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Effect of Welding Fumes on Blood Pressure and Hematological Parameters

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Abstract: Objective: Our work intends to unravel the hematological and cardiovascular modifications owing to exposure to welding fumes particulate metal in order to better understand the influence of welding fume exposure on developing different illnesses.

Methods: Participants included 50 welders and 20 controls from Anbar governate in Iraq. Measurements of blood pressure, and collection of blood, and hair samples took place during welders' worktime.

Results: The blood pressure levels of the welder groups (8-19, 20-40 Years of Working Period) and 32-47, 48-60 Years of Age were categorised as (High normal - Grade 1 Hypertension), which is considerably higher than the blood pressure rates of the non-welder group. The other groups were classed as having Normal Blood Pressure. In comparison to the non-welder group (13.582±0.411 g/dL), the mean value of HGB varied (14.671±0.61 - 15.84±1.487 g/dL) for age groups and (14.658±0.41 - 15.267±1.569 g/dL) for working period groups. The mean HCT value was substantially higher than the non-welder group (40.344±0.633 %) and varied from 43.065±1.641 - 43.983±1.809 % for age groups and 43.275±1.703 - 43.591±1.716 % for working period groups. The age groups' mean value of Fe varied from 9.819±2.813 - 15.05±6.758 mg/Kg, while the working period groups' mean value was 9.928±2.74 - 13.819±3.951 mg/Kg. This is substantially higher than the non-welder groups' mean value of 5.907±1.145 mg/Kg. Furthermore, compared to the non-welder group (5.427±0.576 mg/Kg), the mean value of Pb varied (17.29±4.273 - 36.687±22.805 mg/Kg) for the age groups and (17.415±6.876 - 49.388±27.862 mg/Kg) for the working period groups.If other biochemical indicators were broken down by age or working time groups, they did not vary significantly from controls.

Conclusions: The study shows that welders possess higher Fe, and Pb concentration than non-welders, therefore we suggest that exposure to such heavy metals has a significant impact on the cardiovascular system and hematological hemostasis, and our study indicates that even low concentrations of heavy metals can lead to increased risks of developing CVD and multiple other diseases.

Keywords: Welding Fumes, Heavy metals, Blood Pressure, cardiovascular disease (CVD).

Introduction

The welding occupation is one of the most important occupations, and its considered one of the oldest, many historians' attributes welding invention to Humphry Davy, but welding invention

cannot be credited to only one person, since it's been known and developed since the bronze ages and might even older (Grill,2023).

Welding process needs a high amount of energy, which is responsible for the immediate oxidation of the metals, thus, inhaling such metal oxides interrupts the minerals equilibrium in the blood, which interferes with several biological activities, such as ionic equilibrium (Gómez Marrugo *et al.*, 2020). Any alteration in ions levels can cause systematic changes, for example, enzymes and co-enzymes binds naturally with specific metal ions in their active sites, and any changes in these ions can alter the enzymatic function. On the other hand, heavy metals can damage DNA and proteins which leads to variety of diseases (Gómez Marrugo *et al.*, 2020).

Many studies indicates that exposure to welding fumes increases the risk of developing Cardiovascular diseases CVDs, such as, arrythmia, ischemia, and sclerosis (Lai et al., 2016), other studies showed that inhaling welding particulate matter PM causes vasoconstriction (Brook et al., 2002), indicating that there's an increased risk of developing CVD in welders due to the accumulation of these metals. (Fang et al., 2008). Other studies indicated that short-term exposure and long-term exposure to welding fumes PM alters the hematological homeostasis, such as WBC, platelets, hemoglobin, RBC, and hematocrit HCT(Giorgini et al., 2016, Kauppi et al., 2015; BIRCHARD, 2015).

Exposure to Lead Pb induces many unnatural activates inside the human body, such as sclerosis, hypertension, strokes, and a variety of CVDs. All that through increasing oxidative stress, which decreases oxygen levels, and alters the renin angiotensin system, leading to inhibition of prostaglandins which acts as a vasodilator, thus increasing the blood pressure (Mitra et al., 2022). Another study showed that exposure to high levels of Manganese and iron in welding fumes effects the heart and blood vessels health (Jiang & Zheng, 2005; Cheng & Lian, 2013).

