

## VARIATIONS IN THE HUMAN STERNA

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**ABSTRACT: AIM:** To study the various sternal variations and anomalies in a randomly collected set of 86 dry sterna. **MATERIALS AND METHODS:** 86 randomly collected dry sternal bones in the Department of Anatomy, Navodaya Medical College, Raichur, Karnataka were analysed for variations and anomalies. The observations were documented. **RESULTS:** Sternal variations such as sternal foramen, xiphoid foramen, bifid xiphoid process, broad and thin xiphoid process and elongated xiphoid process were observed. **CONCLUSION:** Sternal variations are not uncommon. A sound knowledge of sternal variations and anomalies is very important for medical practitioners, radiologists and acupuncturists.

**KEYWORDS:** sternum, xiphoid bone, anomalies, acupuncture.

**INTRODUCTION:** The sternum consists of a cranial manubrium (Prosternum), an intermediate body (Mesosternum) and a caudal Xiphoid process (Metasternum). Until puberty, the mesosternum consists of four sternabrae; from their costal relations, these appear to be intersegmental. The total length of the sternum is c.17 cms in males, less in females<sup>1</sup>. The sternum develops independently in the parietal layer of lateral plate mesoderm in the ventral bodywall. Two sternal bands are formed in the parietal (somatic) layer of lateral plate mesoderm on either side of the midline, and these later fuses to form cartilaginous models of the manubrium, sternabrae and xiphoid process<sup>2</sup>.

The sternum is one of the skeleton parts with frequent variation in appearances on images or autopsy series. In living subjects, sternal variations are frequently detected incidentally on cross-sectional images. The largest series evaluating sternal variations and anomalies were based on macroscopic<sup>3</sup> and radiographic<sup>4</sup> appearances of the sternum in autopsy populations. The frequencies of sternal anomalies in living subjects have been described based on their radiograph<sup>5,6</sup>, helical CT<sup>7,8</sup>, or MRI appearances<sup>9</sup>. Knowledge of radiological appearances of sternal variations and anomalies is useful so as not to confuse those with pathological conditions. Awareness of a sternal foramen is important in acupuncture practice<sup>10</sup>.

**OBJECTIVE:** To study the various sternal variations and anomalies in a randomly collected set of 86 dry sterna.

**MATERIALS AND METHODS:** The present study was carried using 86 randomly collected dry sternal bones which were used as a teaching material in the Department of Anatomy, Navodaya Medical College, Raichur, Karnataka. Various kinds of sternal variations and anomalies were observed and documented.

**RESULTS:** The variations observed in the present study are shown in table 1.

In the present study, all the sternal foramina were located in the inferior part of sternum (Figs 1 and 2). The size of sternal foramina ranged between 5 mm and 12 mm. The Size of the foramina was measured using digital calliper. The sternal foramina were situated inferior to the sternal angle, their distance from which ranged from 5 to 8 cms.

**DISCUSSION:** A Specialized mesenchymal condensation of the anterior thoracic wall form the sternum, which is a vertical component of the axial skeleton. As the ribs grow laterally and anteriorly, a pair of mesenchymal sternal bars, condenses and forms within the ventral body wall. By the 8<sup>th</sup> week of development, these bars begin to condense into cartilaginous sternal plates and then fuse into a single midline structure. As the sternal plates fuse together, the superior seven pairs of ribs, which growing and have also begun to condense, make contact with the lateral edges of the plates. The fused sternal plates later ossify to form the sternum through the development of several ossification centers, giving rise to distinctive anatomy of the adult sternum. The manubrium and sternal body begin to ossify until child is about three years of age<sup>11</sup>. Any failure in the developmental process results in various sternal anomalies, such as fissures or foramen<sup>3,4,10</sup>. Fusion of inferior end of sternum is sometimes incomplete, resulting in a bifid or perforated xiphoid process<sup>12</sup>. Malformations of xiphoid process are seen in mice mutant for both HOXc-4 and HOXA-5, and mice mutant for HOXB-2 and HOXB-4 have split sternums<sup>13</sup>.

Congenital anomalies of the sternum comprise a broad spectrum of deformities that is difficult to classify. Reviewing the world literature, Shamberger and Welch<sup>14</sup> in 1990 divided them into four groups: cervical ectopic cordis, thoracic ectopic cordis, thoracoabdominal ectopic cordis and cleft sternum. Few associated anomalies are described<sup>14</sup>: a band like scar from the umbilicus to the sternal defect or from it to the chin, cervicofacial hemangiomas, and diastasis recti.

