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Original Article

A retrospective analysis of chest wall deformities incidentally detected in emergency department patients: an observational study

Osman Sezer Çınaroğlu[1], Mehmet Göktuğ Efgan[1], Hasan Ersöz[2]

[1]Department of Emergency Medicine, Ataturk Research and Training Hospital, Katip Celebi University, İzmir, Turkey.
[2]Department of Thoracic Surgery, İzmir Katip Çelebi University, Faculty of Medicine, İzmir, Turkey

ABSTRACT

Background: The most frequently observed chest wall deformities are pectus excavatum and pectus carinatum. The purpose of this observational study was to examine the prevalence of chest wall deformities in adult patients presenting for various reasons to the emergency department in our institution, a regional reference center for chest deformities, the demographic characteristics of patients with such malformations, emergency presentation symptoms, and the effects of deformities on patients' psychological state.

Materials and Methods: Two hundred forty cases presented to the İzmir Katip Çelebi University Atatürk Training and Research Hospital tertiary emergency department and meeting the inclusion criteria were investigated retrospectively. The cases' demographic data, presence of family histories of similar deformities, presenting symptoms, deformity depths, Haller indices, and patients' psychological deformity levels were determined and subjected to statistical analysis.

Results: The prevalence of pectus excavatum among the patients presenting to our center was 1/308, while the prevalence of pectus carinatum was 1/698. The patients' mean age was 24.75 years, and 84.6% were men. The accompanying psychological deformity was present in only 28.33% of cases. The presence of family history was determined at 38.8%. The patients' mean Haller Index value was 3.16, and the mean depth of deformity was 2.5 cm. Haller Index values were significantly higher among patients with moderate or severe psychological deformity than in the other patients ($p < 0.001$). The Haller Index exhibited a high correlation with depth of deformity ($p < 0.001$) and a negative correlation with patients' body mass index values ($p = 0.024$).

Conclusions: Chest wall deformities are a very common societal health problem, one that exhibits psychological effects and familial predisposition, and that can lead to various physiological problems. Familial disposition levels may vary among societies. Adult patients begin to tolerate the presence of low body mass index and psychological deformity. Prospective studies are now needed for greater clarification of these issues.

Keywords: pectus excavatum, pectus carinatum, chest wall anomalies, psychological deformity, Haller Index

Corresponding Author*: Osman Sezer Çınaroğlu, MD. Department of Emergency Medicine, Ataturk Research and Training Hospital, Katip Celebi University, 35360, Karabağlar, İzmir, Turkey.
E-mail: drsezer@hotmail.com Phone: +90 232 2434343
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Introduction

The shape of the human chest cavity varies from individual to individual [1]. Differences outside normal limits occurring for various reasons during growth in the development of osseous or cartilaginous tissues that comprise the chest wall are known as anterior chest wall deformities. The most common chest wall deformities are pectus excavatum (PE) and pectus carinatum (PC) [2]. PE (sunken chest or cobbler's chest) was first described by Eggel in 1870. It is the most frequently seen chest deformity (80-90%), characterized by varying degrees of depression of the sternum and costal cartilages into the thorax [3]. PC (pigeon chest), characterized by varying degrees of anterior protrusion of the sternum and sternocostal cartilages, is the second most common chest deformity. Although these deformities are congenital, they generally produce findings in adolescence.

These malformations emerging in childhood can cause varying degrees of structural and psychological disturbance [4]. While no life-threatening functional problem is observed in the majority of pectus patients, various system anomalies may be observed in severe cases. The most frequent symptom in patients with chest deformities is dyspnea on exertion, which is more common in individuals with PE. Various cardiac problems and respiratory system disorders associated with structural anomalies may also be seen in these patients. Studies have also reported that the lifea span may be shorter in these patients [5,6].

