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Original Article / Özgün Makale

Demographic characteristics of pectus deformities across Turkey

Pektus deformitelerinin Türkiye genelinde demografik özellikleri

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ABSTRACT

Background: This study aims to investigate the demographic characteristics and familial inheritance of pectus deformities across Turkey.

Methods: Demographic characteristics of a total of 5,098 patients (5,028 males, 70 females, mean age 23.6 years; range, 1 to 56 years) with pectus excavatum and pectus carinatum admitted to our outpatient clinic between January 1996 and December 2018 were retrospectively analyzed. The distribution of the patients across the country was made according to seven regions and 81 provinces. Familial inheritance was investigated using patients' data obtained from the clinical records and telephone calls.

Results: Of all patients, 3,330 (65.3%) had pectus excavatum and 1,768 (34.7%) had pectus carinatum deformity with a pectus excavatum-to-pectus carinatum ratio of 1/1.9. In the Southeast Anatolia region, the rate of pectus excavatum was lower than the overall average and higher in the Marmara region (p=0.009 and p=0.037, respectively). In the Southeast Anatolia region, the rate of pectus carinatum was higher than the general average and lower in the Marmara region (p=0.001 and p=0.003, respectively). Kastamonu, Çankırı, Karabük, and Sinop were the most common provinces for pectus deformity cases. Family history was positive in 39% of pectus excavatum and 43% of pectus carinatum patients. All regions showed a similar distribution in terms of the presence of family history.

Conclusion: This is the first study to report the distribution of pectus deformities in Turkey and the high frequency of pectus deformities in certain regions and provinces of Turkey indicates familial inheritance.

Keywords: Demographic, family history, pectus deformities, pectus excavatum, pectus carinatum, Turkish population.

ÖZ

Amaç: Bu çalışmada, Türkiye genelinde pektus deformitelerinin demografik özellikleri ve ailesel kalıtımı araştırıldı.

Çalışma planı: Ocak 1996-Aralık 2018 tarihleri arasında polikliniğimize pektus ekskavatum ve pektus karinatum ile başvuran toplam 5098 hastanın (5028 erkek, 70 kadın; ort. yaş 23.6 yıl; dağılım, 2-56 yıl) demografik özellikleri retrospektif olarak incelendi. Yedi bölgeye ve 81 ile göre hastaların ülke genelinde dağılımı yapıldı. Klinik kayıtlardan ve telefon görüşmelerinden elde edilen hasta verileri kullanılarak, ailesel kalıtım araştırıldı.

Bulgular: Hastaların 3330'unda (%65.3) pektus ekskavatum ve 1768'inde (%34.7) pektus karinatum deformitesi olup, pektus ekskavatum-pektus karinatum oranı 1/1.9 idi. Güneydoğu Anadolu bölgesinde pektus ekskavatum oranı, genel ortalamadan daha düşük ve Marmara bölgesinde daha yüksek idi (sırasıyla, p=0.009 ve p=0.037). Güneydoğu Anadolu bölgesinde pektus karinatum oranı genel ortalamadan daha yüksek ve Marmara bölgesinde daha düşük idi (sırasıyla, p=0.001 ve p=0.003). Kastamonu, Çankırı, Karabük ve Sinop pektus deformiteli olguların en sık karşılaşıldığı iller idi. Pektus ekskavatumlu hastaların %39'unda ve pektus karinatumlu hastaların %43'ünde aile öyküsü pozitif idi. Tüm bölgeler aile öyküsü varlığı açısından benzer bir dağılım gösterdi.

Sonuç: Bu çalışma Türkiye'de pektus deformitelerinin dağılımını bildiren ilk çalışma olup, Türkiye'nin bazı bölgeleri ve illerinde pektus deformitelerinin yüksek oranda olması ailesel kalıtımı göstermektedir.

Anahtar sözcükler: Demografik, aile öyküsü, pektus deformiteleri, pektus ekskavatum, pektus karinatum, Türk toplumu.