On the other hand, a study revealed that the association between welding fumes and CVD is not solid (Mocevic et al., 2015). Various studies have reported that exposure to PM may cause systemic oxidative stress and inflammation (Bräuner et al., 2007; Vinzents et al., 2005; Barregard et al., 2006), and decreased heart rate (Romieu et al., 2005), thus, it has been shown that PM could be a predictor of CVD and mortality (Konttinen et al., 2013; Xu et al., 2014)

Materials and Methods

Study Design

We recruited 50 welders and 20 controls to study the effects of welding fumes on welders working in confined spaces in the Al-Anbar Governorate. The study was conducted during the welders' working hours in their own workshops, where they primarily welded mild steel using carbon steel electrodes. The non-welder controls were office workers from a medical facility.

The research was conducted in 2022, and participants completed a brief questionnaire on their age, length of employment, marital status, and smoking habits.

monitoring blood pressure Blood pressure was measured after allowing the participants to rest for ten to fifteen minutes. Blood, hair, and BP samples were all taken on the same day while they were at work.

Ethics Declaration

The research was authorised by Anbar University's regional ethics council, and all subjects provided written, informed permission to participate.

Hematological Measurements

Blood parameters measurmets conducted at the same day of samples collection, blood was collected using a 5ml disposable syrange in a 3ml EDTA tube and 2ml plain tube, CBC was used to analysis hematological paramets, including RBC, HGB, and HCT

Biochemical Measurements

On the day of sample collection, biochemical measurements were also carried out. Blood was placed into 2 ml plain tubes and centrifuged for 10 minutes at 3000 rpm. The serum was then separated using a micropipette and transferred to a new white tube. Measurements of electrolytes, uric acid, urea, and creatinine were then made using an automated Fujifilm chemical analyzer.

Heavy Metals Measurements

Heavy metals were measured after a week of sample collection, hair was preserved in a sterile screw tube. Samples were digested, then measurements took place using the Atomic Absorption Spectrophotometer, including Iron Fe, and Lead Pb.

Blood Pressure Measurements

Using an automatic blood pressure monitor, blood pressure was taken while the subject was seated comfortably and rested for ten to fifteen minutes.

Statistical analysis

The statistical analyses were conducted using SPSS 21.0 (SPSS Inc, Chicago, IL, USA) with a one-tailed significance level of $P<0.05$ and a 95% confidence interval (CI).

Results

There were fifty welders in the welders group and twenty office workers in the non-exposure group. The average age of the non-welder was 28.00 years, while the average age of the welder was 33.00 years.

when all welders were categorised as shown in table (1) according to age (18–32, 33–47, and 48–60 years old). The non-welder group had significantly lower mean values of systolic and diastolic blood pressure at $p\leq 0.05$ (12.19 ± 0.271^{sys}, 8.1 ± 0.374^{dia} mmHg) than 33-47 group (13.018 ± 0.894^{sys} mmHg, p=0.049; 8.894 ± 0.624^{dia} mmHg, p=0.021) and 33-47 group (14.25 ± 1.595^{sys} mmHg, p=0.026; 9.417 ± 0.734^{dia} mmHg, p=0.007), the welders' group (18–32 years old) had marginally significant mean values of BP (12.431 ± 0.573^{sys} mmHg, p=0.231; 7.992 ± 0.437^{dia} mmHg, p= 0.358). The non-welder group's HGB value (13.582±0.411 g/dL) was substantially lower than the welders' group's (14.715±0.562 g/dL, p=0.001), (14.671±0.61 g/dL, p=0.004), and (15.84±1.487 g/dL, p=0.019) mean values. The HCT values of the welders' group were substantially higher than those of the non-welder group (40.344±0.633 %) at (43.065±1.641 %, p=0.002, 43.836±2.215 %, p=0.004), and (43.983±1.809 %, p=0.005), respectively. The non-welder group's (5.907±1.145 mg/Kg) had a substantially lower mean value of Fe than the welders' group (9.819±2.813 mg/Kg, p=0.008), (15.05±6.758 mg/Kg, p=0.009), and 12.515±4.116 mg/Kg, p=0.012), respectively. The welders' group had substantially higher mean Pb values (17.29±4.273 mg/Kg, p=0.001), (29.362±16.464 mg/Kg, p=0.006), and (36.687±22.805 mg/Kg, p=0.018) than the non-welder group (5.427±0.576 mg/Kg).

