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Effects of Duration of Exposure on Biochemical and Haematological Profile in Liquefied Petroleum Gas (LPG) Plant Workers

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Abstract

Liquefied Petroleum Gas (LPG) plant workers are exposed to a number of hydrocarbons from handling petroleum and petroleum-based products and this exposure poses a major health challenge to these workers. This study was designed to evaluate the effects of duration of exposure on biochemical and haematological profile in LPG plant workers. A total of one hundred (100) subjects between 20-60 years were recruited for this study which consist of fifty (50) liquefied gas plant workers and fifty (50) non LPG gas plant workers. Blood samples (10ml) were collected from the cubital vein of each subject using sterile needles and syringes into K3-EDTA tubes and plain plastic containers. The biochemical and haematological parameters were analyzed using standard procedures as prescribed by the manufacturers. The results showed that there was significance difference ($p<0.05$) observed in all the heamatological parameters as compared with the respective controls. However, there was no significant difference (($p>0.05$) in neutrophils values obtained as compared with the control. The serum sodium levels were higher in subjects that had one year exposure. Serum potassium was higher in the subjects with 2-3 years of exposure. Urea and creatinine levels were higher in subjects with 4-5 years of experience. AST levels were higher in subjects with one year experience when compared with other years. ALT were higher in subject with 2-3 years exposure. ALP levels were higher in subjects with 4-5 years of exposure while GGT levels were higher in subjects with 5 years of exposure. There was no significant difference ($p>0.05$) observed in the renal and liver profile within the period of exposure to LPG. However, the total white blood cell count was significantly higher ($p<0.05$) in subjects with 4-5 years and over 5 years of exposure when compared with 1 year and 2-3 years of exposure while there was no significant difference ($p<0.05$) observed for other haematological parameters. The results of this study showed that exposure to LPG resulted in significant alterations in haematological parameters. However, exposure to LPG had significant effect only on the total white blood cell count while there was with no significant effect on the renal and liver profile of LPG plant workers.

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Keywords: Liquefied petroleum gas, Exposure, Haematology, Kidney, Liver, Health

1. Introduction

Liquefied petroleum gas (LPG) is extensively used in homes and vehicles (Eva et al., 2017). It is extracted from crude oil and natural gas and it is made of hydrocarbons containing three or four carbon atoms (Eva et al., 2017). Other hydrocarbon derivatives such as petrol and diesel are a mixture of volatile hydrocarbons and distillate petroleum respectively (Donaldson et al., 2015). LPG plant workers are exposed to a number of these hydrocarbons in fuel vapors during dispensing and gases emanating from vehicle exhausts (Rekhadevi et al., 2010). In the LPG work stations, the increased emissions of these volatile hydrocarbons are as result of the volume of LPG dispensed and the ambient temperature.

Several constituents of the LPG products have been found to be hazardous including benzene, xylene and toluene with benzene being the most hazardous (Rekhadevi et al., 2010). These hazardous effects include the onset of anaemia and cancer which is more evident in individuals with prolonged exposure (IPCS, 1993). It is obvious that LPG attendants in filing stations, drivers of gasoline trucks, service station attendants and refinery workers are more susceptible to the harms of LPG due to chronic work-related exposure (Abou-ElWafa et al., 2015). LPG is readily available in the atmosphere any time due to the fact that they are volatile and this is most common in LPG plant stations and depots (Gupta and Dogra, 2012). The deleterious effects of exposure to LPG depend largely on the chemicals that constitute LPG such as benzene and lead (Abou-ElWafa et al., 2015). Inhalation of LPG vapors even in small amounts have been reported to cause dizziness, headaches, nose and throat irritation, breathing difficulties, confusion, vomiting, allergic and skin reaction such as rash and redness (Abou-ElWafa et al., 2015).

Furthermore, a more serious health implication of LPG is related to the alteration of the haemopoietic system with bone marrow depression (Sahb, 2011). Diseases that are related to occupation in LPG plant stations have been reported over the years and affect workers in several ways, and this poses a major threat to their health and wellbeing. There is growing concern over the use of LPG among individuals who constantly inhale this substance with a reported significant higher disease burden (Sugie, 2014). These occupational health hazards have significantly increased mostly in industrialized and developing countries (Saponaro et al., 2009). There tend to be limited studies on the effects of duration of LPG exposure on biochemical and hematological parameters, which however stemmed the interest to carry out this study.

