

REVIEW ARTICLE

PM_{2,5} and Hypertension

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Abstract

Hypertension is usually contributed by such factors including age, sex, heredity, education, smoking, obesity, physical activity and a history of other diseases such as kidney disease. In addition to these risk factors, hypertension can also be caused by particulate sources of air pollution. Air pollution has an impact on health including respiratory disorders, heart disease, cancer of various organs, reproductive disorders and hypertension. Some types of air pollutant most often found are Carbon Monoxide, Nitrogen Oxide, Sulfur Oxide, and dust particles such as Particulate Matter $\leq 2.5 \mu\text{m}$ (PM_{2.5}).

Keywords: *hypertension, particulate, PM_{2.5}*

Introduction

Hypertension is a condition when systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg. The diagnosis of hypertension is if blood pressure higher than normal blood pressure and persists in measurement for several weeks [1]. Non-communicable diseases are grouped into six groups of diseases, such as cancer, diabetes mellitus, heart disease, hypertension, COPD and asthma. Data from Ministry of Health Indonesia shows the percentage of new outpatient cases in that six groups of non-communicable diseases, hypertension being

the most cases followed by heart disease and diabetes mellitus [2].

Hypertension is continuous, non-physiological condition of increased systemic blood pressure. Hypertension affects large amount of entire adult population in the world. Genetic, environmental, and behavioral factors influence the occurrence of hypertension. Hypertension has been identified as one of the main risk factors for cardiovascular disease (CVD) including heart disease, vascular disease, stroke, and kidney disease. An understanding of the basic epidemiology of

hypertension is very important for public health in determining health program to detect and treat hypertension effectively [3].

Other risk factors that contribute to hypertension are age, sex, heredity, education, smoking, obesity, physical activity and a history of other diseases such as kidney disease. In addition to these risk factors, hypertension can also be caused by particulate sources of air pollution. Air pollution has an impact on health including respiratory disorders, heart disease, cancer of various organs, reproductive disorders and hypertension. Some types of air pollutant most often found are Carbon Monoxide, Nitrogen Oxide, Sulfur Oxide, and dust particles such as Particulate Matter $\leq 2.5 \mu\text{m}$ (PM2.5) [4].

PM2.5 is an air pollutant with a diameter of $\leq 2.5 \mu\text{m}$. PM2,5 consists of sulfates, nitrates, organic compounds, ammonium compounds, metals, acidic materials [5].

Factors

Several factors that influence the occurrence of hypertension, are as follows:

Age

Age affects the occurrence of hypertension. As we get older, the risk of developing hypertension becomes greater so that the prevalence of hypertension among the

elderly is quite high at 40% (> 65 years). Hypertension generally develops when a person reaches middle age, it tends to increase, especially those aged over 40 years and even more than 60 years [6].

Sex

Sex factors influence the occurrence of hypertension. Men more suffer to hypertension than women with a ratio of about 2,29 for an increase in systolic blood pressure. Men usually have a lifestyle that tends to increase blood pressure compared to women [6]. In general, hypertension in men occurs above 31 years while women occur at the age of 45 years [7].

Genetic

Genetic factors in families that have history of hypertension will cause family's members to have a risk of suffering from hypertension. This is related to increase in intracellular sodium levels and low ratio between potassium to sodium. Individuals with family history of hypertension were 2 times more likely to have suffering from hypertension than those who don't have families with a history of hypertension. About 70-80% cases of essential hypertension found in person with a family history of hypertension [8].

Education

Education is an indicator level of human ability to understand information obtained from outside, in this case the health information related to awareness to check themselves, recognize early symptoms and know the advanced complications of hypertension. High level of education makes people easier to receive and understand information about health, has ability to manage family resources to prevent hypertension. Previous studies have shown that elderly peoples were more vulnerable to suffer from hypertension due to low ability for absorb information related to health [9].

Smoking Habit

Smoking also can increases heart rate and oxygen to be supplied to the heart muscles. Smoking in people with high blood pressure can increases the risk of damage to arteries. In the autopsy study, it was proven that there was relationship between smoking and the presence of atherosclerosis in all blood vessels [6].

Obesity

Obesity is the percentage of fat abnormalities expressed in Body Mass Index (BMI). BMI is the ratio between body weight with height squared in meters. Body weight and BMI are directly associated with blood

pressure, especially systolic blood pressure [6].

Physical Activity

Regular physical activity such as jogging (at least 30 minutes a day) can reduce blood pressure by 4-9 mmHg. WHO recommends that adults should do at least 30 minutes of moderate physical activity a day such as walking, cycling, doing homework, gardening, dancing or climbing stairs. Peoples who are physically active have HDL cholesterol levels and ratio of HDL/LDL higher compared to peoples who are not physically active [10].

