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ORIGINAL ARTICLE / ÖZGÜN MAKALE

Incidence of chest wall deformity in 15,862 students in the province of Sivas, Türkiye

Türkiye'de Sivas ilinde 15.862 öğrencide göğüs duvarı deformitesi insidansı

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ABSTRACT

Background: This study aims to investigate the prevalence of chest deformity in middle- and high-school students in Sivas province of Turkey, to identify the risk factors associated with the psychological and physical disorders caused by the deformity, and to facilitate early diagnosis and treatment guidance by increasing awareness of this problem.

Methods: Between October 2011 and May 2012, a total of 15,862 students (8,508 males, 7,354 females; mean age: 15.9±1.3 years; range, 12 to 19 years) from public schools were included. A number of schools were randomly selected for study, and the students were screened by physical examination. A study protocol was developed in which patients with deformities were questioned about family history and symptoms.

Results: Chest wall deformity was detected in a total of 250 students (1.6%). The prevalence rates of pectus carinatum and pectus excavatum in the children were 0.7% and 0.6%, respectively. The overall prevalence of chest wall deformity was 1.6%.

Conclusion: Chest wall deformity is more common in boys and pectus carinatum is the most common deformity type. Chest wall deformity is more common in the 15-16 age group and female sex is a risk factor for psychological discomfort.

Keywords: Chest wall deformity, prevalence, Turkish population.

ÖZ

Amaç: Bu çalışmada Türkiye'nin Sivas ilindeki ortaokul ve lise öğrencilerinde göğüs deformitesi prevalansı araştırıldı, deformitenin neden olduğu psikolojik ve fiziksel rahatsızlıklar ile ilişkili risk faktörleri belirlendi ve bu soruna ilişkin farkındalığı artırarak erken tanı ve tedavi yönlendirmesi kolaylaştırıldı.

Çalışma planı: Ekim 2011-Mayıs 2012 tarihleri arasında çalışmaya devlet okullarından toplam 15.862 öğrenci (8.508 erkek, 7.354 kız; ort. yaş: 15.9±1.3 yıl; dağılım, 12-19 yıl) alındı. Çalışma için rastgele bir dizi okul seçildi ve öğrenciler fizik muayene ile tarandı. Deformitesi olan öğrencilerde aile öyküsü ve semptomlarının sorgulandığı bir çalışma protokolü geliştirildi.

Bulgular: Toplam 250 öğrencide (%1.6) göğüs duvarı deformitesi tespit edildi. Çocuklarda pektus karinatum ve pektus ekskavatum prevalans oranları sırasıyla %0.7 ve %0.6 idi. Genel göğüs duvarı deformite prevalansı %1.6 idi.

Sonuç: Göğüs duvarı deformitesi erkeklerde daha sık görülmekle birlikte, pektus karinatum en sık görülen deformite türüdür. Göğüs duvarı deformitesi 15-16 yaş grubunda daha sık izlenir ve kadın cinsiyeti psikolojik rahatsızlık açısından bir risk faktörüdür.

Anahtar sözcükler: Göğüs duvarı deformitesi, prevalans, Türk toplumu.

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Congenital posterior or anterior displacement of the sternum is referred to as anterior chest wall deformity.[1,2] Chest deformities are the result of abnormal development of the costal cartilage due to genetic predisposition or idiopathic mechanisms. These deformities can cause a spectrum of clinical manifestations ranging from psychological disorders to compression of mediastinal organs. The prevalence of chest deformities in the general population has been reported as 1%.[3]

In the present study, we aimed to investigate the prevalence of chest deformities in middle- and high-school students in the Sivas province, to identify factors associated with psychological and physical disorders caused by the deformity, and to increase awareness of this problem to facilitate early detection and treatment referral.

PATIENTS AND METHODS

This prospective study was conducted at Cumhuriyet University Faculty of Medicine, Department of Thoracic Surgery between October 2011 and May 2012. Students attending grades 6 through 12 (aged 12 to 19 years) in the center of Sivas, a province in the Eastern part of the Central Anatolia of Türkiye, were screened for chest wall deformity. A total of 15,862 students (8,508 males, 7,354 females; mean age: 15.9±1.3 years; range, 12 to 19 years) were included in the study. Schools were randomly selected for the study and conducted in 23 schools.

With a medical team of four, two of which are thoracic surgeons visited the schools to conduct physical examinations of the students. Physical examinations were made by examining the anterior and posterior chest walls of female and male students separately

Table 1. Study protocol

Questionnaire

1. Identification
   Name: ..... Age: .....
   Adress: ..... Phone: .....
2. Did you know about chest wall deformity?
   No ☐ Yes ☐
3. Do you have any relatives with a similar defect?
   No ☐ Yes ☐
4. Do you feel any physical discomfort during physical activities?
   No ☐ Yes ☐
   Which one(s)?
   Fatigue ☐ Shortness of breath ☐ Palpitations ☐ Chest pain ☐
5. Do you face any problems at home or at school because of your different physical appearance?

