Pneumoconiosis among quarry workers in a metropolitan town in Southeastern Nigeria

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ABSTRACT

Despite the importance of quarries to man, the dust raised during quarrying process poses a great trait to human life, both to the workers and those living within the environment. Specifically worrisome is the affect on human organs like the heart, lung, liver, and kidney. We determined the total lactate dehydrogenase activity, and serum urea and creatinine concentrations in 236 subjects aged between 20 and 50 years, comprising 176 quarry workers and 60 age-matched non-workers (controls). Our results should that all the parameters increased significantly (p<0.001) in quarry workers when compared with the controls, with lactate dehydrogenase activity of 306.0 ± 5.94iu/L in control and 650.5 ± 9.75iu/l in workers, urea concentration of 4.06 ± 0.16mmol/L in controls and 6.56 ± 0.18mmol/L in workers, and creatinine concentration of 34.31 ± 1.37µmol/L in controls and 53.21 ± 1.49µmol/L in workers. The results also showed that the enzyme activity and urea concentration increased as duration of work increased, while creatinine concentration increased at the onset of work but decreased subsequently. We opine that the organs principally affected by quarry dust in this area are the lungs and hearts. We suggest that owners of quarry industries be compelled to design good health and welfare packages for their workers, and that all quarry industries around residential areas be moved to a satellite town to reduce inhalation of quarry dust by non-workers.

Key words: Pneumoconiosis; Quarry workers; Lactate dehydrogenase; Urea; Creatinine

1. Introduction

Stone quarrying is a multi-step process by which rock is extracted from the ground and crushed to produce aggregate sizes (Northstone, 2008). These steps involve survey, blasting, crushing and screening. The major quarry dust is experienced during crushing and screening. There are four stages of crushing, with each stage producing progressively smaller sized stones. Screening involves the separation of these small stones into sizes. Screens are basically box-frames that are usually driven by electric motor, but this section and crushing process may be done manually in developing countries, thus increasing exposure of workers to quarry dust.
A major content of granite found in Ebonyi State of Nigeria is a high concentration of silicon dioxide, in addition to small contents like aluminum oxide, lead, mercury and arsenic (Ugwu et al, 2008). Apart from the general nuisance arising from the noise and dust from the quarry industries, including reduction in visibility and increase in accident, the dust contents are traits to organs – both systemic and visceral organs (Nwosu and Sanai, 1974; Min Ex, 2008) – affecting the health and safety of quarry workers and people living nearby. These effects give rise to serious disease conditions like pneumoconiosis, kidney and cardiovascular diseases (Smith and Leggat, 2006). These diseases arise mainly due to induction of some reactive oxygen species (ROS) by silicon dioxide, aluminum oxide, and heavy metals like lead, cadmium, mercury, chromium and platinum. Heavy metals, which are toxic at very low doses and are also non-biodegradable with long biological half-life, are easily accumulated by the kidney where they cause different severity of nephropathy (Olivier et al, 2004), in addition to hypertension, neurodegenerative diseases and cognitive impairment (Longman-Adman, 1997). Pneumoconiosis is a group of lung diseases caused by inhalation of airborne dust. They include silicosis, asbestosis and coal workers’ pneumoconiosis (Steenland et al, 2003). Silicosis, which appears as fibrotic nodules in the lungs, is due to exposure to respirable crystalline silica or silicon dioxide, and can be simple, massive or acute, depending on the extent of fibrosis – the product of level and duration but not intensity of exposure (Leigh et al 1997; Mannetje et al, 2002). Apart from its mortality, which is said to be rare (Mannetje et al, 2002), silicosis is known to cause many other disease conditions, directly or indirectly, including occupational asthma, TB infection, lung cancer and chronic obstructive pulmonary disease – COPD (CDC, 1994, Steenland et al, 1996; Wagner and Wegman, 1998; Balmes et al, 2003).