Hypertension in addition mostly caused by behaviour risk factors, can also be caused by history of other diseases. High blood pressure or hypertension can be caused by other diseases such as kidney, diabetes mellitus, endocrine disease and blood vessel malformations. A history of preeclampsia during pregnancy is also a risk factor for hypertension [11]. Epidemiological research shows that PM_{2,5} is associated with increased morbidity and mortality in humans. Epidemiological studies clearly state that the relationship between air pollution particles and health effects is related to the concentration and size of the particles, besides the composition of the particles is also a factor that also plays an important role in determining health risks due to PM_{2,5} [12]. EPA tightened the 24-hour PM_{2,5} standard from the level of 65

$\mu\text{g}/\text{m}^3$ to $35 \mu\text{g}/\text{m}^3$ and maintained the annual $\text{PM}_{2.5}$ standard at $15 \mu\text{g}/\text{m}^3$ [13].

$\text{PM}_{2.5}$ is air particulate that can directly enter the lungs and settle in alveoli. This situation will get worse if there is a synergistic reaction with SO_2 gas in the air. In general, polluted air only contains hazardous metals around 0.01%-3% of all dust particulates in the air but these metals can be accumulative in nature and also possible causing synergistic reactions in body tissues. In addition, it is also known that inhalation of metal that contained in the air has a greater effect than the same dose that comes from food or drinking water (ingestion). Inhalation is most concern exposure routes of air pollutant related to impact on health. However there are also other compounds that are mixed in particulates, such as lead (Pb) and other toxic compounds, which can expose the body through other routes, not only from inhalation. Most of these pollutants can directly affect the respiratory system and cardiovascular system (heart and blood vessels) [14].

Cardiovascular disease is one of the most disease causes of death. Prevention of hypertension focused on traditional prevention efforts such as controlling blood pressure, cholesterol levels, quit smoking and making healthy choices in terms of diet, doing exercise routine, and avoiding passive smoking. However, evidence shows that air pollutants

contribute seriously causing fatal damage to the cardiovascular system and air pollution is a factor that cannot be controlled only through a healthy lifestyle. Harmful air pollutants can cause cardiovascular diseases such as blocked arteries leading to heart attacks and heart tissue death due to lack of oxygen, causing permanent heart damage (formation of infarction). Many research in several countries, have found the results on the effects of air pollution on hypertension. The results of research published in the European Heart Journal found that adults in the same age group who live in areas with high pollution levels are more susceptible to hypertension than those who live in areas with minimal pollution. This risk is equivalent to the effect of obesity with a body mass index between $25\text{-}30 \text{ kg}/\text{m}^2$. Long-term exposure to air pollution is associated with high cases of hypertension [4].

Other evidence of association between $\text{PM}_{2.5}$ with hypertension showed at research in Detroit, a highly-polluted US city that increased $\text{PM}_{2.5}$ levels by $10 \mu\text{g}/\text{m}^3$ resulted in a 3 mmHg increase in systolic blood pressure. The relationship between air pollution exposures and risk of hypertension was also demonstrated in a meta-analysis of 17 epidemiological studies whereas one third of 300.000 participants developed hypertension. The European Study of Cohorts for Air Pollution Effects (ESCAPE) showed that

prolonged exposure to air pollution and traffic noise might be associated with greater incidence of self-reported high blood pressure [15].

Besides respiratory disorders, dust particles can also cause cardiovascular disease. Cardiovascular diseases that associated with air pollution include angina, hypertension, cardiac insufficiency and myocardial infraction [16]. The mechanism of PM_{2.5} to hypertension might caused by an inflammatory mediator due to the inflammatory response to the polluted air in the lungs entering the systemic circulation, and then causing vascular response to the human body. This vascular response can cause hypertension [17].

Particulate matter especially PM_{2.5} in air pollution will cause inflammation in the lungs that can enter the systemic circulation. Inflammation can increase the production of reactive oxygen species (ROS). If antioxidants cannot balance reactive oxygen species (ROS), oxidative stress will occur. This oxidative stress can reduce the bioavailability of nitric oxide (NO). The first mechanism is reactive oxygen species (ROS) reacts directly and deactivates nitric oxide (NO). Second mechanism is reactive oxygen species (ROS) reduces nitric oxide (NO) production by uncoupling endothelial NO synthase (eNOS), eliminating tetrahydrobiopterin which is a cofactor of NOS and increasing assymetrical-

dimethyl-arginine (ADMA) which is an inhibitor of NOS. Reactive oxygen species (ROS) can cause arachidonic acid turn to nonenzymatic oxidation. This oxidation produces proinflammatory vasoconstrictor products in the form of isoprostane which can cause hypertension. In addition, reactive oxygen species (ROS) can also increase intracellular calcium concentration resulting in an increase contraction of vascular smooth muscle. Increased contractions can cause increased systemic vascular resistance, which can cause hypertension. According to the research of Du, Xu and Chu et al. (2016) showed that the relationship between PM_{2.5} and cardiovascular disease is stronger in individuals who have been exposed for more than 5 years [18].

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