Individuals with thoracic deformities are a cause for concern for families from the outset. Individuals with deformities gradually begin to experience various psychological problems deriving from their physical appearance [7]. Psychiatrists have performed numerous studies on this subject since 1960 and have employed the term 'psychological deformity' in reference to it. Problems such as anxiety, motivation disorder, and labeling anxiety were observed at a rate of 82% in one study, lack of self-esteem and timidity at 78%, indecisiveness at 72%, and aggression at 66% [8].

This observational study was designed to examine the prevalence of chest wall deformities in adult patients presenting for various reasons to the emergency department in our institution, a regional reference center for chest deformities, the demographic characteristics of patients with such malformations, emergency presentation symptoms, and the effects of deformities on patients' psychological states.

Materials and Methods

This retrospective observational study was performed in the tertiary emergency department of the Izmir Katip Çelebi University Training and Research Hospital, Turkey. Approval for the study was granted by the Izmir Katip Çelebi University Non-Interventional Clinical Research Ethical Committee (no: 0360 Date: 25/05/2022).

A total of 60,725 patients randomly selected using computer software [PASS 11(Power Analysis Sample Size)] were screened from among all patients aged over 18 and presenting to the emergency department for any reason within the previous five years. The sample size was determined as a result of prehoc analysis at a 95% confidence interval and 0.05 margin of error. Patients with chest wall malformations were identified, and the study was conducted with these.

Patients who refused to participate, with psychiatric diseases other than psychological deformity, with systemic disease, whose imaging records or contact information were unavailable, who underwent surgery, or with an additional musculoskeletal disease were excluded from the study.

Patients' age, sex, family history, disease history, body mass index (BMI), deformity type and depth, and presenting symptoms were recorded on the basis of information in our hospital's data management system. The presence of chest deformities in first- and second-degree relatives was regarded as a positive family history. Deformity depths were calculated and recorded from the physical examination notes for patients with PE in the hospital system, and Haller indices from computed tomography (CT) images in the hospital system.

Depth of deformity refers to the value in centimeters on the measurement bar at the intersection of a transversely placed ruler passing over the most protuberant points on both hemithoraces after the measurement rod has been placed perpendicular to the sternum at the deepest point of the chest with the patient in a standing position. The Haller Index value was determined by proportioning the maximum lateral diameter of the chest at thoracic CT and the distance between the sternum and vertebra at the maximum depression point [5].

The Beck Depression Inventory (BDI) was applied to identify whether any depressive component was present in patients' psychological deformities and to classify the level thereof, if applicable. The BDI, developed by Beck et al.

in 1961, is a self-report scale used to evaluate behavioral findings of depression in adolescents and adults [6]. The individual's level of depressive symptoms is determined by means of this scale. The individual is asked questions under 21 headings, with four options for each. The form is completed in the light of the respondent's answers, and the level of depression is classified in the light of the score obtained [5]. Scores of 0-9 are regarded as normal status, 10-18 as indicating mild depression, and 19-29 as indicating moderate depression. Scores of 30-63 indicate severe depression or risk thereof. Depression can be distinguished at a rate of 90%, depending on the score obtained [7]. In order to be able to perform this measurement with the patients in the present study, they were contacted using the details in the system, and the psychological effects of their diseases were investigated. Depression was accordingly classified as none, minimal, moderate, or severe.

Statistical Analysis

All the study data were analyzed on IBM SPSS Statistics Standard Concurrent User version 26 statistical software (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as unit number (n), percentage (%), mean ± standard deviation ($\bar{x} \pm SD$), median (M), minimum (min), and maximum (max) values. The distribution of data for numerical variables was assessed using the Shapiro Wilk normality test. Since the data did not meet normal distribution conditions, comparisons between two groups were performed using the Mann-Whitney U test, while three-way comparisons were performed with the Kruskal Wallis H test. The Pearson and Fisher exact tests were applied in the comparison of categorical variables. Spearman's Rho correlation coefficient was used to examine relationships between numerical variables. P values < 0.05 were considered statistically significant.

