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Original scientific paper

Shunt in the Diagnosis of Initial Lung Lesion in Smokers

Irena Perić[1], Ivančica Pavličević[2], Nebojša Zagorac[3], Ratko Katić[3], Žarko Šantić[4], Neven Pavlov[5], Marija Stipić[5] and Jadranka Tocilj[3]

[1] University of Split, School of Medicine, Split, Croatia
[2] University of Split, Department of Family Medicine, School of Medicine
[3] University of Split, Faculty of Kinesiology, Split, Croatia
[4] University of Mostar, School of Medicine, Mostar, Bosnia and Herzegovina
[5] University of Split, Split University Hospital Center, Split, Croatia

A B S T R A C T

Cigarette smoking is an important risk factor for all respiratory tract diseases. Unfortunately, the symptoms develop slowly, thus patients feel the consequences of the slowly developing inflammation too late. The inflammation first develops in the area of respiratory bronchioles. In this stage, the disease is asymptomatic. The study included a sample of 31 smokers, mean age 36.38 years, with normal spirometry indices, acid-base status and arterial blood gases. The mean smoking index was 11.28 smoking/years. All subjects were healthy, without any subjective health problems or disease indicators. The aim was to define dead lung area (V/Q) as an early indicator of changes in smokers. Study results demonstrated the mean shunt value in smokers of 8.25%, which showed positive correlation with smoking. The shunt size yielded negative correlation with the forced expiratory volume in one second and midexpiratory flow in smokers. In conclusion, determination of lung shunt is a simple method that is sensitive enough in the diagnosis of initial lung lesion due to cigarette smoking.

Key words: *shunt, cigarette smoking*

Introduction

Vein shunt is part of the high-impact volume that passes from the right part of the heart through the lung circulation and then moves into the arterial circulation unoxygenated. In a healthy person, the physiological part of the blood from bronchial veins and thebesian veins and the usual virtual shunt with mild deviation in the ventilation-perfusion ratio refers to physiological shunt. Physiological shunt accounts for less than 7% of the heart's high-impact volume. The shunt is much greater in the presence of some heart diseases such as right-left shunt in inborn heart anomalies such as interatrial or interventricular septal defects or in case of imbalance of the ventilation-perfusion relations. While it is relatively easy to prove the existence of shunt in heart diseases, the size of shunt can only be demonstrated indirectly in case of ventilation-perfusion impairment. The size of shunt can be determined by mathematical calculation based on the shunt formula, taking into consideration air humidity and oxygen solubility in the blood. First, pure oxygen is inhaled for 30 minutes to wash off nitrogen from the alveolus and to equalize the partial oxygen pressure in the alveolus (PaO2) to partial oxygen pressure (pO2) in the inhaled air. The partial oxygen pressure in peripheral blood (PaO2) is measured. The alveolus-arterial shunt is calculated using the Chanog monogram, based on the parameters recorded[1].

Smoking is one of the main risk factors causing poor health condition and consequently death from diseases of the cardiorespiratory tract[2]. The smokers' quality of life is greatly reduced as compared with nonsmokers, even in the young age group free from other comorbidities[3,4]. Smoking is one of the main risk factors in the development of malignant diseases[5]. In addition, smoking is directly related to the development of chronic obstructive lung disease, lung emphysema and chronic bronchitis[6].

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On an average, smokers live fifteen years less than non-smokers. Most smokers develop bronchiolitis of respiratory bronchioles (RB) associated with only scanty symptoms. However, in some smokers, alongside with inflammation of respiratory bronchioles, pigmentophages clog respiratory bronchioles and the associated acinus and alveolus resulting in the development of bronchiolitis, combined with interstitial disease (RB-ILD)[7–9]. In most smokers with RB-ILD, the computerized tomography (CT) finding is normal. Only when small nodes develop in the lung parenchyma and subpleurally, the phenomenon of »stained glass« and bronchiolar dilatation can be seen on CT[8,9]. When it comes to the disease of the lung parenchyma with the development of eosinophil nodes, known as pulmonary histiocytosis of Langerhans cells or eosinophil granulomas or histiocytosis, smokers tend to develop the disease in 90% of cases. This disease leads to total destruction of the lung parenchyma with development of cysts. CT report depends on the stage of the disease.