Reported developmental anomalies of sternum included branched xiphoid process, V-shaped bifurcation, sternum bifidum, synchondrosis sternii (incomplete ossification of sternum), anomalies in the shape of the sternum (wedge-shaped or asymmetrical bone), sternum gallinaceum and sternal foramen<sup>15</sup>. Sternal foramen associated with accessory fissures on left lung were reported by using high-resolution computed tomography<sup>16</sup>. The incidence of sternal foramen were evaluated as 4.3% on chest CT by Stark<sup>7</sup>, 6.7% in autopsy cases by Cooper<sup>3</sup>, 6.6% by Moore et al.<sup>17</sup>. Aktan and Savas observed it in 5.1% of Turkish population<sup>16</sup>, 9.6% in men and 4.3% in women by McCormick<sup>18</sup>. The present study reported the incidence of 7%. Yekeler et al. reported xiphoid foramen in 27.4% and double ended xiphoid process in 27.2%<sup>17</sup>. In the present study, the incidence of xiphoid foramen was 3.5% (Fig 2) and that of bifid xiphoid process was 4.6% (Fig 3).

The present study also revealed an incidence of 7% for elongated xiphoid process (Fig 4) and an incidence of 5.8% for broad and thin xiphoid process (Fig 5). Yekeler et al. reported elongated xiphoid process in 5 cases in his study of 1000 subjects<sup>17</sup>.

Partial or complete sternal cleft may be observed as an isolated anomaly, or may be accompanied by other anomalies and lesions<sup>16</sup>. Pasic et al. reported a 45-year old woman with a sternal cleft associated with craniofacial and brain hemangiomas, an aneurysm of an aortic arch, anomalous micrognathia, supraumbilical raphe, and a cervical cyst. Hersh et al. reported two additional patients with sternal cleft and cutaneous, craniofacial hemangiomas. It is possible that the formation of the sternum and proliferation of midline angioblastic tissue may be affected by certain mechanisms during the 6<sup>th</sup> to 9<sup>th</sup> gestational weeks. In conclusion, in an asymptomatic patient with sternal cleft, careful investigation is needed to identify possible asymptomatic internal vascular anomalies<sup>16</sup>.

Sternal anomalies are frequently detected accidentally by radiology, multiplanar and 3D reconstructed CT images, and MRI<sup>15</sup>. CT is the modality of choice to evaluate anatomic detail as well as pathological conditions of the sternum, sternoclavicular joints, and adjacent soft tissues<sup>19</sup>. A vertical sclerotic band superior or inferior to the foramen is a common associated finding on coronal CT images. A sternal foramen, has been incidentally detected at CT in nearly 5% of the population. Rarely, a sternal cleft may be seen adjacent to a sternal foramen. CT allows differentiation of the cortex from the medulla; depicts normal spiculations and pits, among other variants; and allows normal variants to be differentiated from pathological abnormalities. The xiphoid appendage may be absent, occurs with structural variations (e.g., a double or triple ended configuration), and contain clumpy or irregular calcifications<sup>19</sup>.

A sound knowledge of sternal variations and anomalies is very important for medical practitioners. Fatal cardiac tamponade resulting from a congenital sternal foramen located in the inferior part of the sternum and low thickness of sternal body was seen during the sternal puncture<sup>15</sup>. Foramina in sternum were misinterpreted as acquired lesions, like gunshot wounds<sup>20</sup>. To be familiar with the imaging appearances of the sternal variation and anomalies, it is necessary to differentiate those from the pathological conditions, such as traumatic fissures or fracture and lytic lesions. Absence of cortical irregularity, expansion and soft tissue mass can be taken into consideration in the differentiation<sup>17</sup>. Acupuncturists should be aware of congenital sternal foramina to avoid serious heart injury by needle insertion, especially since this area holds a commonly used acupuncture point<sup>21</sup>. Deep perpendicular needling at REN 17 is therefore, contraindicated for patients with congenital sternal foramen, oblique or transverse needling should be used<sup>22</sup>. Thus, it is important for doctors to have thorough knowledge about sternal anomalies for better diagnosis and treatment.

**CONCLUSION:** Sternal variations are not uncommon. A sound knowledge of sternal variations and anomalies is very important for medical practitioners, radiologists and acupuncturists.

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**TABLE1. STERNAL VARIATIONS OBSERVED IN THE STUDY**

| SL. NO. | VARIATION                      | NUMBER | INCIDENCE |
|---------|--------------------------------|--------|-----------|
| 1       | STERNAL FORAMEN                | 6      | 7%        |
| 2       | BIFID XIPHOID PROCESS          | 4      | 4.6%      |
| 3       | XIPHOID FORAMEN                | 3      | 3.5%      |
| 4       | ELONGATED XIPHOID PROCESS      | 6      | 7%        |
| 5       | BROAD AND THIN XIPHOID PROCESS | 5      | 5.8%      |



**FIG 1: STERNAL FORAMEN (encircled) FIG 2: STERNAL FORAMEN WITH FORAMEN IN XIPHOID PROCESS**





**FIG 3: BIFID XIPHOID PROCESS**



**FIG 4: ELONGATED XIPHOID PROCESS**



**FIG 5: BROAD AND THIN XIPHOID PROCESS**