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Renal Dysfunction among Arc Welders in Benin City, Nigeria-A Pilot Study

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Authors' contributions

This work was carried out in collaboration between all authors. Author AOA conceived and designed the study, interpreted the data and wrote the first draft. Author SDA conducted data collection and contributed to the final draft. Author EIU analysed the data and contributed to the final draft. All authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

Objective: Occupational exposure to liberated fumes and gases during welding process could be hazardous to the kidneys. The objective of this study was to screen and identify associated factors for renal dysfunction in arc welders.
Methods: A cross-sectional study conducted in 36 arc welders selected by simple random sampling from a sampling frame of registered arc welders in Egor local government area in Benin city. Twenty-two consenting age-matched controls were recruited from the maintenance department of University of Benin Teaching Hospital, Benin city. A proforma was used to obtain vital clinical information and participants' blood and urine samples were collected for biochemical analysis.
Results: There was no significant difference in the mean age, body mass index, blood pressure reading, serum creatinine, eGFR, lipid profile between the arc welders and controls. However,

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proteinuria was significantly commoner in the arc welders compared to controls (p<.001). Likewise, the fasting blood glucose level was also significantly higher in the arc welders compared to controls (135.93±53.92 mg/dL in welders, 97.67±29.28 mg/dL in controls, p =.01). The majority of the arc welders (66.7%) had chronic kidney diseases (CKD) stage 1 compared to 54.6% of the controls. However, a little below half of the control had CKD stage 2. About 11% of the arc welders had CKD stage 3 while none of the controls had CKD stage 3.

Conclusion: Proteinuria, a useful indicator of CKD is commoner among the arc welders compared to the apparently healthy controls. Therefore, there is a need to create awareness among arc welders for early CKD screening in view of the occupational exposure to toxic metals.

Keywords: Renal dysfunction; arc welders; Nigeria; Proteinuria; chronic kidney disease.

1. INTRODUCTION

Welding is a key process in the joining of metals with the use of heat, pressure or electric arc. Arc welders are the most prevalent of welders and they execute this process using an electric arc to generate the temperature necessary for the union of metals [1]. During this process, metal fumes are generated which could be inhaled, absorbed and transported in the blood round the body systems. The kidneys are not spared from the deleterious effects of chronic exposure to metal fumes [2,3].

Occupational exposure to nephrotoxic metals has been associated with both tubular and glomerular injuries in welders [2,4,5]. Sequel to this exposure, welders develop insidious onset of renal disease which is related to the type of metal, electrodes, and duration of exposure [6,7]. Several metals are liberated with the welding fumes, but the most implicated for causing renal dysfunction are lead, chromium, and cadmium [5,8,9].

Exposures to metal fume usually do not result in early and overt clinical symptoms due to the compensatory ability of the kidneys. This insidious onset of symptoms could give rise to late presentation of renal dysfunction in arc welders hence it is imperative for arc welders to have regular screening to assess the burden of renal disease and prevent chronic kidney disease in them [2,10].

The aim of the study was to assess renal function in arc welders and to identify associated factors that could be responsible for renal impairment. To the best of our knowledge, there are no such Nigerian studies in the literature.

2. PATIENTS AND METHODS

A cross-sectional study was conducted in thirty-six arc welders were recruited by simple random sampling from a sampling frame of registered arc welders in Egor local government area of Edo state. A non-exposed group of 22 consenting age and sex-matched workers of the maintenance department of the University of Benin Teaching Hospital who have never been involved in welding was recruited as the control group. Selected subjects were above 18 years of age and had no known history of renal disease, systemic hypertension, diabetes mellitus, urinary tract infection or sexually transmitted infection.

Eligible arc welders had consistently worked for at least a year as arc welders and did not partake in other forms of welding like gas welding and had no known history of renal disease, systemic hypertension, diabetes mellitus, urinary tract disease or sexually transmitted infection.

