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Examination of the levels of structures in the thorax in multidetector computerized tomography images

Multidedektör bilgisayarlı tomografi görüntülerinde toraks'daki yapıların seviyelerinin incelenmesi

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Abstract

Aim: Levels of the anatomical structures found in thorax and their relationships are particularly important in terms of surgical procedures. These levels are indicated with reference to the ribs and most are based on cadaver studies. The vertebral level of many structures is not specified. In this study, it was aimed to determine the level changes of some structures in the thorax according to age and gender by referring to the vertebrae. Methods: Multidetector computed tomography images of the thorax region in the PACS archives of Selcuk University Medical Faculty Hospital were used in the study. Images of 700 people, who did not undergo thoracic surgery, were studied in different age groups. The anatomical structures were evaluated with reference to the vertebrae on these images, and the findings were compared according to age groups and genders.

Results: Some of the levels of the investigations were different from the information in the classical books. It was seen that the entrance level of the aorta from the diaphragm was at Th10 level, the entrance level of superior vena cava to the right atrium was Th7 in the 0-9-year age group, Th6 level in the other age groups, and exit level of the pulmonary trunk from the right ventricle and the apex of the heart were Th7 and Th10, respectively.

Conclusion: Most of our current knowledge is based on cadaver studies rather than living human beings and the intercostal spaces are referenced in defining the levels of structures in the thorax. Age and gender distinctions have not been made in cases where most of the structures are not specified. Vertebral reference is important in terms of comparing superficial and deep structures. As the thoracic surgeon is needed in every age group, it is important that surgeons know these differences.

Keywords: Anatomy, Levels, MDCT, Thorax

Öz

Amaç: Torakstaki anatomik yapıların düzeyleri ve aralarındaki ilişki cerrahi işlemler açısından çok önemlidir. Bu seviyeler genel olarak kaburgalar referans alınarak belirtilir ve çoğu kadavra çalışmalarına dayanır. Birçok yapının vertebral seviyesi belirtilmemiştir. Bu çalışmada torakstaki bazı yapıların yaş ve cinsiyete göre düzey değişiklikleri, vertebralar referans alınarak belirlenmek amaçlanmıştır.

Yöntemler: Çalışmada Selçuk Üniversitesi Tıp Fakültesi Hastanesi Pacs arşivindeki toraks bölgesi Çok Dedektörlü Bilgisayarlı Tomografi görüntüleri kullanıldı. Göğüs cerrahisi geçirmemiş farklı yaş gruplarında 700 kişinin görüntüleri incelendi. Bu görüntülerdeki anatomik yapılar omurlara göre değerlendirildi ve bulgular yaş gruplarına ve cinsiyetlere göre karşılaştırıldı.

Bulgular: Araştırmada tespit edilen bazı düzeyleri klasik kitaplardaki bilgilerden farklıydı. Aortun diyaframdan geçişi T10, vena cava süperior'un sağ atriyuma girişi 0-9 yaş grubunda T7, diğer yaş gruplarında T6, turuncus pulmonalis'in sağ ventrikül'den çıkışı T7 ve apeks kordis'in T10 seviyesinde olduğu görüldü.

Sonuç: Mevcut bilgimizin çoğu canlı insanlardan ziyade yapılan kadavra çalışmalarına dayanmaktadır ve genellikle interkostal aralıklar referans alınarak yapıların seviyeleri belirtilmiştir. Yapılan çalışmaların çoğunda yaş ve cinsiyet ayrımı yapılmamıştır. Vertebraların referans alınması yüzeysel ve derin yapıların karşılaştırılması açısından önemlidir. Göğüs cerrahisinde yaş grupları arasındaki seviye farklılıklarının bilinmesi cerrahlar için son derece önemlidir.

Anahtar kelimeler: Anatomi, Seviyeler, MDBT, Toraks

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Introduction

The thorax (chest) is the part of the body between the neck and the abdomen. There are several organs in the thorax that are the primary organs of the respiratory and cardiovascular systems, as well as components of the digestive, endocrine and lymphatic systems [1,2]. Therefore, it is particularly important to know the anatomy of this part of the body.

The level of structures in the thorax is indicated with reference to ribs and most of them are based on cadaver studies. The vertebral level of many structures is not specified. Multidetector computed tomography (MDCT) method can be used to do several measurements (change of bone formation according to age and gender, level of structures relative to vertebras) about the structures in the thorax. Measurements based on vertebras are important for clinical applications to compare deep and superficial structures [3]. It also makes it easier for radiologists to diagnose images [4].