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Chest deformities are common pathologies characterized by different types and levels of depression or protrusion of the sternum and costae. Congenital chest deformities can be divided into main five groups: pectus excavatum (PE), pectus carinatum (PC), Poland syndrome, sternal cleft and defects, and other thoracic deformities. Deformities of PE and PC account for the majority of congenital chest deformities which do not cause severe dysfunction, except for life-threatening rare cases.[1-3]

Family history and concomitant other congenital anomalies give rise to thought that these deformities may be more common in a particular population or region. Although there are studies screening student groups of a particular age vary in terms of chest deformities in various cities of Turkey, there is no study on the distribution of pectus deformities across our country by region and province.

Our institution is a central hospital to which military patients are referred across Turkey. It can be speculated that the patient population referred to our hospital is a homogeneous group which reflects the general population of Turkey. In the present study, we aimed to investigate the demographic characteristics and familial inheritance of pectus deformities across Turkey.

PATIENTS AND METHODS

Patient records with PE and PC admitted to our outpatient clinic between January 1996 and December 2018 were retrospectively analyzed. The patient records between January 2004 and December 2005 (24 months) were unable to be reached due to technical access restrictions for one of the databases. Finally, demographic characteristics of a total of 5,098 patients (5,028 males, 70 females, mean age 23.6 years; range, 1 to 56 years) were included. Pectus cases with other pathologies such as Poland syndrome, arcus deformity, or musculoskeletal deformity and cases with missing hometown data were excluded from the study. In the outpatient clinic system, the data of patients with sufficient data on familial history were used. Data were collected using patient records or telephone calls. The patients were questioned about the presence of chest deformity in their family members, including third-degree relatives. A written informed consent was obtained from each patient. The study protocol was approved by the Gülhane Training and Research Hospital Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

In Turkey, the obligation of military service is only for male individuals. Although there are female patients in the study, the majority of the cases were male patients aged between 20-30 years. This study was designed in our medical center, which is a reference military hospital in Turkey. Therefore, in the pre-military evaluation, patients with a history of surgery due to pectus deformity were included. Patients from all regions of our country were examined at regular intervals in our outpatient clinic to create a homogeneous patient group according to their province of origin.

In order to determine the distribution of cases by provinces and regions, we attempted to standardize the number of patients according to the population density of that province or region. The number of cases with pectus deformity per 100,000 population in the relevant province or region was calculated using the 2018 population data of the Turkish Statistical Institute (TSI).[4]

Statistical analysis

For this descriptive study, we found a country rate for PE and PC rates obtained from the study group consisting of all positive cases (PE: 65.3%, PC: 34.7%). We, then, compared the ratios calculated for each region using one sample Z-test for proportion with this general ratio. Multiple correspondence analysis was used to evaluate the patterns of relationships of several categorical dependent variables, such as family history, and frequencies of PE and PC. Statistical comparisons were performed using the nationwide PE and PC prevalence rates. Statistical analysis was performed using the IBM SPSS version 25.0 software (IBM Corp., Armonk, NY, USA) and STATA version 16.0 software (StataCorp LLC, TX, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and percentage. A p value of <0.05 was considered statistically significant.

RESULTS

Pectus deformities were diagnosed in 5,098 (7.8%) of a total of 65,827 patients who were admitted to our outpatient clinic throughout the study period (252 months). The distribution of these cases across the country was made according to the current seven regions and 81 provinces. Of the patients with pectus deformity, 3,330 (65.3%) had PE and 1,768 (34.7%) had PC. The rate of PE deformity was the highest in the Marmara region (71.8%) and the rate of PC deformity was the highest in the Southeast Anatolia region (43.6%). About 50% of pectus deformities originated from the Black Sea and Central Anatolia regions, accounting for 26% of the country population. On the other hand, 30% of the cases originated from

the Aegean, Marmara, and Mediterranean regions, accounting for 57% of the country population (Table 1).

According to the calculation of the ratio of positive cases to the general population based on the 2018 population data of the TSI, the average rate of pectus deformities across Turkey was calculated as 6.2/100,000. The Black Sea region was the most common region of pectus deformities with a rate of 15.6/100,000 cases, followed by the Central Anatolia region (9.9/100,000) and Eastern Anatolia region (8.2/100,000). On the other hand, the Marmara and Aegean regions were the least common regions of pectus deformities with 2.4/100,000 and 3.6/100,000 cases, respectively (Table 1).

