

Research Article

A morphometric study of foramen transversarium of dried cervical vertebrae

Md. Jawed Akhtar^{1*}, Premjeet Kumar Madhukar², Shamir Rahman³, Nishant Kashyap⁴

¹Department of Anatomy, Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna, Bihar, India

²Department of Anatomy, Lord Buddha Koshi Medical College & Hospital, Saharsa, Bihar, India

³Department of Orthopaedics, Patna Medical College Hospital, Patna, Bihar, India

⁴Department of Orthopaedics, Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna, Bihar, India

Received: 09 February 2015

Accepted: 01 March 2015

*Correspondence:

Dr. Md. Jawed Akhtar,

E-mail: drjawedakhtarpmch@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: Variation in number, size & shape of foramen transversarium affects the anatomical course of the vertebral vessels, which may cause pathological conditions like vertebrobasilar insufficiency. Since, inner ear derive its blood supply from vertebral and basilar arteries, any spasm of these arteries due to irritation of sympathetic plexus, may causes labyrinthine or hearing disturbances along with neurological symptoms. The objective of present study is to study the incidence of accessory foramen transversarium in dried cervical vertebrae in Indian population & compare it with incidence among various races of world.

Methods: A total of 174 cervical vertebrae (Typical-126 & Atypical-48) of unknown sex & age are analyzed to see the accessory foramen transversarium.

Results: Out of the 174 cervical vertebrae, accessory foramen transversarium is found in 25 (14.36%) vertebrae. Among these 25 vertebrae, 16 (9.19%) are typical and 9 (5.17%) are atypical cervical vertebrae. We observed in these 16 typical cervical vertebrae, 10 (5.75%) vertebrae have accessory FT on right side while 3 (1.72%) vertebrae have on left side and 3 (1.72%) vertebrae have bilateral accessory FT. Among 9 atypical cervical vertebrae, 4 (2.3%) vertebrae have accessory FT on right side while 3 (1.72%) vertebrae have on left side and 2 (1.15%) vertebrae have bilateral accessory FT. Accessory foramen transversarium are more common on right side in both typical & atypical cervical vertebrae. No any accessory FT is found on axis vertebra.

Conclusion: Knowledge of accessory foramen transversarium is important for clinicians because it may affect the course of vertebral vessels & nerves, which causes various symptoms to patients. It is also helpful for spine surgeons in planning surgery around the cervical vertebrae and to avoid post-operative complications. These variations are also of importance and helpful for anatomist, anthropologist and radiologist.

Keywords: Foramen transversarium, Cervical vertebrae, Vertebral artery, Double foramina

INTRODUCTION

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 through these

foramen 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 some time absent.¹ In cervical vertebrae, the transverse process is morphologically composite around the FT. These transverse processes consist of ventral and dorsal bar, which terminates laterally as corresponding tubercles.

These tubercles are connected, lateral to the foramen, by the costal (or, intertubercular) lamella which is commonly known as costotransverse bar.² Variation in number, size & shape of FT affects the anatomical course of the vertebral vessels, which may cause pathological conditions like vertebrobasilar insufficiency. This occurs as a result of compression of vertebral artery during neck movements and characterized by headache, migraine and fainting attack.³ Since, inner ear also derive its blood supply from vertebral and basilar arteries, so any spasm of these arteries due to irritation of sympathetic plexus, may causes labyrinthine or hearing disturbances along with neurological symptoms.⁴ Therefore, the knowledge about these variation is very helpful for radiologist & clinician in interpretation of X-rays, computed tomograms and MRI scans. It is also important for orthopedic surgeon during posterior approaches of cervical spines.

Aim & objective

To study the incidence of accessory foramen transversarium in dried cervical vertebrae in Indian population & compare it with incidence among various races of world.

