Original Article

Is a Long Term Work in Automotive Industry a Risk Factor for Renal Dysfunction?

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Abstract

Background: Disorders of renal system can cause renal failure; therefore screening is necessary especially in workers who are exposed to harmful materials. Hypertension, diabetes mellitus, and hazardous exposures are non-occupational and occupational risk factors for renal diseases. **Aim:** The objective of this study was to determine the effects of working in automotive industry on renal function in Iran. **Subjects and Methods:** In a historical cohort study, workers of automotive industry who worked in production and had low exposure to metal fumes were selected and divided to three groups with 5–10, 11–20, and 21–30 years work duration. risk factors for renal diseases were collected and analyzed with SPSS using one-way ANOVA, correlation coefficient and with $P < 0.05$ and relative risk with a confidence interval (CI). **Results:** The means of work duration in Groups (A), (B) and (C) were 9.8 (0.6), 13.8 (2.0), 22.3 (1.6) years respectively with ANOVA (F) =187.864 and $P < 0.01$. Glomerular filtration rate (GFR) was 59.75 (0.70), 59.16 (1.52) and 59.10 (2.23) in Groups (A), (B), and (C) respectfully The relative risk of creatinine clearance, uric acid and mean blood pressure were the highest in Group (B); 1.970 - CI, 0.541–7.169, 1.571 95% CI: 0.198–12.470, and 1.519 95% CI: 0.425–5.426, but the differences were not significant. **Conclusion:** GFRs were decreased with work duration, but the differences were not significant. Working in automotive Industry with low exposure to toxic metals and solvents has no significant effect on GFR, creatinine clearance, uric acid, and mean blood pressure.

Keywords: Creatinine clearance, Glomerular filtration rate, Kidney disorders, Uric acid, Work duration

Introduction

One of the vital organs is the kidney that its disorders especially chronic renal failure can cause great disability or even death. Some people especially workers who work in special industries are more at the risk of these disorders.[1]

Many studies had been conducted on workers' health; however, a few of them studied renal system because renal disorders usually have more than one etiology. One of the preventable risk factors is work exposure.

According to medical knowledge, renal disorders can cause great impairment and disability. Prevention of renal disorders is possible by screening renal risk factors such as hypertension and diabetes mellitus. Although controlling non-occupational risk factors is necessary, but it is not enough and occupational exposures must be controlled too. In this regard many variables had been assessed and measured such as glomerular filtration rate (GFR), creatinine clearance, uric acid, mean blood pressure, obesity, smoking, and family history. Furthermore, solvents and chemicals, toxic metals, environment temperature, air pollution, shift work, and stress can affect these parameters.[2-6] By pre-employment and periodic examination the high-risk workers can be identified.

Exposure to metal fumes, solvents, analgesic drugs, pesticides, silica, and heat can cause occupational renal disorders.[7-9]

Researchers who had studied work exposures, found that work with toxic metals and exposure to them is an important risk factor for renal injury in related industries. Some of these toxic metals are lead, cadmium and mercury that have a wide usage in the environment and industries.[10-13] In recent years,

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scientists have been tried to replace these metals by harmless ones. Some studies showed the effects of preventive methods in reducing the risk of renal dysfunction.

Some studies found that exposure to solvents is harmful for renal function while other studies had indicated the carcinogenic effects of some solvents such as trichloroethylene and perchloroethylene on kidney.[2,3]

A number of studies had investigated the environmental effects of cadmium on kidney.[14] Industrial workers who are exposed to work hazards affecting kidney must be periodically examined by both clinical and para-clinical examinations. Studies proved the effects of high dose exposures to hazardous material.[15,16] However, chronic exposure to low concentrations in standard levels need more evaluation, and unidentified effects must be assessed. The World Health Organization had published a report showing deaths by cause, sex and mortality in 2000. This report emphasized the importance of renal dysfunction and cancers.[17] In the automobile industry regarding different processes, workers are exposed to different exposures including toxic metals; lead, cadmium, and solvents.