According to the region analysis to the general population, the ratio of PE was found to be lower than the average ratio in the Southeast Anatolia region (56.4%) and was higher in the Marmara region (71.8%) (p=0.009 and p=0.037, respectively). For PC, these two regions were statistically different from the country average. However, in terms of PC, the Southeast Anatolia region (43.6%) was higher than the general average and was lower in the Marmara region (28.2%) (p=0.001 and p=0.003, respectively) (Table 1).

Given the distribution by provinces, Kastamonu, Çankırı, Karabük, Sinop, and Ardahan were the most common provinces for pectus deformity cases. The fact that the prevalence in these provinces (31.8-26.3/100,000) was about four to five-fold of the Turkey's average (6.2/100,000) and the other four were close to each other, except for Ardahan (Table 2).

A color map chart of Turkey was created based on the number of pectus deformity cases calculated by the population density of our provinces. Five different tones of red color were used in this chart. The provinces comprising above four-times more cases than the Turkey's average were illustrated with claret red, the provinces comprising above two-times more cases with red, the provinces comprising above one and a half-times more cases with pink, the provinces comprising above (9.3) and below (3.1) 50% of the average with light pink, and the provinces comprising less than 3.1/100,000 cases with white (Figure 1). Given the color map chart of Turkey, almost all provinces of the Black Sea region along with the northeast provinces of the Central Anatolia region and the northwest provinces of the East Anatolia region had the highest deformity rates. However, a density area was determined in a separate region consisting of Afyonkarahisar, Burdur, and Isparta provinces in the eastern part of the Aegean region and the northwestern part of the Mediterranean region (Figure 1).

Table 1. Distribution and statistical comparison of pectus deformities by region

Regions	PE			PC			Total		Population*		Number of cases Per 100,000 Inhabitants
	n	%	*p*	n	%	*p*	n	%	n	%	n
Mediterranean region	347	63.8	0.614	197	36.2	0.564	544	10.7	10,461,409	13	5.2
Eastern Anatolia region	352	65.2	0.978	188	34.8	0.969	540	10.6	6,582,689	8	8.2
Aegean region	258	67.9	0.599	122	32.1	0.344	380	7.5	10,514,200	13	3.6
Southeast Anatolia region	273	56.4	0.009	211	43.6	0.001	484	9.5	8,323,790	10	5.8
Central Anatolia region	837	64.3	0.633	464	35.7	0.478	1301	25.5	13,114,013	16	9.9
Black Sea region	827	66.6	0.572	415	33.4	0.376	1242	24.4	7,973,211	10	15.6
Marmara region	436	71.8	0.037	171	28.2	0.003	607	11.8	25,034,570	31	2.4
Total	3330	65.3		1768	34.7		5098	100	82,003,882	100	6.2

PE: Pectus excavatum; PC: Pectus carinatum; * Based on 2018 population data of Turkish Statistical Institute.

Table 2. Distribution of pectus deformities by provinces (number of cases per 100,000 inhabitants)

