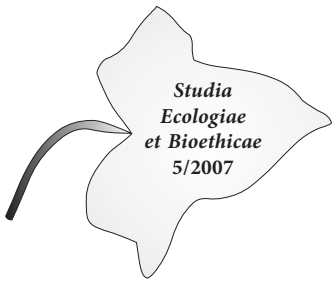

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Exposure to particulate matter and cardiovascular disease risk

Cardiovascular disease (CVD) is the major cause of death in developed and developing countries [1]. Many factors have been recognized to be strongly associated with CV development [2]. Significant role play environmental factors among which diet, physical activity and smoking habits are of great importance. However, a growing body of evidence has been accumulated indicating influence of air pollution on human heath and its association with cardiovascular disease and stroke [3].

Air pollution can be defined as complex and heterogeneous mixture of gases, liquids and particulate matter [4]. Particulate matter (PM) consists of different solid and liquid particles suspended in air. There are primary particles emitted directly into the atmosphere and secondary particles created by physicochemical transformation of gases. Numerous sources of PM exist. Large amounts of particulate matter are formed and emitted by motor vehicle, as well as during different industrial and agricultural processes, construction and demolition activities, residential wood burning, and also during forest fires and combustion of agricultural debris.

In PM thousands of chemical substances can be detected. The most common constituents include nitrates, sulfates, carbon both elemental and organic, variety of metals, organic compounds as polycyclic aromatic hydrocarbons, and biological compounds as cells and cell fragments, or endotoxins.

Nowadays PM are classified according to their size and ability to penetrate in the tracheobronchial tree [5]. Therefore the particles of interest there are PM with diameter ≤ 10 μm (PM 10) called thoracic particles. Among them three subfractions can be recognized: coarse fraction containing particles with diameter from 10 μm to 2.5 μm (PM 10-25), fine particles with diameter lower than 2.5 μm (PM 2.5) and ultrafine particles with diameter lower than 0.1 μm (PM 0.1). Small PM 2.5 particles posses a high ability to deposit in the deep lung,

while larger particles show a greater deposition in the upper tracheobronchial and extrathoracic regions.

Very small PM 0.1 particles have been recognized as a major fraction of PM. They are characterized by a high ratio of surface area to mass, and enhanced biological toxicity. They show the high ability to deposit in human alveoli and may also directly enter the circulatory system. PM 0.1 are described as particles with short live time. They can easily aggregate and formed larger particles. PM 0.1 are produced especially during combustion processes.

Epidemiological studies indicate the relation between exposure to particulate matter and cardiovascular diseases. The Harvard Six Cities Study showed that chronic exposure (14-16 years) to air pollution was independently associated with cardiovascular mortality [6]. The CV risk was 26% higher in the most polluted region then in the least polluted city. The exposure to PM 2.5 and sulfates was most strongly related to cardiovascular mortality. The 16-years follow-up conducted in the ACS Cancer Prevention II study in the population of 500 000 adults in 50 states reveled that increase in PM 2.5 mean level of 10 $\mu g/m^3$ was associated with 4% increase in all cause mortality, 6% in cardiopulmonary and 8% in lung cancer mortality [7, 8]. In addition the relation between PM 2.5 level and adverse health effects was linear and no safe threshold was observed. In this cohort the highest risk increase (18%) associated with exposure to PM 2.5 was found for ischemic heart disease [9], however, the enhanced risk of arrhythmia, heart failure and cardiac arrest mortality by 13% was also observed. The 8-years observation of the group of 5000 adult city residents showed that traffic related pollutants were more strongly associated with total and cardiovascular mortality that citywide air pollutants background levels [10]. The risk of cardiopulmonary mortality was enhanced by 95% in the subpopulation living near the major roads.

Beside long-term also short-term relationships between level of exposure to air pollution and adverse health effects were recognized. The results of the Air Pollution and Health: a European Approach-2 (APHEA-2) study performed in 20 European cities in the population of 43 million peoples showed that for a 2-day exposure time window each 10 $\mu g/m^3$ elevation in PM10 level was associated with 0.69% increase in cardiovascular mortality [11]. Similar changes in PM10 levels in the period of 40 days were accompanied by 1.97% increase of cardiovascular deaths. It was also found that this association was modified by the $N0_2$ level, and stronger relation between PM10 and CV mortality was observed in cities with higher $N0_2$ air level.

