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Electrocardiographic changes and exposure to solvents

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Abstract

Background: Occupational exposures can cause cardiovascular disorders. Some exposures may be harmful, and exposures to chemicals such as metal welding fumes, gases, and pesticides, and stress related to physical and occupational hazard, which results in cardiovascular disorders such as arrhythmia, could be prevented. The objective of this study was to determine the electrocardiographic changes in occupational exposure to organic solvents.

Methods: It was a historical cohort study and was carried out on workers of industries. The study was carried out with flexible interview, physical examination, checklist for obtaining clinical history, and electrophysiology test. Group 1 included the workers in the production line of solvent and paint, group 2 included administrative personnel, and group 3 included workers from other industries who did not have solvent exposure. A number of participants in group 1, group 2, and group 3 were 500, 498, and 501, respectively. Electrocardiographic changes were recorded in health issues.

Results: The frequency of arrhythmia, P wave, and QRS complex changes were highest in group 1. The risk of arrhythmia was 1.15 (1.08-1.49), P wave change was 1.02 (1.01-2.28) which was significant and considered as highest risk,, and QRS complex change was highest in group 1, whose relative risk was 1.53 (1.46-1.61). ST segment and T wave changes (depression or elevation) were highest in group 1 and had no significant differences ($P < .05$).

Conclusion: Working in solvent industry is a risk of developing arrhythmia. Exposure to chemical especially solvent agents mostly affects the cardiovascular system and is effective on electrocardiography, which must be prevented.

KEYWORDS
occupational disease, rhythm disorders, risk factors, solvents

1 | INTRODUCTION

Arrhythmia was a known disorder that more than 50 percent of people in community were affected, and many of them had its complications and resulting disabilities. These disorders had many important risk factors,[1,2] some of which can be prevented. Some of the modifiable risks were nutrition, fatigue, stress, drugs (use and abuse), smoking, environmental and occupational exposures, and nonmodifiable risks were age and genetic factors (positive family history).[3,4]

Occupations had many hazards for cardiovascular system especially for rhythm disorders, which can be modified. These hazards are due to exposure to chemicals such as solvents and pesticides, and due to physical and psychological stress.[3,4] Some of these solvents were toluene, trichloroethane, xylene, heptanes, hexane, ethyl

ether trichloroethylene, and trichlorotrifluoroethane that can cause cardiac sensitization, increased cardiac sensitivity to epinephrine effects, and sudden death.[3,4]

Researchers showed that the occupational risk of heart disease, in this study, demonstrated the effect of toxic exposures on cardiovascular system.[5] Occupational exposures should be controlled in all the jobs.

Other study demonstrated about the hydrocarbon toxicity and introduced its toxicity syndromes.[6] There were many studies on some specific solvent such as toluene. Scientists showed the effects of toluene on heart and atrioventricular block due to hypokalemia.[7] Toluene is a solvent that is used in many industries, which can change the electrolyte level. They demonstrated the atrioventricular conduction abnormality and hyperchloremic metabolic acidosis in toluene sniffing.[8] Cruz et al researched on the inhibition of cardiac sodium currents by toluene exposure.[9] Another study researched on the consequences of short-term occupational exposure to toluene.[10] Researchers studied about the glue (toluene) abuse and increased QT dispersion in relation to syncope.[11]

Other study showed the solvent effect on cardiovascular system.[12] Some studies showed the effects of halogenated hydrocarbons on cardiac system. They demonstrated the symptoms and effects of chloroform poisoning.[13] Researchers studied on the cardiac toxicity of the organochloride solvent trichloromethane.[14] Other study showed the mechanisms of cardiac sensitization caused by volatile anesthetics.[15]

Avella et al demonstrated the fatal cardiac arrhythmia after repeated exposure to 1,1-difluoroethane (DFE).[16] Some authors studied the effects on cardiac system due to occupational exposure to solvents in different jobs.[17,18] Scientists showed the sinus arrhythmia in persons with organic solvent exposure.[19] Researchers showed the atrium fibrillation and sudden death related to occupational solvent exposure.[20]There were some studies about the heart and electrocardiographic changes in solvent exposures.[21-23] Some scientists worked on other chemical exposures and cardiovascular disorders.[24,25]

Other study showed the prevalence of major cardiovascular risk factors related to solvent exposure in the energy industry among workers.[26] Preventive methods were introduced, and changes in behaviors must be made for this reason.[27,28] Some authors had studied on the occupational risk factors in some industries.[29,30] One of the studies explored the effect of solvents on heart rhythm.[31] Because of the importance and priority of the subject, this research was carried out. The objective of this study was to determine the electrocardiographic changes in exposure to solvent in occupational exposures.

