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Health Hazards, Hematological and Biochemical Alterations in Dry-Cleaning Workers using Perchloroethylene.

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Abstract

Perchloroethylene (PERC) is commonly used as a dry-cleaning solvent, it is attributed to many deleterious effects in the biological system. The study aimed to investigate the harmful effect associated with PERC exposure among dry-cleaning workers. The study was carried out in the period between February 2019 to August 2019 and it was conducted on 58 adults in two groups. PERC-exposed group; include thirty-two male dry-cleaning workers using exclusively perchloroethylene (PERC) as a dry-cleaning solvent in Sulaimani and Erbil; northern-cities in Iraq, and twenty-six healthy non-exposed subjects. History of PERC exposure, use of personal protection equipment (PPE), safety measurement of the exposed group was recorded. Blood sample was taken from each participant for measurement of hematological markers, liver and kidney function tests. The results showed that 28.1% of the workers were using PPE regularly while 71.9% of the workers were not. Most of the workers 31(96.9%) were disposed of their waste products in improper way. Non-significant differences were observed in hematological indices between PERC-exposed group and non-exposed group. Serum level of kidney and liver function markers of the dry-cleaning workers were higher with statistically significant difference compared with the non-exposed group. In conclusion, a non-significant alteration in hematological parameters, while significant changes in part of liver and kidney functions indices have been demonstrated. Clinical observation indicated a harmful effect in PERC-exposed group.

Keywords: Occupational, Perchloroethylene, Personal protective equipment, Dry cleaner

المخاطر الصحية و التغيرات الدموية و البيوكيميائية في عمال الغسيل الجاف المستخدمين للبيركلوروأثيلين

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الخلاصة

بيركلوروأثيلين يستخدم بصورة شائعة كمحلول للغسيل الجاف. التعرض لهذا المحلول يؤدي الى العديد من الآثار الضارة للنظام البيولوجي. الهدف من الدراسة الحالية هو البحث عن التأثيرات الضارة المرتبطة بالتعرض لبيركلوروأثيلين بين عمال الغسيل الجاف. أجريت هذه الدراسة على ٥٨ شخص في مجموعتين. المجموعة ألاولى تشمل مجموعة التعرض لبيركلوروأثيلين وتحتوي على ٣٢ من عمال التنظيف الجاف المستخدمين للبيركلوروأثيلين كمحلول تنظيف. أما المجموعة الثانية فتحتوي على ٢٦ شخص سليم وغير معرض لمادة بيركلوروأثيلين. تم تسجيل مدة التعرض لمادة بيركلوروأثيلين واستخدام معدات الحماية الشخصية للمجموعة المعرضة . و تم أخذ عينة الدم من كل مشارك لقياس المؤشرات الدموية و اختبار وظائف الكبد والكلي. أظهرت النتائج أن ٢٨,١٪ من العمال استخدموا معدات الوقاية الشخصية بانتظام في حين ٧١,٩٪ من العمال لم يستخدموا معدات الوقاية الشخصية. معظم العمال ٣١(٩٦,٩٪) تم التخلص من نفاياتهم بطريقة غير سليمة. اظهرت النتائج بان الفرق في المؤشرات الدموية بكلتا المجموعتين غير ملحوظة. هناك فرق ملحوظ في مؤشرات الكبد والكلي في الدم بين المجموعتين حيث كانت نسبة مؤشرات الكبد و الكلي في مصل الدم للمجموعة المعرضة أعلى عند مقارنته مع المجموعة غير المعرضة .

أستنتجت الدراسة ان هناك تغيير غير ملحوظ في المؤشرات الدموية مع وجود تغيير ملحوظ في جزء من مؤشرات وظائف الكبد والكلي. واشارت الدراسة السريرية الى وجود آثار ضارة في المجموعة المعرضة لبيركلوروأثيلين.

