Acute Traumatic Pathologies (Especially Rib Fractures) Based on Age and Gender in Patients with Blunt Thoracic Trauma: a CT Study

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Abstract

Aim: To analyze the differences in acute traumatic pathologies (especially rib fractures) based on age and gender in patients with blunt thoracic trauma.

Material and Method:411 patients aged 18-years or more with acute thoracic traumatic pathology on CT-examination were included in the study. The patients were classified into 3 age groups: Group-1:18-44 years, Group-2:45-69 years, and Group-3:70 years or more. Rib fractures were classified into 3 groups based on their level on the coronal plane(upper(1st-4th ribs), medium(5th-8th ribs) and lower(9th-12th ribs)) and axial plane(anterior, lateral and posterior).

Results: Rib fractures were found to be more common in men(69%) to women(53%)(p=0.002). The incidence of fractures was seen to increase with age(p=0.001; r=615).Rib fractures were most commonly found in the middle ribs(5th-8th ribs)in all-age-groups.The incidence of fractures in the upper ribs was significantly lower in the advanced age than the other age groups(p=0.002).Fractures were least commonly found in the anterior part of the rib in all-age-groups.Rib fractures were observed at a higher rate in the lateral part in young adults unlike the other age groups(p=0.001).A significant difference was found between the age groups in favor of young adults(group 1) in terms of the presence of parenchymal contusion without rib fracture(p=0.014).

Conclusion;Rib fractures are more common in men than women.Fractures possibility of in the upper rib structures is lower in the advanced age group.Fractures in the lateral part of the ribs are more common in young people.One should be aware of the possibility of parenchymal contusion without a rib fracture in the young age group.

Background

Blunt chest traumas comprise 10–15% of all traumas and are the cause of death in 25% of all fatalities due to trauma [1]. Blunt trauma may cause injuries in many anatomical structures such as the thoracic wall, pleura, lung parenchyma, tracheobronchial tree, vascular structures and diaphragm. The pathologies that may occur essentially depend on the trauma severity and the morphology of the anatomical structure exposed to the trauma.

The number of studies on the biomechanics of the human rib cage has increased recently [2–8]. A recent CT study on 339 subjects conducted by Weaver et al. has reported age- and gender-related structural changes.

A recent CT study on 339 subjects conducted by Weaver et al. has reported age- and gender-related structural changes of the rib cage. They found an increase in the diameter of the rib cage in all three directions from birth to adolescence, together with a decrease in thoracic kyphosis, and inferior rotation of the ribs according to the sagittal plane of the vertebrae. They also reported an increase in thoracic kyphosis, superior rotation of the ribs at the sagittal plane, and an increase in the anterior-posterior

diameter of the rib cage from young adulthood to advanced age, that was especially pronounced in men. Studies investigating the biomechanics of the human rib cage have reported that age- and gender-related changes in the thoracic anatomical structures may have an effect on trauma-related damage [8]. However, to our knowledge, there is no study in the literature investigating the relationship between age and gender and the presence and incidence of acute pathologies in patients with blunt thoracic trauma.

The aim of this study was to analyze the difference in acute traumatic pathologies (especially rib fractures) based on age and gender in patients with blunt thoracic trauma.

Material And Method

A total of 2346 patients who had undergone a thoracic CT examination due to blunt thoracic trauma between July 2018 and September 2022 were investigated retrospectively. In the end, 411 adult patients (214 males, 197 females) aged 18 years or more who were found to have acute thoracic traumatic pathology on CT examination were included in the study. Patients whose thorax CT images were not suitable for evaluation or who were not found to have acute traumatic pathology on thoracic CT were not included. The study protocol was approved by the Institutional Review Board of the University Ethics Committee (The registration number for the study is 10354421-2021/12 – 09).

The patients were classified into 3 groups by age as Group 1: aged 18–44 years, Group 2: aged 45–69 years, and Group 3: aged 70 years or more.

Thoracic CT analyses were obtained in the supine position by using a 16-section CT device (Toshiba Alexion™/Advance, Toshiba Medical Systems Corporation Nashu, Japan). Imaging parameters were section thickness 1 mm; 120 kVp; 140 mAs; 0.938 pitch; 0.5 sec rotation time; 4x1 collimation; matrix 512x512; and 250x300 mm FOV.The images were obtained after intravenous contrast material administration.

