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Research Article

Effects of Petrol Fumes on Renal Function Parameters of Petrol Station Attendants in Sagamu, Nigeria

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Abstract

Petroleum fuels contain many toxic chemical compounds and trace metals. Previous studies on the effects of exposure to petroleum fuels on the kidneys in occupationally exposed workers are contradictory. This was a cross-sectional study conducted on 60 participants, including 30 petrol station attendants who have been on the job for at least one year and 30 age and sex matched controls in Sagamu metropolis, Nigeria, that have never been occupationally exposed to petroleum fuels. Blood samples were taken from the participants for the analysis of routine kidney function parameters. The plasma concentrations of sodium, potassium, chloride, bicarbonate, urea and creatinine were determined. The estimated creatinine clearance was calculated using the Cock-croft Gault equation. Significantly ($p < 0.05$) higher plasma urea levels were found in the petrol station attendants when compared to their control counterparts and the levels of plasma sodium, chloride and the calculated creatinine clearance were significantly ($p < 0.05$) lesser in petrol station attendants than in the control group. The results of this study based on the period of exposure have not indicated any progression to renal disease as compared to the control group but however suggest a tendency towards azotaemia and subclinical, prepathologic effects on the kidneys.

Keywords: Petrol; Fumes; Renal; Petrol Station

Introduction

The refining of crude petroleum by fractional distillation results in a variety of complex organic mixtures. They include several classes of liquid fuels like gasoline, diesel fuel, jet fuel and kerosene [1,2]. These fuels are volatile liquid mixtures with popular usage in the internal combustion of engines. The vapour obtained may be considered as petrol fumes. It consists of hydrocarbons (aromatic, saturated and unsaturated) and non-hydrocarbons (N, S, O_2 and various toxic heavy metals) [3]. The

major routes of petrol fumes exposure are inhalational and dermal. The vapours of petroleum fuels are not safe when inhaled even for few seconds [1]. Thus, there is a risk of occupational exposure to petrol fumes and their constituent toxic compounds amongst affected workers. The rate of absorption of petroleum hydrocarbons differs in the various organ systems [1]. The lungs have a higher absorption capacity, with less absorption occurring in the gastrointestinal tract and intact skin, although prolonged contact with gasoline can result in skin burns [2]. The kidneys are particularly susceptible to chemical induced injury because of their unique physiological features viz; a high renal blood flow rate, effective transport systems, together with its bioconcentration and biotransformative functions [2-6].

The exposure of humans to these petroleum products has been demonstrated to produce harmful effects, usually due to toxic accumulation of specific components of the petroleum fuels in the body [1,7]. Many of these effects can be attributed to some specific hydrocarbon components of petrol, such as Benzene, Toluene and Xylenes (BTX), otherwise known as Volatile Organic Components (VOC) [8]. Kidney damage and toxicity caused by xylene and toluene has been reported in humans [9,10]. Organs that accumulate the highest concentration of the toxicants (e.g., VOCs, toxic heavy metals) *in-vivo* are usual targets of specific toxic effects. These hydrocarbon mixtures are oxidized in especially the kidney and liver cells of mammals and in the process are converted into free radicals or activated metabolites [2,11]. It is these activated metabolites that react with cellular components such as membrane lipids to produce lipid peroxidation products resulting in structural changes to the plasma membrane and consequently eliciting their toxic effects. Another possible mechanism of toxicant mediated injury is via inactivation of enzymes through protein oxidation and/ or DNA strand breaks [11]. This toxicant-mediated cellular injury results in tissue damage and consequently compromises the overall functionality of the kidneys.

Renal dysfunction of any kind affects all parts of the nephron to some extent, although sometimes, either glomerular or tubular dysfunction is predominant [2,12]. Nephrotoxicity has been reported following case-control studies in human and animal exposure to unleaded petrol [3,13]. Uraemia, renal tubular acidosis, haematuria and pyuria have been reported following exposure to toluene and xylene [2,14]. Other studies have reported kidney adenoma following rats' exposure to VOCs [15]. Conversely, some studies have reported no significant difference between petroleum constituents and disturbances in renal function parameters [1,2,16,17].

Majority of studies have investigated the nephrotoxic potentials of petroleum components individually; however, being a commonly used source of energy, there is need for more investigation into the effects of petroleum as a mixture. The present study is designed to evaluate the effects of exposure to these petroleum fumes on kidney function parameters (plasma sodium, potassium, chloride, bicarbonate, urea, creatinine and calculated creatinine clearance) in 30 petrol station attendants, comparing them with corresponding levels in 30 sex and age matched controls [1]. Some studies have also reported that a number of diseases and conditions may predispose the kidneys to toxicant-mediated injury; these include preexisting renal dysfunction, diabetes mellitus, septicaemia and exposure to multiple nephrotoxins like drugs [2,5,6].

