



OSTEOLOGICAL STUDY OF VARIATIONS OF STERNAL FORAMEN IN DRY HUMAN STERNUMS FROM NORTH INDIAN POPULATION SAMPLES.

Anatomy

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ABSTRACT

During routine bone demonstrations, we usually come across different anomalies of the sternum bone. Of the total anomalies, sternal foramen accounts sizable proportion. Sternal foramina are almost congenital but can also be due to gunshot injury or lytic bone lesions or sternotomy. During embryonic development, sternum develops from endochondral ossification of two condensed mesenchymal plates which unite in the cranio-caudal direction. When two ossification centers fail to fuse or incomplete fusion leaves sternal foramen. In clinical practice for diagnosis of anaemia most commonly sternal puncture an invasive procedure is performed by the pathologist for bone marrow aspiration. Fatal complications like cardiac tamponade and pneumothorax must be kept in mind if the sternal foramen is close to vital organs in the sternum during the biopsy. Therefore, knowledge of sternal foramen is imperative for pathologists and acupuncturists to avoid life-halting complications.

MATERIAL AND METHOD: After approval of the Institutional Ethical Committee, 110 dried sterna of unknown age and sex were collected from the Department of Anatomy TSM Medical college & Hospital Amausi, Lucknow, King George's Medical University, Lucknow & Integral Institute of Medical Sciences & Research, Lucknow. An exploratory and observatory study was conducted between December 2019 to May 2020. Location, shape, size, and variations were observed and recorded. Observed data were analyzed by using SPSS software version 25 at a 95% confidence interval.

AIM: Our study aimed to explore the pattern of incidence, situation, number, and shape of the foramen and sternal cleft of collected specimens.

RESULT: In our study, 13.63% of sterna had sternal foramen overall. Sternum having single sternal foramen are 11 (10%). Double foramen in 4 sternums (3.63%). 4 sterna (3.63%) with sternal foramen and sternal cleft in the distal portion of the xiphoid process.

KEYWORDS

Sternal Foramen, Mesenchymal, Prosternum, Non-metric, Ethnic, Epigenetic And Ectopiacordis.

INTRODUCTION:

Sternal foramen was first observed in 1649 and later described in 1707¹. The prevalence of sternal foramen in the human population varies from 2.5% to 13.8%¹. Sternum bone is an axial bone of the thoracic cage which lies anteriorly in the midline completing osteoelastic arches bilaterally by articulating with ribs from 1st to 7th via costochondral cartilages. This is segmented and consists of three parts the cranial prosternum (episternum), an intermediate mesoderm or gladiolus, and the caudal xiphoid process². The arrangement and number of centers of ossification vary according to the level of completeness and time of fusion of the sternal plates, and according to the width of adult bone³. During prenatal development, one to three (1-3) ossification centers appear for manubrium at 5 months of intrauterine life². Subsequently, for 1st and 2nd sternbrae, one ossification center for each appears by 5th month and two ossification centers for each 3rd and 4th sternbrae by six months of intrauterine life³. Ossification center for xiphisternum appears postnatally by 3rd year². Sometimes sternbrae ossify by double ossification centers which when fail to fuse in the midline leaves sterna foramen or sterna cleft. The sternal foramen may be associated with rare congenital anomaly the ectopia cordis⁴. Knowledge of incidence, the pattern of association with vital organs, and variation of the sternal foramen is of immense clinical importance. Their cognizance is necessary for bone marrow aspiration. Defects of sternum most commonly found in lower 3rd in the form of single midline sterna foramen⁵, and are usually congenital and symptomless. Sternal foramina are incidentally detected in routine CT scans⁶.

RESULT:

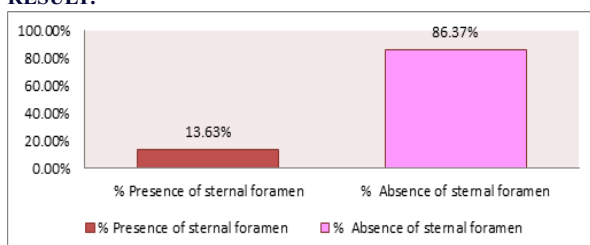


Figure No: 2.1

Table No. 1.1 Prevalence Of Sternal Foramen

%Presence of sternal for a men	% Absence of sternal for a men
15(13.63%)	95(86.37%)

In our study, sternal foramina were recorded in 15 sternums which account for 13.63% out of 110 specimens. In the remaining 95 specimens, sternal foramen was absent which accounts for 86.37%.

Table No. 1.2 Number Of Sternal Foramen

Single	Double
10%(11)	3.63%(4)

In the present study we found eleven sterna were associated with single foramen, account 10%, and three sternums with double foramen, account 2.72%.

