Screening of Right Descending Pulmonary Artery in Chronic Obstructive Pulmonary Disease by Discriminant Functions

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SUMMARY
The presence of pulmonary arterial hypertension (PH) in patients with COPD has been shown to relate to the width of right descending pulmonary artery (rDPA). rDPA > 16 mm is the best discriminant between those patients with and without PH. The aim of this retrospective study was to investigate the enlargement of rDPA and the factors which affected this parameter in 118 patients with stable COPD. Patients were divided into two groups according to width of rDPA (Group 1: rDPA< 16 mm, Group 2: rDPA≥ 16 mm). Stepwise discriminant analysis was performed to evaluate the most important factors related with diameter of rDPA.

PaO2 and hematocrit (Hct) were the most relevant factors for the discrimination of the two groups. There was statistically significant positive correlation between rDPA and smoking (pack-yr) (p< 0.05), RBC (p< 0.05), Hct (p< 0.01), PaCO2 (p< 0.05). Also negative correlation was found between rDPA and PaO2 (p< 0.001), %SaO2 (p< 0.01).

In conclusion, hypoxemia and polycytemia were the most significant factors related with enlargement of rDPA in patients with COPD.

KEY WORDS: COPD, rDPA, discriminant analysis

ÖZET
KRONİK OBSTRÜKTİF AKCIĞER HASTALIKLARINDA SAĞ İNEN PULMONER ARTERİN DİSKRİMİNANT ANALİZİ
KOAH'lı hastalarda pulmoner arteriyl hipertansiyon (PH) varlığı, sağ inen pulmoner arterin genişliği (rDPA) ile ilişkilidir. rDPA’nın 16 mm’den büyük olması PH’lu ve PH’suz hastalanı ayrırdedici en iyi faktördür. Bu retrospektif çalışmadaki amaçımız, 118 stabil KOAH’lı olguda rDPA’daki genișlemeyi ve bu parametreyi etkileyen faktörleri tespit etmekti. rDPA’nın genişliğine göre 2 gruba ayrıldılar (Grup 1: rDPA< 16 mm, Grup 2: rDPA≥ 16 mm ). rDPA çapını belirleyen en önemli faktörleri belirlemek için diskriminant analiz kullanıldık.

PaO2 ve hematokrit (Hct) 2 grup ayrırmında en önemli faktörlerdi. rDPA ve sigara (p< 0.05), eritrosit (p< 0.05), Hct (p< 0.01), PaCO2 (p< 0.05) arasında istatistiksel olarak önemli pozitif koreelasyon vardır. rDPA ve PaO2 (p< 0.001), SaO2 (p< 0.01) arasında negatif koreelasyon bulundu.

Sonuç olarak, hipoksemi ve polisitemi KOAH’lı hastalarda rDPA genişlemesini gösteren en önemli faktörlerdir.

ANAHTAR KELİMELER: KOAH, rDPA, diskriminant analiz

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INTRODUCTION

The development of pulmonary arterial hypertension (PH) in patients with chronic obstructive pulmonary disease (COPD) is related with poor prognosis (1,2). Therefore it is desirable to detect PH early. The right heart catheterisation is the most precise method for the diagnosis of PH. But this invasive and costly method is not applied in most chest clinics. Therefore noninvasive methods (chest X-ray, spirometry, arterial blood gases, Doppler echocardiography) are used in COPD (3-7). These methods' variables do not permit precise prediction of PH. Better results are obtained by a combination of several simple tests.

Previous studies showed that X-ray was a part of the routine examination in COPD. Especially the width of the right descending pulmonary artery (rDPA) was important in the diagnosis of the early pulmonary hypertension (3-5,8-10).

The aim of this retrospective study was to develop a screening for the enlargement of rDPA which applies discriminant function with four variables (demographic features, hemogram “blood viscosity”, arterial blood gases, spirometry) was used for correct identification in patients with COPD.

