A Morphologic and Morphometric Study of the Foramen Transversarium of the Cervical Vertebrae: An Osteological Study in Upper Egypt

Salwa M. Ouies

Lecturer of Human Anatomy and Embryology, Faculty of Medicine, Sohag University, Egypt.
salwaouies@yahoo.com

Abstract: Introduction: The Knowledge of variations in foramen tranversarium of the cervical vertebrae is surgically important, as its anatomical relation with the third part of vertebral artery is one of the proposed causative factors for cervicogenic headache. **Aim of work:** This study was aimed to determine the morphological and morphometrical variations of foramen transversarium (FT) of cervical vertebrae in Upper Egypt. **Methods:**100 cervical vertebrae were collected from Anatomy department of medical College of Sohag and Assiut universities. Each vertebra was examined for the shape of foramen tranversarium and their dimensions were measured. Any other variation observed was also noted. Results were statistically analysed for side and size variation. **Results**: The foramen transversarium take one of 5shapes: rounded, oval with more AP diameter, oval with more transverse diameter, elliptical and triangular. There were no significant differences between the right and left as regard the antroposterior and transverse diameters **Conclusion**: Morphological variations in foreman transversarium are significant as they lead to neurological conditions due to the flow of blood passing through these openings except for C7.

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1. Introduction

There are 7 cervical vertebrae in the human. The first, second and seventh cervical vertebra are known as atypical, while other 4 are typical vertebrae. The cervical vertebrae are identified by the presence of a Foramen Transversarium (FT) in each lateral process. Vertebral artery, vertebral vein and the surrounding plexus sympathicus pass through it. Vertebral artery don't pass through C7's FT, there is only accessory vertebral vein **(1).**

The foramen transversarium (FT) of cervical vertebrae reveals extensive variability in its morphology and morphometry, it may be duplicated or even absent **(2**).

The occurrence of vertebrobasilar insufficiency caused by rotation of the head has been reported due to thickened fibroligamentous structures, osteophyte formation, thyroid cartilage compression, and congenital absence of the transverse foramen **(3).**

The compression of the vertebral artery as a result of stenosis of the transverse foramen may also lead to clinically important consequences for patients at risk. **(4)**.

Aims & Objectives:

The purpose of this work was to study the Morphologic and Morphometric variations of the foramen transversarium in dry human bones in Upper Egypt.

2. Material and Methods:

- 100 complete dried human cervical vertebrae were obtained from Anatomy department of medical College of Sohag and Assiut universities. The data on age, sex, race, and built of the individuals from which these vertebrae were derived was not available. It was not possible to specify if the vertebra is C3/C4/C5 or C6.
- The vertebrae were studied as seen from above in an antero-posterior direction with the arch of the vertebrae facing the examiner:
- Measurements was done using a VWR digital stainless steel vernier caliper with 0.01 mm accuracy,

- The anteroposterior and transverse diameters of transverse foramina were measured bilaterally (in mm). The caliper was placed within each foramen and the widest transverse and anteroposterior diameters were measured.
- Statistical analysis were done using SPSS soft ware version 16. Variables were represented by mean ± SD (mean ±standard deviation of mean). A

student t-test, were performed to determine if there was a significant difference between the right and left sides. the significance was considered according to the level of significance p value as follows:

P > 0.05 non significant.
P ≤ 0.05 significant *
P ≤ 0.01 highly significant**

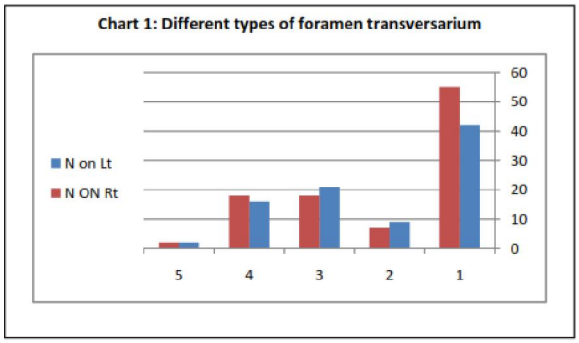
3. Results

This study was done on 100 cervical vertebrae for observation of 200 foramen transversarium according to

A) The shape and direction of the foramen transversarium which take one of five types (chart 1, figure 1).

