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Approach to Anatomical Variations of Sternum on MDCT and Its Clinical Significance

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Abstract: *The sternum is one of the skeletal parts, which shows a high frequency of anatomical variations on cross-sectional imaging and autopsy or cadaveric studies. Identification of sternal variations is important to differentiate them from pathological conditions and to prevent fatal complications prior to sternal interventions like marrow aspiration or acupuncture. Our study aims to evaluate the frequency of various anatomical variations of sternum and to demonstrate their appearance on MDCT. This record based cross sectional study was conducted in one hundred fifty patients who underwent thoracic MDCT examination prospectively and retrospectively over a period of 3years from September 2015 to September 2018.Out of 150 patients, the following major anatomical variations of sternum include24 patients (16%) showed xiphoid foramen,23 patients (15.3%) showed double ending xiphoid process,14 patients (9.3%) showed sterno xiphoid fusion and 12 patients (8%) showed elongated xiphoid process.*

Hence forth the above study showed Sternum shows very high incidence of anatomical variations. The knowledge of these variations is important for clinicians, radiologists and surgeons to differentiate them from other pathologies and to prevent catastrophic complications during interventions.

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I. Introduction

The sternum or breastbone is a long vertical flat axial bone forming the anterior part of thoracic skeleton and thus helps to protect vital organs like heart, lungs and major blood vessels.The average length of sternum in the adult is about 17cm and consists of three parts a cranial manubrium, an intermediate body and a caudal xiphoid process. The manubrium is broad and joins the body and forms projecting sternal angle or angle of Louis. The body or Gladiolus is the longest part of the sternum and the xiphoid process is a thin sword-shaped process and is the smallest and most variable part of the sternum; its caudal end is related to the central tendon of the diaphragm and inferior border of the heart.[1]Human skeletons have many variations that may occasionally necessitate distinction from pathologic changes. The sternum is one of the skeleton parts with frequent variation in appearances on images or autopsy series.[2]

Sternal variations can occur in manubrium, body, or xiphoid. With the increasing use of multidetector computed tomography (MDCT), the sternal variations can be identified more frequently. In a large series, sternal variations and anomalies were characterized based on macroscopic and radiographic appearances in autopsy populations.[3]In another series involving living subjects, the frequency of sternal anomalies has been described based on radiograph[4,5],helical computed tomography (CT)[6,7],and magnetic resonance imaging (MRI)[8]appearances. Although there are many sternal variations that occur with varying appearance and prevalence, most of them are not recognized or are underreported during routine imaging of thorax.Recently, an increasing number of minor sternal variations have been reported with the advent of multidetector computed tomography (MDCT).[9]

Knowledge of radiologic appearances of sternal variations and anomalies is useful so as to not confuse those with pathologic conditions. Awareness of a sternal foramen is important in acupuncture practice and sternal marrow aspiration because of the danger of heart damage.[1]

II. Material And Methods

This record based cross sectional study was carried out on patients of Department of radio diagnosis at Maharajah's institute of medical sciences, Nellimarla, Viziyanagaram, Andhra Pradesh from September 2015 to September 2018.

Study Design: Record based cross sectional study.

Study Location: This was a tertiary care teaching hospital based study done in Department of Radio-diagnosis, at Maharajah's institute of medical sciences, Nellimarla, Viziyanagaram, Andhra Pradesh.

Study Duration: September 2015 to September 2018.
Sample size: 150 patients.

Sample size calculation: The sample size was estimated on the basis of a single proportion design. The sample population was selected based on simple random method.

