Original Research Article

VARIATIONS IN SERUM LEVELS OF URIC ACID AND SOME MARKERS OF RENAL FUNCTION IN PAINT WORKERS IN OWERRI, NIGERIA.

ABSTRACT

Background: Paint is a mixture of homogeneous ingredients namely binder, pigment, heavy metals and additives, which when applied on a surface as a thin layer is converted to a solid film. Increasingly eruption of newly painted buildings is a phenomenon in fast developing Owerri, Nigeria. Despite the toxic nature of some paint constituents, paint worker seems to be ignorant of possible consequence of its occupational exposure on their health, and thus renal function.

Objective: The study was carried out to evaluate the serum levels of uric acid and some markers of renal function in paint workers in Owerri, Nigeria.

Methods: A total of 80 male subjects aged between 20 to 40 years participated in the study. This consists of 40 male paint workers and 40 male controls. Venous blood samples were collected in plain containers, allowed to clot and retract. It was then centrifuged and the serum separated into plain containers and was used for biochemical analysis. Serum Uric acid, Urea and Creatinine were determined spectrophotometrically, while Potassium and Sodium were determined by flame photometric method. The data was subjected to statistical analysis using SPSS version 21.

Results: There were significantly higher serum levels of uric acid (4.29±1.30mg/dl versus 3.59±0.80mg/dl, p=0.030), urea (29.10±4.95mg/dl versus 25.40±3.34mg/dl, p=0.003) and creatinine (0.79±0.11mg/dl versus 0.69±0.07mg/dl, p=0.006) in paint workers compared with the controls. There was a significantly lower serum level of sodium (129.50±4.77mEq/L versus 135.80±2.37mEq/L, p=0.000) in paint workers compared with controls. While there was no statistical difference in the serum level of potassium (3.43±0.15mEq/L versus 3.44±0.10mEq/L, p=0.832) in paint workers compared with controls.

Conclusion: This study shows that uric acid and some markers of renal function are raised in paint workers. This may be an indication of the toxic effect of paint constituents on the renal function of exposed paint workers.

Key Words: paint workers, uric acid, markers of renal function, Owerri.

INTRODUCTION

Paint is a suspension of finely divided pigment particles in a liquid composed of a binder (resin), a volatile solvent or water, and additives that impart special characteristics. The volatile components evaporate from the drying film after application, while the binder holds the pigment

in the dry film, causing it to adhere to the substrate. Some high quality, hard gloss paints are referred to as enamels [1].

The markers of renal function assess the normal functioning of kidney. These markers may be radioactive and non-radioactive. They indicate the glomerular filtration rate, concentrating and diluting capacity of kidneys (tubular functions). If there is an increase or decrease in the valves of these markers it indicates dysfunction of kidney [2]. Creatinine, Urea, Uric acid and Electrolytes (Potassium, Sodium) are markers for routine analysis [3]. Biochemical markers play an important role in accurate diagnosis and also for assessing risk and adopting therapy that improves clinical outcome. Over decades' research and utilization of biomarkers has evolved substantially. National Institute of Health (NIH) 2001, defined biomarkers as "a characteristic that is objectively measured and evaluated as an indicator of normal biological, pathological processes, or pharmacological responses to a therapeutic intervention." As markers of renal function, creatinine, urea, uric acid and electrolytes are for routine analysis whereas several studies have confirmed and consolidated the usefulness of markers such as Cystatin C and B-trace protein [3].

Uric acid (UA) is the end product of purine metabolism in humans, unlike other mammals where UA is metabolized to allantoin by uricase. The amount of UA in blood depends on the ingestion of purines, renal balance, where up to 90% of filtered UA is reabsorbed. Uric acid regulation is complex, with the main causal factors of hyperuricemia being diet, different polymorphisms of renal urate transporters, as well as the inactivation of uricase by various mutations of its gene during the evolution of hominids, which causes UA levels to be up to 10 times higher in humans than in other mammals [4]. According to Rentzos *et el*., [5], UA is not only a waste product of purine metabolism or an inert compound, as has been believed historically, but also has an

important role in many biological functions. Although UA is a powerful antioxidant, it also acts as a pro-oxidant giving rise to an increase in free radicals, endothelial vascular dysfunction, inflammation, changes in nitric oxide production, atherosclerosis and thrombogenesis. Clinically, the harmful pro-oxidant effects predominate over the beneficial antioxidant effects, except in the central nervous system, where the beneficial antioxidant action seems to prevail. Moreover, UA has important actions in the immune system and the development of some inflammatory processes with significant possible effects in various states of health and disease [5].

