Research Article

A study of presence of accessory foramina transversaria in dry human cervical vertebrae of South Indian origin

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ABSTRACT

Background: The unique feature of cervical vertebrae is the presence of foramen bilaterally in their transverse processes called foramen transversarium (FT). Vertebral artery, vertebral vein, and sympathetic nerve pass through it. Normally, there is one FT on either side. Occasionally, it is either absent or duplicated unilaterally or bilaterally. Thorough anatomical knowledge about such variations is essential for surgeons and clinicians. **Objectives:** The objectives of this study were to find out the incidence of accessory foramen transversarium (AFT) in the cervical vertebrae. **Materials and Methods:** The present work was carried out on 100 dry cervical (including both typical and atypical) vertebrae of unknown age and sex. All the vertebrae were macroscopically examined for the presence of AFT. Vertebrae having AFT unilaterally or bilaterally were separated and photographed. Data compiled and analyzed. **Results:** The incidence of AFT was 20% in the cervical vertebrae including both typical and atypical vertebrae. The presence of AFT was more common in typical cervical vertebrae as compared to atypical vertebrae. Unilateral AFT was more commonly seen. In the present study, atypical cervical vertebrae, namely C1 and C2, have not shown AFT at all.**Conclusions:** Anatomical knowledge of such variations is helpful for spine surgeons, clinicians, radiologists, and neurosurgeons, for better pre-operative planning and treatment.

KEY WORDS: Cervical Vertebrae; Foramen Transversarium; Accessory Foramen Transversarium; Vertebral Artery

INTRODUCTION

The unique feature seen in the cervical vertebrae is the presence of foramina transversaria in the transverse processes of all the cervical vertebrae. In all except the seventh cervical vertebra, the foramen transversarium (FT) normally transmits the vertebral artery and vein and a branch from cervicothoracic ganglion (vertebral nerve).[1] The foramina transversaria are known to exhibit variations in their shape, size, and in number. Sometimes, there may be multiple FT or they may be absent. Etiology of such variations may be related to variations in the course of vertebral artery or may be related to development.[2] An accessory transverse foramen (AFT) is present as a smaller foramen posterior to the FT.[3] As a result, distortion of the course of vertebral artery may occur. The above variations in FT can cause complaints such as headache, migraine attacks, and fainting.[4]

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Knowledge of anatomical variations of cervical spine is vital for surgical procedures that involve the screw fixation. The risk of damage to vertebral artery during surgical procedures increases in cases of osseous and vascular variations of cervical spine.[5] The anatomical knowledge of variations of FT is important for the clinicians, neurologists, neurosurgeons, and radiologists.[2]

There are enough studies and case reports regarding variations in the origin and course of vertebral artery. Relatively, fewer

studies are available on the morphology and incidence of the AFT, especially in Southern India. Hence, the present study was undertaken with the objective to find out the incidence of accessory foramina transversaria (AFT) in the cervical vertebrae of South Indian origin.

MATERIALS AND METHODS

Analytical and cross-sectional study was performed on 100 adult dry cervical vertebrae of unknown age and sex. The study was carried out in the Department of Anatomy, Amala Institute of Medical Sciences, Thrissur, Kerala, India. 100 dried human cervical vertebrae were selected for study after excluding damaged and pathologically abnormal vertebrae from the department of anatomy. Of 100 cervical vertebrae, 45 were atypical (C1, C2, and C7) and 55 were typical cervical vertebrae (C3, C4, C5, and C6). All the vertebrae were macroscopically examined for the presence of AFT. Vertebrae having AFT unilaterally or bilaterally were separated and photographed. The data were compiled and descriptive analysis was done using Microsoft Excel software.

As the study was observational and done on dry human bones, ethical clearance was not required.

RESULTS

Of examined 100 (including both typical and atypical) cervical vertebrae, 20 vertebrae have shown the presence of AFT. Of 20 vertebrae, 12 were having unilateral AFT [Figure 1] and eight were having bilateral AFT [Figure 2]. The percentage of AFT was shown in Table 1.

Of 100 cervical vertebrae, 55 were typical vertebrae (C3, C4, C5, and C6). The incidence of AFT in these vertebrae was shown in Table 2.

Of 100 cervical vertebrae, 45 were atypical vertebrae (C1, C2, and C7). The incidence of AFT in these vertebrae was shown in Table 3.

DISCUSSION

From the observations as per the above tables, it was inferred that the presence of AFT was more common in typical cervical vertebrae as compared to atypical vertebrae. Unilateral AFT was more commonly seen. In the present study, atypical cervical vertebrae, namely C1 and C2, have not shown AFT at all. C7 vertebrae showed only unilateral AFT.

Developmentally, vertebrae form from the sclerotome portions of the somites, which are derived from paraxial mesoderm. The transverse processes of cervical vertebrae are directed laterally and slightly forward. Each transverse process presents an opening called FT. The FT is bounded

