

ASSESSMENT OF DIFFERENT HEALTH HAZARDS IN PAINTING INDUSTRY

By

El Mahdy N.M. and Radwan N.M.

From

National Egypt. Center of Env. & Toxicol. Research, NECTR, Cairo Univ.

Abstract:

Introduction: Painters are among the highly and chronically exposed occupational groups either in industrial or commercial field. The health effects of organic solvents have been known for more than a century either from occupational exposure or from organic solvent abuse. Long term heavy solvent exposure is hazardous to the nervous system, hepatic, renal, blood and other body systems.

Aim of the study: to assess the different health hazards encountered in the painting industry with special reference to the effects of organic solvents and toluene as the major solvents used and to assess the effectiveness of urinary orthocresol as a biological indicator of exposure.

Subjects and Methods: The studied population comprised 68 individuals divided into exposed and control groups. The workers were all males with age ranging from 31 to 55 years with a mean value of (40.74 ± 1.63) . The duration of exposure ranged from 9 to 30 years. The age of the control group ranged from 30- 58 years with a mean of (48.33 ± 1.85) . All workers were interviewed with a detailed questionnaire about presence of neuropsychological, respiratory, renal, hepatic and hematological symptoms. Detailed personal, medical and occupational history were included. Thorough physical examination was done. Complete blood picture, liver function tests, kidney function tests, serum electrolytes, ventilatory function tests , urinary o-cresol level and urine analysis were also done.

Results: Liver function tests showed no statistically significant difference between the exposed workers and the control groups. In correlation with duration of exposure statistically significant difference was found between exposed workers as regards SGPT level. Complete blood picture results showed normal levels with no difference between exposed and controls; but some parameters decreased with increased duration of exposure. Urinary o-cresol level showed a statistically significant difference between exposed workers and control group (p-value 0.000). Ventilatory functions of the studied groups showed that exposed workers had lower values of all parameters measured.

Conclusion: The results strengthen the relationship between the different health hazards encountered in painting industry and the duration of exposure. Hematological, immunological and cardiovascular effects are further suggested and should be tested thoroughly in future studies.

Key words: painting- solvents – toluene- occupational exposure- urinary o-cresol.

Introduction:

Paint products are widely used in industry to provide surface coating for protection against corrosion, for appearance, as electrical insulation, for fire retardation and for other special purposes. Paints can be applied by a variety of processes including brush, roller, dip, flow, conventional air spray, airless spray, disk spraying and powder coating. (Handbook of Occupational Safety and Health, 1999).

The conventional solvent based paints consists of the vehicle, filler and additives.

The vehicle represents the total liquid content of the paint and includes the binder which is a naturally occurring oil or resin and solvent. The fillers include pigments and extenders which historically have presented a major hazard in painting.

A group of pigments including lead carbonate, cadmium red, and chrome green and yellow do represent critical exposure both during spray application and surface preparation. A wide variety of additives are added to paints (McCann, 1998).

The most common organic solvents used include aliphatic and aromatic hydrocarbons, ketones, alcohols, glycols and glycol ether/ ethers. These solvents have high vapor pressure and represent the critical worker exposure in most painting techniques. (Handbook of Occupational Safety and Health, 1999). It is however, also true that toluene is the solvent present in the largest proportion in many cases, suggesting that the major toxicity profile may be predominantly determined by toluene with other solvents as minor toxicity modifiers (Hirohiko et.al., 1994).

Conventional air spray is the most common method encountered in industry and presents the principal hazards owing to overspray (Handbook of occupational safety and health, 1999) which is the case in our study.

Organic solvents have long been recognized as being toxic to multiple systems including haematopoietic tissue, the nervous system and all parenchymatous organs rich in fats (Hoeck et al., 2001 and Ari et al., 2004).

Health hazards include inhalation and skin contact with isocyanates used in manufacturing polyurethane paints and coatings (McCann, 1998). The risk of injury depends on the concentration of the substance and duration of exposure and whether it is present alone or in mixture (Jones and Kennedy, 1988).

Aim of the work:

The aim of the study was to assess the different health hazards encountered in the painting industry with special reference to organic solvents effects and toluene as the major solvents used and to assess the possible association of certain hazards with the duration of exposure. In addition to assessment of the effectiveness of urinary ortho-cresol (o-CR) as a biological indicator of exposure.

