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**Research Article**

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# Morphometric and morphological study of most common sternal entity: sternal foramen

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## ABSTRACT

**Introduction**: The sternal foramina are the most common congenital variation which is usually asymptomatic. Since the sternum is used for red bone marrow aspiration and in open heart surgeries, presence of sternal foramen may cause life threatening complications like cardiac tamponade. If death occur due to such life-threatening complication due to sternal foramen may raise medico-legal issue.
**Aims and Objectives**: The present study was aimed to determine the prevalence of sternal foramen and to provide statistical data of the morphometry and morphology of the sternal foramen in the Gujarat population.
**Material and Method**: The study was conducted on 112 human dry sternum bones of unknown age and sex from bone stores of various medical colleges of central Gujarat during June 2022 to December 2022. All the sternum bones were macroscopically inspected for the presence of sternal foramen and its location, size, number and shape. The transverse, vertical and maximum diameters of the sternal foramen were measured. The vertical distance of the sternal foramen from the imaginary line connecting the superior border of adjacent costal cartilage and distance of the foramen from the left and right sternal borders were also measured. All the measurements were obtained using sliding vernier calliper and recorded in millimeter (mm). Statistical analysis was finally conducted in Microsoft excel.
**Results**: In the present study out of 112 dry sternum bones observed the sternal foramina were found in 11 sternums. Out of 11 sternums only 1 sternum had 2 foramina while other sternums had only one foramen. In the present study most of the sternal foramina were located on the body of sternum (72.73%) median in position (91.66%) and round in shape (58.33 %). Average vertical diameter was 7.16 mm and transverse diameter was 5.75 mm while highest diameter measured was 13mm.
**Conclusion**: The sternal foramina are common congenital defect commonly found in body of sternum. it is very important to be aware of its prevalence in various populations and its morphological and morphometric data for clinician, surgeons and forensic experts to diagnose sternal foramen and to prevent unwanted serious complications during invasive procedures.

**Key Words**: *Bone marrow transplant, chest bone, cardiac tamponade, sternebrae.*

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## INTRODUCTION

The sternum consists of a manubrium, body(mesosternum) and xiphoid process. It contains highly vascular trabecular bone enclosed by a compact layer that is thickest in the manubrium. Centrally, the bone is lightly constructed whereas laterally the trabeculae are thicker and wider. The medulla contains haemopoetic bone marrow[1].

A pair of sternal bars develops ventrolaterally in the body wall. Chondrification occurs in these bars as the move medially. By the 10$^{th}$ weeks, they fuse craniocaudally in the median plane to form cartilaginous model of the manubrium, sternebrae and xiphoid process. Centers of ossification appear craniocaudally in the sternum before birth, except that for the xiphoid process, which appears during childhood. A sternal foramen of varying size and form occurs occasionally at the junction of the third and fourth sternebrae. This insignificant foramen is the result of incomplete fusion of the cartilaginous sternal bars during embryonic period[2].

Since the sternum possesses red bone marrow throughout life, it is a common site for bone marrow biopsy. Under a local anesthetic, a wide bore needle is introduced into the marrow cavity through the anterior surface of the sternum. The sternum may also be split at operation to allow the surgeon to gain access to the heart, great vessels and thymus[3].
Sternal foramina are the most common variation and usually asymptomatic. But it could be a risk factor for serious complications like pneumothorax, cardiac tamponade during invasive procedures like bone marrow biopsy, acupuncture etc[4][5].

Clinicians should be aware of such common anatomical variation of sternal foramen and they should recognize it during invasive procedures to prevent any life- threatening complications. Sometimes large foramen may pose a great challenge during sternal closure. If death occur due to such life-threatening complication due to sternal foramen may raise medico-legal issue. The Forensic experts may misinterpret such sternal foramen as gunshot injury. To avoid such misleading conclusions and intraoperative complications knowledge of sternal foramen and preoperative investigations like x-rays and CT scan should be encouraged [6–8].

**Aims and Objectives:**

The present study therefore aimed to determine the prevalence of sternal foramen and to provide statistical data of the morphometry and morphology of the sternal foramen in the Gujarat population.

**Material and Method**

The present study was conducted on 112 human dry sternum bones of unknown age and sex from bone stores of various medical colleges of central Gujarat during June 2022 to December 2022.

**Inclusion criteria**: dry, clean and adult sternums
**Exclusion criteria**: Sternums with any previous trauma, pathological irregularities and any gross breakage.

All the sternums were macroscopically inspected for the presence of sternal foramen and its location, size, number and shape. The transverse, vertical and maximum diameters of the sternal foramen were measured. The vertical distance of the sternal foramen from the imaginary line connecting the superior border of adjacent costal cartilage and distance of the foramen from the left and right sternal borders were also measured. All the measurements were obtained using sliding vernier calliper and recorded in milometer (mm). Statistical analysis was finally conducted in Microsoft excel.

**Results**

Out of total 112 dry sternum bones observed sternal foramina were found in 11 sternums. Out of 11 sternums only 1 sternum had 2 foramina while other sternums had only one foramen. Their morphological and morphometric data were showed in Table 1.