Significant and independent association between mortality and changes in PM10 air concentrations the day before death was also found in the studies performed in 50 million residents of North American cities – National Mortality and Morbidity Air Pollution Study [12]. Average total mortality was increased by

0.21% for each 10 μg/m^3 increase of PM10 level, and cardiovascular mortality by 0.31%.

Higher incidences of cardiovascular events and ischaemic strocks significantly related to elevation of PM10 levels were observed in many European, North American and also Asian (Seul, Taiwan) studies [13-18].

The observed in epidemiological studies strong relation between particulate matter air level and cardiovascular diseases may be explained by indirect or direct influence of PM on different biological processes involved in CVD development [19]. Exposure to PM10, and especially to fine particles (PM 2.5) cause significant increase in the concentration of reactive oxygen species in the lungs and heart, and also markers of oxidative stress in blood [20,21]. Both fine (PM 2.5) and coarse particles (PM10-2.5) induce leucocyte production by bone marrow and proinflammatory cytokines production by human monocytes [22,23]. Exposure to these particles enhances nuclear factor(NF)-kappaB activation and expression of NF-kappaB related genes [24]. After exposure to PM of different sources enhanced levels of lipid and protein oxidation products [20], interleukine-6 and interleucine-1β [25], fibrinogen [26,27] and C-reactive protein [28,29] in human blood were found. The role of oxidative stress and inflammatory process in atherosclerosis development is well established [19]. Enhanced levels of interleukine-6, C-reactive protein and fibrinogen are accepted markers of enhanced risk of coronary heart disease, myocardial infarction and stroke. These factors are involved in development of dysfunction of endothelial cells, atherosclerotic plaque formation, plaque instability and rupture, and thrombus formation. PM by induction of oxidative stress, local and systemic inflammation can promote atherosclerosis progression, enhanced procoagulant blood activity and plaque instability. In addition it was shown that exposure to air pollution was associated with alteration in vascular tone, arterial vasoconstriction and increase of blood pressure, and cardiac arrhythmia [17,30].

Air pollution is significantly associated with risk of enhanced cardiovascular mortality and morbidity, although the relative CVD risk related to this exposure is lower than the risk related to hypertension, tobacco smoking, obesity lipid disorders, and unproper dietary habits. However, air pollution is ubiquitous, and whole population is exposured to different air pollutants during whole life-time. Therefore, improvement of air quality standards and lowering of PM exposure can significantly diminish cardiovascular disease risk and improve public health status.

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ABSTRACT

Epidemiological studies clearly indicate that both long- and short-term exposure to several environmental air pollutants cause significant increase in the risk of cardiovascular events. The observed strong relation between particulate matter air level and cardiovascular diseases may be explained by indirect or direct influence of these particles on different biological processes involved in disease development. Improvement of air quality standards and lowering of particulate matter exposure can significantly diminish cardiovascular disease risk and improve public health status.

Zanieczyszczenia powietrza a choroby układu krążenia

STRESZCZENIE

Badania epidemiologiczne wskazują, że zarówno długotrwała jak i krótkotrwała ekspozycja na wysokie stężenia różnego typu zanieczyszczeń powietrza powoduje istotny wzrost incydentów klinicznych związanych z chorobami układu sercowo-naczyniowego.

U podstaw tego związku leży bezpośredni oraz pośredni wpływ cząstek tworzących te zanieczyszczenia na procesy odgrywające kluczową role w rozwoju tych chorób. Zaostrzenie standardów czystości powietrza, a w efekcie zmniejszenie narażenia na działanie zanieczyszczeń powietrza, może w istotnie obniżyć ryzyko rozwoju chorób układu sercowo-naczyniowego i poprawić stan zdrowia populacji.

Leszczyna

Topola czarna