Hambach *et al*. showed that co-exposure of lead increases the renal response to low levels of cadmium in metallurgy workers.[18] Tian *et al*. reported the increased risk of renal dysfunction caused by occupational lead exposure.[19]

Ogata *et al*. had published a case of lead nephropathy due to chronic occupational lead exposure.[20] Haddam *et al*. determined the confounders in the assessment of renal damages associated with low-level urinary cadmium in an industrial setting.[21]

A few studies about environmental exposures, diet and smoking demonstrated the adverse effects of cadmium and other elements on renal function.[22-26]

Researchers had also showed that work in thermal stress and unsuitable rotation work programs are risk factors for renal dysfunction. Previous studies had talked about the cold exposures and its harmful effects on health.[27] Some studies indicated the positive effects of screening on identification of occupational and non-occupational disorders.[28-30]

The objective of this study was to determine the effects of working in the automotive industry on renal function in Iran.

Subjects and Methods

Ethical consideration

the oral consent had been taken from participants and researcher promised to use cumulative data.

Study setting

The study was performed in Iran automotive industries during 2007–2013. Workers were divided into three groups based on the years working in the same work; A, B, and C with 5–10, 11–20, and 21–30 years of work duration.

Study design and target population

Workers had been selected from a historical cohort study with simple randomized sampling method. Study population was calculated according to $\alpha = 0.05$, $\beta = 0.20$, and $P = 20\%$. About 1000 workers had been evaluated based on inclusion and exclusion criteria. Data were collected from medical records of 506 workers from Iranian factories.

Checklist design

The study tool was a checklist concerning medical issues and tests. The checklist was prepared in the educational department of Health faculty according to professor's opinions, and was used in a pilot study with a correlation coefficient of 88% for reliability.

The checklist had different parts regarding non-occupational and occupational risk factors for kidney disorders. Data were gathered from medical records of workers; they all had periodic physical and para-clinical examinations including control of systolic and diastolic blood pressure, calculation of mean blood pressure with (DP + [SP − DP]/3) formulation, blood sampling for creatinine clearance and calculation of GFR, uric acid, fasting blood sugar and blood sugar, weight and body mass index, urine analysis, pulse rate, previous cardiovascular disorders, previous cardiac unit care admission, age, work duration, smoking, and shift work.

Inclusion criteria were at least 5 years work duration in the same industries and exclusion criteria were previous kidney disorders, hypertension, and diabetes mellitus.

Participants were divided to three groups based on their work duration. The variables ofage, body mass index, shift work, diet, smoking, job stress, thermal stress, and types of exposures were evaluated.

Exposure measurement; with using sampling pump and spectrophotometer pollutants of the work place such as lead, cadmium and solvents were analyzed.

Statistical analysis

Data was entered in SPSS for windows version 16 (Chicago ILL ,USA) and was analyzed using frequency, mean, ANOVA for quantitative variables, correlation coefficient with $P < 0.05$ and relative risk with a confidence interval (CI).

Results

Results are in three parts; demographic information, health information and kidney risk factors. Workers had rotating

shift work. Exposure assessment for lead, cadmium, and solvents showed that the means of exposures levels were in permissible level.

In demographic part, the mean of work duration had been calculated. The mean of work duration in Group (A) was 9.8 (0.6) years, in Group (B) was 13.8 (2.0) years, and in Group (C) was 22.3 (1.6) years with ANOVA (F) = 187.864 and $P < 0.01$.

The mean of age in Groups (A), (B) and (C) were 34.8 (2.4), 38.1 (3.3), 47.3 (5.6) years respectfully with ANOVA (F) = 31.418 and $P < 0.001$.

The mean of body mass index in Group (A) was 24.76 (2.94) kg/m^2, in Group (B) was 25.21 (3.53) kg/m^2 and in Group (C) was 27.31 (3.93) kg/m^2 with ANOVA (F) = 1.904 and $P = 0.16$.

No one had abnormal urine analysis. Group (A) had no smoker.

In health information mean of GFR, creatinine clearance, uric acid, mean of blood pressure, fasting blood sugar, body mass index, and pulse rate were assessed. Table 1 is demonstrating these information and comparison between groups.

