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Changes in some liver function parameters (aspartate transaminase, alanine transaminase, alkaline phosphatase, total and conjugated bilirubin) with long term exposure to paint spray fumes in Enugu area

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Abstract

Occupational exposure to chemical fumes is a recognized public health concern, particularly in developing countries where workplace safety regulations are often poorly enforced. Paint spray fumes contain a complex mixture of volatile organic compounds and heavy metals capable of inducing hepatic toxicity following prolonged inhalation. This study assessed changes in selected liver function parameters among professional painters chronically exposed to painting spray fumes in Enugu, Nigeria. A total of ninety male subjects aged 21–40 years participated in the study, comprising fifty painters with long-term occupational exposure and forty apparently healthy non-painters serving as controls. Serum activities of aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), total bilirubin, and conjugated bilirubin were determined using enzymatic and colorimetric techniques. Results were expressed as mean ± standard deviation (SD). Statistical comparison between test and control groups was performed using Student's t-test. A p-value less than 0.05 were considered statistically significant. The results showed a significant increase in AST activity among painters compared with controls (20.04 ± 7.41 IU/L verses 15.45 ± 5.54 IU/L; $p = 0.002$), while ALT and ALP showed no statistically significant differences between both groups ($p > 0.05$). Total bilirubin and conjugated bilirubin levels were significantly elevated in painters compared with controls ($p < 0.05$). These findings suggest that prolonged exposure to painting spray fumes may induce mild hepatocellular injury and impaired bilirubin metabolism even in the absence of marked elevation of all liver enzymes. Continuous occupational exposure to paint fumes therefore poses a potential risk to liver health. Periodic biochemical monitoring and enforcement of occupational safety measures are recommended.

Keywords: Liver; Liver function parameters; Paint spray fumes; Long term exposure

1. Introduction

The liver is the largest internal organ in the human body and plays a central role in metabolic homeostasis, detoxification, and excretion of endogenous and exogenous substances. It is responsible for carbohydrate, lipid, and protein metabolism, synthesis of plasma proteins, bile production, and biotransformation of toxic compounds (1). Hepatocytes possess enzymatic systems such as the cytochrome P450 complex that convert lipophilic toxins into more water-soluble metabolites for elimination. However, excessive or prolonged exposure to toxic substances can overwhelm these systems, resulting in hepatocellular injury. Liver function tests (LFTs) are widely used biochemical tools for evaluating liver integrity, hepatocellular injury, and biliary obstruction. Aspartate transaminase (AST) and alanine transaminase (ALT) are intracellular enzymes released into circulation following hepatocellular damage, while alkaline phosphatase (ALP) reflects cholestasis and biliary tract involvement (2). Bilirubin, a product of haemoglobin

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breakdown, provides insight into hepatic conjugation and excretory function. Elevation of serum bilirubin often indicates impaired hepatic uptake, conjugation, or bile flow.

Occupational exposure refers to contact with potentially harmful physical, chemical, or biological agents during the course of work. In developing regions, informal occupations such as spray painting are often carried out without adequate personal protective equipment. Paints and spray formulations commonly contain organic solvents such as toluene, xylene, benzene derivatives, isocyanates, and heavy metals, which are capable of inducing oxidative stress and cellular toxicity (3). Chronic inhalation of these compounds allows systemic absorption and subsequent hepatic metabolism.

Paint spray fumes are easily inhaled due to their aerosolised nature, leading to rapid pulmonary absorption and systemic distribution. Several studies have linked prolonged exposure to paint fumes with liver enzyme abnormalities, oxidative stress, and inflammatory responses in exposed workers (4,5). The liver, being the primary organ of detoxification, is particularly vulnerable to solvent-induced injury, which may present initially as mild biochemical alterations before overt clinical disease develops.Painters represent a high-risk occupational group due to repeated and prolonged exposure to chemical fumes, often in poorly ventilated environments. In Nigeria, occupational health surveillance is limited, and many painters are unaware of the long-term health implications of their work. Previous African studies have reported altered liver enzymes among paint workers, suggesting subclinical hepatic stress (6,7).Despite increasing urbanisation and demand for painting services in Enugu, data on the hepatic effects of chronic paint fume exposure remain scarce. This study was therefore designed to evaluate changes in selected liver function parameters among professional painters compared with non-exposed individuals, with the aim of providing evidence for occupational health interventions.

2. Materials and methods

This cross-sectional study involved ninety male subjects aged 21–40 years. Fifty professional painters with long-term occupational exposure to painting spray fumes were recruited as the test group, while forty apparently healthy non-painters with no known exposure to paint fumes served as controls.Venous blood samples were collected aseptically into plain sample bottles, allowed to clot, and centrifuged to obtain serum for biochemical analysis.Serum AST and ALT activities were determined using the method of Reitman and Frankel (8). Alkaline phosphatase activity was measured according to the DGKC method (9). Total and conjugated bilirubin were estimated using the Jendrassik and Grof method (10).Results were expressed as mean ± standard deviation (SD). Statistical comparison between test and control groups was performed using Student's t-test. A p-value less than 0.05 was considered statistically significant.