2. MATERIALS AND METHODS

2.1 Research Design

A comparative cross-sectional study was conducted on LPG plant workers in Benin City, Edo State Nigeria from August 1, 2019, to December 31, 2019 in which workers exposed to LPG were compared with individuals who were not exposed (control group). The LPG gas plant workers were all males who work between 8am to 2pm and from 2pm-8pm daily. The LPG plant workers were interviewed and blood samples were collected in the Manager's office at 12pm and 4pm daily when there were high chances of minimal work load. The control group were interviewed, examined and considered not to have worked or currently working in LPG gas station before collection of blood samples. Also questionnaires were used to collect the information on age, duration of LPG exposure and general health status.

2.2 Study Population

A total of one hundred (100) subjects between 20-60 years were recruited for this study which consist of fifty (50) LPG plant workers and fifty (50) individuals who are not exposed to LPG (controls).

2.3 Inclusion and Exclusion Criteria

Apparently healthy LPG plant workers and controls with no underlying illness or symptoms were recruited for this study. Subjects who are not within 20-60 years, and have underlying illness or symptoms were excluded from this study. Also subjects who did not give consent were not included in the study.

2.4 Ethical Consideration

Ethical approval was obtained from the University Research Ethics Committee. An informed verbal consent of the subjects to participate voluntarily in the study with a full right to withdraw was obtained with assurance of confidentiality and anonymity of the data.

2.5 Sample Collection

Venous blood samples (10mls) were collected from the cubital vein of each subject with the aid of syringe and needle into K3-EDTA tubes and serum plastic containers. The EDTA blood sample was used for haematological parameters. The blood sample in the plain containers was used for the estimation of biochemical parameter. It was centrifuged at 3000 rpm for 15 minutes and serum immediately separated from the cells into plain containers with label corresponding to initial blood sample bottle. The serum samples were stored frozen at -70° C until the time for analysis.

2.6 Sample Analysis

The samples obtained from the LPG plant workers was analyzed for activities of liver enzymes (aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and gamma glutamyl transferase (GGT), renal function tests (creatinine, urea, potassium and sodium) and complete blood count (CBC) (Rietman and Frankel, 1957; Szasz, 1969; Fabiny and Ertingshausen, 1971; Rec,1972). CBC was carried out within 2-4 hours of sample collection using Sysmex KX-21N Analyzer and the heamatological parameters analyzed included the white blood cell (WBC) count, red blood cell (RBC) count, haemoglobin (Hb) concentration, haematocrit (Hct) percentage, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) platelets count (PLT) and differential white blood cell count. The sera obtained were used to estimate AST, ALT, ALP, GGT, creatinine, urea, sodium and potassium using the commercially available reagent kits, standard protocols and equipments.

2.7 Statistical Analysis

The results obtained in this study were analyzed statistically and the mean and standard deviation values calculated in each case. The Student t-test and Analysis of Variance (ANOVA) statistical methods were employed for comparison using a computer programme (SPSS) for window release 21.0. A p-value equal or less than 0.05 ($P \leq 0.05$) were considered statistically significant at 95% confidence level.

3.0 RESULTS

The results showed that there was significance difference ($p<0.05$) in the values of MCHC (32.55 ± 1.13 g/dl), MCH (27.36 ± 1.98 pg), MCV (84.00 ± 5.38 fl) when compared with the controls respectively (32.28 ± 2.64 g/dl), (28.54 ± 3.13 pg) and (86.46 ± 6.90 fl). There was significant difference ($p<0.05$) in the total white blood cell count (5184.00 ± 1352.45 x 10^6/L) when compared with the control (5732.00 ± 1770.21 x 10^6/L). There was significant difference ($p<0.05$) in the platelet count (174.58 ± 60.15 x 10^6/L) when compared with the control (192.64 ± 65.31 x 10^6/L). There was significant difference ($p<0.05$) in the red blood cell count (5.20 ± 0.58 x 10^6/L) when compared with the control (4.81 ± 0.75 x 10^6/L). Also, there was significant difference ($p<0.05$) when the values of the lymphocytes and MIX (eosinophils, basophils and monocytes) were compared with the controls. There was no significant ($p>0.05$) difference in neutrophils values obtained as compared with the control. There was significant difference ($p<0.05$) in the PCV values (43.46 ± 2.91 %) when compared with the controls (42.10 ± 2.69 %). Also significant difference was obtained in the haemoglobin levels of the subjects (14.08 ± 0.92 g/dl) when compared with the control (43.46 ± 2.910.92 g/dl) (Table I).

The results also showed that there was no significant difference ($p>0.05$) in all the haematological parameters when compared across different age groups (Table II).

