JOURNAL OF THE ANATOMICAL SOCIETY OF INDIA 62 (2013) 95–97

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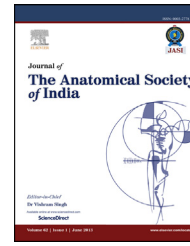

Editorial

Sternal angle revisited – From anatomy to radiology

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The sternum, a dagger-shaped bone, which forms the anterior part of the thoracic cage consists of three parts, cranial manubrium, intermediate body and caudal xiphoid process. In normal stance, sternum slopes down and slightly forward. It is very narrow at the manubriosternal joint. The sternum contains highly vascular trabecular bone enclosed by a compact bone which is thickest in the manubrium.[1]

The manubrium is a quadrilateral bone which is at level with third and fourth thoracic vertebra.[1] Suprasternal notch is the superior margin of manubrium sterni and is easily felt between the prominent medial ends of clavicle in the midline. It lies opposite the lower border of second thoracic vertebrae which act as an anatomical landmark.[2]

The manubrium articulates with the body by a layer of fibrocartilage. These two parts do not lie quite in the same plane but form an angle so that the line of their junction is prominent and is known as Angle of sternum or Angle of Loius.[3] According to the history of cadaveric dissection, manubriosternal angle is called 'angle of Louis' named after a French lawyer turned physician Pierre Charles Alexandre Louis. Chukwuemeka et al[2] state that comprehensive description of sternal angle was a review of Louis work which was studied by Edward Goodman in 1910, who stated that Louis had described sternal angle in the ' Journal of the Society of Medical Observations' in 1837. We have been unable to confirm this from any other source.

Current textbooks of anatomy divide mediastinum into superior and inferior mediastinum by a horizontal plane which passes through manubriosternal angle (Fig. 1). There is lot of controversy regarding the vertebral level through which this plane passes. Basmajian and Slonecker[4] states that "the plane of division passes through T4\5 vertebral level. At this level trachea bifurcates, the arch of aorta traverses thorax from right to left in posterolateral direction." But with the advent of studies in latest radiological techniques many notable individual variation have been reported.[5]

1. Radiology

Computed tomography (CT) is the modality of choice to evaluate anatomic detail as well as pathologic conditions of the sternum, sternoclavicular joints, and adjacent soft tissues. CT allows differentiation of the cortex from the medulla; depicts normal speculations and pits, among other variants; and allows normal variants to be differentiated from pathologic abnormalities.[5]

Chukwuemeka et al[2] studied CT sections passing through sternal angle in thorax. They have reported that plane passing through sternum passed through vertebral columns at level varying from upper part of T4 to lower part of T6 which represent a linear difference of about 5 cm. The standard view is that plane passing through sternal angle intersects vertebral column at lower part of T4 or at T4\T5 intervertebral disc (Fig. 2). In 53% of cases they found that plane passing through sternal angle passed through upper part of thoracic vertebrae T5. Shabshin et al[5] studied the relation of anatomical landmark by magnetic resonance (MR) studies of thoracic spine They found that sternal angle level ranged from T2–T5. They reported that in 55% cases it was at T3 level and in 20% cases it was at T2 level.

Magnetic resonance (MR) imaging is of great value as a secondary modality. It can help clarify CT findings and can provide additional information about the bone marrow and soft tissues adjacent to the sternum.[6] At MR imaging, the sternal anatomy is best depicted with T1-weighted spin-echo pulse sequences. The coronal plane displays the articular surfaces, as well as the intra-articular disk; the sagittal plane is useful for depicting the costoclavicular ligament; and the axial plane best delineates the

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http://dx.doi.org/10.1016/j.jasi.2013.12.008

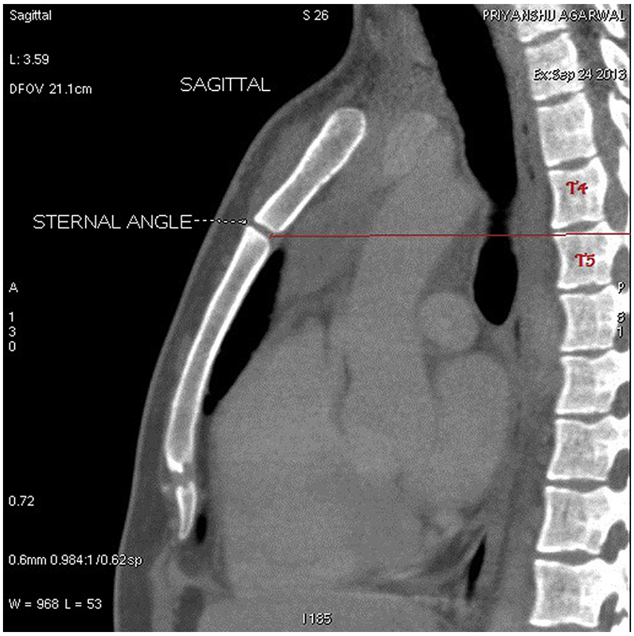

Fig. 1 – CT scan, Sagittal section defining the vertebral level of sternal angle.

anterior and posterior parts of the sternoclavicular joint capsule and the anterior and posterior sternoclavicular ligaments. Normal findings that should not be mistaken for disease include small amounts of joint fluid, nonfatty bone marrow, and poorly defined cortical margins.[6,7]

The sagittal plane is especially useful in evaluating the sternum and retrosternal region. In congenital chest wall deformities such as pectus, secondary effects on intrathoracic structures including the heart are well demonstrated. The extent of bone destruction, marrow infiltration, periosteal elevation and soft tissue component are well delineated in infections as well as primary and secondary tumours.

