

Morphometric study of sternal foramen in adult human dry sternum

K Arumugam, GA Jos Hemalatha

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ABSTRACT

Sternal foramens are congenital defects of sternum. It develops as a result of incomplete fusion of sternabrae. This study was conducted in Department of Anatomy, Tirunelveli Medical College, Tirunelveli in 50 adult dry sternum. Our aim is to observe the presence or absence of the sternal foramen, the

location, number, shape and size of the foramen. In our study 14% of sternum has sternal foramen. Single foramen is present in 5 bones, Double foraminae present in 2 bones. We review our study with previous studies. Awareness of sternal variations such as sternal foramen is important for Radiologists and in Forensic Medicine for proper interpretation. Sound knowledge about this variant is important in bone marrow aspiration and acupuncture practice to avoid complications.

Key Words: *Sternabrae; Foramen; Acupuncture*

INTRODUCTION

The sternum or Breast bone has three parts. They are from above downwards are Manubrium (Prosternum), Body of sternum (Mesosternum) and Xiphoid process (Metasternum). Manubrium sternum has notch over upper border known as jugular notch. On either side there is an articulation facet for clavicle forming sternoclavicular joint (1-6). On the lateral border, there are one full articular facet articulating with 1st costal cartilage forming 1st chondrosternal joint and one demi facet which articulate with the part of 2nd costal cartilage forming 2nd chondrosternal joint.

The body of the sternum articulating above with the manubrium forming manubrio-sternal joint and below articulating with the xiphoid process forming xiphi-sternal joint. The lateral border of the body of sternum have three full facet for 3rd to 6th costal cartilages and two demi facet for 2nd and 7th costal cartilages (7-12).

Body of the sternum is developed from four mesenchymal bars called as sternal bars. Chondrification of the sternal bars taking place from cranial to caudal and form sternabrae. The sternum developed from the six ossification centres. One ossification centre for manubrium, four ossification centre for body of the sternum and one for xiphoid process. The ossification centres for upper part developed earlier and subsequently proceed further downwards. Timing of appearance of ossification centres as follows, 6th IUL appear in the manubrium and 1st piece of body of sternum, 7th IUL second and third piece of body of the sternum, in the first year fourth piece of sternum and for xiphoid process ossification center developed between 5th to 18th year (13-17). Failure of fusion of the sternabrae leads to development of sternal foramen. This is most commonly occurring in between the 3rd and 4th sternabrae. Irregular union, number and position of the ossification centers are the caused for occurrence of sternal foramen.

The morphometric study of the sternal foramen is important in Acupuncture practice and sternal marrow aspiration to prevent the damage of vital structures like pericardium and heart. Knowledge of the existence of such anatomic variants is important to avoid misdiagnosis as an osteolytic process (18-20).

AIM OF THE STUDY

- To study the presence or absence of sternal foramen.
- To study the site, size, shape and number of sternal foramen.

METHODS AND MATERIALS

50 dried human adult sternums were examined grossly from Department

of Anatomy, Tirunelveli Medical College, Tirunelveli for sternal foramen and their variations.

The size of the sternal foramen is measured with the help of digital vernier caliper. Photographic documentation was done.

RESULTS

Presence or absence of sternal foramen

In our study, sternal foramen was present in 7 sternums out of 50 bones, (14%). In the remaining bones sternal foramen was absent (86%), (Table 1).

Number of sternal foramina

TABLE 1

Incidence of sternal foramen

Sl. No	Presence of sternal foramen	Absence of sternal foramen
1	7 (14%)	43 (86%)

TABLE 2

Incidence of number of sternal foramen

Sl. No	Single foramen	Double foramen
1	5	2



Figure 1: Single sternal foramen.

Department of Anatomy, Tirunelveli Medical College, Tirunelveli, Tamilnadu, India.

Correspondence: Dr. GA Jos Hemalatha, Associate Professor, Department of Anatomy, Tirunelveli Medical College, Tirunelveli, Tamilnadu, India, Tel: 9443418663; E-mail: gajoshemalatha@gmail.com

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Figure 2: 2a and 2b-double sternal foramen.

In our study single sternal foramen was noted in 5 bones. Double sternal Foraminae is present in only 2 bones (Table 2 and Figures 1, 2).

Site of Sternal foramen

Out of 7 sternums having sternal foramen, the foramen present over manubrium in 1 bone, foramen present over the body in 3 bones, foramen seen over the xiphoid process in remaining 3 bones.

Among the 3 sternal foramen over the body of the sternum, in 2 bones, sternal foramen present at the junction of 2nd and 3rd sternal segment and in another bone present at the junction of 3rd and 4th sternal segment (Table 3).

