

Study of Sternal foramina in Eastern Indian dry Sterna.

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Abstract: Objective- To study the incidence and morphology of sternal foramina in Eastern Indian population. Methods- Thirty numbers of dry human sterna were studied macroscopically for the presence of sternal foramina. The vertical and transverse diameters of the sternal foramina were measured.

Results- Sternal foramina were observed in 2 out of 30 sterna (incidence 6.66%).

Conclusion- The findings of the study will be useful in medical practice, radiology, anthropology and acupuncture.

Key words- Sternal foramen, Congenital anomaly, Cardiac tamponade, Bone marrow aspiration, Acupuncture.

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I. Introduction

The sternum is a flat bone forming the middle portion of the anterior wall of thorax. It articulates with the clavicles at the sternoclavicular joints and the cartilages of the vertebrosteral ribs. The sternum is made up of manubrium (prosternum), body (mesosternum or gladiolus) and xiphoid process (metasternum)¹.

Sternum develops by bilateral condensation of mesenchymal tissue called sternal bars. Sternal bars, present on either side of midline fuse to give rise to the whole bone. Defective midline fusion leads to anomalies such as sternal foramina or sternal cleft².

Steral foramina have been observed in manubrium, body or xiphoid process of sternum^{3,4}. They are usually found as single midline round or oval defects. Such defects are usually asymptomatic and can be detected only by C T scans⁵.

Sternum is usual site for drawing sample for bone marrow biopsy. Sternum is frequently punctured in acupuncture procedures. During these procedures, inadvertent insertion of needle through sternal foramina during the abovementioned procedures may lead to potentially fatal consequences like cardiac tamponade^{6,7}. Sternal foramina also find mention in forensic literature as they can be confused with gun shot wounds in the pectoral region⁸.

As presence of sternal foramina can greatly influence the outcome of important procedures like bone marrow aspiration, acupuncture and medicolegal autopsy, the current study was taken up to study the incidence and morphology of this congenital anomaly.

II. Materials and Methods

The study included thirty dry human sterna used for teaching osteology in routine MBBS anatomy classes in a Medical College in Bhubaneswar, Odisha. Broken and deformed bones were excluded from the study. All the bones were observed for the presence of sternal foramina. The shape and dimensions (vertical and transverse diameters) of the sternal foramina were observed. The diameters were measured by using slide callipers. However sex determination of the bones was not done.

III. Results

Steral foramina were observed as single midline defects in inferior half of the body of sternum in two out of thirty sterna, incidence being 6.66% (Figure 1). The vertical and transverse diameters were measured (Table 1). In each foramen the vertical diameter was noted to be more than the transverse diameter.

Table No- 1 (Table showing various dimensions of sternal foramen)

Diameter	Sternal foramen 1	Sternal foramen 2
Vertical diameter (in cm)	1	2
Transverse diameter (in cm)	0.5	0.8



Figure 1 (Sternum showing a sternal foramen)

IV. Discussion

The current study has established an incidence of 6.66% for sternal foramina. This is similar to the findings of Cooper et al⁴, Moore et al³, Alkan and Savas⁹. Cooper et al have reported an incidence of 6.7% in an autopsy study. Moore et al have found an incidence of 6.6% whereas the incidence reported by Alkan and Savas is 5.1%. Findings of the study is comparable to the 4.3% and 4.5% incidence observed by Stark¹⁰ and Yekeler et al¹¹ respectively. Peuker et al¹² have also reported an incidence between 5% and 8% in autopsy studies. Among Indian studies, Shivkumar et al¹³ have reported a comparable incidence of 7%. Another Indian study by Chaudhari et al¹⁴ has revealed an incidence of 4.1%. However, higher incidence of 13.8% and 16.6% has been reported by El-Busaid et al¹⁵ and Babinski et al¹⁶ respectively.

Morphometry of sternal foramen in the current study has established similarity with the finding of Yekeler et al¹¹. They have reported the size of sternal foramina ranging from 2 mm and 16 mm. Findings of the current study fall in the same range with the maximum diameter being the vertical one.

