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Effect of environmental air pollution on cardiovascular diseases

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Abstract. – OBJECTIVE: Environmental air pollution has become a leading health concern especially in the developing countries with more urbanization, industrialization and rapidly growing population. Prolonged exposure to air pollution is a risk factor for cardiovascular diseases. The present study aimed to investigate the effects of environmental air pollution on progression of cardiovascular problems.

METHODS: In this study, we identified 6880 published articles through a systematic database including ISI-Web of Science, PubMed and EMBASE. The allied literature was searched by using the key words such as environmental pollution, air pollution, particulate matter pollutants PM 2.5 μm-PM 10 μm,. Literature in which environmental air pollution and cardiac diseases were discussed was included. Descriptive information was retrieved from the selected literature. Finally, we included 67 publications and remaining studies were excluded.

RESULTS: Environmental pollution can cause high blood pressure, arrhythmias, enhanced coagulation, thrombosis, acute arterial vasoconstriction, atherosclerosis, ischemic heart diseases, myocardial infarction and even heart failure.

CONCLUSIONS: Environmental air pollution is associated with increased risk of cardiovascular diseases. Environmental pollution exerts its detrimental effects on the heart by developing pulmonary inflammation, systemic inflammation, oxidative stress, endothelial dysfunction and prothrombotic changes. Environmental protection officials must take high priority steps to minimize the air pollution to decrease the prevalence of cardiovascular diseases.

Key Words:
Air pollution, Environmental pollutants, Cardiac problems.

Introduction

Over the last two decades, there has been an increasing concerns globally about the environmental air pollution and its impact on human health. Large number of health problems are related with longterm exposure to environmental pollution. The environmental related diseases acquired during childhood, manifested during adulthood and are not easily diagnosed[1]. Air pollution is a heterogeneous and a complex mixture of dust, fumes, gases, carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ozone (O_3)[2-4]. The particle pollution also called Particulate Matter [PM] is a composite mixture of very small particles and liquid droplets made up of chemicals, acids, metals and soil or dust. The adverse health effects of air pollutants are highly dependent on the pollutant's nature, type, content, chemical composition and an individual's genetic makeup[5-7]. Particulate matter [PM] are broadly categorized by aerodynamic diameter. The particles with an aerodynamic diameter [PM-2.5-10 μm] are called coarse thoracic particles [PM-2.5 μm] fine particles and [PM-0.1 μm] are ultrafine particles[8]. Air pollutants have their own health risk profile and have been linked with pulomary, systemic inflammation, oxidative stress, endothelial dysfunction, prothrombotic and coagulant changes and the progression of atherosclerosis[9-10]. There is a growing evidence that exposure to air pollution is not only associated to respiratory problems but the current perception is that air pollution is the main source of cardiovascular diseases[5], although the evidence is limited and diverse. Therefore, the aim of this study was to assess the association between exposure to environmental air pollution and progression of cardiac problems.

Research Methodology

Selection of studies: For this study, we identified 7038 published articles from systematic database searches including ISI-Web of Science, PubMed and EMBASE. We examined the allied literature by using the key terms including air pollution, environmental pollution, dust, fumes, PM 2.5 μm, PM 10 μm, and gases, carbon monoxide (CO), ozone (O_3), nitrogen dioxide [NO_2) and sulfur dioxide (SO_2). In

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addition, we also entered the keywords in the Google Scholar search engine and after getting any related article, we re-entered the title of that article in the ISI-Web of Science and PubMed to verify for any missing article. The title and abstract of the artiecles were evaluated to determine the eligibility for the documents. All studies in which cardiac problems and environmental air pollution were discussed were considered eligible for inclusion. Studies such as brief communication, editorials, case reports, small sample size studies, non-English language of publications were excluded while cohort, cross sectional studies, systematic review, studies which estimated the effect of long-term exposure to air pollution, including PM 2.5 μm, PM 10 μm, and NO_2, on risk of cardiac problems were included. The studies published in non-ISI and non-pubmed indexed journals were also excluded. We reviewed 6880 papers, finally we included 67 studies and remaining articles were excluded.