Table 1 : Hematological and Heavy metals parameters of welders grouped by Age

Parameters	18 - 32 Years No. 26		33 - 47 Years No. 17		48 - 60 Years No. 7		Control No. 20
	Mean (±CI)	p-value	Mean (±CI)	p-value	Mean (±CI)	p-value	Mean (±CI)
Sys BP	12.4±0.6	0.231	13±0.9	0.049	14.3±1.6	0.026	12.2±0.3
Dia Bp	8±0.4	0.358	8.9±0.6	0.021	9.4±0.7	0.007	8.1±0.4
RBC	5.1±0.1	0.001	5±0.2	0.002	5.3±0.3	0.001	4.6±0.1
HGB	14.7±0.6	0.001	14.7±0.6	0.004	15.8±1.5	0.019	13.6±0.4
HCT	43.1±1.6	0.002	43.8±2.2	0.004	44±1.8	0.005	40.3±0.6
Fe	9.8±2.8	0.008	15.1±6.8	0.009	12.5±4.1	0.012	5.9±1.1
Pb	17.3±4.3	0.000	29.4±16.5	0.006	36.7±22.8	0.018	5.4±0.6

when all welders were arranged as shown in table (2) according to the total amount of time they had worked (1–7, 8–19, 20–40 Years). The non-welder group (12.19 ± 0.271^{sys}, 8.1 ± 0.374^{dia} mmHg) had a significantly lower mean value of systolic blood pressure than the 8-19, 20-40 years working groups

(12.886±0.609^{sys} mmHg, p=0.024), (14.717±1.576^{sys} mmHg, p=0.012), and diastolic blood pressure (8.572±0.363^{dia} mmHg, p=0.041), (9.533±0.719^{dia} mmHg, p=0.004), respectively. The 1-7 years working group (12.25±0.643^{sys} mmHg, p= 0.434), (8.058±0.921^{dia} mmHg, p= 0.468), had a marginally significant value. The non-welder group's HGB value (13.582±0.411 g/dL) was substantially lower than the welders' groups' (15.127±1.008 g/dL, p=0.008), (14.658±0.41 g/dL, p=0.001), and (15.2667±1.569 g/dL, p=0.045) mean values. The mean value of HCT in welders' groups (43.275±1.703 %, p=0.003), (43.591±1.716 %, p=0.001), (42.343±1.953 %, p=0.048) respectively, was higher than the non-welder group (40.344±0.633 %). The mean value of Fe in welders' groups (12.726±5.225 mg/Kg, p=0.014), (9.928±2.74 mg/Kg, p=0.006), (13.819±3.951 mg/Kg, p=0.007) respectively, was higher than the non-welder group (5.907±1.145 mg/Kg). The mean value of Pb in welders' groups (17.415±6.876 mg/Kg, p=0.003), (20.993±7.957 mg/Kg, p=0.001), (49.388±27.862 mg/Kg, p=0.011) respectively, was higher than the non-welder group (5.427±0.576 mg/Kg).

Table 2: Hematological and Heavy metals parameters of welders grouped by Working period

Parameters	1 - 7 Years No. 12		8 - 19 Years No. 31		Over 20 Years No. 7		Control No. 20
	Mean (±CI)	p-value	Mean (±CI)	p-value	Mean (±CI)	p-value	Mean (±CI)
Sys BP	12.3±0.6	0.434	12.9±0.6	0.024	14.7±1.6	0.012	12.2±0.3
Dia Bp	8.1±0.9	0.468	8.6±0.4	0.041	9.5±0.7	0.004	8.1±0.4
RBC	5.1±0.2	0.000	5.1±0.1	0.000	5.2±0.4	0.007	4.6±0.1
HGB	15.1±1	0.008	14.7±0.4	0.000	15.3±1.6	0.045	13.6±0.4
HCT	43.3±1.7	0.003	43.6±1.7	0.001	42.3±2	0.048	40.3±0.6
Fe	12.7±5.2	0.014	9.9±2.7	0.006	13.8±4	0.007	5.9±1.1
Pb	17.4±6.9	0.003	21±8	0.000	49.4±27.9	0.011	5.4±0.6

Other biochemical and kidney functions results Table (3),(4) showed no meaningful difference between welders and non-welder groups although some has high statistical significance at p≤0.05, but remains within the normal acceptable range.