Subjects and Methods:

The study was conducted in one of the painting industry in Cairo. The studied population comprised 68 individuals divided into exposed and control groups. The spray painters had been exposed to a mixture of organic solvents including toluene (as the main constituents), xylene, methyl ethyl ketone and ethyl acetate.

The workers were all males with age ranging from 31 to 55 years. The duration of exposure ranged from 9 to 30 years. All

of them were exposed to a mixture of solvents. The control group included 30 individuals working in the same factory in the administration away from the field of exposure.

Both groups were matched regarding age, sex, socioeconomic status and special habits.

All workers were personally interviewed with a detailed questionnaire about presence of neuropsychological symptoms (mood changes, memory and lack of concentration, easy fatiguability), respiratory, renal, hepatic, hematological manifestations. Detailed personal medical history, occupational history including previous occupational exposure, pattern of exposure, risk factors and duration of employment were included. Comprehensive physical examination was done. Complete blood picture, liver function tests (SGPT, SGOT), kidney function tests (blood urea and creatinine), serum electrolytes, ventilatory function tests, urinary o-cresol level and urine analysis were also done. A written consent was taken from the studied group to perform the work.

Air sampling results was obtained from the executive director of the company.

The work room air analyses had been performed on several occasions in all the

plants by the industrial hygienists. The mean exposure level of toluene was 62 ppm.

Laboratory Investigations:

Seven ml of venous blood were taken from the studied group under aseptic conditions; two ml was put into a tube containing Ethylene Diamine Tetraacetate (EDTA) for blood picture examination. The following parameters were measured: hemoglobin level, total and differential leucocytic count, total red blood cell count, platelet count.

Five ml of blood were left to clot, centrifuged for serum preparation and chemical analysis which was performed using the photometer PM 750 for measurement of SGPT, SGOT (normal values up to 12 U/L), serum creatinine (normal value = 0.5 -1.2 mg%) and blood urea (normal value = 19-50 mg%).

Serum electrolytes were measured using the AVL apparatus. The ISE module measures the ionic activity of Na⁺ and K⁺ in serum and plasma, this activity is compared to standards whose ionic activities are adjusted to mimic that normally found in serum or plasma (normal values for serum sodium = 136-145 mM/L and Potassium = 3.5-5 mM/L).

Spirometry:

Resting ventilatory function test values were assessed from the flow volume curve using the standard techniques according to the American Thoracic society recommendations. Ventilatory function tests were performed using the Medgraphic spirometer in the Fitness and Rehabilitation Unit, Kasr El Aini Hospital. The following parameters were measured for each subject: FVC, FEV₁, FEV₁/FVC%, FEF 25%, FEF 50%, FEF 75%, FEF 25-75%, MVV, SVC, IC and ERV. Results were expressed as % of predicted. It is advocated that lung function tests are considered abnormal only when the value deviates by 20% or more from the mean normal value (100%) (Ruppel, 2003).

Ortho-cresol analysis in urine:

Urinary o-CR was determined by high-performance liquid chromatography (HPLC) (Truchon et al., 1999). The urine samples were hydrolyzed, centrifuged, saturated with sodium chloride, extracted and introduced to the chromatographic system for measurement. Urine samples from the studied groups were collected at the end of the shift.

Urine sampling conditions:

Urine samples from the studied group were collected at the end of the shift in

plastic sterile containers immediately shut with lid before storage for immediate analysis.

Data handling and Statistical Analysis:

Data were collected, checked, revised and entered the computer. Data were analyzed by SPSS statistical package version 15. Excel computer program was used to tabulate the results and represent them graphically. Qualitative variables were expressed as percentages.

The differences in the distribution of the qualitative variables were tested by the Chi square non - parametric test at level of significance $p < 0.05$.

Quantitative variables from normal distribution were expressed as mean and standard error (S.E.). The significant difference between before and after was tested by using paired t-test at level of significance $p < 0.001$.

The significant difference between groups were tested by using independent t-test at level of significance $p < 0.05$.

Pearson correlation coefficient was calculated to measure the power and direction of the relationship between the quantitative variables at $p < 0.05$. (Armitage 1971).

Results:

The studied population comprised 68 individuals divided into exposed and control groups. The workers were all males with age ranging from 31 to 55 years with a mean value of 40.74 ± 1.63 . The duration of exposure ranged from 9 to 30 years with a mean of 19.5 years. The age of the control group ranged from 30- 58 years with a mean of 48.33 ± 1.85 .

