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The Relation Between Prevalence of Emphysema and Artery Blood Gases, Pulmonary Function Test and Patients' Performance in Patients with Emphysema: Descriptive Clinical Research

Amfizemli Hastalarda Amfizem Yaygınlığının Arter Kan Gazı, Solunum Fonksiyon Testi ve Hastaların Performanslarıyla Olan İlişkisi: Tanımlayıcı Klinik Araştırma

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This study was presented as discusion poster at the Turkish Respiratory Society (TÜSAD) with International Participation 41st National Congress. 26-29 October 2019, Muğla, Turkey.

ABSTRACT Objective: In emphysema, changes such as decrease in the maximum expiratory air flow, excessive ventilation and air trapping occur. These changes affect the patients' exercise tolerance and effort capacities in the later period. Our purpose was to determine the relation between the prevalence of emphysema and patients' performance, the level of obstruction in the patients, the changes occurring in patients' artery blood gas (ABG) and other emphysema parameters. **Material and Methods:** A total of 55 consecutive patients with definite emphysema were included in the study. Patients' demographic and clinical characteristics were recorded. High resolution computed tomography (HRCT), pulmonary function tests, ABG measurement, patient performance evaluation and lung quantitative perfusion scintigraphy were performed to all patients. HRCT and visual emphysema score were used to determine the distribution and prevalence of emphysema. **Results:** Negative correlation coefficients were found between the emphysema scores and forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), FEV_1/FVC, diffusing capacity of the lung for carbon monoxide, oxygen saturation percentage and 6 minutes walking test (6MWT) and positive correlation coefficients were found residual volume (RV), total lung capacity, partial carbon monoxide tension, Global Obstructive Lung Disease stage and Modified Medical Research Council ($p<0.05$). **Conclusion:** It was determined that among all the parameters, the strongest negative correlation was with the 6MWT, and the strongest positive correlation was with the RV. It was seen that in terms of the zones, the percentage of perfusion decreased as the emphysema scores increased.

Keywords: Emphysema; perfusion

ÖZET Amaç: Amfizemde maksimum ekspiratuar hava akımında azalma, aşırı havalanma, hava hapsi gibi değişiklikler oluşur. Bu değişiklikler ilerleyen dönemde hastaların egzersiz toleransı ve efor kapasitelerini etkiler. Amfizemli hastalarda tespit edilen amfizem yaygınlığının hastanın performansı, hastada oluşan obstrüksiyonun düzeyi ve hastanın arter kan gazında (AKG) oluşan değişiklikler ve diğer amfizem parametreleri olan ilişkisini tespit etmeyi amaçladık. **Gereç ve Yöntemler:** Daha önce kesin amfizem tanısı almış ardışık 55 hasta alındı. Hastaların demografik ve klinik özellikleri kaydedildi. Hastaların tümüne yüksek rezolüsyonlu bilgisayarlı tomografi (YRBT), solunum fonksiyon testleri, AKG ölçümü, hasta performansını değerlendirmeye yönelik testler, akciğer kantitatif perfüzyon sintigrafisi yapıldı. Amfizem dağılımı ve yaygınlığının belirlenmesi için YRBT ile görsel amfizem skoru kullanıldı. **Bulgular:** Amfizem skorları ile zorlu vital kapasite (FVC), 1. saniyedeki zorlu ekspiratuar volüm (FEV_1), FEV_1/FVC, karbonmonoksit difüzyon kapasitesi, yüzde oksijen satürasyonu ve altı dakika yürüme testi (6DYT) arasında negatif yönlü; rezidüel volüm (RV), total akciğer kapasitesi, parsiyel karbondioksit basıncı, Global Obstrüktif Akciğer Hastalığı evresi ve Modifiye Tıp Araştırması Konseyi arasında aynı yönlü ilişki katsayıları bulundu ($p<0,05$). **Sonuç:** Tüm bu parametreler arasında en kuvvetli negatif yönlü korelasyon 6DYT ile, en kuvvetli pozitif yönlü korelasyon ise RV ile saptandı. Zonlara göre amfizem skorları arttıkça perfüzyon yüzdelerinin düştüğü görüldü.