III. Subjects & Methods

This study was carried out on 150 patients who underwent thoracic MDCT examination over a period of 3 years from September 2015 to august 2018 (prospectively and retrospectively)irrespective of age and sex.MDCT imaging was performed in our centre using 16 slice CT scanner (Revolution ACTs, GE health care) from the level of thoracic inlet to the level of adrenals in a cranio-caudal direction. Common scanning parameters for all patients were as follows: 120kVp, 100-180mAs, 0.5-sec gantry rotation, 16 x 0.625mm collimation and 2-mm axial and 3-mm multiplanar reconstruction image thicknesses. The entire sternum including xiphoid process was included in all the cases.For better identification of sternal variations, images are analyzed in axial, sagittal, and coronal multiplanar reconstruction (MPR) using bone algorithm followed by maximum intensity projection (MIP) and volume rendering (VR). Various kinds of sternal variations such as Suprasternal or EpisternalOssicle, Sternal Tubercle, Manubriosternal Fusion, Sternal Foramen, Ventral Deviation Of Xiphoid, Elongated Xiphoid (>4cm), Sternoxiphoid Fusion, Xiphoid Foramen, Double Ending Xiphoid and Triple Ending Xiphoid were documented.

Inclusion criteria: All patients who underwent thoracic MDCT examination.

Exclusion criteria: Patients whose imaging findings are inconclusive due to artifacts.

IV. Results

In our study of 150 patients who underwent thoracic MDCT exmanination – 88 are males and 62 are females.

