



Journal of Biological Sciences

ISSN 1727-3048

science
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Air Pollution and In-Hospital Mortality of Ischemic Heart Disease Patients

¹S. Saadat, ²S. Sadeghian, ³R. Hamidian and ⁴M.A. Najafi

¹Sina Trauma Research Center, Tehran University of Medical Sciences, Tehran, Iran

²Tehran Heart Center Hospital, Tehran University of Medical Sciences, Tehran, Iran

³Clinical and Experimental Unit, Tehran Heart Center Hospital,
Tehran University of Medical Sciences, Tehran, Iran

⁴Division of Air Pollution Modeling, Air Quality Control Company,
Tehran Municipality, Tehran, Iran

Abstract: This study is aimed to evaluate the impact of air pollution on the in-hospital mortality of ischemic heart disease patients in Tehran as a polluted metropolis. A cross sectional study conducted in Tehran heart center. We compared two separate exposure levels of air pollutants in patients expired in hospital (n = 23) versus patients discharged alive (n = 1219). The first was air pollutants daily mean concentration at the date of admission and the second was air pollutants daily mean concentration at the date of admission and the three following days. Patients' demographic, clinical and paraclinical data were gathered from the hospital databank between 23 September and 21 December 2005. Meteorological data were obtained from Tehran air quality control company. In-hospital mortality rate was 1.9% for men and 1.8% for women. The expired patients were older than survived patients. The mean concentration of carbon monoxide, dust, nitrous oxide, other nitrogen compounds and sulfur dioxide were significantly higher and mean temperature was significantly lower at admission date of expired patients. In expired patients, mean concentrations of nitrous oxide, nitrogen dioxide, other nitrogen compounds, sulfur dioxide, dust and non-methane hydrocarbons were significantly higher at admission date and three following days compared to survived patients. There was significant direct relationship between air pollution level and in-hospital mortality of ischemic heart disease patients.

Key words: Air pollution, coronary disease, epidemiology, ischemic heart disease, mortality

INTRODUCTION

Industrial progress during several past decades has led to production of numerous environmental pollutants including air pollutants. In the developed countries, air pollution is under surveillance and controlled to some extent; it is, however, rising in the developing countries due to unstructured changing of traditional to industrialized lifestyle and absence of a strict control on environmental pollution (Mage *et al.*, 1996; Mayer, 1999).

On the other hand, there is an increasing occurrence of cardiovascular diseases and related mortality in developing countries imposing immense socioeconomic burden on the society (Furman *et al.*, 2001; Boersma *et al.*, 2003). Many studies have increasingly shown a marked relationship between short- and long-term exposure to air pollution and cardiovascular morbidity and mortality; but much is remained to be understood about this correlation. Increasing surveys with different approaches (daily time-series, case-crossover, cohort, etc.) have proposed that

there is a prominent correlation between ambient air pollution and coronary adverse events (Maheswaran *et al.*, 2005). Moreover, patients who survive Acute Myocardial Infarction (AMI) are at increased risk of recurrent ischemic events (Jokhadar *et al.*, 2004) and heart failure (Hellermann *et al.*, 2003).

Tehran, the capital of Iran, is a metropolis with approximately 7.9 million population and total area of about 700 km², which only 30% of the days in year profits healthy air quality (Institutes for Global Environmental Strategies, 2003). Tehran air pollution is monitored by Air Quality Control Company (AQCC), a sub division of Tehran municipality. The AQCC records the hourly concentration of air pollutants according to the US Environmental Protection Agency (1998) through its several stations across Tehran.

Tehran Heart Center (THC) was founded in Tehran in January 2003 to provide specialized services to cardiovascular patients. Annually, 14000 patients with

coronary artery diseases are admitted to THC; their clinical data are stored in a data bank under rigid quality control.

A critical period of air pollution occurred in the Autumn 2005, from 28 November to 11 December. Pollutant Standard Index (PSI) rose above 310 and concentration of air pollutants reached to hazardous on the night of 29 November. The red alarm for air pollution was announced on 30 November 2005 that led to closing of schools and government offices on 4 December 2005. Since, even acuteness or chronicity of the air pollution exposure can affect the risk of adverse events (Johnson, 2004), this polluted period provoked this study to evaluate the effect of air pollution on the in-hospital mortality of Ischemic Heart Disease (IHD) patients admitted to THC during the Autumn 2005.

MATERIALS AND METHODS

Study population: The study was conducted in THC. Patients admitted to THC are mainly residents of Tehran.

Study design: This is a cross sectional study. The exposure level of IHD patients expired in hospital during the Autumn 2005 was compared to that of IHD patients discharged alive during the same period.

Patients admitted in THC during the Autumn 2005 (23 September until 21 December 2005) with primary diagnosis of IHD, were recruited into the study. This period of time spanned duration of air pollution crisis. In case electrophysiological and enzymatic investigation did not confirmed IHD diagnosis for a patient, he/she was excluded from the study.

Patients' data were gathered from the hospital databank which contains demographic, clinical and paraclinical data of all patients admitted since January 2003 (the beginning of the hospital activity) under rigid quality control supervision.