Anahtar Kelimeler: Amfizem; perfüzyon

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Emphysema is abnormal and permeant enlargement of the air tracts in distal terminal bronchioles in the lungs. The appearance of the acinus and its components might be distorted or completely disappeared. Major physiological defect is the loss in the elastic spring back and this loss causes such changes as decrease in the maximum expiratory air flow, excessive ventilation and air trapping.[1]

Due to ventilation and gas change disturbances, in the later period, patients' exercise tolerance and effort capacities decrease gradually, and their vital activities get restricted and their quality of life deteriorates.[2]

Due to airway obstruction in chronic obstructive pulmonary disease (COPD), loss of flexibility in lung tissue and alveolar destruction a decrease is detected in forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), FEV_1/FVC. In emphysema patients, diffusing capacity of the lung for carbon monoxide (DLCO) decreases due to alveolar-capillary bed loss. Because of the increasing air trapping, residual volume (RV) and total lung capacity (TLC) increase.[2,3]

The main pathology in emphysema is the hyperinflation related to elastic tissue destruction. For this reason, lung parenchyma is monitored in computed tomography as low density areas. Pulmonary capillaries get damaged and perfusion deteriorates due to increased pulmonary capillary vascular resistance and alveolar wall destruction around air trapping areas developing in emphysema. Quantitative lung perfusion scintigraphy is a reliable method in evaluation of the differences in the localised perfusion reflecting the prevalence of emphysema.

In this study, we aimed to determine the relation between the prevalence of emphysema and patients' performance, the level of obstruction in the patients, the changes occurring in patients' artery blood gas (ABG) and other emphysema parameters.

MATERIAL AND METHODS

This text is intended as a descriptive clinical study. Fifty-five consecutive patients, regardless of gender, who were admitted to the chest diseases clinic of hospital of Sivas Cumhuriyet University between November 2017 and November 2018 and examined, determined to be previously diagnosed with definite emphysema after the investigation of their files, treated and/or followed-up by us and who agreed to participate were included in the study. About 45 patients who did not want to participate, who had chronic morbidity (chronic kidney failure, decompensated congestive heart failure, malignancy etc.) and did not complete the tests were excluded from the study. Before the study, ethics committee approval was obtained from Cumhuriyet University Non-interventional Clinical Research Ethics Committee (9.7.2017/ N:2017-09/01). Patients were informed about the study. Informed consent was obtained from all patients. The study was conducted according to WHO Helsinki Declaration rule.

Patients' personal information such as age, gender, smoking status, complaints on admission to the polyclinic were recorded. Patients' body mass indexes (BMI) were calculated and recorded.[3] Patients' arterial blood gases were measured via Radiometer brand ABL 800 model blood gas measuring device. Modified Medical Research Council (MMRC) dyspnea scale was used to determine the severity of the patients (Table 1).[4] According to this;

Stage 0: I experience shortness of breath only while a heavy exercise.

Stage 1: I experience shortness of breath only when I walk fast on a straight road or I walk up a slight hill.

Stage 2: Because of the shortness of breath I have to walk on a straight road slower than my peers or stop and take a rest off-and-on.

Stage 3: After walking on a straight road for 100 meters or for a few minutes, I experience a shortness of breath and stop.

Stage 4: Because of the shortness of breath, I can't go outside or I experience shortness of breath when I change my clothes.

In order to determine the exercise performances of the patients, a six minutes walking test was performed. Pulmonary function test (PFT) was applied to the patients on spirometry mode via CareFusion MasterScreen APS brand V-781261-027 model de-

TABLE 1: Patients' demographic and clinical characteristics.

	Demographic and clinical features	n (%)
Number		55 (100)
Age	<65	28 (50.9)
	≥65	27 (49.1)
Gender	Male	51 (92.7)
	Woman	4 (7.3)
Smoking history	0-10 pack-year	8 (14.5)
	11-20 pack-year	11 (20)
	21-30 pack-year	4 (7.3)
	31-40 pack-year	12 (21.8)
	>40 pack-year	20 (36.4)
Application complaint	Dyspnea	41 (54.5)
	Dyspnea+cough	13 (23.6)
	Dyspnea+cough+hemoptysis	1 (1.8)
BMI	<18.50 kg/m^2 (Weak)	7 (12.7)
	18.50-24.99 kg/m^2 (Normal)	25 (45.5)
	25.00-29.99 kg/m^2 (Overweight)	14 (25.4)
	≥30.00 kg/m^2 (Obese)	9 (16.4)

BMI: Body mass index.

vice. Patients' FEV_1, FVC and FEV_1/FVC values were recorded. Patients' FEV_1 findings were staged per Global Obstructive Lung Disease (GOLD) staging system and GOLD Stage 1-2 patients were categorized as not-severe COPD and GOLD Stage 3-4 patients as severe COPD. Using the same device, both carbon monoxide test on Diffusion SB Realtime mode and helium dilution PFT on FRC Rebreathing mode were performed on patients and the values of the first test, the RV and the TLC values were recorded.

