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THE IMPACT OF AIR POLLUTION ON THE CARDIO-PULMONARY SYSTEM

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The impact of air pollution on public health is visibly increasing. The process of industrialization and economic development has significant effects on the human body, causing changes at the respiratory and cardiovascular levels. In this article, we tried to summarize the way in which the main respiratory and cardiovascular pathologies are affected by air pollution and to show the degree of progression of these diseases in the context of constant exposure to inhalant noxes. We tried to focus on respiratory and cardiovascular pathologies because these systems are the first to come into contact with air pollutants and are the most exposed. Constant monitoring of atmospheric parameters is important in order to improve air quality and human health.

Keywords: air pollution, exposure, particulate matter, COPD, Atherosclerosis.

INTRODUCTION

Air pollution represents an invisible risk factor, which if not controlled in time, can have devastating effects on the human body[1–3]. According to World Health Organization (WHO), 7 million people die each year due to air pollution, but more surprising and disturbing is the fact that 9 out of 10 people breathe polluted air[4,5].

Depending on the degree of exposure to air pollutants, the consequences are different. In case of short-term exposure, the symptoms that people develop are general symptoms characterized by cough or shortness of breath. The higher the exposure, the more severe the changes will be to the human body, causing systemic or local effects[1,2].

Air pollutants are divided into primary air pollutants and secondary air pollutants. The primary ones are represented by carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), as well as volatile organic compounds (VOC). Motor vehicles or any means of transport based on combustion, as well as industrial sources, are the main sources of origin. The release of these compounds takes place directly into the atmosphere[3]. On the other hand, secondary air pollutants appear as a result of various chemical reactions with oxygen and water, forming in the atmosphere. Ozone and particulate matter (PM) are the main compounds[6].

Particulater matter particles are divided according to their size: PM10 are particles smaller than 10ug/m^3, PM2.5 are particles smaller than 2.5ug/m^3 and ultrafine particles, smaller than 0.1ug/m^3. The smaller the size of these compounds, the deeper the damage to the body. They are mainly consisted of sulfats, nitrates, black carbon and water[3,7].

The solubility of air compounds is also very important. Compounds with increased solubility will be absorbed by the body at the level of the upper airways, causing their local damage. On the other hand, those with low solubility will have a greater penetration in the body, causing more severe effects[5] (Table 1).

In 2005, WHO released a guide regarding on normal values of air pollutants and the degree above which these values would be harmful to the human body. In 2021, an update to this appeared, noting that the initial values were too permissive and highlighting that more attention should be paid. In Table 1 it is exposed the normal values according to the latest guide released by WHO[5].

Table 1

Atmospheric pollutants	Normal values	Observations
PM 10	45 μg/m^3 annual average 15 μg/m^3 average/24h	Affecting the mucous membrane of the upper respiratory tract
PM 2.5	15 μg/m^3 annual average 5 μg/m^3 average/24h	Affecting the lower respiratory tract (alveoli)
SO2	40 μg/m^3 average/24h	High solubility Affecting the upper respiratory tract
O3	100 μg/m^3 average/8h	Low solubility Profound lung penetration Inflammation of the lower respiratory tract
NO2	10 μg/m^3 annual average 25 μg/m^3 average/24h	Low solubility Profound lung penetration Inflammation of the lower respiratory tract

Furthermore, we tried to analyze how the main pulmonary and cardiovascular diseases are affected by air pollutants.

RESPIRATORY RISK FACTOR

CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Chronic Obstructive Pulmonary Disease (COPD) is a respiratory condition characterized by cough, dyspnea and expectoration. These symptoms are a result of the appearance of irregularities in the airways that will eventually cause an irreversible obstruction[8].

Patients with COPD are one of the risk groups that are affected by air pollution. Besides the fact that deaths caused by COPD are in 4th place worldwide, air pollution contributes a lot to this statistic. Cigarette smoke is considered to be the biggest risk factor in the development of COPD, but air pollution has an increasing role[5,9,10,11].

In an observational study, which took place in the western part of Romania, it was shown how air pollution with micro-particles affects this vulnerable group of patients. After monitoring the air quality with the help of devices installed in the homes of these patients, it was observed that the measured values were significantly increased in the group of patients more prone to exacerbations, which in most cases require hospitalization[9]. As in this study, a similar study was conducted in Taiwan, which included patients with different degrees of lung damage due to COPD[12].

COPD is the 3rd cause of death worldwide, these patients having numerous other comorbidities. Air pollution contributes significantly to the degradation of respiratory function, with the occurrence of exacerbations and generation of multiple other complications[9,13].

LUNG CANCER

Lung cancer patients are another risk group with a poor prognosis. According to GLOBOCAN estimates, in 2018 lung cancer was on the second place in the incidence of cancers among men and women after prostate and breast cancer[14].

A significant percentage of patients with lung cancer also have COPD[13]. NO_2 and ozone cause changes in the cellular cycle producing inflammation, increasing oxidative stress and thus altering the repair and replication cycles[1].