The anatomy of the thorax varies from person to person. The levels of anatomic structures and their relationship with each other are very important for surgical procedures [3,4]. In this study, by using the MDCT method, it was aimed to investigate the levels of some formations in the thorax compared to the vertebral bodies on patients who had not undergone thoracic trauma or operation.

Materials and methods

The study was started with the approval of the Non-Invasive Clinical Research Ethics Committee of Selcuk University, Faculty of Medicine dated 20.02.2017 and numbered 2017/69.

A total of 897 images of thin-slice thorax MDCT were examined between January 2016 and May 2017. The images of 78 cases were excluded due to intervention in the region and the images of 119 cases were excluded due to low resolution. 700 cases without thoracic trauma and operation history were included in the study (Figure 1). The MDCT images of 1 mm cross-sectional thickness in the axial plane were transferred to the workstation, along with sagittal and coronal reformat images.

The 700 cases that were measured were grouped according to gender and 7 different age ranges (0-9 years, 10-19 years, 20-29 years, 30-39 years, 40-49 years, 50-60 years, over 60 years) and results were evaluated (Table 1).

Levels of anatomically and surgically important structures were examined with reference to vertebrae. These structures are the level of passage of the aorta through the diaphragm (ADL), the entry level of the superior vena cava into the right atrium (SVCL), the entry level of the inferior vena cava into the right atrium (IVCL), the exit level of the pulmonary trunk from the right ventricle (PTL), aortic arch level (AAL), cardiac apex level (CAL), carina level (CL), right principal bronchus level of separation to segmental bronchus (RPBL), left principal bronchus level of separation to segmental bronchus (LPBL), level of sternoclavicular joint (SCJL), jugular notch level (JNL), manubriosternal joint level (MSJL) and xiphosternal joint level (XSJL) (Figure 2).

Figure 1: Number of cases according to inclusion and exclusion criteria

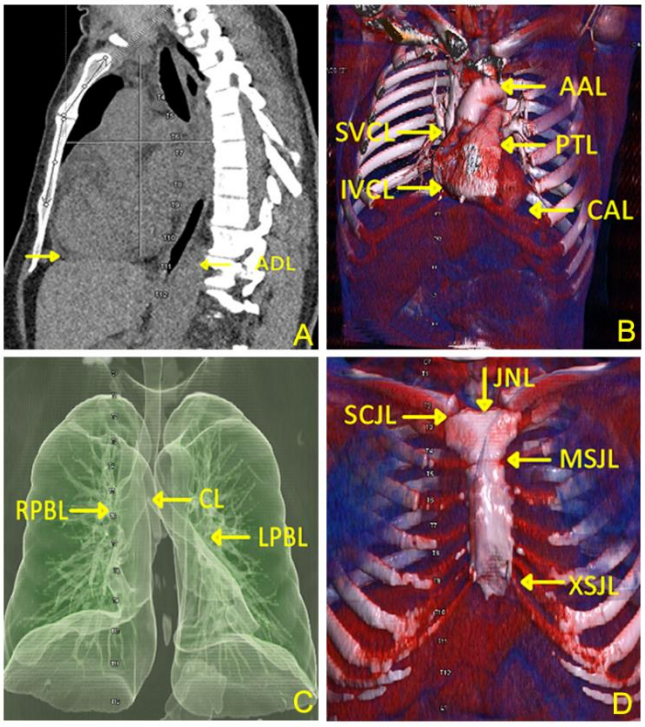

Figure 2: A: ADL level, B: AAL, SVCL, IVCL, PTL, CAL level, C: CL, RPBL, LPBL level, D: JNL, SCJL, MSJL, XSJL level

Statistical analysis

The data obtained in the study were analyzed using SPSS (Statistical Package for Social Sciences) for Windows 22.0 program. Number, percentage, mean, and standard deviation were used as descriptive statistical methods in the evaluation of the data. The relationship between grouped variables was analyzed by Chi-square analysis. The t-test was used to compare the quantitative continuous data between two independent groups, and One-way Anova test was used to compare the quantitative continuous data between more than two independent groups.