الكلمات المفتاحية : المهنية ، بيركلوروأثيلين ، معدات الحماية الشخصية ، غسيل الجاف

Introduction

Perchloroethylene (PERC), also known as tetrachloroethylene, is uncolored, volatile, nonflammable liquid and widely known for its use in dry cleaning of fabrics and clothes. PERC is released into the environment from processes utilized in dry cleaning systems, by evaporation from dry cleaned clothing, from spills, and from waste products containing PERC [(1,2)]. Acute exposure via inhalation may lead to irritation of the upper respiratory tract and the central nervous system. Hepatic, renal, respiratory, hematological, ocular and dermal systems are target organs for PERC toxicity in humans [(3)]. Additionally, the neurobehavioral function of healthy individuals is also influenced adversely as a result of chronic exposure to PERC. Chronic inhalation to PERC is associated with headaches, loss of memory, motor neurobehavioral functioning, color vision impairment [(4,5).]

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Furthermore, United State Environmental Protection Agency (US EPA) declared PERC as potential occupational carcinogen [6]. Metabolic pathways of PERC are mainly cytochrome P450 pathway and glutathione conjugation pathway, the former one generates metabolite of tri- and dichloroacetate in liver, that are associated with hepatic toxicity and carcinogenicity. While the glutathione pathway is related to the formation of reactive metabolites targeted the kidney to induce renal toxicity and carcinogenicity [7]. Therefore, many studies elaborated the impact of PERC exposure in various target tissues including liver, kidney and hematological tissues and highlighted the noncancerous toxicity of PERC [8-11]. Furthermore, a toxicological review on PERC has highlighted the scientific issues associated with deleterious effect of PERC on the human health [12].

A preliminary study conducted by Habib *et al* (2018) has concluded that PERC is a widely-spread cleaning solvent, and the exposure of PERC among dry-cleaning workers is high. Therefore, installation of local exhaust ventilation systems and monitoring devices of PERC level is very important among dry-cleaning along with increase the awareness of workers about the harmful effects of PERC and the significance of using personal protective equipment (PPE) while performing their job such as wearing appropriate chemical resistant gloves and clothing, safety goggles with a face shield for eye protection and respirator for respiratory protection [13]. In some countries, manufacturers have begun using alternative cleaning methods that do not require the use of PERC [14]. However, in Iraq especially in Kurdistan region this solvent is the main dry-cleaning agent so far. Therefore, the current study was designed to investigate the effect of PERC on hematological markers, renal and liver function in the dry-cleaning workers, and to observe the awareness of the workers on the safety and occupational risks of this toxic substance in their workplaces.

Subjects and Methods

Study population and data collection

The study was designed as a cross-sectional analysis, it was carried on 58 adult male subjects arranged in two groups, workers group (i.e. exposed to PERC); includes thirty-two male dry-cleaning workers employed in 15 laundry shops that used exclusively perchloroethylene (PERC) as a dry-cleaning solvent in Sulaimani and Erbil; northern-cities in Iraq, and twenty-six healthy non-exposed subjects who were matched with the workers group in sex and age, subjects with different smoking habits have been excluded. The study was carried out in the period between February 2019 to August 2019. A written informed consent was obtained from each participant. The study protocol was approved by the ethical committee of the College of Medicine, University of Sulaimani (Registration No#54 in 15.08.2017). A structured questionnaire, which was especially designed for the study, has been utilized and the responses of the participants were recorded by the researcher through face to face interview. The questionnaire was comprised of different sections to collect the information on the various aspects including demographic characteristics of the participants, exposure history to PERC, level of awareness of the workers on the safety measurement and hazards of the PERC, use of PPE during working hours, methods of disposal of PERC waste byproducts; whether the management of PERC waste is performed properly i.e through a specific management system or improperly through pouring them down the municipal sewer system.

