



ISFAHAN UNIVERSITY OF MEDICAL SCIENCES

SCHOOL OF MEDICINE

CARDIOLOGY DEPARTMENT

Thesis for obtaining the speciality degree in cardiology

Title:

**Exposure to Occupational Air Pollution and  
Vascular Endothelial Dysfunction in Workers  
of the Esfahan Steel Industry, Iran**

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## ABSTRACT

**Background:** Air pollution is a risk factor for cardiovascular diseases, but the mechanisms are not clear yet.

**Aims:** We investigated occupational air pollution exposure and endothelial function among workers of the steel industry.

**Methods:** Workers of the coke-making part of the Esfahan Steel Company and workers in the administrative parts with no known history of cardiovascular risks were studied. Data of age, body mass index, duration of employment, blood pressure, fasting blood sugar, and lipid profile were gathered. Flow-mediated dilation (FMD) was measured to evaluate endothelial function.

**Results:** Baseline brachial artery diameter was greater (mean difference [95% CI] = 0.068 mm [0.008 to 0.128]), but the FMD was lower (mean difference [95% CI] = -0.908 % [-1.740 to -0.075]) in the coke-making group compared with controls. Controlling for possible confounders, working in the coke-making part of the industry was associated with lower FMD ( $F = 3.954$ ,  $P = 0.049$ ).

**Conclusions:** These results show that occupational air pollution exposure in workers of the steel industry is associated with impaired endothelium-dependent vasodilation.

**Keywords:** Occupational Exposure, Air Pollution, Cardiovascular Diseases, Endothelium, Steel, Coke

## References

1. Su TC, Chen SY, Chan CC. Progress of ambient air pollution and cardiovascular disease research in Asia. *Prog Cardiovasc Dis* 2001; 53: 369-78.
2. Shah AS, Langrish JP, Nair H, McAllister DA, Hunter AL, Donaldson K, et al. Global association of air pollution and heart failure: a systematic review and meta-analysis. *Lancet* 2013;382: 1039-48.
3. Yamamoto SS, Phalkey R, Malik AA. A systematic review of air pollution as a risk factor for cardiovascular disease in South Asia: limited evidence from India and Pakistan. *Int J Hyg Environ Health* 2014; 217: 133-44.
4. Brook RD, Franklin B, Cascio W, Hong Y, Howard G, Lipsett M, et al. Air pollution and cardiovascular disease: a statement for healthcare professionals from the Expert Panel on Population and Prevention Science of the American Heart Association. *Circulation* 2004; 109: 2655-71.
5. Chin MT. Basic mechanisms for adverse cardiovascular events associated with air pollution. *Heart* 2015; 101: 253-6.
6. Mills NL, Donaldson K, Hadoke PW, Boon NA, MacNee W, Cassee FR, et al. Adverse cardiovascular effects of air pollution. *Nat Clin Pract Cardiovasc Med* 2009; 6: 36-44.
7. Tornqvist H, Mills NL, Gonzalez M, Miller MR, Robinson SD, Megson IL, et al. Persistent endothelial dysfunction in humans after diesel exhaust inhalation. *Am J Respir Crit Care Med* 2007; 176: 395-400.
8. Brook RD, Brook JR, Urch B, Vincent R, Rajagopalan S, Silverman F. Inhalation of fine particulate air pollution and ozone causes acute arterial vasoconstriction in healthy adults. *Circulation* 2002; 105: 1534-6.
9. Krishnan RM, Adar SD, Szpiro AA, Jorgensen NW, Van Hee VC, Barr RG, et al. Vascular responses to long- and short-term exposure to fine particulate matter: MESA Air (Multi-Ethnic Study of Atherosclerosis and Air Pollution). *J Am Coll Cardiol* 2012; 60: 2158-66.

10. Lanzinger S, Breitner S, Neas L, Cascio W, Diaz-Sanchez D, Hinderliter A, et al. The impact of decreases in air temperature and increases in ozone on markers of endothelial function in individuals having type-2 diabetes. *Environ Res* 2014; 134:331-8.
11. Kato T, Inoue T, Morooka T, Yoshimoto N, Node K. Short-term passive smoking causes endothelial dysfunction via oxidative stress in nonsmokers. *Can J Physiol Pharmacol* 2006; 84: 523-9.
12. Heiss C, Amabile N, Lee AC, Real WM, Schick SF, Lao D, et al. Brief secondhand smoke exposure depresses endothelial progenitor cells activity and endothelial function: sustained vascular injury and blunted nitric oxide production. *J Am Coll Cardiol* 2008; 51: 1760-71.
13. Gul I, Karapinar H, Yarlioglu M, Ozdogru I, Kaya MG, Yilmaz A, et al. Acute effects of passive smoking on endothelial function. *Angiology* 2011; 62: 245-7.
14. Pinnamaneni K, Sievers RE, Sharma R, Selchau AM, Gutierrez G, Nordsieck EJ, et al. Brief exposure to secondhand smoke reversibly impairs endothelial vasodilatory function. *Nicotine Tob Res* 2014; 16: 584-90.
15. Weber LP, Al-Dissi A, Marit JS, German TN, Terletski SD. Role of carbon monoxide in impaired endothelial function mediated by acute second-hand tobacco, incense, and candle smoke exposures. *Environ Toxicol Pharmacol* 2011; 31: 453-9.
16. Newby DE, Wright RA, Labinjoh C, Ludlam CA, Fox KA, Boon NA, et al. Endothelial dysfunction, impaired endogenous fibrinolysis, and cigarette smoking: a mechanism for arterial thrombosis and myocardial infarction. *Circulation* 1999; 99: 1411-5.
17. Fang SC, Cassidy A, Christiani DC. A systematic review of occupational exposure to particulate matter and cardiovascular disease. *Int J Environ Res Public Health* 2010; 7: 1773-806.
18. Friesen MC, Demers PA, Spinelli JJ, Eisen EA, Lorenzi MF, Le ND. Chronic and acute effects of coal tar pitch exposure and cardiopulmonary