Glomerular filtration rate was 59.75 (0.70) ml/m in Group (A), 59.16 (1.52) in Group (B), and 59.10 (2.23) in Group (C) but the difference was not significant.

Then correlation of variables such as GFR < 60 ml/m, creatinine clearance (more than 1 mg/dl), uric acid (more than 6 mg/dl), mean of blood pressure (more than 90 mmHg), fasting blood sugar (more than 90 mg/dl), body mass index (more than 25 kg/dl), and pulse rate (more than 75/min) with work duration was calculated and reported in Table 2.

the relative risk of above variables in different groups are presented in Table 3. The relative risk of GFR < 60 ml/m was higher in Group (B); 1.66 CI: 0.27–10.09. The relative risk

Table 1: Comparison of risk factors between work term groups

Variable	Group (A) μ (SD)	Group (B) μ (SD)	Group (C) μ (SD)	ANOVA (*F*)	*P*-Value
GFR	59.75 (0.70)	59.16 (1.52)	59.10 (2.23)	0.407	0.67
Creatinine clearance	1.13 (0.13)	1.19 (0.18)	1.12 (0.16)	0.558	0.57
Uric acid	5.85 (0.91)	5.24 (1.40)	4.5 (1.08)	1.144	0.34
Mean blood pressure	84.40 (9.14)	88.75 (8.64)	90.64 (11.65)	1.180	0.31
Fasting blood sugar	84.50 (5.89)	83.68 (5.49)	81.42 (10.78)	0.521	0.59
Body mass index	24.76 (2.94)	25.21 (3.53)	27.31 (3.93)	1.904	0.16
Pulse rate	73.00 (5.83)	70.33 (6.81)	72.76 (8.99)	0.442	0.64
Age	34.8 (2.4)	38.1 (3.3)	47.3 (5.6)	31.418	<0.001

P<0.05. GFR: Glomerular filtration rate, SD: Standard deviation, ANOVA: Analysis of Variance

Table 2: Correlation of signs with work term groups

Variable	Group (A)		Group (B)		Group (C)	
	Value	*P*-Value	Value	significance	Value	significance
GFR <60 ml/m	0.025	0.87	0.164	0.31	−0.247	0.12
Creatinine clearance >1 mg/dl	−0.019	0.90	0.068	0.67	−0.070	0.66
Uric acid >6 mg/dl	−0.168	0.30	0.102	0.53	0.000	1.00
Mean blood pressure >90 mmHg	0.055	0.73	−0.057	0.72	−0.015	0.92
Fasting blood sugar >90 mg/dl	−0.097	0.55	−0.188	0.46	0.182	0.26
Body mass index >25 kg/m^2	−0.183	0.25	−0.063	0.70	0.278	0.08
Pulse rate >75/m	−0.205	0.20	0.238	0.13	−0.070	0.96
Smoking	−0.145	0.44	0.102	0.59	0.000	1.00

P<0.05. GFR: Glomerular filtration rate

Table 3: RR of risk factors in work term groups

Variable	RR 95% CI		
	Group (A)	Group (B)	Group (C)
GFR <60 ml/m	0.400 95% CI: 0.04-4.02	1.66 95% CI: 0.27-10.09	1 95% CI: 0.150-6.67
Creatinine clearance >1 mg/dl	1.120 95% CI: 0.278-4.508	1.970 95% CI: 0.541-7.169	0.347 95% CI: 0.090-1.338
Uric acid >6 mg/dl	0.867 95% CI: 0.080-9.343	1.571 95% CI: 0.198-12.470	0.590 95% CI: 0.056-6.266
Mean blood pressure >90 mmHg	0.464 95% CI: 0.111-1.940	1.519 95% CI: 0.425-5.426	1.00 95% CI: 0.273-3.667
Fasting blood sugar >90 mg/dl	1.389 95% CI: 0.216-8.927	0.714 95% CI: 0.115-4.451	0.917 95% CI: 0.146-5.757
Body mass index >25 kg/m^2	0.439 95% CI: 0.107-1.801	0.771 95% CI: 0.213-2.796	3.667 95% CI: 0.826-16.273
Pulse rate >75/m	0.583 95% CI: 0.103-3.307	0.560 95% CI: 0.121-2.597	2.333 95% CI: 0.539-10.098