There was no statistically significant difference between the exposed and control groups as regards the age and smoking habits.

Twenty subjects among exposed group (52.6%) were cigarette smokers versus 10 subjects (33.3%) of the control group and 6 subjects from both groups were ex-smokers. Twelve subjects (31.5%) of the exposed group had a duration of employment less than 15 years with a mean value of (10.67 ± 0.92) while 26 subjects (68.4%) had been employed for more than 15 years with mean value of (23.77 ± 1.17) .

Analysis of liver function tests revealed that values of SGPT and SGOT were within normal range with no statistically significant difference between the exposed and the control groups. However, in correlation with duration of exposure table (1) showed gradual increase in the SGPT level with

statistically significant difference between exposed workers; while the SGOT level although higher than normal, no statistically significant difference was detected.

Blood picture showed normal levels of all parameters measured with no difference detected between exposed and controls except in basophil and monocyte levels; but with increased duration of exposure, table (2) showed a statistically significant difference among exposed workers as regards haemoglobin level, red blood cell count, haematocrite value and platelet count. All levels decreased with increased duration of exposure.

As regards urinary o-cresol level, a statistically significant difference was found between exposed workers and control group (p-value 0.000). Also the level increased with increased duration of exposure among workers. Among smokers, the level was found to be higher than non smokers with statistically significant difference between them (figure 1).

Table (3) illustrates the means of ventilatory functions of the studied groups. Exposed workers showed lower values of all

parameters measured. There was significant difference in FEV1/FVC %, FEF 50 % and MVV percent of the predicted values between exposed workers and control group before bronchodilator inhalation.

After analysis of the results, no significant difference was detected in ventilatory functions of the exposed group in relation to smoking.

Table (4) presents different urinary parameters of the investigated groups. There was a statistically significant difference between exposed workers and control group in all parameters measured; excretion of proteins (36.8%), pus cells (100%), RBC's (94.7%), crystals (89.5%), urates (73.7%) and casts (31.6%).

Table (5) illustrates the distribution of the investigated group regarding clinical symptoms. There was a statistically significant difference between exposed workers and control group in cardiovascular symptoms. Respiratory, renal, neuropsychological and hematological symptoms were recorded only among workers. As regards hypertension 15.8% of exposed group were affected.

Table (1): Effect of duration of exposure on the liver function tests, kidney function tests and serum electrolytes.

	<=15 (n=12)	>15 (n=26)	t value	p-value
	Mean±S.E	Mean±S.E		
SGPT (U/L)	12.42±1.76	24.54±2.8	2.78	0.013*
SGOT (U/L)	15.00±2.98	19.15±3.0	0.85	0.409
Urea (mg%)	33.00±3.27	31.77±2.10	0.32	0.751
Creatinine (mg%)	1.00±0.08	1.02±0.06	0.22	0.826
Sodium (mM/L)	141.00±1.29	141.62±0.79	0.42	0.679
Potassium (mM/L)	4.05±0.16	4.32±0.18	0.94	0.362

* There is a significant difference between patient and control group by using independent t-test at $p<0.05$

Table (2): Effect of duration of exposure on the blood picture.

	<=15 (n=12)	>15 (n=26)	t value	p-value
	Mean±S.E	Mean±S.E		
HB	13.10±0.26	12.09±0.15	3.56	0.002*
RBC	4.18±0.21	3.78±0.05	2.47	0.024*
HCT	38.33±0.31	36.28±0.39	3.30	0.004*
TLC	7.05±0.20	8.05±0.43	1.50	0.152
Platelets	301.33±4.05	256.46±13.27	2.24	0.039*
Basophils	0.58±0.09	0.52±0.04	0.73	0.476
Oesinophils	4.93±0.20	4.30±0.28	1.42	0.174
Segmented	46.05±4.15	51.84±1.23	1.76	0.096
Monocytes	7.73±0.34	8.16±0.33	0.80	0.438
Lymphocytes	39.50±4.31	34.95±1.71	1.19	0.250

* There is a significant difference between patient and control group by using independent t-test at $p<0.05$