The images were evaluated at a workstation (Sectra Workstation IDS 7, Linköping, Sweden) using both the bone window and soft tissue window on axial, coronal, and sagittal plane and volume rendering 3D images. Evaluation was performed by two radiologists who were experts in Thorax CT, with a joint decision. Fracture (of the costa, scapula, sternum, vertebra, or clavicle), hemothorax, pneumothorax, pneumomediastinum, and posttraumatic pathology (contusion, laceration) and diaphragmatic or vascular damage in the lung parenchyma were recorded on the CT examination.

Rib fractures were classified in 3 groups based on their level in the coronal plane as upper level: 1st -4th ribs, medium level: 5-8th ribs, and lower level: 9th -12th ribs. In addition, rib fractures were divided into 3 groups as anterior, lateral, and posterior, based on their location in the axial plane, similar to what Diaz and Azar reported with anterior denoting from the sternum to the anterior axillary line, lateral from the anterior axillary line to the posterior axillary line, and posterior from the posterior axillary line to the costal head [9](Fig. 1).

Statistical analysis was performed by using the Statistical Package for the Social Sciences (SPSS 21.0). The relationship between the age groups of the patient and the level of rib fractures, the location, and the presence of traumatic pathologies was analyzed by using one-way ANOVA. The relationship between the gender of the patient and the level of rib fractures, the location, and the presence of traumatic pathologies was investigated by using Student's t test. The relationship between age groups and the fracture incidence was analyzed with the Spearman correlation test.

Results

A total of 411 patients consisting of 214 (52%) males and 197 (48%) females were included in the study. The mean age was 51.1 ±19.2 years in the males and 54.15 ±19.3 years in the females. No statistically significant difference was present between the patients in terms of age according to gender (p=0.704).

The incidence of the pathologies based on the age groups and gender of the patients is summarized in Table 1 and 2.

Rib fracture was observed in 251 patients (61%). Analysis of the rib fracture incidence by age groups revealed a rib fracture in 76 Group 1 patients (50.6%) (n=150), 94 Group 2 patients (59.1%) (n=159), and 87 (%85.2) Group 3 (n=102). A positive correlation was present between the age groups and fracture incidence (p=0.001; r=615).

When the patients were analyzed based on the level of the fractures at the coronal plane, a total of 471 fractures at various levels were found in the 251 patients (n=108 upper level, n=195 middle level, and n=168 lower level). The distribution of the fracture level based on age groups is presented in Table 3 and there were 138 fractures at various levels in Group 1, 186 in Group 2, and 147 in Group 3 (Table 3).

Fractures were more common at the middle level (5th-8th ribs) in all age groups and in both genders. The incidence of fractures in the upper ribs was lower at advanced age (Group 3), that an increase in the incidence of fractures in the lower ribs was also found compared to other age groups (Table 3). The incidence of upper rib fractures was significantly lower in Group 3 (p=0.002).

Analysis of the location of the fractures on the axial plane revealed the following distribution for the 516 fractures in 251 patients: n=90 for anterior, n=216 for lateral, and n=210 for posterior. The distribution of fracture location based on age groups is presented in Table 4. There were 153 fractures in Group 1,192 in Group 2, and 171 in Group 3 (Table 4). The rib location with the lowest fracture incidence was the anterior section in all age groups (Table 4). However, rib fractures were observed at a higher rate in the lateral part in Group 1, unlike the other groups (p=0.001).

Analysis of the relationship between gender and the presence of rib fractures revealed a higher incidence in men (69%) than in women (53%) (p=0.002). A positive correlation was found between the presence of a rib fracture and the detection of a pneumothorax or hemothorax (p=0.001, r=0.752; p=0.001, r=0.614, respectively). No relationship was encountered between the presence of a rib fracture and the other

traumatic pathologies. Parenchymal contusion was detected in 81 patients (54%) in Group 1 (n=150), 81 (50.9%) in Group 2 (n=159), and 45 (44.1%) in Group 3 (n=102). No relationship was found between the presence of a rib fracture and parenchymal contusion. On the other hand, parenchymal contusion was observed in 42 Group 1 patients (n=75) and 21 Group 2 patients (n=75) but none of the Group 3 patients (n=15) without rib fracture. A significant difference was present between the age groups in terms of the presence of parenchymal contusion without rib fracture (p=0.014).