2 | METHODS

Study design and target population: It was a historical cohort study (2002-2017) and was carried out on the workers who were employed in industries to determine arrhythmia and electrocardiographic changes. The data were taken from personnel with flexible interview, physical examination, checklist filling to know the clinical history, electrophysiologic tests, and electrocardiography, and if necessary, ambulatory cardiac monitoring was also performed. According to the exposures, the population of the study was divided into 3 groups.

Study population was workers from 19 general factories. The author researched and carried out the physical examination on the study population within the research duration. Simple random sampling method was used with $\alpha = 0.05$, power = 80, P1 = 43%, and P2 = 10%. A number of participants in group 1, group 2, and group 3 were 500, 498, and 501, respectively. Inclusion criteria were workers who worked in production line in solvent and paint works, administrative works, and in other industries with at least 4.5 years of work experience in the same work. Exclusion criteria were having the cardiovascular disorders and related diseases before the inception of this study.

Participants were evaluated and observed for risk factors of cardiovascular and rhythm disorders: age (40s and more than 40s), smoking (1 pack-year and more), nutrition (caffeine), stress (environmental), family history (cardiovascular disorders), history of arrhythmia, drugs (use and abuse), and fatigue.

Checklist design for the study: The checklist validity and reliability were checked with physicians' opinions and also a pilot study was carried out with correlation coefficient 93%.[3,15] The author interviewed using a checklist and carried out the tests in suitable site in periodic poststate examination: ambulatory cardiac monitoring and electrocardiographic tests. Monitoring both in the working hours and off hours was performed if necessary. The normal waves are defined as follows: P wave is a positive wave for depolarization of atriums, QRS complex is a complex of three waves (Q is a negative, R is a positive, and S is a negative one) for depolarization of ventricles, and T wave is a positive wave for repolarization or recovery of ventricles. Abnormality from the normal shape and number of all waves were considered and were assessed according to Minnesota code classification.[32]

Exposure assessment: For exposure assessment in this study, physical hazards—noise—and chemical hazards—solvent—were measured and the risk was calculated. According to the findings, 3 groups were demonstrated in industries: group 1, solvent and paint workers; group 2, administrative at the same industry; and group 3, other industries with low physical and other chemical hazards and had not solvent exposure. They had the same rotating shift work. Occupational exposures were measured and assessed. Sometimes, group 1 had more exposures than the recommended exposure limits but not more than permissible exposure limits. It was shown in random sampling. Toluene, trichloroethane, xylene, trichloroethylene, and trichlorotrifluoroethane were the solvents sampled.

For statistical analysis, data were analyzed with SPSS 16. *t* test, ANOVA, and chi-square test were used to compare quantitative and qualitative variables, *P* value less than .05 was considered for significant levels, and relative risks were calculated with 95% confidence interval.

This study, with human beings as study samples, was carried out according to 1964 Helsinki Declaration and ethical standards. Consent was obtained from the study participants to utilize them from health issue perspectives.

3 | RESULTS

According to the exposures, in this study the participants were divided into 3 groups. A number of participants in group 1, group 2, and group 3 were 500, 498, and 501, respectively. The mean age of population was 34.75 ± 4.22 years old. The mean of work duration was 8.35 ± 2.41 years at the beginning of study. The mean of body mass index (BMI) was 25.32 ± 1.44 kg/m^2.

Table 1 shows the comparison between frequencies of electrocardiographic changes risk factors in three groups ($P < .05$). History of arrhythmia, family history, stress, drugs, nutrition, and fatigue were highest in group 1 but with no significant differences.

Table 2 demonstrates the comparison between the frequencies of electrocardiographic changes in three groups ($P < .05$). Pulse rate was highest in group 1 and had significant differences ($P < .05$). Arrhythmia 14 (2.8), P wave 2 (0.4), and QRS complex 1 (0.2) were highest in group 1 and had significant differences($P < .05$). Atrial fibrillation 1 (0.2) and premature ventricular contraction (PVC) 2 (0.4), tachycardia 10 (2), and Wolf-Parkinson-White (WPW) 1(0.2) were observed and tried to treat. ST segment 12 (2.4) and T wave changes 4 (0.8) were highest in group 1 and had no significant differences ($P < .05$).

P wave low amplitude 2 (0.4), QRS complex low amplitude 1 (0.2), ST segment depression 1 mm or more than 1 mm 12 (2.4), and T wave changes amplitude 4 (0.8) (negative 2 (0.4) or diphasic 2 (0.4), respectively) were observed in group 1.

