# Accessory Transverse Foramen in Cervical Vertebrae: A Morphological Study

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## ABSTRACT

**Background**

Cervical vertebrae are irregular bone. Seven cervical vertebrae form the cervical region of the vertebral column, which encloses the spinal cord and meninges. The cervical vertebra has a characteristic feature that is presence of foramen in transverse process. Out of seven cervical vertebrae, 3rd - 6th cervical vertebrae are typical and remaining are atypical ones.

**Objective**

To observe the presence of accessory transverse foramen and shape of accessory foramen.

**Method**

The study was conducted on forty-eight cervical vertebrae available at Department of Anatomy, School of Basic Sciences, and Chitwan Medical College from July 2023 to January 2024. Total dry forty-seven human cervical vertebrae were included in the study. Out of them five were atypical (four atlas and one axis). The ethical approval was provided by CMC IRC on 4th January 2024 (CMC-IRC/080/081-078). All observations were taken by same investigator. All observations were recorded in preformed proforma. All observations were taken by same investigator. All observations were recorded as data in preformed proforma. Data entered in Epidata 3.1 version. Statistical analyses were done using SPSS 20.

**Result**

Total dry forty-seven human cervical vertebrae were included in the study. Out of them five were atypical cervical vertebrae (four axis and one atlas). One was excluded due to observed defect and damaged vertebrae. Out of forty-two accessory foramens of typical cervical vertebrae two were bilateral complete, two were one complete and other incomplete, one right sided unilateral complete and one left sided unilateral incomplete. Accessory foramen transversarium was absent in all five atypical cervical vertebrae.

**Conclusion**

Knowledge of variations of the presence of accessory transverse foramen in the typical cervical vertebrae is not only important to anatomist but also to radiologist in identifying the presence of duplicate vertebral artery and hence helping the neuro surgeons in preventing accidental bleeding from the vertebral artery while performing surgery on the cervical spine.

## KEY WORDS

*Accessory transverse foramen, Cervical vertebrae, Foramen transversarium*

## INTRODUCTION

Cervical vertebrae are irregular bone. Seven cervical vertebrae form the cervical region of the vertebral column, which encloses the spinal cord and meninges. The stacked, centrally placed vertebral bodies support the head, and the intervertebral (IV) articulations especially the craniovertebral joints at its superior end provide the flexibility necessary to allow positioning of the head. The cervical vertebra has a characteristic feature that is presence of foramen in transverse process. Out of seven cervical vertebrae, 3rd - 6th cervical vertebrae are typical and remaining are atypical ones.[1]

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 normally transmits the vertebral artery and vein and a branch from cervicothoracic ganglion (vertebral nerve).[2]

The foramen transversarium is a result of the special formation of the cervical transverse processes. It is formed by the vestigial costal element fused to the body and the true transverse process of the vertebra. The vertebral vessels and nervous plexus are caught between these two bony parts. The foramen transversarium is closed laterally by the costotransverse bar, a thin plate of bone connecting the rib element to the original transverse process.[3]

Presence of accessory foramen transversarium may leads to its vertebral artery compression that results in headache, migraine and fainting attacks. The anatomy and morphology of foramen transversarium is useful to the operating spine surgeons and radiologists in the interpretation of radiographic films and computed tomogram scans.

## METHODS

The study was conducted on forty-eight cervical vertebrae available at Department of Anatomy, School of Basic Sciences, and Chitwan Medical College from July 2023 to January 2024. The ethical approval was provided by CMC IRC on 4th January 2024 (CMC-IRC/080/081-078). Out of them five are atypical cervical vertebrae (four atlas and one axis). All observations were taken by same investigator. All observations were recorded in preformed proforma. All observations were taken by same investigator. All observations were recorded as data in preformed proforma. Data entered in Epidata 3.1 version software. Statistical analyses were done using SPSS 20 software.

## RESULTS

Total dry forty-seven human cervical vertebrae were included in the study. Out of them five are atypical cervical vertebrae (four axis and one atlas). One was excluded due to observed defect and damaged vertebrae.