Data extraction and quality assessment: Findings were extracted by both investigators; the results were determined by using a standardized form including a full description of the study characteristics.

Ethics statement: For this study we reviewed the database literature on environmental air pollution and cardiac problems, hence we did not require the ethical approval.

Results

Table I demonstrates the effect of various types of environmental air pollutions and their

Table I. Effect of various types of air pollutants and their association with cardiovascular diseases.

Author and year	Pollutants	Cardiovascular diseases
Stanković et al 2015[11]	Black smoke, sulpher di oxide	Increased blood pressure
Giorgini et al 2015[12]	PM 2.5 μm	Increased blood pressure
Dong et al 2015[13]	PM 2.5 μm	Increased blood pressure
Pieters et al 2015[14]	Ultrafine particles	Increased blood pressure
Chan et al 2015[15]	$PM_{2.5}$ and NO_2	Increased blood pressure
Xu and Guo 2013[16]	PM_{10}	IHD
Bennett et al 2014[17]	NOx, Ben	Hear failure
Yang et al 2014[18]	PM, NO_2, SO_2	Heart failure
Siponen et al 2015[19]	PM 2.5 μm	Systemic inflammation
Dutta et al 2015[20]	PM 2.5-PM10 μm	Hypertension, CVD
Li and Chen 2015[21]	PM; 10 μm, SO_2, NO_2	CHD
Ghosh et al 2015[22]	PM, Carbon, gases	CHD
Chen and Weng 2015[23]	$PM_{2.5}$-10 μm	IHD, CHF, arrythmia
Bartel et al 2013[24]	PM	Ventricular tachycardia
Hsieh and Tsai 2013[25]	$PM_{2.5}$	CHF
Shah et al 2013[26]	CO, SO_2, NO_2	HF
Wang et al 2013[27]	PM10, SO_2, NO_2	CHD
Xie et al 2014[28]	PM 10, SO_2,NO_2	Acute MI, ischemic cardiomyopathy, angina, sudden death
Goldberg et al 2015[29]	$PM_{2.5}$, CO	Tachycardia and increased systolic BP
Morishita et al 2015[30]	Coarse PM, Cu, Mo	Tachycardia and increased systolic BP
Bloomfield and Lagat 2012[31]	House-hold air pollution	Pulmonary hypertension, right heart failure
Padula et al 2013[32]	PM 10 μm, heavy traffic Density	Pulmonary valve stenosis and ventricular septal defects,
Agay et al 2013[33]	PM10	Multiple congenital heart defects
Dominguez et al 2013[34]	NO_2	Heart failure
Huang and Deng 2013[35]	$PM_{2.5}$, Black Carbon, CO	Autonomic cardiac dysfunction
Beckerman et al 2012[36]	NO_2	IHD
Gan and Davies 2012[37]	Noise, Black Carbon, NO_2, NO	CHD
Scarborough et al 2012[38]	Air pollution	CHD

PM: Particulate matter with aerodynamic diameter; SO_2; Sulfure dioxide, NO_2; Nitrogen dioxide, CO; Carbon monoxide, IHD: Ischemic heart diseases, MI: Myocardial infarction, CHD: Coronary heart diseases, HF: Heart failure. CVD: Cardiovascular diseases, CAD: Coronary artery disease.

association with cardiovascular diseases (CVD). There is a strong association between CVD and dust, fumes, gases, particulate material PM 2.5 μm-PM 10 μm, nitrogen dioxide (NO_2), carbon monoxide (CO) and sulfur dioxide (SO_2). The air pollutants can cause systemic inflammation, increased blood pressure, pulmonary hypertension, arrhythmias, ventricular septal defect, congenital heart diseases, ischemic heart diseases, cardiomyopathy, angina, myocardial infarction and heart failure.