Petroleum products are highly volatile organic solvents with potential to induce organ toxicity following acute or chronic exposure. Various organs including the kidney are affected. This research would add to existing scientific data concerning the toxic effects of long-term exposure to petroleum products in humans using biochemical indicators of renal toxicity and dysfunction [1,2]. There is paucity of data on the nephrotoxic effects of occupational exposure to petroleum products in these categories of workers. Our study therefore has included a survey on past personal and family history of some of the aforementioned conditions including anthropometric characteristics. The scope of the study is limited to Sagamu metropolis, Ogun State, Nigeria. The analysis of blood specimen will also be limited to sodium, potassium, chloride, bicarbonate, urea and creatinine. Urine will also be examined for the presence or absence of certain substances like blood and albumin in the study population.

Ethical Statement

Ethical clearance for the study was obtained from the Babcock University Health Research Committee (BUHREC).

Methodology

Study Area and Population

Thirty (30) blood and urine samples each was collected from petrol station attendants and from thirty (30) age and sex matched

controls in Sagamu metropolis, in Ogun State, Nigeria. These two categories show contrasting degree of exposure for the phenomenon under study. The study was explained to the participants and their voluntary consent obtained.

Procedure For Recruiting Participants

A health promotion talk was arranged for the volunteers where knowledge and benefits of the study, including its limitations was explained to them. A phlebotomist aided in the collection of samples. Anthropometry was also considered for the participants. Consent form and questionnaire were distributed to all the volunteers (both subjects and controls).

Collection of Samples

Under aseptic conditions, 5 mls of blood sample was drawn by venepuncture technique from any one prominent vein of the pre sterilized cubital fossa and transferred immediately into a lithium heparin anticoagulant bottle pre-labeled with the name, identification number, sex and the tests to be carried out. Urine samples were also collected into sterile universal containers and labeled accordingly. Fasting was not required prior to the collection of blood and urine samples. After collection, the blood samples were spun in a centrifuge at 4000 rpm and the plasma separated into plain bottles for analysis, stored at a temperature of -20℃ and analyzed within 24 hours. Haemolyzed samples were excluded from the analysis.

Selection Criteria

The study included apparently healthy, full time petrol station attendants who have spent one year and above in the trade; while the control are apparently healthy individuals but are not petrol station attendants.

Data Collection and Analysis

Interview with Questionnaire

An interview with questionnaire to obtain the clinical data was used for each participant in this study.

Anthropometric Measurements

Height: Measured with a meter rule to the nearest centimeter against a flat, vertical surface with the subjects standing upright.

Weight: Taken with Salter bathroom scale placed on a flat surface, with readings was recorded to the nearest 0.5 kg.

Body Mass Index (BMI) was then calculated using the formula

$$BMI\ (kg/m^2) = \frac{weight\ in\ (kg)}{Height\ in\ m^2}$$

Biochemical Tests

Estimation of Urea (By Berthelot's Reaction Method)

Principle: Urea in serum was measured photometrically by Berthelot's reaction after enzymatic hydrolysis by urease.

$$Urea + H_2O \xrightarrow{Urease} 2NH_3 + CO_2$$

$$NH_3 + hypochlorite + phenol \rightarrow indophenol\ (blue\ compound)$$

Reference values: 10-50mg/dl (1.7-9.1mmol/l)

Estimation of Creatinine

Colorimetric Method

Principle: Creatinine in alkaline solution reacts with picric acid to form a coloured complex. The amount of the complex formed is directly proportional to the creatinine concentration. The creatinine concentration is then derived from the following formula based on Beer and Lambert's law [4].

$$\text{Creatinine concentration} = \frac{\text{Absorbance of test} \times \text{conc. of standard}}{\text{Absorbance standard}}$$

The estimated urinary creatinine clearance was calculated from the Cockcroft-Gault's equation, assuming a uniform age for males [4].