No	Region code*	Province	*PE	*PC	Total number of deformities	Population	Number of cases per 100,000 inhabitants
1	B	Kastamonu	80	42	122	383,373	31.8
2	C	Çankırı	47	20	67	216,362	31.0
3	B	Karabük	46	21	67	248,014	27.0
4	B	Sinop	40	19	59	219,733	26.9
5	E	Ardahan	20	6	26	98,907	26.3
6	C	Kırıkkale	43	28	71	286,602	24.8
7	C	Yozgat	69	33	102	424,981	24.0
8	B	Zonguldak	102	39	141	599,698	23.5
9	B	Çorum	73	44	117	536,483	21.8
10	B	Rize	50	16	66	348,608	18.9
11	C	Kırşehir	30	15	45	241,868	18.6
12	B	Bartın	20	16	36	198,999	18.1
13	C	Sivas	62	45	107	646,608	16.5
14	B	Amasya	32	23	55	337,508	16.3
15	E	Tunceli	10	3	13	88,198	14.7
16	B	Tokat	50	33	83	612,646	13.5
17	B	Ordu	67	33	100	771,932	13.0
18	B	Bolu	25	15	40	311,810	12.8
19	E	Kars	24	13	37	288,878	12.8
20	B	Samsun	99	57	156	1,335,716	11.7
21	B	Artvin	17	3	20	174,010	11.5
22	C	Nevşehir	26	8	34	298,339	11.4
23	A	Afyon	54	27	81	725,568	11.2
24	B	Gümüşhane	13	5	18	162,748	11.1
25	E	Muş	26	19	45	407,992	11.0
26	B	Trabzon	64	24	88	807,903	10.9
27	B	Giresun	35	14	49	453,912	10.8
28	E	Erzincan	16	9	25	236,034	10.6
29	E	Erzurum	52	29	81	767,848	10.5
30	Md	Burdur	18	8	26	269,926	9.6
31	Md	Isparta	29	13	42	441,412	9.5
32	C	Aksaray	28	11	39	412,172	9.5
33	E	Bitlis	23	9	32	349,396	9.2
34	E	Iğdır	11	7	18	197,456	9.1
35	C	Ankara	312	186	498	5,503,985	9.0
36	S	Siirt	17	13	30	331,670	9.0
37	A	Kütahya	28	24	52	577,941	9.0
38	S	Adıyaman	31	24	55	624,513	8.8
39	S	Batman	29	19	48	599,103	8.0
40	S	Mardin	36	30	66	829,195	8.0
41	A	Uşak	24	4	28	367,514	7.6
42	Mr	Edirne	27	4	31	411,528	7.5
43	Md	K. Maraş	44	41	85	1,144,851	7.4

Table 2. Continues

No	Region code*	Province	*PE	*PC	Total number of deformities	Population	Number of cases per 100,000 inhabitants
44	C	Niğde	18	9	27	364,707	7.4
45	C	Kayseri	64	32	96	1,389,680	6.9
46	E	Malatya	42	13	55	797,036	6.9
47	C	Konya	90	55	145	2,205,609	6.6
48	E	Van	42	30	72	1,123,784	6.4
49	E	Elazığ	21	17	38	595,638	6.4
50	C	Karaman	11	5	16	251,913	6.4
51	S	Kilis	4	5	9	142,541	6.3
52	E	Ağrı	20	14	34	539,657	6.3
53	C	Eskişehir	37	17	54	871,187	6.2
54	B	Bayburt	2	3	5	82,274	6.1
55	E	Bingöl	14	3	17	281,205	6.0
56	E	Hakkâri	14	3	17	286,470	5.9
57	S	Diyarbakır	58	44	102	1,732,396	5.9
58	Mr	Kırklareli	14	7	21	360,860	5.8
59	Md	Osmaniye	18	13	31	534,415	5.8
60	E	Şırnak	17	13	30	524,190	5.7
61	Md	Adana	82	33	115	2,220,125	5.2
62	B	Düzce	12	8	20	387,844	5.2
63	Md	Mersin	59	27	86	1,814,468	4.7
64	S	Şanlıurfa	46	49	95	2,035,809	4.7
65	Md	Hatay	49	26	75	1,609,856	4.7
66	A	Manisa	39	23	62	1,429,643	4.3
67	Mr	Balıkesir	38	13	51	1,226,575	4.2
68	Mr	Çanakkale	16	6	22	540,662	4.1
69	S	Gaziantep	52	27	79	2,028,563	3.9
70	Mr	Sakarya	30	9	39	1,010,700	3.9
71	Md	Antalya	48	36	84	2,426,356	3.5
72	Mr	Bursa	66	30	96	2,994,521	3.2
73	Mr	Bilecik	7	0	7	223,448	3.1
74	Mr	Kocaeli	31	16	47	1,906,391	2.5
75	A	Denizli	16	9	25	1,027,782	2.4
76	A	İzmir	67	25	92	4,320,519	2.1
77	Mr	Tekirdağ	12	9	21	1,029,927	2.0
78	A	Muğla	15	4	19	967,487	2.0
79	A	Aydın	15	6	21	1,097,746	1.9
80	Mr	İstanbul	194	76	270	15,067,724	1.8
81	Mr	Yalova	1	1	2	262,234	0.8
Total			3,330	1,768	5,098	82,003,882	6.2

* Region codes; PE: Pectus excavatum; PC: Pectus carinatum; B: Black Sea region; E: Eastern Anatolia region; C: Central Anatolia region; A: Aegean region; Md: Mediterranean region; Mr: Marmara region; S: Southeast Anatolia region.