Physical examination

1. Weight: ..... Sex: ..... Height: .....
2. Deformity: Measurements:
   Excavatum ☐ Chest circumference: ☐
   Carinatum ☐ Lateral diameter: ☐
   Miks ☐ Anterior-posterior diameter: ☐
   Others ☐ Depth: ☐
3. Degree of deformity:
   Mild ☐ Moderate ☐ Severe ☐
4. Murmur:
   No ☐ Yes ☐

in examination cabins with their tops completely removed. A study protocol was developed in which questionnaire and physical examination form in for children with chest wall deformities (Table 1). In the first part of the questionnaire filled by the authors, the students were asked about their names, whether they were aware of the chest wall deformities, their family history, physical discomfort (such as chest pain, shortness of breath) and whether they felt any psychological discomfort due to this deformity. When family history was questioned in the study protocol, the children's first- or second-generation parents did not migrate from elsewhere before.

In the second part of the study protocol, the children's height and weight were measured and all children were examined for scoliosis. A murmur was examined on heart auscultation. If a chest wall deformity was detected in this examination, the width and depth of the deformity and the circumference and diameters of the chest were measured using a caliper, ruler, and tape measure. Deformity severity was measured by the ratio of the sternal deformity depth to the largest diameter of the chest wall using the anthropometric index calculation.[4] The type and degree of deformity (mild, moderate, severe) were determined by examination. If we could clearly see the deformity on physical examination, we considered it as moderate or severe. The subjective degree of deformity was determined by the same physician for all students. In particular, those with severe deformities were informed about the treatment methods of the deformity and were advised to apply to the hospital.

Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 26.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. In the analysis of categorical data, the chi-square analysis was performed. A binary logistic regression analysis was performed for psychological state estimation. In this logistic analysis, the "Enter" method, in which the significance of the coefficients of all variables was evaluated in one step, and Hosmer-Lemeshow statistics were used to test the goodness-of-fit. A p value of <0.05 was considered statistically significant.

RESULTS

Of a total of 15,862 students included in the study, chest wall deformity was detected in 250 students (1.6%). Of these, 116 (46.4%) had pectus carinatum, 98 (39.2%) had pectus excavatum, 29 (11.6%) had mixed deformities, and seven (2.8%) had isolated rib anomalies. Deformity was most frequent in the 15-16 age group with 131 (52.4%) students and demographic characteristics of the patients are shown in Table 2.

Scoliosis was detected in 13 (5.2%) of the students with chest deformity, and one student had also Poland syndrome. The prevalence rates of pectus carinatum and pectus excavatum in the children screened were 0.7% and 0.6%, respectively. Boys accounted for 81 (82.7%) of the students with pectus excavatum (female-to-male ratio=1:4.7) and 109 (93.9%) of the students with pectus carinatum (female-to-male ratio=1:15.6).

In students with pectus excavatum, the mean chest circumference was 78.7±6.8 cm, deformity depth was 1.7±0.8 cm, anterior-posterior chest depth was 20.2±2.7 cm, and lateral chest width was 41.1±4.7 cm. In students with pectus carinatum, the mean chest circumference was 77.3±5.6 cm, anterior-posterior

Table 2. Distribution of demographic variables

Variables	Frequency	Percent (%)
Age groups (year)		
12-14	40	16.0
15-16	131	52.4
17-19	79	31.6
Sex		
Male	216	86.4
Female	34	13.6
Deformity type		
Pectus excavatum	98	39.2
Pectus carinatum	116	46.4
Others	36	14.4
Deformity awareness		
(+)	75	30.0
Family history		
(+)	44	17.6
Physical disturbance		
Chest pain	39	15.6
Dyspnea	36	14.4
Palpitation	35	14.0
Psychological disturbance		
(+)	60	24.0
Deformity degree		
Mild	136	54.4
Moderate	107	42.8
Severe	7	2.8
Total	250	100.0

Table 3. Logistic regression analysis between psychological disturbance and sex, age, deformity degree, family history, deformity type, deformity awareness