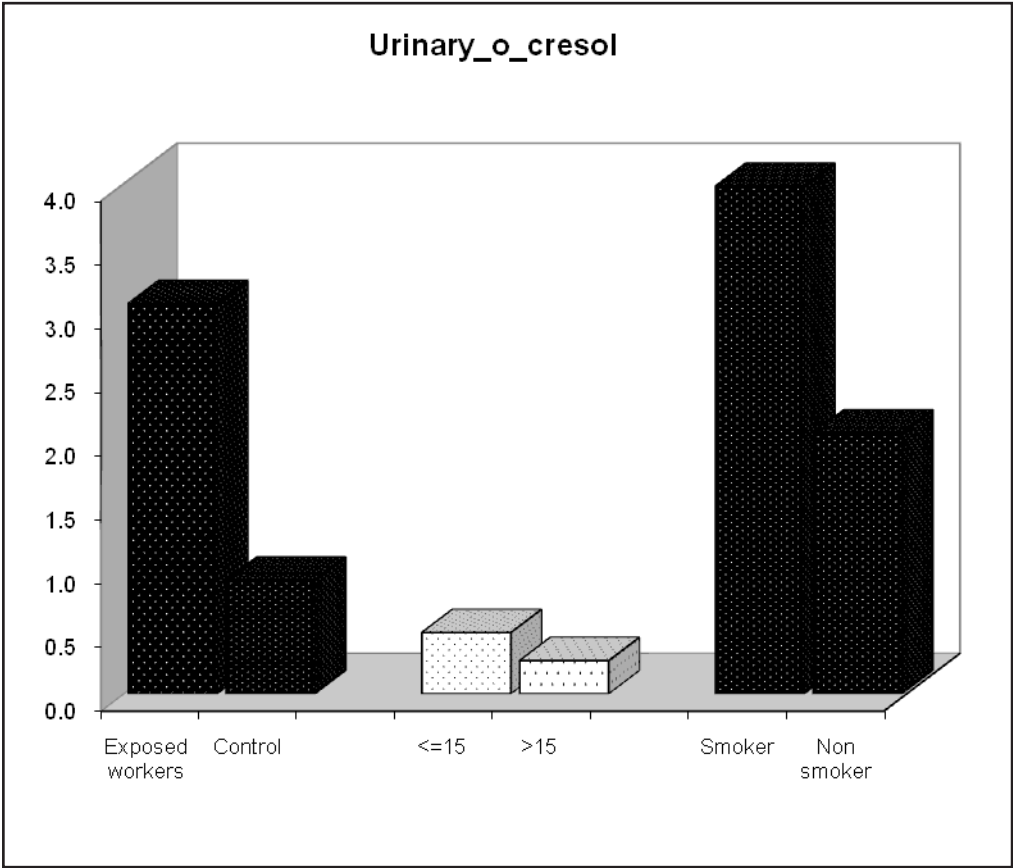


Figure (1): Level of urinary o-cresol in studied groups and relation with duration of exposure and smoking.

Table (3): Comparison between exposed workers and control group in ventilatory functions.

	exposed (n=38)	Control(n=30)	t-value	p-value
	Mean±S.E	Mean±S.E		
FVC % of pred.	93.68±2.141	95.13±1.376	0.54	0.596
FEV1 % of pred.	91.58±1.992	93±1.317	0.56	0.579
FEV1/FVC %	80.84±0.799	83.33±0.882	2.09	0.045*
FEF25% of pred.	87.58±4.407	88.13±0.827	0.11	0.913
FEF50% of pred.	70.16±3.853	83.47±1.023	3.00	0.005*
FEF75% of pred.	78.16±3.737	86.07±0.727	1.85	0.073
FEF25-75% of pred.	84.16±3.224	88.8±1.418	1.21	0.237
MVV % of pred.	76.74±4.08	90.07±0.983	2.84	0.008*
SVC % of pred.	94±1.953	98.07±1.629	1.54	0.132
IC % of pred.	98.26±4.518	102.53±2.724	0.76	0.455
ERV % of pred.	84.32±9.698	87.93±1.733	0.33	0.746

* There is a significant difference between patient and control group by using independent t-test at $p < 0.05$

Table (4): Comparison between exposed workers and control group regarding urinary parameters.