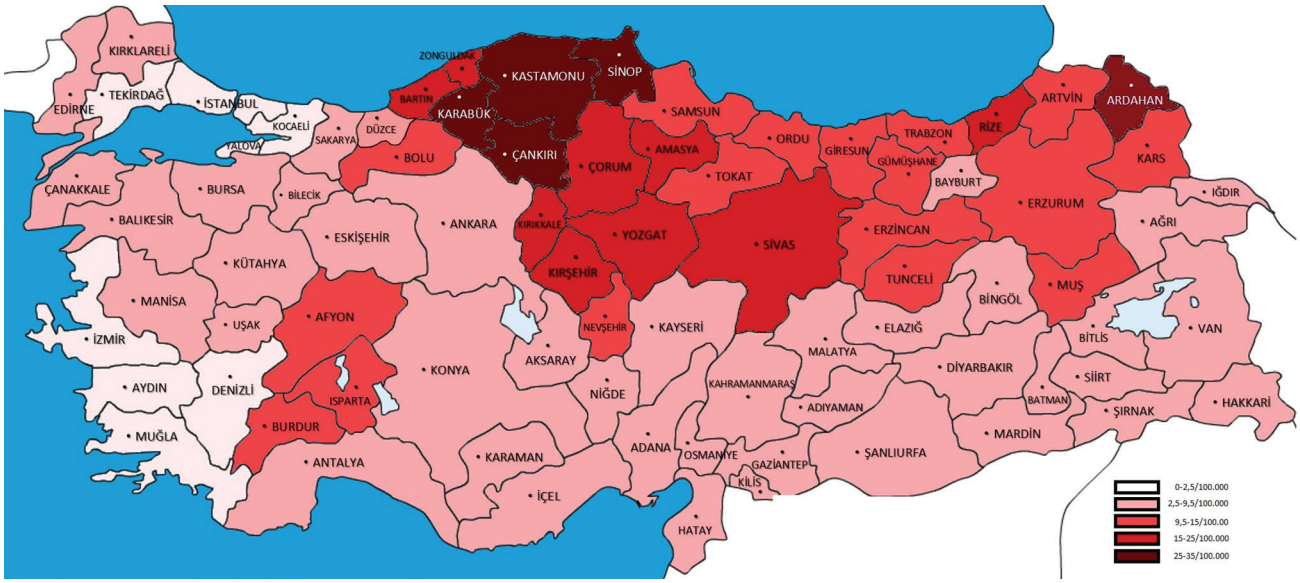

Figure 1. Color scale map based on pectus deformity case rates.

Given the family history in pectus deformities, 1,348 (26.4%) of 5,098 patients with pectus deformity had compölete data in terms of family history characteristics. The data were obtained from medical records in 872 (64%) of 1,348 patients, while family history was able to be obtained via telephone calls in the remaining 476 (36%) patients. Of 1,348 patients with complete information on family history, 852 (63%) had PE and 496 (37%) had PC deformity. A total of 329 (39%) of 852 patients with PE deformity and 215 (43%) of 496 patients with PC deformity had a positive family history. Considering both deformities together, a positive family history was found in 544 (40%) of 1,384 cases. Given the distribution of the cases with a positive family history by region, it was remarkable that the Aegean region had significantly high rates (66% and 64%, respectively) for both PE and PC deformity, while in the Southeast Anatolia region had the lower rates (13% and 19%, respectively). When the family history between regions was analyzed with the multiple correspondence analysis, there was a close distribution between the regions (Figure 2).