Spirometry parameters of the smokers' lung function remain normal until the late stage of the disease. Not until the disease is fully developed obstructive and/or restrictive ventilation problems appear. The fall of the flow value to the level of small bronchi in flow-volume curve occurs earlier. The fall of the value of the midexpiratory flow (FMF) and mild lowering of the transfer factors values indicates bronchiolitis and changes in the interstitium of the lung parenchyma[10].

Because of the low sensitivity of radiological tests[11] and the fall of the values of spirometry parameters, tests that are more sensitive should be used before advanced lesions have occurred, i.e. tests that will detect earlier the inflammation of respiratory bronchioles.

Subjects and Methods

The study included a sample consisting of 31 subjects, 20 (65%) men and 11 (35%) women, mean age 36.38 (standard deviation, SD 10.86) years and mean smoking index 11.28 smoking/years (Table 1). On clinical examination, all study subjects were found to be healthy and free from subjective complaints or any disease symptoms. Data on their smoking habit were collected and smoking index was calculated from their history data. Spirometry, i.e. the flow/volume curve, was performed on a MasterLab device[12] and the results were compared with standard values according to Cotes[13]. Arterial blood gas analysis was done on a Radiometer abl 1 device. Shunt was calculated from the oxygen partial pressure values before and after inhalation of 100% oxygen by use of Chiang nomogram[1]. The basic statistical parameters of the pulmonary ventilation function variables and correlation coefficients between these variables were calculated and are reported.

Results

The mean (±SD) vital capacity (VC) (%) was 99.67% (5249.82 l) (SD 11.36%), minimum 66.03% and maximum 118.78%; the mean forced expiratory volume in one second (FEV_1, %) was 106.25%, maximum 133.18%; and the mean FMF (%) was 99.36% (SD 37.62%), minimum 18% and maximum 167% (Table 2).

The mean pH value was 7.37 (SD 0.02), minimum value 7.32 and maximum 7.43; the mean pCO_2 value was 4.99 (SD 0.42), minimum 9.82 and maximum 5.99; the

TABLE 1
DESCRIPTIVE CHARACTERISTICS OF STUDY SUBJECTS AND SMOKING INDEX

Variable	$\overline{X}$	SD	Range	MIN	MAX	Count
Age (yrs)	36.38	10.86	40	19	59	31
Smoking index (packs/year)	11.28	13.74	60	0	60	30

TABLE 2
DESCRIPTIVE CHARACTERISTICS OF THE LUNG VENTILATION FUNCTION IN STUDY SUBJECTS

Variable	$\overline{X}$	SD	Range	MIN	MAX	Count
VC (%)	99.67	11.36	53.00	66.00	119.00	29
VC (L)	5308.96	1234.76	4700	2100	6800	29
FEV_1 (%)	106.25	16.09	82.00	51.00	130.00	29
FEV_1 (L/sec)	4356.55	1107.92	4920	1180	6100	29
FMF %	99.36	37.62	149.00	18.00	167.00	23
FMF (L/sec)	0.04	0.02	0.08	0.04	0.08	23

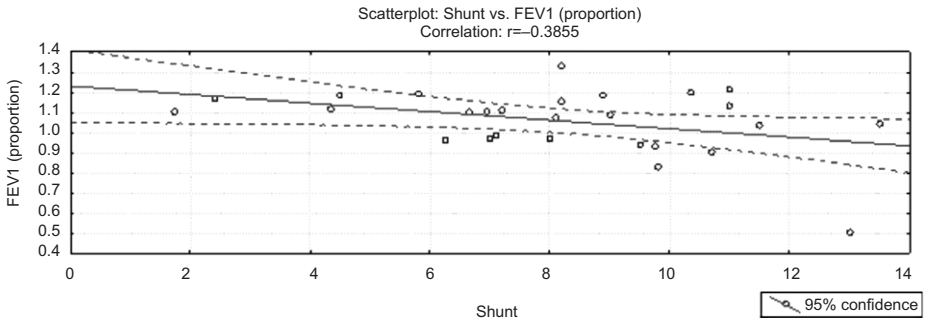

Fig. 1. Correlation between shunt and forced expiratory volume in one second.