	Exposed workers		Control		χ^2	p-value
	Count	%	Count	%		
Proteins	14	36.8%	0	0.0%	-	-
Pus cells	38	100.0%	12	40.0%	5.54	0.019*
RBC's	36	94.7%	12	40.0%	6.00	0.014*
Crystals	34	89.5%	12	40.0%	5.26	0.022*
Urates	28	73.7%	4	13.3%	9.00	0.003*
Casts	12	31.6%	0	0.0%	-	-

Table (5): Comparison between exposed workers and control group regarding clinical symptoms.

	Exposed workers		Control		χ^2	p-value
	Count	%	Count	%		
Respiratory	6	15.8%	0	0.0%	-	-
Renal	20	52.6%	0	0.0%	-	-
Cardiovascular	16	42.1%	2	6.7%	5.44	0.020*
Neuropsychological	20	52.6%	0	0.0%	-	-
Hematological	14	36.8%	0	0.0%	-	-
Hypertension	6	15.8%	4	13.3%	0.20	0.655

* significant

Discussion:

The health impact of chronic workplace exposure to mixture of solvents is still a worldwide health issue due to their widespread use as constituents in paints, cleaners, adhesives, inks and many other products commonly found in many workplaces.

Neuropsychological effects:

Several epidemiological studies have suggested that exposure to a mixture of organic solvents may contribute to an increased risk of neuropsychological disorders such as mood changes, abnormal fa-

tigue, concentration difficulties, irritability and fatigue (White et al., 1995; Hoeck et al., 2000 and Nordling et al., 2007).

Our study revealed that 52.6% of exposed workers were complaining of dizziness, ataxia, short memory, lack of concentration, mood changes and easy fatigability (table 5). These symptoms were nearly similar to the study done by Hassan et al., (2001). In agreement with these results are the studies done by Attia et al., 2006 and Soliman et al., 2002 which confirmed that neuropsychiatric symptoms were more common among the exposed than among

the control group and that the findings were consistent with residual central and peripheral nervous system dysfunction due to long term exposure to organic solvents.

Highly significant associations were found by Dick et al., 2002 and Kaukiainen et al., 2004 between cumulative intensity of long term solvent exposure and symptoms of memory concentration and mood which was previously recorded by Nasterlack et al., in 1999.

In contrast with this, some studies showed no evidence of neuropsychological disorders among workers exposed to mixture of solvents (Bukowski et al., 1992; Williamson and Winder 1993 ; Myers et al., 1999).

Juntunen et al., in 1985 and Antti-Poika et al., in 1985 stated that acute exposure to toluene may damage the central nervous system (CNS). Cerebral and cerebellar atrophy have been well documented in solvent abusers exposed to high levels of toluene; but in the occupational setting levels of exposure are generally lower and clinical neurobehavioural deficits are often absent.

The present study showed that the prevalence of the neuropsychiatric symptoms were recorded among workers with higher age group with increased duration of exposure which is in contrast with the study

done by Choong Ryeol et al., 2005 who found no significant correlations between neurobehavioral performance and cumulative exposure index. However, when the duration of exposure in years was used as a measure of dose the results between the group with exposure < 10 years and the group with exposure > 20 years were significantly different after controlling age and education level. This controversy may be attributed to certain limitations in the study. We didn't perform any of the neurobehavioral test battery so that we could evaluate various functions of the central nervous system. So, an objective neurobehavioral test is recommended on evaluating neurobehavioral performance of long term solvent exposed workers.

Effect on the liver:

Many investigators have reported that the spray painting operation and paint manufacturing industry usually do not produce damage to the liver (Axelson, 1983). However, as the exhaust ventilation is generally not well designed or installed in Egypt, so, we are still concerned that paint manufacturers and sprayers might be suffering from different health hazards in the workplace.

So, one of the purpose of this study was to determine biochemical alterations in liver function among paint sprayers and their

association with exposure to the organic solvents used.

In general detection of subclinical hepatic injury in workplace surveillance programs has relied on measurements of activities of serum hepatic transaminases (Brodikin et al., 1995). However, the study done by Amr et al., in 1985 revealed that there was no specific correlation between serum enzyme activity and the severity or extent of toxic liver injury, their values varied significantly. Thereafter, in another study Amr et al., in 2001 found that all parameters of liver function were high among the production and storage exposed groups.

However, the SGOT is released not only by the liver but also by the heart, skeletal muscles and pancreas thus clinical diagnosis can not be based on this laboratory value alone (Sherlock, 1981).

