

Research Article

## An Osteological Study of Foramen Transversarium in Typical Cervical vertebrae with its Embryological and Clinical Significance

Prathap Kumar J<sup>1</sup>, Pavithra N<sup>2</sup>,

Padmalatha K<sup>3</sup> and Prakash B S<sup>4</sup>

### Article Info

<sup>1</sup>Assistant Professor, Department of Anatomy, Chikkamagaluru Institute of Medical sciences, Chikkamagaluru, India

<sup>2</sup>Assistant Professor, Department of Psychiatry, Chikkamagaluru Institute of Medical sciences, Chikkamagaluru, India

<sup>3</sup>Professor, Department of Anatomy, ESI Medical College-PGIMS, Chennai, India

<sup>4</sup>Professor & HOD, Department of Anatomy, Hassan Institute of Medical Sciences, Hassan, India

### **\*Corresponding author:**

#### **Prathap Kumar J.**

Assistant Professor, Department of Anatomy, Chikkamagaluru Institute of Medical sciences, Chikkamagaluru, India

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### **ABSTRACT**

**Background:** The knowledge of variations of the foramen transversarium and hence vertebral artery is important for the Neurosurgeons, orthopedicians and radiologists for various procedures and investigations.

**Aims and Objectives:** To study the incidence of accessory foramina transversaria in cervical vertebrae and to interpret them with emphasize on their embryological and surgical importance. The present study was done on the typical cervical vertebrae of South Indian population to know the number of foramen transversarium and to discuss the embryological basis and clinical significance of the variations.

**Materials & methods:** The present study was done in 150 dried typical cervical vertebrae which were taken from Department of Anatomy, Chikkamagaluru Institute of Medical sciences, Chikkamagaluru and Hassan Institute of Medical Sciences, Hassan, India and studied keenly for the number of the foramen transversarium, accessory and duplicated foramen transversarium were photographed.

**Results:** Out of 150 typical cervical vertebrae, only 6 (4%) vertebrae showed the double foramina transversarium. Among them 3 (2%) vertebra had bilateral double foramina transversarium and remaining 3 (2%) had unilateral double foramina transversarium. Among the unilateral, 2 were present on the right side and only 1 was on the left side. No vertebrae showed the absence of foramen transversarium.

**Conclusion:** The present study observed the presence of accessory foramina transversarium in 4% of cases. The unilateral and bilateral accessory FT, both had same incidence, i.e, 2% each, contrary to the findings as mentioned in most of the previous similar studies. The surgical anatomy of these variations is important for the spine surgeons and for radiologists for interpreting the computed tomogram and magnetic resonance image scans of neck region. It is clinically important since the course of the vertebral artery may be distorted in such situations and may result in certain clinical conditions like posterior headache, migraine and fainting attack.

**Key words:** Cervical vertebra, vertebral artery, foramen transversarium, duplication, accessory

## INTRODUCTION

Vertebral artery provides the main source of blood supply to the hind brain in the human body. The vertebral artery enters the C6 vertebra and travels superiorly C1 vertebra, through a foramen in the transverse process of the cervical vertebrae termed as 'foramen transversarium (F.T)'. The Pedicle is attached midway between the discal surfaces of the vertebral body. The laminae are thin and slightly curved. The junction between the pedicle and lamina bulges laterally between the superior and inferior articular facet to form an articular pillar called 'Lateral Mass' on each side. The transverse process is morphologically composite around the F.T. Its dorsal and ventral bars terminate laterally as corresponding tubercles.