Figure 1: Unilateral accessory foramen transversarium

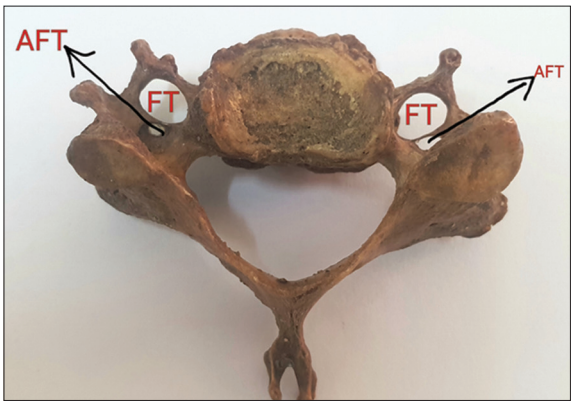

Figure 2: Bilateral accessory foramen transversarium

by anterior root and anterior tubercle, costotransverse bar, posterior tubercle, and posterior root in order. The costal element is represented by anterior root, anterior tubercle, costotransverse bar, posterior tubercle, and distal part of the posterior root. Proximal part of the posterior root represents the true transverse element. Developmentally, FT is formed by fusion vestigial costal element and true transverse process of the cervical vertebra. The vertebral vessels and nerve plexuses are caught between these two bony elements. Developmentally, vertebral arteries are formed from cervical intersegmental arteries which arise from the dorsolateral aspect of the dorsal aorta. These arteries link up with one another and form the longitudinal anastomotic channels, except the seventh cervical intersegmental artery. Remaining arteries regress and modified to form the vertebral artery.[6] When there is failure in controlled regression, it leads to variations in the vertebral artery origin and course. As the vertebral artery passes through FT, variations in vertebral artery might lead to variations in foramen. Hence, it can be interpreted that the variations in the course of the vertebral arteries will lead to variations in FT.[7]

AFT may be unilateral or bilateral, in the present study, we observed that the incidence of AFT in cervical vertebrae was 20%, of which unilateral AFT was 12% and bilateral AFT was 8%. In Table 4, the incidence of the AFT in the present study was compared with various other studies.

From Table 4, we can see that incidence of AFT varies from 1.5% to 27.33%. A study done by Das *et al.*,[2] on 132 vertebrae, it was observed double foramina transversaria unilaterally and bilaterally only in two cervical vertebrae, respectively. However, Taitz *et al.*[7] from their study observed doubling of FT in 34 cases of 480 cervical vertebrae amounting to 7%. In the same study, it was also reported triple foramina transversaria in one vertebra and absent foramen in four vertebrae.[7] In the present study, 20 vertebrae showed AFT of 100, and we did not observe more than one AFT. In the present study, we also observed that the incidence of AFT is more in typical cervical vertebrae as compared to atypical. Of 133 cervical vertebrae studied by Chaudhari *et al.*,[14] double foramina transversarium was observed in 22 vertebrae (23.15%), of which unilateral double foramen was found in 14 vertebrae (14.73%), and the bilateral was found in 8 vertebrae (8.42%). The above results were more in conformity with our study. Compared to other South Indian studies done by Murlimanju *et al.*,[8] Ambali MP *et al.*,[13] Sumalatha and Manasa,[17] and Katikireddi *et al.*,[18] the present study results were more in line with the North Indian studies such as Patra *et al.*[16] and Choudhari *et al.*[14] Knowledge of variations in the morphology of FT in cervical vertebrae is clinically important because the course of the vertebral artery may be distorted under such condition. Even the presence of extraforaminal in the transverse processes may indicate multiplication of the number of structures running through them. Hence, understanding of such anatomical variations is very much relevant for clinicians, surgeons, and radiologists.

Limitations

The sample size was small, limited to 100 vertebrae.

Table 1: Percentage of AFT in cervical vertebrae

Total number of cervical vertebrae	Number of vertebrae with AFT	Unilateral AFT	Bilateral AFT
N=100	20 (20%)	12 (12%)	8 (8%)

AFT: Accessory foramen transversarium

Table 2: Percentage of AFT in typical cervical vertebrae

Total number of typical cervical vertebrae	Number of vertebrae with AFT	Unilateral AFT	Bilateral AFT
55	16 (29.09%)	8 (14.54%)	8 (14.54%)

AFT: Accessory foramen transversarium

Table 3: Percentage of AFT in atypical cervical vertebrae

Total number of atypical cervical vertebrae N=45	Number of vertebrae with AFT	Unilateral AFT	Bilateral AFT
C1	0	0	0
C2	0	0	0
C7	4	4 (8.88%)	0

AFT: Accessory foramen transversarium

Table 4: Comparison of incidence of AFT with other studies

Authors	Number of cervical vertebrae	Incidence of AFT (%)	Unilateral AFT (%)	Bilateral AFT (%)
Das *et al.*[2]	132	1.5	-	-
Taitz *et al.*[7]	480	7	-	-
Murlimanju *et al.*[8]	363	1.60	1.40	0.30
Shah *et al.*[9]	210	16.19	9.52	6.67
Sharma *et al.*[10]	200	8	3.50	4.50
Gujar *et al.*[11]	150	27.33	18	9.33
Akhtar *et al.*[12]	174	14.36	11.49	2.87
Ambali MP *et al.*[13]	163	14.72	4.90	9.81
Chaudhari *et al.*[14]	133	23.15	14.73	8.42
Mishra *et al.*[15]	220	14.09	4.54	9.54
Patra *et al.*[16]	150	22	10.67	11.33
Sumalatha and Manasa[17]	148	11.48	5.40	6.08
Katikireddi *et al.*[18]	100	3	2	1
Present study 2018	100	20	12	8

AFT: Accessory foramen transversarium

CONCLUSION

The incidence of AFT in the present study was 20%. AFT was more common in typical cervical vertebrae as compared to atypical vertebrae. Unilateral AFT was more commonly seen than bilateral AFT. The first and second cervical vertebrae (atypical) have not shown AFT at all. Among the atypical vertebrae, only the seventh vertebra showed unilateral AFT. A thorough knowledge of these variations will be helpful to clinicians, radiologists, and neurosurgeons.

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