Table 3 shows the relative risks of electrocardiographic changes in three groups. The risk of electrocardiographic changes and P wave abnormality were significant in group 1: 1.15 (1.08-1.49) and 1.02 (1.01-2.28), and QRS complex disturbance was highest in the group and significant too. Relative risk in group 1 was 1.53 (1.46-1.61).

4 | DISCUSSION

Also, according to the study results, the number of workers with arrhythmia was highest in group 1 with 2.8 percent, whereas they were 0.8 and 0.2 percent arrhythmia in group 2 and group 3, respectively.

Group with solvent exposue: Atrial fibrillation 1 (0.2) and premature ventricular contraction (PVC) 2 (0.4), tachycardia 10 (2), and Wolf-Parkinson-White (WPW) 1(0.2) were observed.

According to scientific literature, solvents could cause tachycardia, and some kind of arrhythmia was observed in low concentration with adrenergic and sympathetic effects and release of norepinephrine in the atria, whereas sudden death and heart depression were observed in high concentration with blocked heart conductivity.[2,3] In recent decades, occupational exposures were in standard concentrations. Cardiovascular disorder is an important cause of death in the world.[33] The low level of exposures must be prevented perfectly especially in people with the history of arrhythmia.

In this study, the number of workers with P wave and QRS complex changes was highest in group 1 with the significant level of $P < .05$ and this group had exposure to solvents. In the subsequent follow-up study, it was observed that the risk factors were increased. Researchers demonstrated that heart disease in workers exposed to fumes and particles.[5] Some of the workers had no sensible heart beat but treated, because P and QRS changes can cause arrhythmia, and ST segment and T wave changes can conflict with ischemic heart diseases and diagnostic problems. These changes in P wave low amplitude, QRS complex low amplitude, ST depression, and T wave amplitude negative or biphasic are not for symptomatic disorder in cardiovascular system but may be predicted for arrhythmia, ischemia, and heart block.

TABLE 1 Comparison between frequencies of electrocardiographic changes risk factors in three groups ($P < .05$)

	Groups				
Risk factors	Group 1 N(%)[a] N = 500	Group 2 N(%) N = 498	Group 3 N(%) N = 501	*T* test or chi-square or Exact test	*P* value
Age	34.05 ± 0.12	34.02 ± 0.02	33.98 ± 1.01	1.24	.96
Body mass index	25.11 ± 0.11	25.10 ± 0.05	25.02 ± 1.02	1.27	.97
Work duration	8.10 ± 0.14	8.02 ± 0.24	8.56 ± 1.01	1.87	.96
History of arrhythmia	10 (2)	2 (0.4)	1 (0.2)	1.75	.07
Positive Family history	3 (0.6)	1 (0.2)	1 (0.2)	1.50	.26
Stress	6 (1.2)	4 (0.8)	5 (1)	5.00	.08
Drugs	5 (1)	4 (0.8)	4 (0.8)	4.61	.1
Fatigue	6 (1.2)	5 (1)	4 (0.8)	7.47	.06
Nutrition	14 (2.8)	12 (2.4)	10 (2)	8.75	.75

[a]Number of worker with risk factor.

TABLE 2 Comparison between frequencies of electrocardiographic (ECG) changes in three groups ($P < .05$)

	Groups				
Disorders	Group 1 N(%)[a] Or μ ± SD[b]	Group 2 N(%) Or μ ± SD	Group 3 N(%) Or μ ± SD	Chi-square or Exact test	*P* value
Heart rate	89.01 ± 1.01	71.73 ± 7.63	71.44 ± 7.33	6.29	.01
Arrhythmia	14 (2.8)	4 (0.8)	1 (0.2)	4.31	.03
P wave low amplitude	2 (0.4)	1 (0.2)	0	1.85	.04
QRS complex low amplitude	1 (0.2)	0	0	0.53	.04
ST segment depression	12 (2.4)	3 (0.6)	1 (0.2)	2.87	.23
T wave amplitude negative or diphasic	4 (0.8)	2 (0.4)	1 (0.2)	1.95	.43

[a]Number of disturbances.
[b]Mean ± SD.