In order to assess the patients' emphysema distribution and prevalence, high resolution computed tomography (HRCT) imageries were obtained from the whole lung through 1 mm section thickness and 10 mm section distance from the apex to basal. HRCT sections were analysed by our university's radiology department and in data collection visual emphysema score was used. In the visual emphysema score, emphysema severity was evaluated for a total of 6 zones, for left and right lungs being top, middle and bottom. It was scored as:

0: No emphysema

1: ≤25% of lung parenchyma

2: 26%-50% of lung parenchyma

3: 50%-75% of lung parenchyma

4: 76%-100% of lung parenchyma, for each zone maximum 4, for the whole lung maximum 24.[5]

Via digital gamma camera system, a quantitative lung perfusion scintigraphy was performed in order to asses the pulmonary perfusion of the patients. Perfusion lung zones and non-perfusion lung zones were assesses qualitatively and quantitatively. Perfusion ratios of the data obtained from the imaging and top, middle and bottom zones of the right and left lungs obtained from anterior and posterior imageries were calculated separately.

STATISTICAL ANALYSIS

The obtained data were uploaded to the SPSS 22.0 program and in data assessment Spearman's rho correlation coefficient was calculated in order to determine the correlations between the variables. When the parametric test hypothesis couldn't be met, to investigate the difference between the score and percent values, Kruskal-Wallis test and Mann-Whitney U test was used and bias level were considered as 0.05.

RESULTS

Total of 55 patients who were followed-up and/or treated in our clinic and agreed to participate, were included in the study. Patients' demographic and clinical characteristics were shown Table 1.

On MMRC dyspnea scale used for assessing patients' dyspnea severity, it was found that 5 patients were on Stage 4, 19 patients on Stage 3, 15 patients on Stage 2, 13 patients on Stage 1 and 3 patients on Stage 0. Table 2 shows the data regarding patients' PFT, ABG, 6 minutes walking test (6MWT) and MMRC.

According to FEV_1 results; 6 patients were on Stage 1, 21 patients on Stage 2, 15 patients on Stage 3 and 13 patients on Stage 4.

Table 3 indicates the emphysema scores and percentages for lungs in HRCT imageries.

On the HRCT, the correlation between right-middle, right-bottom and left-middle zone emphysema score and the BMI was found significant ($p<0.05$). Between the emphysema scores of right-top, middle, bottom and left-top, obtained from HRCT imageries and FVC, FEV_1FEV_1/FVC, DLCO, 6MWT, RV, TLC, partial carbon monoxide tension ($PaCO_2$) and MMRC, a significant relation was found ($p<0.05$) (Table 4).

TABLE 2: The findings regarding patients' pulmonary function test, artery blood gas, 6 minutes walking test and modified medical research council.

Parameters	AO±SD
FVC (Liter)/(%)	68.02±19.92
FEV_1 (Liter)/(%)	48.62±23.17
FEV_1/FVC	53.17±12.23
RV %	153.47±60.62
TLC %	105.75±19.85
DLCO %	56.75±23.93
$PaCO_2$ (mmHg)	40.41±7.23
SO_2 (mmHg)	90.13±7.40
6MWT (meter)	299.55±142.00
MMRC	2.18±1.07

FVC: Forced vital capacity; FEV_1: Forced expiratory volume in one second; RV: Residual volume; TLC: Total lung capacity; DLCO: Carbon monoxide diffusion capacity; $PaCO_2$: Arteril partial pressure of carbon dioxide; SO_2: Arterial oxygen saturation; 6MWT: Six minute walk test; MMRC: Modified Medical Research Council dispne scala; AO±SS: Arithmetic mean±standard deviation.

TABLE 3: Emphysema scores and percentages according to zones.

	HRCT emphysema scores	n	%
Right upper zone emphysema score	1	22	40
	2	12	21.8
	3	15	27.3
	4	6	10.9
Right-middle zone emphysema score	1	28	50.9
	2	11	20.0
	3	15	27.3
	4	1	1.8
Right lower zone emphysema score	1	31	56.4
	2	13	23.6
	3	2	3.6
	4	9	16.4
Left upper zone emphysema score	1	25	45.5
	2	15	27.3
	3	12	21.8
	4	3	5.5
Left middle zone emphysema score	1	32	58.2
	2	10	18.2
	3	12	21.8
	4	1	1.8
Left lower zone emphysema score	1	34	61.8
	2	9	16.4
	3	5	9.1
	4	7	12.7

HRCT: High resolution computed tomography.

It was determined that among all the parameters, the strongest positive correlation were with the RV and DLCO (Figure 1, Figure 2).