Table 1: Distribution of cases by age and gender

Age	0-9	10-19	20-29	30-39	40-49	50-59	Over 60	Total
Female	9	22	32	45	56	46	127	337
Male	16	25	41	53	41	45	142	363

Results

Levels of important anatomical structures were examined, and differences were found according to gender and age. ADL was most commonly at the T10 level in all age groups. A significant correlation was found between ADL and age groups (P<0.05). It was most commonly at the T10-11 level in individuals between the ages of 40-59 years and at the T10 level in individuals under 40 and over 60 years of age. T10-11 level was the highest (25.6%) in males (P<0.05) and T10 level was the highest (28.2%) in females (Table 2).

A significant relationship was found between SVCL age groups and gender groups (P<0.05). T7 level was the most

prominent in the 0-9-year age group while the T6 level was higher in other age groups (Table 3), and T6 level was more commonly found in women (45.4%) than men (39.7%) (P<0.05).

There was a significant difference between the age groups of IVCL. Although it was highly observed at the T9 level in all age groups, the level slightly lowered (T10 level) with increasing age. However, it was found that the probability of being seen at the T9 level increased in individuals over 60 years of age (Table 4). There was no significant difference between the genders in terms of IVCL (P>0.05). The T9 level was the most common among men and women.

There was a significant difference between the age groups with regards to PTL (P<0.05). PTL was at the T7 level the most and the rate PTL being detected at the T8 level increased with age (Table 5). The rate of PTL being at the level of T7 was significantly higher in women (42.1%) than men (38%) (P<0.05).

AAL was most frequently observed in the T4 level in all age groups (Table 6), and the rate of being seen at the T5 level significantly increased with age (P<0.05). It was found that it was significantly more commonly found at the T4 level in women (61.4%) compared to men (56.5%) (P<0.05).

CAL was most frequently observed at the T10 level in all age groups, but the frequency of it being detected at T11 significantly increased with age (P<0.05). It was significantly more at the T10 level in women (41.2% T10 level, 26.1% T9 level) compared to men (34.7% T10 level, 22.9% T11 level) (Table 7) (P<0.05).

CL was most frequently observed at the T5 level in all age groups, but the frequency of observation at the T6 level significantly increased with age (P<0.05). T5 level was significantly higher in women (59.9% T5 level, 15.7% T6 level) than men (48.8% T15 level, 29.5% T6 level) (Table 8) (P<0.05).

RPBL was most frequently observed at the T5-6 level in all age groups, but the frequency of observation at the T6-7 level significantly increased with age (P<0.05). It was located significantly higher in women (52.2% T5-6 level, 10.4% T6-7 level) compared to men (39.9% T5-6 level, 28.7% T6-7 level) (Table 9) (P<0.05).

LPBL was most frequently observed at the T6 level in all age groups, but the frequency of observation at the T7 level significantly increased with age (except over 60 years old) (P<0.05). It was significantly higher in women (52.5% T6 level, 14.5% T7 level) compared to men (39.1% T6 level, 29.8% T7 level) (Table 10) (P<0.05).

SCJL was most frequently observed at the T2 level in all age groups, but the frequency of observation at the T1 level significantly increased with age (P<0.05). There was no significant relationship between SCJL and gender (P<0.05) (Table 11).

JNL was most frequently observed at the T2 level in all age groups, but the frequency of observation at the T1 level significantly increased with age (P<0.05). There was no significant relationship between JNL and gender (Table 12) (P<0.05).

MSJL was most frequently observed at the T3 level between the ages of 0-9 years and at the T4 level in all other age groups, but the frequency of observation at the T4 level significantly increased with age (P<0.05). There is no significant relationship between MSJL and gender (Table 13) (P<0.05).

XSJL was most frequently observed at the T7 level between the ages of 0-9 years and at the T9 level in all other age groups, but the frequency of observation at the lower levels significantly increased with age (P<0.05). There was no significant relationship between XSJL and gender (Table 14) (P<0.05).