Urea is a major nitrogenous end product of protein and amino acid catabolism, produced by the liver and distributed throughout intracellular and extracellular fluid. In kidneys urea is filtered out of blood by glomeruli and is partially being reabsorbed with water [6].

The most frequently determined clinical indices for estimating renal function depends upon concentration of urea in the serum. It is useful in differential diagnosis of acute renal failure and pre renal condition where blood urea nitrogen-creatinine ratio is increased. Urea clearance is a poor indicator of glomerular filtration rate as its overproduction rate depends on several non-renal factors, including diet and urea cycle enzymes. Increased blood urea nitrogen (BUN) is seen associated with kidney disease or failure, blockage of urinary tract by a kidney stone, congestive heart failure, dehydration, fever, shock and bleeding in the digestive tract [6].

Creatinine is a breakdown product of creatine phosphate in muscle, and is usually produced at a fairly constant rate by the body depending on muscle mass. Creatinine is commonly used as measure of kidney function. The normal creatinine clearance test value is 110-150ml/min. in male and in female it is 100-130ml/min. The National Kidney Disease Education Program recommends calculating glomerular filtration rate from serum creatinine concentration. The creatinine clearance test is used to monitor the progression of renal disease. The diagnosis of

renal failure is usually suspected when serum creatinine is greater than the upper limit of the "normal" interval [7]. In chronic renal failure and uremia, an eventual reduction occurs in the excretion of creatinine by both the glomeruli and the tubules. Creatinine values may alter as its generation may not be simply a product of muscle composition, activity, diet and health status. The increased tubular secretion of creatinine in some patients with kidney dysfunction could give false negative value. The elevated values are also seen in muscular dystrophy paralysis, anemia, leukemia and hyperthyroidism. The decreased values are noticed with glomerulonephritis, congestive heart failure, acute tubular necrosis, shock, polycystic kidney disease, and dehydration [7].

Electrolytes are minerals that carry an electric charge. Electrolyte panel is frequently used to screen for an electrolyte or acid-base imbalance and to monitor the effect of treatment on a known imbalance that is affecting bodily organ function. The test for electrolytes includes the measurement of Sodium, Potassium, Chloride, and Bicarbonate for both diagnosis and management of renal, endocrine, acid-base, water balance, and many other conditions. Potassium used as a most convincing electrolyte marker of renal failure [2]. The combination of decreased filtration and decreased secretion of Potassium in distal tubule during renal failure cause increased plasma Potassium. Hyperkalemia is the most significant and life-threatening complication of renal failure. The above discussed glomerular and tubular function markers are effective in proper assessment of renal function test. These markers act as an indicator of biological, pathologic processes, or pharmacologic responses to a therapeutic intervention [8].

MATERIALS AND METHODS

Study Area

The study was carried out in Imo State University and its environs in Owerri, the capital of Imo State, Nigeria.

Ethics and Pre-Survey Contacts

This study was approved by the Research Ethics Committee of Medical Laboratory Science Department, Faculty of Health Sciences, Imo State University Owerri, Nigeria. Modalities for the survey were reached and dates were fixed for blood sample collection at the participants work site. Informed consent was sought and obtained before commencement of sample collections.

Study Population and Size

A total of eighty (80) male subjects were selected for the study in Owerri. The study population consists of 40 male paint workers between the age range of 20-35 years who were working in new building sites in Imo State University and its neighborhoods in Owerri. The study group was age-matched with the Control group which consist of 40 apparently healthy male students of Imo state University, who are none paint workers.

Selection Criteria

Inclusion criteria

i. Male Subjects that have been Paint worker for up to 3years
ii. Paint workers without any chronic disease.
iii. Subjects that gave informed consent.

Exclusion criteria

i. Subjects who did not give their consent were excluded from the study.
ii. Female subjects were excluded.

iii. Subjects with chronic diseases.

Sample Collection and Processing

Using a sterile needle and syringe, 5mls of venous blood was collected aseptically from the median cubital or antecubital vein and was dispensed into a labelled plain container. The sample was allowed to clot after which the serum was separated with the aid of a Pasteur pipette. The serum was then introduced into another specimen container (plain container), and stored at -20^0C prior to use. Samples were analyzed within 2 days of collection.

Analytical Methods and Procedures

All reagents were commercially purchased and the manufacturers Standard Operating Procedures strictly adhered.

Serum Uric acid level was determined by Spectrophotometric method as described by Caraway [9]. This uses the reducing property of uric acid in alkaline phosphotungstic acid to form tungsten blue whose colour is estimated colorimetrically at 700nm wavelength.