The results on renal profile showed that serum sodium levels were higher in subjects that had one year exposure. Serum potassium was higher in the subjects with 2-3 years of exposure. Urea and creatinine levels were higher in subjects with 4-5 years of experience; though these observations were not statistically significant ($p>0.05$) (Table III).

Furthermore, AST levels were higher in subjects with one year experience when compared with other years. ALT were higher in subject with 2-3 years exposure. ALP levels were higher in subjects with 4-5 years of exposure while GGT levels were higher in subjects with 5 years of exposure, though these observations were not statistically significant ($p>0.05$) (Table IV).

The results showed that white blood cell count was significantly higher ($p<0.05$) in subjects with 4-5 years and over 5 years of LPG exposure when compared with 1 year and 2-3 years. There was no significant difference ($p>0.05$) in all other haematological parameters; though there were variations across the years of exposure (Table V).

Table I: Haematological Parameters of LPG Plant Workers with the controls

Parameters	Control (n=50)	Subjects (n=50)	t-value	P-value	Remark
MCHC(g/dl)	32.28±2.64	32.55±1.13	4.573	0.000	S
MCH (pg)	28.54±3.13	27.36±1.98	4.215	0.001	S
MCV (fl)	86.46±6.90	84.00±5.38	3.236	0.002	S
WBC($\times10^6$/L)	5732.00±1770.21	5732.00±1770.21	2.865	0.006	S
PLT ($\times10^6$/L)	192.64±65.31	174.58±60.15	2.123	0.039	S
RBC ($\times10^9$/L)	4.81±0.75	5.20±0.58	4.722	0.000	S
LYM (%)	36.84±6.86	50.34±9.83	9.707	0.000	S
MIX (%)	3.56±2.71	5.72±3.39	4.510	0.000	S
NEU (%)	44.30±7.34	44.28±9.82	0.014	0.989	NS
PCV (%)	42.10±2.69	43.46±2.94	3.268	0.002	S
HB (g/dl)	12.40±1.41	14.08±0.92	12.998	0.000	S

Key: n=Sample Size, S: Significant, NS: Not significant; MCHC= Mean corpuscular haemoglobin concentration; MCH= Mean corpuscular haemoglobin; Mean corpuscular volume; WBC=White blood cell; PLT=Platelets; RBC= Red blood cell; LYM=Lymphocytes; MIX=granulocytes; NEU= Neutrophils; PCV=Packed cell volume; HB=Haemoglobin.

Table II: Age comparison of haematological Parameters of LPG Plant Workers

Parameters	20-30yrs (n=25)	31-40yrs (n=17)	41-50yrs (n=05)	51-60yrs (n=03)	F-value	P-value
MCHC(g/dl)	32.40±0.99ᵃ	32.56±1.39ᵃ	33.10±1.17ᵃ	32.80±0.36ᵃ	0.582	0.630
MCH (pg)	27.15±1.96 ᵃ	27.55±2.29ᵃ	27.38±1.67ᵃ	28.03±0.59 ᵃ	0.254	0.858
MCV (fl)	83.43±5.48 ᵃ	84.21±5.63ᵃ	85.28±6.40 ᵃ	85.43±1.00 ᵃ	0.256	0.856
WBC($\times 10^6$/L)	5280.00±1433.24 ᵃ	4976.47±1275.01ᵃ	5460.00±1425.83ᵃ	5100.00±1552.42ᵃ	0.237	0.870
PLT($\times 10^6$/L)	170.32±55.85ᵃ	190.53±53.47ᵃ	171.80±103.89ᵃ	124.33±23.50ᵃ	1.152	0.338
RBC($\times 10^9$/L)	5.08±0.62 ᵃ	5.32±0.59ᵃ	5.50±0.35ᵃ	4.99±0.85 ᵃ	1.224	0.312
LYM (%)	52.32±10.15 ᵃ	49.71±10.47ᵃ	44.40±6.50 ᵃ	47.33±4.16 ᵃ	1.067	0.372
MIX (%)	6.00±3.64ᵃ	5.12±3.50ᵃ	5.40±2.61ᵇ	7.33±1.53ᵃ	0.462	0.710
NEU (%)	42.96±9.00 ᵃ	46.18±11.32ᵃ	43.80±12.30ᵃ	45.33±3.06 ᵃ	0.362	0.780
PCV (%)	44.16±2.88 ᵃ	43.18±2.43ᵃ	41.40±4.83 ᵃ	42.67±0.58 ᵃ	1.452	0.240
HB (g/dl)	14.36±0.82ᵃ	13.93±0.95ᵃ	13.30±1.10ᵇ	13.97±0.35ᵃ	2.330	0.087

Key: Values in a row with a different superscript are significantly different at p<0.05.
P<0.05: Significant, P>0.05: Not significant, n=Sample Size; MCHC= Mean corpuscular haemoglobin concentration; MCH= Mean corpuscular haemoglobin; Mean corpuscular volume; WBC=White blood cell; PLT=Platelets; RBC= Red blood cell; LYM=Lymphocytes; MIX=granulocytes; NEU= Neutrophils; PCV=Packed cell volume; HB=Haemoglobin.