TABLE 3
ARTERIAL BLOOD GAS ANALYSIS AND SHUNT IN STUDY SUBJECTS

Variable	$\overline{X}$	SD	Range	MIN	MAX	Count
pH	7.37	0.02	0.10	7.32	7.43	30
pCO_2	4.99	0.42	1.60	4.39	5.99	30
pO_2	13.22	1.29	5.72	9.82	15.54	30
Shunt	8.25	2.80	11.75	1.75	13.50	29

pH – acidity, pCO_2 – carbon dioxide partial pressure, pO_2 – oxygen partial pressure

mean pO_2 value was 13.22 (SD 1.29), minimum 9.82 and maximum 15.54; and the mean shunt value was 8.25 (SD 2.80), minimum 1.75 and maximum 13.50 (Table 3).

The coefficient of linear correlation between FEV_1 (%) and shunt was –0.385 and was statistically significant ($p \leq 0.05$), yielding negative correlation between FEV_1 (%) and shunt; the correlation coefficient was statistically significant at the level of 5% (Fig. 1).

The coefficient of linear correlation between FMF (%) and shunt was –0.548 and was statistically significant ($p \leq 0.01$), yielding negative correlation between FMF (%) and shunt; the correlation coefficient was statistically significant at the level of 1% (Fig. 2).

The coefficient of linear correlation between smoking and shunt was 0.523 and was statistically significant ($p = 0.000$), yielding positive correlation between smoking and shunt; the correlation coefficient was statistically significant at the level of 1% (Fig. 3).

The coefficient of linear correlation between FMF (%) and smoking was –0.409 and was statistically significant ($p \leq 0.05$), yielding negative correlation between FMF (%) and smoking; the correlation coefficient was statistically significant at the level of 10% (Fig. 4).

Discussion

In their study carried out in 2003, Samardžić et al. found that one million people in Croatia, i.e. every third inhabitant of Croatia, were smokers[14], clearly pointing to

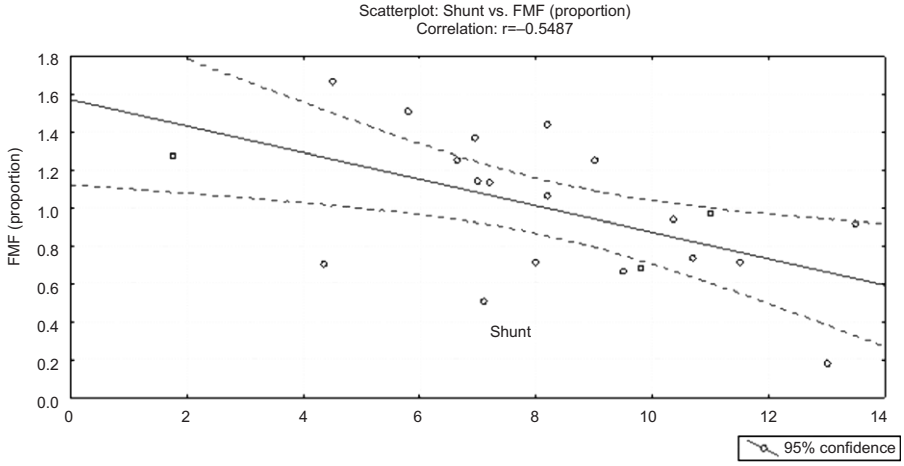

Fig. 2. Correlation between shunt and forced midexpiratory flow.