TABLE 3 Relative risks with confidence intervals of electrocardiographic (ECG) changes in three groups

		Groups		
Disorders	Duration	Group 1[a] RR (CI)[b]	Group 2 RR (CI)	Group 3 RR (CI)
Arrhythmia	2009-2011	1.14 (1.07-1.48)	1.70 (0.78-3.18)	0.21 (0.03-1.45)
	2012-2014	1.14 (1.07-1.49)	1.70 (0.79-4.19)	0.21 (0.03-1.45)
	2015-2017	1.15 (1.08-1.49)	1.71 (0.78-4.19)	0.21 (0.03-1.45)
P wave change	2009-2011	1.01 (1.01-2.38)	2.81 (0.54-14.14)	1.28 (0.24-1.44)
	2012-2014	1.01 (1.00-2.18)	2.81 (0.55-14.02)	1.29 (0.26-1.22)
	2015-2017	1.02 (1.01-2.28)	2.82 ((0.56-14.12)	1.30 (0.25-1.34)
QRS complex change	2009-2011	1.52(1.44-1.62)	1.12 (0.11-1.26)	1.28 (0.27-1.44)
	2012-2014	1.52 (1.46-1.60)	1.12 (0.11-1.18)	1.28 (0.24-1.54)
	2015-2017	1.53 (1.45-1.61)	1.13 (0.10-1.16)	1.29 (0.25-1.34)
ST segment change	2009-2011	1.58 (0.56-4.39)	1.14 (0.66-1.43)	0.25 (0.06-1.79)
	2012-2014	1.58 (0.55-4.49)	1.14 (0.76-1.52)	0.25 (0.04-1.70)
	2015-2017	1.59 (0.56-4.49)	1.15 (0.86-1.53)	0.26 (0.04-1.79)
T wave change	2009-2011	2.42 (0.73-7.85)	1.86 (0.48-1.56)	0.60 (0.17-3.72)
	2012-2014	2.42 (0.73-7.76)	1.86 (0.47-1.56)	0.61 (0.11-3.83)
	2015-2017	2.43 (0.74-7.95)	1.87 (0.46-1.66)	0.62 (0.10-3.82)

[a]Group 1 in contrast to other groups.
[b]Relative risk with confidence interval.

This study showed that the P wave and QRS complex had the most changes in solvent exposure, and there were some studies about the atrial fibrillation and premature ventricular contraction in solvent exposure that could cause the same disturbances in the electrocardiogram.[8,20]

This study demonstrated more incidence of arrhythmia in solvent exposure, and this result was related to other studies.[7,11] Pulse rate was highest in group 1 with solvent exposure. According to scientific literature, solvents could cause tachycardia.[2,3]

Some studies showed the cardiac effects of halogenated hydrocarbons.[13] In this study, workers exposed to organic and halogenated solvents too. Another study showed the mechanisms involved in cardiac sensitization by halogenated hydrocarbons.[15] Researchers demonstrated the fatal cardiac arrhythmia after repeated exposure to halogenated hydrocarbons.[16]

Author study demonstrated the sinus arrhythmia in persons with organic solvent exposure.[19] In this study, arrhythmia were sinus or none sinus rhythm such as atrial fibrillation and premature ventricular contraction(PVC). It seems that sinus arrhythmia was more compared to none sinus.

Researcher showed the atrial fibrillation and sudden death related to occupational solvent exposure.[20] This study showed the atrial fibrillation in group 1. P wave and QRS changes were the most in group 1 with solvents exposure. In this study, one person had Wolf-Parkinson-White (WPW) with early ventricular sensitization. It was an uncommon disturbance. Electrocardiography was used to determine the level of sinus rhythm on the following parameters delta wave, short PR interval, and widened QRS complex in preplacement and periodic examination, which means that the

above-said parameters were checked on the workers before and at the inception of the study.. There was no change in the first electrocardiography and the last electrocardiography.

In this study, the author tried to isolate the three groups with special exposures, but workers in group 3 might be exposed to some physical and chemical hazards, and these results might be related to other occupational exposures or hazards. Solvents had effects on heart, but their effects on each wave of electrocardiogram were unknown. Solvent compound was an important exposure and had synergistic effect on nervous system, but their effects on heart were not known in this situation, and study about the wave changes in occupational setting was not enough.[31]

Limitation of the study: In this study, the author analyzed only the risks associated with occupation exposure and did not complete the assessment about psychological stress that could affect cardiovascular system and health too. Studies with better isolation of groups could be more useful and are recommended.

According to this study, the researcher suggested that job analysis in relation to occupational exposure and the determination of risk factors related to it in different industries especially with solvents exposure are necessary.

The author found that the work in solvent industry had risk of electrocardiographic changes. The chemical hazards in high exposure are more effective on electrocardiography.

Although these chemicals could be the most effective occupational hazards for cardiovascular disorders especially arrhythmia and sudden death, the psychological risks should not be forgotten at all.

5 | CONCLUSIONS

Working in solvents industry had risk of arrhythmia. Exposure to chemical especially solvent agents is more effective on cardiovascular system and electrocardiography, which must be prevented.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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