3. Results

Table 1 The Mean ±SD of AST, ALT, and ALP of the test verses control

Parameters (IU/L)	Test (n=50) Mean ±SD	Control (n=40) Mean ±SD	p-value
AST	20.04±7.41	15.45±5.54	0.002
ALT	15.68±9.04	15.60±9.59	0.785
ALP	48.63±12.74	49.30±16.53	0.883

Table 1 showed a statistically significant increase in AST activity among painters compared with controls ($p = 0.002$). No significant differences were observed in ALT and ALP activities between both groups ($p > 0.05$).

Table 2 The Mean ±SD of total bilirubin and direct bilirubin of the test verses control

Parameters (umol/l)	Test (n=50) Mean ±SD	Control (n=40) Mean ±SD	p-value
Total bilirubin	14.11±4.81	10.30±3.99	0.000
Direct bilirubin	8.10±3.29	5.88±3.37	0.002

Table 2 revealed significantly higher total bilirubin and conjugated bilirubin levels in painters compared with controls ($p < 0.05$), indicating altered bilirubin metabolism among exposed individuals.

4. Discussion

Occupational exposure to paint spray fumes represents a significant health concern due to the presence of volatile organic compounds (VOCs), heavy metals, and organic solvents capable of inducing hepatic toxicity. The liver, being the principal organ responsible for detoxification, is particularly vulnerable to chronic inhalational exposure to these substances. This study evaluated changes in selected liver function parameters among painters with long-term exposure to spray paint fumes in Enugu, Nigeria, in comparison with non-exposed controls.

The results demonstrated a significant elevation in serum aspartate transaminase (AST) among painters compared to non-painters (P<.05). AST is a cytosolic and mitochondrial enzyme present not only in the liver but also in cardiac and skeletal muscle. Its elevation suggests hepatocellular stress or injury, which may arise from prolonged exposure to hepatotoxic compounds found in paint fumes, including toluene, xylene, and other organic solvents (11). The significant increase in AST observed in this study indicates that chronic exposure to paint fumes may compromise hepatocellular integrity, even in relatively young adults aged 21–40 years.In contrast, alanine transaminase (ALT) showed no statistically significant difference between painters and controls (P>0.05). ALT is more liver-specific than AST and is commonly used as a marker of hepatocellular damage. The absence of a significant ALT elevation suggests that the hepatic injury associated with paint fume exposure may be mild or subclinical rather than overt hepatocellular necrosis. Similar findings have been reported in occupational studies where AST elevation precedes ALT changes, particularly in early or low-grade toxic liver injury (12).Similarly, alkaline phosphatase (ALP) activity did not differ significantly between painters and controls (P>0.05). ALP is primarily associated with cholestasis and biliary obstruction. The lack of significant ALP alteration suggests that prolonged paint fume exposure in this population does not markedly affect biliary function. This finding implies that the toxic effects of paint fumes may preferentially target hepatocellular metabolism rather than the biliary system, consistent with previous occupational exposure studies (13).

A more pronounced effect of paint fume exposure was observed in bilirubin metabolism. Total bilirubin levels were significantly higher in painters compared to non-painters (P<0.05). Bilirubin is a product of haem catabolism and serves as an important indicator of hepatic uptake, conjugation, and excretion. Elevated total bilirubin suggests impaired hepatic handling of bilirubin, which may result from hepatocellular dysfunction induced by chronic toxic exposure. Organic solvents have been shown to interfere with hepatocellular transport mechanisms and conjugation pathways, leading to bilirubin accumulation (14).

Furthermore, direct (conjugated) bilirubin was also significantly elevated in painters relative to controls (P<0.05). This finding indicates that while bilirubin conjugation may still occur, its excretion into the bile may be compromised. Elevated direct bilirubin in the absence of significant ALP elevation suggests early or partial impairment of hepatobiliary excretory function rather than complete cholestasis. This pattern has been described in toxin-induced liver dysfunction, where conjugated bilirubin accumulates due to impaired canalicular transport (15,4,7).).The combined pattern of significant AST elevation with normal ALT and ALP, alongside significantly increased total and direct bilirubin, suggests a state of subclinical hepatic dysfunction rather than advanced liver disease. This biochemical profile is characteristic of chronic low-level toxic exposure, where hepatocytes experience metabolic stress without widespread cell death. Such alterations may remain asymptomatic for long periods but could progress with continued exposure (16).Importantly, the study population consisted of relatively young adults, indicating that occupational exposure to paint fumes may exert hepatic effects early in working life. This underscores the need for preventive occupational health measures, including adequate ventilation, use of personal protective equipment, and regular biochemical monitoring of exposed workers. Routine liver function testing among painters may allow early detection of hepatic dysfunction and prevent progression to clinically significant liver disease. The findings of this study demonstrate that long-term exposure to painting spray fumes is associated with significant alterations in selected liver function parameters, particularly AST and bilirubin levels. While ALT and ALP remained within comparable ranges to controls, the observed changes suggest early hepatocellular stress and impaired bilirubin metabolism among exposed individuals. These results highlight the occupational health risks associated with paint fume exposure and emphasize the importance of protective strategies and regular health surveillance for painters.

5. Conclusion

This study demonstrated that prolonged occupational exposure to painting spray fumes is associated with significant alterations in selected liver function parameters, particularly AST, total bilirubin, and conjugated bilirubin. Although ALT and ALP remained within comparable ranges, the observed biochemical changes indicate early hepatic stress among exposed painters. Regular health surveillance, use of personal protective equipment, and enforcement of occupational safety standards are strongly recommended to prevent long-term liver damage among painters in Enugu.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from every individual participant included in the study.

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