**Table 1.** Table Showing Number of Typical and Atypical Vertebrae

| Typical Cervical Vertebrae | Atypical Cervical Vertebrae (n=5) | | |
|---|---|---|---|
| | First | Second | Seventh |
| 42 | 1 | 4 | - |

**Figure 1.** Typical cervical vertebrae

**Figure 2.** First Cervical Vertebrae

**Figure 3.** Second Cervical Vertebrae

**Table 2.** Classification of Cervical Vertebrae with Accessory Foramen Transversarium

| Category | | Typical cervical vertebrae (n=42) | Atypical cervical vertebrae (n= 5) | | |
|---|---|---|---|---|---|
| Bilateral | Bilateral complete | 2 | - | - | - |
| | One complete other incomplete | 2 | - | - | - |
| | Bilateral incomplete | - | - | - | - |
| Unilateral | Complete | 1 (right) | - | - | - |
| | Incomplete | 1 (left) | - | - | - |

Among the accessory foramen transversarium of forty-two typical cervical vertebrae two were bilateral complete, two were one complete and other incomplete, one right sided unilateral complete and one left sided unilateral incomplete. Accessory foramen transversarium was absent in all five atypical cervical vertebrae.

**Table 3.** Classification of Cervical Vertebrae with Foramen Transversarium

| Category | Typical Cervical Vertebrae | | Atypical Cervical Vertebrae | | |
|---|---|---|---|---|---|
| | | | 1st | 2nd | 7th |
| Bilateral | Bilateral complete | 42 | 1 | 4 | |
| | One complete other incomplete | - | - | - | - |
| | Bilateral Incomplete | - | - | - | - |
| Unilateral | Complete | - | - | - | - |
| | Incomplete | - | - | - | - |

Among the foramen transversarium of forty-two typical cervical vertebrae all showed bilateral complete foramen transversarium. A single first cervical vertebra and four second cervical vertebrae showed bilateral complete foramen transversarium respectively. Among the five atypical cervical vertebrae, single first cervical vertebra and four second cervical vertebrae showed bilateral complete foramen transversarium.

**Figure 4.** Typical Cervical Vertebrae with Bilateral Complete Foramen Transversarium

**Figure 5.** First Cervical Vertebrae with Bilateral Complete Foramen Transversarium

**Figure 6.** Second Cervical Vertebrae with Bilateral Foramen Transversarium

**Table 4.** Shape of Foramen Transversarium

| Category | Typical Cervical Vertebrae (n=42) | | Atypical Cervical Vertebrae (n=5) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Right | Left | 1st | | 2nd | | 7th | |
| | | | Right | Left | Right | Left | Right | Left |
| Round | 16 | 18 | - | - | 2 | 2 | - | - |
| Oval | 26 | 19 | 1 | 1 | 2 | 2 | - | - |
| Elliptical | 2 | 2 | - | - | - | - | - | - |
| Kidney | 1 | - | - | - | - | - | - | - |

Among the foramen transversarium of forty-two typical cervical vertebrae. sixteen on right side and eighteen on left showed rounded shape; twenty-six on right side and nineteen on left side showed oval shape; two on right and left side showed elliptical shape and one on right side showed kidney shaped foramen transversarium.

Among forty-two typical cervical vertebrae, the accessory foramen transversarium was found to be bilaterally absent. Among the remaining vertebrae the shape of accessory foramen transversarium on left side showed one round, three oval, one elliptical, two crescentic and one semilunar. Out of five atypical cervical vertebrae (one first cervical and four second cervical vertebrae) showed lack of accessory foramen transversarium on both sides.