In the present study most of the sternal foramina were located on the body of sternum (72.73%) median in position (91.66%) and round in shape (58.33 %). Average vertical diameter was 7.16 mm and transverse diameter was 5.75 mm while highest diameter measured was 13mm.

**Table 1: Morphological and morphometric data of sternal foramina.**

| Sample No. | Position: Manubrium/ Body of sternum/ xiphoid process | Location: Median/ paramedian/ lateral | Shape: Round/oval triangular/ ellipsoid/ trapezoid/ irregular | vertical distance of the foramen from the imaginary line connecting the superior borders of adjacent costal cartilage. (mm) | Distance of the foramen from the right sternal border (mm) | Distance of the foramen from left sternal border (mm) | Vertical diameter of the foramen (mm) | Transverse diameter of the foramen (mm) | Maximum diameter of the foramen (mm) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Manubrium | Median | irregular | 4 | 16.8 | 14.3 | 11 | 9 | 11 |
| 2 | Body of sternum | Median | oval | 5 | 13.8 | 13 | 4 | 4 | 5 |
| 3 | Body of sternum | Median | round | 2 | 15.3 | 15.2 | 6 | 5 | 6 |
| | Xiphoid Process | Median | oval | 3 | 9 | 8.3 | 8 | 3 | 8 |
| 4 | Body of sternum | Median | round | 2 | 14.5 | 14.9 | 5 | 4 | 5 |
| 5 | Body of sternum | Median | round | 3 | 16.9 | 15.8 | 8 | 7 | 8 |
| 6 | Body of sternum | Median | round | 4 | 17.2 | 14.9 | 5 | 6 | 6 |
| 7 | Body of | Median | ellipsoid | 5 | 14.3 | 15.2 | 12 | 9 | 13 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | sternum | | | | | | | | |
| 8 | Body of sternum | Median | round | 9 | 11. | 9 | 6 | 5 | 7 |
| 9 | Body of sternum | Median | round | 8 | 18.7 | 9.2 | 5 | 4 | 5 |
| 10 | Body of sternum | Lateral | round | 7 | 19.6 | 5.7 | 7 | 6 | 7 |
| 11 | Xiphoid process | Median | ellipsoid | 5 | 12.3 | 13.4 | 9 | 7 | 9 |

**DISCUSSION:**

The present study was compared with various past studies. Table 2 showed comparison of present study with observation of other authors.

**Table:2 Comparison of the present study with the past studies:**

| | Present study | Benjamine D Gans et al(9) | | Dr Rekha (10) | Maja Vulvonic et al (11) (MDCT imaging) | Berjinafarooqnaqshi et al (12) (CTscan) | GG Kirum et al(13) | Chakravarthi et al (14) | Shivaji et al(15) | Gkantsinikoudis et al (16) | Chaudhari et al(17) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Study Year | 2022 | 2021 | | 2020 | 2019 | 2019 | 2017 | 2017 | 2016 | 2016 | 2016 |
| Study Population | Gujarat | Indigenous Bolivians | | Jammu | Central serbia | Kashmir | - | - | Marathwada | - | - |
| | | Tsimane | Moseten | | | | | | | | |
| Sample size | 112 | 900 | 434 | 25 | 422 | 52 | 85 | 120 | 71 | 35 | 96 |
| Sternal foramen | 12 | 115 | 58 | 3 | 24 | 2 | 11 | | 3 | 5 | 4 |
| Prevalence of Sternal foramen(%) | 10.7 | 12.78 | 13.36 | 12 | 5.9 | 3.84 | 12.9 | | 4.22 | 14.2 | 4.1 |
| Average Diameter in mm | | | | | | | | | | | |
| Vertical Diameter | 7.16 | - | - | 5.6 | 3.9 | - | - | - | - | - | 3 |
| Transverse Diameter | 5.75 | - | - | 7 | 4.2 | - | - | - | - | - | 10 |
| Highest Diameter | 13 | - | - | 10 | - | - | - | - | 12 | - | - |
| Location of Sternal foramen (%) | | | | | | | | | | | |
| Manubrium | 9.09 | - | - | | | | | | | | |
| Body of Sternum | 72.73 | - | - | 100 | 100 | 100 | - | 7.5 (complete foramen) 3.3(incomplete foramen) | 100 | 40 | 100 |
| Xiphoid Process | 9.09 | - | - | - | - | - | - | 5.8 | - | 40 | - |
| Junction of Xiphisternal Joint | - | - | - | - | - | - | - | - | - | 20 | - |
| Both in Sternal Body and xiphoid Process | 9.09 | - | - | - | - | - | - | 6.6 | - | - | - |

The comparison of present study with previous studies confirms that the prevalence of the sternal foramen was variable in different population but it was most commonly present in the body of the sternum. Also various parameters like transverse diameter, vertical diameter were vary in different regions.

**CONCLUSION:**

The sternal foramina are common congenital defect commonly found in body of sternum. it is very important to be aware of its prevalence in various populations and its morphological and morphometric data for clinician, surgeons and forensic experts to diagnose sternal foramen and to prevent unwanted serious complications during invasive procedures.

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