A proforma was developed for data collection of participants' vital information like the biodata, clinical information and use of protective devices at work. Height (m) of participants was measured using a stadiometer and without shoes while weight in kilograms was measured using Hanson weighing scale with subjects in light clothing; body mass index (BMI) was calculated using formula: Weight(kg) / Height(m)^2 and BMI of <18.5, 18.5 – 24.9, 25.0-29.9, ≥30 were categorized as underweight, normal, overweight and obese respectively [11]. An Accoson sphygmomanometer was used to measure the blood pressure of subjects in sitting position after resting for at least 10 minutes.

Early morning spot urine samples were collected into sterile containers and immediately tested with medi-test combi 9 urinalysis strips (machery-Nagel GmbH, Duren) for protein, glucose, specific gravity, and pH. Urinalysis was repeated in all patients three months after the initial test. Venepuncture was also done in which 10 mls of venous blood was collected for serum electrolytes, urea, creatinine as well as fasting

blood glucose and fasting lipid profile. The estimated glomerular filtration rate (eGFR) was calculated using the modified Modification of Diets in Renal Disease (MDRD) [12]:

$$GFR=186 \times (Cr)^{-1.154} \times (Age)^{-0.203} \times 0.742 \text{ (if female)} \times 1.210 \text{ (if Black)}$$

Estimated GFR of ≥ 90 mls/min, 60 – 89 mls/min, 30 – 59 mls/min, 15 – 29 mls/min and <15 mls/min were taken as stages 1, 2, 3, 4 and 5 of chronic kidney disease (CKD) respectively.

Institutional ethical approval was obtained from the ethical and research committee of the University of Benin Teaching Hospital, Benin city and all the participants gave informed consent.

Data analysis was done using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA). The continuous variables were presented as the mean while the discrete variables as proportion / percentages. The means were compared using the Student's t-test while the chi-squared test and Pearson's correlation coefficient were used in testing for association and correlation respectively. A p-value less than .05 was considered significant.

3. RESULTS

The study population comprised of 36 arc welders and 22 unexposed individuals whose ages were in the range of 18 to 58 years. The mean age of arc welders and controls was 29.00±10.27 years and 34.00±13.32 years respectively and there was no significant difference. All the participants were males.

Table 1 shows no significant difference in the mean BMI, blood pressure reading serum creatinine, eGFR, lipid profile between the arc welders and controls. However, the fasting blood glucose level was significantly higher in the arc welders with a mean of 135.93±53.92 mg/dL compared with the mean of 97.67±29.28 mg/dL in the unexposed group (p = .02). The majority of the arc welders (66.7%) had CKD stage 1 compared to 54.6% of the controls. However, a little below half of the control had CKD stage 2 to a relatively lesser percentage of arc welders (22.2%). About 11% of the arc welders had CKD stage 3 as to none of the control group. None of the participants had stages 4 and 5 CKD.

Table 2 shows significantly higher quantity and frequency of proteinuria in the arc welders compared to the control. (x^2 = 15.135, p<.001). Proteinuria persisted in all patients even after three months of the initial testing. None of the arc welders in the study used any protective device like facemask and protective aprons.

4. DISCUSSION

This study shows a higher fasting blood glucose, marked proteinuria, and worsened degree of chronic kidney disease in the arc welders compared to the apparently healthy group.

Table 1. General characteristics and stages of CKD in arc welders and controls

Mean of parameter	Welders N=36	Controls N=22	P value
Age (years)	29.00±10.27	34.00±13.32	0.14
BMI (Kg/m^2)	22.03±3.54	23.58±2.77	0.07
SBP (mmHg)	118.79±12.79	124.55±21.32	0.26
DBP (mmHg)	76.59±7.26	77.27±12.41	0.82
FBS (mg/dl)	135.93±53.92	97.67±29.28	0.01*
Serum creatinine (mg/dl)	1.07±0.34	0.99±1.70	0.27
eGFR (ml/min/1.73m^2)	105.80±29.72	111.90±29.37	0.83
Total cholesterol (mg/dl)	142.76±48.85	160.15±39.07	0.19
Triglyceride (mg/dl)	61.56±43.74	74.18±72.92	0.53
HDL (mg/dl)	21.10±24.17	27.39±7.74	0.18
CKD stage			
1	24(66.7%)	12(54.55%)	0.08
2	8(22.2%)	10(45.45%)	
3	4(11.1%)	0(0%)	