Table III: Comparison of length of exposure with renal profile of LPG Plant Workers

Parameters	1yr (n=03)	2-3yrs (n=12)	4-5yrs (n=15)	5yrs&above (n=20)	F-value	P-value
Sodium (mmol/l)	151.50±2.12ᵃ	145.42±7.06 ᵃ	144.00±5.77 ᵃ	143.90±4.54 ᵃ	1.259	0.300
Potassium (mmol/l)	4.00±0.28 ᵃ	4.18±0.53 ᵃ	4.02±0.48 ᵃ	3.94±0.38 ᵃ	0.682	0.568
Urea (mg/dl)	22.00±8.49 ᵃ	28.25±6.36 ᵃ	28.80±8.25 ᵃ	28.25±7.09 ᵃ	0.509	0.678
Creatinine (mg/dl)	0.70±0.01ᵃ	0.68±0.17ᵃ	0.75±0.20 ᵃ	0.71±0.15ᵃ	0.414	0.744

Key: Values in a row with a different superscript are significantly different at p<0.05.
n=Sample Size, P<0.05: Significant, P>0.05: Not significant.

Table IV: Comparison of length of exposure with liver profile of LPG Plant Workers

Parameters (U/L)	1yr (n=03)	2-3yrs (n=12)	4-5yrs (n=15)	5yrs&above (n=20)	F-value	P-value
AST	16.00±0.01ᵃ	13.42±5.50ᵃ	10.87±3.66ᵃ	13.45±3.72ᵃ	1.713	1.178
ALT	5.50±0.71 ᵃ	8.17±3.74ᵃ	6.40±3.64ᵃ	5.70±2.87 ᵃ	1.460	0.755
ALP	26.50±0.71 ᵃ	27.58±7.46ᵃ	32.67±8.93 ᵃ	30.55±7.10 ᵃ	1.132	0.346
GGT	77.15±65.5ᵃ	81.71±57.13ᵃ	87.65±79.61ᵇ	109.68±81.35ᵃ	1.132	0.346

Key: Values in a row with a different superscript are significantly different at p<0.05.
n=Sample Size, P<0.05: Significant, P>0.05: Not significant, AST: Aspartate amino transferase, ALT: Alanine amino transferase, ALP: Alkaline phosphatase, GGT: Gamma glutamyl transferase.

Table V: Comparison of length of exposure with haematological profile of LPG Plant Workers

Parameters	1yr (n=03)	2-3yrs (n=12)	4-5yrs (n=15)	5yrs&above (n=20)	F-value	P-value
MCHC(g/dl)	32.05±0.07[a]	32.37±1.49[a]	33.16±1.13[a]	33.01±0.83[a]	2.012	0.126
MCH (pg)	28.25±1.34[a]	27.22±2.03[a]	27.45±2.21[a]	27.39±1.93 [a]	0.152	0.928
MCV (fl)	88.25±4.17[a]	82.72±6.23[a]	85.17±4.83 [a]	83.73±5.33 [a]	0.887	0.455
WBC($\times10^6$/L)	3700.00±141.42[a]	4433.33±856.35[a]	5713.33±1321.72[b]	5320.00±1443.90[ab]	3.265	0.030
PLT($\times10^6$/L)	121.50±30.41[a]	167.42±63.33[a]	196.87±60.33[a]	172.50±54.94[a]	1.328	0.277
RBC($\times10^9$/L)	5.00±0.14 [a]	5.04±0.55[a]	5.34±0.59[a]	5.18±0.62[a]	0.650	0.312
LYM (%)	55.50±4.95 [a]	50.751±10.85[a]	48.47±8.72 [a]	51.45±10.60[a]	0.434	0. 730
MIX (%)	5.00±7.07[a]	6.83±3.30[a]	5.00±2.90[b]	5.50±3.55[a]	0.696	0.559
NEU (%)	41.00±4.24 [a]	46.08±9.17[a]	39.73±8.17[a]	46.65±11.08 [a]	1.717	0.177
PCV (%)	44.50±3.53 [a]	42.33±2.67[a]	43.13±3.20 [a]	44.15±2.85 [a]	1.093	0.362
HB (g/dl)	14.15±1.06[a]	13.67±0.87[a]	14.09±0.78[b]	14.29±1.02[a]	1.170	0.332