The relation between lung zones emphysema scores evaluated with age and HRCT and total emphysema scores was found insignificant ($p>0.05$). Patients' FEV_1 values were found significant to zones emphysema scores measured with HRCT for each zone ($p<0.05$). Comparing the GOLD Stage 1-2 (Not-Severe) and Stage 3-4 (Severe) with the variables, except for the left-bottom zone score, the relation was found significant ($p<0.05$) (Table 5).

According to HRCT right-top zone emphysema scores, comparing the right-top zone perfusion percentage values, the difference was found significant ($p<0.05$) (Table 6).

TABLE 4: Correlation between lung zones emphysema scores and age, smoking history, body mass index data, pulmonary function test, artery blood gas, 6MWT and MMRC parameters.

Parameter		HRCT right upper zone emphysema score	HRCT right midle zone emphysema score	HRCT right lower zone emphysema score	HRCT left upper zone emphysema score	HRCT left midle zone emphysema score	HRCT left lower emphysema score
Age	r value	0.60	0.179	0.161	0.075	0.150	0.091
	p value	0.662	0.191	0.234	0.585	0.274	0.509
Smoking history	r value	0.088	0.005	-0.056	0.080	-0.060	-0.103
	p value	0.525	0.971	0.686	0.560	0.663	0.456
BMI	r value	-0.253	**-0.326(*)**	**-0.292(*)**	**-0.298(*)**	**-0.379(**)**	-0.257
	p value	0.063	0.015	0.030	0.027	0.004	0.058
FVC	r value	**-0.312(*)**	**-0.300(*)**	**-0.360(**)**	**-0.338(*)**	**-0.375(**)**	**-0.335(*)**
	p value	0.020	0.026	0.007	0.012	0.005	0.012
FEV_1	r value	**-0.509(**)**	**-0.505(**)**	**-0.584(**)**	**-0.530(**)**	**-0.556(**)**	**-0.506(**)**
	p value	0.001	0.001	0.001	0.001	0.001	0.001
FEV_1/FVC	r value	**-0.593(**)**	**-0.601(**)**	**-0.682(**)**	**-0.629(**)**	**-0.630(**)**	**-0.562(**)**
	p value	0.001	0.001	0.001	0.001	0.001	0.001
RV	r value	**0.845(**)**	**0.885(**)**	**0.872(**)**	**0.856(**)**	**0.866(**)**	**0.789(**)**
	p value	0.001	0.001	0.001	0.001	0.001	0.001
TLC	r value	**0.839(**)**	**0.872(**)**	**0.853(**)**	**0.854(**)**	**0.855(**)**	**0.777(**)**
	p value	0.001	0.001	0.001	0.001	0.001	0.001
DLCO	r value	**-0.695(**)**	**-0.738(**)**	**-0.723(**)**	**-0.709(**)**	**-0.765(**)**	**-0.690(**)**
	p value	0.001	0.001	0.001	0.001	0.001	0.001
$PaCO_2$	r value	**0.355(**)**	**0.328(*)**	**0.360(**)**	**0.397(**)**	**0.372(**)**	**0.356(**)**
	p value	0.008	0.015	0.007	0.003	0.005	0.008
SO_2	r value	**-0.531(**)**	**-0.355(**)**	**-0.280(*)**	**-0.463(**)**	**-0.299(*)**	**-0.115**
	p value	0.001	0.008	0.038	0.001	0.026	0.405
6MWT	r value	**-0.768(**)**	**-0.757(**)**	**-0.770(**)**	**-0.798(**)**	**-0.789(**)**	**-0.729(**)**
	p value	0.001	0.001	0.001	0.001	0.001	0.001
MMRC	r value	**0.501(**)**	**0.551(**)**	**0.561(**)**	**0.515(**)**	**0.589(**)**	**0.447(**)**
	p value	0.001	0.001	0.001	0.001	0.001	0.001

HRCT: High resolution computed tomography; BMI: Body mass index; r: HRCT: High resolution computed tomography; BMI: Body mass index; FVC: Forced vital capacity; FEV_1: Forced expiratory volume in one second; RV: Residual volume; TLC: Total lung capacity; DLCO: Carbon monoxide diffusion capacity; $PaCO_2$: Arteril partial pressure of carbon dioxide; SO_2: Arterial oxygen saturation; 6MWT: Six minute walk test; MMRC: Modified medical research council; r: regression coefficient, *p<0,05: Significant.