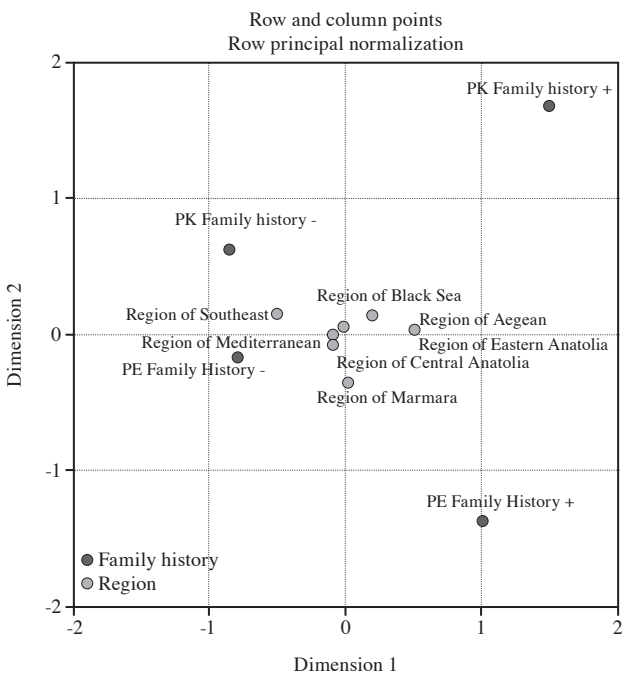

Figure 2. Two-dimensional multiple correspondence analysis graph for PE, PC, and family history.
PE: Pectus excavatum; PC: Pectus carinatum.

DISCUSSION

Abnormal distortions in the osseous and cartilaginous structures forming the rib cage due to congenital and acquired causes are defined as chest deformities. Congenital chest deformities do not usually cause severe dysfunction, except for life-threatening rare cases. Pectus deformities consist of two basic deformities: *(i)* PE, where the first and second costae are mostly normal and the other costae are displaced posteriorly with the sternum; and *(ii)* PC, where the sternum is protruded anteriorly.[1-3,5,6]

Pectus excavatum is the most common (80 to 90%) anterior chest wall deformity, followed by PC with a prevalence of 5 to 20%. In different studies, it has been

reported that the ratio of PC/PE may range between 1:13 and 1:45.[1-3,6-9] In our study, in contrast with these basic literature data, of pectus deformities, 65.3% were PE, 34.7% were PC deformities, and the ratio of PC/PE was approximately 1/1.9. In three different studies screening school-age children for chest deformity, two from Turkey and one from Brazil, PE was reported in 76 (38%) of 199 cases, 19 (55%) of 34 cases, and 14 (54%) of 26 cases, respectively.[10-12] Taken together, these results indicate that PE deformity is the most common anterior chest wall deformity; however, the ratio of PC/PE is around 1:2 for our country.

The incidence of PE deformity is 1/300-4,000 to 1/1,000 births and three to five-times higher in males than in females, and the incidence of PC deformity is 1/10,000 births and four times higher in males.[1,3,6-8,10] In the literature and studies conducted in our country, the prevalence of chest deformity is similar, ranging from 0.7 to 1.4%.[11-15]

There are screening studies including school children to determine the prevalence of pectus deformities. In the research by Akkas et al.[11] including 14,108 students aged between 11 and 14 years in Ankara province, the rate of chest deformity was found to be 1.41%. Therefore, studies conducted by adhering only to a particular province may produce misleading results. Considering this issue, we believe that our study would be a guide for future research.

Pectus deformities may coexist with some other congenital anomalies. Scoliosis, congenital heart disease, asthma, and Marfan syndrome are among the most common concomitant anomalies. It has been reported that scoliosis is found in 15 to 26% of patients with PE deformity and in 10 to 12% and 21% of patients with PC deformity; asthma and congenital heart diseases are more common in these patients than in normal population. In addition to these anomalies, the coexistence of PE and chromosomal anomalies such as Prune-Belly syndrome, myopathies, and Turner syndrome has been reported.[1,3,9,16,17]

Our country is divided into seven different geographical regions. Although the Black Sea region comprising 18 provinces includes 10% of the entire Turkish population, the majority of pectus cases as much as 24% (1,242 cases) originate from this region. This corresponds to about 2.5-fold of the Turkey's average (6.2/100,000) with 15.6 deformity cases per 100,000 individuals. Although the Black Sea region is followed by the Central Anatolia region with 9.9 cases per 100,000 individuals, the East Anatolia region with 8.2 cases per 100,000 individuals and they appear to be above the Turkey's average, they fall behind compared to the Black Sea region in terms of case density.