Discussion

We found age and gender to be determinants of the pathologies that may occur due to chest trauma (especially rib fractures) in this study where we investigated the acute pathological findings in patients with blunt thoracic trauma according to their demographic data.

The gradual increase in the aging population has created the need for a more detailed analysis of elderly individuals. Therefore, there has been increased interest in studies investigating the age- and gender-related changes in the thoracic structure in recent years [2–8].

Kent et al. (2005) have found age to be an important factor regarding the costal angles measured in the sagittal plane in their study on 161 males aged 18–89 years. They found the ribs to become more perpendicular to the spine with increasing age [3]. Gayznik et al. found morphological changes such as an increase in the thoracic kyphosis and the anterior-posterior diameter of the rib cage to develop with increased age [5]. Campbell and Lefrak have similarly reported increased chest wall stiffness, decreased lung capacity, and decreased chest wall muscle strength with increasing age [6].

The most common finding in thoracic trauma is rib fractures. Fractures of the first three ribs may damage the brachial plexus and subclavian vascular structures. Fractures of the lower three ribs may be associated with liver, spleen, and kidney injuries, and less commonly lung injury. Rib fractures can lead to restricted respiratory movements and an increased incidence of atelectasis, which can cause subsequent pneumonia and increased mortality and morbidity [10]. We mainly investigated rib fractures in this study. Rib fractures have been reported to occur most commonly between the 4th and 9th ribs after blunt thoracic trauma in the literature [11]. Our study revealed this finding to be valid for all the age groups and both genders.

In contribution to the literature, we found that the upper ribs were injured at a lower rate in the advanced age group compared to the other age groups in our study (p = 0.002). In addition, we found the lateral part of the ribs to be more fragile in the young age group than the other age groups (p = 0.001). These findings reveal that the age-related alterations in the costal angles result in deviation of the forces and fractures at different locations.

The chest wall resists injury during blunt chest trauma. The transferred kinetic energy is decreased if a rib fracture develops while it is directly transmitted to the lung if it does not. In the latter case, the alveoli are stretched and torn due to positive pressure, and blood passes into the interstitium and alveolar space [12,

13]. We showed in our study that rib fractures are less common in the younger age group compared to the advanced age group while parenchymal contusion may occur more commonly in the younger age group, consistent with the pathophysiology of trauma.

It is extremely important to detect traumatic pathologies quickly and to start treatment during the diagnosis and treatment phase of thoracic traumas as they have high mortality and morbidity rates. Our results reveal that age and gender are determinants for traumatic pathologies, and we believe that these criteria must be considered during the evaluation of patients with thoracic trauma.

Conclusion

Rib fractures in blunt thoracic trauma patients are more common in males than females. The possibility of fractures in the upper rib structures is lower in the advanced age group than in other age groups. Fractures in the lateral part of the ribs are more common in young patients than in the other age groups and one should also be aware of the possibility of parenchymal contusion without a rib fracture in this group.

Declarations

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Author Contributions: ET: Concept, literature search, manuscript preparation, editing and review. YT: concept, literature search, manuscript preparation, editing and review. All authors read and approved the final manuscript.

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Availability of data and materials: The datasets generated and analyzed during the current study are not publicly available due to the fact that they contain information that could compromise the privacy of research participants. Data that support the fndings are avail- able via the corresponding author upon reasonable request.

Ethics approval and consent to participate: Ethics committee approval was provided by the Institutional Review Board of the University Ethics Committee (The registration number for the study is 10354421-2021/12-09).Informed consent: Not applicable

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Consent for publication: All authors consent for publication.

Competing interests: The authors declare that they have no competing interests.

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Tables

Table 1. The incidence of the acute traumatic pathologies based on the gender.