MATERIALS and METHODS

One hundred and eighteen patients with COPD admitted to Pulmonary Diseases Dept. University of Ankara were included in this retrospective investigation. Patients were diagnosed according to the ATS (11). The patients, aged 42-80 years, were in a clinically stable condition and showed moderate and severe airways obstruction (FEV1/FVC< 60%) (12).

The patients with the following conditions were excluded: Typical bronchial asthma, recurrent lung embolism, bronchiectasis, cystic fibrosis, state after major thoracic surgery, systemic hypertension (under resting conditions: > 155 mmHg systolic, > 95 mmHg diastolic), congenital or acquired heart defect, chronic ischaemic heart disease, hepatic or renal failure, anemia (hemoglobin< 7gr/dL).

Fifty-two patients had chronic bronchitis, 12 patients had emphysema and 54 patients had chronic bronchitis and emphysema. Smoking status was also noted.

Standard chest X-ray was performed on all patients. The diameter of the right descending branch of the pulmonary artery was measured on standard X-ray of the thorax with a focus-film distance of 1.5 m according to the method Teichmann et al, at the proximal part of the truncus intermedius about 1 cm below the level of the right upper lobe bronchus (4).

Our patients were divided into two groups according to the width of right descending pulmonary artery (rDPA). Group 1: 67 patients with rDPA< 16 mm, group 2: 51 patients with rDPA 16 mm (10,13,14).

Pulmonary function tests (PFT) (FVC, FEV1, FEV1/FVC, FEF 25-75) were performed by system 2400 pulmonary function laboratory (Sensor Medics). Ventilatory tests were applied in sitting position, according to ATS criteria (15). The best of the minimum 3 acceptable tests, was selected. Kory-Polgar nomogram was used for prediction (16).

Arterial blood gases (ABG) analysis were performed while the patients were sitting and breathing room air. Arterial blood gases were evaluated by ABL 330 (Radiometer, Copenhagen). pH, PaO2, %SaO2 and PaCO2 levels were reported.

Statistical evaluation: SPSS for windows package program was used for statistical analysis. Stepwise discriminant analyses was performed for the determination of predictors of the enlargement rDPA. Linear correlation was used for the evaluation of the relationship between rDPA s and other parameters.

RESULTS

All patients were male with the mean age 63.02 ± 8.65 years, ranging between 42-80 years. The demographic features and hemogram are shown in Table 1. Smoke was 1/2-3 packets of cigarettes per day. Smoking status is shown in Table 2.

Most of them had respiratory symptoms such as cough, sputum production and dyspnea. The rDPA was measured on the X-ray films of all the COPD patients. The mean rDPA was 10.3 ± 13.03 mm in group 1 whereas in group 2 the mean rDPA was 18.82 ± 1.99 mm (p< 0.001). In the second group, the rDPA was enlarged.
The results of the PFT, arterial blood gases are summarized in Table 3. ABG analysis showed moderate hypoxemia and hypercapnia in Group 2.

We applied the discriminant function (DA) by the method of Ahrens and Lauter (17). We had calculated this function in 118 COPD. The discriminant function is:

\[ y = -0.095 \text{Hct} + 0.052 \text{PaO}_2 + 1.554 \]

If \( y \) becomes upper than -0.08849, the patient is considered as Group 2. The sensitivity for the enlargement of r DPA was 63.3%, specificity was 75.8%.

PaO\(_2\) and Hct were the most relevant factors for the discrimination of two groups (Table 4).

