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Comparative Effect of Petroleum Products and Biomass Fuel Exposure on Serum Lipid profile and Atherogenic Indices of male Albino wistar Rats

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Abstract

The effects of petroleum products and biomass fuel on serum lipid profile and atherogenic indices were investigated in male wistar rats. Fifty adult male wistar rats were randomly assigned to five groups of ten animals each. Rats in group A served as control (exposed to fresh air). Group B, C, D and E were exposed to inhalation of kerosene, gasoline, liquefied petroleum gas and biomass smoke (wood smoke) respectively. All the exposures were done using whole body exposure chambers 70cm x 60cm x 60cm measurement for six weeks. Five millilitres of fasting blood sample were collected at the end of six weeks and used for analysis of lipid profile using mindray BS 120. Atherogenic indices were calculated using the appropriate formula. Values were analysed statistically using SPSS version 23.0. The result shows significant increase in the serum total, LDL, VLDL cholesterol and triglyceride concentrations of test groups relative to control ($p<0.05$), while inducing a significant decrease in HDL cholesterol though the effect appear to be more pronounced with kerosene exposure. The exposure also led to significant increase in CRR, AC and AIP ($p<0.05$). These results suggest that petroleum products and biomass fuel exposure could potentiate the risk of atherosclerosis through elicitation of dyslipidaemia.

Keywords: Petroleum products • Biomass fuel • Lipid profile • Atherogenic indices • Exposure

Introduction

Petroleum-related activities globally and Nigeria in particular, have raised concerns about the adverse effects of contamination of petroleum products on the environment [1]. Human exposure has been associated with growing incidence of a range of acute and long-term adverse health effects and diseases [2]. It has been estimated that, up to 24% of human diseases and disorders are attributable to environmental factors [1] and that the environment plays a role in 80% of the most deadly diseases, including cancer, respiratory and cardiovascular diseases [3]. Exposures to these petroleum products are considered an environmental pollutant and toxicant with attendant effects on some organs like kidney, heart, gonads, lungs and liver [1,3,4]. In recent times, there has been increase in petrochemical firms, including the emergence of many petroleum stations, to meet the increasing demands of a fast-growing population and because of globalization, urbanization, and accelerated economic development [5]. Moreover, there is a concomitant increase in the number of individuals serving as full-time stations service attendants who spend a full work-day exposed to petroleum products from different sources, including losses from underground tanks, displacement vapour, losses from filler pipes during refuelling, fuel spillage, and evaporative and exhaust pipe emissions from motor vehicles [6]. In Nigeria, due to the unreliable public power supply, many homes, offices and businesses rely greatly on electric generators, biomass and liquid fuel-dependent machines for day to day activities. The fuel for operating these machines are purchased and stored in homes and offices where their fumes constitute environmental health hazards especially during refuelling. The use of kerosene and biomass in homes as cooking and lighting fuels has further increased the exposure of humans to these products [5,6]. Furthermore, the current trend of locating filling and gas stations in residential areas exposes the residents of those areas to liquid fuel fumes. It has also been noticed that the owners of filling stations attach well designed and built duplexes or bungalows to their filling stations [7]. This also exposes the occupants of these apartments to petrol fumes. Apart from these, petroleum products have been abused as therapeutic agents for the treatment of snake bites, convulsion, arthritis, gastro-intestinal disorders and a host of other conditions [8]. Exposure to these pollutants and toxicants are on increase as man have invented a lot of equipments and materials which make use of these products in order to better his life [8]. Toxicological studies indicated that the light-chain volatile compounds (benzene, toluene, ethylbenzene, and xylene (BTEX)) are the components most toxic to humans [2]. Biomass smoke exposure is an age long practice and has been shown to consist of over 200 different compounds, some of which include carbon monoxide (CO), varying sizes of particulate matter (PM), mostly PM10; sulphur and nitrogen oxides, polycyclic aromatic hydrocarbons (PAH), aldehydes, free radicals and non-radical oxidising species; and volatile organic compounds [9]. Exposure to indoor pollution from biomass fuel has been linked to nearly 2 million excess deaths in developing countries and 4% of global burden of disease [7]. Exposure to biomass smoke has been reported to cause marked histopathological, haematological and some biochemical changes. Akor-Dewu et al [3], reported no relevant difference in haematological parameters, but a significant increase in cardiovascular parameters. Ambient fine particulate air pollution (PM) has been reported to have a strong adverse association with cardiovascular health [9].There appears to be dearth of literatures relating the effect of petroleum products and biomass fuel on serum lipid

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profile and atherogenic indices. Therefore, the present study was designed to comparatively evaluate the effect petroleum products and biomass fuel on serum lipids profile and atherogenic indices of male albino wistar rats.