Clinical and laboratory investigation

A physical examination was performed by the researcher using a structured questionnaire to investigate the indoor-toxic effect of the PERC on the workers including dizziness, headache, ataxia, eye irritation, respiratory tract effect and its dermatotoxicity. Blood sample (10 ml) was taken from each subject. Three milliliters of blood were collected in an EDTA tube and used for the determination of hematological markers including complete blood cells count using Beckman Coulter method (15). Seven milliliters were collected in a plain tube for isolation of the serum by centrifugation at 5,000 rpm for 10 min. The serum was used for measurement of the markers of renal function (serum urea and creatinine) and liver function (Total bilirubin, serum Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), alkaline phosphatase (ALP) and lactate dehydrogenase (LDH)) spectrophotometrically using the clinical chemistry analyzer Cobas c311 and ready-made kits (Roche Diagnostics GmbH, Mannheim, Germany) according to the manufacturer's specifications.

Statistical analysis

Statistical analysis was performed using GraphPad Prism 5.0.1 softwares (GraphPad Software Inc., La Jolla, CA, USA). Categorical data were analyzed with Chi-square test. Continuous variables were analyzed using independent sample t-test or the two-way ANOVA and Bonferroni's post hoc test. A P-value of less than 0.05 was considered to be statistically significant.

Results

The total number of the exposed dry-cleaning workers was 32 while of non-exposed subjects was 26. Their mean age was (35.43±6.7) year for exposed group while (35.2±6.9) for non-exposed group. The occupational history of participants, ventilation status, vapor leakage and other characteristics of the workplace is summarized in Table 1. The results reveal that most of the participants 20(62.5%) were with the duration of work of 5-10 years as a dry-cleaning worker. While

12(37.5%) were with more than 10-year duration. The other finding of the present study was relevant to the awareness of the workers on the safety and hazards of the PERC. The results showed that 28.1% of the workers (n=9) were using the PPE such as chemical resistant gloves and clothing, goggles, apron and boots regularly while 71.9% of the workers (n=23) were not. Almost all of the dry-cleaning laundry workers were disposed of PERC hazardous waste products improperly 31(96.9%). Simply they pouring them down the drain or into sanitary sewer system. The fact sheet on PERC which provides information on health effects was available only for 13(40.6%) of the dry-cleaning laundry workers, while it was not available for 19(59.4%) of the them (*p-value*=0.081) (Table 1).

Table 1. Demographic characteristics of the dry-cleaning workers (n=32) and workplace condition.

Parameter	**Number (%)**	**P-value**
Age (Year)		
35.43± 6.7		
Duration of exposure to PERC (Year)		
< 5 years	0(0)	0.012
5-10 years	20(62.5)	
> 10 years	12(37.5)	
Ventilation status in the workplace		
Poor	5(15.6)	0.02
Good	25(78.1)	
Excellent	2(6.3)	
Vapor leakage		
Positive	6(18.8)	0.011
Negative	26(81.2)	
Protection Facilities (PPE)		
Available	9(28.1)	0.032
Not available	23(71.9)	
Waste Disposal		
Appropriately disposed	1(3.1)	0.01
Inappropriately disposed	31(96.9)	
Availability of fact sheets		
Available	13(40.6)	0.081
Not available	19(59.4)	

Values are presented as percent or mean±SD; PPE: Personal Protective Equipment.

Additionally, most of the workers had no education on occupational hazards 27(84.4%) and they had no a periodic health follow-up 31(96.9%). Few numbers of the workers 2(6.3%) have taken a training course on the protection aspects of human exposure to PERC in their workplace and non-remarkable number 1(3.1%) of dry-cleaning workplace has been visited by health authority (Table 2).

Table 2. Safety and health concerns of the dry-cleaning workers (n=32).

Safety concern	**Yes *n*(%)**	**No *n*(%)**
Education on workplace hazards	5(15.6)	27(84.4)
Periodic health follow-up	1(3.1)	31(96.9)
Reported cancer cases in workplace	0(0)	32(100)
Accidental death in workplace	2(6.3)	30(93.7)
Training in workplace	2(6.3)	30(93.7)
Follow-up by health authority	1(3.1)	31(96.9)

Values are presented as numbers and percentages.

