

Conference Paper

HbA_{1c}, Total IgE, and TNF α as Blood Markers for Long Exposure of Traffic-related Fine Particles: A Study on Mechanics at Vehicle Test Stations

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Abstract

Particulate matter such as hydrocarbons, sulfur oxides (SO_x), and nitrogen oxides (NO_x) dominate air pollutants released from vehicle emission and are notorious for their adverse health effects. High concentrations of traffic-related air pollutants in urban areas are sometimes neglected by society despite being harmful to human health. This study aimed to discover the blood markers of traffic-related particulate matter in humans. The study collected traffic-related particulate matter 2.5 (PM_{2.5}) data from 32 mechanics working in vehicle emission test stations in Pulo Gadung and Ujung Menteng, Jakarta. Every measurement was made according to the Environmental Protection Agency Isopropil Alcohol 10A (EPA IP 10 A) method. Blood and urine samples were collected from 43 mechanics as an exposed group and 23 non-exposed workers as a control. Profile lipid, glycated haemoglobin (HbA_{1c}), total Immunoglobulin (IgE), calcium, and Tumor Necrosis Factor- α (TNF α) in blood were measured in all 66 samples. Urinary 1-hydroxypyrene (1-OHP) was detected in 21 exposed group samples using a liquid chromatography fluorescence detector. As a result, the mean concentration of PM_{2.5} from mechanics was $306.91 \pm 99.19 \mu\text{g}/\text{m}^3$. Independent t-test results of the biochemical analysis from blood examination within those groups showed a significant difference in several parameters such as triglyceride ($p = 0.005$), HbA_{1c} NGSP ($p = 0.01$), HbA_{1c} IFFC ($p = 0.01$), total IgE ($p = 0.02$), calcium ($p = 0.03$), and TNF α ($p = 0.00$). Total cholesterol and personal PM_{2.5} exposure showed a moderate correlation with $r = 0.355$ ($p = 0.046$). Urinary 1-OHP mean concentration from the exposed group was $21.61 \pm 10 \mu\text{g}/\text{L}$. In conclusion, HbA_{1c}, IgE, and TNF α can be considered as a blood marker for long exposure to PM_{2.5}, while further study is needed to determine the possibility of using 1-OHP as non-invasive method to detect the particulate matter exposure in humans, particularly from traffic-related sources.

Keywords: Biomarker, Fine Particles, Tnf α , 1-OHP, Vehicle Emission

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1. INTRODUCTION

Particulate matter such as hydrocarbons, sulfur oxides (SO_x), and nitrogen oxides (NO_x) dominate the air pollutants released from vehicle emissions and are notorious for their adverse health effects. Motor vehicle emissions are one of the largest sources of particulate matter, especially diesel-engined vehicles. Diesel engines that are widely used for the transportation industry have the potential to emit exhaust gas (gas exhaust) which contains a mixture of gas and very small particles that can endanger health. Particulate components of diesel exhaust which include a mixture of black carbon, carbon organic elements, sulfates, metals and trace elements are known as Diesel Particulate Matter [4].

Another study stated that exposure to traffic-related particulate matter is responsible for several adverse health effects such as lung dysfunction, asthma, chronic obstructive pulmonary disease (COPD), arteriosclerosis, and stroke [3, 8].

Studies related to the association between particulate exposure and reproductive system dysfunction are still uncommon. Our prior study using male Fischer 344 rats found that nano-sized particle from diesel engine emission was responsible for reproductive dysfunction such as an increase of the testosterone hormone in low (15 µg/m³) and middle (36 µg/m³) exposure groups [9]. Society sometimes neglects high concentrations of traffic-related air pollutants in urban areas despite being harmful to human health. This study aimed to discover the blood markers of traffic-related particulate matter in humans.

2. METHODS

Coarse, fine, and ultrafine particles were collected according to the EPA IP-10A method adapted SKC Inc. using the Sioutas Cascade Impactor, which can divide particulate matter by size. Four 25 mm and one 37 mm diameter quartz fiber filters were placed in the impactor and sucked by the Leland Legacy personal pump with a flow rate of 9 L/min. Thirty-four mechanics from both Pulogadung and Ujung Menteng vehicle test stations were selected to use these particulate matter personal exposure apparatus during their work time. The mean concentration of particulate matter was calculated by a gravimetric method using a micro balance, in which all the filters were conditioned in a balanced room for 24 hours before initial and final weighing.

Prodia Laboratories conducted all blood tests. A spectrophotometric method was used for the determination of a lipid profile in blood. HbA_{1c} in blood and

1-hydroxypyrene (1-OHP) in urine were measured using the high-performance liquid chromatography ion exchange technique. Immunochemiluminescent assay and ortho measured total IgE and calcium levels. Furthermore, immunoturbidimetric and electrochemiluminescence immunoassay (ECLIA) methods were used to determine the concentration of hs-CRP and testosterone. For the last test, nitrate/nitrite colorimetric assay and human TNF immunoassay were selected as methods to calculate the concentration of nitrogen Oxide (NO) and TNF α .