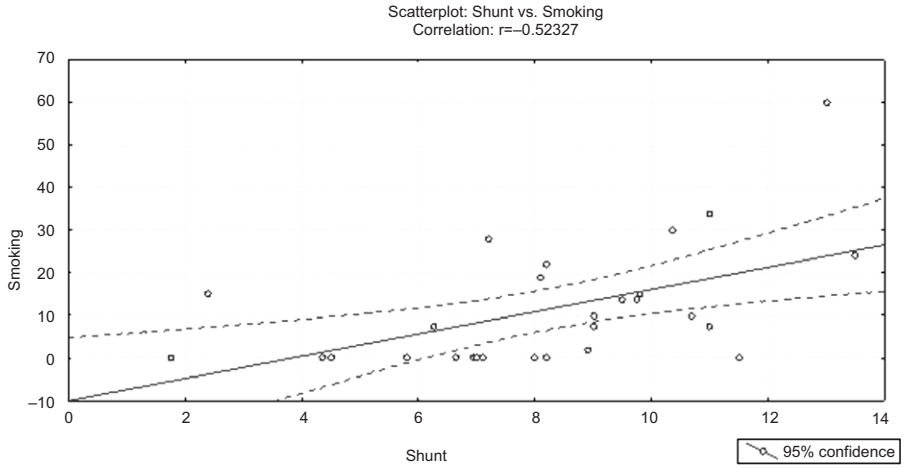

Fig. 3. Correlation between shunt and smoking.

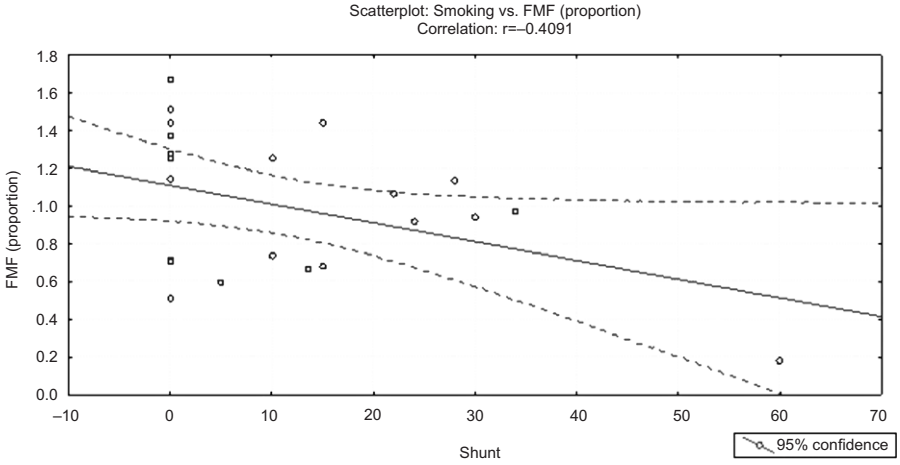

Fig. 4. Correlation between smoking and forced midexpiratory flow.

the severity of the problem. Their further study revealed middle aged men to be heavy smokers and women light smokers in Croatia[15].

Smoking is an important risk factor in all cardiorespiratory diseases[2]. Smoking is directly related to development of diseases of the lung interstitium, combined with bronchiolitis of respiratory bronchioles (RB-ILD, desquamative pneumonitis), histiocytosis of Langerhans cells and idiopathic lung fibrosis. The inflammation first develops in the area of respiratory bronchioles, and in this stage the disease is without clinical symptoms. Inflammation with accumulation of inflamed cells develops, alongside with hypertrophy of the bronchiole wall and closing of the lumen with mucus[16]. No changes can be seen on standard radiological or CT findings. Spirometry finding is also normal. However, symptoms develop later, making the disease detectable too late due to its gradual and insidious development.

