Effect of Chronic Noise Stress on Neutrophil Functions in Rats

Archana R
Department of Physiology,
Saveetha Medical College, Saveetha University,
Thandalam, Chennai-602 105, INDIA

Abstract: Long term exposure to loud noise acts as an environmental stressor which affects the physiological as well as the psychological well being of the individual. The aim of the present study was to determine whether chronic noise exposure could affect the neutrophil functions in albino rats. A significant enhancement of the neutrophil functions was observed as indicated by the increase in the candida phagocytosis and nitroblue tetrazolium reduction test in the noise stressed animals. The lymphocyte count was increased and the neutrophil count was decreased. Noise exposure altered the organ weight of spleen, thymus and adrenal gland. The total leukocyte count was unaltered while the corticosterone level was suppressed. In conclusion, the chronic exposure to noise acts as a stressor affecting the neutrophil functions while certain parameters like corticosterone and total leukocyte count gets adapted.

Key words: Corticosterone, noise stress, neutrophil function, phagocytosis, spleen, thymus, adrenal.

I. INTRODUCTION

Today technology and rapid industrialization has thrown up a new and rapidly spreading environmental pollutant – Noise. Nowadays, noise has become the most commonly encountered stressor in our daily lives. When noise intensity that we are exposed to exceeds 90dB, then it becomes a stressor. Depending on the frequency, intensity and duration of exposure noise affects the body in different ways. Exposure to noise of high intensity causes hearing loss, damage to hair cells and affects the auditory cortex [1]. Chronic noise stress affects the extra-auditory system by causing hypertension [2], duodenal ulcers [3], behavioural disturbances [4] and alters the immune system [5]. Though noise is known to affect almost all the systems of the body, so far very few studies have been done on the effect of noise stress on neutrophil functions. As we are all exposed to noise in our daily lives we found it highly relevant to study the effect of chronic noise exposure on neutrophil functions which are the first line of defence and on haematological parameters in albino rats.

II. MATERIALS AND METHODS

Wistar strain male albino rats weighing 150-200 gm were used for the study. The animals were reared in the animal house of the Institute and were maintained under standard laboratory conditions with food (Hindustan Lever Ltd., Bangalore, India) and water ad libitum in a 12 hour light and 12 hour dark cycle. Ethical clearance was obtained from the ethical committee of this institute before the commencement of the experiments. The animals were divided into three groups of 9 animals each, as Control (Group 1) and two experimental groups (Group 2 and Group 3). Group 2 animals were exposed to chronic noise stress (4hr/day) for fifteen days and sacrificed on the sixteenth day. The Group 3 animals were exposed to chronic noise stress of similar duration for thirty days and sacrificed on the thirty first day.

A. Noise Exposure: Broad band (White) noise at 100dB intensity was used for the study. The sound was produced by a white noise generator. This was amplified by an amplifier (40 watt) which was connected to a loud speaker fixed 30cm above the animal cages. A sound level meter (Cygnet, D 2023) was used to measure the intensity of noise. The background noise level in the stress room was at 44±2dB due to the ventilation system. Throughout their stress exposure period these animals remained in the stress room to prevent other unnecessary stress on the animals.

B. Biological assays: The blood collection and animal sacrifice was done between 8.00-10.00 a.m in order to avoid variations in the parameters studied due to circadian rhythm. The animals were anaesthetized with ether and stress free [6] heparinized blood samples were collected from the jugular vein for haematological studies and steroid estimation. The spleen, thymus and adrenals were removed, blotted and weighed. The total leukocyte count and differential leukocyte count were determined by standard methods. Neutrophil functions...
were evaluated by Candida phagocytosis [7] and Nitroblue tetrazolium reduction (NBT) test [8]. Candida phagocytosis assesses the phagocytic ability of the neutrophils. The number of neutrophils positive for candida ingestion in the 100 neutrophils gives the phagocytic index (PI). The total number of candida albicans counted within the 100 positive cells divided by 100 gives the mean particle number or the avidity index (AI). NBT assesses the killing ability of the neutrophils. When neutrophils are exposed to the yellow dye NBT, it is taken by the cells into phagosomes and intracellular reduction of the dye converts it to an insoluble blue crystalline form (formazan crystals). 100 cells were observed and the positive cells with the formazan granules were counted. The plasma corticosterone level was estimated by spectrofluorimetric method [9].

C. Statistical Analysis: The data obtained in this study was statistically analysed using One Way Analysis of Variance (ANOVA) followed by Tukey’s Multiple comparison test. The values were expressed in the Table1, Table 2 and Table 3 as mean±standard deviation. P<0.05 was considered statistically significant.

III. RESULTS

Chronic noise stress caused enhancement of the neutrophil functions (Table 1). A significant increase in the NBT reduction and in candida phagocytosis as indicated by an increase in the PI and AI were observed in the stressed animals. No changes were observed in the total leukocyte count (Table 2). The lymphocyte count was increased, neutrophil count was decreased and a suppression in corticosterone level was observed. Noise exposure for 15 days caused a significant increase in the organ weight of spleen, thymus and adrenal gland (Table 3).

