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Case Report

CONGENITAL FORAMEN IN THE BODY OF STERNUM

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ABSTRACT

Background: The knowledge of sternal variations is important as this bone is usually chosen for bone marrow aspiration.One such developmental anomaly is the presence of foramina, of varying dimensions, in manubrium or body or xiphisternum.Usually, the defect occurs in the lower third of sternum,in the body, as a single midline foramen (oval or round) and is usually asymptomatic and can be demonstrated only by CT scanning. The observation and knowledge of these foramina are of utmost importance in clinical, forensic and acupuncture techniques.Hence, this observation could be a useful one.

Materials and methods: During a routine osteology class in the Department of Anatomy,Kanyakumari Government Medical College,an adult sternum of unknown sex and age was found to have a foramen in the lower part of body at the level of articular facets for fifth costal cartilages.

Results: The following observations were made: (1)The sternum presented an oval foramen in the lower part of the body. (2) It was located in midline at the junction between third and fourth sternebrae.(3) Its margins were smooth and measured 5mm×6mm.

Conclusion: Embryologically,sternum is formed by the craniocaudal fusion of two sternal bars,which are condensations of mesenchymal tissue which get converted to pre-cartilage before fusion. Any defect in this fusion may cause cleft sternum or sternal foramina(single or multiple). The single sternal foramen presented here could have clinical implications. Its knowledge helps in preventing fatal cardiac tamponade following needle insertion during bone marrow biopsy or acupuncture performed in this region. Forensic misinterpretation of this defect is also possible.

KEYWORDS: Developmental anomaly, Single midline foramen, Mesenchymal tissue, Fusion defect, Cardiac tamponade.

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BACKGROUND

The sternum is a flat bone lying in the median part of anterior thoracic wall.The heart is related to the posterior surface of sternum.The bone is formed by the bilateral condensations of mesenchymatous tissue , also called sternal bars, which are initially present on either side of the midline.They fuse cranio-caudally.Any defect in such midline fusion may lead to congenital anomalies such as foramina or cleft sternum or a hybrid deformity like a key-hole shaped deformity[1] in sternum.

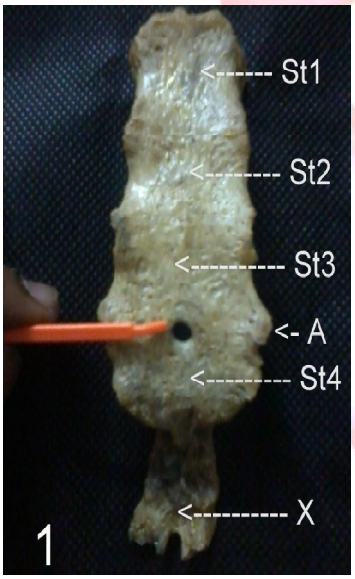
Sternal foramina may be of various dimensions.They have been reported in manubrium,body and xiphisternum[2,3,4]. Usually,the defect occurs in the lower third of the sternum[5], in the body, as a single midline foramen(oval or round). They are usually asymptomatic and can be demonstrated only by CT scanning[6]. The knowledge of such foramina

is essential because of the potential danger of cardiac tamponade , which may result due to insertion of needle through such defects , during Bone Marrow Aspiration(BMA) or bone marrow biopsy[7] or acupuncture[8], which are commonly performed in this region.It is also forensically important [9]. Hence, this observation could be a useful one.