Table no 1 : Shows Sex distribution

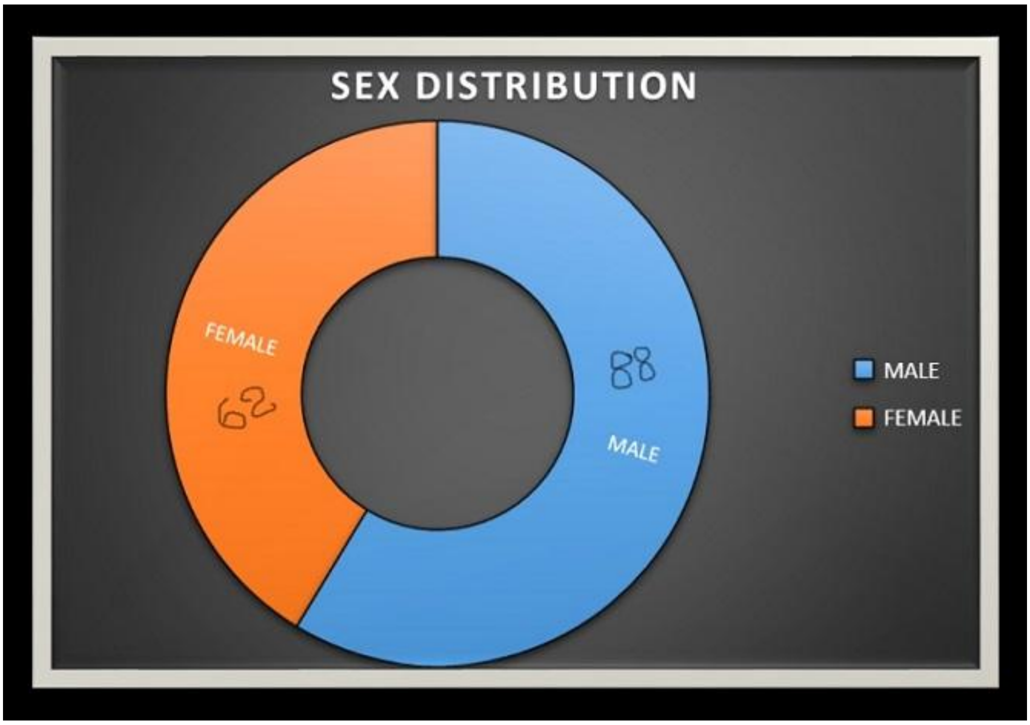


Table no 2 : Shows Age distribution

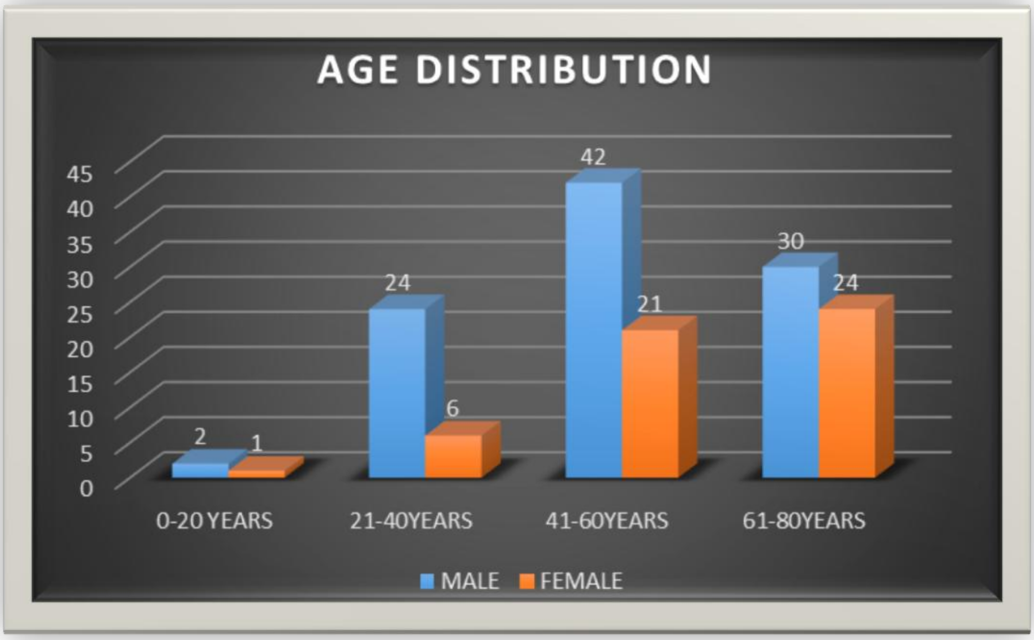


Table no 3 : Showing patients with one sternal variant and patients with multiple sternal variants

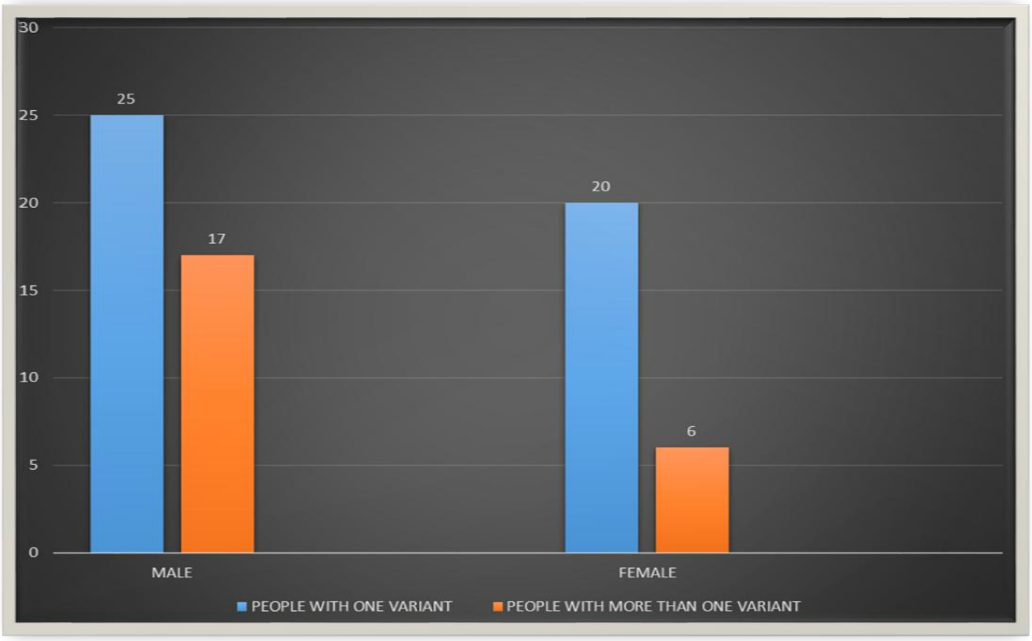


Table no 4: Showing male and female patients with sternal variants and without sternal variants

