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Effects of Quarry Dusts on the Electrocardiogram of Quarry Workers in Abakaliki Metropolis

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Abstract

Associations between high level of occupational dust and cardiovascular diseases have been known for more than half a century. This study aims to evaluate the effects of quarry dusts on the electrocardiogram of quarry workers in Abakaliki metropolis. 100 workers from quarry industry (test group) and 100 civil servants (control group) participated in this study. They were within the age of 18 to 65 years. A questionnaire was issued to obtain some vital medical and workplace information. Signed consents forms were obtained. An electrocardiogram machine was used to examine the electrical activities of their hearts. Data were presented as Mean ± SEM, analyzed using a 2-way ANOVA, and a multiple comparison test using Tukey's Post Hoc Test. Level of significance was set at $p<0.05$. All statistical analyses were carried out using Graph Pad prism 7 software. The result showed no significant difference in the QRS duration, QT interval, QTC interval, RV5 and SV1 amplitudes of quarry workers when compared with control. Significant increase was observed in the PR- intervals of quarry machine operators ($p= 0.0219$), quarry stone carriers ($p=0.0316$) and quarry stone crushers ($p=0.0259$) when compared with the control. Furthermore, significant decrease in the p value- axis of quarry machine operators ($p=0.0001$), quarry stone carriers ($p=0.0001$) and quarry stone crushers ($p=0.0001$) when compared with the control was detected. The result also showed a significant increase in the QRS- axis of quarry machine operators ($p=0.0258$), quarry stone carriers ($p=0.0346$) and quarry stone crushers ($p=0.0467$) when compared with the control. Additionally, among the different groups of quarry workers, quarry machine operators recorded prolonged PR intervals and a significant decrease in T-axis when compared with other quarry workers. In conclusion, quarry workers have inadequate PR – Interval, QRS axis and P axis than non-quarry workers thus have compromised electrical activities of their hearts. Also, prolonged PR- interval recorded by the quarry machine operators when compared with other groups of quarry workers is an indication that greater exposure to quarry dust may cause greater damage to the heart. Quarry workers need to be encouraged to adopt cardiovascular health safety strategies and also, be educated on quarry dusts hazards.

Keywords: Occupational hazard; Electrical activities of the heart; Quarry dust

Introduction

Associations between high level of occupational dust and cardiovascular diseases have been known for more than half a century [1]. Dust are small dry, solid particles projected into the air by natural forces such as wind, volcanic eruption and by mechanical or man-made processes such as crushing, grinding, milling, drilling, demolition, shoveling, conveying, screening, bagging and sweeping IUPAC [2]. Dusts, when in high concentration could harm animals, humans and vegetation [3]. There are four major types of dust found in work environment namely: mineral dust, organic and vegetable dust, metallic dust, and chemical dust. Examples of mineral dust are quartz, coal and quarry dust. Quarry dust has high concentration of crystalline silica. Crystalline silica is found in stones, rocks, sands and clays. Different types of stones contain different amounts of silica. Sand stone, gritstone and quartzite contains about 70%, concrete and mortar 25% to 70%; shale 40% to 60%, China stone 50%, slate 40%, brick 30%, granite 30%, ironstone 15%, basalt and dolerite 5%, limestone, chalk and marble contains 2% of silica [4]. Crystalline silica that is fine enough to reach or enter the lung alveoli is called respirable crystalline silica [5]. Dust particles are usually in the size range from about 1 to 100μm in diameter, and they settle slowly under the influence of gravity. They are generally called particulate matters. Particulate matters are classified by size of the particles into ultrafine PM<(0.1μm), coarse (Pm 1.0-2.5 μm), fine (PM>2.5μm) and PM ≤ 10μm [1]. These particles are composed of solid and liquid components that originate from vehicle exhaust, road dust, forest fire,

wind-blown soil and quarry dusts. Particle size, surface area and chemical composition determine the health risk posed by particulate matters. Particulate and gaseous pollutants coexist in the air and may induce adverse health effects, whereas compelling data implicate particulate matters as a major perpetrator of various types of cardiovascular diseases, particulate matters rarely exists by itself within the ambient environment because gaseous and semi volatile compounds are constantly changing and interacting Schwartz & Morris6. Many of these vapor-phase compounds attach to the surface of particulate matters and/or by themselves form secondary aerosol particles [7]. These particles are composed of solid and liquid compounds depositing in the alveoli and entering the pulmonary circulation and presumably into the systemic circulation [8]. The potential mechanisms by which pollutants may cause cardiovascular diseases include alterations in autonomic function, increase repolarization abnormalities, local and systemic inflammation, increase reactive oxygen species, coagulation and myocardial ischemia [1]. Cardiovascular diseases that may be cause by air pollution include cardiac arrhythmias, myocardial ischemia, hypertension, myocardial infarction, atherosclerosis etc. Many studies have been carried out to determine the effects of occupational dust on the ECG parameters of the exposed workers. Ljungman et al. [9] and Zareba et al. [10] revealed that exposure to particulate matters can lead to a significant increase in the PR, QT and QTc interval of the exposed individuals. Peters et al. [8] revealed that exposure to air pollution can lead to an increase in ventricular arrhythmias. The menace of air pollution with respect to ventricular arrhythmias may not have been well documented in Nigerian. Furthermore, no study sought to have investigated the effects of quarry dusts on the ECG of quarry workers in Ebonyi State where majority of people's major sources of living comes mostly from either quarry, timber or rice-mill industries all dust emitting industries. More so, studies carried out in other regions cannot be extrapolated for Ebonyians due to genetic and socio-demographic characteristics. Thus, this study aimed to bridge the gap in knowledge. The study aimed to evaluate the effects of quarry dust on the ECG of quarry workers in Abakaliki metropolis.