MATERIALS AND METHODS

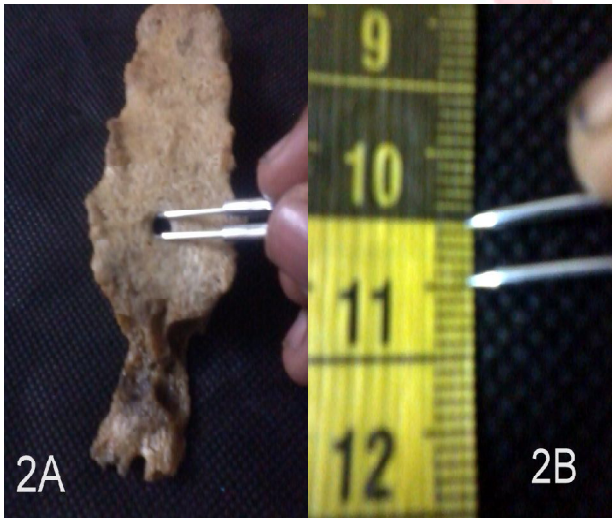
During a routine osteology class in the Department of Anatomy, Kanyakumari Govt. Medical College, Tamil Nadu, an adult sternum of unknown sex and age was found to have a foramen in the lower part of the body at the level of articular facets for fifth costal cartilages (Fig. 1). Its dimensions were measured in millimeters using a divider and inch tape.

Fig. 1: The specimen with the congenital foramen (manubrium removed). (The foramen has been pointed.)



St1, St2, St3, St4 – Sternebrae
X - Xiphisternum
A – Articular facet for 5th left costal cartilage

Fig. 2: The vertical diameter of the sternal foramen (5 mm).



CASE REPORT

The sternum presented here had an oval foramen in the lower third of the body.It was present at the junction of third and fourth sternebrae. It was located at the level of articular facets for fifth costal cartilages in the midline.Its margins were smooth. Its vertical diameter measured 5 mm (Fig. 2) and its transverse diameter measured 6 mm (Fig. 3). Its transverse diameter is a little more than its vertical diameter.

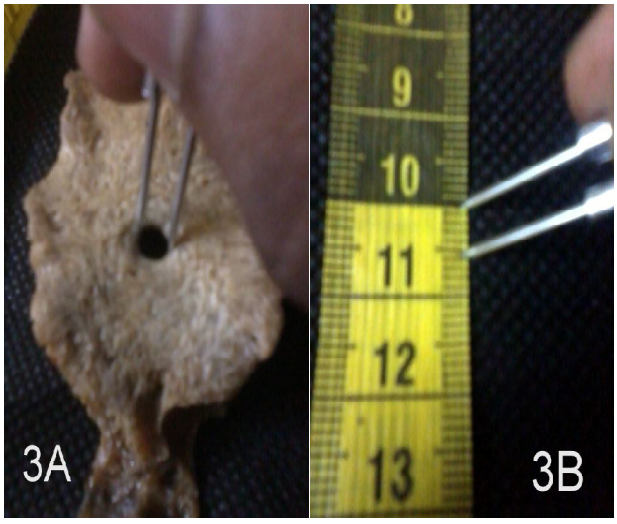
DISCUSSION

Sternal foramen is an oval or round defect usually present in the lower third of body of sternum.Foramina have also been reported in manubrium sterni and xiphisternum.It may be of various sizes and shapes.Other sternal defects have been reported as complete midline sternal cleft and a hybrid abnormalities like key-hole shaped deformity[1] and multiple sternal foramina[10]. All these are fusion defects of sternum[11].

Anatomical and embryological basis of sternum:

The sternum is the median bone of the anterior thoracic wall.It is about 17 cm long in adult males, a little less in females. It consists of three parts: manubrium(the upper shield shaped part), body or gladiolus or corpus sterni(middle part) and xiphoid process or xiphisternum or processus xiphoidus or ensiform appendix (terminal part). The sternocostal surface of heart is separated from the body of sternum by the pericardium.In a small area behind the lower left

Fig. 3: The transverse diameter of the sternal foramen (6 mm).



half of the body of the sternum and the sternal ends of left fourth and fifth costal cartilages, the pericardium is in direct contact with the thoracic wall whereas the lungs and pleura cover the remaining part of pericardium anteriorly[11].

In the fetus,the sternum consists of two cartilaginous bars(bars of mesenchymatous tissue) called sternal bars which become attached to the upper nine costal cartilages on each side of the midline.During the eighth week of gestation,these bars migrate, converge towards the midline and fuse with each other in a cranio-caudal pattern.This fusion is completed by the tenth week, forming the manubrium and body. The xiphisternum is formed as a caudal extension of the sternal bars.

