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Effect of occupational exposure to vat dyes on kidney functions of dye users in Abeokuta, Nigeria

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ABSTRACT: Textile dyeing involving the use of vat dyes characterized by the presence of a carbonyl functional group (C=O) with chromophores such as anthraquinoids and indigoids is a leading indigenous occupation in Abeokuta, Nigeria. Dyes and their intermediate compounds have been shown to have adverse effects on human health especially organ functions. Using convenience (haphazard) sampling technique, a cohort of dye workers (n= 117) with a minimum of 1 year and a maximum of 60 years duration of exposure (mean =17.03 ± 1.19 years) were recruited for this study. Sixty traders, matched for age and sex and who had no previous exposure to vat dyes were selected as controls. Demographic, occupational and environmental characteristics of the subjects were obtained using a structured questionnaire. Kidney function tests: urea and creatinine were carried out in plasma obtained from all subjects using standard spectrophotometric techniques. Plasma electrolytes, sodium and potassium were determined by flame emission photometry while chloride and bicarbonate were determined by titrimetric method. Plasma urea and creatinine were significantly higher ($p<0.05$) in the exposed compared to control while plasma sodium, chloride and bicarbonate were significantly lower ($p<0.05$). These findings indicate impairment of the glomerular and tubular functions of the kidney. Thus the study provides a scientific basis for protective measures against occupational exposure and health education among users of vat dyes.

Key Words: Occupational exposure; Textile dyeing; Vat dyes; Kidney function; Subtle pathological events

Introduction

Textile dyeing has become a prominent occupation among the people of Abeokuta, the capital of Ogun State, South Western Nigeria. The end product of which is known as “adire” meaning tie and dye. It involves the use of vat dyes, a class of dyes containing carbonyl functional group.

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Dyes may gain entrance into the system through inhalation, dermal contact and inadvertent ingestion.NIOSH,1980 Systemic effect may occur beyond the site of contact when the dye is absorbed into the bloodstream and distributed throughout the body. A high blood flow (about 25% of the cardiac output) reaches the kidney meaning that chemicals in the systemic circulation will be delivered in relatively high amounts thus making the kidney highly susceptible to chemical injury. Potential toxicant can become concentrated in the tubule as reabsorption of other substances take place. Intracellular toxicity can take place due to either secretion or even passive reabsorption. James (1985).The kidney had been observed to be affected by work exposure. (Harrington and Waldron 1981). End organ effect markers including renal function test has also been included in most medical surveillance programmes because of the myriad and mixed nature of exposures. (Gochfeld, 1994)

Materials and Methods

Subjects

One hundred and seventeen (117) subjects that were occupationally exposed to vat dye with minimum of 1year and maximum of 60 years duration of exposure (mean = 17.03) were recruited for this study from Itoku market, Abeokuta, Ogun state, Nigeria. Sixty subjects who were traders in textile materials apart from "adire" were selected as controls. They had no previous exposure to vat dye. The two groups were age and sex matched. Pregnant mothers and those less than 18 years of age were excluded from this study. All the subjects gave their informed consent and approval for study was received from the Scientific and Ethical Review Committee of Olabisi Onabanjo University Teaching Hospital, Ogun State, Nigeria. A semi structured questionnaire was used to obtain information on demographic, occupational, and environmental characteristics of the subjects

Methods

Blood was obtained from the ante-cubital vein using disposable syringes with steel needles and discharged into lithium heparin specimen tubes. Plasma was separated from cells by centrifuging blood at 700xg for 5minutes.

Plasma was stored at -20^{o}C until analyzed. Plasma urea was determined by urease method of Weatherburn, Picric method of Jaffe was used for the estimation of Plasma creatinine. Plasma sodium and potassium were determined by flame emission photometry while chloride and bicarbonate were determined using titrimetric method.

Statistical methods

Data collected were analyzed using Chi-square, Student's t- test and Pearson's Correlation co-efficient as contained in the SPSS statistical package (version 11.0). Results were expressed as means ± (SEM). P values ≤ 0.05 were considered significant.