**Figure 7.** Typical cervical vertebrae with Bilateral Oval Shaped Foramen Transversarium

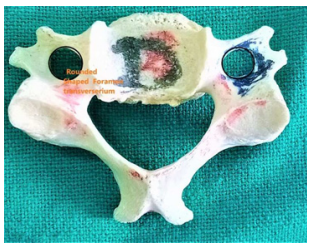

**Figure 8.** Typical cervical vertebrae with Bilateral Rounded Shaped Transverse Foramen

**Figure 9.** Typical Cervical Vertebrae with Bilateral Elliptical Transverse Foramen

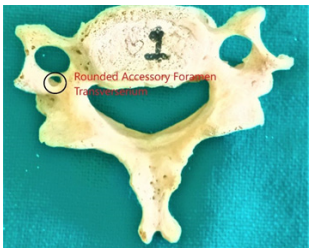

**Figure 10.** Rounded Left Sided Accessory Transverse Foramen

**Figure 11.** Elliptical Accessory Transverse Foramen (Black encircled)

**Figure 12.** Oval Shaped Accessory Transverse Foramen (Black encircled)

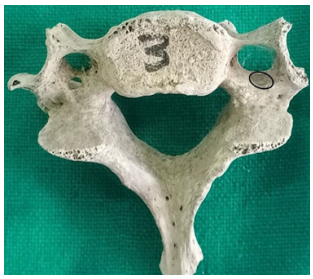

**Figure 13.** Semilunar Accessory Transverse Foramen (Black encircled)

**Figure 14.** Crescentic Accessory Transverse Foramen (Black arc marked)

## DISCUSSIONS

Various researchers have reported anatomical variations in the foramina transversarium in its number double or multiple, absence or variation in the shape of foramen

**Table 5. Shape of Accessory Transverse Foramen**

| Category | Typical Cervical vertebrae (n=42) | | | Atypical Cervical vertebrae (n=5) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Right | Left | Absent | 1st | | | 2nd | | | 7th | | |
| | | | | Right | Left | Absent | Right | Left | Absent | Right | Left | Absent |
| Round | 1 absent | 1 | | - | - | One both side absent | - | - | Four both side absent | - | - | - |
| Oval | 3 | 2 | | - | - | | - | - | | - | - | - |
| Elliptical | 1 | 1 | | - | - | | - | - | | - | - | - |
| Crescentic | 1 | 1 present And 1 absent | | - | - | | - | - | | - | - | - |
| Semilunar | 1 | - | | - | - | | - | - | | - | - | - |

transversarium. In present study, we found that out of forty-seven cervical vertebrae, forty-two were typical cervical vertebrae and five atypical cervical vertebrae. Out of five atypical vertebrae, four were atlas and one axis. Among forty-two typical cervical vertebrae, the accessory foramen transversarium was found to be bilaterally absent. Among the remaining vertebrae the shape of accessory foramen transversarium on left side showed one round, three oval, one elliptical, two crescentic and one semilunar. Out of five atypical cervical vertebrae (one first cervical and four second cervical vertebrae) showed lack of accessory foramen transversarium on both sides.

Taiz et al. conducted a study on four and eighty transverse foramina showed that single oval shaped, two circular and three elliptical transverse foramina. Eight single transverse foramen, 34 double transverse foramen and absent in four cervical vertebrae.[3]

Gupta et al. performed a study on 248 cervical vertebrae showed that transverse foramen found in all cervical vertebrae.[4] Accessory transverse foramen found in 49 cervical vertebrae (38 typical and 11 atypical). Among atypical vertebrae Accessory transverse foramen absent in 1st and 2nd cervical vertebrae and only 7th cervical vertebrae found with presence of Accessory transverse foramen. Bilateral Accessory transverse foramen observed in 21 cervical vertebrae. Nineteen typical and 2 atypical cervical vertebrae. Unilateral Accessory transverse foramen observed in 28 cervical vertebrae (19 typical and 9 atypical cervical vertebrae).[4]

Agrawal et al. studied dry typical cervical vertebrae showed cervical vertebrae having four unilateral double transverse foramen, two bilateral double transverse foramen, one asymmetrical transverse foramen and one incomplete transverse foramen.[5]