Our results showed no statistically significant difference between exposed workers and control group regarding SGPT & SGOT levels similar to the results of Hirohiko et.al., 1994 ; but table (1) showed difference between exposed workers in relation to the duration of exposure with statistically significant difference in SGPT level but not in SGOT; with increased duration of exposure there is gradual increase of both levels which might reach higher lev-

els on the future specially if influenced by other additive factors; a finding that should be put in consideration for further evaluation in future researches.

Ahmed et al., in 2004 found high level of SGPT among the studied group and they stated that measurable increase in either enzyme suggests possible damage or even hepatocellular necrosis with a severity that varies directly with the levels of the enzymes. However, they recommended doing hepatic ultrasonography which may provide a more sensitive indicator than biochemical tests for detecting the severity of hepatic disease.

In contrast, the results of Lundberg and Hakanensson in 1985; Chen et al., in 1991 revealed no significant increase in SGOT, SGPT or γ -GT in serum of the exposed workers in paint industry. Also, the study done by El Shourbagy and Eid in 1999 on young car paint workers revealed no significant difference regarding the level of blood urea, SGOT, SGPT, serum calcium, potassium and acid phosphatase.

This contradiction might be explained by the fact that SGOT and SGPT were proved not to be a reflection for the hepatic injury in the absence of significant necrosis and inflammation thus causing underestimation of the early hepatotoxic effects

(Brodkin et al., 1995). Also this can be explained according to Lundberg et al., 1994 who found that the prevalence of possible signs of liver dysfunction was more among workers with heavy exposure to organic solvents for a short time than those with light exposure for long periods; a point which should be put in consideration.

Some authors argued that measurement of serum bile acids (SBA) concentration would be more sensitive than conventional liver function tests such as SGOT, SGPT, GGT activities and bilirubin concentration (Franco et al., 1986 and Chen et al., 1997).

As regards the effect of smoking, we found that transaminases levels were higher among exposed smokers as compared to non smokers, this could be explained by the fact that smoking could have an additional role with the exposure to solvents as smokers were proved to have significant higher blood concentrations of benzene, toluene and n-hexane than non smokers (Brugnone and Perbellini, 1994). We recommend that a longitudinal study with a long term follow up should be performed to define more clearly the possible hepatotoxic effect among paint workers.

Effect on the blood:

Great controversies were present as regards effect of solvents on different param-

eters of blood picture.

Our results showed no statistical difference between exposed workers and the control group regarding different parameters of blood picture except for the basophils and the monocytes which showed statistically significant difference between workers and the controls. Basophils have been considered to be important mediators of late-phase allergic reactions, however, they play a more pivotal role in initiation rather than maintenance of IgE-mediated chronic inflammation at least in the skin (Gibbs 2005). Monocytes play an important role in the development and duration of the inflammatory reaction.

So our results might be an indication of immune system dysfunction which was recorded in several studies that stated that organic solvents may impair the immune system and are considered as immune-suppressors (Hardell et al., 1998).

This will need further assessment through measurement of immunoglobulins.

In contrast, the study of Attia et al., 2006 revealed lower values with statistically significant difference between workers and controls as regards RBC's, WBC's and Hb levels. However, the study of Emara et al., 1996 found increase in the number of

RBCs, WBCs and the level of hemoglobin among the exposed group when compared with the controls.

However table (2) showed statistically significant difference between exposed workers relative to the duration of exposure regarding the hemoglobin level, the red cell count, the hematocrite value and the platelet count all of which showed gradual decrease with increased duration of exposure which was evidenced by the presence of some manifestations including general malaise, bleeding tendency, generalized bony aches, easy fatiguability, purpura and pain on the sternum (36.8 % of exposed) which were completely absent among control group (table 5).

The laboratory results were consistent in part with the work of El Shourbagy and Eid in 1999 who found that the mean value of hemoglobin was significantly decreased after 3 months of exposure among the examined group.

Also the study done by Hirohiko et al., in 1994 showed that a few examinees in the exposed and control groups fell in the borderline category of hematological changes due to subclinical anaemia or subclinical leucocytosis, but the distribution pattern did not differ significantly between the two groups.

As regards the white blood cell count our results showed no significant difference between the exposed workers and the control group which is similar to the results of Karakaya et al., 1997 and Beshir and Saad 1999 who also found no significant difference between both groups. As regards the lymphocyte count Beshir and Saad 1999 found no significant difference between the compared groups in contrast to our results which showed higher levels in exposed as compared to controls although not statistically significant.