The tubercles are connected, lateral to the F.T, by the costal lamella/ Intertubercular lamella. These three elements represents morphologically the capitellum, tubercle and the neck of the cervical costal element. The F.T normally transmits the vertebral artery, vertebral vein and a branch from cervicothoracic sympathetic ganglion, called ' vertebral nerve'. [1]

Transverse process is dorsomedial to the F.T. the costal process, corresponding to the head, neck and tubercle of a rib, limits the F.T ventrolaterally. The distal parts of these cervical costal process do not normally develop. In case of 7th cervical vertebrae, they occasionally do so and form the cervical rib, which may reach the sternum. [2]

The narrow F.T may place patients at high risk for vertebrobasilar insufficiency or thrombus formation. Duplication of F.T is suggestive of fenestrations or even duplication in the vertebral artery. [3]

## MATERIALS AND METHODS

An osteological study on foramen transversarium in typical cervical vertebrae was conducted in Department of Anatomy, Chikkamagaluru Institute of Medical sciences, Chikkamagaluru and Hassan Institute of Medical Sciences, Hassan, Karnataka, India. This study was done in 150 dried typical cervical vertebrae (C3 to C6). Each bone is examined in detail for the number and position of Foramen Transversarium. The foramen transversarium is identified by the presence of a foramen in the transverse process of the cervical vertebrae. The age, sex and race of these cervical vertebrae were not available. It was also not possible to specify the exact vertebral number from C3 to C6, since they were typical. Any variations like duplications or absence of F.T were photographed and noted.

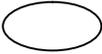
**Inclusion Criteria:** Adult human typical cervical vertebrae irrespective of sex, race was taken for study.

**Exclusion Criteria:** Typical cervical vertebrae showing any gross asymmetry or broken was rejected as they were unsuitable for the study.

## RESULTS:

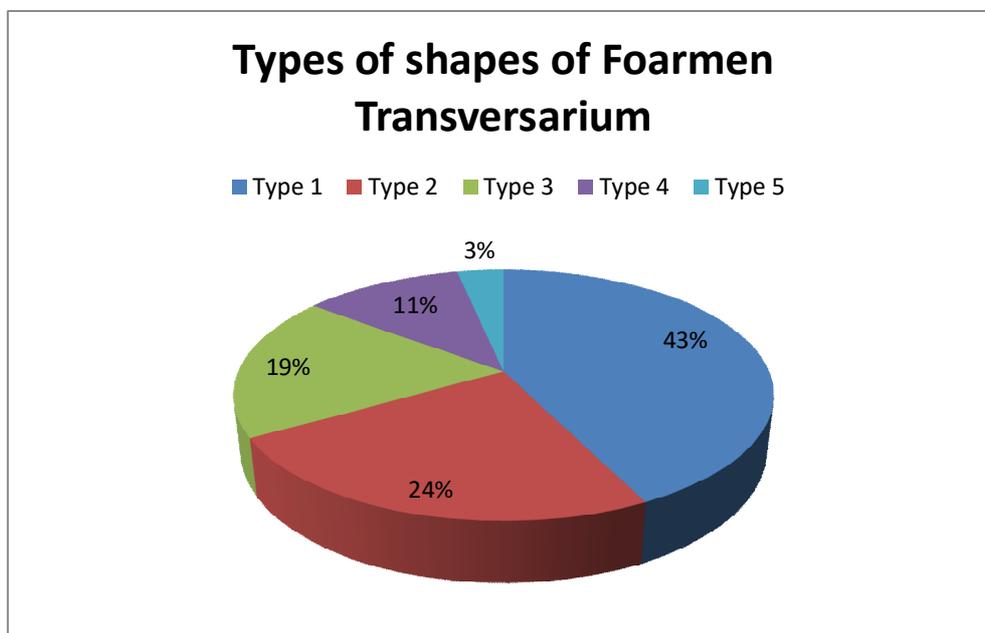
According to the shape and direction of the main diameter, foramen transversarium were classified into five types. This observation is done according to studies made by C.Taitz, H.Nathan and B.Arensberg, Department of Anatomy, Israel. The vertebrae were studied as seen from above in an antero-posterior direction with the body of the vertebrae facing the examiner. [4]

**Table No. 1:** Showing the various types of Foramen transversarium based on the shape.

Type of F.T	Shape	Diagram
Type 1	Round	
Type 2	Elliptical, with main diameter [length] anterior-posterior	
Type 3	Elliptical, with main diameter transverse [breadth]	
Type 4	Elliptical, with main diameter oblique from right to left	
Type 5	Elliptical, with main diameter oblique from left to right	

In the present study, out of 150 typical cervical vertebrae studied, 64 (43%) were type 1, 36 (24%) were type 2, 28 (19%) were type 3, 17(11%) were type 4 and 5(3%) were type 5. Results are depicted in the graph 1.