Table 3: Biochemical parameters of welders grouped by Age

Parameters	18 - 32 Years No. 26		33 - 47 Years No. 17		48 - 60 Years No. 7		Control No. 20
	Mean (±CI)	p-value	Mean (±CI)	p-value	Mean (±CI)	p-value	Mean (±CI)
Blood Uric Acid	5.9±0.4	0.231	5.5±0.5	0.304	5.8±1.1	0.390	5.7±0.4
Blood Urea	25.5±2.8	0.020	31±3.8	0.319	34.4±4.7	0.068	29.9±2.8
Serum creatinine	0.8±0	0.017	0.9±0	0.142	0.9±0.1	0.342	0.9±0.1
Na	142.7±0.7	0.237	142.9±0.9	0.129	142.9±2.4	0.335	142.3±0.7
K	5.1±0.2	0.001	5±0.2	0.007	5.1±0.4	0.043	4.6±0.1
Cl	101.6±1.1	0.000	101.6±1	0.000	101.7±2.9	0.005	96.3±0.9

Table 3: Biochemical parameters of welders grouped by Working period

Parameters	1 - 7 Years No. 12		8 - 19 Years No. 31		Over 20 Years No. 7		Control No. 20
	Mean (±CI)	p-value	Mean (±CI)	p-value	Mean (±CI)	p-value	Mean (±CI)
Blood Uric Acid	5.8±0.4	0.357	5.7±0.4	0.430	5.8±1.1	0.418	5.7±0.4
Blood Urea	25.9±4.4	0.079	28.8±2.9	0.312	32.3±5.1	0.215	29.9±2.8
Serum creatinine	0.8±0.1	0.025	0.8±0	0.054	0.9±0.1	0.387	0.9±0.1
Na	142.7±0.8	0.245	142.7±0.7	0.203	143.3±2.3	0.222	142.3±0.7
K	5.2±0.3	0.003	5±0.2	0.001	5±0.4	0.088	4.6±0.1
Cl	100.9±1.5	0.000	101.8±0.9	0.000	102.1±2.8	0.002	96.3±0.9

Discussion

The amount of studies examining the effects of welding fumes' toxicity on environmental and human haematological variables has increased recently. High exposure to particulate matter (PM) including Fe, Mn, Pb, Cr, Cd, and many other elements is caused by the welding process.

This research, which comprised 50 welders and 20 non-welders, attempted to evaluate the health impact of welding fumes. It revealed that the welders had higher systolic and diastolic blood pressures than the controls, and that their blood pressure rose considerably with age and working duration. One of the study's advantages was that it was limited to male welders since there weren't many women in the examined culture employed in this field. Given that women may be more vulnerable to the danger of PM-induced CVD (Chen et al., 2005; Kan et al., 2008), our findings demonstrating elevated blood pressure in male welders may suggest that female welders are at even greater risk.

Several groups were created for the research participants based on their age and length of employment. According to ESH-ESC recommendations (ESH-ESC 2023), age groups 18–32 and 32–47 years old had average systolic and diastolic blood pressure in the "High normal" range; however, age group 48–60 years old had average systolic and diastolic blood pressure in the "Grade 1 hypertension" range. According to ESH-ESC 2023, the working age groups of 1–7 and 8–19 years also had average systolic and diastolic blood pressure in the "High normal" range. However, the group of 20–40 years had average systolic and diastolic blood pressure in the "Grade 1 hypertension" range. The effect of PM inhalation on the arterial partial pressure of oxygen (PaO2), which normally ranges from 75 to 100 mm Hg (Scheufler 2004), may be the cause of the participants' elevated blood pressure. Any PM from welding heavy metals may also have an impact on PaO2 homeostasis, as demonstrated by the effect of lead (Pb) exposure on kidney function, which raises blood proteins as in gout (Baki et al., 2016). Lead also has a variety of effects on various cardiovascular system sites. It directly affects the heart's excitability and contractility, which changes the vascular smooth muscle tissue's compliance. Additionally, lead directly affects the areas of the central nervous system that control blood pressure (Nash et al., 2003; Kopp et al., 1988). However, recent research (Li et al., 2015) revealed that damage to human coronary artery epithelial cells (Lai et al., 2015), decreased heart rate variability and ectopic heartbeats (Cavallari et al., 2016), and impaired cardiac automatic function (Zhang et al., 2018) could also be contributing factors to elevated blood pressure.