P<0.05. RR: Relative risk, CI: Confidence interval

of creatinine clearance, uric acid, and mean blood pressure had the highest rate; 1.970 95% CI: 0.541–7.169, 1.571 95% CI: 0.198–12.470 and 1.519 95% CI: 0.425–5.426.

Discussion

According to this study results, there is no correlation between work duration in the automotive industry and kidney disorders. The mean of GFR was higher in Group (A) with less duration of exposure, but the differences were not significant. The mean of following variables were higher in reported groups: Creatinine clearance in Group (B), uric acid in Group (A), blood pressure in Group (C), and fasting blood sugar in Group (A), but no significant differences were observed. GFR < 60 ml/m, clearance creatinine more than 1 mg/dl, uric acid more than 6 mg/dl and mean of blood pressure more than 90 mm Hg were more common in Group (B). Some studies demonstrated the relation between exposure to high level of toxins and kidney disorders. In metal industries, some risk factors existed like lead, mercury, cadmium that could damage the kidney.[10-12] However, the low level of fumes in chronic exposures might also damage the kidney and cause renal dysfunction. Hambach *et al*. demonstrated that the co-exposure to lead increases the renal response to low levels of cadmium in metallurgy workers, which is somehow different from our results.[18] this difference could be because in metallurgy the workers are exposed to some harmful and pollutant processes that were not existed in automotive industry in this study.

Work exposure to high level and even to lower levels of lead, cadmium and mercury could be a risk factor for kidney dysfunction; this reality had been demonstrated in a case report and other research studies.[10-13] Ogata *et al*. defined the lead nephropathy due to chronic occupational lead exposure in one patient.[20] Interestingly, this result showed the effects of lower level exposure. It is controversial that whether the lower levels of lead is related to kidney dysfunction, the relation between chronic interstitial nephritis and lower levels of cadmium is controversial too. Solvents may affects renal function.[6] In this study the renal dysfunction related to such low level exposures was not observed. Researchers found that work with solvents was a risk factor for renal diseases specially neoplasia. other studies showed that work with trichloroethylene and perchloroethylene were a risk factor for renal cancer.[2]

In addition to occupational exposures, other disorders such as hypertension and diabetes mellitus can cause renal disorders and long time disability and out of work. Forbidding the smoking, control of blood pressure and blood sugar are popular advices for managers of industries who are interested to their workers health.

In this study, low level of exposures was in the standard levels that could not cause renal disorders during career years. According to this study results, workers with more than 20 years' work duration had the higher levels of creatinine clearance and uric acid compared with other groups, but had a lower level of GFR, but the difference were not significant.

Screening of renal disorders risk factors in all high risk works and industries is helpful and beneficiary. Based on studies application of some engineering and administrative controls are helpful for controlling risk factors. The studied industry had engineering controls such as general and local ventilation.

In present study, after the calculation of relative risk; it was found that the relative risk was more than one for GFR < 60 ml/m, creatinine clearance more than 1 mg/dl, uric acid more than 6 mg/dl and mean of blood pressure more than 90 mm Hg, in Group (B), but their CIs were included one.

Automotive industry have a lot of chemicals and some physicals hazards which are risk factors for renal disorders, their control reduce the risk of occupational renal disorders. Some of the control ways are engineering control, then administrative control and at the end using personal protective devices.

In this study, no exact job analyses were performed, but workers had perfect medical examination. Medical surveillance with periodic examination for screening of non-occupational and occupational disorders, especially risk factors for vital organs function such as kidney could be helpful.

Conclusion

Glomerular filtration rate decreased with work duration, but the difference was not significant. The automotive *industry* with low exposure to toxic metals had no effect on creatinine clearance, uric acid, and mean blood pressure.

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