Original research

Effect of occupational exposure on hematological and biochemical parameters in workers at oil and gas companies

Ghada M. Salem[1,2]*, Seham Shaboun[3], Yosra M. Algamodei[2], Maram F. Almalyan[2], Ekhlass M. Althwadi[2], Ahmed A. Zaid[4], Sara A. Hwisa[2,5], Fakhri F. Aljidaemi[2,6], Salah A.B. Bahroun[7]

[1]Libyan Authority for Scientific Research, Tripoli, Libya
[2]Department of Medical Biotechnology and Genetic Engineering, Faculty of Medical Technology, University of Sabratha, Sabratha, Libya
[3]Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Benghazi, Benghazi, Libya
[4]Departmentof Biochemistry, Faculty of Medicine, University of Tripoli, Tripoli, Libya
[5]Department of General and Basic Sciences, Faculty of Dentistry, University of Zawia, Zawia, Libya
[6]Biotechnology Research Centre, Tripoli, Libya
[7]Libyan Medical Research Centre, Zawia, Libya

*Corresponding author: Ghadasalem551@gmail.com
https://orcid.org/0000-0002-1830-7049

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Abstract: Petroleum refineries are largest chemical industries that are responsible for emission of several pollutants into the atmosphere. Benzene and its metabolites are regarded as the most hazardous compounds that are emitted by petroleum refineries. These contribute to toxic oxidants, which cause many serious health risks to petroleum refineries workers. This study was aimed to analyze the effects of chemical exposure on hematological and biochemical parameters among workers at Zawia oil refinery and Mellituh oil and gas refinery companies. A total of 200 workers participated in this study which consisting of two equal groups (each group: n = 100). The first group consists of petroleum refineries workers and the second group consists of non-oil work civil servants serving were recruited as exposed and control subjects, respectively. The results of blood picture, liver enzymes and kidney functions were compared between the groups. Mean white blood cells counts, platelet counts, and hematocrit count were significantly higher, while the mean red blood cells count was insignificantly changed in petroleum refineries workers. While the mean hemoglobin and corpuscular hemoglobin concentration levels were significantly lower, whereas the mean corpuscular volume and mean corpuscular hemoglobin levels were insignificantly changed in petrol refineries workers. Liver enzymes and renal functions were significantly higher in petrol refineries workers. The present findings indicate that occupational exposure to benzene causes significant alterations in hematological and biochemical parameters and workers are at high risk of developing blood, hepatic or renal related disorders. Protection and frequent medical attention should be given to petroleum refineries workers.

Keywords: Biochemical parameter, hematological parameter, Libya, petroleum refinery, occupation exposure