The ossification of sternum is by six centres:one for manubrium,four for body and one for xiphoid process. They appear between the articular facets for costal cartilages and divide the sternum into six transverse pieces. The fourth and fifth pieces are often formed from paired ossification centres.The third and fourth appear during the fourth and fifth months of fetal life respectively. The fifth usually appears an year after birth.Incomplete fusion of sternal bars in this region accompanied by eccentric centres of ossification account for the occurrence of sternal foramen or sternal fissure.Ossification of sixth part (xiphoid process) does not begin until the fifth to eighteenth year of life and partial cartilaginization may persist into adult life. Thus, xiphoid abnormalities are rare as compared to manubrial and gladiolal defects[9,11].

The complete fusion defect leads to cleft sternum whereas partial fusion defects lead to sternal foramina. Failure of fusion maybe due to an early disturbance affecting midline mesodermal structures during sixth to ninth weeks of gestation.

Frequency of variations:

Sternal variations discussed above are rare. The occurrence of sternal foramina is more common among these rare variations.The incidence of sternal foramen was evaluated as 4.3 % on chest CT by Stark[12], 6.7 % in autopsy cases by Cooper[4], 6.6 % by Moore et al[3]. Aktan and Sowas observed it in 5.1 % in Turkish population[13]. High prevalence of this variation was observed in cadavers and dry bones by Babinski et al[14].

The size of foramen ranges between 2 mm and 16 mm , with a mean of 6.5 mm[15]. In this case, it measures close to this mean value with the longest diameter being transverse.

Foramen in the body of sternum is more common than that in manubrium or xiphisternum.In this case, it is located in the lower part of the body.

Clinical implications:

The clinical importance of this defect lies in the fact that a fatal cardiac tamponade can occur following insertion of needle in this region.If the needle is inserted without the knowledge of the presence of a foramen,it may easily penetrate the pericardium through the foramen.

Sternum is one of the two bones chosen for bone marrow aspiration in hematological diseases(the other site being the posterior part of iliac crest of hip bone).Improper needling may lead to cardiac tamponade or great vessel injury.

Another importance of sternum is that the acupuncture point CV-17 (Danchu or Shanzong or sea of energy) is located at the level of nipples in the midline.Vertical insertion of acupuncture needle can lead to pericardial effusion followed by cardiac tamponade.An oblique insertion of needle is recommended in these cases.However, in lean individuals who can have skin-heart distance of only 1-2 cm, even correct needling could lead to pericardial perforation[16].

Another problem is in the diagnosis of this foramen.It is usually asymptomatic,usually not palpable because of the overlying muscles and not normally visible in a radiograph because of the underlying pericardium.But, it can be well demonstrated in a CT. Multiplanar and 3D reconstructed Multi-Detector CT (MDCT) images are the modality of choice for detecting sternal anomalies.

Thus, a puncture performed without the knowledge of these anomalies could be fatal.

Forensic misinterpretations:

The sternal foramen could be misinterpreted as bullet injuries. On the forensic side, they could also be confused with ante-mortem traumatic injuries.

A close examination of the specimen should confirm the presence of sternal foramen: The defect will be located in the midline, usually the lower half of body of sternum;the measurement of this defect will be the same on both outer and inner surfaces of the bone; a careful examination of the edges would reveal it to be smooth and covered with cortical bone.In specimens exposed to insects,fauna,etc. , characteristic erosion,teeth or claw marks maybe present around the foramen, but it should not be mistaken for ante-mortem traumatic injury.

The misinterpretation of such defects in medico-legal cases can be a serious pitfall in determining the nature and cause of death in some suspected cases of homicide and suicide[9].

CONCLUSION

The knowledge of anatomical variants such as congenital foramina of sternum is essential, especially for medical professionals,radiologists and acupuncturists, because of the danger of penetration of needle into pericardium during bone marrow aspiration or acupuncture.As it is asymptomatic, proper MDCT imaging could help in avoiding the risk of fatal cardiac tamponade.

List of abbreviations used

CT – Computed Tomography
MDCT - Multi-Detector CT
BMA – Bone Marrow Aspiration

Conflicts of Interests: None

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