METHODS

The present study has been carried out on 174 cervical vertebrae (Typical-126 & Atypical-48) of unknown sex & age, which are available in the Departments of Anatomy, Orthopaedics & Forensic Medicine & Toxicology of Indira Gandhi Institute of Medical Sciences (Patna, Bihar, India), Lord Buddha Koshi Medical College (Saharsa, Bihar, India), Patna Medical College (Patna, Bihar, India) & Nalanda Medical College (Patna, Bihar, India) after obtaining consents and permission for the study from heads of the department. Among the 48 atypical cervical vertebrae, 18 are C1, 14 are C2 and 16 are C7. Each cervical vertebra is examined for the presence of accessory foramen transversarium. Cervical vertebrae having marked deformities and damaged FT are excluded from the study. Representative photographs of different cervical vertebrae having accessory FT are taken using a digital camera (HTC desire mobile phone 13 megapixels).

RESULTS

Out of the 174 cervical vertebrae, accessory foramen transversarium is found in 25 (14.36%) vertebrae. Among these 25 vertebrae, 16 (9.19%) are typical and 9 (5.17%) are atypical cervical vertebrae.

We observed in these 16 typical cervical vertebrae, 10 (5.75%) vertebrae have accessory FT on right side while 3 (1.72%) vertebrae have on left side and 3 (1.72%) vertebrae have bilateral accessory FT (Figure 2, 3 & 4).

Among 9 atypical cervical vertebrae, 4 (2.3%) vertebrae have accessory FT on right side while 3 (1.72%) vertebrae have on left side and 2 (1.15%) vertebrae have bilateral accessory FT. Accessory foramen transversarium are more common on right side in both typical & atypical cervical vertebrae. No any accessory FT is found on axis vertebra (Table 1 & Figure 1, 5, 6 & 7).

Table 1: Distribution of accessory foramen transversarium.

	U/L double FT		B/L double FT	Total
	Right	Left		
Typical cervical vertebra	10 (5.75%)	3 (1.72%)	3 (1.72%)	16 (9.19%)
Atypical cervical vertebra	4 (2.3%)	3 (1.72%)	2 (1.15%)	9 (5.17%)
Total	14 (8.05%)	6 (3.44%)	5 (2.87%)	25 (14.36%)

FT- Foramen transversarium

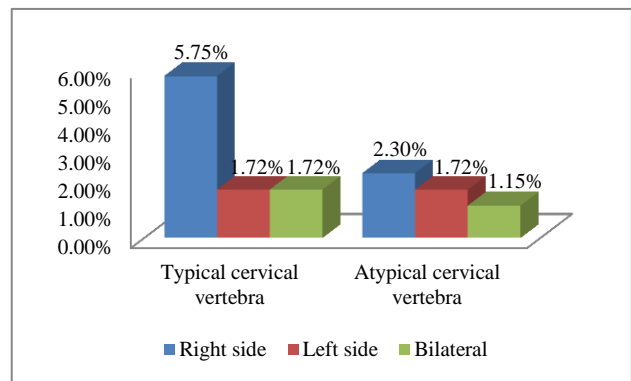


Figure 1: Side wise allocation of accessory foramen transversarium.



Figure 2: Unilateral (right sided) double foramen transversarium in a typical cervical vertebra (C5).



Figure 3: Unilateral (left sided) double foramen transversarium in a typical cervical vertebra (C4).

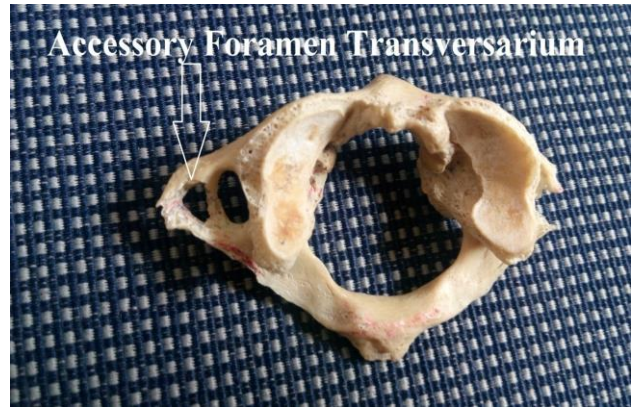


Figure 6: Unilateral (left sided) double foramen transversarium in an atypical cervical vertebra (C1).