All study subjects were smokers with smoking index of 11.24 packs/year. They had no health problems or symptoms. The mean shunt value was 8.25, showing a statistically significant increase and linear correlation between shunt and smoking. That means that the inflammation of the respiratory bronchiole wall causes obstruction distally in the associated acinus and alveolus, and thus decreased ventilation. A part of the heart high-impact volume passing through that capillary bed is not oxygenated because this part of the alveolus is not ventilated. The only way to prove this pathologic shunt is by measuring the alveolus-arterial gradient (A/a). Using this method we proved that the shunt was increased in smokers that were free from any health complaints. That means that the inflammation of respiratory bronchioles was present, with consequential termination of ventilation in that part of the lungs[7,8]. The only therapy to stop further development of histopathologic lesions is giving up smoking[16]. Although the results of spirometry were within the limits of reference values, analysis of their correlation with smoking showed negative correlation of FEV_1 and FMF with smoking. Because of the large span of the normal values of this parameter, ±20%, the method is not sensitive enough to prove any changes in this stage of disease development[17]. In our subjects, peripheral blood gas values were normal. Because of this and due to the absence of symptoms in smokers, shunt measurement appears to be the only diagnostic method at the time when bronchiolitis is present alone, as it can indicate some lesions that will progress unless ceasing smoking.

If a smoker does not quit smoking, interstitial pneumonitis will develop in addition to bronchiolitis. This usually occurs in smokers whose smoking index is over 30 packs/year. Alveolar macrophages with pigmented cytoplasm (pigmentophages) develop distally from respiratory bronchioles in corresponding acinus and alveolus. Alveolar sepsis in the area around the bronchiole becomes thick because of fibrosis changes, but these usually do not transform into fibrosis interstitial changes. Further progression, if one does not stop smoking, causes irreversible destruction of the lungs with emphysema.

Accordingly, we believe that shunt is a simple diagnostic method, important for early diagnosis of lung lesions caused by smoking. It is especially important because at the stage of respiratory bronchiolitis, there is no other method available to objectify these lesions.

Conclusion

In our study sample, all spirometry parameters and blood gas results were within the reference values. However, there was negative linear correlation of the forced expiratory volume in one second (FEV_1) and midexpiratory flow (FMF) with smoking, while the mean shunt value was 8.25, considerably exceeding the allowed limit of 5. Shunt was found to correlate positively with smoking and negatively with FEV_1 and FMF.

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R. Katić

University of Split, Faculty of Kinesiology, Nikole Tesle 6, 21000 Split, Croatia
e-mail: ratko.katic@gmail.com

ŠANT U DIJAGNOSTICI POČETNIH OŠTEĆENJA PLUĆA KOD PUŠAČA

SAŽETAK

Pušenje je bitan rizični čimbenik za sve bolesti dišnog sustava. Nažalost, simptomi se sporo razvijaju, tako da bolesnici kasno počnu osjećati posljedice kronične upale koja se razvija postupno i podmuklo. Upala najprije nastaje u području respiracijskih bronhiola. Tada je bolest asimptomatska. Analiza je provedena na uzorku od 31 pušača prosječne dobi 36,38 godina koji su imali uredne spirometrijske pokazatelje, acidobazni status i plinove arterijske krvi. Prosječni indeks pušenja je bio 11,28 pakovanja/godina. Svi ispitanici bili su zdravi, bez subjektivnih tegoba ili pokazatelja bolesti. Cilj je bio odredili mrtvi prostor u plućima (V/Q) kao rani pokazatelj promjena kod pušača. Dokazana je srednja vrijednost šanta kod pušača od 8,25% i njezina korelacija s pušenjem. Veličina šanta bila je u negativnoj korelaciji s forsiranim ekspiracijskim volumenom u prvoj sekundi i srednjim ekspiracijskim protokom kod pušača. Zaključuje se da je određivanje plućnog šanta jednostavna metoda koja je dovoljno osjetljiva u dijagnostici početnih promjena u plućima koje nastaju kao posljedica pušenja.