- Type 1 – round.
- Type 2 – oval with main diameter [length] anterior-posterior.
- Type 3-– oval with main diameter [length] transverse.
- Type 4– elliptical with main diameter oblique from right to left.
- Type 5- triangular.

Type	shape	Number on Rt	Number on Lt
Type.1		55	52
Type.2		7	9
Type.3		18	21
Type.4		18	16
Type.5		2	2



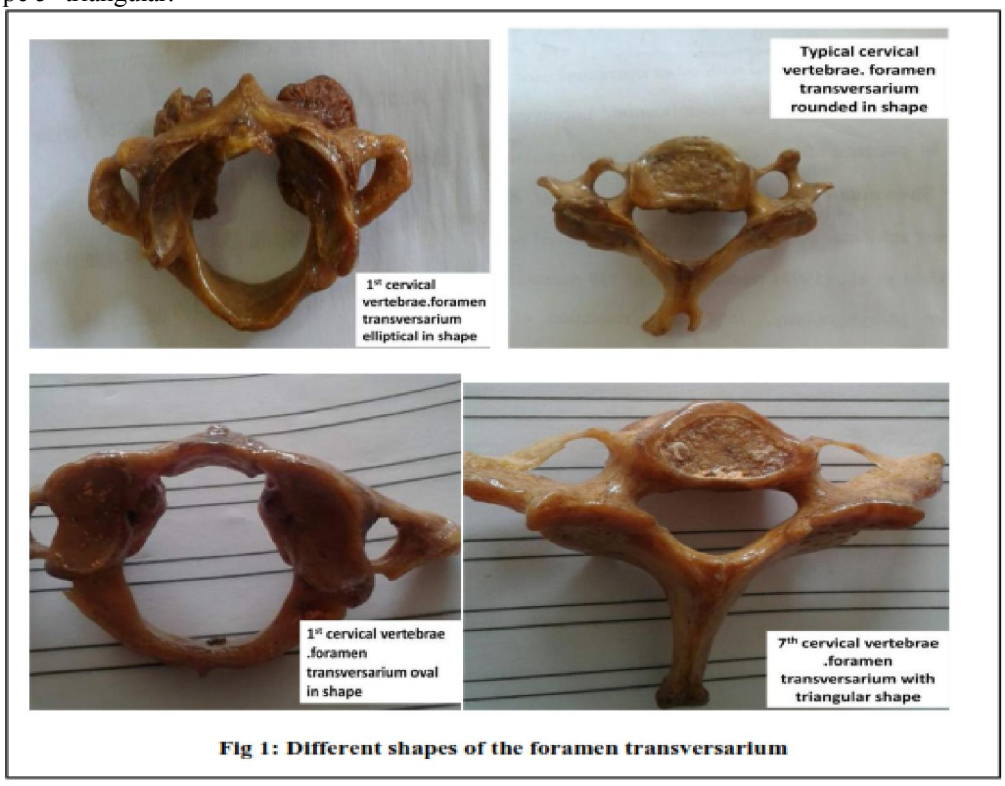


Fig 1: Different shapes of the foramen transversarium

B) Accessory foramen (Fig 2)

Accessory foramens were observed in 19vertebrae. Incidence was calculated to be 19%. The accessory FT were unilateral in 10 vertebrae (10%) present mostly on the left side. They were present bilaterally in 9vertebrae (9%).

The accessory foramina were smaller compared to the regular foramina. All the accessory foramen were posterior to the main FT.