Figure 4: Bilateral double foramen transversarium in a typical cervical vertebra (C4).



Figure 7: Bilateral double foramen transversarium in an atypical cervical vertebra (C7).



Figure 5: Unilateral (right sided) double foramen transversarium in an atypical cervical vertebra (C1).

The accessory foramen transversarium found in typical cervical vertebrae are much smaller in size than the main FT and they present posterior to the main foramen. A thin bar of bone separates the accessory foramen from the main one. The accessory foramen transversarium found in atlas are little smaller than main FT, while in seventh cervical vertebra they are much smaller than main FT. In Atlas vertebra, the accessory FT is present posterior in the right side while lateral in the left side.

DISCUSSION

Many studies have been done by different authors on the variation of number, size & shape of FT in past (Table 2). In one of the study, which was conducted on 480 foramen transversarium by Taitz et al.,⁴ double FT was shown only in 34 (7%) cervical vertebrae. 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 found three C4 & one C6 cervical vertebrae in which there was no FT and a single cervical vertebra having triple FT also. In the present study, we found 25 (14.36%) vertebrae having accessory foramen transversarium among 174 cervical vertebrae, in which 16 (9.19%) are typical and 9 (5.17%) are atypical cervical vertebrae. In 2005, Das S et al.⁵ studied on 132 dried human cervical vertebrae & reported only two cases (1.5%) of double foramen transversarium. While, Sharma et al.⁶ observed accessory FT in 8% cases i.e. 16 among 200 cervical vertebrae, in which incidence of double FT was higher in C6 vertebra. Kaya et al.³ studied on 22 Byzantine cervical vertebrae and observed that double FT were present only in five cervical vertebrae (22.7%), in which three cases were unilateral & two cases were bilateral. One vertebra showed asymmetrical FT. They found diameter of FT was 6.2 mm (5.7 to 6.5 mm) in

right side while 6.4mm (2.3 to 6.7 mm) in left side. Murlimanju et al.⁷ found only six (1.6%) vertebrae with accessory FT among 363 cervical vertebrae, in which five had bilateral & one had unilateral accessory FT. In another study by Laxmi C et al.⁸ on 210 cervical vertebrae, double FT was found only in 10 cases (4.76%), in which 8 (3.8%) vertebrae have bilateral & 2 (0.95%) vertebrae have unilateral double FT. Chaudhari et al.⁹ described 22 vertebrae with double FT among 133, in which unilateral double FT was present in 14 (14.73%) & bilateral FT was present in 8 (8.42%) cervical vertebrae. While we found 25 (14.36%) vertebrae having accessory foramen transversarium among 174 cervical vertebrae, in which 16 (9.19%) are typical and 9 (5.17%) are atypical cervical vertebrae. Rathnakar P et al.¹⁰ found only 8 (5.7%) vertebrae with accessory FT among 140 cervical vertebrae. Patil NP et al.¹¹ observed 175 cervical vertebrae and explain double FT only in 10 (5.71%) cases, in which 6 (3.42%) cases were unilateral & 4 (2.28%) cases were bilateral. They explained unilateral double FT was more common than bilateral and accessory FT was more common in lower cervical vertebrae i.e. in fourth, fifth, sixth & seventh. An another study done on Kenyan population by Karau PB & Odula P¹² on 102 cervical vertebrae, in which only 4 (3.9%) have double FT. Ramachandran K et al.¹³ observed 19 (15.8%) cervical vertebrae having double FT among 120 vertebrae, in which 10 (8.3%) cases was bilateral & 9 (7.5%) cases was unilateral. We found 14.36% cases of double FT in our study, which is very near to the findings of Ramachandran K et al.¹³ They describe five different shapes of FT, in which type I i.e. round was most common, which was seen in 76 (63.3%) vertebrae. The findings of Murugan M et al.¹⁴ is slightly lower than our finding, they report only 19 (12.6%) cases of bilateral double FT among 150 cervical vertebrae. Only 3 (3%) cases of double FT was reported by Katikireddi RS et al.¹⁵ after study of 100 cervical vertebrae, in which 2 were unilateral & 1 was bilateral. Yadav Y et al.¹⁶ got only 8 (6.67%) cases of double FT among 120 cervical vertebrae, in which 3 were unilateral & 5 were bilateral. A single sixth cervical vertebra with bilateral double foramen FT with non-bifid spine was reported by Mishra GP et al.¹⁷ Double foramen transversarium is also known as "foramen transversarium bipartitia". Depending upon the course of vertebral artery it may be unilateral and bilateral. The tortuosity of vertebral artery along with embryological factors contribute important role in the development of FT bipartitia. But, the exact cause of double FT is not well known. Still this is a matter of debate the direct relationship between the size of foramen transversarium & the vertebral artery. The tortuosity of vertebral artery may be a cause of bone destruction and becomes an important factor in the size of FT, as explained by Hadley LA¹⁸ & Hyypa SE et al.¹⁹ The vertebral artery of left side are larger than the right side of FT as described by Epstein BS.²⁰ The duplication of foramen transversarium is associated with different anatomical variation of vertebral artery like duplication & fenestration. There are two origins and fusion point of