International Agency for Research on cancer has classified ambient air pollution and PM as carcinogenic to humans[3, 15]. In the Ahsmong-2 study for each 10ug/m^3 increase of PM2.5, it was observed that lung cancer increased, although the exposure to PM2.5 was at low levels and patients didn't smoke[16].

Numerous studies have shown an association between the risk of developing lung cancer and PM2.5, and in an animal study it was observed that exposure to diesel particles is corroborated with benign and malignant lung tumors[1].

It is important to monitor air pollution because any exposure can lead to changes in the cells of the respiratory system, with the gradual appearance of genetic mutations and pre-neoplastic changes of dysplasia, metaplasia and hyperplasia. Thus, interrupting the exposure at the right time can contribute to stopping the triggering of the carcinogenesis process.

ASTHMA

Asthma is a heterogeneous disease, characterized by chronic inflammation in the airways. It is characterized by the history of respiratory symptoms such as dyspnea, wheezing, cough or chest constriction[17].

The increase in industrialization at the global level has contributed to the development of asthma in developing countries, and the exposure of people to various inhaled particles has contributed to the emergence of asthma[18].

In a study conducted by Bowatte *et al.*, it was observed that residents living at < 200 m from a main road had an increased risk of having persistent asthma compared to those living at < 200 m from a major road[19].

The way in which air pollutants will influence immunity is through epithelial changes at the level of the epithelium of the respiratory system, determining the intensification of allergic reactions[20,21].

RESPIRATORY INFECTIONS

One of the main causes of death worldwide is represented by respiratory infections. A study conducted in China observed that an increase in PM2.5 levels was associated with an increase in the number of consultations and hospitalizations due to respiratory tract infections or pneumonia[22]. At the same time, a study carried out in Kenya on 229 participants showed a correlation between acute respiratory infections and PM10[23]. In the United States of America, it was observed that an increase with 10ug/m3 of PM10 was corroborated with the increase of 1.95% of pneumonia cases[24].

Tuberculosis is a concern for public health, even if the incidence is decreasing globally. A correlation was observed between its prevalence and socio-economic factors, more precisely its association with urban areas where the agglomeration is much greater, but also the degree of pollution significantly increased compared to rural areas[25,26].

Respiratory infections are extremely debilitating and in patients with pre-existing pathologies, it can have serious effects.

CARDIOVASCULAR RISK FACTOR

ATHEROSCLEROSIS AND ISCHEMIC HEART DISEASE

Myocardial infarction is the main cause of death from cardiovascular diseases and air pollution is a great risk factor that contributes to the number of deaths from cardiovascular causes[27,28]. Premature deaths from stroke or ischemic heart disease due to air pollution represented approximately 58% of the total number of premature deaths caused by pollution[27]. Initially this is not immediately visible because there is an oxidative reaction that takes place at the pulmonary level which will further determine a systemic reaction[29]. It was observed that diesel particles cause an increase in oxidative stress through polycyclic aromatic hydrocarbons[30]. Successive to the production of these mediators at the level of the lung, there time to inhalant pollutants is corroborated with the increase of the coagulation blood function[31].

It is known that endothelial dysfunction is an early marker for atherosclerosis[32]. PM2.5 has a significant effect on human health. The size is so small that it ends up penetrating very deep into the lungs, managing to pass right into the bloodstream and further circulate to other organs[33].

In a study it was observed that people who live closer to a main street, at a distance of 50–100 m from it, had a higher score than those who do not live so close. They actually had a higher risk of having calcified atheroma plaques[34].

ARRHYTHMIAS

Arrhythmias are represented by an abnormal electrical activity developed in the heart[35]. Air pollutants have a significant increase in the development of pro-arrhythmic effects in patients with a history of myocardial infarction[36].

In a study that took place in Korea, a correlation was observed between PM2.5 as well as PM 10 and the increased risk of arrhythmias such as premature atrial contractions, bradycardia or right bundle branch blocks[37]. In a meta-analysis in which 23 clinical studies were included, it was observed that mortality and hospitalizations due to arrhythmias were associated with increased levels of PM2.5, PM10, NO2, SO2, and carbon monoxide[38].

Both short-term and long-term exposure to PM2.5, PM10, carbon monoxide or nitrogen dioxide has been associated with the development of atrial fibrillation[37].

Thus, PM2.5 represents a risk factor for the cardiovascular system, being associated with hypertension, heart failure and even arrhythmias, due to the fact that it is involved in the process of inflammation, atherothrombosis and atherosclerosis at the level of the coronary vessels[33].

CONCLUSIONS

In this review, we tried to summarize the effects of air pollution on the respiratory and cardiovascu-

lar system. Although we managed to corroborate the data from various studies with the main pathologies of the human body, the effects that air pollution has on them is much more complex. The consequences are not only for these particular organs from the human body, as they can also affect the whole human organism.

Air pollution is an invisible risk factor that affects each of us to a greater or lesser degree, depending on the time and quantity of exposure. Measurement of atmospheric compounds is crucial, thus being able to determine the moments with the greatest risk.

More studies should be conducted in order to better understand how the human body is affected and what should be done to reduce these inhalable noxes because every healthy or sick human body is affected.

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