Results

Investigation of the 60,725 patients screened for the study showed that chest deformity accompanied emergency department presentation symptoms in 284 cases. In terms of the cross-sectional prevalence of the sample, chest deformity was present in a mean one in 214 patients. One hundred ninety-seven (69.37%) of the patients with deformity were diagnosed with PE and the remaining 87 (30.63%) with PC. Prevalence was thus 1/308 for PE and 1/698 for PC.

Twenty-four of the 284 patients with chest wall deformity were excluded since they could not be contacted for various reasons or else declined to take part in the study, 12 due to imaging results being unavailable, one patient due to a diagnosis of schizophrenia, and seven due to various accompanying systemic or musculoskeletal diseases (diabetes, rheumatoid arthritis, Marfan syndrome, and osteogenesis), and the study was therefore finally conducted with 240 patients.

As shown in table 1 the patients' mean age was 24.75 years, and 203 (84.58%) were men. Scoliosis was observed as a structural anomaly in 20 patients (8.33%). No psychological deformity was encountered in 68 patients (28.33%), while at least minimal accompanying psychological deformity was present in the remaining 172 (71.67%). Examination of emergency department presentations in terms of symptoms that may occur in association with chest deformity revealed that the most common complaint was back pain, in 23 cases (9.58%), followed by effort dyspnea in 19 (7.91%), and chest pain in 16 (6.66%). The patients' mean BMI value was 21.52.

As shown in table 2, Haller Index values were higher in patients with moderate and severe psychological deformity than in the other patients ($p < 0.001$).

As shown in table 3, Haller Index values exhibited a significant correlation with the depth of deformity in patients with PE (the one increasing with the other at a value of 76.00%) ($p < 0.001$)

However, in other patients, there was a negative statistically significant correlation of 57.70% between the Haller index and the BMI value, with one increasing and the other decreasing ($p = 0.024$). As shown in table 1, the mean age of the patients with PE alone was 25.17. Male patients represented one hundred fifty (85.71%) of the patients with PE, with male gender predominating over female. A family history was present in 56 patients (32.00%). Ten (5.71%) patients exhibited structural anomalies diagnosed as scoliosis. No psychological deformity was encountered in 62 patients (35.43%), while at least minimal accompanying psychological deformity was present in all the remaining cases. The patients' mean Haller Index value was 3.16, and their mean depth of deformity was 2.50. The most common symptom potentially associated with chest deformity was also back pain, observed in 17 (9.71%) cases. BMI values ranged between 15 and 35..

Table 1. Descriptive values.

Variables	Values	Patients with pectus excavatum
Group, n (%) Pectus excavatum Pectus carinatum Other	175 (72.9) 29 (12.1) 36 (15)	
Age, years $\bar{x}$±SD M (min-max)	24.75±6.14 24 (18-55)	25.17±6.22 24 (18-55)
Gender, n (%) Female Male	37 (15.4) 203 (84.6)	25 (14.28) 150 (85.71)
Family history, n (%) Yes No	93 (38.8) 147 (61.2)	56 (32.00) 119 (68.00)
Structural anomalies, n (%) ASD Aortic insufficiency Dextrocardia Mitral valve insufficiency Scoliosis VSD	6 (2.50) 6 (2.50) 3 (1.25) 8 (3.33) 20 (8.33) 3 (1.25)	2 (1.14) 4 (2.28) 2 (1.14) 3 (1.71) 10 (5.71) 2 (1.14)
Psychological deformity, n (%) None Minimal Mild Moderate Severe	68 (28.33) 97 (40.41) 41 (17.08) 26 (10.83) 8 (3.33)	62 (35.43) 58 (33.14) 31 (17.71) 17 (9.71) 7 (4.00)
Emergency presentation Symptom, n (%) Dyspnea Palpitation Effort dyspnea Chest pain Syncope Back pain Other reasons for presentation	12 (5.00) 15 (6.25) 19 (7.91) 16 (6.66) 3 (1.25) 23 (9.58) 152 (63.33)	10 (5.71) 12 (6.85) 11 (6.28) 9 (5.14) 1 (5.20) 17 (9.71) 115 (65.71)
BMI $\bar{x}$±SD M (min-max)	21.51±3.07 21 (15-35)	21.71±3.13 21 (15-35)
Haller Index $\bar{x}$±SD M (min-max)		3.16±0.54 3.00 (2.60-5.60)
Depth of deformity $\bar{x}$±SD M (min-max)		2.50±0.83 2.40 (1.00-5.60)

Abbrev.; %: Row percentage, M: Median, $\bar{x}$: Mean, SD: Standard Deviation

Table 2. A comparison of psychological deformity and Haller Index values.