In addition, vehicular related environmental air pollution can cause high systolic blood pressure, atherosclerosis, arrhythmias, ST-depression and myocardial infarction (Table II).

Discussion

Air pollution is the mixture of dust, fumes, gases, chemicals, particulate matter and biological materials that may cause damage to natural environment and harm to living organisms. The group of molecules and pollutants identified as highly heterogeneous, including dust, fumes, synthetic chemicals, industrial solvents, lubricants, plastics, pesticides and fungicides. Pollutants are different on multiple time scales, emission rates, weather patterns and diurnal/seasonal cycles. The behavior of pollutants is governed by its formation rate and the length of time it remains in the atmosphere. In the present study, we found that environmental pollution can cause pulmonary inflammation, systemic inflammation, increased blood pressure, atherosclerosis, arrhythmias, ischemic heart diseases, cardiomyopathy, heart failure and myocardial infarction.

Literature indicates that particulate matter amount is associated to increase in arterial blood pressure. 1-4 mmHg blood pressure increase per 10 g/m^3 elevation in PM[57]. Long term exposure to increase PM 2.5 μm has been linked with higher concentration of circulating endothelin (ET-1) with an an increase pulmonary arterial pressure[58]. Wu et al[59] found a significant interaction between temperature and traffic-related air pollutants PM ≤ 2.5 μm, organic carbon, elemental carbon and nitrogen dioxide on blood pressure. They conclude that, air pollution affects blood pressure more at low temperature levels than at high temperature levels. Jung et al[60] found that, high systolic and diastolic blood pressure was associated with overweight or obese subjects when they were exposed to longterm pollution. Similarly, Stanković et al[11] reported that exposure to low levels of air pollution increases the blood pres-

Table II. Effect of motor vehicle pollutants and their association with cardiovascular diseases.

Author names and study year	Traffic pollutant	Cardiovascular diseases
Kluizenaar et al 2013[39]	Air pollution, noise	Ischemic heart disease
Dzhambov et al 2015[40]	Air pollution, noise	Myocarial infarction
Kälsch et al 2014[41]	Air pollution, noise	Atherosclerosis
Halonen et al 2013[42]	Noise exposure	Ischemic heart disease
Hart et al 2013[43]	Traffic, NO_2	Myocardial infarction
Hansell et al 2013[44]	Aircraft noise	CAD
Selander et al 2013[45]	Noise, job strain	MI
Sørensen et al 2012[46]	Traffic exposure	Myocardial Infarction
Floud et al 2013[47]	Aircraft noise	Myocardial Infarction
Gan et al 2012[48]	Air pollution	CHD
Woodcock et al 2009[49]	Motor vehicles	Ischemic heart disease
Hoffmann et al 2007[50]	Traffic pollution	Atherosclerosis
Selander et al 2009[51]	Traffic pollution	Myocardial infarction
Gan et al 2010[52]	Traffic pollution	Hypertension heart disease,
Grahame et al 2010[53]	Vehicular emissions	Atherosclerosis, arrhythmias, ST-depression, blood pressure
Su et al 2015[54]	PM 2.5 μm, PM 10 μm, NO_2, NOx	Atherosclerosis
Bard et al 2014[55]	Benzene, gasoline-fueled	Myocardial infarction
Katsoulis et al 2014[56]	Traffic-related air pollution	CVD and IHD

PM: Particulate matter with aerodynamic diameter; SO_2; sulfure dioxide, NO_2; Nitrogen dioxide, CO; Carbon monoxide, IHD: Ischemic heart diseases, MI: Myocardial infarction, CHD: Coronary heart diseases, HF: Heart failure. CVD: Cardiovascular diseases, CAD: Coronary artery disease.

sure. Physical activity has proved to be statistically significant protective factor for the development of hypertension. Bilenko et al[61] investigated the association between particulate matter composition and blood pressure. They found that, exposure to particulate matter constituents increases blood pressure in children. Similarly, Giorgini et al[12] and Chan et al[15] reported that, short-term exposures to ambient PM 2.5 μm and residential air pollution associated with substantial increases in BP. Pieters et al[14] also found that children attending school on days with higher UFP concentrations (diameter < 100 nm) had higher systolic blood pressure. Prolonged PM 2.5 μm and NO_2 exposures were associated with high blood pressure.