**Graph 1:** Showing the various types of Foramen transversarium based on the shape.



Out Of 150 cervical vertebrae examined, the double FT was found in 6 vertebrae. The incidence of which is calculated as 4%. Among them, bilateral duplication was found in 3 number in typical cervical vertebrae [Figure 1,2,3] accounting for 2%

**Fig 1:** Bilateral duplication of foramen transversarium typical cervical vertebrae, Accessory F.T on left side is present posterior and Accessory F.T on right side is present anterior to the main foramen transversarium.



**Fig 2:** Bilateral duplication of foramen transversarium typical cervical vertebrae, Accessory F.T on both sides is present posterior to the main foramen transversarium.



**Fig 3:** Bilateral duplication of foramen transversarium typical cervical vertebrae, Accessory F.T on both sides is present posterior to the main foramen transversarium. Right Accessory F.T is larger than the Left. And unilateral duplication was found in 3 typical cervical vertebrae [Figure 4,5,6] accounting for 2%



**Fig 4:** Unilateral duplication of foramen transversarium typical cervical vertebrae, Accessory F.T on right side is present posterior to the main foramen transversarium and left side osteophyte growth invading the FT.



**Fig 5:** Unilateral duplication of foramen transversarium typical cervical vertebrae, Accessory F.T on right side is present posterior to the main foramen transversarium. Left side-Normal FT.



**Fig 6:** Unilateral duplication of foramen transversarium typical cervical vertebrae, Accessory F.T on left side is present posterior to the main foramen transversarium. Right side-Normal FT.



Further, the accessory foramina were smaller than the regular foramina. Furthermore, the double foramina were observed only in the typical cervical vertebrae (C3,C4,C5, C6). Each vertebra was having at least one FT on either side. The incidence of the accessory foramen transversarium is tabulated in Table 2.

**Table No.2:** Showing the number of typical cervical vertebrae examined along with accessory foramen transversarium.

Description	Number	Incidence (%)
Number of typical cervical vertebrae examined	150	100
Typical cervical vertebrae with Unilateral Accessory F.T	3	2
Typical cervical vertebrae with Bilateral Accessory F.T	3	2
Total Typical cervical vertebrae with double F.T	6	4

### DISCUSSION:

A foramen transversarium (F.T), typical of the foramina of the cervical vertebral transverse processes, has been found in the first lumbar, fifth lumbar, and first sacral vertebrae. An accessory transverse foramen, posterior to and smaller than the primary foramen, may be found in the sixth vertebra, less frequently in adjacent vertebrae The transverse foramen of the seventh cervical is typically small and may be absent. It rarely transmits the vertebral artery but frequently allows passage of a vein.[5]

Anatomically, the FT is described to be divided by fibrous or bony bridge, separating the vertebral artery from the vertebral vein.[6] In double FT, the smaller posteriorly placed foramen encloses a branch of vertebral nerve and vertebral vein is called accessory foramen transversarium.[7] The vertebral nerve ascends from the stellate ganglion up to the level of C3, two branches from this nerve are formed, and one of these branches passes through the accessory foramen. [8]

**Table No.3:** Showing the Comparison of double foramen transversarium (F.T) of the present study with the previous studies.