The foramen present in the manubrium sternum and xiphoid process is double in number (Figures 3-5).

Shape of sternal foramen

Sternal foramen over manubrium and body of sternum is round in shape. Those over xiphoid process are oval in shape (Table 4).

Size of sternal foramen

The size of sternal foramen is measured with Vernier caliper and recorded. Sizes of all the foramens were more or less equal except in one where the size is more (40 x 5 mm) (Table 5 and Figure 6).

TABLE 3

Location of sternal foramen

Sl. No	Site of sternal foramen		
	Manubrium	Body of sternum	Xiphoid process
1	1	3	3

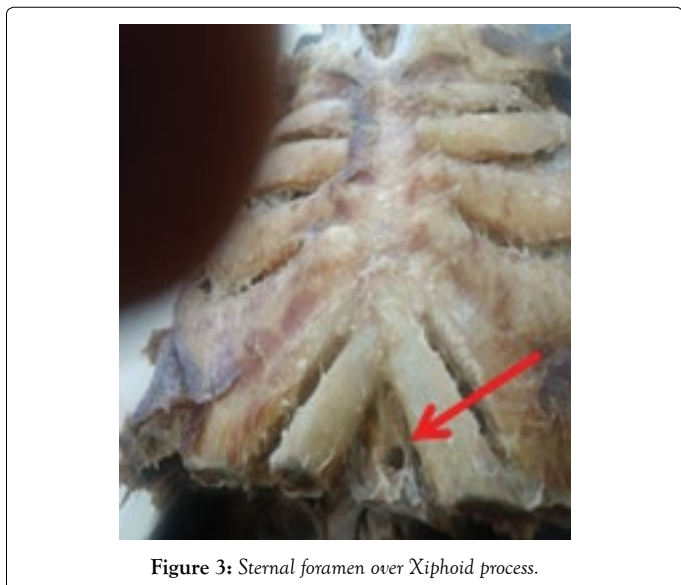


Figure 3: Sternal foramen over Xiphoid process.

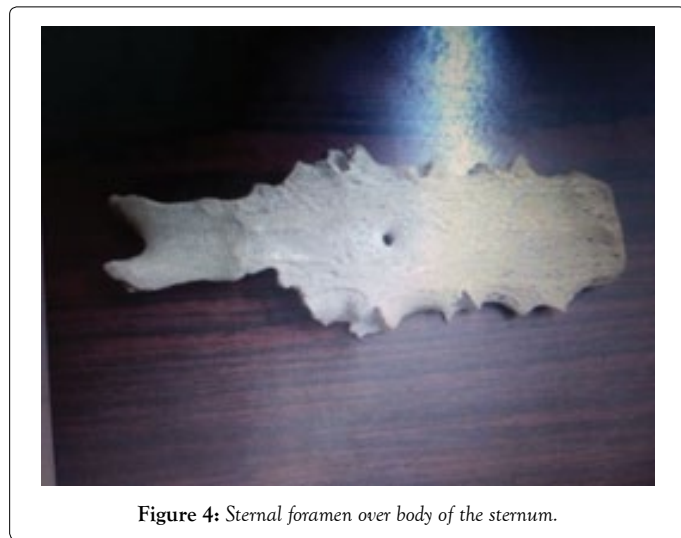


Figure 4: Sternal foramen over body of the sternum.



Figure 5: Sternal foramen over xiphoid process.

TABLE 4

Shape of sternal foramen

Sl. No	Shape of sternal foramen	
	Round	Oval
1.	4	3

TABLE 5

Size of sternal foramen

Sl. No	Size of Foramen
1.	15 x 15 mm
2.	18 x 15 mm, 10 x 5 mm
3.	20 x 10 mm
4.	10 x 10 mm
5.	40 x 5 mm

DISCUSSION

Presence or absence of sternal foramen

Percentage of sternal foramen in present study is 14%. It is more than that of study conducted by Cooper et al. (4) (6.7%) and Gkantsinikoudis et al. (14) (6.6%) of sternal foramen in female. It is less than the findings of Paraskevas et al. (16) (18.3%), Babinski et al. (13) (16.6%), Gkantsinikoudis et al. (14) (14.2% in male), Busaid et al. (9) (13.8%) and Kirum et al. (7) (12.9%), Kumarasamy et al. (18), Kumar et al. (10) and Tandon et al. (1) in their study noted sternal foramen in only one specimen (Table 6).



Figure 6: Measurement of size of sternal foramen by using vernier caliper.