*Plus –Minus values are means ± standard deviations; * significant p-value*
SBP= Systolic Blood Pressure, DBP= Diastolic Blood Pressure,
FBS= Fasting Blood Sugar, eGFR= Estimated Glomerular Filtration Rate,
HDL= High-density Lipoprotein, LDL= Low-density Lipoprotein

Table 2. Frequency of proteinuria in arc welders and controls

Proteinuria	Welders (N=36) N (%)	Controls (N=22) N (%)
Negative	8(22.2%)	16(72.7%)
+	23(63.9%)	6(27.3%)
++	5(13.9%)	0(0%)
	(X^2 = 15.135, p<.001)	

Hyperglycemia has been reported in individuals exposed to heavy metal in the past, which is similar to our finding [13-17]. Jones et al. [16] postulated environmental reasons for the increase in diabetes mellitus in the developed and developing countries. Likewise in a study done in Nigeria, Akinloye et al. [13] discovered a high level of cadmium and lead in Type 2 diabetes mellitus patients in Oshogbo, Nigeria, further establishing a relationship between heavy metals and diabetes mellitus. Similarly, Rahman et al. [15] in Bangladesh found exposure to arsenic as a risk factor for diabetes mellitus while Chang et al. [14] established a molecular relationship between cadmium exposure and pancreatic B-cells apoptosis causing suppression of insulin secretion. In addition, reactive oxygen species which can be generated during welding have been demonstrated to cause islet cells dysfunction by overwhelming its anti-oxidative defense system [18]. The elevated fasting blood glucose in the welders in our study may be due to recurrent inhalation of welding fumes worsened by their non-utilization of protective device, as none of the welders used the face mask. The inhalation, absorption and systemic distribution of the metal fume to the different organs with the pancreas not spared could be responsible for the hyperglycemia in the exposed individuals.

Some studies have shown that recurrent exposure to metal fumes could result in the urinary excretion of low molecular weight proteins [5,7,9] although this state might be reversible at the onset unless there is already established renal impairment as evident by decreasing glomerular filtration rate [9]. Chronic exposure to heavy metals like lead, chromium and cadmium may produce insidious, yet progressive tubulointerstitial nephropathy often leading to renal failure [7,8]. In contrast to tubular proteinuria in which low molecular weight proteins are seen, glomerular proteinuria is readily detected by testing for urinary albumin using albustix [9]. We found significant proteinuria in the welders which could be attributed to their occupational exposure to heavy metals and even at a higher severity than the unexposed group. This is particularly worrisome as they may present at a later stage when it will be irreversible.

Both acute and chronic exposure to heavy metals have been demonstrated to cause nephropathies with various levels of severity [2]. However, the kidney's compensatory ability for renal damage makes the use of serum creatinine for eGFR estimation rather insensitive since the derangement is only overt when a large part of the nephron mass is lost [19]. Despite the low eGFR (CKD stage 3) in some active welders, there might be a number who have quit their job from severe impairment in renal function or coexistent of other ailments. Therefore, the principle of healthy workers effect phenomenon [20] may come to bear as those who are not fit to work might have quit and would not be sampled in the study.

This study was limited by the inability to identify appropriate blood or urinary biomarkers that could detect an early adverse effect on the kidney. We recommend a multicenter study for early detection of renal impairment and the urgent need for awareness among arc welders for the use of protective devices while welding.

5. CONCLUSION

Proteinuria as an indicator of CKD was commoner among the arc welders. The need to create awareness among arc welders of imminent CKD due to occupational exposure to toxic metals is imperative. Furthermore, enforcement of safety laws among workers to ensure that workers use protective devices is also paramount. Thus, sufficient preventive measure with early detection of nephrotoxic effects from occupational exposure to heavy metals could avert renal damage if identified at a reversible stage.

ETHICAL APPROVAL

Informed consent was obtained from the patients and also an institutional ethical approval was given by the Ethical Committee of the University of Benin Teaching Hospital, Benin city, Nigeria.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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