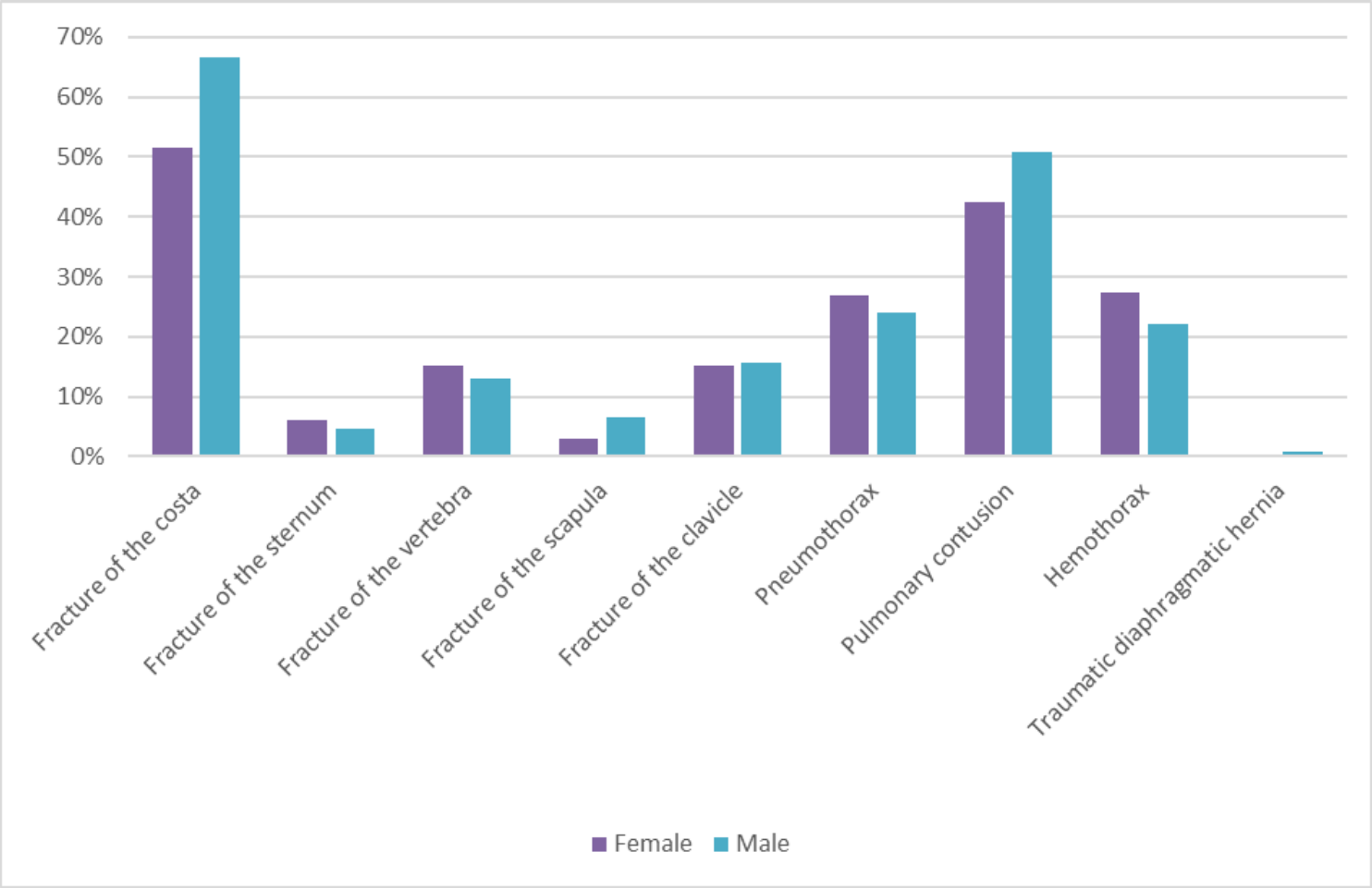

Table 2. The incidence of the acute traumatic pathologies based on the age.