Results

The characteristics of the exposed and the control group are as displayed in table 1.There was no significant difference between the mean ages of the exposed and the control populations. Also, the sex distribution between the exposed and the control groups were similar. Table 2 shows the means (±SEM) plasma concentrations of the parameters of kidney function: urea, creatinine, sodium, potassium, chloride and bicarbonate. Comparison of means of the concentrations of these parameters in the exposed and in control showed that mean plasma levels of urea and creatinine were significantly higher in the exposed than control ($p<0.05$). Mean plasma sodium, chloride and bicarbonate were significantly lower in the exposed than control ($p<0.05$). The means of all the parameters were observed to lie within the reference interval obtained in this environment. Table 3 shows the correlation of the duration of exposure with plasma levels of parameters of kidney function: urea, creatinine, potassium, sodium, and chloride and bicarbonate. No significant correlation was observed between the two. $p > 0.05$.

Table1: Characteristics of the exposed and the control groups

Variable	***Exposed***	***Control***
(1) Mean ± age (years)	42.53	38.78
SEM	1.32	1.93
(Range)	(18-70)	(18-70)
t =1.629; p> 0.05		
(2) Sex distribution		
Male	18(15.4%)	11(18.3%)
Female	99(84.6%)	49(81.7%)
X^2 =0.252; p> 0.05		

t=t test; $\times^2$ = chi square; p = probability.

Table 2: Urea, creatinine, potassium, sodium, chloride and bicarbonate in the exposed and control

Biochemical parameter	**Exposed (n=117)**	**Unexposed (n=60)**	**t**	**p**	**Statistical Inference**
Urea (mmol/L)	4.52 ± 0.16	3.02 ± 0.17	5.86	0.000	S
Creatinine (µmol/L)	99.9 ± 2.65	87.5 ± 4.42	2.59	0.011	S
Potassium (K^+) (mmol/L)	4.26 ± 0.06	4.10 ± 0.13	1.42	0.158	NS
Sodium (Na^+) (mmol/L)	130.04 ± 0.60	134.43 ± 0.51	4.81	0.000	S
Chloride (Cl^+) (mmol/L)	98.58 ± 0.60	103.08 ± 0.44	4.68	0.000	S
Bicarbonate (HCO_3^-) (mmol/L)	20.09 ± 0.20	20.65 ± 0.33	3.06	0.003	S

P value≤0.05 represents significance; n=sample number; S = significant; NS=Not significant.

Table 3: Correlation of duration of exposure and parameters of kidney function

Parameter	r	p	Statistical Inference
Urea	0.118	>0.05	NS
Creatinine	0.121	>0.05	NS
Potassium	0.036	>0.05	NS
Sodium	0.094	>0.05	NS
Chloride	0.091	>0.05	NS
Bicarbonate	-0.091	>0.05	NS

r= correlation coefficient; p= probability; NS = not significant at $p \geq 0.05$

Discussion

A typical kidney function test is categorized as either test of the glomerular or the tubular function (Mayne, 1996). The glomerulus is expected to freely filter both the plasma urea and creatinine. When the glomerulus therefore is impaired, both urea and creatinine are not adequately filtered and therefore their concentrations increase in plasma (Kale, 2001). The tubules reabsorb the electrolytes and in situations where the tubules are impaired, the consequence is plasma reduction of both. The trend in parameters of kidney function observed in this study is consistent with kidney involvement in occupational exposure to vat dyes. The significantly higher mean values observed in plasma creatinine and urea may indicate a compromise in the glomerular function of the kidney. Also, the significant lowering of plasma levels of sodium, chloride and bicarbonate is suggestive of wastages of these important electrolytes which may be due to defective reabsorption by the tubules.

Though significant changes were observed with parameters of kidney function, the plasma levels of these parameters were observed to lie within the normal reference range in this environment. This may be attributed to the fact that, the kidney possesses considerable functional reserve capacity. Clinical manifestation of kidney impairment does not become evident until more than 50 % of the nephrons have been destroyed (Goodman, 1985).The effect of exposure on both the glomeruli and the tubules are sub-clinical.

The adverse effect produced by a chemical is dependant on duration of exposure (Park, 2002), hence the duration of exposure was correlated with plasma mean level of parameters of liver and kidney functions. No significant correlation was found. The lack of significance may be because the parameters estimated in this study are those used routinely. They have been described as not so sensitive for discovering early damage and their use in detecting sub-clinical health effect is said to be limited. (Kale et al 2001). Perhaps if more sensitive parameters are employed, the effect could be more evident.

These findings indicate impairment of synthetic function of the glomerular and tubular functions of the kidney. It confirms earlier reports that clinical evidence of target organ damage may be absent in the face of suggestive biochemical evidence of subtle pathological events. Thus the study provides a scientific basis for protective measures against occupational exposure and health education among users of vat dyes.

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