Key: Values in a row with a different superscript are significantly different at $p<0.05$.
$P<0.05$: Significant, $P>0.05$: Not significant, n=Sample Size. MCHC= Mean corpuscular haemoglobin concentration; MCH= Mean corpuscular haemoglobin; Mean corpuscular volume; WBC=White blood cell; PLT=Platelets; RBC= Red blood cell; LYM=Lymphocytes; MIX=granulocytes; NEU= Neutrophils; PCV=Packed cell volume; HB=Haemoglobin.

DISCUSSION

LPG plant workers are exposed to a number of these hydrocarbons in fuel vapors during dispensing and gases emanating from vehicle exhausts and as such are susceptible to the risk of exposure to LPG which could lead to health complications.

The results of this study revealed that the mean values for MCHC, red blood cell count, lymphocytes, MIX (eosinophils, basophils and monocytes), packed cell volume and haemoglobin were significantly higher in LPG plant workers, while the mean values of MCH, MCV, white blood cell count and platelet count were significantly lower. There was no significant difference when the mean values of the neutrophils were compared with the control. This observation is in line with the work of Sirdah et al., (2013) where a similar trend of result was obtained. This result also results agree with studies of subjects exposed to natural gas (Saadat and Bahaoddini, 2014). Other studies where different petroleum products were used also agreed with the findings of this study (Ukaejiofor, 2016; Ukaejiofor et al., 2016). In this fashion, there are other studies that have reported the effect of exposure to natural gas on haematological parameters (Saadat and Bahaoddini, 2014). However Sugie, (2014) and Fukunaga, (2015) reported cases of sudden death due to the inhalation of LPG where the liver and the kidney are the mostly affected organ considering the accumulation of LPG.

Furthermore, the findings showed the mean values of all the haematological parameters varied across the age group. As the LPG plant workers were separated on the basis of exposure period, it was observed that there was significant difference in the mean values of white blood cell count (WBC) in LPG plant workers with 4-5 years and above 5 years of LPG exposure. MCHC, platelet count, and red blood cell count levels were higher in LPG plant workers with 4-5 years exposure. The MIX (eosinophils, basophils and monocytes) were higher in LPG plant workers with 2-3 years exposure. MCH, MCV, lymphocytes and packed cell volume were higher in LPG plant workers with 1 year of exposure. Neutrophils and haemoglobin levels were higher in LPG plant workers that had 5 years and above exposure. These observations were consistent with the findings of Ezejiofor et al., (2014).

Also, sodium levels were higher in LPG plant workers with 1 year exposure, followed by 2-3 years, 4-5 years and 5 years and above. Potassium levels were higher in LPG plant workers with 2-3 years of exposure followed by 4-5 years, 1 year and 5 years. Serum urea values were higher in LPG plant workers with 4-5 years of exposure while serum creatinine levels were higher also higher within 4-5 years of exposure. The observations in serum sodium, creatinine, urea and creatinine as regards the variations in the age groups and years of exposure were consistent with the findings of Ezejiofor et al., (2014).

It was also observed that AST levels were higher in LPG plant workers with 1 year exposure, ALT in 2-3 years of exposure, ALP in 4-5 years of exposure and GGT in 5 years and above. These observations are consistent with the findings of Ezejiofor et al., (2014). The liver enzymes form the centre core of the major functional markers of the liver (Mayne, 1998; Balisteri and Shaw, 1999). The variations of the liver enzymes of the LPG plant workers served as a pointer to the possible deleterious effect of LPG inhalation on the liver. Damage to the liver by LPG exposure has resulted in the marked increase in enzymes and could result to circulatory failure with 'shock' and hypoxia and myocardial infarction. Also, the significant increase in GGT level clearly points to the existence of liver dysfunction among LPG plant workers on exposure to LPG (Tate and Meister, 2005).

Conclusion

This study revealed that there were significant alterations in the haematological parameters among the LPG plant workers as compared to the controls. There was significant increase in the total white blood cell count of LPG plant workers exposed between 4-5 years and above 5 years. However, the comparison of length of exposure revealed that there was no significant alteration in the renal and liver profile of LPG plant workers.

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