Table No. 1.3 Site Of Sternal Foramen

Prosternum	Body of sternum	Xiphoid process	Xiphisternal articulation
2.72%(3)	5.45%(6)	3.64%(4)	1.82%(2)

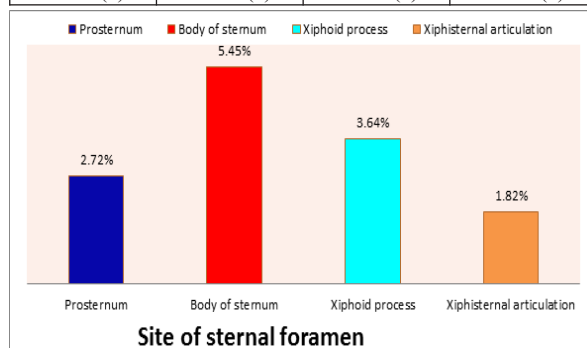


Figure No: 2.2

We recorded distribution of sternal foramina over prosternum 2.72% (3), body of sternum 5.45% (6), xiphoid process 3.64% (4), and xiphisternal articulation 1.82% (2).

Table No. 1.4 Shape Of The Sternal Foramen

Round	Oval
10%	3.63%

Table No. 1.5 Sternal Foramen With Sternal cleft

Sternal for a men with sterna cleft in xiphoid process	3.63%(4)
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We reported a new variant in 4 sternums, sternal foramen in xiphoid process with a sternal cleft.

Table No. 1.6 Prevalence Of Sternal Foramen In Different Studies In Chronological Order.

S.No	Authors	Years	% of sternal foramen
1.	Cooper P.D. et al ⁷	1988	6.7
2.	Jitendra Kumar et al ⁸	2011	1specimen
3.	Kumarasamy et al ⁹	2011	1specimen
4.	Gkantsinikoudis et al ¹⁰	2011	14.2(male),6.6(female)
5.	Bussaid H.E.L et al ¹¹	2014	13.8
6.	Kirum G.G et al ¹²	2017	12.9
7.	Babinski M.A. et al ¹³	2018	16.6
8.	Arumugam and Hemalatha ¹⁴	2018	14
9.	Present study	2020	13.63

DISCUSSION:

The occurrence of sternal foramen in percentage in this study was found 13.63%. Our finding is significantly more in comparison to the work done by Cooper P. D. et al⁷ which was 6.6%. The result of our study is nearly closer to the findings of Bussaid H.E.L et al¹⁰ (13.8%) and Kirum G.G et al¹² (12.9%). While studies that were having their findings quantitatively higher are Babinski M.A. et al¹³ (16.6%), Gkantsinikoudis et al¹⁰ (14.2%), and Arumugam and Hemalatha¹⁴ (14%) from table 1.6.

In the present study, we found a higher percentage of the site of incidence was over the body of sternum, 5.45%. Though our finding (5.45%) is significantly lesser in percentage as compared to Bussaid H.E.L et al¹¹ (81.8%), Gkantsinikoudis et al¹⁰ (40%) and Babinski M.A. et al¹³ (38.5% over 5th segment, 64.2% 4-5th segment) yet favors the common site of the sternal foramen is the body of the sternum. As lower 3rd and 4th sternbrae usually ossify by paired ossification center which appears during the 5th and 6th month of intrauterine life² respectively. One of either pair of ossification centers may be delayed until seven or eight months of intrauterine life or may be absent¹. This is a ready explanation of the common site of the sternal foramen.

Table No.1.7 Area Of Situation Of Sternal Foramen Over Different Parts Of The Sternum.

S. No.	Year	Authors	Manubrium	Body of the Sternum	Xiphoid	Sterno-xiphoid
1.	1988	Cooper P.D. et al ⁷	Not specified	1 specimen	-	-
2.	2011	Jitendra Kumar et al ⁸	-	1specimen over lower third	-	-
3.	2011	Subha Ananthi Kumarasamy et al ⁹	-	1 specimen	-	-
4.	2014	Bussaid H.E. Let al ¹¹	-	81.1%	-	-
5.	2016	Tandon et al ¹⁵	-	1 specimen	-	-
6.	2017	Gkantsinikoudis et al ¹⁰	-	40%	40%	-
7.	2018	Babinski M.A. et al ¹³	-	38.5% over 5 th segment, 64.2% 4-5 th segment	-	-
8.	2018	Arumugam and Hemalatha ¹⁴	2%	6%	6%	-
9.	2020	Present study	2.72%	5.45%	3.64%	1.82%

We reported 10% sternal foramina were round in shape and singly associated with the sternum. We did not find any sternum associated

with double foramina over the body of sternum while Balta et al¹⁶ showed the incidence of double in the body of sternum in his radiological study. In the present study, 2.7% sternums (from table 1.7) were associated with single foramen in the prosternum part slightly higher in comparison, as documented by Arumugam and Hemalatha¹⁴ (2%) but the thing is different that later reported double foramen over manubrium in one sternum. In this study, 3.64% sterna are showing the presence of sternal foramen with sternal cleft and 1.82% sterna over the Sterno-xiphoid junction. 3.63% sternal foramen over the xiphoid process was oval in shape

Table No. 1.8 Incidence Of A Sternal Foramen In Major Populations Of The World.