Esakkiammal et al. concluded from the study on 241 dry cervical vertebrae that accessory transverse foramen was either bilateral complete in four or incomplete nine or unilateral complete six and unilateral incomplete 12 were observed.[6] Six typical cervical vertebrae showed presence of complete accessory transverse foramen on one side and incomplete accessory transverse foramen on the other side in the same vertebra.[6]

Muralimanju et al. studied 363 cervical vertebrae which showed that only six vertebrae showed the accessory foramina.[7] Among them five vertebra had double foramina and only one vertebra showed three foramina. Only one vertebra showed the foramen on both sides and the remaining five had unilateral foramina. Among the unilateral, four were present on the right side and only one was on the left side. No vertebrae showed the absence of foramen transversarium.[7]

Ratnakar et al. concluded from a study among 140 cervical vertebrae that eight out of 140 vertebrae presented accessory foramen transversaria. Five vertebrae had unilateral accessory foramen and two vertebrae had bilateral double foramen transversaria. One of the vertebrae showed multiple foramen transversaria on right side and incomplete accessory foramen transversarium on the left.[8]

Malik et al. studied 420 cervical vertebrae belonging to 60 sets of skeletons showed that double transverse foramen was observed in 58 cervical vertebrae, out of vertebrae showing double transverse foramen, 21 vertebrae showed bilateral double transverse foramen whereas 37 vertebrae showed unilateral double transverse foramen.[9] Out of vertebrae showing double transverse foramen, 21 vertebrae showed bilateral double transverse foramen whereas 37 vertebrae showed unilateral double transverse foramen.[9]

Single accessory transverse foramen was found in four cases on the left side and two cases on both the sides, whereas double accessory transverse foramen was found in one case on the left side only. No triple FT was found.[10]

Gul et al. conducted a study among hundred cervical vertebrae showed presence of nine accessory transverse foramen.[11] Bilateral presence of accessory foramen transversarium was observed in four cervical vertebrae. Five cervical vertebrae showed unilateral accessory foramen transversarium. Absent foramen transversarium was found in none of these vertebrae.[11]

Agrawal et al. performed a study on Out of 160 cervical vertebrae, eight were found to have anomalous foramen transversarium.[12] Four of them had double foramen

transversarium unilaterally (3 on the right side). Bilateral double foramen transversarium were observed in two cases. One case showed asymmetry in the size of foramen transversarium and in another, there was a bony spicule incompletely dividing the transverse foramen.[12]

Katireddi et al. concluded from a study of hundred cervical vertebrae showed the presence of double transverse foramen in three vertebrae, Bilateral double foramen was seen in single vertebrae and unilateral double foramen transversarium was seen in two vertebrae (one on right side and another one on left side.[13]

Gujar et al. performed study on 150 vertebrae, accessory foramen transversarium was found in 41 vertebrae. Among 41 vertebrae unilateral accessory foramen transversarium was found in 27 vertebrae and bilateral was found in 14 vertebrae.[14]

Ramachandran et al. showed from the study conducted on 120 cervical vertebrae that accessory Foramen transversarium was observed in 19 vertebrae.[15] Out of this, ten vertebrae showed unilateral accessory foramen transversarium and nine vertebrae showed bilateral accessory foramen transversarium. Five shapes of foramen transversarium were observed and round shape was the predominant shape observed in 76 vertebrae.[15]

Chaudari et al. studied 133 dried cervical vertebrae which showed 22 cervical vertebrae with double transverse foramen.[16] Among them seven unilateral accessory transverse foramina found in 7th cervical vertebra. the double accessory transverse foramina were observed only in the lower cervical vertebrae (C5, C6, C7).[16]

The study with limited sample size which represents the limited sample population conducted in limited study period.

## CONCLUSION

Knowledge of variations of the presence of accessory transverse foramen in the typical cervical vertebrae is not only important to anatomist but also to radiologist in identifying the presence of duplicate vertebral artery and hence helping the neuro surgeons in preventing accidental bleeding from the vertebral artery while performing surgery on the cervical spine.

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