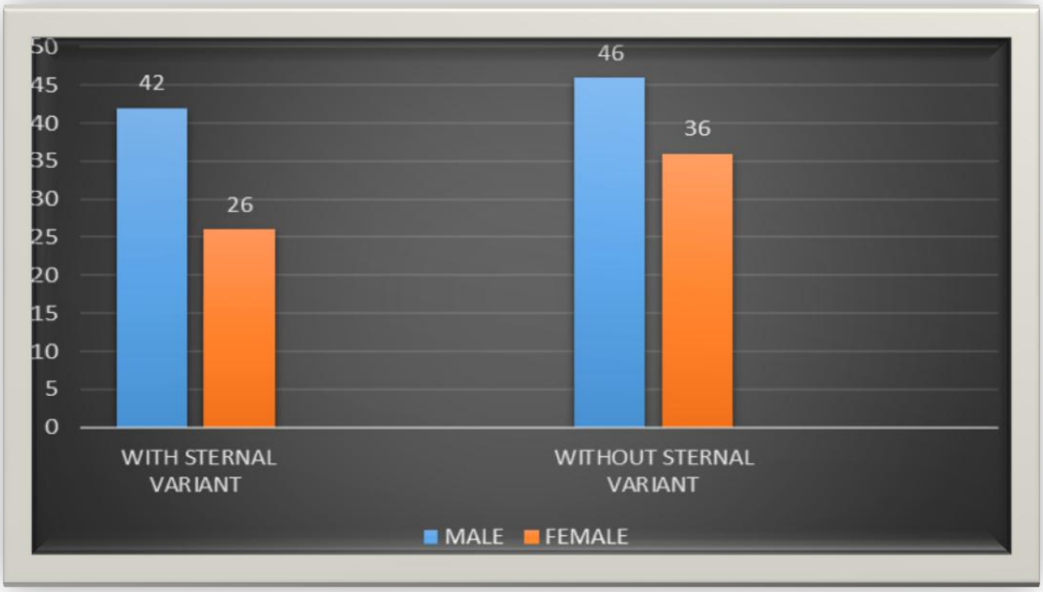
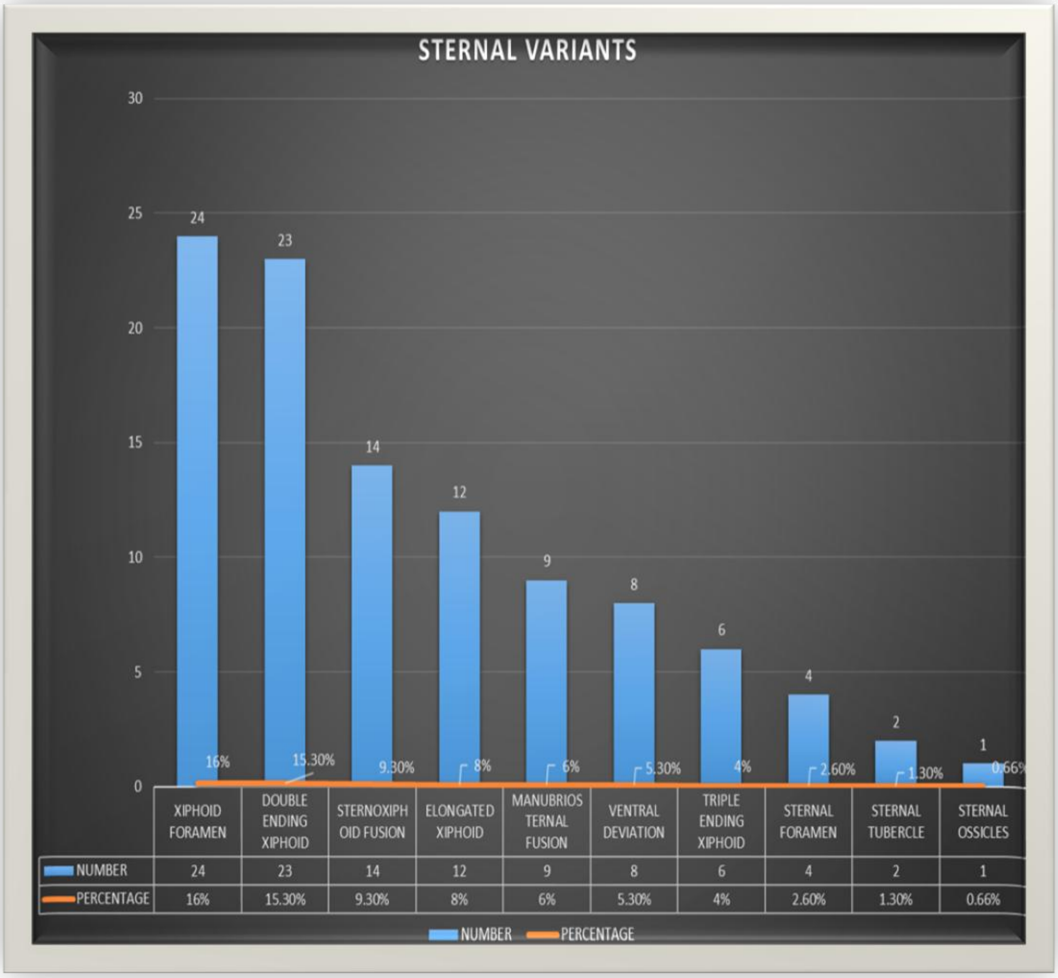