Table 1: Effect of noise stress on Neutrophil functions

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>15 day noise stress</th>
<th>30 day noise stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phagocytic Index</td>
<td>65.5±.53</td>
<td>85.06±.66</td>
<td>72.8±.73</td>
</tr>
<tr>
<td>Avidity Index (%)</td>
<td>2.31±.03</td>
<td>3.72±.02</td>
<td>2.98±.11</td>
</tr>
<tr>
<td>NBT (%)</td>
<td>9.8±.23</td>
<td>29.4±.67</td>
<td>50.27±.98</td>
</tr>
</tbody>
</table>

Table 2: Effect of noise stress on total leukocyte count and differential leukocyte count

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>15 day noise stress</th>
<th>30 day noise stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total leukocyte count (cu mm)</td>
<td>14317±547</td>
<td>11022±474</td>
<td>13870±796</td>
</tr>
<tr>
<td>DC - Lymphocyte %</td>
<td>68.9±.54</td>
<td>79.7±.71</td>
<td>81.1±.53</td>
</tr>
<tr>
<td>DC - Neutrophil %</td>
<td>20.65±.35</td>
<td>10.06±.36</td>
<td>8.47±.35</td>
</tr>
</tbody>
</table>

Table 3: Effect of noise stress on organ weight and plasma corticosterone level

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>15 day noise stress</th>
<th>30 day noise stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organ weight -Adrenal</td>
<td>.207±.003</td>
<td>.284±.005</td>
<td>.211±.006</td>
</tr>
<tr>
<td>Organ weight -Spleen</td>
<td>3.84±.11</td>
<td>4.49±.24</td>
<td>3.91±.21</td>
</tr>
<tr>
<td>Organ weight-Thymus</td>
<td>1.14±.04</td>
<td>2.05±.08</td>
<td>1.22±.03</td>
</tr>
<tr>
<td>Corticosterone (µg/dl)</td>
<td>42.38±1.26</td>
<td>10.89±.28</td>
<td>15.77±1.42</td>
</tr>
</tbody>
</table>
IV. DISCUSSION

The exposure to chronic noise stress caused an increase in the percentage of lymphocytes and a decrease in the neutrophil percentage with no significant changes being observed in the total leukocyte count. Activation of hypothalamo-pituitary adrenal system leads to the corticosteroid related reduction in absolute number of lymphocytes [10]. In this study, the plasma corticosterone level was significantly lower in the noise stress group compared to the control. Thus the reduced corticosteroid may be the reason for the increased lymphocytes. The percentage of lymphocytes and neutrophils are inversely related to each other both in basal and stressed conditions. Thus the decrease in the neutrophil count could be secondary to the increase in the lymphocyte count.

Scanty literature evidence exists on neutrophil function tests in stress. In our previous study in albino rats exposed to acute noise stress, a significant enhancement in candida phagocytosis, increase in NBT reduction, elevated plasma corticosterone level and leukocytopenia was observed indicating that acute noise is a potent stressor causing intense alterations in the neutrophil functions [11]. Phagocytosis is an energy dependant phenomena and cyclic adenosine monophosphate (cAMP) acts as a second messenger. cAMP regulates the selective extrusion of lysosomal enzymes in phagocytosing neutrophils and ability to kill candida albicans. Sympathetic neurohormone (catecholamines) acts through cAMP [12]. Studies in mice exposed to noise stress have shown similar increase in oxidative response of the peritoneal macrophages. Phagocytes have beta adrenergic receptors and possess receptors for neuropeptides. Thus phagocytes can be greatly affected by the nervous system products. So, the phagocytic and oxidative response of neutrophils may be controlled by the sympathetic nervous system [13] which is activated during stress. NBT reduction relies on the generation of bactericidal enzymes like NADPH-oxidase in neutrophils which are essential for normal intracellular killing of foreign antigens. During intracellular killing, the cellular oxygen consumption increases and glucose metabolism reduces the colourless NBT to blue formazan [14]. The increased NBT reduction observed in our study may be due to increase in the bactericidal enzymes within the neutrophils caused by noise stress.
Noise exposure for 15 days has increased the weight of spleen, thymus and adrenal glands. The increase in the spleen weight may be due to an increase in the number of splenic macrophages [15]. The increased organ weight of thymus could be due to an increase in the thymocyte number [16]. This could be due to the effect of the autonomic nervous system which innervates extensively both thymus and the spleen. The autonomic nervous system permits the movement of thymocytes and T cells to the gland by selectively altering the permeability of thymic blood barrier. In our study, chronic (30 day) noise exposure did not alter the organ weight of spleen, thymus and adrenals which might be due to adaptation of the system due to chronic noise stress. Studies were available to show that, changes occurring in adrenal and thymus weight due to acute noise exposure decreased and the response turned into a chronic inhibitory state in chronic noise exposure [17].

No variation observed in the total leukocyte count and the suppression of the corticosterone level observed in this study contradictory to our previous – acute noise stress studies, could be due to the operation of the adaptation process in the animals due to expose to the same stressor over a long period of time. Though the exact mechanism behind this corticotesterone suppression is not fully known, similar adaptive response of corticosteroid has also been reported in rats exposed to one month chronic stress [18]. Further it was shown that repeated administration of noise stress and CRF desensitizes the neurons of the locus coeruleus while acute administration of both activates the locus coeruleus. Using electrophysiological response of locus coeruleus as an assay, it was shown that repeated white noise stress resulted in reciprocal cross-desensitization between the CRF and stress [19]. This interaction between the CRF and the locus coeruleus may be the reason behind the mechanism of adaptive response to stress.

Thus exposure to chronic noise acts as a stressor causing definite alterations in the neutrophil functions of albino rats and the influence of noise stress on human neutrophil functions and its impact on immune status needs further in depth study.

REFERENCES


ACKNOWLEDGMENT

I am grateful to Late Dr. A. Namasivayam for his advice and guidance.

AIJRFANS 13-242; © 2013, AIJRFANS All Rights Reserved