Prevalence of Sternal Variants in the Adult Population of Benghazi: A CT-Based Observational Study

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Abstract: ***The sternum, a key anatomical component of the thoracic cage, may present with numerous anatomical variations, often asymptomatic yet clinically relevant in diagnostic imaging. This retrospective study aimed to assess the prevalence of such sternal variations in the adult population of Benghazi using 128-slice CT scans over a one-year period. A total of 500 patients (141 males, 359 females) were included, and variations such as sternal foramen, clefts, double-ended xiphoid processes, and episternal ossicles were analyzed. The most common variation identified was the double-ended xiphoid, particularly among the 41–60 age group. The findings underscore the need for radiologists to recognize these variations to prevent misdiagnosis and avoid potentially fatal procedural complications.***

Keywords: sternum, anatomical variations, CT scans, Benghazi, sternal variations

1. Introduction

Sternal anatomical variations are asymptomatic incidental findings that could be mistaken for another pathological lesion, for example, lytic sternal deposit, if not detected before any puncture, may lead to critical complications such as cardiac tamponade or cardiac rupture [1]. Some variations (double-ended xiphoid process) may present with vague pain, which may be mistaken for epigastric pain. With the advent of MDCT, it has become easier to detect even minor sternal variations that were previously diagnosed by autopsy. The sternum is a flat bone, congenitally formed by the fusion of two mesenchymal bars and multiple craniocaudally ossified centers [2]. Between the sternum, manubrium, and xiphoid process, there is fibrocartilaginous tissue. The xiphoid process itself has two ossification centers; hence, any failure of fusion during the pathway may result in morphological anomalies such as a sternal cleft, sternal foramen, suprasternal ossicle, xiphoid foramen, and double-ended xiphoid process [3].

The purpose of this study is to determine the frequency and types of sternal anatomical variations in the adult Benghazi population using multidetector computed tomography. Understanding the prevalence of sternal variants in the local population is critical for reducing diagnostic errors in radiology and preventing potentially life-threatening complications during invasive procedures such as biopsies or acupuncture.

2. Methodology

This retrospective study was conducted at the radiological department of the National Cancer Center of Benghazi (NCCB). Approval was obtained from the research ethical committee. Inclusion criteria were non-trauma patient, both sexes, age more than 18 years old, where the sternal bone is fully developed. Exclusion criteria were traumatic patients and patients with bone pathology, and age less than 18 years old. The sample comprised 500 patients living in Benghazi, Libya over a period of a year (2022). MDCT Protocol: Using a 128-slice CT scanner to perform MDCT examinations of the chest from the thoracic inlet to the adrenals, the scans were acquired in a cranio-caudal direction. In all cases, the entire sternum, including the xiphoid process, must be included. The typical scanning parameters include 120 kVp, with the mA ranging from 100 to 300 depending on the body mass index, and a collimation of 64 × 0.625 mm [4]. It is recommended to use a 1 mm axial and multiplanar reconstruction image thickness for isotropic resolution. In order to better identify variations in the sternum, it is recommended to first analyze images in axial, sagittal, and coronal multiplanar reconstruction (MPR) using a bone algorithm. This should be followed by maximum intensity projection (MIP) and volume rendering (VR) for a more comprehensive evaluation [5]. The study reviewed 3D, sagittal, and axial views in bony windows of all CT scan films using Picture Archiving Communication System (PACS) from GE work station software and Radiant DICOM viewer software double-reading was used to reduce interpretation bias. Statistical analysis: Data collected and outcome measures were coded, entered, and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis. Qualitative data was represented as numbers and percentages. Data were collected and submitted for statistical analysis.

3. Results

About 500 cases were included in this study, one of them was ≤20 years old, 57 of them were between 21 and 40 years old, 292 of them were between 41 and 60 years old, and 150 cases were >60 years old. 141 of cases were males, while 359 of them were females. Analysis of the distribution of sternal variations among cases (Figure 1) , it was found that 2 cases presented carinatum (Figure 2), 24 cases showed hook-shaped sternum (Figure 3), 3 were cleft, 74 were double (Figure 4),44 were foramen (Figure 5), 2 were tubercles, 1 was ep释sternal ossicles (Figure 6), 346 were no variation, 1 case was foramen and double, 1 case was double and carinatum, and 2 were hook and foramen. Analysis of the distribution of sternal variations among cases regarding age revealed that the most common variation was the double among the age group of 41–60, followed by the foramen in the same age group (Figure 7). The distribution of sternal variations among cases regarding sex revealed that the most common variation was the double among both sexes (Table 1).