Table no 4: Showing Frequency of various sternal variants in our study



The sternal variations and anomalies depicted on axial and multi-planar reconstructed images were documented.
Xiphoid foramens were found in 24 patients (16%),
Double ending xiphoid were found in 23 patients (15.3%),
Sternoxiphoid fusion were found in 14 patients (9.3%),
Elongated xiphoid process were found in 12 patients (8%),
Manubriosternal fusion were found in 9 patients (6%),
Ventral deviation of xiphoid were found in 8 patients (5.3%),
Triple ending xiphoid were found in 6 patients (4%),
Sternal foramen were found in 4 patients(2.6%),
Sternal tubercle were found in 2 subjects(1.3%) and
Sternal ossicles were found in 1 patient (0.66%).

V. Discussion

The sternum (or breastbone) is a flat bone situated vertically in the median and the anterior part of the thoracic cage.[10] The sternum can be divided into three parts; the manubrium, body and xiphoid process. In children, these elements are joined by cartilage. The cartilage ossifies to bone during adulthood.The ossification centres at each segment of the sternal body generally fuse to form single ossification centre during 6 to 12 years of age. The calcification and fusion of sternal body segments is usually complete by 25 years of age. Failure in this developmental process results in sternal variations and anomalies.[3,4,11,12]In our study 10 anatomical variations of sternum were documented.

Suprasternal or episternalossicles: It is a small accessory ossicle at the superior margin of manubrium that results from supernumerary ossification centers.It can be unilateral or bilateral[12]. In our study bilateral suprasternal ossicle was reported in 1 patient.The presence of these suprasternal ossicles is usually incidental, but they should be differentiated from vascular calcifications, calcified lymph nodes, fracture fragments, and foreign bodies.[13]

Sternal tubercle: It forms when a suprasternal ossicle fuses with manubrium.Similar to suprasternal ossicle, it can be unilateral or bilateral.Occasionally, the suprasternal ossicle and sternal tubercle occur in the same patient.[4]In our study unilateral sternal tubercle in 1 patient and bilateral sternal tubercle in 1 patient were reported.

