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Short Communication

Air pollution and possible risk of dementia in the Czech Republic

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Abstract

A review of recent literature indicates a significant effect of air pollution on the increased incidence of dementia, particularly Alzheimer's disease. A possible mechanism is related to oxidative damage and inflammation. In the Czech Republic in previous decades the mining districts of Northern Bohemia suffered from very high air pollution levels, while during the last period in Northern Moravia this problem was also noted. This specific situation could be used to study the impact of air pollution on dementia, using new methods of molecular epidemiology together with the complex analysis of the lifestyle of the population living in the polluted regions.

Impact of PM2.5 exposure to dementia

Air pollution exposure to PM2.5 (particulate matter < 2.5 µm) represents a risk factor for dementia, particularly Alzheimer's disease (AD). Although the exact mechanism is not fully understood, many studies suggest that enhanced oxidative stress and inflammation are key mechanisms involved in PM2.5 neurotoxicity [1-3].

Chronic PM2.5 exposure significantly affects cognitive functions, as was observed in studies in Mexico City [4], and reduces white matter in the frontal and temporal cortex in non-demented older women [5]. A U.S. study of older adults (+55 years old) demonstrated the effect on working memory and orientation [6]. A study from North Carolina analyzed the population aged 65+ the effect of PM2.5 exposure (study group exposed to > 10 µg/m^3 vs. control group exposed to < 7.6 µg/m^3). In the study group increased mortality and hospital admissions for AD were observed [7]. A study in Seattle observed increased dementia in subjects exposed for 10 years to PM2.5 concentrations > 10.1 ± 2.9 µg/m^3 [8].

Parra, et al. [9] analyzed participants in a UK biobank followed older > than 60 years without dementia in 2010. Exposure to PM2.5 during the next 7 years was associated with AD (HR = 1.17, 95% CI: 1.06, 1.29]. Dhiman, et al. [10] published a meta-analysis, showing the impact of PM2.5 on AD (HR = 1.08, 95% CI: 1.01, 1.15). Cheng, et al. [11] reviewed 13 studies, PM2.5 exposure significantly increased the risk of AD (HR = 1.47, 95% CI: 1.22, 1.78). A study in China [12] compared participants living with middle and high levels of PM2.5 exposure versus those with low exposure, the odd ratio (OR) was 1.50 (95% CI 0.90-2.50) and 3.92 (2.09 – 7.37). 1.01, 1.15). All these studies indicate the significant impact of PM2.5 exposure to increase AD.

History of air pollution in the Czech Republic

The results of these studies inspired us to examine the possible impact of PM2.5 air pollution on the aging process and its effect on dementia. Northern Bohemia in the Czech Republic, particularly the district of Teplice, was in the late eighties one of the most air-polluted areas in Europe [13]. Mean concentrations of PM2.5 in the year 1993 were 60 µg/

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m^3, between the years 1994- 2009 approx. 30 μg/m^3 [14]. Life expectancy in the district of Teplice in 1988 was for both males and females 2 years shorter than in the whole Czech Republic [15]. Now life expectancy in the Czech Republic is longer, but in the mining districts, it is still 2 years shorter for males as well as females [16]. This development may indicate, that in mining districts population is seriously affected. The fact that concentrations of PM2.5 in mining districts of Northern Bohemia were much higher than those in studies in North Carolina and Seattle suggests, that the population in the mining districts of Northern Bohemia could be the relevant target for molecular epidemiology studies on the incidence of AD and other types of dementia. Another such region could be Northern Moravia, which became during the last years the worse air-polluted region in the Czech Republic, especially due to steel plants.

Proposal for the complex study in the Czech Republic

US consortium [17] proposed several priority areas for mitigating air pollution's impact on brain health and dementia: highlighting vulnerable populations and detailing the impact of ambient PM2.5 on brain health. Our proposal corresponds to their idea.

The planned molecular epidemiology study will be complex to cover all the aspects of possible neurotoxic effects of environmental pollution. It includes molecular biological analyses of cell processes characterizing lifestyle factors and external and internal exposure to environmental pollutants in the elderly population, including seniors suffering from neurodegenerative diseases, including AD. The analyses will involve gene and protein expression changes, lipidomics (omics technologies), DNA damage and repair, telomere length, analyses of parameters of oxidative stress and antioxidant protection, epigenetic changes on the level of DNA, RNA, and proteins, and inflammatory markers. Our recent studies [18,19] suggest, that epigenetic modifications of DNA and parameters of oxidative stress in persons living in various areas of the Czech Republic are affected by other factors than organic pollutants in the air. These findings might be also important for the etiology of neurodegeneration in the elderly population.

These biological changes will be accompanied by the chemical analysis of the most important pollutants and their metabolites in blood and urine (polycyclic aromatic hydrocarbons and their metabolites, persistent organic pollutants, etc.).

The complex study on the relation of environmental pollution to neurodegenerative changes should involve the newly developed theory of epigenetic adaptation. Recently, we have demonstrated the plasticity of the human epigenome to the adverse effects of a polluted environment [20,21]. The findings suggest the model of epigenetic adaptation as a relatively quick protective mechanism. Therefore, epigenetic adaptation should be evaluated in the whole genome and the adaptation should be analyzed in persons living in a polluted environment for many years. Special attention should be given to the epigenome, origin, and exposure history of persons with dementia.

To better understand the complex brain effects of environmental pollution, it would be highly desirable to study the changes in the whole age spectrum of the population, starting with newborns, young children, middle-aged cohorts, and finally the elderly population. There are multiple benefits coming from such a complex study. First of all, suggestions of some preventive measures to avoid a premature decrease in the quality of life of many thousands of seniors suffering from neurodegenerative diseases. The impact of air pollution on CNS seems to be a new and important topic [22]. It would be pertinent to establish several cohorts as proposed and study neuropsychological changes during the aging process.

Conclusion

The project studying complex brain effects of environmental pollution in cohorts from newborns to the elderly population (both, healthy and with Alzheimer's disease) in polluted regions affected during the last years by increased air pollution in the Czech Republic may contribute to the limited knowledge of the environmental factors in the development of neurodegenerative diseases.

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