	Haller Index	Test statistics	
	M (min-max)	H value	p value
Psychological deformity None	2.9 (2.6-3.6)[a]		
Minimal	3.0 (2.6-3.8)[b]		
Mild	3.2 (2.7-4.3)[c]	84.279	<0.001
Moderate	3.9 (3.2-4.7)[d]		
Severe	4.9 (3.8-6.0)[d]		

Abbrev.; M: Median, H: Kruskal Wallis test. The letters a b c d represent multiple comparisons. There is no statistical difference between groups containing the same letter, there is a statistically significant difference between groups containing different letters.

Table 3. Correlation relationships.

Group			Age	Haller Index	BMI
Pectus excavatum	Haller Index	rho	-0.077		0.010
		p	0.344		0.900
	Depth of deformity	rho	-0.026	0.760	-0.027
		p	0.753	<0.001	0.738
Other	Haller Index	rho	0.182		-0.577
		p	0.517		0.024
	Depth of deformity	rho	-0.059	0.417	-0.010
			0.836	0.122	0.971

Abbrev.; rho: Spearman Correlation Coefficient

Discussion

The most common chest wall malformation is PE, followed by PC. Reported incidences are 1/300-400 for PE and 1/1000 for PC [1,2,8]. Both deformities are five times as common in males [1,2,9]. Prevalence among patients presenting to our hospital emergency department for various reasons in the present study wa 1/308 for PE and 1/698 for PC. The frequency of the male gender was 84.6% for all chest wall deformities and 85.7% for PE. Accordingly, the prevalence of PE in the present study was consistent with the previous literature, while that of PC was higher. In addition, a slightly higher frequency of male gender was determined for both deformities.

Examination of family histories in the patients with chest wall deformities included in the study revealed a rate of chest deformity in first- and second-degree relatives of 38.75%, and a figure of 32% among the isolated PE patients. The genetic basis of PE is still unknown, although the presence of similar genetic deformities in 40% of family members is clinical evidence corroborating the idea that PE is a genetic disease [4]. The familial dominance in PC is 25% [9]. Lower familial disposition was determined for PE among the patients in the present study, while such disposition was higher than previously reported for PC. These rates may vary among countries and cultures since the frequency of all diseases with such familial disposition increases in societies with higher rates of consanguineous marriage.

Posture disorders accompany deformity in 50-80% of patients with PE. They are thin and tall in appearance, with a narrow chest, increased dorsal lordosis, shoulders slumped forward, and a protruding abdomen. Accompanying scoliosis is present in 26-30% of cases [10]. Although PC may appear as an isolated deformity, 51.6% of patients exhibit one or more associated musculoskeletal system abnormalities (posture impairment), with forward head posture, uneven shoulders, rounded shoulders, thoracic kyphosis, lumbar lordosis, anterior pelvic tilt, and scoliosis having been reported [11]. Comparatively lower rates of scoliosis and other structural anomalies were encountered in the present series.

Mean and median BMI values of 21 were determined in both the PE and PC groups. These values, within normal ranges for an adult individual, were surprising, since patients with chest deformities exhibit lower BMI values than in society in general. In a study published in 2016, Park et al. investigated 1371 patients and reported a mean BMI of 18 [12]. However, it should not be forgotten that the majority of patients seen in clinical practice and in Park et al.'s study are in the pediatric population, while we included patients in the adult age group. Although chest deformities cause some degree of BMI depression in the early age group, patients can tolerate this and normalize their BMI levels at later ages.