Figure no 1:

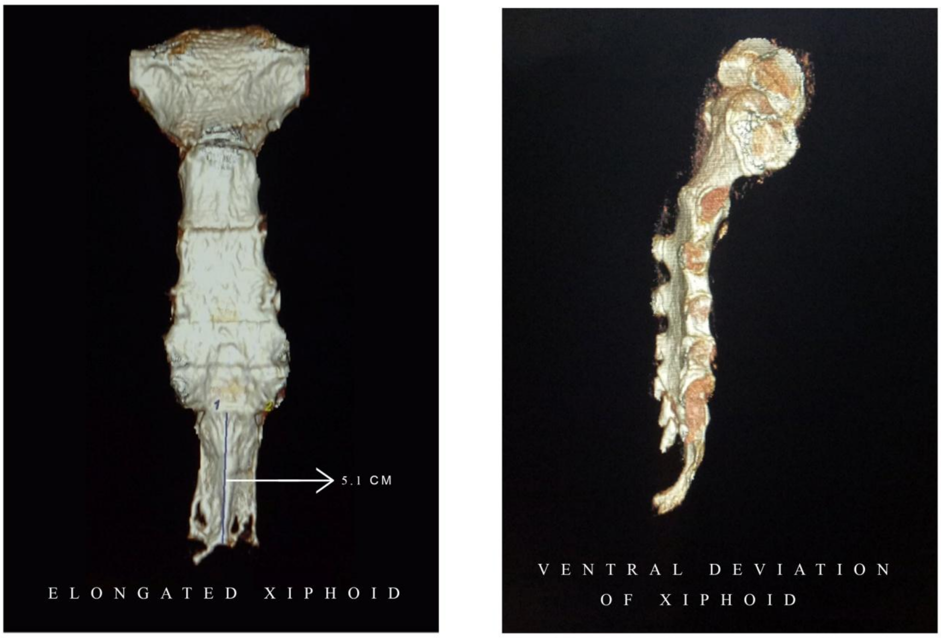
Manubriosternal fusion: It can be partial or complete.Complete fusion can be seen in younger and older patients.Manubriosternal fusion in the older age group due to degeneration can be associated with bridging osteophytes.[14]Inflammatory arthritis (especially ankylosing spondylitis) can lead to similar fusion of manubriosternal joint.[15,16] But this pathological ankylosis can be differentiated by its clinical features, involvement of other joints (including sternoclavicular joint and spine), and biochemical markers.Developmental fusion without osteodegeneration can occur in younger age group and should be differentiated from pathological bony ankylosis.[12]In our study manubriosternal fusion were reported in 9 patients(5 patients are <60years and 4 patients are >60 years age).

Sternal foramen: It occurs from incomplete fusion of a pair of sternebrae.It can be single or multiple and is usually seen in lower part of the sternal body.[12]Sometimes, the sternal foramen can mimic a lytic lesion, especially in bone scintigraphy where it appears as a focal defect.[17]Identification of such variations is important to prevent fatal complications during sternal marrow aspiration,acupuncture or penetrating wounds.Since mediastinal structures are unprotected, complications like cardiac tamponade can occur.[18,19,20]In our study sternal foramen was documented in 4 patients.

Ventral deviation of sternum: Review of literature shows elongated and ventrally deviated xiphoid process can be mistaken for an epigastric mass and cause pain.[9]In our study ventral deviation of sternum were reported in 8 patients.

Elongated xiphoid: Normal length of xiphoid process is less than 4cm.Xiphoid process length of more than 4cm is called elongated xiphoid.Elongated xiphoid process can be mistaken for an epigastric mass and causes pain.[9]In our study elongated xiphoid process were reported in 12 patients.(maximum length measured in a patient was 5.1cm)

Figure no 2:



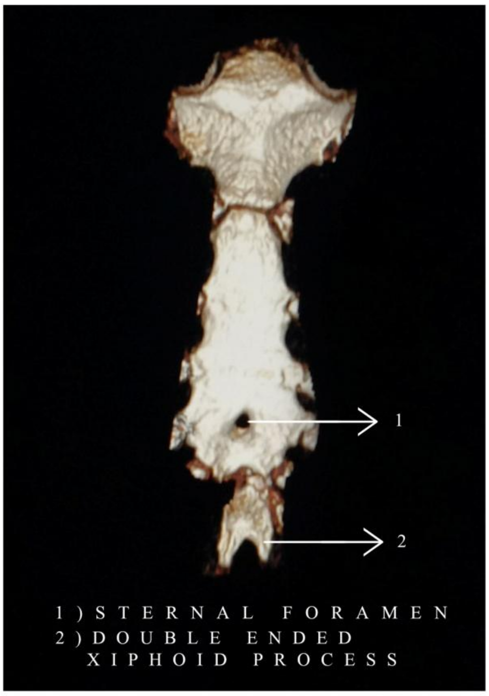
Sternoxiphoid fusion: Sternoxiphoidal fusion can be partial or complete.It is best seen in sagittal and oblique coronal planes.Complete fusion can be seen in younger and older patients.[14]In our study sternoxiphoid fusion were reported in 14 patients.

Xiphoid foramen: Compared to sternal foramen these have lesser clinical significance.In our study xiphoid foramen were reported in 24 patients.

Figure no 3:

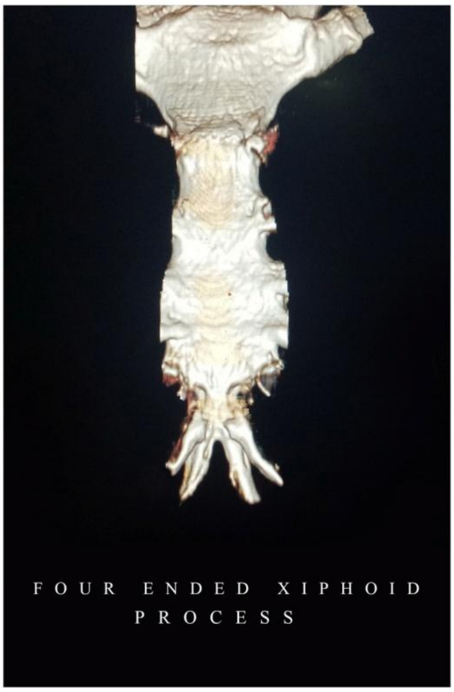
Xiphoid ending types: Xiphoid ending is classified as single, double, or triple. The most common xiphoid ending is single, followed by double and triple ending.[14,16]In our study 23 patients with double ending xiphoid and 8 patients with triple ending xiphoid were reported.

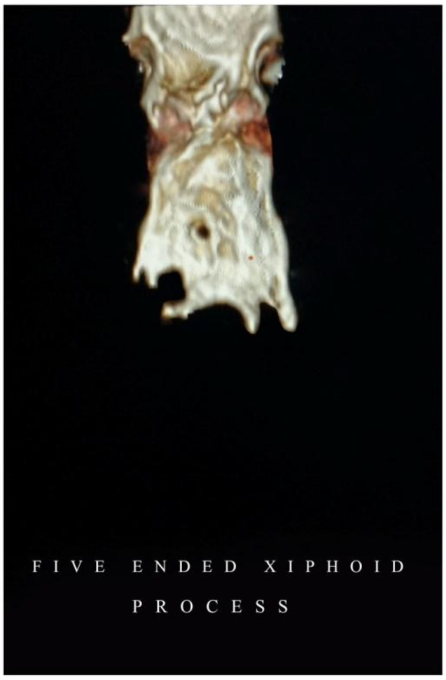
Figure no 4:



Rare variants of xiphoid process ending:Four ended xiphoid process and five ended xiphoid process were probably first described in present study.

Figure no 5:





VI. Conclusion

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.Sternal foramen can mimic as lytic lesion in bone scintigraphy.Elongated and ventrally deviated xiphoid can present as epigastric mass.Developmental fusion of manubriosternal joint in younger age group should not be misinterpreted as pathological bony ankylosis.Prior identification of sternal foramen in invasive sternal procedures prevents complications like cardiac tamponade.Suprasternal ossicles should be differentiated from vascular calcifications, calcified lymph nodes, fracture fragments, and foreign bodies.Radiologists and clinicians should be aware of the existence of these anatomical variations of the sternum as well as be familiar with their imaging features, in order to avoid diagnostic uncertainities.

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