Serum Urea was estimated Spectrophotometrically using Diacetyl Monoxime method as described by Natelson, [10]. Proteins in whole blood, plasma or serum are precipitated with trichloroacetic acid. The urea in the supernatant reacts with diacetyl monoxime in the presence of thiosemicarbazide and cadmium ions under acid conditions. The absorbance of the red rose-purple solution is measured at 530nm.

Serum Creatinine (anhydride of creatine) was determined by Jaffes Reaction method as described by Bonsnes and Toussky, [11] spectrophotometrically. Creatinine reacts with picric acid in an alkaline medium (alkaline picrate solution) to give a red colour (jaffes reaction) which absorbs at 510nm.

Serum Sodium was determined by Flame Photometry method as previously described by Fledman and Rains, [12]. Sodium solution under carefully controlled condition as a very fine spray is supplied to a burner. In the flame, the solution evaporates, the salt dissociates to give neutral ions. Some of these moves into high energy state. When these excited atoms fall back to the ground state-the ions of characteristic wavelength emitted at 590nm. This light passes through a suitable laser on to photosensitive element and the amount of current thus induced is measured.

Serum Potassium is determined by Flame Photometry method. An alkali metal salt (Potassium) drawn into a non-luminous flame ionizes, absorb energy from the flame and then emit light of a characteristic wavelength (770nm) as the excited atoms decay to the unexcited ground state. The intensity of emission is proportional to the concentration of the element (potassium) in the solution.

Statistical Analysis

All values were as Mean ± Standard Deviation (SD). The statistical analysis was carried out using the student T-test and Z-score to detect the level of significance. Tests with a probability value of $P<0.05$ was considered statistically significant.

RESULTS

Serum Uric Acid, Urea, Creatinine, Sodium and Potassium in Paint Workers versus Controls.

There were significantly higher levels of serum uric acid ($p = 0.030$), serum urea ($p = 0.003$) and serum creatinine ($p = 0.006$) in paint workers compared to controls. There was a significantly lower level of serum sodium ($p = 0.000$) in paint workers compared to control. While there was no significant difference in serum potassium ($p = 0.832$) in paint workers compared to controls.

Pearson Correlation of Uric Acid, Urea, Creatinine, Sodium and Potassium in Paint Workers.

There was significant negative correlation of uric acid with sodium ($r = -0.448$, $p= 0.048$) in paint workers. There was significant positive correlation of urea with sodium ($r= 0.764$, $p=0.000$) in paint workers. There was no significant correlation of creatinine with uric acid ($r = 0.290$, $p = 0.214$), urea ($r = 0.257$, $p = 0.274$), sodium ($r = 0.104$, $p = 0.662$) and potassium ($r = 0.244$, $p = 0.300$) in paint workers. There was no significant correlation of potassium with uric acid ($r = 0.199$, $p = 0.399$), urea ($r = 0.210$, $p = 0.375$), creatinine ($r = 0.244$, $p = 0.300$) and sodium ($r = -0.145$, $p = 0.541$) in paint workers.

Table 1: Serum Uric Acid, Urea, Creatinine, Sodium and Potassium in Paint Workers versus Controls

Variables (mean ± SD)	**paint workers** (n = 20)	**control** (n = 20)	**t-value**	**p-value**
Uric acid (mg/dl)	4.29±1.30	3.59±0.80	2.351	0.030
Lower 95% C.I	3.68	3.21		
Upper 95% C.I	4.89	3.96		
Urea (mg/dl)	29.10±4.95	25.40±3.34	3.377	0.003
Lower 95% C.I	26.78	23.83		
Upper 95% C.I	31.41	26.96		
Creatinine (mg/dl)	0.79±0.11	0.69±0.07	3.110	0.006
Lower 95% C.I	0.73	0.65		
Upper 95% C.I	0.84	0.73		
Sodium (mEq/l)	129.50±4.77	135.80±2.37	-5.581	0.000
Lower 95% C.I	127.26	134.68		
Upper 95% C.I	131.73	136.91		
Potassium (mEq/l)	3.43±0.15	3.44±0.10	-0.216	0.832
Lower 95% C.I	3.35	3.39		
Upper 95% C.I	3.50	3.48		

Table 2: The Pearson Correlation of Uric Acid, Urea, Creatinine, Sodium and Potassium in Paint Workers