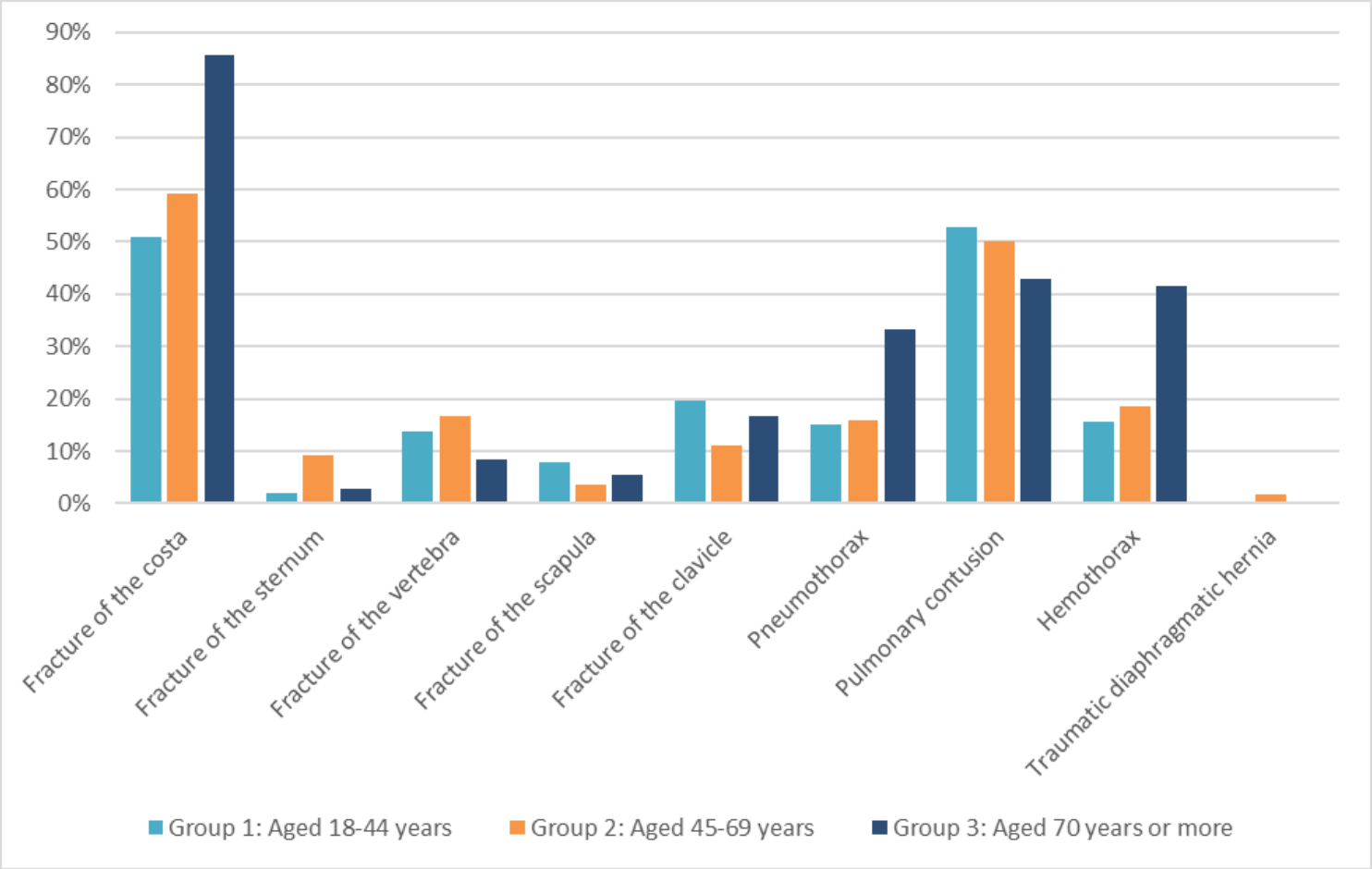

Table 3. The distribution of rib fracture level in the coronal plane based on age group.

Rib Fracture Level	Age Groups		
	Group 1 (n=138)	Group 2 (n=186)	Group 3 (n=147)
Upper (n=108)	39 (28.2%)	54 (29.1%)	15 (10.2%)
Middle (n=195)	54 (39.1%)	72 (38.7%)	69 (46.9%)
Lower (n=168)	45 (32.6%)	60 (32.2%)	63 (42.8%)

Table 4. The distribution of rib fracture location in the axial plane based on age group.