Table 2: The relationship between ADL& age and gender

ADL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T7	8	0	0	0	0	0	0.4	0.4	<0.001	0.6	0.3	0.002
T7-8	0	0	0	0	1	1.1	0.4	0.4		0	0.9	
T8	20	4.3	0	1	1	2.2	0	1.6		1.1	2.1	
T8-9	4	4.3	2.7	6.1	1	3.3	2.2	3		2.8	3.3	
T9	20	10.6	2.7	8.2	8.2	2.2	4.8	6.1		4.7	7.7	
T9-10	0	14.9	16.4	18.4	15.5	19.8	14.9	15.7		12.1	19.6	
T10	36	23.4	32.9	25.5	19.6	23.1	29	26.7		25.3	28.2	
T10-11	0	27.7	28.8	20.4	29.9	30.8	21.2	24		25.6	22.3	
T11	12	8.5	11	11.2	17.5	9.9	11.2	11.7		13.8	9.5	
T11-12	0	6.4	4.1	6.1	6.2	6.6	11.5	7.9		11	4.5	
T12	0	0	1.4	3.1	0	1.1	4.5	2.4		3	1.8	

ADL: These structures are the level of passage of the aorta through the diaphragm

Table 3: The relationship between SVCL& age and gender

SVCL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T3	12	0	0	0	0	0	0	0.4	<0.001	0.6	0.4	0.014
T4	0	0	0	4.1	0	0	0.4	0.7		0.8	0.7	
T4-5	4	0	0	0	0	0	0	0.1		0.3	0.1	
T5	16	8.5	12.3	16.3	9.3	7.7	7.4	9.9		6.1	9.9	
T5-6	4	0	0	0	0	1.1	0.4	0.4		0.6	0.4	
T6	24	48.9	42.5	45.9	42.3	39.6	42.8	42.4		39.7	42.4	
T6-7	0	2.1	1.4	0	1	2.2	0.7	1.0		0.8	1	
T7	40	31.9	37	25.5	37.1	31.9	34.6	33.6		38	33.6	
T8	0	8.5	6.8	7.1	10.3	16.5	10.8	10		11.6	10	
T9	0	0	0	1	0	1.1	3	1.4		1.7	1.4	

SVCL: The entry level of superior vena cava into the right atrium

Table 4: The relationship between IVCL& age and gender

IVCL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T5	12	0	0	0	0	0	0	0.4	<0.001	0.6	0.3	0.158
T6	0	0	0	2	0	0	0.4	0.4		0.3	0.6	
T7	8	0	1.4	3.1	3.1	2.2	2.6	2.6		1.4	3.9	
T8	32	23.4	19.2	27.6	19.6	20.9	19.7	21.6		18.5	24.9	
T8-9	0	0	0	0	0	1.1	0.4	0.3		0.3	0.3	
T9	44	38.3	47.9	41.8	38.1	36.3	47.6	43.3		43.3	43.3	
T9-10	0	4.3	0	0	0	0	0	0.3		0.8	0.3	
T10	4	25.5	27.4	17.3	30.9	30.8	18.6	22.6		25.6	19.3	
T10-11	0	0	0	1	0	0	0.4	0.3		0.6	0	
T11	0	8.5	1.4	7.1	8.2	7.7	8.6	7.1		8	6.2	
T12	0	0	2.7	0	0	1.1	1.9	1.1		1.4	0.9	

IVCL: The entry level of inferior vena cava into the right atrium

Table 5: The relationship between PTL& age and gender

PTL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T4	12	0	0	2	0	0	0	0.7	<0.001	0.8	0.6	0.023
T5	8	4.3	1.4	7.1	3.1	0	3	3.3		1.7	5	
T6	32	12.8	19.2	24.5	21.6	16.5	19	19.9		17.6	22.3	
T6-7	0	0	0	1	0	1.1	0.4	0.4		0.6	0.3	
T7	36	46.8	46.6	36.7	36.1	40.7	39.8	40		38	42.1	
T7-8	0	2.1	0	2	1	1.1	0.7	1		1.7	0.3	
T8	12	29.8	26	20.4	34	28.6	28.6	27.4		30.3	24.3	
T8-9	0	0	0	1	1	0	0.7	0.6		0.8	0.3	
T9	0	4.3	6.8	5.1	3.1	12.1	4.5	5.4		6.9	3.9	
T10	0	0	0	2	0	0	3.3	1.3		1.7	0.9	

