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DOES THE POLLUTION INFLUENCE THE LUNG DEVELOPMENT?

Ruxandra ULMEANU[1,2], Alina CROITORU[1,3] and Alexandra ULMEANU[4]

[1] Marius Nasta Institute of Pneumophtysiology, Bucharest, Romania
[2] Faculty of Medicine, Oradea Uiniversity, Oradea, Romania
[3]Carol Davila University of Medicine and Pharmacy, Bucharest, Romania
[4]Regina Maria Hospital, Bucharest, Romania

Corespondence author: Alina Croitoru, MD, PhD, Marius Nasta Institute of Pneumophtysiology, Bucharest, Romania
Email address haulicaalina@yahoo.com

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Air pollution represents one of the major challenges of the modern area, with consequences on lung development. The main particles involved are particulate matter, ozone, greenhouse gases.

The negative effects of air pollutants are starting from the prenatal period and leads to premature births, lower birth weight, impaired lung development, increased later respiratory morbidity, higher infant mortality, earlya lterations in immune development.

The children are also exposed to climate change, related to their behavior (playing outside in the polluted area, increased ventilation rates). They are also exposed to outdoor but also indoor pollution from biomass, environmental tabaco. These factors have negative impact in respiratory function, asthma development.

Keywords: air pollution, lung growth, children.

LUNG GROWTH AND DEVELOPMENT

Lung growth and development starts from the prenatal period and is finished in the adolescence. Throughout this period there are many external factors that can influence, such as smoking and pollution.

Embiogenesis of lower respiratory tract begin on the day 22. The process is divided in 5 stages: embryonic, pseudoglandular, canalicular, saccular, and alveolar stage. In the embryonic period (weeks 3–7) is lung bud formation and trachea and bronchi differentiation. In pseudoglandular period (weeks 7–17) is formation of conducting airways, terminal bronchiole sand appearance of type II pneumocytes. In canalicular period (weeks 17–27) is lung periphery formation with increased vascularization and appearance of type I pneumocytes , apparition of of air-blood interface. In sacular period (weeks 27–36) is alveolar sacules formation, the surfactant is detectable in amino fluid. Post natal lung growth from birth to 7–10 years is alveolar period with mature alveoli formation, proliferation and expansion of capillaries, nerve and gas exchange area. Complete maturation of the lung is completed when the child reaches 10 years old.[1,2]

Survival of premature babies is linked to which respiratory tract stage was achieved at birth.[1] Exposure to air pollution during intrauterine development and early childhood may have lasting effects, which will continue to manifest during adulthood.

AIR POLLUTION

Air pollution decreases air quality, and some pollutants harm public health and wealfare even at low levels. What we breathe impacts our health and, in our days, 9 out of 10 people worldwide breathe polluted air.

99% of the world population live in regions who are not up to WHO criteria for clean air. Among children the impact is dramatically, with 570 000 children under 5 years dying from respiratory infections attributable to indoor, outdoor air pollution and second-hand smoke.[4,5] It is estimated that climate change will be responsible for an additional 250.000 deaths / year during 2020–2030 period.[4]

Although air pollution is not visible, it can be deadly, being responsible for 36% deaths from lung cancer, 34% deaths from stroke and 27% deaths from heart disease.

The main pollution factors are:[5]

- particulate matter (PM)
- ozone (O_3)
- greenhouse gases
- carbon dioxide (CO_2)
- nitrogen dioxide (NO_2)
- sulfur dioxide (SO_2).

Particulate Matter PM 2.5 are very small particles, 2.5 microns, 30 × smaller than a single strand of hair. Particulate matter are the deadliest form of air pollution due to their ability to penetrate deep into the lungs and blood system. WHO estimates around 800.00 deaths annually linked to PM pollution, but the figures don't take into consideration their indirect effect.[7]

These particulate matter particles can be clasified in: coarse particles, PM10 with diameter 2.5–10 μm, fine particles PM2.5 with diameter 2.5 μm or less, inhalable particles ≤ 1 μm, ultrafine particles ≤ 100 nm. Because of the high affinity for alveoli, PM are considered responsible for accute change in pulmonary functions and thus increasing the prevalence of COPD and Asthma in adulthood. PM are also linked to higher cardiovascular and cerebrovascular events.[7] The source of particulate maters is: biomass combustion, transportation, incinerators, and manufacturing industries.

Ozone. There is a "good" ozone and a "bad" ozone. The "good" ozone found in the stratospheric layer of the atmosphere, and it protects earth from harmful UV radiation.

The "bad" ozone is a harmful air pollutant. Ozone at ground level is formed by a photo-chemical reaction pollutants from vehicles and industry, plus sunlight resulting in nitrogen oxides (NOx) and volatile organic compounds (VOCs). VOC are one of the major constituents of photochemical smog.[8] The highest levels of ozone pollution occur during periods of sunny weather.