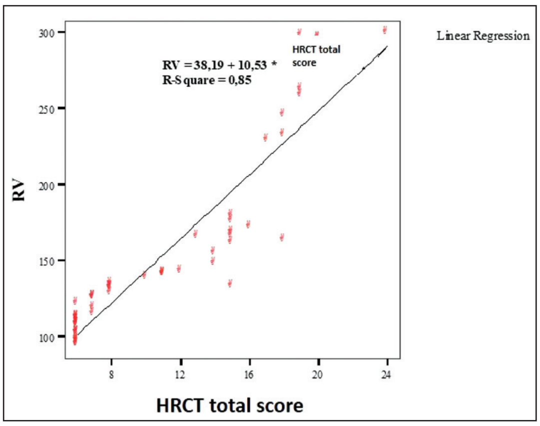

FIGURE 1: Total lung emphysema scores and percentages.
HRCT: High resolution computed tomography;
RV: Residual volume.

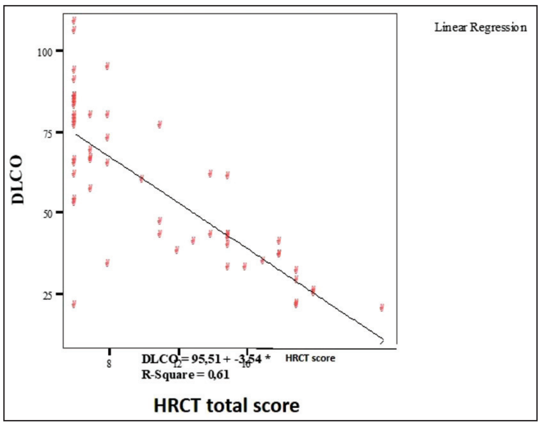

FIGURE 2: Total lung emphysema scores and diffusing capacity of the lung for carbon monoxide correlation diagram.
HRCT: High resolution computed tomography; DLCO: Diffusing capacity of the lung for carbon monoxide.

TABLE 5: The relation between the emphysema scores according to zones and the global obstructive lung disease stage parameter.

HRCT emphysema score		**GOLD stage 1**		**GOLD stage 2**		**GOLD stage 3**		**GOLD stage 4**			**GOLD stage 1-2 (Non severe)**		**GOLD stage 3-4 (Severe)**		
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**		**n**	**%**	**n**	**%**	
HRCT right upper zone emphysema score	1	6	100	11	52.4	3	20.0	2	15.4	x^2:20.40	12	70.6	3	18.8	x^2:13.38
	2	0	0	5	23.8	5	33.3	2	15.4	**p=0.016***	5	29.4	5	31.3	**p=0.004***
	3	0	0	3	14.3	6	40.0	6	46.2		0	0	5	31.3	
	4	0	0	2	9.5	1	6.7	3	23.1		0	0	3	18.8	
HRCT right midle zone emphysema score	1	6	100	14	66.7	5	33.3	3	23.1	x^2:16.98	15	88.2	7	43.8	x^2:8.55
	2	0	0	3	14.3	5	33.3	3	23.1	**p=0.048***	2	11.8	4	25.0	**p=0.036***
	3	0	0	4	19.0	5	33.3	6	46.2		0	0	4	25.0	
	4	0	0	0	0	0	0	1	7.7		0	0	1	6.1	
HRCT right lower zone emphysema score	1	6	100	16	76.2	6	40.0	3	23.1	x^2:19.93	16	94.1	8	50.0	x^2:9.64
	2	0	0	4	19.0	5	33.3	4	30.8	**p=0.018***	0	0	3	18.8	**p=0.022***
	3	0	0	1	4.8	0	0	1	7.7		1	5.9	1	6.3	
	4	0	0	0	0	4	26.7	5	38.5		0	0	4	25.0	
HRCT lef upper zone emphysema score	1	6	100	12	57.1	5	33.3	2	15.4	x^2:20.22	13	76.5	5	31.3	x^2:9.62
	2	0	0	6	28.6	6	40.0	3	23.1	**p=0.017***	4	23.5	5	31.3	**p=0.023***
	3	0	0	2	9.5	4	26.7	6	46.2		0	0	4	25.0	
	4	0	0	1	4.8	0	0	2	15.4		0	0	2	12.5	
HRCT left midle zone emphysema score	1	6	100	15	71.4	8	53.3	3	23.1	x^2:20.40	16	94.1	9	56.3	x^2:7.93
	2	0	0	5	23.8	3	20.0	2	15.4	**p=0.016***	1	5.9	1	6.3	**p=0.047***
	3	0	0	1	4.8	4	26.7	7	53.8		0	0	5	31.3	
	4	0	0	0	0	0	0	1	7.7		0	0	1	6.3	
HRCT left lower zone emphysema score	1	6	100	15	71.4	10	66.7	3	23.1	x^2:19.60	15	88.2	10	62.5	x^2:4.97
	2	0	0	4	19.0	1	6.7	4	30.8	**p=0.021***	1	5.9	1	6.3	**p=0.174**
	3	0	0	2	9.5	2	13.3	1	7.7		1	5.9	1	6.3	
	4	0	0	0	0	2	13.3	5	38.5		0	0	4	25.0	

HRCT: High resolution computed tomography; GOLD: Global obstruktif lung disease; *p<0.05: Significant.