PTL: The exit level of the pulmonary trunk from the right ventricle

Table 6: The relationship between AAL& age and gender

AAL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T2	12	0	0	4.1	0	0	0.7	1.3	0.001	1.1	1.3	0.001
T3	8	10.6	17.8	13.3	23.7	18.7	19.7	18		13.8	18	
T3-4	0	0	0	0	1	0	1.5	0.7		1.1	0.7	
T4	72	74.5	58.9	65.3	51.5	53.8	56.9	58.9		56.5	58.9	
T4-5	0	0	0	0	1	0	0.4	0.3		0.6	0.3	
T5	8	10.6	23.3	14.3	20.6	26.4	16.0	17.9		23.1	17.9	
T5-6	0	0	0	1	0	0	0	0.1		0.3	0.1	
T6	0	4.3	0	1	2.1	1.1	4.8	2.7		3.6	2.7	
T7	0	0	0	1	0	0	0	0.1		0	0.1	

AAL: Aortic arch

Table 7: The relationship between CAL& age and gender

CAL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T7	12	0	0	4.1	0	0	0.4	1.1	0.007	1.4	0.9	0.003
T8	12	4.3	4.1	10.2	9.3	3.3	5.9	6.6		3.9	9.5	
T8-9	0	0	0	0	1.	0	0.7	0.4		0.3	0.6	
T9	28	25.5	24.7	29.6	21.6	27.5	21.9	24.4		22.9	26.1	
T9-10	0	0	0	1	2.1	3.3	1.5	1.4		1.9	0.9	
T10	44	42.6	41.1	34.7	37.1	30.8	39.4	37.9		34.7	41.2	
T10-11	0	4.3	5.5	1	7.2	1.1	3	3.3		4.4	2.1	
T11	4	17	21.9	15.3	17.5	7.5	18.6	18.9		22.9	14.5	
T11-12	0	2.1	0	0	3.1	1.1	1.1	1.1		1.4	0.9	
T12	0	4.3	2.7	4.1	1	5.5	7.1	4.7		6.1	3.3	
T12-l1	0	0	0	0	0	0	0.4	0.1		0.3	0	

CAL: Level cardiac apex level

Table 8: The relationship between CL& age and gender

CL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T3	4	0	1.4	3.1	0	0	0	0.7	<0.001	0.6	0.9	<0.001
T4	40	12.8	13.7	12.2	11.3	7.7	8.9	11.4		7.7	15.4	
T4-5	0	2.1	4.1	1	1	3.3	2.2	2.1		1.7	2.7	
T5	52	68.1	53.4	63.3	55.7	49.5	49.8	54.1		48.8	59.9	
T5-6	0	6.4	6.8	4.1	5.2	3.3	3.3	4.1		5.2	3	
T6	4	10.6	20.5	12.2	26.8	34.1	26	22.9		29.5	15.7	
T6-7	0	0	0	2	0	0	2.2	1.1		2.2	0	
T7	0	0	0	2	0	2.2	7.1	3.3		4.4	2.1	
T8	0	0	0	0	0	0	0.4	0.1		0	0.3	

CL: Carina level

Table 9: The relationship between RPBL& age and gender

RPBL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T3-4	4	0	1.4	1	0	0	0	0.4	<0.001	0.6	0.3	<0.001
T4	0	0	0	1	0	0	0	0.1		0	0.3	
T4-5	20	8.5	8.2	8.2	10.3	6.6	6.3	8		5.2	11	
T5	20	4.3	9.6	5.1	2.1	4.4	4.1	5.1		3.6	6.8	
T5-6	36	48.9	39.7	52	53.6	45.1	43.1	45.9		39.9	52.2	
T6	16	25.5	19.2	16.3	7.2	7.7	10	12.4		14.3	10.4	
T6-7	0	12.8	20.5	11.2	26.8	31.9	25.3	22.1		28.7	15.1	
T7	4	0	1.4	4.1	0	2.2	1.9	1.9		1.9	1.8	
T7-8	0	0	0	1	0	2.2	9.3	4		5.8	2.1	

RPBL: Right principal bronchus level of separation to segmental bronchus

Table 10: The relationship between LPBL& age and gender

LPBL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T4	4	0	1.4	1	0	0	0	0.4	<0.001	0.6	0.3	<0.001
T4-5	0	0	0	1	0	0	0	0.1		0	0.3	
T5	8	6.4	8.2	8.2	9.3	6.6	6.3	7.3		4.7	10.1	
T5-6	20	6.4	9.6	5.1	3.1	4.4	4.1	5.4		3.6	7.4	
T6	44	48.9	39.7	51	51.5	45.1	42.8	45.6		39.1	52.5	
T6-7	16	25.5	19.2	16.3	8.2	7.7	10	12.6		14.3	10.7	
T7	4	12.8	20.5	11.2	27.8	31.9	25.3	22.4		29.8	14.5	
T7-8	4	0	1.4	3.1	0	1.1	2.6	1.9		1.9	1.8	
T8	0	0	0	3.1	0	3.3	8.6	4.1		6.1	2.1	
T9	0	0	0	0	0	0	0.4	0.1		0	0.3	