Variables	β	SE	W	df	*p* (sig)	Exp (β)	95% CI for Exp (β)	
							Lower limit	Upper limit
Age	-0.283	0.218	1.688	1	0.194	0.753	0.492	1.155
Sex	5.704	0.853	44.677	1	0.001*	299.919	56.321	1,597.108
Deformity degree								
Mild			5.821	2	0.054			
Moderate	2.079	1.295	2.576	1	0.108	7.998	0.631	101.304
Severe	3.024	1.353	4.997	1	**0.025***	20.576	1.452	291.658
Family history	-4.722	0.684	47.631	1	**0.001***	0.009	0.002	0.034
Deformity type								
Pectus carinatum	-0.592	0.832	0.506	1	0.477	0.553	0.108	2.826
Pectus excavatum	-0.814	0.796	1.045	1	0.307	0.443	0.093	2.110
Deformity awareness	0.209	0.602	0.120	1	0.729	1.232	0.379	4.007
Constant	0.491	3.435	0.020	1	0.886	1.634		

Exp (β): Odds ratio; CI: Confidence interval; β: Parameter estimation; SE: Standard error; W: Wald statistic; df: Degrees of freedom.

chest depth was 22.2±2.8 cm, and lateral chest width was 41.2±3.8 cm.

According to the subtypes and severity of these two main chest deformities, most of the deformities were mild (n=136, 54.4%) (Table 2). Localized pectus excavatum and inferior pectus carinatum were the most common types.

When the students with deformities were asked whether other members of their families had these deformities, 44 (17.6%) responded affirmatively. Family history was positive in 24 (17.6%) of 136 students with mild pectus deformity, 18 (16.8%) of 107 students with moderate pectus deformity, and 28% of students with severe deformity.

Cardiorespiratory symptoms reported among the 98 students with pectus excavatum included chest pain in 21 (21.4%) students, dyspnea in 19 (19.3%) students, and palpitations in 14 (14.2%) students. Of the 116 students with pectus carinatum, chest pain was reported by 18 (15.5%) students, dyspnea by 17 (14.6%) students, and palpitations by 21 (18.1%) students (Table 2).

Logistic regression analysis was performed for psychological state assessment. A binary logistic regression model was established in which the psychological state was the dependent variable of sex, age, family history, deformity degree, pectus carinatum, pectus excavatum and deformity awareness were independent variables. According to the Hosmer-Lemeshow statistics to test the goodness-of-fit of the model, the data belonging to the established model was a statistically sufficient model in estimating the psychological state (χ^2=10.979, df=8; p=0.203>0.05). Parameter estimates (β), standard errors (se), Wald statistics (W), degrees of freedom (df), odds ratios (Exp (β)) and confidence intervals (95% CI) of the variables are given in Table 3. For psychological status, girl, family history and severe deformity were found to be statistically significant factors (p<0.05). However, age, deformity type, mild and moderate deformity, and the awareness were not statistically significant factors for predicting the psychological state correctly (p>0.05).

Awareness was higher in children with a positive family history and children with severe deformity. There was no statistically significant difference between the age groups according to the distribution of sex, deformity type and psychological status variables among the participants (p>0.05).

DISCUSSION

The prevalence of chest deformities in the general population varies by society, with some authors reporting a rate of approximately 1%.[2,3] In a post-mortem study, pectus excavatum was identified in 0.12% of the individuals.[5] The prevalence of chest wall deformities varies between 1 and 1.95% in the literature.[6,7] In terms of race, Westfal et al.[6] reported that the prevalence was higher in Whites.

In the few studies conducted in Türkiye on the prevalence of anterior chest wall deformities, the rate has been reported as 0.768% by Esme et al.,[8] 0.76% by Yucesan et al.,[9] and 1.28% by Soysal et al.[10] Işık et al.[11] determined the frequency of chest deformities in the different regions of Türkiye and reported the prevalence of pectus deformity in Sivas as 16.5/100,000. According to another school survey by Akkaş et al.,[12] the prevalence was 1.41%. In the present study, we detected anterior chest wall deformity at a rate of 1.6%, consistent with the literature.

Studies published in the literature have demonstrated that chest deformity is more common among males.[13-15] In a study to determine the prevalence of pectus deformities among students in the Central Anatolia region of Türkiye, 68% of cases were in males.[12] Our findings also support the literature, with boys comprising 86.4% of students with chest deformity in this study.

When the deformities are examined separately, differences in prevalence are seen between the deformity types. In the literature, pectus excavatum is more common than pectus carinatum, with a reported ratio of 2.2 to 5:1 in the studied populations. There are studies conducted in Türkiye that have yielded similar findings.[15,16] However, pectus carinatum has been reported to be more frequent than pectus excavatum in Argentine and African populations.[3] Similarly, pectus carinatum was more common than pectus excavatum both in our study and that by Akkaş et al.[12] We believe that studies involving more regions are needed to better elucidate differences in the prevalence of chest deformities in our country.