Materials and Methods

Experimental animals

Fifty adult male albinos' rats (wistar strain) seven weeks old, that weighed 130±10g obtained from the Animal Breeding Unit of the Faculty of Veterinary Medicine, University of Nigeria, Nsukka, were used as the experimental animals. The rats were kept in cages for two weeks allowed to acclimatize to Animal House of the College of Health Sciences, Nnamdi Azikiwe University, Nnewi campus and were allowed free access to food and water ad libitum. The protocol was in line with the guidelines of the National Institute of Health (NIH) (NIH Publication 85-23, 1985) for laboratory animal care and use. Thereafter, the animals were randomly (while controlling for weight differences) distributed into five groups of ten animals each based on the exposed compound.

Petroleum products and biomass

The petroleum products; gasoline, kerosene and Liquefied petroleum gas were purchased from Juhel filling station at Awka, Anambra State, Nigeria, while the biomass Melina wood (G arborea) was purchased from commercial wood seller at Nnewi City, Anambra State, Nigeria.

Design of exposure chamber and wood combustor

The exposure chamber was fabricated using plywood (China OSB), while the wood combustor was made using iron, with an outlet for the release of the smoke into the chamber and a 10cm x 10cm square oxygen inlet on the lid. The exposure chamber of measurement 70cm x 60cm x 60cm as previously described by Akintunde et al [4], was constructed to allow at least 20% ventilation, as stipulated by the Organisation for Economic Co-operation and Development guidelines for inhalation toxicity. The burning process was initiated first before exposure by igniting 4kg Gmelina arborea wood with a lighter in a fabricated combustor. The wood smoke was diverted from the combustor into the exposure chamber using a metal host.

Experimental design

The fifty adult male wistar rats obtained from the animal breeding unit of the faculty of Veterinary Medicine, University of Nigeria, Nsukka, after two weeks of acclimatization to the animal house were randomly (while controlling for weight differences) assigned to five groups of ten animals each designated as A, B, C, D and E. Rats in group A served as control (exposed to fresh air). Group B, C, D and E were exposed to inhalation of kerosene, gasoline, liquefied petroleum gas and biomass smoke (wood smoke) respectively. All the exposures were done using whole body exposure chambers 70cm x 60cm x 60cm measurement. The animals in group A were exposed to fresh air only. Animals in group B and group C were exposed by placing the cages housing the animals into respective exposure chambers of measurement 70cm x 60cm x 60cm, each containing two open calibrated beakers of 500cm^3 containing 500cm^3 of liquid Kerosene for group B and gasoline for group C respectively. The kerosene and gasoline were allowed to evaporate freely within the respective exposure chambers at ambient humidity and temperature. Animals in group B were exposed to vapours (20.2 ± 4.5 cm3 h-1 Kg-1m-3 day-1) generated from direct evaporation of the liquid Kerosene, while animal in group C were exposed to vapours (30.8 ± 5.1 cm3 h-1 Kg-1m-3 day-1) generated from direct evaporation of the liquid gasoline. The animals were exposed 5 h/day (9.00 a.m - 2.00 p.m), 6 day/week, to vapours for 6 weeks. During the exposure period, the initial and final volumes of liquid Kerosene and gasoline were recorded before and after daily exposure. The daily differences in volume were used to calculate relative concentrations of vapours used in this group. Group D were exposed to liquefied petroleum gas from a compressed gas cylinder with pressure gauge and mass flow controller or flow meter in a whole body exposure chamber 70cm x 60cm x 60cm for 5 h/day (9.00 a.m - 2.00 p.m), 6 day/week, to LPG vapours for 6 weeks. Animals in group D were exposed to LPG vapours (202.2 ± 4.5g h-1 Kg-1m-3 day-1) generated from direct evaporation of the LPG. The initial and final volumes of LPG were recorded before and after daily exposure. The daily differences in volume were used to calculate relative concentrations of LPG used. Group E were exposed to biomass smoke by igniting 3kg Gmelina arborea wood with a lighter in a fabricated combustor. The wood smoke was diverted from the combustor into the exposure chamber using a metal host. The animals in group E were exposed to 1005ug/m^3 of PM_{10} from wood smoke for 1h/day, 6 day/week for 6 weeks. The PM concentration in the chamber was monitored using a PM_{10} monitor (portable particulate monitor PCE-RCM 10, PCE Deutschland GmbH). At the end of each exposure day, the animals were transferred vapours-free section of the experimental animal house. Body weight of animals and mortality data were routinely monitored. The study lasted for 6 weeks and blood.