The mechanisms of actions of these dust contents are not yet fully understood. However, in addition to induction of oxidation stress due to increased ROS, potential damage to the lungs is seen to be directly related to the dust concentration in the air, as well as the duration of exposure (MinEx, 2008). When the particle is deposited on the respiratory tract lined with ciliated and mucus secreting cells, it will be swept into the GIT where it causes direct injury, or be dissolved and absorbed to cause systemic disturbances. On the other hand, if the particulate is sufficiently soluble, it may be absorbed from the air ways directly into the blood stream from where it can be carried into different organs. Inside the system, dissolved or non-dissolved particulates can interact with proteins to produce complexes of more transportable forms, thus ensuring the appearance of these materials in the various organs (Houman, 1971). Injury to epithelial cells by ROS (possibly enhanced by heavy metals) and activation of nuclear regulatory factors will lead to absorption of inflammatory cytokines (including IL-8 and IL-6), and increased expression of nitric oxide synthetase (Stringer and Kolzik, 1998), thus increasing oxidative stress in the inhaler.

Lactate dehydrogenase (LDH) activity is usually higher in organs of expression – heart, reticulo-endothelial system, lungs, kidneys, liver and striated muscles (Flores, 2001) than in the serum. The tissue levels are about 500 times greater than serum level; therefore leakage of the enzyme from even a small mass of damaged tissue increases the serum level significantly (Henderson and Moss, 2006). Highly elevated LDH activity in serum is used as a marker for cardiac dysfunctions including myocardial infarction, myocarditis, cardiac failure with hepatic congestion, as well as severe shock. Though haemolysis has the same effect on serum LDH activity (including the isoenzyme pattern) as cardiac dysfunction, research has shown that the effect of haemolysis depends markedly on increased percentage of reticulocytes (Henderson and Moss, 2006). LDH is increased up to 10 times above reference value in toxic hepatitis but increased activities of aminotransaminases (in addition to clinical symptoms) are
better indicators of this condition. It also increases in renal disorders, especially tubular necrosis or pyelonephritis, but serum urea and creatinine concentrations, and more specifically creatinine clearance, are better indicators of renal tubular dysfunction. Increased LDH activity has also been reported in disease conditions with respiratory complications, especially HIV patients with pneumocystitis (PCP) and histoplasmosis - where the activity could be as high as 600 iu/L (Butt et al, 2002). Cardiac and lung dysfunctions, in many cases, build gradually and such gradual impairment of function is observed when an organ sustains a pressure or volumes overload for a prolonged period (Braunwald, 1997). Such can be said of a quarry worker in whom these organs have been under prolonged insult from the toxic contents of quarry dust. In our study area, the major health complaint from the quarry workers was persistent cough, especially in those who have worked for more than five years. Minor complaints include mild chest pain, muscle fatigue/weakness and occasional dizziness. We assessed some biochemical changes in these quarry workers in an urban town of Abakaliki in Ebonyi State of Nigeria to evaluate the impact of quarry dust contents on these workers. Ethical clearance was obtained from the Ethics and Research committee of Ebonyi State University Teaching Hospital, Abakaliki, while additional consents were sought and obtained from the quarry workers and their managers.

2. Materials and methods

2.1. Study area: Abakaliki is the capital city of Ebonyi State in Southeastern Nigeria. Though a small town, the creation of Ebonyi State in 1996 changed and increased the population of the town astronomically. Since early 1980s till the time of this study, the main industries in the town were quarry industries and rice mills. Quarry sites in the town are many and flanged both sides of the major entrant road that measures approximately 6km from the entrance to the major motor park.

2.2. Subjects: Local villages adjoining Abakaliki town are inhabited by peasant farmers who use their non-farming period to work in the quarry industries as crushers and screeners. For more than a decade now, some of them have abandoned farming for this artisan job, probably due to relatively higher financial returns. Our subjects included 236 people aged between 20 and 50 years. Among these were 176 people who have worked for two to ten years in quarry industries and 60 age-matched apparently healthy people from the same adjoining villages, but who have never worked in quarry industry.