The PFTs indicated severe airways obstruction in group 2. There was statistically significant positive

<table>
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<tr>
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<th>Group 1 (n: 67)</th>
<th>Group 2 (n: 51)</th>
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<tr>
<td></td>
<td>Mean ± SD</td>
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<tr>
<td>Age (yrs)</td>
<td>62.63 ± 9.73</td>
<td>63.51 ± 8.78</td>
<td>NS</td>
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<tr>
<td>Dur. disease (yrs)</td>
<td>11.94 ± 8.22</td>
<td>14.48 ± 10.62</td>
<td>&lt; 0.05</td>
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<tr>
<td>Smoking (pack-yr)</td>
<td>20.76 ± 25.22</td>
<td>35.23 ± 31.15</td>
<td>&lt; 0.01</td>
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<tr>
<td>RBC (/mm(^3))</td>
<td>4.95 ± 0.76</td>
<td>5.45 ± 0.77</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>43.22 ± 6.31</td>
<td>47.52 ± 6.21</td>
<td>&lt; 0.001</td>
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<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
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<tr>
<td>PaO(_2) (mmHg)</td>
<td>58.78 ± 14.38</td>
<td>47.09 ± 12.11</td>
<td>&lt; 0.001</td>
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<td>SaO(_2) (%)</td>
<td>84.21 ± 14.61</td>
<td>77.03 ± 13.11</td>
<td>&lt; 0.01</td>
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<tr>
<td>PaCO(_2) (mmHg)</td>
<td>46.01 ± 10.65</td>
<td>52.54 ± 9.43</td>
<td>&lt; 0.01</td>
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<td>FVC (L)</td>
<td>1.82 ± 0.90</td>
<td>1.57 ± 0.63</td>
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<tr>
<td>FVC (%pred)</td>
<td>54.17 ± 20.89</td>
<td>41.65 ± 14.87</td>
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<td>FEV(_1) (L)</td>
<td>1.17 ± 0.62</td>
<td>0.83 ± 0.40</td>
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<td>FEV(_1) (%pred)</td>
<td>43.60 ± 22.16</td>
<td>30.22 ± 12.83</td>
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<td>FEV(_1)/FVC (%)</td>
<td>60.49 ± 15.75</td>
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<td>FEF(_25\text{-75}) (L/sec)</td>
<td>0.80 ± 0.60</td>
<td>0.47 ± 0.19</td>
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<td>FEF(_25\text{-75}) (%pred)</td>
<td>24.54 ± 19.21</td>
<td>14.39 ± 39.19</td>
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correlation between the mean rDPA and smoking history (yrs) (r: 0.19, p < 0.05), RBC (r: 0.23, p < 0.05), Hct (r: 0.27, p < 0.01), PaCO2 (r: 0.24, p < 0.05) (Figure 1, Table 5). At the same time, statistically significant negative correlation was found between the rDPA and PaO2 (r: -0.36, p < 0.001) and %SaO2 (r: -0.25, p < 0.01) (Fig. 3; Table 5).

**DISCUSSION**

COPD is frequently complicated by the development of PH. It is important to identify those patients with PH because it is the principal cause of right ventricular enlargement and failure in patients with COPD. Also PH is a sign of poor prognosis in COPD, therefore the development of PH is important in the course and treatment of COPD (1,2,5,13,18).

Severe airway narrowing, insufficient ventilation and ventilation/perfusion (VA/Q) imbalance were the main mechanisms leading to arterial hypoxemia in our COPD patents. Also, high Hct levels inc-

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Table 4. Mean ± SD and stepwise discrimination between group 1 and 2.