Introduction

Worldwide, a huge number of people are exposed to petrol vapor as a part of their occupation or environmentally place [1]. Petrol can be defined as volatile liquid containing mixtures of particles and gases. Typically, there are more than 150 particulate chemicals in petrol, including minor quantity of organic compounds like aromatic and aliphatic hydrocarbons, metals as lead and minute quantity of other compounds [2]. As the size of most particulate chemicals is less than ten microns, and the size of numerous particulate chemicals is less than one microns, so an approximately all those particles is respirable [3, 4]. The oil and gas industry have harmful chemicals through processing and operating. Environmentally, this industry is the main source of volatile aromatic hydrocarbons (VAHs) [5]. These VAHs were considered as toxic oxidants that affect human health and environments. The environments levels of VAHs vapor can be increased significantly by the ambient temperature and the amount of petrol used in refinery operations [6, 7]. The most abundant hydrocarbon compounds is benzene, toluene, ethylbenzene and xylene (o-, m- and p-) are commonly abbreviated as BTEX [8]. In petroleum refineries, among this group, BTEX, benzene is regarded as the most dangerous as it is involved in nearly each operation of petroleum refinery processes [6, 7]. The health hazard of benzene exposure at the atmosphere of petroleum refineries has been announced by numerous organizations using guideline values [9]. Benzene is classified as a class one carcinogen and mutagen which can contact animals and humans through several routes including inhalation, oral and dermal exposure. But, the main route of benzene exposure at work place is via inhalation [10]. The health consequences of benzene depend on duration of exposure, in which, acute exposure to benzene causes dizziness, drowsiness, headache, fatigue, tremors and unconsciousness. Though, more serious health outcomes occur on chronic benzene exposure including myeloma, myeloid leukemia and decreased production of white and red blood cells, weakened immunity. In addition to liver and kidney failure, central nervous system damage and cancer can be induced [11, 12]. The toxicity of benzene can be described using several mechanisms. The major toxic consequence of continuous benzene exposure is leucopoiesis suppression that causes increased vulnerability to infections and injuries [13]. Many years ago, health hazards were recognized among petroleum refineries workers in different ways. These hazards are problems in different parts of the world. Therefore, series of studies were conducted to investigate the blood parameters in addition to renal and hepatic function testes of exposed workers [14, 15]. The objective of this study was to investigate the effects of exposure to petrol vapor on hematological and biochemical parameters (blood picture, liver enzymes and kidney functions) among Libyan workers in Zawia oil refinery and Mellituh oil and gas refinery companies located west Tripoli (the capital city of Libya). This may indicate hepatotoxic or nephrotoxic response among exposed workers at these companies.

Materials and methods

Study design: A comparative cross-sectional study was conducted among workers in Zawia refinery and Mellituh Company in west Libya during the period from 1st of March 2019 to 30th of July, 2019. The questionnaire was used to collect following information: sociodemographic data, occupational profile of the workers; usage of personal protective equipments, general health status and respiratory complaints.

Study group: The target group was the workers of Zawiya oil refinery and Mellitah oil and gas refinery companies in west Tripoli. The workers in these two companies were either working in the field (exposed group) or doing office work (non-exposed group). A total of 200 blood samples were collected from the two groups. 100 blood samples

from the first exposed group working in refinery services for full time. The second group comprised 100 of non-exposed workers working in services and offices at Zawia Medical Research Center, Zawia, Libya, comparable to the exposed group in most of the variables except for the risk of exposure to petrol. The workers in the two groups were interviewed and blood sample was taken at the Department of Public Health and Community Medicine during the work day. Ethical consideration approval of the studied petrol refineries were obtained (2/2019). A consent of participation in the study was obtained for exposed group and non-exposed voluntaries office workers at the two-refinery companies. The investigation was done for free.

Laboratory analysis: Each participant gave five ml blood sample through vein puncture for the following investigations. Complete blood picture (CBC) parameters were measured by placing two ml of blood sample in the ethylene diamine tetra-acetic acid (EDTA) test tube. While, the rest three ml of the blood sample were kept in plastic test tube for kidney function tests (urea and creatinine) and liver function tests (alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP). The two test tubes for each participant were sent to laboratory for analysis by 200 Mindray chemistry analyzer and 4040.

Statistical analysis: Data of petrol exposed and unexposed subjects from the laboratory for all the investigations were reviewed and processed for statistical analysis. Descriptive statistics were used to express the data as Mean and Standard Deviation for each group. Paired t-test was used to assess the difference between benzene exposed group and non-exposed group: $P < 0.05$ was considered as a statistical significant.

Results

Demographic characteristics: The subjects' demographic data were shown in Table 2. A total of 200 subjects were included in this study. 100 subjects were exposed to petrol and the rest accounting 100 were unexposed to petrol. The mean age for the exposed workers and the control group were 38.5 ± 9.5 years and 40 ±11.5 years, respectively. Length of employment for the exposed group was 10.4 ± 3.2 years.

Table 1: Demographic characteristic data of the subjects

Variable	Unexposed group	Exposed group
Age (years)	38.5 ± 9.5	40.2 ± 11.5
Experience (years)	----	10.4 ± 03.2

Data are mean ± SD.