Authors	Populations	Sample size (male+female)	Methodology	% Prevalence
Cooper P. D. et al ⁷	USA	2016	Radiographs	6.7
Grossner ¹⁷	German	352	C T	4.2
Paraskevas ¹⁸	Greek	60	Dried sterna	5
Aktan and Savas ¹⁹	Turkish	412	350 CT+62 Dried	5.4 CT And 3.2 Dried
Yekeler et al ²⁰	Turkish	1000	Cadavers	4.5
Babinski P.D. et al ¹³	Brazilian	180	Cadavers	16.6
Babinski M.A. et al ²¹	Brazilian	114	MDCT	16.6
Bussaid H.E.L et al ¹¹	Kenyan	80	Dried sterna	11.2
Singh and Pathak ²²	Indian	343	Cadaveric	11.9 (13.5% in male, 8.1% in female)
Present study	North Indian	110	Dried sterna Without sex determination	13.63

It is evident from table 1.8 that the occurrence of the sternal foramen is the lowest 3.2% in the dried bone while 5.4% in CT study in the Turkish¹⁹ population. Other populations showing low incidence are German¹⁷ 4.2% in CT study, Turkish²⁰ 4.5% in the cadaveric study followed by Greek¹⁸ 5% in dried bone, and 6.7% in USA⁷ in the radiographic study. Populations showing higher incidence are 16.6% in cadaveric study¹³ and the same (16.6%) in MDCT²¹ in Brazilian. Kenyan¹¹ 11.2% in the dried bone study nearly closer (11.9%) to the Indian Population²² in a cadaveric study. We find 13.63% in the dried bone study very much close to the finding of Singh and Pathak¹⁹ 11.9% overall (males + female) in a cadaveric study. Our finding (13.63%) is very much close to the finding of Singh and Pathak²² about the male (13.5%) population. In other terms, we can conclude that the sterna collected by us belong to male individuals. It can be interpreted from the above discussion that difference in incidences of sternal foramen appears to be ethnic association across the globe and corresponds to the demographic distribution of human populations. It is of racial and regional importance and a non-metric variant of the sternum. The sternal foramen is a non-inheritable epigenetic trait.

Development of axial skeleton involves the interaction of many tissues including the embryonic notochord, neural tube, somite compartments, Intersomitic Angiopotent cells, and neural crest cells. The development of these tissues occurs in an interdependent and hierarchical manner over an extended period of time²³. These characteristics may make the axial skeleton disproportionately susceptible to environmental influence, accounting for the high incidence of axial skeletal defects among living and stillbirths²³. In the north Indian population, the sternal foramen is relatively higher in percentage incidence. The environmental factors that can be supposed to influence the incidence of may be fast (starvation) during pregnancy due to poverty or as some religious customs to worship their deities. As in village areas home, births are the most common, and prolonged labour may cause hypoxia²³ which acts as teratogen for development to the axial skeleton in the foetus. Among pharmaceutical compounds, retinoic acid commonly used to treat acne in young adults during pregnancy may cause maldevelopment in the axial skeleton²³. An abnormal (malformed) sternum in intrauterine life may be a part of

certain genetic disorders²⁴, and is usually dominated by genetic cause. A sternal cleft or foramen in the lower part of the sternum may sometimes be associated with congenital anomalies of the heart²⁵ and lung or may be an indicator of a particular syndrome.

CONCLUSION:

A sternal foramen is not uncommon which may be associated with congenital anomalies of vital organs. The realization of these variations is important for physicians, pathologists, surgeons, acupuncturists, and radiologists during bone marrow aspiration. Equally important to physical anthropologist because of its racial and regional association.

CONFLICT OF INTEREST: We declare no conflict of interest.



Figure 2.3. Sternal Foramen In Prosternum.



Figure 2.4. Foramen At Xiphisternal Junction And Sternal Groove In Xiphoid Process.



Figure 2.5: Foramen In Lower Body With Sternal Cleft



Figure 2.6: Foramen In Lower Body.

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