		Uric acid	urea	creatinine	sodium	potassium
Uric acid	r-value	1	-0.134	0.290	-0.448*	0.199
	p-value		0.574	0.214	0.048	0.399
	N	20	20	20	20	20
Urea	r-value	-0.134	1	0.257	0.764**	0.210
	p-value	0.574		0.274	0.000	0.375
	N	20	20	20	20	20
Creatinine	r-value	0.290	0.257	1	0.104	0.244
	p-value	0.214	0.274		0.662	0.300
	N	20	20	20	20	20
Sodium	r-value	-0.448*	0.764**	0.104	1	-0.145
	p-value	0.048	0.000	0.662		0.541
	N	20	20	20	20	20
Potassium	r-value	0.199	0.210	0.244	-0.145	1
	p-value	0.399	0.375	0.300	0.541	
	N	20	20	20	20	20

DISCUSSION

Some chemicals (organic and inorganic) used in paint industries contain heavy metals with known risks. Exposure to certain heavy metals has been shown to be associated with middle-

term and long-term health risks such as abdominal pain. Adults may also experience high blood pressure, fatigue, kidney and brain disturbances [13].

In this present study, there were significantly higher levels of serum uric acid, urea and creatinine ($p< 0.005$) in paint workers compared with controls. There was a significantly lower level of serum sodium ($p=0.000$) in paint workers compared with controls. While there no significant difference in serum potassium ($p> 0.05$) in paint workers compared with controls. During the application of paint, workers are exposed primarily to solvents, whereas the mechanical removal of paint mainly leads to exposure to pigments and fillers. Exposure both by inhalation and via skin contact, occurs specifically in operations that involve manual handling during preparation of paint [14]. Bio-monitoring of workers exposed to paints has shown elevated levels of paint compounds or their metabolites in blood [15]. Paint workers are exposed to a various variety of harmful chemicals present in paint products such as solvents (aromatic hydrocarbons: Benzene, Toluene, and Xylene) [15]. Also paints contain pigments such as Lead, Cadmium, Arsenic and Chromium [16]. Besides, Titanium dioxide and Silver are nanoparticles used as paint additives [17]. All these constituents were reported by many studies to have adverse effects on neurobehaviour, blood, kidney, liver, cardiac respiratory functions, spleen and many body systems [18,19,20]. It is likely that these constituents of paint may have caused some toxic effects on the renal function of the exposed paint worker in this present study, thus the observed raised values of uric acid, urea and creatinine in the paint workers.

The kidney is responsible for the elimination of 70% of the daily uric acid production. Decreases in glomerular filtration rate (GFR) has been associated with uric acid retention. Raised serum uric acid has been incriminated in the pathogenesis of gout and kidney stones. High serum uric acid was proposed to be in association with other diseases including hypertension, chronic

kidney disease and diabetes mellitus [21]. This is consistent with the present study since there is significant increase in serum uric acid. Kanbay *et al*., [22] described how uric acid has been resurrected as a potential mediator of acute kidney injury. Urea measured in the blood is used as an index of renal function though not a reliable marker because it is easily influenced by causes unconnected to GFR [23]. Serum creatinine according can also serve as a marker of renal function. The tubular secretion of creatinine increases with chronic kidney disease leading to an unpredictable overestimation of GFR [24]. The kidneys play a pivotal role in the regulation of electrolyte and acid-base balance. With progressive loss of kidney function, derangement in electrolytes and acid-base inevitably occur and contribute to poor patient outcomes. Potassium disorders are common in patients with kidney disease, particularly in patients with tubular disorders and low glomerular filtration rate. Regulation of the retained body sodium is maintained by the kidneys, with excess excreted in the urine and fine control carried out by tubular reabsorption [25]. The impairment of the kidney's ability to excrete sodium is either genetic, as in essential hypertension, or it can be superimposed as in obesity, primary hyperaldosteronism, or renal disease [26].

CONCLUSSION

The results of this study indicates that serum levels of uric acid, urea, and creatinine are raised in paint workers. Serum level of sodium is significantly lower in paint workers, while the serum level of potassium in paint workers is indifferent. Thus, occupational exposure to harmful chemicals present in paint products may be consequential to elevation in serum level of uric acid and some markers of renal function.

RECOMMENDATION

It is recommended that paint workers wear personal protective equipment during work which can

substantially reduce uptake of chemicals found in paint product. It is also recommended that they should have regular medical monitoring to assess their kidney and any other related organs that could be affected due to exposure to some paint components.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ETHICAL APPROVAL AND CONSENT

The study protocol was approved by the Department of Medical Laboratory Science, Imo state University, Owerri, Nigeria, Research Ethics Committee with reference number MLS/IMSU/REC/2021/011. Written informed consent was obtained from all study participants prior to their enrolment and collection of blood samples in accordance with the "1964 Helsinki declaration" and its later amendments in 2000.

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