TABLE 6: Comparison of the emphysema scores according to zone and the perfusion percentages of the zones.

	HRCT amphysema score	n	Mean (minimum-maximum)	
Percentage of right upper zone perfusion	right upper zone			
	1	22	13.27 (9-17)	kw:8.58
	2	12	12.33 (6-21)	**p=0.035***
	3	15	12.93 (5-25)	
	4	6	8.00 (4-12)	
Percentage of right midle zone perfusion	right midle zone			
	1	28	24.54 (11-33)	kw:3.69
	2	11	24.82 (19-34)	p=0.296
	3	15	23.20 (16-39)	
	4	1	20.00 (20-20)	
Percentage of right lower zone perfusion	right lower zone			
	1	31	15.16 (7-23)	kw:3.55
	2	13	16.69 (11-29)	p=0.313
	3	2	11.50 (8-15)	
	4	9	12.33 (3-22)	
Percentage of left upper zone perfusion	left upper zone			
	1	25	12.92 (9-25)	kw:2.80
	2	15	11.67 (5-18)	p=0.414
	3	12	12.92 (4-24)	
	4	3	8.67 (4-13)	
Percentage of left midle zone perfusion	left midle zone			
	1	32	23.06 (14-33)	kw:4.28
	2	10	23.80 (15-31)	p=0.232
	3	12	21.25 (15-31)	
	4	3	17.00 (17-17)	
Percentage of left lower zone perfusion	left lower zone			
	1	34	14.06 (7-21)	kw:6.59
	2	9	13.78 (7-24)	p=0.086
	3	5	10.00 (6-18)	
	4	7	11.00 (7-21)	

HRCT: High resolution computed tomography; kw: Kruskal-Wallis. *p<0.05: Significant.

DISCUSSION

Major physiological defect in emphysema is the loss in the elastic spring back and this loss causes such changes as decrease in the maximum expiratory air flow, excessive ventilation and air trapping.[1] Due to ventilation and gas change disturbances, in the later period, patients' exercise tolerance and effort capacities decrease gradually, and their vital activities get restricted and their quality of life deteriorates.[2] Kauczor et al. carried out a study on patients with lung disease suspicion and found no relation between the prevalence, scope and the severity of air trapping and age values.[6] Similarly, we found no correlation between the visual emphysema score and age values.

In many studies, it is stated that stimulation of the risk factors, particularly smoking, causes the destruction of the balance between protease-antiprotease, oxidant-antioxidant, which play an important role in emphysema pathogenesis, and especially in smoking individuals alveolar destruction occur due to the activities of metalloproteinase such as elastase and collagenase, which are released from inflammatory cells. In their study, Hoessein et al. detected that as the consumed cigarette packet/year value increases, measured emphysema prevalence also increases.[7] Similarly, in their study, Zach et al. found out that as the amount of the consumed cigarette increases, low density area intensity, which is considered a sign of emphysema in computed tomography, also increases.[8] In our study, smoking history was present in all the patients in variable ratios. Of the patients 65.5% showed a 20 packets/year smoking history. We found no significant relation between the HRCT visual emphysema scores and smoking history. The reason might be the fact that all of the patients in our study were heavy smokers.

Being the most easily applicable and non-invasive method in detecting emphysema, PFT can be insufficient in the early stages of the emphysema, in which especially the functional loss is mild. In this case, the most effective method is determining the air trapping by lung tissue density via HRCT.[9] Contrary to spirometry, radiology allows the localised assessment of several parts such as air tracts, parenchyma and vascular system. HRCT is the most sensitive (96%) method in detecting especially early stage emphysema diagnosis and its prevalence. With HRCT, small emphysematous areas up to 0.5 cm can be detected.[10] In emphysema assessment via HRCT, there are several qualitative and quantitative methods and scoring systems. It was found in the study that since the radiologic scoring in HRCT presents the functional and anatomical features of emphysema ideally, it is sensitive in diagnosing. There are publications stating that the evaluation of the HRCT scanning with HRCT score can be used as a non-invasive method to asses the prevalence and the distribution of emphysema. There are also several studies comparing the HRCT findings and PFT.[11,12] In their study, Sakai et al. used an observation method based on the prevalence and the severity of emphysema and obtained a strong correlation between visual scoring values and PFT. FEV_1 and FEV_1/FVC percentage was determined as the strongest relation.[11] Pescarolo et al. found a negative correlation between the emphysema level and FEV_1 and FEV_1/FVC. Comparing the emphysema level and the PFT, they found that the strongest correlation was with FEV_1/FVC.[12] Similarly, Sandek et al. detected a significant inverse correlation between emphysema and FEV_1, FVC and FEV_1/FVC.[13] In our study, we found a negative significant correlation between emphysema scores and FEV_1, FVC and FEV_1/FVC.