Hematological parameters: The results of complete blood picture were presented in **Table 2**. There are differences in hematological parameters between the unexposed and exposed subjects to petrol. The exposed workers experienced significantly increased mean WBC counts compared with the unexposed subjects (8.1 ± 2.3 versus 7.5 ± 2.2, $P < 0.05$). Similarly, the mean platelet counts in the petrol exposed group was significantly elevated compared with the non-exposed group (239.64 ± 50.9 versus 206.98 ± 50.2, $P < 0.001$). The mean HB level (14.01 ± 2.2 versus 14.9 ± 1.2, $P < 0.001$), the percent hematocrit and MCHC level (39.37 ± 6.3 versus 37.8 ± 5.3, $P < 0.05$), (37.07 ± 5.6 versus 39.24 ± 5.78, $P < 0.01$) were significantly lower in petrol workers than the control group. All other blood parameters showed non-significant difference between the groups.

Table 2: Hematological parameters of exposed and unexposed subjects to petrol

Parameters (units)	Exposed group (n = 100)	Unexposed group (n = 100)	P value
WBC (× 10^3 per µL)	08.1 ± 02.3 ↑	07.5 ± 02.2	0.05*
Platelets (× 10^3 per µL)	239.64 ± 50.9 ↑	206.98 ± 50.2	0.001***
RBCs (million cells per mcL)	4.74 ± 0.53 ↑	4.66 ± 0.86	0.10
Hemoglobin (g per dL)	14.01 ± 2.19 ↓	14.9 ± 1.18	0.001***
Hematocrit (%)	39.37 ± 06.3 ↑	37.8 ± 05.3	0.05*
MCV (fem to liter)	84.42 ± 12.61 ↓	98.38 ± 09.9	0.07
MCH (pg/cell)	29.62 ± 02.27 ↓	29.74 ± 02.9	0.37
MCHC (gm/dL)	37.07 ± 05.6 ↓	39.24 ± 05.78	0.01**

*Differences between benzene exposed and unexposed groups, Mean ± SD. WBC White blood cells, RBC Red Blood cells, MCV mean corpuscular volume, MCH mean corpuscular hemoglobin, MCHC mean corpuscular hemoglobin concentration. Cells/mcL = cells per microliter and pg/cell = picograms per cell.

Liver function test (LFT): Data of LFT are presented in **Table 3**. The results showed statistically significant differences in all the liver function parameters between the exposed and non-exposed subjects to petrol. The exposed group had a highly significantly elevated mean concentration of alkaline phosphatase (u/L) as compared to non-exposed (178.2 ± 84.3 versus 132.32 ± 52.7, P < 0.001). The mean aspartate aminotransferase (IU/L) levels were significantly higher in the exposed group compared with unexposed group (25.6 ± 7.4 versus 23.5 ± 7.5, P < 0.05). Similarly, the mean serum alanine aminotransferase (IU/L) levels were increased significantly in the benzene exposed group compared with the unexposed group (22.3 ± 9.47 versus 18.87 ± 9.6, P < 0.01).

Table 3: Liver function parameters of exposed and unexposed subjects to petrol

Laboratory parameter (units)	Exposed group (n = 100)	Unexposed group (n = 100)	P value
Alkaline phosphatase (u per L)	178.2 ± 84.3	132.32 ± 52.7	0.001***
Aspartate aminotransferase (units per L)	25.6 ± 7.4	23.5 ± 7.5	0.05*
Alanine aminotransferase (units per L)	22.3 ± 9.47	18.87 ± 9.6	0.01**

Data expressed as mean and SD, *Differences between petrol exposed and unexposed groups are significant.