Methods and Materials

Research Design

This was a cross sectional study designed to evaluate the effects of quarry dusts on the electrocardiogram of quarry workers in Abakaliki metropolis. There are three different groups of quarry workers in Abakaliki metropolis namely; quarry machine operators, quarry stone carriers, and quarry stone crushers. ECG parameters were also compared among the different groups of quarry workers.

Sampling Technique

Purposive sampling Technique was used in this study with inclusion and exclusion criteria. Quarry workers within the age of 18 to 65 years were included in this study. Quarry workers that have been in the service for at least minimum of three years and are not engaged in other air pollutant Jobs were included. Quarry workers that have been previously diagnosed of any cardiovascular diseases were excluded from this study. Pregnant females and workers taking drugs that can directly or indirectly affect the cardiovascular system were also excluded from this study.

Sample size

Cohen sample size formula [11] was used to estimate sample size in this study. The formula is as follow:

$$N = \frac{\left\{Z\left(\frac{1-a}{2}\right)\right\}^2}{D} \times PQ$$

$$Z = \left(\frac{1-a}{2}\right) = 1.96$$

P- Expected prevalence = 0.07

Q = 1- P; i.e. 1- 0.07 = 0.93

D-degree of accuracy = 0.05

$$Sample\ size = \left\{\frac{1.96}{0.05}\right\}2 \times 0.07 \times 0.93$$

Sample size = 100. This suggests that the minimum number of participants that must take part in this study is 100.

Study areas

Study areas were quarry industries where there are many quarry workers exposed to the quarry dust.

Research Population

200 subjects participated in this study. 100 quarry workers as test group and and100 non-quarry workers as control group with informed knowledge that they are not working at any dust emitting industries.

Materials used in this study are: ECG machine – BPL – model: 6208 and its graph paper, an examination couch, a lubricating electrostatic k-y jelly, a methylated spirit and a cotton wool.

Procedure

The participant was made comfortable, the aims of the procedure was explained, a signed consent obtained and a questionnaire filled by the participant to find out if the participant is qualified to participate in the study. The participant was made to lie on a comfortable and a well elevated couch. Then the chest and the limbs where the leads were placed were exposed. A cotton wool soaked in methylated spirit was used to clean the two legs and arm at the various points for the leads. Then an electrostatic lubricating jelly was applied to those points after that, the electrodes (leads) corresponding to their part were fastened, that is, the electrode for the right foot placed on the right foot while that for the left arm placed at the left arm. All these constituted the bipolar lead connections. For the chest lead, the electrodes connected to a pump (six in number) were attached with their chest lead to their positions on the thorax (chest), following this sequence; Chest lead one (v1) was placed at the fourth intercostal space at the right sternal border. Chest lead two (v2) was placed at the fourth intercostal space at the left sterna border. Chest lead three (v3) was placed mid-way between chest lead two and chest lead four. Chest lead four (v4) was placed at the fifth intercostal space at the mid clavicular line. Chest lead five (v5) was placed at the left anterior axillary line at the same horizontal level as v4. Chest lead six (v6) was placed at the mid axillary line at the same horizontal line level as the chest lead v4. With the chest leads placed in this order then it was ready for recording. The electrocardiogram machine (ECG), recorded the cardiac waves namely p-wave, QRS complex and T- waves. Also the variables that were calculated included the amplitudes, axis, intervals, etc. The totality of

this waves and variables determined the electrical activities of the heart weather normal (normal sinus) or abnormal (arrhythmias) and the medical implications.

Data Analysis

Data were presented as Mean ± SEM, analyzed using a 2-way ANOVA, and a multiple comparison test using Tukey's Post Hoc Test. Level of significance was set at $p<0.05$. All statistical analyses were carried out using Graph Pad prism 7software.

Result

The result showed a significant increase in the PR- intervals of quarry machine operators (p= 0.0219), quarry stone carriers (p=0.0316) and quarry stone crushers (p=0.0259) when compared with the control. No statistical difference (P>0.05) was observed in the QRS- duration, QT and QTc- intervals of quarry workers when compared with the control.