Effect of PERC vapor on hematological parameters is shown in Table 3. Non-significant differences were observed in hematological indices between the non-exposed group and PERC-exposed group.

Table 3. The hematological indices of both PERC-non-Exposed and PERC-Exposed group (n=58)

Parameters	EERC-non Exposed group (n=26)	PERC-Exposed group (n=32)	P-value
Hb (g/dl)	15.47±1.01	15.75±0.94	0.28
Hct (%)	46.30±2.74	46.77±2.81	0.52
Total WBC (x 10^9/L)	7.19±1.37	7.42±1.42	0.54
Lymphocytes (x 10^9/L)	2.42±0.63	2.43±0.52	0.98
Granulocytes (x 10^9/L)	4.54±0.90	4.52±1.15	0.93
Platelets (x 10^9/L)	207.9±64.4	231.3±63.8	0.17

Values are presented as mean±S.D. *n*: number of participants; unpaired *t*-test was utilized to predict significance at $P<0.05$; Hb: Hemoglobin; Hct: Hematocrit; WBC: White blood cell.

Effects of exposure to PERC vapor on the kidney and liver function markers of the dry-cleaning workers as shown in table 4. The results show significant higher serum urea, ALT and ALP level of the dry-cleaning workers group compared with non-exposed group (*P*-value <0.05).

Table 4. Kidney and liver function markers of PERC-non Exposed and PERC-Exposed group (n=58)

Parameters	PERC-non Exposed group (n=26)	PERC-Exposed group (n=32)	P-value
S. Urea (mg/dl)	26.2±3.2	30.9±6.7*	0.0017
S. Creatinine (mg/dl)	0.83±0.15	0.84±0.18	0.76
S. Bilirubin (mg/dl)	0.49±0.26	0.52±0.34	0.75
ALT (U/L)	20.0±6.6	27.0±15.8*	0.04
AST (U/L)	22.3±6.7	23.9±9.6	0.46
ALP (U/L)	67.0±23.2	87.0±40.4*	0.029
LDH (U/L)	154.9±31.0	161.3±28.3	0.42

Values are presented as mean±S.D; * significantly different compared with the non-exposed group values ($P<0.05$); ALT: Alanine Aminotransferase; AST: Aspartate Aminotransferase; ALP: alkaline phosphatase; LDH: lactate dehydrogenase

The clinical observation of the PERC-exposed workers shows a profound clinical sign such as memory loss, dizziness, headache, irritation of the eye, respiratory tract irritation, ataxia and dermatological problems (Table 5).

Table 5. Percentage of certain clinical signs that appear frequently in PERC-exposed dry cleaning workers (n=32)

Clinical sign	Incidence *n* (%)
Memory loss	10(31.3)
Dizziness	9(28.1)
Headache	12(37.5)
Irritation of the eye	4(12.5)
Respiratory tract irritation	6(18.8)
Ataxia	3(9.4)
Dermatologic problems	4(12.5)

Values are presented as numbers and percentages

Discussion

Perchloroethylene (PERC), has been used commercially in many countries in dry cleaning, textile processing, and metal-cleaning operations [6]. In dry-cleaning laundries, release of PERC vapors into the environment and subsequent worker exposure to PERC vapors is greatest during maintenance of dry-cleaning machine and disposal of waste products [16]. Although the present study has not measured the blood or urine concentration of PERC or its metabolite in the exposed dry-cleaning workers, many studies have detected a significant measurable concentration of this substance in their biological fluids [9] which indicate that the dry-cleaning employees have occupational exposure to PERC [10]. Further studies have shown that people exposed to PERC either during work or residential proximity to PERC dry cleaners have elevated levels of PERC in blood, exhaled breath and urine [4,17].