EMBRYOLOGICAL BASIS OF STERNAL FORAMEN

The sternum is mesodermal in origin. The sternum develops by complete fusion of two sternal plates on either side of the median plane¹. The manubrium is ossified in two to three centres which appear in fifth month of intrauterine life. The body of sternum is formed by fusion of four segments called sternebrae. The upper two sternebrae ossify in single centres appearing in fifth month of intrauterine life. The lower two sternebrae ossify in paired centres. The centres for the third sternebra appear in fifth month whereas those for the fourth sternebra appear in sixth month of intrauterine life. The appearance of centres for lower two sternebrae may be delayed till sixth or seventh month of intrauterine life. After birth, the xiphisternum begins to ossify in the third year. In some cases all the centres of ossification are single and situated in the median plane. In other cases only the centre for the manubrium is single and rest sternebra centres are all paired. These paired centres are usually symmetric but may be asymmetric. Union between the sternebra centres begins at puberty and proceeds from below upwards. It's complete by 25 years of age. So the arrangement and number of sternal centres of ossification vary according to the level of completeness and time of fusion of sternal plates, mentioned earlier and according to width of the adult bone. Incomplete fusion results in a sternal foramen¹.

CLINICAL SIGNIFICANCE OF STERNAL FORAMEN

(a) Sternum and dorsal segment of iliac crest are the usual sites for bone marrow aspiration. Improper needling may lead to accidental entry of the needle into sternal foramen. This leads to fatal complications like cardiac tamponade and injury to great vessels in the thorax^{6,7}.

- (b) An important acupuncture point CV- 17 (Danchu or Shanzong or sea of energy) is located in the midline. Vertical insertion of acupuncture needles into sternal foramen can result in cardiac tamponade as well^{6,7}.
- (c) The detection of sternal foramen is also fraught with difficulties as the foramina usually don't give rise to significant symptoms. Routine radiographs can not detect them because the fibrous pericardium is located just beneath such foramina⁵.

So the following precautions are recommended while planning sternal puncture :

- (a) Multiplanar and Multi- Detector C T scan can be done instead of routine skiagraphy as and when required to detect sternal foramina as they are the modalities of choice to detect such anomalies⁵.
- (b) The sternal puncture needle should be introduced obliquely and not vertically. However in lean persons, the skin to heart distance is only 1- 2 cm. In such cases even correct needling may result in pericardial effusion and tamponade¹⁷.
- (c) The depth of pericardium from skin varies from 3 to 9.1 cm. It can be put forward that if the needle is not inserted deeper than 2.5 cm, pericardium or great vessels are least likely to get punctured¹⁴.

MEDICOLEGAL ASPECTS OF STERNAL FORAMEN

- (a) Sternal foramen may be regarded as a marker for personal identification¹⁴.
- (b) Sternal foramen may be confused with gun shot wound or osteolytic lesions¹⁴.
- (c) During autopsy, sternal foramen may be misinterpreted as antemortem injury¹⁴.
- (d) Sternal foramen may be confused with superimposition of necklace⁵.

However the definitive diagnosis of sternal foramen can be made on close and meticulous scrutiny in case such confusion prevails in medicolegal autopsy and sternal foramina are misadjudged as gun shot wounds or antemortem trauma¹⁴. Careful examination will reveal that a supposed sternal foramen will be mostly a midline defect in inferior half of mesosternum having smooth margin covered with cortical bone in contrast to a gun shot wound which will show bevelled outline with fracture lines surrounding the wound and absence of cortical bone at the edges. Similarly the presence of typical erosion by insects and claw or teeth marks of animals should go against an assumption of antemortem trauma. Meticulous pathological and biochemical investigations should be done to rule out osteolytic conditions in case of such confusion.

V. Conclusion

Sternal foramen is an anatomical variation resulting from defective ossification of sternum. The knowledge of this anomaly is highly significant for medical personell, radiologists and in acupuncture because accidental penetration of pericardium by the needle through such defect may result in pericardial effusion or cardiac tamponade during bone marrow aspiration and acupuncture. Use of proper Multi Detector C T imaging is advocated to ward off such hazardous and life threatning complications. Forensic pathologists should be meticulous enough to rule out fallacies in determining the nature and cause of death in concerned cases as sternal foramina are highly likely to be confused with gun shot wounds or antemortem traumatic injury.

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