Authors (year)	Number of specimen	Incidence of double FT (%)	Incidence of Unilateral double FT (%)	Incidence of Bilateral double FT (%)
Taitz et al (1978) <sup>9</sup>	480	7	0	0
Sharma et al (2010) <sup>10</sup>	200	8	3.5	4.5
Kaya et al (2011) <sup>11</sup>	22	22.7	13.6	9
Murlimanju et al (2011) <sup>12</sup>	363	1.6	1.4	0.3
Chaudhari et al (2013) <sup>13</sup>	133	23.1	14.7	8.4
Rathnakar et al(2013) <sup>14</sup>	140	5.7	3.6	1.4
Chandravadiya et al (2013) <sup>15</sup>	140	4.7	3.8	0.9
Katikireddi et al (2014) <sup>16</sup>	100	3	2	1
Mishra et al (2014) <sup>17</sup>	220	14	9.5	4.5
Patra et al (2015) <sup>18</sup>	150	22	10.6	11.3
Sunitha et al(2016) <sup>19</sup>	50	8	5	3
Present Study	150	6	3	3

Epstein in 1969 found the vertebral arteries of the left side was bigger than those on the right side. [20]

A study done by Rawal Jitendra D, revealed an asymmetry of the vertebral artery with a larger diameter on left side than on the right. Henceforth, larger diameter of vertebral artery on left side could be accounted for the larger diameter of foramen transversarium on the left side.[21]

**Embryological Significance:** Vertebral artery develops from a fusion of longitudinal anastomosis that links second to sixth cervical intersegmental arteries. Most of the intersegmental arteries regress except the seventh which forms the origin of vertebral artery. Failure of occlusion of intersegmental arteries may be responsible for duplication/fenestrations of vertebral artery. A duplicate vertebral artery may potentially serve to protect patients against ischemic attacks to the brain and provide collateral blood flow to the basilar artery. However, fenestrated vertebral arteries have been demonstrated histologically to be weak with irregular elastic fibers in the vessel wall. [22]

**Clinical Significance:**

Fenestrated/double vertebral arteries may carry more risk of thrombus formation and embolization leading to severe transient ischemic attacks.[22]

Bowhunter's stroke is a symptomatic vertebrobasilar insufficiency caused by stenosis or occlusion of the vertebral artery with head rotation It is a common finding on angiography that head rotation produces stenosis or occlusion of a contralateral vertebral artery. The narrowing of the transverse foramen may predispose patients to vertebrobasilar insufficiency and thrombus formation especially with head rotation.[23,24]

**CONCLUSIONS:**

- The study reports variations in the dimensions of the foramina transversarium - narrow, duplication and accessory in a significant number of specimens.
- Injury to the vertebral artery during anterior operative intervention in the subaxial cervical spine may give rise to the catastrophic iatrogenic complications.
- The osteophytes impinging on the transverse foramen may be responsible for vertebral artery compression and trauma.
- In order to avoid vertebral artery injury during anterior surgical approaches to the cervical spine.
- The accessory transverse foramina seen in the study suggest fenestrations or duplications in the vertebral artery.
- The knowledge about these foramina is useful in the surgical procedures to preserve the circulation.
- The increasing incidence of neck injuries and related syndromes necessitates the study of bony variations of the transverse foramina. Due to the duplication of the foramen transversarium the second part of vertebral artery is prone to be damaged easily during posterior cervical injuries and Surgeries

**REFERENCES**

1. Baron E.M, Tunstall R. Back. In: Susan Standring, Gray's anatomy. 41st edn, Elsevier, 2016; 721.
2. Christ B.EA, Scaal N. Development of the Back. In: Susan Standring, Gray's anatomy. 41st edn, Elsevier, 2016, 758.
3. Sangari SK, Dossous PM, Heineman T, Mtui EP. Dimensions and anatomical variants of the foramen transversarium of typical cervical vertebrae. Anat Res Int 2015;391823.
4. Taitz C , Nathan N H, B.Arensberg. Some observations on the posterior bridge of