In our study, since the entire population was not scanned for the presence of pectus deformity, the ratio of pectus deformity-positive cases in each region was compared with the total average rate. Accordingly, the PE ratio was found to be lower in the Southeast Anatolia region than the country average (56.4%) and higher in the Marmara region (71.8%) (p=0.009 and p=0.037, respectively). Conversely, the ratio of PC was higher in the Southeast Anatolia region (43.6%) than in the general average and lower in the Marmara region (28.2%) (p=0.001 and p=0.003, respectively). The prevalence we obtained can be considered to constitute only half of the population, as approximately 99% of the patients in our study consisted of male patients. The true prevalence should be approximately two-times more than the given rates.

Given the distribution by provinces, Kastamonu, Çankırı, Karabük and Sinop, which are adjacent to each other, seem to have four to five-teams higher density (26.9-31.8/100,000) than the Turkey's average (6.2/100,000). Ardahan (26.3/100,000), which ranks the fifth, draws attention with its close neighborhood with the Black Sea region.

It can be thought that some provinces close to each other in terms of prevalence rates may replace each other over time and small changes may occur in the color map chart of Turkey that we created in our study. However, we observed that a 1.5 to 5-times higher density than the Turkey's average was notable in all Karadeniz provinces, particularly in Kastamonu, Çankırı, Istanbul, Sinop, Zonguldak, and Bartın (except Bayburt) in the data we made before and updated over the years.

Increased familial inheritance is present in pectus deformities. Family history in PE deformity was first described by Erich Ebstein in 1921. Sainsbury reported six cases in four generations in 1947 and Elisberg reported 11 cases in four generations in 1958.[18-20] Currently, it is reported that 37% of PE cases have an inheritance of chest deformity in one of their family members and this rate is 25% in PC deformity.[1] In the genetic research by Creswick et al.[10] on family history in PE deformity, of 34 families, 14 had autosomal dominant inheritance, four had autosomal recessive inheritance, six had X-linked recessive inheritance, and 10 had complex inheritance patterns, and that mostly multifactorial hereditary characteristics appear to play a role, although Mendelian inheritance may occur.

In our study, 39% of PE cases had a family history, which is consistent with the literature. In addition, family history (43%) was found to be higher in patients with PC compared to the literature data (25%).[1] It is remarkable that the positive family history reaches up to 65% in the Aegean region, whereas this rate is 15% in the Southeast Anatolia region. However, we do not have enough data to discuss the reasons for this which needs to be explained.

In our study, although the number of cases with a positive family history was found to be higher in the cases of Black Sea region, all regions showed a similar distribution in terms of presence of family history according to the multiple correspondence analysis graph. In which region the incidence of familial transmission is higher can be only explained by extensive scanning studies. For the high rate of family history we found in the Black Sea region and some provinces, the first explanations springing to mind may be as follows: the settlements of certain communities in these regions as a result of migrations in the historical process, consanguineous marriages, migrations, socioeconomic and nutritional factors in this disease, which may exhibit family history. Based on these data, it is necessary to investigate additional topics such as the rate of other congenital anomalies that may be seen with pectus deformity in these regions and provinces or the presence of a similar family history.

In our study, there are certain limitations to prevent us to reach some proportional results. Due to being a military hospital, the majority of the patients in the registry system are male patients of a certain age range, and sufficient statistical studies cannot be performed for female patients. Although pectus deformities are not a disease group of a certain age group, age-related deformity incidence rates are unable to be obtained. As the severity of pectus deformities, indications for surgery, patients undergoing surgery do not contribute to the main idea of the article, and these issues are not addressed here.

In conclusion, we believe that our study, which is the first study regarding the distribution of pectus deformity by regions and provinces across Turkey, may be a reference study for future research in terms of prevalence, social characteristics, consanguineous marriages, socioeconomic structure, migrations, and other congenital diseases. Pectus deformities are more frequent in certain regions and our study would shed light on further studies about the reasons of this situation.

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