Kidney function parameters (KFT): Data of KFT were presented in **Table 4**. The findings showed statistically significant differences in the tested kidney function parameters between the exposed and unexposed subjects to petrol. The mean serum creatinine levels were significantly increased in the petrol exposed group compared with the unexposed group (0.98 ± 0.27 versus 0.70 ± 0.24, P < 0.001). The mean blood urea nitrogen levels were significantly increased in petrol exposed subjects compared with the unexposed subjects (33.9 ± 9.3 versus 22.4 ± 9.1, P < 0.001).

Table 4: Kidney function test parameters between benzene exposed and unexposed groups

Laboratory parameter	Exposed group	Unexposed group	P Value
Serum creatinine (mg per dL)	0.98 ± 0.27	0.70 ± 0.24	0.001***
Blood urea nitrogen (mg per dL)	33.9 ± 9.3	22.4 ± 9.1	0.001***

Data expressed as mean and standard deviation, *Differences between benzene exposed and unexposed groups are significant

Discussion

Benzene, which is a major organic component of crude oil and gasoline, this is known as one of the predominant toxic air pollutants in the atmosphere. Environmental exposure to benzene has long been known as a carcinogen of human blood components. In addition, occupational exposure to benzene may cause non-carcinogenic effects including hematologic, hepatic, neurologic, renal and immunologic dysfunctions. However, the precise mechanism of the toxic effects of the benzene is not fully understood [14, 16, 17]. Thus, a thorough knowledge of the health consequences of benzene exposure is important for determining approaches to estimates the risk that may help in early detection of pathological alterations caused by benzene exposure. Earlier, it has been approved that the other chemicals in addition to benzene in petroleum refineries affect the blood, kidney and liver functions [14, 17, 18]. Many epidemiological studies in different countries shown an association between defined types of health problems and exposure to benzene and/or benzene containing blends. Therefore, this search study was directed to inspect the health consequences of occupational exposure to petrol components mainly benzene on the hematological and biological parameters of petrol refineries exposed group of workers compared to control unexposed group of workers [13].

The findings of medical analysis demonstrated these findings. First, the funding's showed that the exposure to petroleum at oil refineries resulted in significant increase in mean white blood cells counts, platelets count, hematocrit percent and non-significant increase in red blood cells count. While, there were significant decreases in hemoglobin concentration, MCHC counts and non-significant decrease in MCV volume and MCH counts of petrol refineries workers than those of the comparison group. Similarly, in hematological assessment of gasoline exposure among petrol filling workers in Baghdad, the mean hemoglobin, white blood cells and red blood cells were significantly lower [19, 20], which is comparable to the current study for hemoglobin and different for white and red blood cells. While, in hematological assessment of petrol station attendants in Egypt, the mean WBCs, platelets, HCT, hemoglobin were increased in exposed group, which is in line with current study. Although, red blood cell decreased and the other parameters have not changed among exposed, which is different to present study [14]. On other hands, in hematological and biochemical assessment of liquefied petroleum gas exposed group in Gaza governorates. The mean platelet, red blood cells, HCT were significantly higher, which is in line to present findings. Meanwhile, the other counts increased and white blood cells decreased in exposed group that is different to present findings [21]. Similarly, the mean hemoglobin, MCV, MCH, MCHC were decreased which agreed with current findings. Although, the red and white blood cells counts were significantly decreased among petroleum exposed group at petroleum stations in Basra city which was different from the results of this study [13]. The Sudanese study done among petroleum station workers showed RBC, HCT, PLT and Hb decreased that is different with this study and comparable with the decrease in the mean WBC [22]. Although several earlier studies

did not detect decreased blood cell counts on routine monitoring of workers exposed to low level of benzene [14, 23, 24]. These results showed significant effect of petroleum vapor exposure on the hematological parameters of petroleum refineries workers. Our results agree with the findings of previous studies of subjects exposed to petroleum vapor [14, 15, 17].