Moszczynsky et al., in 1989 and Rothman et al., in 1996 found that the lymphocyte counts were decreased among workers with exposure to solvents. The decrease in peripheral counts of circulating lymphocytes was proved to be an early sign of toxicity as it appears before any other hematologic effects of solvent exposure.

In fact our results proved the opposite as we found that with increased duration of exposure there was gradual decrease in the lymphocyte count.

Effect on the kidney:

The renal toxicity of organic solvents included both acute tubular necrosis and glomerulonephritis (Gerr and Letz, 1998; Jens et al., 2005).

Some investigators (Yaqoob et al., 1992 and Daniell et al., 1993) have suggested that exposure to organic solvents is likely to play a role in the pathogenesis of glomerulonephritis; while others (Hoeck et al., 2000 and Hassan et al., 2001) did not find any effect. The lack of association between the renal effects and the intensity or duration of exposure was reported in most of the studies. It has been suggested that this can be attributed to individual susceptibility. Available information points to a possibility of mild renal effects, but not to a serious influence on the kidney function at the current levels of occupational exposure to organic solvents. Biological monitoring of early effects can help to identify individuals susceptible to nephrotoxicity of this group of chemicals (Jakubowski, 2005).

In the present study, we recorded higher urea level in exposed workers when compared to the controls although not statistically significant; with no significant difference among the exposed in relation to the duration of exposure This can be explained by the results of Stengel et al., (1998) who concluded that toluene at 50 ppm (the threshold limit value–time-weighted average (TLV–TWA) proposed by the American Conference of Governmental Industrial Hygienists (ACGIH) in 2001 for toluene is

50 ppm for an 8 h work shift) was not related to detectable renal dysfunction, and toluene level in our study was 62 ppm which is not so far from the standard value.

The creatinine level was found to be within normal range with no difference between exposed and controls and with no effects with increased duration of exposure. This result is in agreement with the study done by Elfar et al., in 1998 who found no statistically significant difference between solvent exposed group and control group as regards kidney functions and no significant correlation between them and the duration of exposure. Also, Ari K. et al., in 2004 found a negative relationship between serum creatinine level and solvent exposure.

In contrast, Attia et al., in 2006 found a statistically significant difference between both groups in urea and creatinine levels in addition significant positive correlation with the duration of exposure.

As regards the renal manifestations; It was recorded in 52.6% of the exposed group and non of the controls which is in agreement with the study of Attia et al., in 2006 who found higher prevalence of manifestations among exposed workers with no significant difference between them and the controls.

Respiratory effects:

In our study, 15.8 % of workers were complaining of acute respiratory manifestations in the form of attacks of cough, throat irritation, chest tightness or asthmatic like attacks. While 17 % of workers who were smokers were complaining of chronic symptoms in the form of chronic cough with expectoration, asthmatic attacks which might indicate presence of chronic bronchitis. These results were consistent with the results of Ari et al., in 2005 and Attia et al., in 2006 who detected high prevalence of respiratory symptoms and chronic bronchitis among construction painters and metal degreasers respectively.

An association between construction painting and COPD have been reported in one study (White and Baker 1988), where an interaction was observed between smoking and duration of employment.

Polyurethane paints (PUP) contain low volatility isocyanate which can irritate the respiratory tract and may result in asthma attacks either immediately or some hours after exposure. Repeated exposures may result in impairment of lung functions (Redlich et al., 2006). A finding that could explain asthmatic like attacks in exposed workers.

The pulmonary function tests revealed lower values of all parameters measured in exposed workers when compared to the control group with a statistically significant difference in FEV1/FVC %, FEF 50% and MVV (table 3) which denoted obstructive pattern; also we found negative correlation with the duration of exposure ($r = -0.42$ in FEV1, $r = -0.45$ in FEF 25%) suggesting a close relationship between the extent of exposure and the obstructive element. Our results were in agreement with the studies of Amr et al., in 2001; Saad and Beshir in 2005 ; and Attia et al., in 2006 who showed significantly lower values in most of the parameters among exposed workers when compared to those of the control group; also with negative correlation with the duration of exposure.

As regards smoking effects, in our study both exposed and control groups were matched as regards the smoking habits so the effect of smoking was neglected.