The most frequent emergency department presentation symptoms potentially associated with chest deformity are back pain, effort dyspnea, and chest pain. We think that presentations to the emergency department due

to back pain are particularly common because such pain is prevalent in society and in trauma patients. Dyspnea with exertion, generally the most common symptom, was the second most frequent symptom in our series.

The Haller Index is calculated as the ratio of the maximal transverse diameter of the chest to the minimal anteroposterior diameter; values are lower than 2.0 in healthy individuals, while values exceeding 3.5 have been reported as an indication for surgery [13,14]. Values between 2.0 and 3.2 are defined as 'mild excavatum,' 3.3-3.5 as 'moderate excavatum,' and values of 3.6 or higher as 'severe excavatum.' The mean Haller Index value in the present series was 3.16, with a median value of 3. This shows that we screened individuals from all patient groups, not solely those with severe excavatum. This also confirmed the data obtained concerning the depth of deformity. A depth of less than 1 cm is regarded as minimal, 1-3 cm as moderate, and greater than 3 cm as severe deformity (1.0-5.6). From that perspective, the Haller Index and depth of deformity values obtained were mutually consistent.

Chest wall deformities are problems that generally require correction. Indications for corrections occur in two groups – functional (cardiac, pulmonary, and postural-orthopedic) or psychosocial-esthetic indications. In other words, even in the absence of any functional complaint, patient dissatisfaction with his appearance is by itself an indication for correction. It is therefore of great importance to establish the prevalence of 'psychological deformity, even in an observational study such as the present research. We employed a depression inventory in the context of psychological deformity in this study, and determined at least minimal depression in all patients with chest wall deformity, and in 64.6% of those with PE. From that perspective, the rate of psychological deformity revealed by our data differed only minimally from that in the previous literature. Due to the low number of presentations among patients under 18, since ours is an adult hospital, this patient group was excluded from the study, and this may account for the lower rate of psychological deformity than in the previous literature. This is because older adult patients may be expected to be more reconciled to their deformities than the adolescent group aged under 18.

Another finding emerging from this study is that the severity of psychological deformity increased in line with Haller Index values. This correlation was highly significant. This suggests that the Haller Index is a good indicator not only of the patient's physiological characteristics, but also of his psychological state. Another advantage of the Haller Index lies in the fact that BMI values decrease as Haller values rise. This is because, as an indicator of the severity of the deformity, the Haller Index is also correlated with the problem of low BMI emerging secondary to the deformity. This makes the Haller Index particularly significant.

The significant correlation between the Haller Index and depth of deformity confirmed that-, similarly to the index itself, the latter is also an important marker. In addition, while radiological imaging is required to calculate Haller Index values, measuring the depth of deformity is noteworthy as a highly practical method that can be applied anywhere.

Limitations

The principal limitations of the present study are its retrospective and single-center nature, the fact that patient randomization was not performed, and that pediatric cases were not included. Since the study was retrospective, patients were reached through their contact information. This has led to the possibility that the depression level of the patients may change over time. Further randomized, multi-center clinical studies consisting of large series and patients from all age groups are now needed to clarify the situation.

In conclusion, chest wall deformities are a relatively common health problem in society, involving psychological effects that frequently result in psychological deformity, involving a familial predisposition, and are capable of leading to problems such as low BMI in adult patients. The Haller Index and the depth of deformity are both potentially good indicators of both psychological and physical state. Further prospective studies are now needed to shed greater light on this subject.

Declaration of conflicting interests

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Ethics approval

The study was approved by the Izmir Katip Çelebi University Non-Interventional Clinical Research Ethical Committee (no: 0360 Date: 25/05/2022).

Authors' contributions

OSC, HE; conceptualized and designed the study, collected analyzed, and interpreted the patient data regarding pulmonary metastasis, co-wrote the paper, MGE; collected and analyzed data, revised the final version of the manuscript, and wrote the paper. All authors read and approved the final manuscript.

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