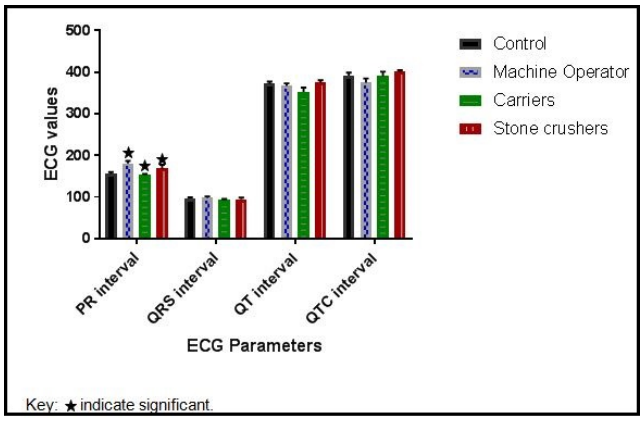

Figure1. Comparison of ECG Intervals between quarry workers and control.

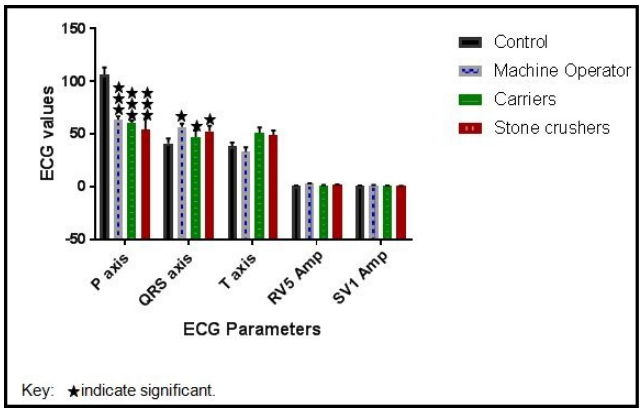

Figure 2. Comparison of axis and amplitudes between quarry workers and control.

The result showed a significant decrease in the P- axis of quarry machine operators (p=0.0001), quarry stone carriers (p=0.0001) and quarry stone crushers (p=0.0001) when compared with the control. The result also showed a significant increase in the QRS- axis of quarry machine operators (p=0.0258), quarry stone carriers (p=0.0346) and quarry stone crushers (p=0.0467) when compared with the control. No statistical difference (p>0.05) was observed in the T- axis, RV5 and SV1 amplitudes of quarry workers when compared with the control.

Discussion

The data in this study observed significant increase in the PR-intervals of quarry workers when compared with the control. This finding is an indication that quarry workers may be at a risk of developing first degree AV block because of their prolonged PR-interval. This result is in line with the finding of Ljungman et al [9] who showed that a 10 μg/m3 rise in particulate matter (PM2.5) was significantly associated with increase PR-interval. In addition, this finding is also in agreement with the finding of Zareba et al [10] who revealed that exposure to particulate matters can lead to a significant increase in the PR intervals.

Furthermore, the result showed a significant decrease in the P- axis of quarry workers when compared with the control. This result indicates that quarry workers may be prone to left bundle branch block which is an indication for left axis deviation. A significant increase was observed in the QRS- axis of quarry workers when compared with the control. This result suggests that quarry workers may be prone to right bundle branch block, an indication for right axis deviation. Unfortunately, sufficient studies have not been carried out to determine the effects of occupational dusts on the axis of heart.

Comparing the ECG parameters among quarry workers themselves, the result revealed a significant increase in the PR- interval and a significant decrease in the T-axis of quarry machine operators when compared with other groups of quarry workers. This observation indicates that quarry machine operators may be more liable to first degree AV block because of their prolonged PR-interval and left axis deviation because of their decreased T-axis value. Also, prolonged PR-interval recorded by the quarry machine operators when compared with other groups of quarry workers is an indication that greater exposure to quarry dust may cause greater damage to the heart.

Conclusion

In conclusion, quarry workers have inadequate PR – Interval, QRS axis and P axis than non-quarry workers thus have compromised electrical activities of their hearts. Also, prolonged PR- interval and decreased T axis recorded by the quarry machine operators when compared with other groups of quarry workers is an indication that greater exposure to quarry dust may cause greater damage to the heart. Quarry workers need to be encouraged to adopt cardiovascular health safety strategies and also, be educated on quarry dusts hazards.

Ethical consideration

Ethical approval was obtained from the Ebonyi State University Ethical Committee and the Ministry of Health Ethical Committee with reference number Ref: EBSU/TETfund/IBR/2015/26.

Limitations

1) Data were collected at different locations which may have different sizes and types of quarry dusts viz-a-viz different arrhythmias.

2) Inability to determine the sizes and types of quarry dusts at different location prior to data collection in order to ensure uniformity.

3) Lifestyles of participants are also a potential bias.

Recommendations

1) The work exposure limits for quarry dusts must not exceed eight hours per day.

2) Dust extraction must be provided at working machines to capture and remove dust before it can spread.

3) Dampers should be fitted in every quarry industry to prevent spread of dusts.

4) Education of quarry workers by the public health workers on the danger of exposure to quarry dusts through health out reach.

5) A suitable face mask should be worn by every quarry worker to prevent quarry dust inhalation and consequent absorption into the circulation.

Acknowledgement

We are very grateful to our esteemed colleagues for their immense support towards the success of this paper. We also thank the quarry workers and other participants for facilitating the data collection.

Conflicts of Interest

The authors declare that this is our own work, and all the sources used in this paper have been duly acknowledged and there is no potential conflict of interest.

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