mortality among aluminum smelter workers. *Am J Epidemiol* 2010; 172: 790-9.

19. Gallagher LG, Ray RM, Li W, Psaty BM, Gao DL, Thomas DB, et al. Occupational exposures and mortality from cardiovascular disease among women textile workers in Shanghai, China. *Am J Ind Med* 2012; 55: 991-9.

20. Hart JE, Garshick E, Smith TJ, Davis ME, Laden F. Ischaemic heart disease mortality and years of work in trucking industry workers. *Occup Environ Med* 2013; 70: 523-8.

21. Costello S, Brown DM, Noth EM, Cantley L, Slade MD, Tessier-Sherman B, et al. Incident ischemic heart disease and recent occupational exposure to particulate matter in an aluminum cohort. *J Expo Sci Environ Epidemiol* 2014; 24: 82-8.

22. Jena PK, Behera DK, Mishra CS, Mohanty SK. Assessment of air quality in and around a steel industry with direct reduction iron route. *J Environ Sci Eng* 2011; 53: 437-42.

23. Liu L, Kauri LM, Mahmud M, Weichenthal S, Cakmak S, Shutt R, et al. Exposure to air pollution near a steel plant and effects on cardiovascular physiology: a randomized crossover study. *Int J Hyg Environ Health* 2014; 217: 279-86.

24. Utell MJ, Frampton MW, Zareba W, Devlin RB, Cascio WE. Cardiovascular effects associated with air pollution: potential mechanisms and methods of testing. *Inhal Toxicol* 2002; 14: 1231-47.

25. Atkinson G, Batterham AM. The percentage flow-mediated dilation index: a large-sample investigation of its appropriateness, potential for bias and causal nexus in vascular medicine. *Vasc Med* 2013; 18: 354-65.

26. Thijssen DH, Black MA, Pyke KE, Padilla J, Atkinson G, Harris RA, et al. Assessment of flow-mediated dilation in humans: a methodological and physiological guideline. *Am J Physiol Heart Circ Physiol* 2011; 300: H2-12.

27. Green DJ, Jones H, Thijssen D, Cable NT, Atkinson G. Flow-mediated dilation and cardiovascular event prediction: does nitric oxide matter? *Hypertension* 2011; 57: 363-9.
28. Vardavas CI, Panagiotakos DB. The causal relationship between passive smoking and inflammation on the development of cardiovascular disease: a review of the evidence. *Inflamm Allergy Drug Targets* 2009; 8: 328-33.
29. Langrish JP, Unosson J, Bosson J, Barath S, Muala A, Blackwell S, et al. Altered nitric oxide bioavailability contributes to diesel exhaust inhalation-induced cardiovascular dysfunction in man. *J Am Heart Assoc* 2013; 2: e004309.
30. Ikeda M, Watarai K, Suzuki M, Ito T, Yamasaki H, Sagai M, et al. Mechanism of pathophysiological effects of diesel exhaust particles on endothelial cells. *Environ Toxicol Pharmacol* 1998; 6: 117-23.
31. Yang B, Li M, Chen B, Xu Y, Li TD. Deterioration of endothelial function and carotid intima-media thickness in Tibetan male adolescents exposed to second-hand smoke. *J Renin Angiotensin Aldosterone Syst* 2012; 13: 413-9.
32. Bouthillier L, Vincent R, Goegan P, Adamson IY, Bjarnason S, Stewart M, et al. Acute effects of inhaled urban particles and ozone: lung morphology, macrophage activity, and plasma endothelin-1. *Am J Pathol* 1998; 153: 1873-84.
33. Vyas MV, Garg AX, Iansavichus AV, Costella J, Donner A, Laugsand LE, et al. Shift work and vascular events: systematic review and meta-analysis. *BMJ* 2012; 345:e4800.
34. Backe EM, Seidler A, Latza U, Rossnagel K, Schumann B. The role of psychosocial stress at work for the development of cardiovascular diseases: a systematic review. *Int Arch Occup Environ Health* 2012; 85: 67-79.
35. Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, et al. Auditory and non-auditory effects of noise on health. *Lancet* 2014; 383: 1325-32.