duplicated vertebral artery in the neck which lies outside of spinal cord. But, the fenestrated artery have only single origin which divides into two parallel trunks, which may lies outside or within the vertebral canal. In the literature, only 74 cases of fenestrated artery have reported, most of them were left predominance. Only 5% i.e. four cases among them were bilateral. While, duplication of vertebral artery reported in 22 cases, in which only 5% i.e. one case was bilaterally symmetrical.²¹

Table 2: Comparison of studies about incidence of accessory FT by different authors.

Author (Year of study)	No. of specimen studied	Incidence of accessory FT (%)
Taitz et al. ⁴ (1978)	480	7%
Das S et al. ⁵ (2005)	132	1.5%
Sharma et al. ⁶ (2010)	200	8%
Kaya et al. ³ (2011)	22	22.7%
Murlimanju et al. ⁷ (2011)	363	1.6%
Laxmi C et al. ⁸ (2013)	210	4.76%
Chaudhari et al. ⁹ (2013)	133	23.15%
Rathnakar P et al. ¹⁰ (2013)	140	5.7%
Patil et al. ¹¹ (2014)	175	5.71%
Karau et al. ¹² (2014)	102	3.9%
Ramachandran K et al. ¹³ (2014)	120	15.8%
Murugan M et al. ¹⁴ (2014)	150	12.6%
Katikireddi RS et al. ¹⁵ (2014)	100	3%
Yadav Y et al. ¹⁶ (2014)	120	6.67%
Present study (2015)	174	14.36%

CONCLUSION

In the present study we observed 14.36% cases of accessory FT which are more common on right side in both typical & atypical cervical vertebrae. Knowledge of accessory foramen transversarium is important for clinicians because it may affect the course of vertebral vessels & nerves, which causes various symptoms to patients. It is also helpful for spine surgeons in planning surgery around the cervical vertebrae and to avoid post-operative complications. These variations are also of importance and helpful for anatomist, anthropologist and radiologist.

ACKNOWLEDGEMENTS

We sincerely thank the heads of the Departments of Anatomy, Orthopaedics And Forensic Medicine & Toxicology of Patna Medical College (Patna, Bihar, India), Lord Buddha Koshi Medical College (Saharsa, Bihar, India) & Nalanda Medical College (Patna, Bihar, India) for granting the permission to carry out the study in their department.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