Gelb and colleagues performed a PFT before the thoracotomy in patients scheduled for lobectomy or pneumonectomy, then between the pathological samples and air tract obstruction a correlation was investigated and it was found that while all of the 7 cases, in which emphysema was detected, showed a DLCO level of <70%, FEV_1/FVC value was on normal limits and also in 5 of these cases FEV_1 value was determined as normal.[14] This study states that emphysematous parts were detected in lungs without any decrease in FEV_1/FVC and FEV_1 values and thus it is thought that in emphysema diagnosis HRCT preceded the PFT, yet in the assessment of emphysema patients DLCO can be superior. In a study by Tylen et al., HRCT findings and PFT values were compared and it was found out that while only 15 of the cases showed functional finding regarding emphysema, of the 19 cases DLCO values were low and in 33 cases emphysema score was higher than 0.[15] HRCT method showed the best correlation in DLCO measure. In the study by Cerveri and colleagues, similarly, a negative relation was found between emphysema score and DLCO.[16] Gurney et al. draw attention that while the emphysema scores of the cases increase, DLCO values decrease.[17] Baldi et al. stated that the decrease in DLCO was strongly correlated with quantitatively assessed emphysema size and there was a weak relation between FEV_1 and emphysema size.[18] Bayramoğlu et al. found out that the strongest correlation was between emphysema score and DLCO and a strong negative correlation between emphysema score and FEV_1 and FEV_1/FVC.[19] We found a negative correlation between emphysema scores and DLCO also in our study. The correlation between emphysema score and DLCO was detected to be stronger than FVC, FEV_1, FEV_1/FVC.

Fotheringham et al. stated that decreased attenuation, as one of the most important findings in HRCT, showed a significant correlation with RV.[20] In their study Petty et al. calculated and compared the TLC and FEV_1 values of the case group consisting of 21 small air tract disease cases, which were known to be mild emphysema, and a control group of 18 cases. In the mild emphysema group, TLC showed a significant increase and there was no difference between the control group in terms of FEV_1 values.[21] In our study, we found out a significant positive correlation between total lung emphysema scores and TCL and RV values. The correlation with TCL and RV was found to be stronger compared to FEV_1. Comparing the emphysema scores and all the PFT, we found out in our study that the strongest correlation was with the RV values. In our study the lung was divided into 6 zones and each zone was compared with the PFT parameters separately, and the results were also similar with the results from the total lung score comparison. Pescarolo et al. detected a positive correlation between emphysema level and COPD stage.[12] In our study, similarly, comparing both the zones emphysema scores separately and total lung scores with GOLD staging system with the data obtained, the relation was found to be significantly positive. The relation between the severe and not-severe group in terms of HRCT, total emphysema score was found to be associatively significant.

Small air tract obstruction, which distributes on the lung zones non-homogenously, and emphysema causes difference in ventilation/perfusion ratio and this causes hypoxemia. Decrease in the lung flexibility tension and increase in the gas volume in thorax, occurring as a result of obstruction, cause a change in the normal position of the diagram and, in time, cause diaphragm and other ventilatory muscles to tire. In this period, in which alveolar ventilation extremely deteriorates, hypoxemia increases and hypercapnia occurs.[22] In the study by Sarıaydın et al., a negative correlation was found between visual emphysema score and oxygen saturation percentage (SO_2) and a positive correlation was found between $PaCO_2$ *(Sarıaydın M. KOAH Hastalarında Solunum Fonksiyonları, Bilgisayarlı Tomografi ve Yaşam Kalitesi Anketi Arasındaki Korelasyon. Tıpta Uzmanlık Tezi, 2010, 51)*

In our study, similarly with the literature we detected a negative correlation between visual em-physema score and SO_2 and a positive correlation between $PaCO_2$. At the same time lung zones were separately analysed and compared with SO_2 values and a stronger correlation was detected between lung top zones than middle and bottom zones. This situation can be linked to prevalence of the emphysema in the lung top zones. It can cause this situation that perfusion was lower in the normal lung apex. It is thought that in studies carried out with more patients can present more significant results.