LPBL: Left principal bronchus level of separation to segmental bronchus

Table 11: The relationship between SCJL& age and gender

SCJL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
C7	0	0	0	1	0	2.2	1.1	0.9	<0.001	1.1	0.6	0.085
C7-T1	0	0	0	0	1	0	0.4	0.3		0	0.6	
T1	4	19.1	23.3	29.6	32	37.4	40.1	32.7		29.8	35.9	
T1-2	0	2.1	4.1	1	4.1	2.2	3.7	3		4.1	1.8	
T2	72	55.3	60.3	54.1	47.4	42.9	44.2	49.3		49	49.6	
T2-3	0	4.3	0	3.1	3.1	1.1	1.5	1.9		2.8	0.9	
T3	4	19.1	12.3	9.2	12.4	14.3	8.2	10.7		11.6	9.8	
T4	20	0	0	2	0	0	0.7	1.3		1.7	0.9	

SCJL: Level of sternoclavicular joint

Table 12: The relationship between JNL& age and gender

JNL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
C7	0	0	0	1	2.1	4.4	1.5	1.6	<0.001	1.7	1.5	0.208
C7-T1	0	0	0	0	1	1.1	1.1	0.7		0.6	0.9	
T1	0	19.1	23.3	30.6	29.9	35.2	41.3	32.7		30.6	35	
T1-2	0	2.1	2.7	1	4.1	2.2	3	2.6		3.3	1.8	
T1-3	0	0	0	0	0	0	0.4	0.1		0	0.3	
T2	72	57.4	61.6	53.1	49.5	41.8	43.1	49.1		48.5	49.9	
T2-3	0	4.3	0	3.1	2.1	2.2	1.5	1.9		3.0	0.6	
T3	4	17	12.3	9.2	11.3	13.2	7.4	10		10.7	9.2	
T4	20	0	0	2	0	0	0.7	1.3		1.7	0.9	

JNL: Jugular notch level

Table 13: The relationship between MSJL& age and gender

MSJL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T2	20	2.1	1.4	4.1	1	2.2	5.6	4.1	<0.001	4.1	4.2	0.382
T2-3	0	0	0	0	2.1	3.3	2.6	1.7		2.2	1.2	
T3	40	12.8	12.3	23.5	17.5	28.6	26	23		20.7	25.5	
T3-4	0	4.3	9.6	7.1	7.2	18.7	10.4	9.7		11.3	8	
T4	36	40.4	39.7	34.7	43.3	29.7	40.9	38.6		37.7	39.5	
T4-5	0	4.3	9.6	7.1	13.4	9.9	3.3	6.7		8.3	5	
T5	4	25.5	23.3	19.4	11.3	4.4	7.1	11.9		11.	12.8	
T5-6	0	4.3	1.4	2	1	2.2	1.1	1.6		1.9	1.2	
T6	0	6.4	1.4	2	3.1	1.1	2.6	2.4		2.5	2.4	
T6-7	0	0	0	0	0	0	0.4	0.1		0	0.3	
T7	0	0	1.4	0	0	0	0	0.1		0.3	0	