In the present study, the occupational observation of the laundry shops demonstrated inadequate safety profile that necessitate establishment of more educational and awareness program to overcome a potential risk of utilizing dry-cleaning solvent in these workplaces. Azimi Pirsaraei *et al* stated that the dry-cleaning workers are highly exposed to PERC in their occupational settings, therefore protective measure should be considered to avoid the harmful effect of this toxic substance on the workers [3]. The finding of the present study is inconclusive whether there is a correlation between using protective equipment and health status of the workers, however a recent study also emphasized on the proper use of personal protective equipment to avoid early DNA damage in dry cleaners [11].

In the present study the clinical status, hematological and biochemical parameters of the dry-cleaning workers in the laundry shops of

Sulaimani and Erbil cities were investigated. Certain clinical signs in PERC-exposed dry cleaning workers have been reported such as dizziness, headache, dermatological and respiratory tract effect. This clinical surveillance of the dry-cleaning workers in the present study is consistent with the other studies which have concluded that short-term inhalation of PERC can lead to irritation of the nose and throat and depress the central nervous system [(3)]. Since exposure of PERC at the workplaces primary occurs through inhalation and dermal contact where perchloroethylene is produced or used [(18)] and inhalation of PERC can pose psycho-physiological effects include fatigue, anorexia, irritability, impaired memory, and confusion. Direct skin contact with liquid PERC may lead to erythema, papules and burns [(19)].

Furthermore, the findings of other study also demonstrated that the dry-cleaning workers exposed to PERC are at risk of developing acute or chronic adverse health effects, depending on the concentrations of PERC [(13)]. Other principle finding of the present study was a non-significant alteration in the hematological parameters in PERC- exposed dry cleaning workers compare with the non-exposed group. Meanwhile Emara *et al*, has documented the hematotoxicity and immunotoxicity induced by PERC in dry-cleaning workers [(20)]. The liver and kidney are well-documented target organs for PERC-induced toxicity. In a previously published animal study, a slight increase in weight of liver was noted after exposure to PERC at different concentration which were coincided with very slight hypertrophy of centrilobular hepatocytes of the liver [(21)]. Our results are inconsistent with this previous report as the data of liver enzymes in the present study did not indicate a complete alteration in the liver function which can be explained by inadequate exposure of the workers to this dry-cleaning solvent due to non-commitment of the workers to the working hours in the studied laundry shops. Other past study reported no effect of PERC on liver and kidney function at the exposed level to dry-cleaning workers [(9)] which can support the finding of the present study.

Although the kidney has also been reported as a target organ for PERC, previous reports stated that the effects of PERC are typically noted at concentrations higher than those that induce liver effects after intermediate duration of exposure [(22)]. The results of the present study demonstrated a significant alteration in serum urea level while non-significant changes in serum creatinine of the exposed group compare with the non-exposed participants. This finding is consistent with the previous study which had suggested a weak but dose-related effect of PERC on the kidney of the dry-cleaning workers and it considered glutamine synthetase in urine as the most reliable biomarkers of renal changes in human exposed to low level of PERC as it could indicate a specific effect of this solvent on the proximal tubules [(9)]. Recent study emphasized on urine sample as another non-invasive biomarker for detection and evaluation of PERC in urine which might explain the potential deleterious effect of PERC on renal system [(23)].

For the present study, there are some limitations. First; biological level of PERC has not been considered as a marker of the exposure. Second; the environmental level of PERC has not included as a studied parameter. However, the strength of the current study was that both clinical and biochemical parameters are included.

Conclusion

A non-significant alteration in hematological parameters, while significant changes in some liver and kidney function indices have been demonstrated in the present study. Additionally, inadequate use of protection facilities (i.e. personal protective equipment) has been reported among the workers that need awareness about hazards of PERC and training on how to protect themselves from its deleterious effects.

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Ethical Approval

The study protocol was approved by the ethical committee of the College of Medicine, University of Sulaimani (Registration No#54 in 15.08.2017).

Informed Consent

Written informed consent was obtained from each participant.

Conflict of Interest

The a*uthor declares no Conflict of Interests for this article.*

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