Lee et al[62] reported that, the association of PM 2.5 μm and PM 10 μm, nitrogen dioxide (NO_2), and elemental carbon were associated with cardiovascular diseases, stroke, and altered blood pressure. Similarly, Kälsch et al[41] investigated associations of long-term exposure to fine PM and road traffic noise with thoracic aortic calcification (TAC). They found that, exposure to fine PM and night-time traffic noise are associated with subclinical atherosclerosis.

The epidemiological and experimental studies demonstrated that short and long-term exposure to particulate matter PM2.5 μm is associated with cardiovascular diseases including myocardial infarction, stroke, heart failure, arrhythmias, and venous thromboembolism[63]. To et al[64] found that, congestive heart failure, ischemic heart disease and cerebrovascular accident were 20% upsurge with increase in PM 2.5 μm after adjusting for risk factors. Moreover, risks were elevated in smokers and those with obesity. Colais et al[65] found that an increased risk of cardiac admissions was associated to 10 μg/m PM 10 μm pollutants. The effect was higher for cardiac failure and acute coronary syndrome than for arrhythmias. Females were at higher risk of heart failure, whereas males were at higher risk of arrhythmias.

Furthermore, Li and Chen[21], Ghosh et al[22], Wang et al[27], Gan and Davies[38], Scarborough et al[38]; de-Kluizenaar et al[39] determined the association between air pollutants and coarse particles levels (PM 2.5-10 μm) with frequency of hospital admissions and mortality due to cardiovascular diseases (CHD). They reported that environmental pollution increases the CHD with an increase in particulate matter and sulfur dioxide and nitrogen dioxide. Mustafic et al[66] also observed that short-term exposure to air pollutants including carbon monoxide, nitrogen dioxide, sulfur dioxide and particulate matter PM 2.5-10 μm are linked with acute coronary syndrome and myocardial infarction. Pope et al[67] demonstrated that, fine particulate matter (PM 2.5 μm) air pollution contributes to risk of cardio-metabolic disorders and increasing risk of coronary artery disease. Padula et al[32] found that PM 10 μm are ssociated with pulmonary valve stenosis and ventricular septal defects.

The literature confirmed that air pollution is a leading risk factor in the development of cardiovascular diseases. The possible mechanism for the adverse effect of air pollution on cardiovascular diseases is the pulmonary, systemic inflammation, endothelial damage, oxidative stress and prothrombotic changes (Figure 1).

Larger cohort studies, especially from developing countries, are needed to provide a more precise assessment of the adverse effects of long-term exposure to air pollution on cardiovascular diseases.

Conclusions

Exposure to air pollutants is associated with increased risk of cardiovascular diseases. Air pollutants exert their detrimental effects on heart by developing pulmonary inflammation, systemic inflammation, oxidative stress, endothelial dysfnction and platelets and prothrombotic changes, atherosclerosis, coronary artery disease and congestive heart failure. The findings suggest an important health impact on human populations, occupational and environmental health officials must develop policies to minimize air pollution to decrease the cardiovascular diseases. Moreover, the researchers and physicians must consider the environmental pollution as a serious and an emerging factor in the development of cardiovascular diseases.

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Conflict of Interest

The Authors declare that there are no conflicts of interest.