COPD is a multi-component disease, which has systemic impacts, and weight loss, myolysis and muscle dysfunction are the systemic symptoms of the disease.[23] Renvall et al. detected a negative correlation between BMI and emphysema scores.[3] O'Donnel et al. showed that dynamic hyperinflation resulting from ex-ercise and the energy needed for the ventilation were higher in the emphysema cases than healthy adults.[24] Similarly with the literature, we also found in our study that there was a negative significant correlation be-tween HRCT emphysema scores and BMI values.

While in HRCT the prevalence of emphysema increases, air tract obstruction increases, diffusion capacity decreases, and hyperinflation occurs. Being a progressive disease, COPD causes increase in the symptoms, especially of dyspnea, and decrease in the exercise capacity in patients in the later periods. In the study by Scnchez et al., 6MWT distances of the severe COPD patients were significantly lower than that of mild COPD patients and their MMRC dyspnea levels were found to be higher.[25] In several studies in the literature, similarly, it was shown that as the COPD level and emphysema severity increase, MMRC dyspnea score also increases.[4,26] This may be due to the increase in the severity of symptoms in severe COPD and an increase in the intensity of dyspnea due to the need for more energy and oxygen in the muscles. Similarly with the literature, we also found in our study that there was a positive significant correlation between emphysema score and MMRC dyspnea score.

In patients with severe air tract obstruction, exercise capacity largely decreased.[27] It is known that as the severity of COPD and the prevalence of emphysema increase, walking distance decreases. İnal İnce et al. carried out a study on 35 COPD patients with moderate and severe obstructions, the 6MWT distance was significantly shorter in the cases with severe obstruction than that of the cases with moderate obstruction.[5] This result supports the lack of distance in patients with severe airway obstruction and frequent exacerbation in studies evaluating the 106MWT distance of COPD patients with different GOLD levels in the literature.[28,29] In our study, it was found that as the emphysema scores of the patients increased, 6MWT distance decreased.

Lung perfusion scintigraphy isn't a standard diagnosing method in emphysema, however it can be considered in patient selection for bronchoscopy volume decreasing spiral treatment, which is a new method in emphysema treatment. In the success in the bronchoscopy volume decreasing spiral treatment, patient's anatomical and physiological features and careful patient selection play a critical role. As in the surgical volume decreasing treatment, in the bronchoscopy volume decreasing spiral treatment also, it can be helpful to perform a quantitative perfusion scintigraphy in order to obtain an additional information regarding the heterogeneity of the functional damage caused by emphysema in addition to HRCT and the distribution.[30] Yıldız et al. carried out a study to determine the importance of quantitative perfusion scintigraphy in detection of the target lobe of the patients who were going to receive bronchoscopy volume decreasing spiral treatment, and found that as the emphysema score increased, perfusion decreased, yet the relation was not significant.[31] Cleverly et al. showed a good correlation between emphysema prevalence evaluated with HRCT and perfusion prevalence evaluated with scintigraphy.[32] In our study, lung zone emphysema scores measured with HRCT and the perfusion percentages obtained from quantitative perfusion scintigraphy were compared and found not significant. Although it was found not significant, it was seen that as the emphysema scores increased, perfusion percentages decreased. We think that with studies carried out on more patients more significant results can be found between emphysema scores and perfusion percentages.

CONCLUSION

Finally, a negative significant correlation was found between the emphysema scores obtained with HRCT and semi-quantitative visual emphysema scoring and FEV_1, FEV_1/FVC, DLCO PFT and a positive significant correlation found with the RV and TLC. A positive correlation was found with $PaCO_2$ and a negative correlation was found with SO_2. With MMRC, patients' quality of life and exercise performance scale, a positive, and with 6MWT negative correlation was detected. The strongest correlation among all the parameters was found between emphysema score and RV. Therefore, it can be considered that RV parameter can be used in the follow-ups of the emphysema patients.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Sulhattin Arslan, Kübra Güldemir; **Design:** Sulhattin Arslan; **Control/Supervision:** Kübra Güldemir, Sulhattin Arslan; **Data Collection and/or Processing:** Kübra Güldemir, Zekiye Hasbek, Büşra Soylu, Cesur Gümüş; **Analysis and/or Interpretation:** Sulhattin Arslan, Kübra Güldemir; **Literature Review:** Kübra Güldemir; **Writing the Article:** Kübra Güldemir; **Critical Review:** Sulhattin Arslan; **References and Fundings:** Kübra Güldemir; **Materials:** Kübra Güldemir.*

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