Pectus deformities can be classified subjectively based on clinical examination or objectively using clinical or radiological measurements. One of the most widely used radiological methods to grade the severity of pectus excavatum is the Haller index, which is calculated by dividing the transverse diameter of the rib cage by the anterior-posterior diameter at the level of greatest depression on computed tomography images.[5] However, this method is not suitable for school screenings, as it requires radiological examination. In a study conducted in Brazil, quantitative classification of pectus excavatum using simple tools showed 86% correlation with the Haller index.[17] In our study, we used simple hand tools (i.e., ruler, measuring tape, and caliper) to obtain measurements among students with deformity.

Although genetic predisposition is not confirmed, family history is positive in approximately 30% of cases.[2] According to a study conducted in Brazil, 65% of cases were associated with a family history, which is much higher than the average rate.[17] In our study, self-reported family history was positive for only 44 students (17.6%). This lower rate compared to the literature may be a result of family members hiding their deformities.

A study in children demonstrated that the involvement of heredity changed with the severity of pectus deformity, with a stronger association between family history and severe pectus deformity.[18] In our study, we also observed that severe pectus deformity was more frequently associated with genetic predisposition (mild 17.6%, moderate 16.8%, and severe 28%).

The coexistence of chest wall deformities and scoliosis is a generally recognized phenomenon.[12] The frequency of this association was reported to be 15% among Brazilian students in one study.[5] Although some theories have been put forward to explain this association, the reasons remain unclear.[19] In our study, the prevalence of scoliosis among students with chest deformity was 5.2%. This difference may be due to the lack of simultaneous examination and radiological examination in our study.

There are many studies in the literature reporting that chest wall deformities affect cardiopulmonary function. These studies have also shown that cardiopulmonary function improved after surgical correction. In particular, in pectus excavatum patients, forced expiratory volume in 1 sec (FEV1) improved and cardiac symptoms resolved, as the heart reached its normal position three years after the removal of a pectus bar placed by minimally invasive surgery.[20-22] This may explain the decrease in postoperative symptoms seen in such patients in most studies.[23,24]

There are conflicting data regarding symptoms in patients with chest wall deformity. Although some studies have reported a few patients with symptoms such as hypotension and syncope, these symptoms are rare even among patients with severe deformities. The analysis of various surgical studies in the literature demonstrated that a wide range of symptoms such as chest pain, tachycardia, tachypnea, and decreased exercise tolerance were present in 26.8 to 67.0% of cases.[5] Koumbourlis and Stolar[25] reported that pectus excavatum caused no physical symptoms at rest, but the prevalence of obstructive pulmonary disease was high. According to Coelho et al.,[26] symptoms reported by patients were either due to comorbidities or psychological disorders. In our study, the most common complaint was chest pain in 39 students.

In the present study, 30% of the children with deformity were aware of the condition, and physical discomfort was more common in this group. This suggests that deformities affect children psychologically, as well as physically. Indeed, it has been reported that the main reason for surgical correction in patients with chest wall deformity is to correct the body image rather than the physical disorders.[15,27] Favorable outcomes were reported after the Nuss surgery in pectus excavatum patients who were dissatisfied with their appearance and experienced adverse psychological effects.[28] Ji et al.[29] reported that children with pectus excavatum had more psychosocial problems compared to the general population and that more severe deformity and mockery exacerbated these problems. When the answers given to the fifth question of our study protocol, which we applied to the cases with deformities in our study, were examined; in some children, responses showing psychosocial stress were encountered. They reported that they disliked of oneself, embarrassment, avoidance of sports activities, social relations and contact with their peers, discomfort that could lead to social isolation, anxiety and even depression. In this study, for psychological status, girl, family history and severe deformity were found to be statistically effective ($p<0.05$). We attribute the more common of psychosocial stress in girls to the fact that girls attach more importance to body image than boys. We believe that psychological disorders are more common in children with a positive family history due to increased awareness.

In particular, in closed societies, deformity awareness increases, when family history is positive.[12] Since the region where our study was conducted was a closed society, deformity awareness was more common in the group with a positive family history. In addition, awareness was naturally higher in the group with severe deformity.

Nonetheless, there are some limitations to this study. One of them is that the study was conducted in a specific region and age range. The other is that the study was conducted with medical history and physical examination. Therefore, cardiopulmonary symptoms were evaluated subjectively.

In conclusion, in this study conducted in a large population, chest wall deformity was more common in boys and pectus carinatum was found to be the most common deformity type. Based on these results, chest wall deformity is more common in the 15-16 age group and female sex is a risk factor for psychological discomfort.

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Patient Consent for Publication: A written informed consent was obtained from each patient.

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