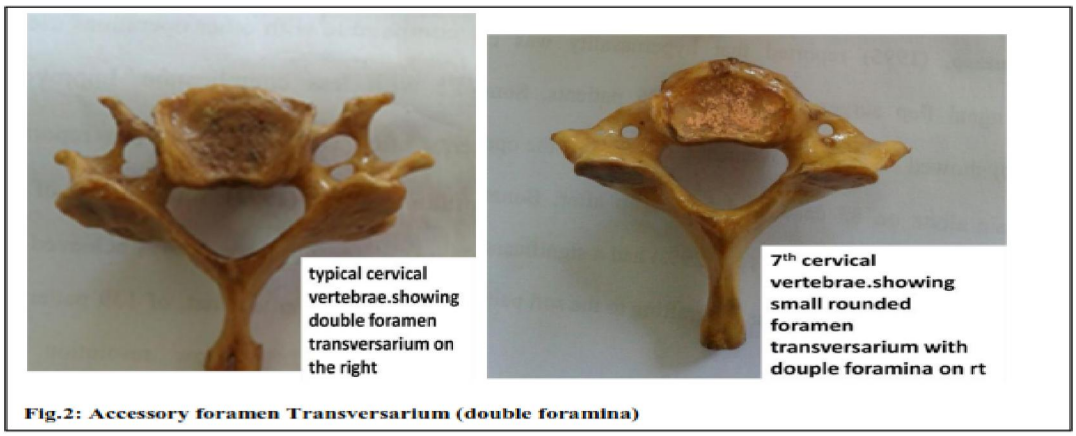


Fig.2: Accessory foramen Transversarium (double foramina)

C) The antroposterior diameters of the foramen transversarium for C1 to C7 cervical vertebra were calculated (Table 1 chart 2).

- There were no significant differences between the antroposterior diameter of the atlas on the right rang from5.9 to 8.9(mean=7.3) and on the left rang from 5.53 to 8.93(mean=7.2).
- There were no significant differences between the antroposterior diameter of the axix on the right rang from 3.64 to 5.84 (mean=5,2) and on the left rang from 3.03 to 6.51 (mean=5.1).
- There were no significant differences between the antroposterior diameter of the typical cervical vertebrae (C3-6) on the right rang from 4 to7.92 (mean=5.8) and on the left rang from 4.2 to6.81 (mean=5.4).
- There were no significant differences between the antroposterior diameter of the 7th cervical vertebrae on the right rang from 2.66 to 7.8 (mean=4.9) and on the left rang from 2.81 to8.24 (mean=5.0).

Table 1: antroposterior diameters of the foramen transversarium for C1 to C7 cervical vertebra

	Right. AP	mean±SD	Left AP	mean±SD	P value (between Rt and Lt)
Atlas (n=20)	5.9-8.9	7.3±.87	5.53-8.93	7.2±.89	.6
Axis (n=13)	3.64-5.84	5,2±.67	3.03-6.51	5.1±1.1	.7
Typical (n=40)	4-7.92	5.8±1.1	4.2-6.81	5,4±.6	.09
7th (n=27)	2.66-7.8	4.9±1.6	2.81-8.24	5±1.5	.68

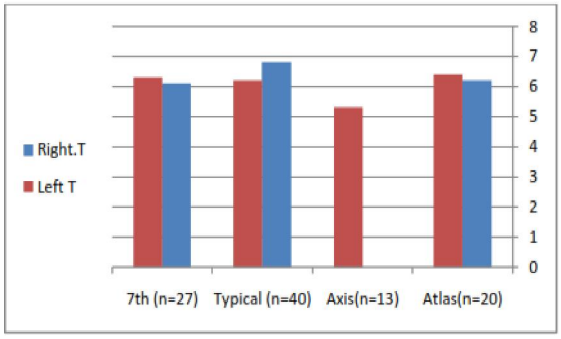


Chart 2: antroposterior diameters of the foramen transversarium for C1 to C7 cervical vertebra

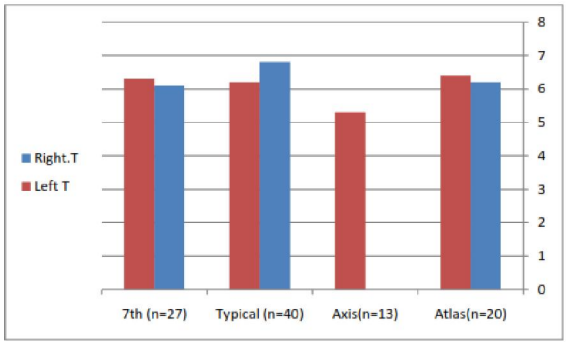


Chart 3: Transverse diameters of the foramen transversarium for C1 to C7 cervical vertebra

C) **The Transverse diameters of the foramen transversarium for C1 to C7 cervical vertebra were calculated** (Table 2 chart 3).