Determination of serum lipid profile/indices

The lipid profiles were determined using Cobas reagent kits manufactured by Roche Diagnostics GmbH, Sandhofer Strasse 116, D-68305 Mannheim, Germany. Serum total cholesterol was determined by the method of Allain et al [10]. HDL-cholesterol by Sugiuchi et al [3]. LDL-cholesterol by Rifai et al [2] and triglycerides by Wahlefeld and Bergmeyer. The concentrations of the biochemical parameters were measured using Mindray BS 120 analyse

The atherogenic indices were calculated as described by Dobiasova [7]:

1. Cardiac Risk Ratio (CRR)=TC/HDLC
2. Atherogenic Coefficient (AC)=TC-HDLC/HDLC
3. Atherogenic Index of Plasma (AIP)=Log(TG/HDL)

The biochemical analyses were carried out using the facilities of Chemical Pathology Laboratory, Nnamdi Azikiwe University Teaching Hospital Nnewi, and Anambra State, Nigeria.

Statistical analysis

Data collected were subjected to analysis of Variance (ANOVA). In order to test whether or not significant differences existed between groups. Pairwise comparisons were made using the Post-hoc test. The mean±SD of each parameter was taken for each group. Test probability value of $p<0.05$ was considered significant. The analyses were carried out on SPSS for Windows version 23.0.

Results

The effect of petroleum products and biomass exposure on serum lipid profile. From the results, there was a significant increase in the serum total, HDL, LDL, VLDL cholesterol and triglyceride concentrations of test groups relative to control ($p<0.05$), though, insignificant difference was observed in certain groups for serum HDL (D and E), triglyceride (C, D and E) and VLDL (B, C and E) relative to control. All this effect appears to be more pronounced at test group D. Intra group comparison show that the mean total and LDL cholesterol of test group D were statistically significant compared to group B and E. More so, the mean HDL cholesterol of test group C compared to groups (B and E) and group D compared to group B were statistically significant ($p<0.05$). Furthermore, there was a significant difference in the mean triglyceride level when group B were compared to groups (D and E) and group C compared to group E.

Depicts the effect of Petroleum products and Biomass fuel Exposure on on cardiac risk ratio (CRR), atherogenic coefficient (AC) and atherogenic index of plasma (AIP). The results showed that there was a significant increase in CRR, AC and AIP levels relative to control ($p<0.05$), though insignificant differences were observed in level of AIP in groups C, D and E relative to control.

Discussion

The Exposure to petroleum products and biomass smoke has become a routine practice as man has invented a lot of equipment that makes use of these products in other to better his life. Exposures to these products are considered environmental toxicant and have been proposed as a risk factor for cardiovascular disease [3]. Hence this study sought to investigate the effects of persistent exposure to these products on serum lipid profile and atherogenic of male albino wistar rats. The result showed that exposure to petroleum products and biomass smoke significantly increased serum levels of total cholesterol, LDL and triglyceride and decrease in HDL cholesterol which are one of the major risk factors for cardiovascular disease. The decrease in HDL cholesterol appears to be more pronounced with kerosene exposure. Cholesterol is an essential substance involved in many cellular functions, including the maintenance of membrane fluidity, production of vitamin D on the surface of the skin, production of hormones and possibly helping cell connections in the brain [5,6]. It is important that the body cells should have adequate supply of cholesterol. However, when cholesterol levels rise in the blood, they can have deleterious consequences, particularly its role in atherosclerosis. The increase in serum total, LDL cholesterol and triglyceride found in this study is indicative of possible cardiovascular risk involvement of petroleum products and biomass smoke exposure and this result appears to be more pronounced with exposure to liquefied petroleum gas. This result is in agreement with the findings of Ekwere et al [11] and Dadzie et al [10] who both reported significant dyslipidaemia upon exposure to petroleum fumes and biomass smoke. Similar findings have also been reported upon exposure to petroleum fumes and biomass smoke [7,6]. This effect could be attributed to petroleum fumes and particulate matter modification of LDL cholesterol through acceleration of its oxidation [12]. Hence increase oxidized LDL cholesterol is a risk factor for cardiovascular disease. More so, petroleum fumes and particulate matter has been revealed to alter the structure and functions of lipids through oxidative stress and inflammation, producing reduced dysfunctional HDL cholesterol with decrease anti-inflammatory potentials [8,9]. Atherogenic indices are strong indicators of the risk of heart disease: the higher the value, the higher the risk of developing cardiovascular disease and vice versa [7]. According to Usoro et al [9], low atherogenic indices are protective against coronary heart disease while higher atherogenic indices increase the risk. From the result obtained it's apparent that exposure to petroleum fumes and biomass smoke significantly increased the atherogenic indices; CRR, AC and AIP indicating the likely role in cardiovascular disease. These findings is in tandem with Uboh et al [12] and Ubani et al, who reported significant increase in atherogenic indicies of wistar rats exposed to petroleum products.

Conclusion

In conclusion, the results of this work suggest that repeated exposure to petroleum products and biomass smoke could potentiate the risk of atherosclerosis through elicitation of dyslipidaemia. Therefore petroleum workers and those occupationally exposed to biomass smoke should at regular intervals undergo medical check-up to ascertain their health condition.

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