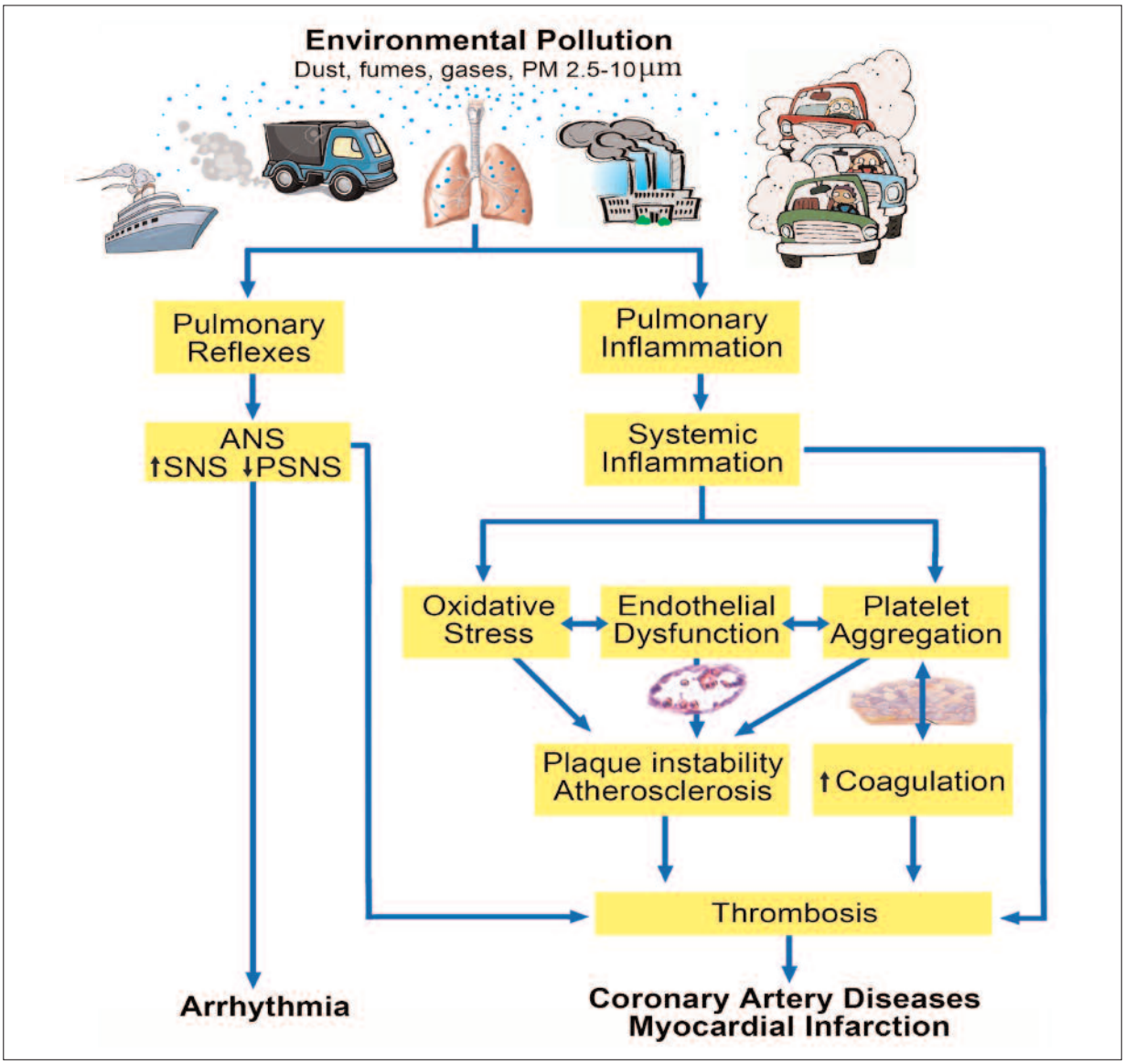

Figure 1. Mechanism involved in environmental pollution and cardiovascular diseases.

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