REFERENCES

1. Ellis H. Foramen transversarium. In: Ellis H, eds. *Clinical Anatomy*. 5th ed. Miami: MA: Blackwell Publishing; 2006: 325-328.
2. Standring S. "The Back" in *Gray's anatomy: the anatomical basis of clinical practices*. Standring S, Ellis H, Healy JC, eds. *Gray's Anatomy*. 40th ed. New York, NY, USA: Elsevier. Churchill Livingstone; 2008: 718-719.
3. Kaya S, Yilmaz ND, Pusat S, Kural C, Kirik A, Izci Y. Double foramen transversarium variation in ancient byzantine cervical vertebrae: preliminary report of an anthropological study. *Turk Neurosurg.* 2011;21:534-8.
4. Taitz C, Nathan H, Arensburg B. Anatomical observations of the foramina transversaria. *J Neurol Neurosurg Psychiatry.* 1978;41:170-6.
5. Das S, Suri R, Kapur V. Double foramen transversaria: an osteological study with clinical implications. *Int Med J.* 2005;12:311-3.
6. Sharma A, Singh K, Gupta V, Srivastava S. Double foramen transversarium in cervical vertebra an osteological study. *J Anat Soc India.* 2010;59(2):229-31.
7. Murlimanju BV, Prabhu LV, Shilpa K, Rai R, Dhananjaya KVN, Jiji PJ. Accessory transverse foramina in the cervical spine: incidence, embryological basis, morphology and surgical importance. *Turk Neurosurg.* 2011;21(3):384-7.
8. Laxmi C, Shailesh P, Jatin G, Vipul C, Srushti R. Double foramen transversarium in cervical vertebrae: morphology and clinical importance. *Int J Res Med.* 2013;2(1):103-5.
9. Chaudhari ML, Maheria PB, Bachuwar SP. Double foramen transversarium in cervical vertebra. morphology and clinical importance. *Indian J Basic Appl Med Res.* 2013;8(2):1084-8.
10. Rathnakar P, Remya K, Swathi B. Study of accessory foramen transversaria in cervical vertebrae. *Nitte Univ J Health Sci (NUJHS).* 2013;3(4):97-9.
11. Patil NP, Dhapate SS, Porwal S, Bhagwat VB. The study of incidence of accessory foramen transversaria in the cervical vertebra. *J Dent Med Sci.* 2014;13(7):85-7.
12. Karau PB, Odula P. Some anatomical and morphometric observations in the transverse foramina of the Atlas among Kenyans. *Anat J Afr (AJA).* 2013;2(1):61-6.
13. Ramachandran K, Ravikumar PC, Manavalan MS. A study on the foramen transversarium in cervical vertebrae. *Int J Health Sci Res.* 2014;4(12):178-83.
14. Murugan M, Verma S. A study on variation of foramen transversarium of cervical vertebrae. *Natl J Clin Anat.* 2014;3(1):4-7.
15. Katikireddi RS, Setty SNRS. A study of double foramen transversarium in dried cervical vertebra. *Int J Health Sci Res.* 2014;4(1):59-61.
16. Yadav Y, Goswami P, Bharihoke V. An osteological study of foramen transversarium: variations and clinical aspects. *J Evol Med Dent Sci.* 2014;3(68):14562-6.
17. Mishra GP, Kumari S, Bhatnagar S, Singh B. Sixth cervical vertebra with bilateral double foramen transversarium and non-bifid spine: a rare case. *Int J Res Med Sci.* 2015;3(1):352-3.
18. Hadley LA. Tortuosity and deflection of the vertebral artery. *AJR Am J Roentgenol.* 1958;80:306-12.
19. Hyyppa SE, Laasonen EM, Halonen V. Erosion of cervical vertebrae caused by elongated and tortuous vertebral arteries. *Neuroradiology.* 1974;7:49-51.
20. Epstein BS. The spine. In: Epstein BS, eds. *A Radiological Text and Atlas*. 3rd ed. Philadelphia: Lea and Febiger; 1969: 24,25,65.
21. Sim E, Vaccaro AR, Berzlanovich A, Thaler H, Ullrich CG. Fenestration of the extracranial vertebral artery: review of the literature. *Spine.* 2001;26:E139-42.

DOI: 10.5455/2320-6012.ijrms20150418

Cite this article as: Akhtar MJ, Madhukar PK, Rahman S, Kashyap N. A morphometric study of foramen transversarium of dried cervical vertebrae. *Int J Res Med Sci* 2015;3:912-6.