- atlas, Acta Anat,Basel. 1978; 127: 212 – 217.
5. Bergman RA, Thompson SA, Afifi AK, Saadeh FA. Compendium of Human Anatomic Variation. Germany: Urban and Schwarzenberg; 1988. 197.
  6. De Boeck M, Potvliege R, Roels F, De Smedt E. The accessory costotransverse foramen: A radioanatomical study. J Comput Assist Tomogr 1984;8:117-20
  7. Tondury G. Applied and topographic anatomy pad. Lliepzig: George Thieme Verlag; 1970. 293-453.
  8. Patra A, Kaur H, Chhabra U, Kaushal S, Kumar U. Double foramen transversarium in dried cervical vertebra: An osteological study with its clinical implications. Indian J Oral Sci 2015;6:7-9
  9. Taitz C, Nathan H, Arensburg B. Anatomical observations of the foramina transversaria. J Neurol Neurosurg Psychiatry 1978;41:170-6.
  10. Sharma A, Singh K, Guptha V, Srivastava S. Double foramen transversarium in cervical vertebra an osteological study. J Anat Soc India 2010;59:229-31.
  11. Kaya S, Yilmaz ND, Pusat S, Kural C, Kirik A, Izi Y. Double foramen transversarium variation in ancient Byzantine cervical vertebrae: Preliminary report of an anthropological study. Turk Neurosurg 2011;21:534-8.
  12. Murlimanju BV, Prabhu LV, Shilpa K, Rai R, Dhananjaya KV, Jiji PJ. Accessory transverse foramina in the cervical spine: Incidence, embryological basis, morphology and surgical importance. Turk Neurosurg 2011;21:384-7.
  13. Chaudhari ML, Maheria PB, Bachuwar SP. Double foramen transversarium in cervical vertebra: Morphology and clinical importance. Indian J Basic Appl Med Res 2013; 2:1084-88.
  14. Rathnakar P, Remya K, Swathi B. Study of accessory foramen transversaria in cervical vertebrae. Nitte Univ J Health Sci 2013;3:97-9.
  15. Chandravadiya L, Patel S, Goda J, Chavda V, Ruparelia S, Patel S. Double foramen transversarium in cervical vertebra: Morphology and clinical importance. Int J Res Med 2013;2:103-5.
  16. Katikireddi RS, Setty SN. A study of double foramen transversarium in dried cervical vertebra. Int J Health Sci Res 2014;4:59-61
  17. Mishra G.P, Bhatnagar S, Singh B, Mishra P.P, Mishra A. Anatomical Variations in Foramen Transversarium of Typical Cervical Vertebrae and Clinical Significance. IJBR.2014; 5(6): 405-7.
  18. Patra A, Kaur H, Chhabra U, Kaushal S, Kumar U. Double foramen transversarium in dried cervical vertebra: An osteological study with its clinical implications. Indian J Oral Sci 2015; 6:7-9.
  19. Sunitha NS,Karpagajothi J, Rani SB. Interesting Facts about the Foramen Transversarium of Cervical Vertebra. IOSR Journal of Dental and Medical Sciences. 2016; 15(1):20-24.
  20. Epstein B.S, The Spine. The Radiological Text and Atlas. 3<sup>rd</sup> edn, 1969, 24-25,65.
  21. Jitendra D.R, Hrishikesh J, Histomorphometric comparison of diameter of Rt & Lt vertebral artery. National Journal of Medical Research. 2012, 2 (3): 260 – 63.
  22. Ionete C, Omojola MF. “MR angiographic demonstration of bilateral duplication of the extracranial vertebral artery:unusual course and review of the literature,” American Journal of Neuroradiology. 2006: 27(6):1304–06.
  23. Citow J. S, Macdonald R.M. “Posterior decompression of the vertebral artery

- narrowed by cervical stenosis,” *Surgical Neurology* 1999;51 (5):495–99.
24. Seki T, Hida K, Akino M, Iwasaki Y. Anterior decompression of the atlantoaxial vertebral artery to treat bow hunter’s stroke: technical case report. *Neurosurgery*. 2001; 49(6) :1474–76.