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<tr>
<td>Smoking (pack-yr)</td>
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<td>35.23 ± 31.15</td>
<td>5.76</td>
</tr>
<tr>
<td>RBC (/mm³)</td>
<td>4.95 ± 0.76</td>
<td>5.45 ± 0.77</td>
<td>10.91</td>
</tr>
<tr>
<td>Hct (%)</td>
<td>43.22 ± 6.31</td>
<td>47.52 ± 6.21</td>
<td>13.59</td>
</tr>
<tr>
<td>PaO2 (mmHg)</td>
<td>58.78 ± 14.38</td>
<td>47.09 ± 12.11</td>
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<tr>
<td>SaO2 (%)</td>
<td>84.21 ± 14.61</td>
<td>77.03 ± 13.11</td>
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<tr>
<td>PaCO2 (mmHg)</td>
<td>46.01 ± 10.65</td>
<td>52.54 ± 9.43</td>
<td>11.31</td>
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Step no | Variable | F value to enter | Wilks’ lambda |
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<tr>
<td>1</td>
<td>PaO2</td>
<td>17.69</td>
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</tr>
<tr>
<td>2</td>
<td>Hct</td>
<td>13.59</td>
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**Figure 1.** The correlation between the mean rDPA and smoking history (yrs) (r: 0.19, p < 0.05)
reased preload, which caused an increase on the work of right ventricle. These mechanisms cause PH (4, 13, 18).

At the present time the precise diagnosis of PH in COPD requires the insertion of a pulmonary arterial catheter. While this technique is widely available, it is expensive and has associated limit its routine use. This reality has stimulated research to detect and quantitate the severity of PH using less invasive techniques (13, 18).

The use of the chest X-ray, spirometry, arterial blood gases in identifying patients with COPD who have PH is more significant. In previous studies, Chetty and et al, Teichmann and et al, Keller and et al showed significant the correlation between the mean pulmonary artery pressure (PAP) and

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**Figure 2.** The correlation between the mean rDPA and HCT (r: 0.27 p < 0.01)

**Figure 3.** The correlation between the mean rDPA and PaO₂ (r: -0.36, p < 0.001)
rDPA (4,5,13). In our previous investigation, we saw positive correlation between the mean PAP and rDPA as in the literature. If 16 mm was accepted as the threshold for rDPA, sensitivity was 97% and specificity was 71% (9).

In this study, we investigated the determinants of the enlargement of rDPA, especially the parameters assessed by noninvasive methods. We used the discriminant function to calculate various parameters. We observed two relevant factors for the enlargement of rDPA: high Hct and low PaO2. If 16 mm threshold for rDPA, the sensitivity was 63.3% and specificity was 75.8%. If y becomes greater than -0.08849, the patient is considered as having the enlargement of rDPA.

Evers and et al showed that the diameter of the rDPA, FEV1, PaO2 at rest and age turned out to be relevant for discrimination of groups with and without manifest PH in male with COPD. In their study, discriminant functions in male patients are better than female patients (19). Oswald-Mammosser and et al were performed the discriminant analysis in 52 patients with COPD. They showed that Doppler echocardiography and ECG findings and FEV1 could predict the absence or presence of PH correctly (3). In our study, we investigated only the width of rDPA and other noninvasive methods (demographic features, spirometry, arterial blood gases). By discriminant analysis, we showed that hypoxemia and polycytemia were the most relevant factors for the discrimination of groups (patients with the enlargement of rDPA and without the enlargement of rDPA).

The most significant correlation were between rDPA and smoking, Hct, PaO2, %SaO2, PaCO2 as in the literature. Keller and et al, indicated that measurement of the diameter of rDPA, PaCO2, PaO2 contributed to the prediction of mean pulmonary arterial pressure (13). Chetty and et al demonstrated that there were significant correlation between pulmonary arterial pressure and FEV1, PaO2 and radiologic findings (5). Teichmann showed high percentage of agreement between radiological signs and haemodynamics data in patients with chronic bronchitis and lung emphysema only in patients in whom the measurement of the rDPA was feasible (4). In these studies, it was demonstrated that PH was usually present when rDPA was...
enlarged (4,5,9,10,13). In our study, we investigated the correlation between rDPA and other factors. We found significant correlation between rDPA and PaO2, SaO2, PaCO2, Hct, RBC levels.

In conclusion we found high Hct levels and low PaO2 as the predictor parameters of the width of the right descending pulmonary artery. We think that, in our small COPD group, the discriminant analysis is very important to evaluate the enlargement of rDPA and PH. Further investigations are needed in this field.

REFERENCES

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