The study was ethically approved in THC board of review. The ethical committee waived the need for patients' written consent considering all data were gathered from hospital databank and the fact that patients had already permit the hospital by written consent to use their data anonymously for research purposes.

Exposure measurement: Meteorological data from 23 September until 21 December 2005 (Autumn 2005) were obtained from AQCC. The daily mean concentration of the air pollutants over the whole city was used as exposure level. The acquired data included hourly concentration of nitrogen dioxide (NO₂), nitrous oxide (NO), other nitrogen compounds (NO_x), sulfur dioxide (SO₂), carbon monoxide (CO), 8 h ground level ozone (O₃), dust (including

particulate pollutants with diameter 2.5 to 10 μm), hydrocarbons (CH) and non-methane hydrocarbons (NMHC).

We used two different indices as exposure level. The first was the daily mean concentration of air pollutants at the date of admission of patients. The second measure was mean concentration of air pollutants at the date of admission and the three following days which was calculated for every patient.

To control the effect of age and AMI on relationship between air pollution level and in hospital mortality, logistic regression approach was used. We considered in hospital mortality as dependant variable and forced AMI and age into the model then put air pollutants in the logistic model. Considering the correlation of every air pollutant with other pollutants, we did not put all pollutants in the same model instead; we fitted several models each containing age, AMI and daily mean concentration of one single pollutant.

The p-value <0.05 was considered significant.

RESULTS

During the Autumn, 1242 patients eligible to this study were admitted to THC; they were consisted of 557 (44.8%) female and 685 (55.2%) males. The mean age of male patients was 60.4 (SD:12.76) years and that of females was 63.8 (SD: 10.95); the difference was statistically significant (p<0.001). Twenty three patients expired in hospital during the Autumn 2005. The general in-hospital mortality rate was similar in both genders: 1.9% for men and 1.8% for women. The AMI was more common in men (31.1%) compared to women (14.7%) (p<0.001). Patients expired in hospital were older than patients discharged alive and the difference was statistically significant (Table 1).

Table 2 shows the daily mean concentration of air pollutants at admission date of patients died in hospital compared to patients discharged alive. The mean concentration of CO, dust, NO, NO_x and SO₂ were significantly higher at admission date of died patients. There was not statistically significant difference in wind speed and mean concentration of hydrocarbons and O₃ at admission date of died patients compared to others.

To control the effect of AMI and age on the association between mortality and air pollutants we used logistic regression. The association between daily mean concentration of CO, dust, NO, NO_x and SO₂ remained statistically significant after controlling the effect of AMI and age (p<0.05).

We attempted to determine either the air pollution level at the admission date or the air pollution during

Table 1: Characteristics of IHD patients died in hospital and patients discharged alive

Variables	Died	Discharged alive	p-value
Number	23 (1.9%)	1219 (98.1%)	-
Mean age (SD)	71.43 (13.225)	61.73 (12.004)	<0.001
Gender			
Male	13 (1.9%)	672 (98.1%)	0.894
Female	10 (1.8%)	547 (98.2%)	
AMI			
Yes	19 (6.4%)	276 (93.6%)	<0.001
No	4 (0.4%)	943 (99.6%)	

SD: Standard deviation; AMI: Acute myocardial infarction

Table 2: Daily mean concentration of air pollutants at admission date of patients died in hospital and patients discharged alive

Air pollutant	Daily mean concentration at admission date (ppm)		Difference	p-value
	Patients died in hospital	Patients discharged alive		
CH	4.2291	3.9403	0.2888	>0.050
CO	10.6141	8.7454	1.8687	0.042
Dust	166.3109	137.7358	28.5751	0.005
NO	0.3198	0.2757	0.0441	0.021
NOx	0.4014	0.3420	0.0594	0.010
Ozone	0.0148	0.0140	0.0008	>0.050
SO ₂	0.1445	0.1175	0.027	0.003

CH: Hydrocarbon, CO: Carbon monoxide, NO: Nitrous monoxide, NOx: Nitrous oxide, SO₂: Sulfur dioxide, ppm: Part per million

Table 3: Mean concentration of air pollutants in first 4 days of admission of patients died in hospital and patients discharged alive

Air pollutant	Mean concentration in first 4 days of admission (ppm) [¶]		Difference	p-value
	Patients died in hospital	Patients discharged alive		
CH	4.3442	3.9722	0.3720	0.050
CO	10.9075	8.9768	1.9353	>0.050
Dust	160.9785	140.1075	20.8710	0.050
NO	0.3205	0.2826	0.0379	0.009
NO ₂	0.0797	0.0667	-0.01299	0.002
NOx	0.4002	0.3493	0.0509	0.035
Ozone	0.0167	0.0143	0.0024	>0.050
SO ₂	0.1418	0.1210	0.0208	0.011*

CH: Hydrocarbon, CO: Carbon monoxide, NO: Nitrous monoxide, NOx: Nitrous oxide, SO₂: Sulfur dioxide, ppm: Part per million

hospitalization had more strong relationship with in-hospital mortality. We calculated mean concentration of the air pollutants at the date of admission and three subsequent days for every patient as another measurement of exposure level (Table 3). The mean concentrations of NO, NO₂, NOx, SO₂, dust and CH were significantly higher at admission date and three following days of patients died in hospital.