2.3. Exclusion criteria: Subjects who have spent less than two years on the job and those who were not doing it as full time job were excluded from the study. This was to ensure that there was constant and sustained exposure to quarry dust. Also those who have stayed for more than 10 years on the job were excluded because the number obtained was not significant.

2.4. Analysis: A total of 3.0ml of blood was collected from each subject and put into a chemically clean glass test tube. This was allowed to clot and retract, and then spun at 3,000rpm for 10 minutes. The serum obtained was than separated and analyses done the same day of sample collection. LDH activity was determined by method of Bergmeyer et al (1972) and serum urea by urease Bertholet method as previously described (Weatherburn, 1967) using reagent kits prepared by Randox (UK), while serum creatinine was estimated by Jaffe method (Spierto et al, 1979) using reagent kit prepared by Quimica Clinica Applicada – QCA (Spain).
3. Results

Table 1 shows the means ± SEMs of all the parameters measured – total LDH activity, serum urea and creatinine. The results were 306.0 ± 5.94 iu/L in controls and 650.5 ± 9.75 iu/L in workers for LDH, 4.06 ± 0.16 mmol/L in controls and 6.56 ± 0.18 mmol/L in workers for urea, and 34.31 ± 1.37µmol/L in controls and 53.21 ± 1.49µmol/L in workers for creatinine. All the parameters increased significantly in quarry workers (p<0.001 each). When workers were grouped according to duration of stay on the job, total LDH activity and serum urea concentration showed significant and progressive increase as duration increased (Figures 1 and 2). However serum creatinine concentration showed initial significant increase at early stage of the work (2 – 4 years) but subsequently decreased as duration increased (Figure 3).

**Table 1:** Means ± SEMs of all the parameters in controls and quarry workers.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Controls  n=60</th>
<th>Workers n=176</th>
<th>P-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDH (iu/L)</td>
<td>306.0(5.94)</td>
<td>650.5(9.75)</td>
<td>&lt;0.001</td>
<td>Significant</td>
</tr>
<tr>
<td>Urea(mmol/L)</td>
<td>4.06(0.16)</td>
<td>6.56(0.18)</td>
<td>&lt;0.001</td>
<td>Significant</td>
</tr>
<tr>
<td>Creatinine(µmol/L)</td>
<td>34.31(1.37)</td>
<td>53.21(1.49)</td>
<td>&lt;0.001</td>
<td>Significant</td>
</tr>
</tbody>
</table>

- SEM (standard error mean) in parenthesis
- Level of significance p ≤ 0.05

**Figure 1:** Total LDH activities at different work duration
Our results showed that LDH activity in the control group (306.0 iu/L) was higher than the reported reference values of 125 – 225 iu/L (Henderson and Moss, 2006). This difference implies that even non-quarry workers living around quarry industries are also under threat by the dust contents. This enzyme also increased significantly (p<0.001) in quarry workers over non-workers, and this increase was progressive as duration of work increased. LDH is present in a wide variety of organisms including plants and animals (Butt et al, 2002). In animals, it is widely distributed in different organs including liver, heart, kidneys, lungs, muscles, brain and red blood cells (Flores, 2001); thus increased activity of the enzyme in the serum is indication of pathology of any or many of these organs. Delineation of the actual source of increased activity of the enzyme in the serum is based on fractionation into its isoenzymes or on firm knowledge of the route of entry of its inducer. In the case of quarry dust, the main mode and route of entry is by inhalation through the lungs, hence it has been noted that the first problem caused by such dust, apart from low visibility and eye damage, is serious lung diseases (Northstone, 2008). This confirms the source of intractable cough reported by our
subjects, especially those that have worked in the sites for more than five years. This finding is in agreement with earlier report (Butt et al, 2002) that LDH activity is highly increased in HIV patients with respiratory complications like pneumocystitis (PCP) and histoplasmosis. Therefore, though the enzyme was not fractionated, the possible source of the increase is principally the lungs, probably with minor contributions from the heart, due to occasional mild heart pains. The intractable cough which could likely be as a result of silicotic pneumoconiosis may have resulted from silicon dioxide content of the quarry dust. Development of this condition is know to be dependent on particle size and shape, compositions, concentration and duration of exposure (Northstone, 2008), as well as form (free or bound) of the particles (Lui et al, 1999) and segment of the absorbing organ (Thevenod, 2003) – in this case the lung. On the other hand, mild heart ache/pain may be attributed to physical insult during crushing, and biochemical injury due to dust contents. Therefore, the combined expression of this enzyme from the lungs and heart would have accounted for the highly elevated activity of the enzyme (650.5 iu/L) in these quarry workers.