MSJL: Manubriosternal joint level

Table 14: The relationship between XSJL& age and gender

XSJL	Age 0-9 (%)	10-19 (%)	20-29 (%)	30-39 (%)	40-49 (%)	50-59 (%)	Over 60 (%)	Total (%)	*P*	Male (%)	Female (%)	*P*
T4	0	0	0	1	0	0	0	0.1	0.002	0	0.3	0.081
T5	0	0	0	0	0	0	0.4	0.1		0	0.3	
T5-6	0	0	0	0	0	0	0.4	0.1		0.3	0	
T6	20	0	2.7	1.	0	0	2.6	2.1		1.7	2.7	
T7	28	8.5	0	12.2	9.3	11	14.9	11.7		10.5	13.1	
T7-8	0	0	1.4	3.1	1	3.3	0.7	1.4		1.7	1.2	
T8	24	21.3	31.5	25.5	26.8	28.6	26	26.6		24.8	28.5	
T8-9	0	2.1	5.5	3.1	5.2	13.2	4.8	5.4		4.1	6.8	
T9	24	29.8	35.6	32.7	30.9	25.3	26.8	29		29.2	28.8	
T9-10	0	6.4	5.5	3.1	8.2	6.6	4.1	5		6.9	3	
T10	4	25.5	15.1	17.3	16.5	7.7	15.6	15.1		16.3	13.9	
T10-11	0	0	0	0	1	2.2	1.1	0.9		1.1	0.6	
T11	0	6.4	2.7	1	1	2.2	2.2	2.1		3.3	0.9	
T12	0	0	0	0	0	0	0.4	0.1		0.3	0	

XSJL: Xiphosternal joint level

Discussion

The surface anatomy must be known for safe clinical and practical implementations. The current information is based on textbooks. In anatomy textbooks, surface marks are generally made with reference to costae, and the level of many structures is not included. Most of the included ones are based on cadaver work. In our study, we examined some of the structures in the thorax by reference to the vertebras according to gender and age groups. Reference to the vertebras is important for comparison of superficial and deep structures and facilitating clinical evaluation on radiological images [4]. Knowing the changes in levels according to age group and gender will facilitate surgical procedures.

ADL was found at the T12 level [3,5-7] in some studies and at the T11 [3,4] level in others. In another study, it was determined at the T11 level in the 0-1 year age group, at the T12 level in the age group of 1-4 years, and at the T11 level in the 4-12 years age group [3]. In our study, although there are differences between age groups, it is mostly at the T10 level, and when we evaluate it according to gender, the rates of it being found at the T10 level in women and T10-11 levels in men are high. While performing surgical interventions, level differences between age groups and genders should be taken into consideration.

It was stated that SVCL was at the right third cartilage costae level [8,9] in some anatomy books and at the T6 level [4,10] in some other studies. In our study, it was seen that T7 was the most common level in the 0-9 year-age group and T6 was most common in other age groups. In terms of gender, the rate of it being found at the T6 level was significantly higher in women. Superior vena cava catheterization may be required to feed clinically severe patients or for other purposes. Therefore, it is very important to know the surface anatomy of this vein [11]. We think that the possibility of SVCL being at the T6 level in

men and children should be considered in interventional practices.

IVCL is reportedly between the T8-T9 levels or at the level of right sixth costae [8]. In this study, it was observed that the IVCL was highly found at the T9 level in all age groups, but significant differences were found between the age groups as well (Table 4). We believe that the level at which this vein can be found should be evaluated according to the age of the patient.

Anatomy books indicate that PTL is at the level of the third cartilage rib [9]. In our study, although there was a significant difference between PTL levels between age groups, it was mostly seen at the T7 level in all age groups, followed by the T6 level in the 0-9 age group and the T8 level in the other age groups. Pulmonary thromboembolism is a common clinical problem in the world, often difficult to diagnose, and mortality can be quite high if not treated appropriately. In pulmonary thromboembolism, the rate of embolism in pulmonary trunk is high [12,13]. It is especially important to know PTL in radiological and interventional procedures.

Studies have reported that AAL is at the T4 level [4,5,9,14]. In another study, it was found over the T4 level in the age group of 0-1 year and under the T4 level in the age groups of 1-4 and 4-12 years [15]. In our study, although there was a significant difference between the age groups, it was generally found at the T4 level, which was followed by T2 in the 0-9 year-age group and the T5 level among all other age groups. Similar to the literature, AAL was located lower with increasing age. It is important to know the AAL in the head, neck, and thorax region in radiological and surgical procedures.

CAL is known to be at the level of the 5^{th} intercostal space [1,9,11] and in a study based on vertebral reference, CAL was found at the T9 level [4]. In our study, although there was a significant difference between the age groups, it was determined that the T10 level was the most common in all age groups. The rate of it being observed in lower levels increased in older age (except for the individuals over 60 years of age) and in males. Knowing the level of the cardiac apex is especially important in the accurate evaluation of the dimensions of the heart and in the diagnosis of hypertrophy [4].