Estimated Creatinine clearance = $\frac{[(140- \text{age}) \times \text{ideal body weight (kg)}\ [0.85 \text{ (in women)}]}{72 \times \text{plasma creatinine concentration}}$

Reference Range: Serum: Men: 53 - 97 mmol/l (0.6 - 1.1 mg/dl)
Women: 44 - 80 mmol/l (0.5 - 0.9 mg/dl)

Determination of Plasma Electrolytes
Principle (Ion Selective Electrode (ISE) Method): Structurally an ISE analyzer is based on an electrochemical cell. ISE analyzers measure (sense) the electrochemical activity of ions, relative to the electrical potential of a reference electrode.
Procedure: The plasma sample is aspirated by the ISE machine and the concentration of the respective electrolytes measured. The results is read from the screen of the analyzer and printed out.

Statistical Analysis
Statistical Package for Social Science (SPSS version 14.0) computer software was used for data analysis. The mean and standard deviation of the plasma electrolytes, urea and creatinine were calculated. The simple student t-test was used for comparison (significant level set at $p \leq 0.05$). Person correlation analysis was used to assess relationship between duration of exposure to petroleum products and plasma level of electrolytes, urea and creatinine. The results were presented in form of tables and figures.

Result
A total of sixty (60) subjects participated in the study. These included thirty (30) apparently healthy petrol station attendants and (30) apparently healthy individuals with no previous occupational exposure to petrol or any hydrocarbon fuel as controls. Table 1 describes the anthropometric characteristics of study participants and controls as well as the comparison between the two groups. There was no significant difference in the age and weight. However, there was a significant difference in the height ($p = 0.011$) and Body Mass Index (BMI) ($p = 0.000$) between the study participants and the control group.

Table 2 shows the comparison of the renal function parameters measured (mean± SD) between the study participants and control. A significant difference ($p < 0.05$) was observed between the levels of plasma Na^+ ($p = 0.036$), Cl^- ($p = 0.042$), urea ($p = 0.008$) and estimated creatinine clearance ($p = 0.034$) in the petrol station attendants and control group. The petrol station attendants had lesser values of plasma Na^+, Cl^- and estimated creatinine clearance; and higher plasma urea levels (although within the clinically acceptable reference range) when compared to their control counterparts. There was no statistically significant difference in the plasma levels of K^+, HCO^{3-} and creatinine in the petrol station attendants and control group.

Table 3 shows the frequency distribution of the duration of service in the petrol filling stations among the study participants. A total of 60 participants were included in the study, 26.75% of whom had been in the service for 1-2 years, 11.7% had been in the service for 3-4 years; 11.7% had been in the service for 4-5 years while 50% (the control group) reported to have no previous service in a petrol filling station.

Table 4 illustrates the frequency distribution of history of diseases between study participants and controls. There was no statistically significant difference in the family history of kidney disease, hypertension and diabetes mellitus between the study participants and control group. There also was no statistically significant difference in the personal history of hypertension between the study participants and control group. None of the respondents reported to have any personal history of kidney disease and diabetes mellitus.

Table 5 shows the relationship between duration of exposure and anthropometric characteristics and renal function parameters in study participants and control group using Pearson's correlation. There was positive and significant correlation between duration of service and body mass index (BMI) ($p = 0.003$), HCO_3- ($p = 0.021$) and urea ($p = 0.000$), in both the cases and controls. There was a negative and significant correlation between the duration of service in the petrol stations and estimated creatinine clearance ($p = 0.005$). There was however no significant correlation between age, height, weight, K^+, Na^+, Cl^- and creatinine.

Parameters	Cases (n= 30)	Controls (n=30)	t - value	p - value
Age (years)	26.13±8.94	27.0 ± 8.21	−0.391	0.697
Height (m^2)	1.66± 0.10	1.73 ± 0.85	−2.631	0.011*
Weight (kg)	68.0±9.26	71.40±12.71	−1.184	0.241
BMI (kg/m^2)	33.90±10.9	23.77 ± 4.14	4.760	0.000*

Table 1: Comparison of anthropometric measurement in study participants and Controls (mean ± SD).

Parameters	Cases (n=30)	Controls (n=30)	t - value	p - value
K^+ (mmol/l)	3.66 ± 0.34	3.73 ± 0.31	−0.788	0.434
Na^+ (mmol/l)	135.8 ± 2.19	137.44 ± 3.44	−2.150	0.036*
Cl −(mmol/l)	102.37 ± 1.56	104.13 ± 4.38	−2.079	0.042*
HCO_3 − (mmol/l)	21.43 ± 2.69	20.27 ± 2.56	1.722	0.090
Urea (mg/dl)	26.57 ± 6.45	22.90 ± 3.48	2.740	0.008*
Creatinine (mg/dl)	0.66 ± 0.14	0.64 ± 0.14	0.731	0.468
eCrclearance (ml/min)	157.23 ± 48.23	182.53 ± 41.90	−2.169	0.034*
* Statistically significant at P < 0.05				

Table 2: Comparison of Renal function parameters between study participants and controls (mean ± SD).