The increase in LDH activity in these quarry workers could also be attributed to kidney disease based on the fact that some significant increases have been reported in previous studies (Bailey et al, 1970, Vaziri et al, 1990). However, heavy metals known to be the main causes of renal damage in such workers (Olivier et al, 2004) are in minute amounts in quarry dust from our study area (Ugwu et al, 2008), and the association between silicosis and renal disease are said to be rare and isolated (Saldanha et al, 1975; Giles et al, 1978). Moreover, involvement of kidney disease in elevation of LDH activity in our patients cannot be confirmed because the values of better indicators of kidney disease – serum urea and creatinine concentrations, in this study did not indicate that. For instance, though there was significant increase in serum urea in the quarry workers (p<0.001) and the increase was progressive as duration of work increased (Figure 2), the mean value obtained in the longest work duration – 8.01mmol/L, was still within the reported reference interval of 2.9 – 8.2mmol/L (Newman and Price, 2006). It is also known that serum urea concentration can be influenced by many factors including protein intake and tissue breakdown. Protein and tissue breakdown is a constant feature in these quarry workers whose jobs involve serious physical exercise. Thus, the longer the duration of work, the higher the urea concentration. This also justifies the initial increase in serum creatinine concentration – due to muscle breakdown. Hence, with continuous exhaustion of muscle tissues as duration of work increased, creatinine concentration eventually starts decreasing while urea concentration continues to increase.

Deaths due to occupational disease and injury place a heavy burden on the society in terms of economic costs and human suffering (Steenland et al, 2003). This should be especially felt in the developing countries, where more workers are expected to be exposed due to many reasons including ignorance of the dangers posed by the by-products of such operations, heavy socioeconomic burden exposing the poor to the risky jobs, and unplanned health programmes for such workers by their employers among others. More than a decade ago, occupational deaths were 8th leading cause of death in US, with estimated annual loss of $23 billion (Leigh et al, 1997). However, this is expected to have fallen reasonably by now with improved working conditions. Unfortunately, there are no such documented effects in the developing countries, which are expected to be worse than that obtainable in US. To worsen matter, quarry workers in our study area are peasants with no planned medical care by the government or the employers. Instead, the constant cough which those with long years of service are experiencing is usually treated with drugs bought over the counter, without proper clinical assessment and prescription. The purchase of drug over the counter without proper
assessment and prescription is a practice commonly encountered in many developing countries and which has contributed immensely to the development of drug resistance (Ogbodo et al, 2011). This practice will definitely increase morbidity and mortality from this source of livelihood. This is confirmed by the fact that those who have spent more than ten years on the job were few, implying that when the health burden becomes too heavy for any person, he/she gives way while those who are still strong continue. We suggest that government should make it compulsory for quarry industry owners to have good medical and welfare packages for their workers. This will ensure that sick ones can be promptly taken care of and many can stay on the job for long time if necessary. We are also of the opinion that all quarry industries within urban areas should be relocated to satellite areas to ensure the health of non-workers living around.

5. References


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