There were no significant differences between the transverse diameter of the atlas on the right rang from 5.08 to 8.09 (mean=6.2) and on the left rang from 5.19 to804 (mean=6.4).

There were no significant differences between the transverse diameter of the Axis on the right rang from 3.53 to 6.47 (mean=4.9) and on the left rang from 4.22 to7.3 (mean=5.3).

There were no significant differences between the transverse diameter of the typical vertebrea on the right rang from 4.8 to 9.75 (mean=6.8) and on the left rang from 4.4 to 8.1 (mean=6.2).

There were no significant differences between the transverse diameter of the 7th vertebrea on the right rang from 3.26 to12.8 (mean=6.1) and on the left rang from 3.26-16.01 (mean=6.3).

Table 2: Transverse diameters of the foramen transversarium for C1 to C7 cervical vertebra.

	Right T	mean	Left T	mean	P value (between Rt and Lt)
Atlas (n=20)	5.08-8.09	6.2±.93	5.19-804	6.4±.84	.4
Axis (n=13)	3.53-6.47	4.9±1.0	4.22-7.3	5.3±1.1	.36
Typical (n=40)	4.8 -9.75	6.8±1.1	4.4 -8.1	6,2±1.0	.14
7th (n=27)	3.26 -12.8	6.1±2.5	3.26-16.01	6.3±2.5	.7

4. Discussion:

The vertebral vessels are the important in the creation of the FT, it can be obvious that variations in the existence and course of the vertebral vessels will be concluded variation in FT. A narrowing of the FTs point out narrowness of the vessels and so on. **(5).**

Variable shapes of foramen transversarium have been known to have a correlation with the tortuosity and size of vertebral artery, which is inturn dependent subsequent to loading forces and stresses in the neck **(6).**

In this study The anteroposterior and mediolateral diameter didn't show any significant side variation. However in a study conducted on 102 atlas vertebrae of Kenyan population the antreoposterior diameter was found to be significantly larger on right side **(7).** It is said that preponderance of osteophytes on lateral margins of FT could lead to narrowing of mediolateral diameter leading to compression of vertebral artery and its dissection **(8).**

Studies have shown that left FT has larger area as compared to right FT which is in parallel with bigger size of vertebral artery on left side (**9).**

Studies report that vertebrae with anteroposterior diameter greater than transverse diameter had minimal risk of vertebral artery compression syndrome. also, it is well known that any narrowing of FT may result in formation of atheromatous plaques in vertebral artery which may result in thrombosis/emboli /reflex spasm which presdisposing to vertebrobasilar insufficiency **(10).**

In Comparison with the present study which report accessory FT in 19% cases (mainly in the left) previous studies report presence of the accessory **foramen in** 24% cases **in** typical cervical **(11)** and in 13.72% **cases (12).** A double foramen of the transverse process with disproportion in the diameter may indicate a splitting of the vertebral artery and its renewed joining **(13)**.

The vertebrae characterized by significant narrowing of the transverse foramen when the dimensions were smaller than one standard deviation away from the mean dimension (14).

With this method we found that most of the transverse foramina of cervical vertebrae in this study were within ±1 SD.

- It said that the different variants and developmental defects of the atlas often occur together, especially in families by hereditary transmission **(15**). These variants could be accompanied by other defects within the vertebral column, deformation of the skull base, and cervical ribs (**16).**

Conclusion

- Knowing the significance, incidence and variations of double FTs during cervical surgery would be critical in avoiding misdiagnosis.
- No significant differences between the right and left FTs are seen.
- No significant narrowing were seen in studying FTs of cervical vertebrae in upper Egypt.

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