Duration (years)	Frequency	Percentage	Valid Percentage	Cumulative Percentage
0	30	50.0	50.0	50.0
1-2	16	26.7	26.7	76.7
3-4	7	11.7	11.7	88.3
4-5	7	11.7	11.7	100.0
Total	60	100.0	100.0	

Table 3: Frequency distribution of duration of service in petrol filling stations among study participants.

History of Diseases	Cases	Controls	x^2	p - value
FKD	4	1	1.964	0.161
FHTN	7	10	0.739	0.390
FDM	2	5	1.456	0.228
PKD	0	0		
PHTN	0	1	1.017	0.313
PDM	0	0		

*Statistically significant at P < 0.05 (using 2×2 Chi-square)

KEY: FKD: Family history of kidney disease

FHTN: Family history of Hypertension

FDM: Family history of Diabetes Mellitus

PKD: Personal history of kidney disease

PHTN: Personal history of Hypertension

PDM: Personal history of Diabetes Mellitus

Table 4: Frequency distribution of history of diseases between study participants and control group.

Parameters	r	P
Age (years)	0.073	0.580
Height (m^2)	−0.152	0.246
Weight (kg)	−0.188	0.156
BMI (kg/m^2)	0.373	0.003*

K + (mmol/l)	0.107	0.416
Na + (mmol/l)	−0.146	0.265
Cl − (mmol/l)	−0.246	0.065
HCO_3 (mmol/l)	0.298	0.021*
Urea (mg/dl)	0.474	0.000*
Creatinine (mg/dl)	0.249	0.555
eCrclearance (ml/min)	−0.357	0.005*
* Correlation is significant at 0.05 levels (2-tailed)		

Table 5: Pearson's correlation of duration of exposure and anthropometric characteristics and renal function parameters in study participants and control group.

Discussion

In this study, the levels of plasma sodium, chloride and estimated creatinine clearance were statistically significantly lesser in petrol station attendants than in the control group. Reduced plasma sodium and chloride levels have also been reported in laboratory animals exposed to gasoline and petrol station attendants and in oil industry workers exposed to various other petroleum hydrocarbons [1,2,8,18,19]. Significant higher plasma urea levels were found in the petrol station attendants when compared to their control counterparts. Although these changes cannot be considered clinically significant since the mean values were within the normal reference range, it is however suggestive of subclinical prepathologic early kidney dysfunction and is in agreement with the works of Lawal and Nsonwu-Anyanwu, et al., [11,20].

The plasma potassium and creatinine levels did not show any statistically significant difference between the petrol station attendants and the control group. The considerable reserve capacity of the kidneys and the fact that creatinine levels do not change much until significant renal function is lost, may explain the fact that its levels did not follow increases in urea concentration [2]. Statistically significant higher urea and creatinine levels have been reported on exposure to diesel and gasoline in rats [2, 21] and petrol station attendants [22]. Usually, an increase in plasma urea and creatinine concentrations and decrease in creatinine clearance indicates a decreased Glomerular Filtration Rate (GFR) and impaired renal function. This can be due to progressive renal disease or result from an adverse effect of renal hypoperfusion, an often-reversible scenario which can be due to exogenous chemical induced toxicity in the kidneys.

Conclusion

Some studies have shown a relationship between petroleum fuels and renal disorders, while others have refuted it. However, the findings of this study based on the period of exposure have only suggested a subclinical prepathologic renal effect and not particularly any progression to renal disease as compared to the control group. This study has been focused on petrol station attendants; further studies should be carried out on other groups of petrol industry workers who are occupationally exposed to petroleum fuels e.g. oil refinery workers and oil rig operators and drillers, for a long term exposure. Petroleum fuels include many chemicals and additives where anyone could be the cause of potential deterioration in renal functions. Although this study has not suggested absolute clinical renal dysfunction amongst workers occupationally exposed to petroleum fuels, the use of adequate personal protective equipment is advised considering the widely demonstrated toxic potentials of its constituent compounds.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Consent to Participate

Informed consent was also obtained from each subject who participated in the study before the collection of blood sample.

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Data Availability
Data is available for the journal. Informed consents were not necessary for this paper.

Author's Contribution
The authors contributed equally.

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