Liver cells may be damaged by benzene exposure and this damage can be determined by liver transaminase. The alanine transaminase enzyme is an enzyme present in numerous tissues' mitochondria. Though, it is most commonly connected with the liver. So, it is a good biomarker of hepatocellular injury [25]. While, the aspartate transaminase enzyme is present in eighty percent of tissues' mitochondria named mAST that primarily appears in blood as a result of severe cell necrosis and damage. While, the rest 20% is found in the cytoplasm named cAST appears in blood as a result of cell injury. Therefore, different liver function parameters should be measured to increase the sensitivity, like alkaline phosphatase [26]. More specifically, in this study, the liver function was examined by estimating the serum enzyme levels among petrol exposed group and compared with the unexposed subjects. The findings showed that the serum levels were significantly elevated in the petrol refineries workers. Similarly, both liver enzymes were increased among liquefied petroleum gas exposed group significantly as mentioned previously [21, 27] that come in line with current results. Also, comparable results were obtained in Nigeria [28] that stated the levels of the liver enzymes were significantly higher in volatile petroleum hydrocarbons exposed group. These results agree with the results obtained from Liquefied petroleum products or organic solvents exposures showed that long term exposure to benzene vapor increased risk of liver dysfunction. The reported significant elevation of some liver enzymes in these subjects may have been related to their exposure to benzene. The elevated serum levels of these enzymes could be due to the overproduction or release of enzymes from the hepatic cells in response to stimuli of hepatocellular injury or cell death. However, the exact mechanisms for overproduction or release of these serum enzymes in benzene exposed subjects still remain to be explained [14, 17]. Urea and creatinine are nitrogenous end products of metabolism; the determination of serum creatinine and serum urea nitrogen levels is of great value in helping to check the renal function in the clinical setting. Kidney dysfunction has been investigated using blood urea nitrogen and creatinine-based measures of renal function [29, 30]. Present findings showed that serum creatinine and blood urea nitrogen levels were significantly increased in petrol workers in Zawia refinery and Mellitah Company. Although, several previous studies reported similar findings done among petroleum station workers in Sulaimani city (Kurdistan) and Mosul city (Iraq), in which serum levels of urea and creatinine were shown to be significantly elevated in exposed group [31- 33]. Also, kidney functions (urea, creatinine and uric acid) were increased among liquefied petroleum gas exposed group significantly [21]. Similarly, the urea and creatinine were higher in petrol station attenders in Egypt [14]. The mixtures of aliphatic and aromatic hydrocarbons contained in petrol affect different organs in body including kidney. A previous study on both animals and humans suggest that the kidney can affected by several chemicals [34].
However, in this study, the findings showed that the occupational exposure to petrol vapor is accompanied with prepathological, subclinical and clinical changes in blood parameters, liver and kidney function. In some earlier published studies, the effect of exposure to benzene was well established and raised the hazard of carcinogenesis as lung and blood cancers in exposed group [1, 6].

Conclusion: This study demonstrates that occupational exposure to petrol at oil and gas refineries caused significant alterations in

hematological and biochemical parameters indicating that petrol refineries workers exposed to chemicals may be at a high risk of developing blood, hepatic or renal related disorders. Clinical investigations and periodic medical checkup include hepatic, renal, pulmonary, cardiac, neurologic should be performed to monitor the long-term health consequences for petrol-exposed subjects. Personal protective equipment should be used at work to minimize workplace petrol exposure.

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Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author contributions: GMS, YMA, MFA, EMA and FFA conceived and designed the study, collected and analysis data; AAM, HA and OE collected data; SAH, SAB and SS analyzed and interpreted the results; AAZ and GMS drafting the first form of the manuscript with support from SS, FFA and SAH. All authors critically reviewed the final form of the manuscript and approved its submission.

Data availability statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical issues: Including plagiarism, informed consent, data fabrication or falsification and double publication or submission have completely been observed by authors.

Author declarations: We confirm all relevant ethical guidelines have been followed and any necessary IRB and/or ethics committee approvals have been obtained.

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