2. Physiological variation

Body habitus and posture are supposed to have an effect on position of thoracic vertebrae. Karabulut[8] investigated the

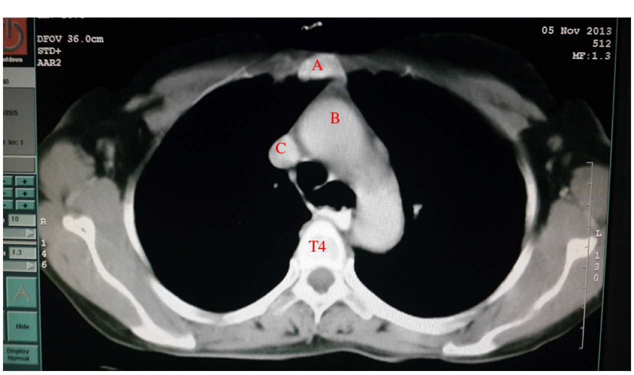

Fig. 2 – CT scan, coronal section defining the sternal angle (A – Sternal angle, B – Arch of Aorta, C – Superior vena cava).

effect of body habitus, dimensions of thoracic cavity, location of tracheal angle within the mediastinum and the effect of left atrial size on tracheal carinal angle using CT scans. He found that tracheal bifurcation angle ranged widely and was found to be significantly greater in obese people and female gender. The angle size was inversely related with the distance from tracheal angle to vertebral body. He also studied the effect of size of left atria to tracheal angle and reported an increase in tracheal angle in relation to size of left atria. But Murray et al[9] concluded that tracheal carinal angle is an insensitive and non-specific sign of left atrial enlargement.

The ascending aorta ends and descending aorta begins at the level of sternal angle i.e. it marks the concavity of aortic arch but Chukwuemeka et al[2] found that in 26% cases the plane passing through the sternal angle passed through convexity of aortic arch and higher. Shabshin et al[5] found that aortic level ranged from T2–T4. In 38% cases they found it at T4 level and at T3 level in 35% cases.

The pulmonary trunk divides into two pulmonary arteries just below the level of sternal angle. Shabshin et al[5] found the level of pulmonary artery ranged fromT4–T7 level. In 38% cases it was at T5 level and in 27% cases at T6 level.

Tatar et al[10] studied the anatomy of azygos vein in 103 cases. The arching and opening of azygos vein in most cases was at same level as that of carina.

3. Clinical significance

Sternum has a great clinical significance, considering that median sternotomy is the most common surgical approach used in open cardiac surgery.

Jugular venous pressure is commonly estimated by measuring height of jugular venous pressure to right atrium at the level of sternal angle. Classical anatomy teaching states that right atrium lies approximately 5 cm below the sternal angle. Ramana et al[11] measured the distance from sternal angle to right atrium location and correlated with patient's body habitués. They found that traditional 5 cm distance of sternal angle from right atrium varies extensively among the patients and was associated with body mass index. Therefore while measuring jugular venous pressure to calculate central venous pressure, physicians should keep in account the specific patient factors and patient's position.

When applying this surgical intervention, the sternum is cut through midline from the jugular notch to the xiphoid process and thus access to the anterior and middle mediastinal organs, especially to the heart and major blood vessels is gained. Dehiscence of the sternotomy closure and consequential separation of the sternum halves as well as development of deep mediastinitis is a relatively rare but a serious complication.[12]

Clinical significance of the sternum is also manifested during procedures of cardiopulmonary resuscitation. Sternum fracture is common consequence of active compressive-decompressive cardiopulmonary resuscitation (ACD–CPR), in other words of artificial respiration and heart massage. Fractures sustained during this procedure may cause severe heart injuries which often lead to patient's death. Studies conducted on cadavers show that sternum fractures are more common in the females over 50 years of age.[12,13]

The important factor causing fractures, besides osteoporosis, is considered to be the fact that female sternum is considerably thinner than the male and therefore more prone to fractures. With regard to exceptional variability of sternum dimensions and shape, it is very probable that divergence from standard sternum may also influence occurrence of sternal dehiscence and cause proneness to fractures. Despite that, morphometry of different organs and parts of the skeleton is well known, data of the sternum morphology and morphometry are still insufficient. Those findings are of great importance in anthropological researches in future.

4. Conclusion

Different radiological studies broadly agree with cadaveric data of standard textbooks, but significant individual variations do exist. There is need for further research to define the level of different structures with standard anatomical landmarks and radiological variations. This will be of immense value to the clinicians and cardiac surgeons.

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