TABLE 6
Incidence of sternal foramen in different studies

Sl. No	Name of the study	Percentage of sternal foramen (%)
1.	Cooper PD et al. [4]	6.7
2.	Suba Ananthi Kumarasamy et al. [18]	1 Specimen
3.	Marcio A. Babinski et al. [13]	16.6
4.	H.EL.Busaid et al. [9]	13.8
5.	Paraskevas. G et al. [16]	18.3
6.	Jithender Kumar et al. [10]	1 Specimen
7.	Aseem Tandon et al. [1]	1 Specimen
8.	N Gkantsinikoudis et al. [14]	14.2 in male and 6.6 female
9.	G.G. Kirum et al. [7]	12.9
10.	Present study	14

Site of sternal Foramen

Gkantsinikoudis et al. (14), Busaid et al. (9) and Babinski et al. (13) studies stated that high percentage of sternums showed the sternal foramen over the body of the sternum. But in this study it is reported as only 4%.

Cooper et al. (4) stated the presence of sternal foramen in manubrium but they didn't mention the prevalence rate. The presence of sternal foramen over the manubrium is 2% in our study which is in line with above mentioned literatures (Table 7).

Shape of sternal foramen

In a cadaveric study by Selthofer et al. (17), the longitudinal oval type was the standard shape of sternal body. Recently, in a study by Bayarogullari et al. (9) evaluated postnatal development of the sternum by MDCT; flat type was most commonly seen.

A CT study by Duraikannu et al. (6) shows a well-corticated, round to oval-shaped defect in the midline of the sternal body with an average diameter of 6 mm.

The shape of sternal foramen in the present study is oval or round similar to above mentioned previous studies (Table 8).

Number of sternal foramina

Balta et al. (2) in his radiological study stated the incidence of double sternal foraminae in body of sternum.

In our study double sternal foramen present over the manubrium in one bone and in other specimen double foramina present in xiphoid process. Our study correlated with that of Balta et al. (2).

Cooper et al. (4) detected sternal foramina in 6.7% in autopsy population that were usually solitary and located in the body of the sternum. They also detected a foramen in the manubrium.

TABLE 7
Site of sternal foramen

Sl. No	Name of the study	Site of sternum			
		Manubrium	Body of sternum	Xiphoid	Sterno-xiphoid
1.	Cooper PD et al. [4]	Not Specified	1 specimen	-	-
2.	Suba Ananthi Kumarasamy et al. [18]	-	1 specimen in lower one third	-	-
3.	Marcio A. Babinski et al. [13]	-	38.5% (5 th segment) 64.2% (4 th -5 th segment)	-	-
4.	H.EL.Busaid et al. [9]	-	81.8% (5 th segment)	-	-
5.	Paraskevas. G et al. [16]	-	27.5%	3.3%	-
6.	Jithender Kumar et al. [10]	-	1 specimen over lower third	-	-
7.	Aseem Tandon et al. [1]	-	1 specimen	-	-
8.	N Gkantsinikoudis et al. [14]	-	40%	40%	-
9.	Present study	2%	6%	6%	-

TABLE 8
Comparison of size of sternal foramen

Sl. No	Name of the study	Size of the foramen
1.	Suba Ananthi Kumarasamy et al. [18]	20.81 x 1.42 mm
2.	Marcio A. Babinski et al. [13]	5.5 x 4.5 mm
3.	Jithender Kumar et al. [10]	18.75 x 12.50 mm
4.	Aseem Tandon et al.[1]	8.75 x 7.35 mm
5.	Kosuri Kalyan Chakravarthi et al. [12]	17 x 16 mm
6.	Present study	20 x 11 mm

Vora et al. (5), in his study observed single foramen. Yekeler et al. (20) presented one single visible sternal foramen.

Our study also similar to that of findings observed by previous authors.

Size of sternal foramen

Kumarasamy et al. (18) noted the size sternal foramen to be 20.8 mm and 11.4 mm, a larger size.

Chakravarthi et al. (12) noted the highest vertical diameter of 19 mm and transverse diameter of 17 mm. Kumar et al. (10) stated the size of foramen as 18.75 x 22.50 mm. Our study is similar to the study by the above mentioned authors.

According to Yekeler et al. (20) the size of sternal foramina ranged between 2 and 16 mm, with mean of 6.5 mm. Babinski et al. (13) noted the size of foramen as 5.5 x 4.5 mm. The size of sternal foramen in our study is more than that of above mentioned authors.

CONCLUSION

Serious complications after sternal puncture such as cardiac tamponade and pneumothorax should be kept in mind before performing an intrinsic procedure like bone marrow biopsy acupuncture etc. It is advisable to take X-ray to rule out such variations of the sternum.

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