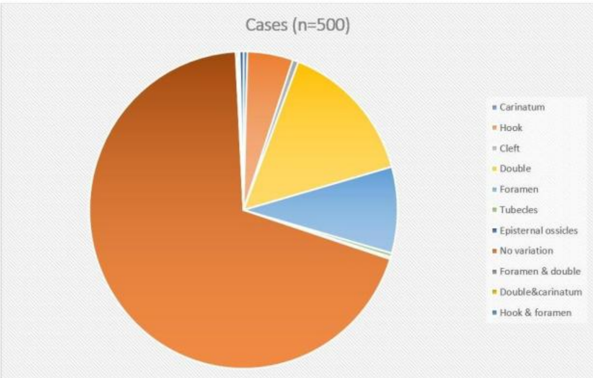

Figure 1: Distribution of sternal variation among cases

Figure 2: Sagittal bone window CT shows pectus carinatum

Figure 3: Sagittal bone window CT shows hook sternum

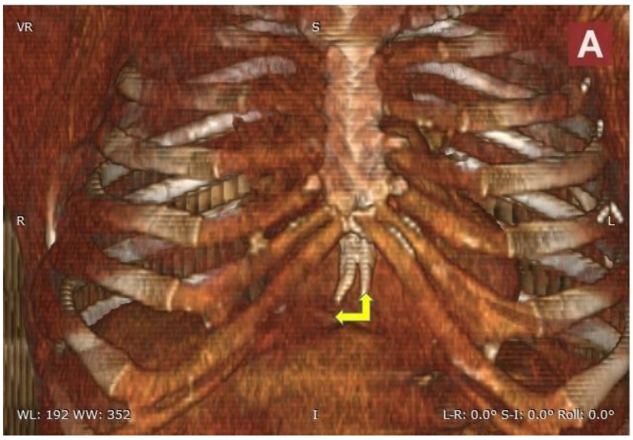

Figure 4: 3D CT shows double ended xiphoid

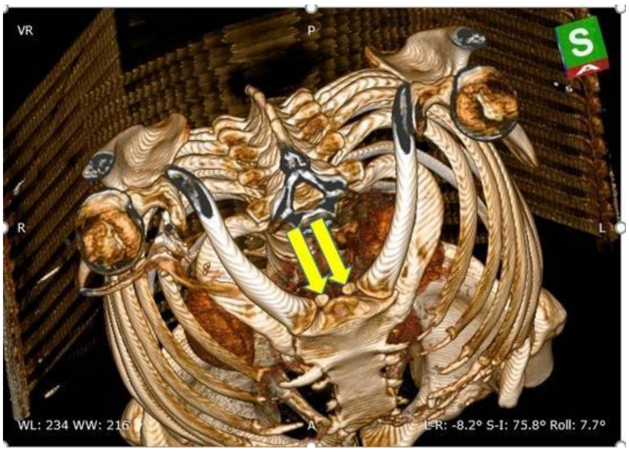

Figure 5: 3D CT shows suprasternal ossicles

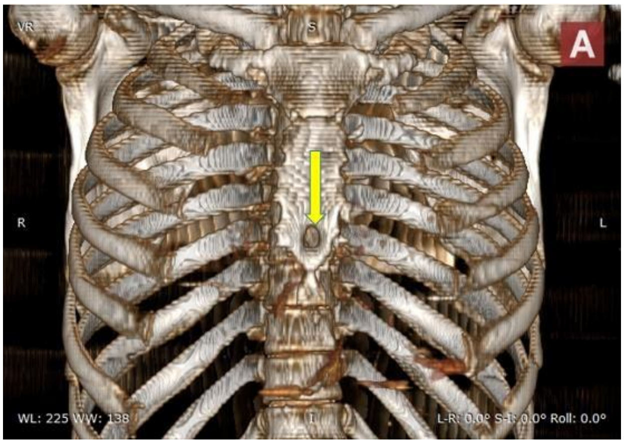

Figure 6: 3D CT shows sternal foramen

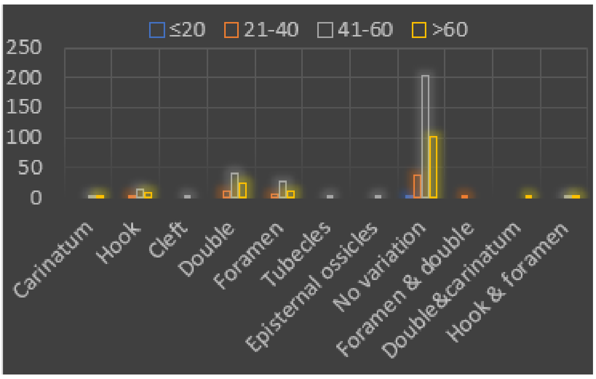

Figure 7: Distribution of sternal variations among cases regarding age

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Table 1: Distribution of sternal variation among cases regarding sex