AIR POLLUTION IN PRENATAL PERIOD

Lung sensitivity to air pollutants is different for an adult *versus* a fetus.

Maternal exposure to air pollution directly influences the fetus. The transfer of pollutants takes place through the amniotic fluid and placenta. Other mechanism imply a direct toxicity of particles, via translocation across biological barriers, or direct penetration through membranes.[11]

The cummulative effect of oxidative stress, inflammation and lacking of antioxidant mechanisms result in hemodynamic alterations. The consequence of these alterations are decreased placental blood flow and decreased transfer of nutrients to the fetus.

Exposure to air pollution during pregnancy leads to:[11]

- preterm birth
- lower birth weight
- impaired lung development
- increased later respiratory morbidity
- higher infant mortality
- early alterations in immune development.

A study who examinated 5 placentas of mothers living in London revealed the first ever evidence of carbon particles, created by burning fossil fuel, in maternl placentas. In the placentas examined, a total of 3,500 placental macrophage cells were examined under a high power microscope. 72 dark particles carbon were found, thus proving for the first time that inhaled pollution particles move from the materal lung towards the placenta.[12]

AIR POLLUTION IN CHILDHOOD

Children have a specific behaviour, spending more time outside, and in the summer afternoons ozone levels are the highest.[8] Considering that children are more active, their ventilation rates are increased and thus we can observe a higher concentration of air pollutants.

The childrens are also exposed to indoor pollution represented by environmental tobacco, biomass. Thirdhand smoke constituents of tobacco smoke deposit on surfaces in indoor environments which are carried by dust. They are absorbed through skin, nhaled or ingested. Third-hand smoke is especially harmful to infants who are exploring their environment.[21]

The population living close to a stree are exposed to near-roadway air pollution (NRAP)[13] with significant adverse effects on childhood lung function

The physiopathological efects of air pollution on children lung are:

- oxidative stress – inflammation – repair mechanisms
- impaired lung structural development – airway remodeling

- Ly T genes inhibition – allergic inflammation
- decreased lung growth
- increased lifetime risk for asthma, COPD, lung cancer.

Oxidant gases, airborne particles and environmental tobacco smoke are common air pollutants that affect critical signals or mediators expressed during distinct stages of lung development.[14] These particles are also responsible for the pathogenic influence on cell differentiation, proliferation and/or maturation.[14]

AIR POLLUTION IN ADOLESCENCE

A study regarding the effect of air pollution on children included 1759 fourth grade children (average age, 10 years) from the elementary school in 12 southern California communities. Lung function was measured annualy for 8 years. Deficits in the growth of FEV_1 were associated with exposure to nitrogen dioxide, acid vapor, $PM_{2.5}$, elemental carbon.[15]

HELIX subcohort was formed of 1033 mother and child pairs in which the influence of air pollution on lung function was studied. Admittedly the cohort reported 85 prenatal and 125 postnatal exposure to air pollution. Spirometry was performed annualy from age 6 to 12 years. Nine postnatal exposures were associated with lower FEV1%: copper, ethyl-paraben, phthalate metabolites, mono-2-ethyl-5-hydroxyhexyl phthalate, mono-2-ethyl-5-oxohexyl phthalate, mono-4-methyl-7-oxooctyl phthalate, house crowding, facility density around schools. This study also found that inverse distance to nearest road during pregnancy was associated with higher FEV1%.[16]

Another study about lung function growth in children with long term exposure to air pollutants in Mexico City consist of a cohort of 3,170 children aged 8 years at baseline which were followed for 3 years, with healt visit taking place every 6 months. Deficits in FVC and FEV(1) growth over the 3-year follow-up period were significantly associated with exposure to ozone, particulate mater and nitrogen dioxide.[18]

3535 children with no history of asthma were recruited from schools in 12 communities in southern California with high exposure to ozone. They were followed up for up to 5 years and 265 children reported a new diagnosis of asthma during follow-up.[19]

In communities with high ozone concentrations the relative risk of developing asthma in children playing three or more sports was 3.3 increased *versus children playing no sports*.

AIR POLLUTANTS – SPECIFIC EFFECTS

Each pollutant has an specific effect on lung development. Ozone is considered responsible for an increase in respiratory symptoms, decrease in lung function and small airways dysfunction. SO2, which results from coal and oil combustion or automobile and industrial emission, is responsible for chest constriction, headache, vomiting and increase in respiratory episodes.[7] NO, which results from gas stoves and kerosene heaters, cooking or automobile and industrial exhausts, decreases the rate of growth in forced vital capacity.[7] PM10 exposure decreases the rate of growth in forced vital capacity.

CONCLUSIONS

- Air pollution have a substantial impact on lung development in pre and postnatal period
- There is need of prophylactic strategies regarding the children health and their exposure to air pollutants.

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