Rib Fracture Location	Age Groups		
	Group 1 (n=153)	Group 2 (n=192)	Group 3 (n= 171)
Anterior (n= 90)	24 (15.7%)	33 (17.2%)	33 (19.3%)
Lateral (n= 216)	78 (50.9%)	75 (39%)	63 (36.9%)
Posterior (n= 210)	51 (33.4%)	84 (43.8%)	75 (43.8%)

Figures

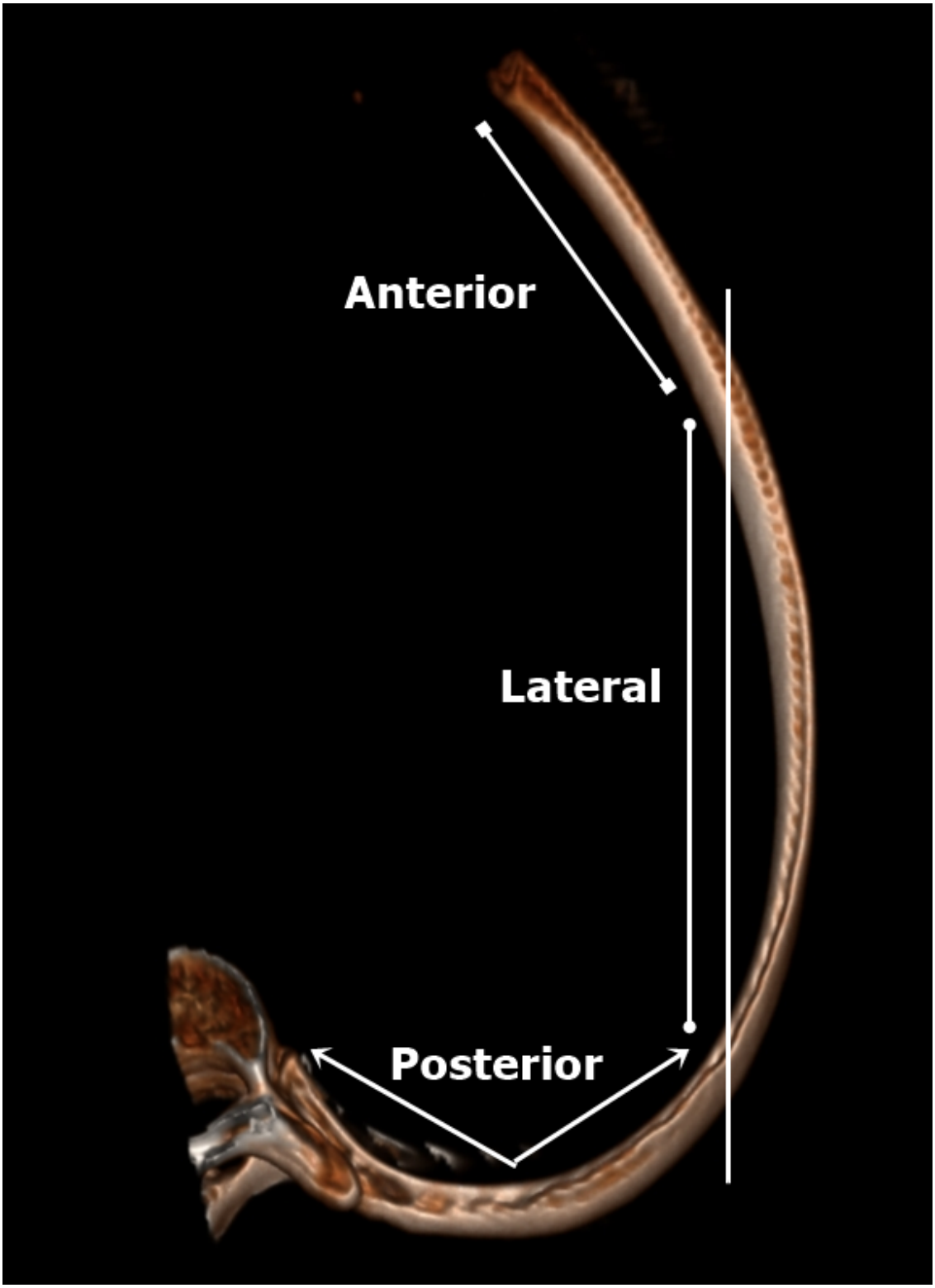

Figure 1

Rib anatomy in volume rendering 3D CT image. Anterior: from the sternum to the anterior axillary line. Lateral: from the anterior axillary line to the posterior axillary line. Posterior: from the posterior axillary line to the costa head.