All the gathered data would be calculated statistically using an independent t-test that would be applied to exposed and control groups. Correlation between all blood markers and fine particle concentrations would be calculated statistically using simple linear regression and Pearson's correlation test.

3. RESULTS

Particulate matter was gathered from 32 respondents in both Pulogadung and Ujung Menteng. Every respondent was asked to use particulate matter sampling apparatus during their work hours for various durations from 6 to 12 hours a day. The mean concentration of fine particle personal exposure for mechanics was $306.91 \pm 99.2 \mu\text{g}/\text{m}^3$. Fine particles peaked at $480.57 \mu\text{g}/\text{m}^3$ and no sample was below $110.7 \mu\text{g}/\text{m}^3$.

The mean concentration of the total of LDL and HDL cholesterol did not show any significant differences, while the mean comparison of a triglyceride in the exposed and the control groups showed a significant difference with $p = 0.005$. Both HbA1c NGSP and IFFC also showed a significant difference with $p = 0.01$ and 0.011 , respectively. Similar to the prior results, calcium and TNF α had significant differences while the other parameters, such as the total IgE, hs-CRP, and NO, had no significant differences.

The urinary 1-OHP mean concentration was calculated from 21 urine sample in the exposed group. The 1-OHP mean concentration for the exposed group was 21.61 ± 10 ppb. The minimum and maximum concentrations of all samples were 7.85 and 45.20, respectively.

4. DISCUSSION

The abundant levels of particulate matter in the vehicle emission tests correlated with the work performed there. The vehicle emission test sites in Pulogadung and Ujung Menteng had the same workplace design, where the sites were shaped like a tunnel with one entry and exit door for the vehicle that would be tested. The vehicle would

TABLE 1: Blood markers mean concentration for exposed and control groups.

Parameter	Mean concentration		Unit value
	Exposed Group	Control	
Total cholesterol	196.30 ± 33.14	196.60 ± 34.40	mg/dL
Low Density Lipoprotein (LDL) cholesterol	128.25 ± 29.39	121.52 ± 30.23	mg/dL
High Density Lipoprotein (HDL) cholesterol	42.79 ± 7.34	46.87 ± 9.25	mg/dL
Triglyceride	190.74 ± 120.26	123.60 ± 65.83	mg/dL
Testosterone	445.04 ± 152.78		ng/dL
HbA _{1c} (NGSP)*	6.24 ± 2.11	5.34 ± 0.37	% of total Hb
HbA _{1c} (IFCC)**	44.58 ± 23.20	34.91 ± 4.22	mmol/mol
Total IgE	473.47 ± 713.28	163.69 ± 207.33	µg/L
Calcium	9.06 ± 0.37	9.30 ± 0.38	mg/dL
High-sensitivity C-reactive protein (hs-CRP)	3.84 ± 4.19	2.81 ± 5.84	mg/L
TNF α	3.05 ± 2.51	1.31 ± 0.70	pg/ml
NO	4.19 ± 2.32	3.26 ± 1.09	
*National Glycohemoglobin Standardization Program			
**International Federation of Clinical Chemistry			

be checked at several points along the tunnel by mechanics. The particulate matter itself was emitted from vehicle combustion emission, the braking process, and road dust from the vehicle's tires. The majority of tests at the sites were of heavy vehicles using a diesel engine. The mean concentration of fine particles in this study was double those of a previous study conducted at Pulogadung vehicle test stations in 2015 [10].

Of all blood markers tested using independent t-tests, several parameters showed significant differences; these were triglyceride ($p = 0.005$), HbA_{1c} NGSP ($p = 0.01$), HbA_{1c} IFCC ($p = 0.01$), total IgE ($p = 0.02$), calcium ($p = 0.03$), and TNF α ($p = 0.00$). The individual mean concentration of fine particle exposure and personal total cholesterol levels also showed moderate correlation with $r = 0.355$ ($p = 0.046$). This result was in line with a 10-year cohort study of 73,117 subjects and over 600,000 samples from the largest healthcare provider in Southern Israel, which found an association between PM₁₀ exposure and an increase of serum glucose, HbA_{1c}, LDL, and triglyceride [11]. Furthermore, long-term exposure to particulate matter is strongly associated with mortality from particular causes of death such as ischemic heart disease, dysrhythmias, heart failure, and cardiac arrest [7]. The high level of triglyceride in the exposed group might occur due to the heavy metal particles emitted from vehicle exhausts [2]. Significance differences in blood lipid and blood sugar parameters in this study agree

with a study of the elderly in Taiwan that found long-term exposure of air pollution is associated with changes in blood lipids and blood sugars [1].

1-OHP is a biomarker of polycyclic aromatic hydrocarbon (PAH) exposure [6]. More than 130 studies used 1-OHP as a biomarker of PAH exposure in the workplace [5]. The correlation between 1-OHP in this study was still unclear.

5. CONCLUSIONS

HbA_{1c}, total IgE, and TNF α can be considered as blood markers for long exposure to particulate matter 2.5 (PM_{2.5}), while further research is needed to determine the possibility of using urinary 1-OHP as a non-invasive method to detect the particulate matter exposure in humans, particularly from traffic-related sources.

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