Age (years)	Male	Female	Percentage
Carinatum	1	1	0.4%
Hook	8	16	4.8%
Cleft	1	2	0.6%
Double	20	54	14.8%
Foramen	17	27	8.8%
Tubercles	1	1	0.4%
Episternal ossicles	1	0	0.2%
No variation	91	255	69.2%
Foramen & double	0	1	0.2%
Double & carinatum	1	0	0.2%
Hook & foramen	0	2	0.4%
Total	141	359	100%
Age (years)	Male	Female	Percentage
Carinatum	1	1	0.4%
Hook	8	16	4.8%

4. Discussion

The use of MDCT has made it easier to spot even the modest sternal variations that were previously identified by autopsy. The sternum is an important anatomic structure of the chest wall, and it has several variations that may be confused with pathologic conditions. This study aimed to collect comprehensive data to minimize bias and better understand the prevalence of variations and determine whether it's within normal accepted limits. Yekeler et al. determined manubrial clefts in 0.6% and sternal clefts in 0.8% of patients [6]. On the other hand, Macaluso et al. examined a total of 122 patients and did not observe a sternal cleft [7]. Similarly, Turkay et al. observed a thin sternal cleft in 3 (0.6%) patients and they did not observe a manubrial cleft among their patient population [8]. The frequency of sternal foramen appears to be independent of ethnic variation. Although the sternal foramen frequency has importance on an anatomical level, its relation to mediastinal structures gains clinical significance [9]. Similarly, Gossner et al. (2013) examined 352 chest CTs and reported a 4.5% frequency for sternal foramen presence. They also clarified that in radiologic and anatomic studies; the frequency of sternal foramina was reported between 4.3 and 6.7% [10]. In the study of Turkay et al. (2017) corresponding to previous studies, the sternal foramen frequency was 5.2% [8].

Gossner et al. (2013) reported that 53.3% of the foramina were adjacent to the lung, 33.3% were adjacent to mediastinal fat, and 20% were adjacent directly to the pericardium or heart [10].

Similarly, Turkay et al. (2017) observed that in 50% of patients, the sternal foramen was adjacent to the lung; in 38.4%, it was adjacent to mediastinal fat; and in 11.5%, it was adjacent directly to the pericardium or heart [8].

Additionally, Papadimitriou et al. (2013) found that the foramen at the inferior part of the sternum, where the sternal foramen is most frequent, typically neighbors the right ventricle in 99.31% of cases. Therefore, awareness of the presence of the sternal foramen and its relation to mediastinal structures is important to avoid unwanted complications [11]. While sternal sclerotic bands and cortical notches may not hold direct clinical relevance, the knowledge of these variants is especially important for distinguishing them from posttraumatic fissures and fractures. Identifying these variations with X-ray graphy is challenging [12].

Since CT is more sensitive for detecting osseous variations, radiologists' familiarity with these anatomic variants in CT images is important. The non-existence of cortical irregularities and a continuous cortex around the fissure are helpful findings for differential diagnosis [13].

Yekeler et al. (2006) observed vertical sclerotic bands in 37.1% of cases and cortical defects or sternal notches in 7.7% [12]. Also, Turkay et al. (2017) report similar frequencies for sclerotic band (24%) and cortical defect/notch (8.8%) among their population [8].

Furthermore, Babinski et al. reported a frequency of 17.5% for double-ended xiphoid (1). Similarly, El-Busaid et al. (2012) reported a frequency of 20% for bifurcated or duplicated xiphoid among 80 cadavers [13]. Akin et al. (2011) evaluated the MDCT images of 327 patients and observed single- ended, double-ended, and triple-ended xiphoid processes in 62.6, 32.8, and 4.6% of patients, respectively [14].

In addition, Xie et al. (2014) examined 942 patients, and they separated single-ended xiphoids as pointed (44.75%) and oval (41.04%). In some patients, there was no xiphoid [15]. Yekeler et al. (2006) examined 1000 patients and found the xiphoid to be single-ended in 71%, double-ended in 27.2%, and triple-ended in 0.7% of patients [16].

According to Turkay et al. (2017), the xiphoid was single-ended in 72.2%, double-ended in 25%, and triple-ended in 0.8% of patients. Rarely, the xiphoid process is reported to be absent [8].

Yekeler et al. (2006) reported the absence of the xiphoid in 1.1% of a population of one thousand [16]. Similarly, Turkay et al. (2017) found that the xiphoid was absent in 1.8%

5. Conclusion

This study confirms that sternal anatomical variations are common in the adult population of Benghazi and must be acknowledged during radiological evaluations to avoid misdiagnoses. Variants such as sternal foramina and clefts pose potential procedural risks if unrecognized. Hence, radiological education and further population-based studies are essential to enhance diagnostic safety and anatomical understanding.

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