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Original Research Article.

Evaluation of Topographic Anatomy of Sternal Angle by Magnetic Resonance Imaging: An Institutional Based Study

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ABSTRACT

Background: Anatomical variations of the sternal angle are unique happenings of major clinical significance. Radiologists should be aware and suspicious of this variant as a potential differential diagnosis. The present study was conducted to assess topographic anatomy at sternal angle on magnetic resonance imaging.

Materials and Methods: The present study was conducted to assess topographic anatomy at sternal angle on magnetic resonance imaging. 160 MRI scans of the cervicodorsal spine of patients were reviewed over a period of 6 months at our institution. All the MRI scans were performed in supine position. For each individual, the vertebral levels corresponding to each of the following structures were noted: TB, AA, and SA. The recorded data was compiled, and data analysis was done using SPSS (SPSS Inc., Chicago, Illinois, USA).

Results: In the present study 160 MRI scans were analysed. The SA corresponded to Level 3 in most of the individuals (65.18%) followed by level 2 in 29.62% individuals. The under surface of the AA corresponded to Level 2 in most of the individuals (71.53%). The bifurcation of the trachea corresponded to Level 2 in most of the individuals (56.25%).

Conclusion: The present study concluded that the SA corresponded to Level 3 in most of the individuals, AA corresponded to Level 2 in most of the individuals and the bifurcation of the trachea corresponded to Level 2 in most of the individuals.

Keywords: Sternal Angle, Arch of Aorta, Tracheal Bifurcation.

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INTRODUCTION

Sternal angle (SA), the forward prominence formed by the manubriosternal joint, is an important landmark in the anatomy of the thorax. Based on cadaveric studies, conventional anatomical textbooks mention the SA plane and surface marking of SA to correspond to many anatomical structures including tracheal bifurcation (TB) and aortic arch (AA).[1-3]

The sternal angle is an important clinical landmark for identifying many other anatomical points: It marks the point at which the costal cartilages of the second rib articulate with the sternum. This is particularly useful when counting ribs to identify landmarks as rib one is often impalpable. The counting of ribs is essential when one is attempting to make a thoracic incision. If the wrong rib is counted, access to the internal chest organs can be difficult. Additionally, making an incision at the first or second rib interspace can result in damage to large, important blood vessels and the brachial plexus. Identification of the second rib and thus the second intercostal space inferiorly is also useful when auscultating heart sounds. The optimal location for auscultation of the aortic valve is generally the right second intercostal space, whereas the optimal location for auscultation of the pulmonic valve is generally the left second intercostal space. It is at the level of the T4-T5 intervertebral disc. It marks the level of the transverse thoracic plane which divides the mediastinum into the superior and inferior mediastinum. It overlies the aortic arch on the left and the superior vena cava on the right. The pericardium extends from just superior to the angle of Louis to the level of the xiphisternal joint. It is roughly at the level of the bifurcation of the trachea. The tracheal carina is deep to the sternal angle. It is roughly at the level of the bifurcation of the pulmonary trunk. Ligamentum arteriosum attaches to the aortic arch deep to the angle of Louis.[4]

Anatomical variations of the sternal angle are unique happenings of major clinical significance. For instance, a misplaced sternal angle may cause inaccurate counting of ribs thereby complicating intercostal nerve blocks, needle thoracostomies and physical

examination of the chest. A misplaced sternal angle is also associated with increased risk of sternal fractures in blunt chest trauma.[5] An additional sternal symphysis can mimic a fracture, traumatic fissure, or an osteolytic lesion during sternal imaging.[6,7] Radiologists should be aware and suspicious of this variant as a potential differential diagnosis. The present study was conducted to assess topographic anatomy at sternal angle on magnetic resonance imaging.

MATERIALS AND METHODS

The present study was conducted to assess topographic anatomy at sternal angle on magnetic resonance imaging. 160 MRI scans of the cervicodorsal spine of patients were reviewed over a period of 6 months at our institution. Before the commencement of the study ethical approval was taken from the Ethical Committee of the institute and written consent was taken from the patient after explaining the study. Patients with scoliosis of the cervical and/or dorsal spine, patients with basilar invagination, Patients with collapse vertebrae, Patients with any congenital vertebral anomaly, Patients with evidence of sternotomy, Suboptimal visualization of structure under study were excluded from the study. All the MRI scans were performed in supine position with both arms lying parallel to and by the side of the torso. The routine protocol for MRI of the cervicodorsal spine consisted of T1-weighted (T1W) and T2-weighted (T2W) TSE sagittal and coronal and T2W gradient recalled echo (GRE) axial images, respectively, of which only the T1W and T2W coronal and sagittal images were reviewed. The imaging parameters for the MR scan were as follows:

- T1W TSE sagittal: Repetition time (TR) – 407 ms and time to echo (TE) – 14 ms
- T2W TSE sagittal: TR – 4000 ms and TE – 115 ms
- T1W TSE coronal: TR – 400 ms and TE – 15 ms.