DISCUSSION

Occurrence of air pollution crisis in Autumn 2005 triggered the present study to evaluate the effect of air pollution on the IHD patients' mortality as vulnerable people to air pollution. In this study, we did not intend to evaluate underlying mechanism of relationship between

air pollution and mortality; instead, we documented this relationship specifically on in-hospital mortality. According to our findings, there is a significant relationship between air pollution and in-hospital mortality. This finding is in agreement with some other studies (Zeller *et al.*, 2006).

There are some explanations for such a relationship in the literature. Atherothrombotic effect of air pollutants could lead to myocardial infarction and ischemic stroke (Zeller *et al.*, 2006). Many studies proposed different underlying mechanisms including inflammatory responses leading to plasma histamine activity and thrombotic tendency (Nemmar *et al.*, 2001, 2002, 2005; Hoek *et al.*, 2001; Khandoga *et al.*, 2004) increased volume and advanced phenotype of coronary atherosclerosis (Suwa *et al.*, 2002), altered endothelial function and activated sympathetic response (Rajagopalan *et al.*, 2005).

A study by Peters *et al.* (2001) concluded that age older than 60 years is a risk factor for cardiovascular mortality after exposure to air pollution. The mean age of patients admitted in THC was more than 60 years.

Air pollution might cause deterioration of health status of patients with lower cardiovascular reservoir. This may increase frequency of refer of patients with serious cardiovascular diseases to the hospital, which in turn results in increased in-hospital mortality. Other explanations of increased in hospital mortality following air pollution crisis might be as following: increased risk of myocardial infarction following exposure of susceptible persons to air pollution (Peters *et al.*, 2004; Vermynen *et al.*, 2005), heart rate variability in AMI patients exposed to air pollution (Wheeler *et al.*, 2006), increased risk of MI among patients exposed to pollution (D'Ippolitti *et al.*, 2003; Von klot *et al.*, 2005) and increased mortality in MI patients (Biggeri *et al.*, 2004). Adjustment of the effect of AMI and age did not remove the difference in air pollutants level among cases and controls. We conclude that air pollution has an independent effect on in-hospital mortality. As mentioned above, we did not intend to investigate the probable underlying mechanism of impact of air pollution on cardiovascular mortality; but as a presumable cause we can lay stress on arrhythmias (Wheeler *et al.*, 2006; Anderson *et al.*, 2003), aggravation of baseline risk factors (Anderson *et al.*, 2003) and cytokines derangement (Brook *et al.*, 2004).

Besides, another probable explanation for raised in-hospital mortality might be the effect of indoor air pollution. Although, THC has utilized HEPA filtering system which purifies dust and particulate matters, it is not capable of absorption of gaseous pollutants including CO, SO₂, NO and NOx. The higher mean concentration of

pollutants in the first 4 days of admission of died patients, is consistent with this hypothesis. According to a detailed study by department of environment of Australia, indoor air pollution (especially NO₂, CO and CH) is 3-5 times more than outdoors. The reason is simple: there is no source of air production within buildings and the air inside buildings originates from outdoors atmosphere.

Barnett *et al.* (2006) showed that CO, NO₂ and particulate pollutants significantly influence on cardiovascular admissions in the elderly. This could partly explain the association of air pollution and in hospital death. Meanwhile, increased admission of elderly could not be considered the only reason of relationship between air pollution and in-hospital mortality as the association remained significant after adjustment for age.

PM10 is represented to be responsible for higher admission for cardiovascular diseases, AMI occurrence and increases cardiovascular mortality (Brook *et al.*, 2004). In the present study, we failed to separate the components of dust, but since dust is composed of particulate matters (including PM2.5 and PM10) we may extend our finding about dust to the particulate pollutants.

Present study was subject to limitations. We did not measure the air pollution level of admitted patients' home. Patients' exposure to air pollution at their home or work place may affect their hospitalization outcome and we were not able to measure it. It was not possible to differentiate Particulate Matter pollution according to particle size. We measured all particulate matters generally as dusts.

CONCLUSION

We found significant direct association between air pollution level (mostly CO, dust, NO, NO_x and SO₂) and in-hospital mortality of ischemic heart disease patients. This association remained significant after adjustment for AMI and age of patients.

ACKNOWLEDGMENTS

We appreciate AQCC, especially Yusef Rashidi, CEO of AQCC, Solmaz Ahadi and Shima Almasi (both in charge of data monitoring). We also especially thank Zohre Mansour Khosravi (Senior Meteorologist and in charge of Tehran province weather prediction, Islamic Republic of Iran Meteorological Organization). This study is funded by Clinical and Experimental Research Unit, Tehran Heart Center hospital, Tehran University of Medical Sciences.

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