In anatomy books, CL was found at the T5 level [8] and in the literature it is recorded at the T4-5 level [3,5,6,16]. In another study, it was higher than the T4 level in the 0-1-year age group and below T5 in the 1-4 and 4-12-year age groups [15]. In our study, although there was a significant difference between the age groups, it was generally at the T5 level. Similar to the literature, it was determined that with the progression of age, the probability of being observed at a lower level increased. The T4 level was the second most common in the 0-9-year age group and in older ages, the T6 level was the second most common. Normally the carina is in the sagittal plane and has almost sharp borders. If tracheobronchial lymph nodes at the angle between the main bronchi grows due to the bronchogenic cancer metastasis, the carina breaks down, expands posteriorly, and becomes immobilized. Therefore, changes in carina level are important in the differential diagnosis of respiratory diseases [9].

In previous studies, it was stated that RPBL was at T5 level and LPBL was at T6 level [8]. In our study, RPBL was most commonly at the T5-6 level and LPBL was most commonly at the T6 level. Both were found to be significantly lower in older age and in men.

SCJL is known to be at the level of the first cartilage rib [2,9]. In our study, SCJL was most commonly found at the T2 level. Also, it significantly relocated to the T1 level with increasing age. The internal jugular vein and subclavian vein join next to the sternoclavicular joint to form the brachiocephalic vein [2]. It is important to know the level of sternoclavicular joint in terms of its proximity to these vessels.

In the literature, JNL is mostly found at the T2 level [9,11]. We also observed JNL most frequently at the T2 level in all age groups and it was significantly observed at the T1 level as age increased. Left brachiocephalic vein is located behind the upper half of the manubrium. In the first years of life, this vein could be observed at a higher level to be over jugular notch. This should be taken into consideration when performing a tracheotomy in children [1,2]. Median sternotomy is one of the most common procedures in cardiac surgery. Surgeons cut the sternum from jugular notch to the lower end of xiphoid process and try to reach the heart and large vessels. Sternal dehiscence is the separation of the sternum halves. It is very rare, but it is a serious and mortal condition [17,18]. Jugular notch is therefore a clinically important reference point.

In the literature, it is stated that MSJL is at the T4-5 level [1,9,11]. In the study done by Fischer et al. (2017), it was found above T4 in 0-1-year and 1-4-years age group and below T4 in the age group of 4-12 years [15]. It was at the T5 level in the study of Badshah et al. [4] and above T5 level in the study of Chukwuemeka et al. [19]. In our study, MSJL was most commonly at the T3 level in the age group of 0-9 years and at the T4 level in all other age groups. The level of MSJL was found to increase significantly with age.

Xiphosternal joint (XSJL) is located at the T9 level, as stated in the anatomy books [9, 11] and the literature [3-5,14]. In our study, XSJL was most commonly found at the T7 level in the 0-9-year age group and at the T9 level in all other age groups. It was also determined that the incidence of it being observed at lower levels was significantly higher with increasing age. Xiphosternal joint is an important reference point and determines the lower edge of the heart and the upper limit of the liver [11].

Manubriosternal joint anomalies are usually unidentified causes of chest pain. The joint should be evaluated in rheumatoid diseases and in patients with non-arthritic chest or shoulder pain [20]. In this respect, it is important to know the Louis angle, the normal anatomy of manubriosternalis joint and xiphosternalis joint. In addition, bone marrow biopsy examinations are mostly performed from the manubrium, and it is also important to know the level at which the manubrium and corpus make joints [21].

Limitations

As our study is a retrospective study, there is no information about the height, weight, occupation, and sports activities of the patients. In addition, all level measurements belong to patients reclined in the supine position. It would be beneficial to conduct a similar study by knowing the height and weight of the patients.

Conclusion

Much of our current surface anatomy knowledge is based on cadaver studies rather than living humans. The levels of most structures are not specified by vertebras, and there is also no age group and gender distinction for many of them. Our study examining the images of 700 women and men in different age groups may be the basis for defining the levels of the structures in the thorax according to age group and gender. Radiological imaging is especially important in the evaluation of the levels. Thoracic intervention can be performed in any age group. Therefore, it is important to know the differences in the anatomy of this region according to age and gender. In this sense, our study results contain important reference information. Using modern imaging techniques, reviewing human anatomy, and adding findings to anatomical and clinical sources, and comparing them to medical textbooks will help in interventional interference.

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