All the scans were done at a field of view of 280 mm, slice thickness 3 mm, and with a matrix size 512 × 512. For each individual, the vertebral levels corresponding to each of the following structures were noted: TB, AA, and SA. For ease of statistical analysis, these vertebral levels were grouped into three broad groups.

Level 1: Superior to T4 vertebral body level

Level 2: At the T4 vertebral body and T4–5 IV-disc level

Level 3: Inferior to T4–5 IV-disc level.

The recorded data was compiled, and data analysis was done using SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA).

Table 1: Number of cases included in the study.

Parameter	Studied
Sternal angle	135
Arch of aorta	137
Tracheal bifurcation	112

Table 2: Vertebral levels of the sternal angle

Level- wise distribution	No. of individuals
Level 1	7(5.18%)
Level 2	40(29.62%)
Level 3	88(65.18%)

Table 3: Vertebral levels of the arch of the aorta

Level- wise distribution	No. of individuals
Level 1	12(8.75%)
Level 2	98(71.53%)
Level 3	27(19.70%)

Table 4: Vertebral levels of tracheal bifurcation

Level- wise distribution	No. of individuals
Level 1	6(5.35%)
Level 2	63(56.25%)
Level 3	43(38.39%)

RESULTS

In the present study 160 MRI scans were analysed. The SA corresponded to Level 3 in most of the individuals (65.18%) followed by level 2 in 29.62% individuals. The under surface of the AA corresponded to Level 2 in most of the individuals (71.53%). The bifurcation of the trachea corresponded to Level 2 in most of the individuals (56.25%).

DISCUSSION

The sternum, a flat bone located in the middle of the chest, forms part of the anterior thoracic wall overlying the heart and great vessels in the middle mediastinum. It consists of three parts: manubrium, body, and xiphoid process. The manubrium, the superior part of the sternum, is located anterior to third and fourth thoracic vertebrae and is somewhat triangular. The body of the sternum is located anterior to fifth and ninth thoracic vertebrae. It is longer, thinner, and narrower than the manubrium, but its width varies owing to the scalloping of its lateral borders by the costal notches.[8] 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.[5] The manubrium and body lie in slightly different planes; hence, their junction forms a projecting sternal angle or angle of Louis, named after a French Surgeon and Physiologist who first described it.[8]

In the present study 160 MRI scans were analysed. The SA corresponded to Level 3 in most of the individuals (65.18%) followed by level 2 in 29.62% individuals. The under surface of the AA corresponded to Level 2 in most of the individuals (71.53%). The bifurcation of the trachea corresponded to Level 2 in most of the individuals (56.25%).

A review of literature found two studies[9,10] that have documented the size of the sternal angle, one in Kenya and the other in Croatia. The sternal angle across populations with Ugandan and Kenyan sterna being smaller than Croatian sterna. This difference may be attributed to geographical variations in the size of the angle and probably body mass index, as sample size and methodology used in these studies were similar.

Various imaging modalities have been used to study the level of SA in relation to the other mediastinal structures and vertebral levels. Arora and Singh in an editorial have comprehensively reviewed the role of imaging in assessing the SA. They suggested that CT and MR are preferred modalities for accurate depiction of mediastinal anatomy. They also noted that there is significant

individual variation in the level of mediastinal structures in various studies.[11] Shabshin et al. correlated the superior margin of the aorta with the vertebral level and found it to vary from T2–T4 level, with only 8% of the cases above the level of T3 vertebra.[12]

Connor et al.[13] have found that the mean vertebral level of the superior surface of AA is T3 with a range of T2–T5.

Sharan et al. studied the vertebral level of the sternal notch on T1 scout mid-sagittal MRI images in 106 consecutive patients to determine the appropriate surgical approach for thoracic spinal reconstruction without using thoracotomy or sternotomy.[14]

CONCLUSION

The present study concluded that the SA corresponded to Level 3 in most of the individuals, AA corresponded to Level 2 in most of the individuals and the bifurcation of the trachea corresponded to Level 2 in most of the individuals.

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