Chronic diseases:

The study of Kaukiainen et al., in 2004 revealed that there was increased prevalence of diabetes and cardiovascular diseases mainly hypertension, arrhythmias, coronary disease and valvular diseases among exposed workers. Our results revealed presence of diabetes (10.5%), hypertension (15.8%) and cardiovascular

diseases (42.1); but their presence may be related to solvent exposure or to other factors as smoking which is a risk factor for cerebrovascular diseases.

Also, Amr et al., in 2001 found that 16.7% of exposed workers were hypertensive. The answer to this conflict is present in the study of Rugulies 2002 whose study proved the occurrence of cerebrovascular effects in exposed workers who were initially healthy before employment and he attributed that the cause may be a direct effect or via depression and anxiety.

O- cresol:

To assess urinary o-CR level, urine must be collected at the end of the labor-day, or even during the shift, as the biological half-life ranges from 1 h to 2 h (WHO 2000).

Several studies were done in order to investigate the significance of urinary excretion of hippuric acid (HA) and ortho-cresol (o-CR) for the biological monitoring of workers with occupational exposure to toluene. Dossing et al., in 1983 found an increase in the urinary HA and o-CR excretion during 6.5 hours of experimental exposure to 100 ppm toluene with no difference in HA and o-CR excretion between exposed workers and controls. Another study proved that toluene exposure was well correlated

to post shift urinary o-CR and HA levels. But at low exposure level (below 50 ppm) o-CR showed a stronger correlation; so the level of urinary o-CR is a more sensitive index of exposure to low concentrations of toluene than HA (Truchon et al., 1999).

Also, Pierce, et al., in 1998 stated that among toluene metabolites, o-CR was least influenced by background contributions, whereas HA was obscured by endogenous and dietary sources.

Our results showed statistically significant difference between exposed workers and control group in urinary o-CR level; also significance was found among exposed group with increased duration of exposure (figure 1). Our results are in agreement with that of Nadeau, et al., in 2006 who proved that o-CR excretion increased at the end of the work shift and it increased proportionally with increasing work load at exposure to 50 ppm toluene. These results confirm the possibility of using o-CR level as a biological indicator at low level of exposure.

However, Ikeda et al., in 2008 concluded that HA and o-CR are among the markers of choice to monitor occupational toluene exposure at high levels (60-100 ppm) and that only un-metabolized toluene in urine or in blood is recommended when toluene exposure level is low (e.g., 10 ppm

or less). Toluene in urine may be preferred rather than that in blood due to practical reasons, such as non-invasiveness

In contrast, Fustinoni, et al., in 2007 in their study showed that from the point of view of sampling conditions and analytical requirements, toluene in urine (TOL-U) and o-CR showed similar properties, but comparison of their intrinsic characteristics showed that TOL-U had higher specificity and sensitivity, lower background values, was better correlated with airborne exposure, and was not influenced by cigarette smoking. Therefore TOL-U may be considered superior to o-CR as a biomarker of occupational exposure to toluene. The study of Ducos et al., in 2008 measured both parameters as indicator of toluene exposure and they noted that urinary toluene was shown to be a very interesting surrogate to o-CR and could be recommended as a biomarker of choice for solvent exposure. From this contradiction we can conclude that urinary o-CR can be better used as a biological indicator at low level of toluene (up to 50 ppm) exposure after controlling the smoking factor, whereas at higher level of that recommended or in case of lack of use of preventive measures or bad ventilation procedures toluene in urine will show better correlation.

Conclusions and Recommendations:

Organic solvents are commonly used in modern industries. Toxicity profiles are usually described as those of single pure chemicals and that of solvent mixtures is uncertain; especially in the presence of other confounding factors. So a lot of studies are needed to identify possible health hazards due to exposure to solvent mixtures. The prevalence of present solvent related health hazards are not obvious due to low or nearly within the recommended level of exposure; so, it is desirable to investigate possible modification of toxicity and metabolism at exposures greater than the occupational exposure limit.

The presence of diabetes and cardiovascular diseases among exposed workers should be investigated on a wider scale basis so as to assess their prevalence and direct relation to the occupational exposure.

The biological monitoring of workers exposed to solvents, complementary to atmospheric monitoring can be used to better assess individual uptake related to body burden (workload and working habits), to evaluate the efficiency of protective measures, to detect exposure routes other than inhalation (skin or oral absorption).

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