessary foramen transversarium [Fig-11] were seen in 16 vertebrae and Vertebrae with right sided incomplete unilateral accessary foramen transversarium [Fig-12] were seen in 07 vertebrae. One side complete & other side incomplete foramen transversarium were seen in 04 (02%) vertebrae [Table-2]. Out of these two vertebrae had left incomplete and right complete foramen transversarium [Fig-13] and other two vertebrae had left complete and right incomplete foramen transversarium [Fig-14].

Fig. 1: Type-1 Foramen transversarium.

Fig. 2: Type-II Foramen transversarium.

Fig. 3: Type-III Foramen transversarium.

Fig. 4: Type-IV Foramen transversarium

Fig. 5: Type-V Foramen transversarium

Fig. 6: Asymmetric Foramen transversarium.

Fig. 7: B/L Complete accessory F T.

Fig. 8: B/L Incomplete accessory F T

Fig. 9: Left U/L Complete Accessory F T

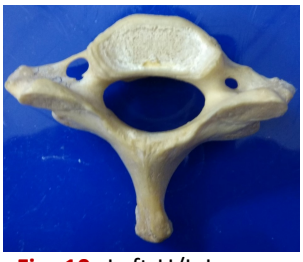

Fig. 10: Left U/L Incomplete Accessory F T

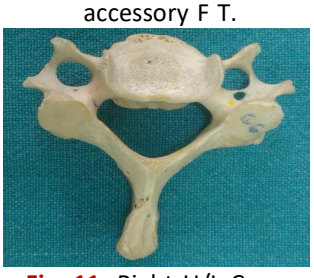

Fig. 11: Right U/L Complete Accessory F T

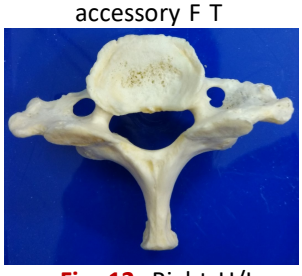

Fig. 12: Right U/L Incomplete Accessory F T.

Fig. 13: Left incomplete & Right complete Accessory F T

Fig. 14: Left complete & Right incomplete Accessory F T

Shape & direction of foramen transversarium	Right side number	Right side percentage	Left side number	Left side percentage	Total number	Total percentage
Type- I	56	15%	42	12%	98	27%
Type- II	11	3%	22	6%	33	9%
Type- III	45	12%	43	12%	88	24%
Type- IV	29	8%	33	9%	62	17%
Type- V	44	12%	39	11%	83	23%

Table 1: Shape of Foramen transversarium (among 182 cervical vertebrae with 364 transverse processes).

Table 2: Variation in the accessary foramen transversarium.

Vertebrae with accessary foramen transversarium	Unilateral (no)	Percentage (%)	Bilateral (no)	Percentage (%)	Total (no)	Percentage (%)
Complete double foramen transversarium	29	16%	11	6%	40	22%
Incomplete double foramen transversarium	17	9%	7	4%	24	13%
One side complete & other side incomplete foramen transversarium	-	-	-	-	4	2%

Number of Vertebrae with unilateral accessary foramen transversarium	Right sided	Left sided
Complete	16	13
Incomplete	7	10

Table 3: Vertebrae with unilateral accessary foramen transversarium.

Table 4: Showing the prevalence of accessory foramen transversarium in different study populations.

Author	Year	Prevalence	Study sample	Population
Taitz et al [9]	1978	7%	480	Indian
Nagar et al. [12]	1999	8.60%	1388	Roman-Bynzatine Jews
Das et al [13]	2005	1.50%	132	Indian
Kaya et al [7]	2011	22.70%	262	Jewish
Rekha et al [14]	2013	6.54%	153	Indians
Manicka Vasuki A K et al [10]	2016	41.60%	300	Indians
Present study	2020	37%	364	Indians

DISCUSSION

The shape of the foramen transversarium in the present study showed 27% of the foramen transversarium were of type -1 (round) followed by type-3 (elliptical with main diameter(breath) transverse) which was 24%. In a study conducted by Manicka Vasuki A.K. et al [10] showed that 43.6% were of type-1 followed by type-3 which was 22.8% and this study was in accordance with the present study. In the present study we found 68 (47%) cervical vertebrae which showed accessary foramen transversarium. Out of these 40 (22%) vertebrae showed complete double foramen transversarium. Among these 29 (16%) were unilateral and 11 (06%) were bilateral. Incomplete double foramen transversarium were seen in 24 (13%) of vertebrae and among these 17 (09%) were seen on right side and 07 (04%) were seen on left side. One side complete & other side incomplete foramen transversarium were seen in 04 (02%) vertebrae. Murlimanju et al [11] study showed, total 6 (1.6%) out of 363 vertebrae, he found double foramina in 5 (1.4%), and both side foramen transversarium in 1 (0.3%), one sided foramen transversarium in 5 (1.4%). Prevalence of foramen transversarium in the present study is 37% which is compared with studies by different authors are shown in Table-4.

In a study conducted by Vaishakhi G et al [15] showed that complete accessary foramen transversarium were seen in 20% of the vertebrae and 11% of the vertebrae showed incomplete accessary foramen transversarium. In a study conducted by Singh. A P et al [16] showed that complete accessary foramen transversarium were seen in 20% of the vertebrae and 6% of the vertebrae showed incomplete accessary foramen transversarium. The present study also showed the results which are in accordance with the above studies.

CONCLUSION

The presence of accessory foramen transversarium increases the risk of thrombus formation and embolization. Hence variations in Foramen transversarium carry a lot of clinical significance and should not be ignored. It should be remembered that the vertebral and basilar artery contribute blood supply not only to the brain and also to the inner ear, so compression or spasm of the vertebral artery may be manifested by neurological symptoms and hearing problems.

Knowledge of such variations is important for Physicians,Neurologists Otorhinolaryngologists and Orthopedicians. Due to the presence of accessory foramen transversarium especially incomplete variety, the second part of vertebral artery may be dislodged and prone to get damaged easily during posterior cervical injuries. It is useful for the radiologists during CT and MRI scan. It helps in radiological imaging, neurological diagnosis and complex surgical procedures in the cervical area. This variation of foramen transversarium is also important for the surgeons during posterior cervical surgery.

Conflicts of Interests: None

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