The analysis also revealed elevated HGB, HCT ratio%, and RBC count. Based on these findings, we hypothesise that welding fume metals may be the source of the elevated HGB, RBC, and HCT, which would result in a moderate hypoxia. Increased levels of erythropoietin stimulate the production of blood cells, which increases the oxygen carrying capacity to compensate for decreased oxygen levels. Inhaled PM causes adverse effects on the respiratory system, leading to several respiratory diseases (Lockey et al., 1988). One effect of zinc exposure (Vogelmeier et al., 1987) and occupational chromium exposure (Sobaszek et al., 2000) is decreased forced vital capacity. With prolonged exposure to welding fumes, this situation may result in moderate hypoxia that might worsen (Elia et al., 2019; Semenza et al., 2004).

According to a recent research (Kozlova et al., 2022), exposure to various chemicals and health conditions may result in the body having free iron Fe2+ in one form or another. This can lead to the production of ROS owing to the Fenton reaction (Fe2+ + H2O2), which has a variety of consequences on blood cells.

Results for heavy metals revealed higher concentrations of Pb and Fe. This increase could be caused by welding fume particulate matter getting on the welder's hair or by not wearing protective gear. Studies (Chang et al., 2011; Singhi et al., 2003) suggest that it is still unclear how iron affects biologic activities. Iron excess in the workplace, however, is thought to be harmful to the kidney and vascular system, as well as having negative effects on the central nervous system and the potential to induce metabolic acidosis. Nevertheless, both iron excess and shortage may raise ROS, oxidative stress, and inflammatory reactions. These factors have a negative impact on the endothelium layer and can raise blood pressure.

It is possible to see iron's capacity to produce ROS as the primary harmful mechanism at the cellular level, as well as the Fenton reaction's enhanced production of hydroxyl radicals. One of the most harmful ROS that attacks DNA, proteins, and carbohydrates is the hydroxyl radical. Furthermore, hydroxyl radicals are known to react with (8-OHG) 8-hydroxyguanine, resulting in oxidative stress-related malignancies and congenital abnormalities (Kohgo et al., 2008). Oh my. Lipid hydroperoxide radicals and hydroxyl radicals have comparable effects. When the body experiences an iron overload, certain chemicals like malondialdehyde and 4-hydroxy-2-nonenal are elevated, which increases the levels of RO- and ROO- (alkyl oxy radicals). These two lipid radicals have a longer half-life than hydroxyl radicals and are more capable of causing cellular toxicity and genotoxicity (Kohgo et al., 2008).

Lead also induces oxidative stress in two ways: first, by forming ROS such hydrogen peroxides and hydroperoxides; second, by depleting antioxidants. As Iron, ROS generation is thought to be the primary harmful mechanism of Lead (Flora et al., 2012). One of the antioxidants most affected by lead exposure is SOD, and CAT. While superoxide detection is reduced when CAT is down, superoxide radical production is enhanced when SOD is lowered. Additionally, research revealed that lead exposure has detrimental effects on the vascular system, such as hypertension and CVD, which may result in mortality (Navas-Acien et al., 2007). Both people and animals may develop hypertension as a result of low-concentration lead exposure (ATSDR, 2020). Lead may also take the place of zinc ions in co-enzymes, SOD and CAT, rendering them inactive (Flora et al., 2012). Lead has the capacity to substitute positive monovalent ions like Na+ and positive bivalent ions like Ca^{2}+, Mg^{2}+, and Fe^{2}+, impacting a number of essential bodily functions (Flora et al., 2012).

Conclusion

Welders exposed to heavy metal vapors exhibited a notable change in many hematologic parameters and blood pressure, as shown by the results of this research. Our research indicates that additional research is necessary to fully understand the effects of heavy metals on the human body, including the harmful effects on the cardiovascular system. Preventive measures also need to be implemented to reduce the harmful effects of welding fumes on employees.

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