ASSESSMENT OF BLOOD SERUM IMMUNOGLOBULIN AND C-REACTIVE PROTEIN CONCENTRATIONS IN WORKERS OF X-RAY DIAGNOSTICS UNITS

PIOTR KŁUCIŃSKI1, BOGDAN MAZUR2, JOANNA KAUFMAN2, ANTONI HRYCEK3, PAWEŁ CIEŚLIK1, and GAYANE MARTIROSIAN1

1 Chair and Department of Medical Microbiology
2 Chair and Department of Physiopathology and Endocrinology
3 Chair and Clinic of Internal Diseases and Clinical Pharmacology
Medical University of Silesia
Katowice, Poland

Abstract
Objectives: Workers of x-ray departments are occupationally exposed to long-term low levels of ionizing radiation. The aim of the study was to investigate the influence of occupational exposure of low-level x-ray radiation on immunoglobulin and C-reactive protein (CRP) concentrations in radiology workers. Materials and Methods: In the study group of 41 x-ray department workers and the control group composed of 32 persons, immunoglobulins (IgM, IgG, IgA) and CRP concentrations were analyzed. The study group was subdivided by gender and smoking habit. Results: A significant decrease in IgG level was found in the workers and the female subgroup. The same observation was made when smokers and nonsmokers of both groups were compared. Smoking workers showed lower concentrations of IgA than non-smokers. The remaining results of immunoglobulin and CRP concentrations did not show significant differences. Conclusions: Occupational exposure to low levels of ionizing radiation is associated with suppressive influence on the immunoglobulin production, especially IgG. In addition, smoking decreases the production of IgA in radiology workers.

Key words: Occupational exposure, X-rays, Immunoglobulins, C-reactive protein

INTRODUCTION
Radiological equipment operators are occupationally exposed to chronic low doses of ionizing radiation, which may affect their immune system. Among leukocytes, lymphocytes, mostly lymphocytes B, are most sensitive to ionizing radiation [1,2]. Its adverse effects observed in radiology workers are manifested by chromosomal aberrations in lymphocytes [3] and changes in the structure and function of lysosomal membranes of those cells as well as in their T cell receptors (TCR) in lymphocytes T and immunoglobulin β cell receptors (BCR) and Fc immunoglobulin fragment receptors in lymphocytes B [4–6]. C-reactive protein (CRP), so called positive protein of the acute phase, dramatically increases in serum during inflammatory processes occurring in the body [7]. It should be noted that ionizing radiation induces produc-
tion of interleukin 1β (IL-1β) proinflammatory cytokine, tumor necrosis factor α (TNF-α) and interleukin 6 (IL-6), thereby contributing to the development of inflammation and possibly increasing CRP concentration [8,9].

The aim of this work is to assess the effect of low ionizing radiation doses on blood serum immunoglobulins M, G, and A (IgM, IgG, IgA) and CRP concentrations in x-ray equipment operators.

MATERIALS AND METHODS

The study group comprised 41 workers of x-ray diagnostics units (10 men and 31 women), aged 25–54 years (mean age, 43.5 years). Their employment duration ranged from 2 to 33 years (mean, 15.3 years). The subjects were subdivided by gender and smoking habit. There were 9 smokers (8 women and 1 man), aged 25–54 years (mean, 42 years), with the mean smoking index of 19.9 pack-years. Their exposure to ionizing radiation was assessed each year and it did not exceed 1 mSv. The control group consisted of 32 healthy people (12 men and 20 women), aged 28–60 years (mean, 40.5 years), occupationally non-exposed to the ionizing radiation. The age of male/female subgroups was similar in the study and control groups. The control group comprised 10 smokers (8 women and 2 men), aged 28–50 years (mean, 41 years), with the mean smoking index of 17.6 pack-years.

Blood serum IgM, IgG, IgA and CRP concentrations were determined using a TurbiTimer turbidimetric analyzer (Dade Behring Inc., Germany) and applying reagents obtained from the same company.

The results were compared according to the following schedule:

- subjects vs. controls,
- male and female subjects vs. male and female controls,
- non-smoking subjects vs. non-smoking controls,
- non-smoking subjects vs. smoking controls,
- smoking subjects vs. smoking controls.

Statistical analysis

Arithmetic mean values (x̄) and standard deviations (SD) preceded by the Shapiro-Wilk test results were used in the statistical analysis. To analyze normal distribution data the t-Student test was used. Otherwise, the results were analyzed by Mann-Whitney U test. The statistical analysis was done with a level of significance set at p < 0.05.

The study was approved by the Bioethics Commission, Silesian Medical University, Katowice.

RESULTS

The analysis of immunoglobulin concentrations in the whole group of workers and in the subgroups divided by gender showed a significantly lower IgG concentration.

Blood serum IgM, IgG, IgA and CRP concentrations were determined using a TurbiTimer turbidimetric analyzer (Dade Behring Inc., Germany) and applying reagents obtained from the same company.

The results were compared according to the following schedule:

- subjects vs. controls,
- male and female subjects vs. male and female controls,
- non-smoking subjects vs. non-smoking controls,
- non-smoking subjects vs. smoking controls,
- smoking subjects vs. smoking controls.

Table 1. Concentrations of immunoglobulins IgM, IgG, IgA (g/l) and C-reactive protein (CRP) (mg/l)

<table>
<thead>
<tr>
<th>Group/subgroup</th>
<th>IgM</th>
<th>IgG</th>
<th>IgA</th>
<th>CRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects (n = 41)</td>
<td>0.97 ± 0.52</td>
<td>8.84 ± 1.54</td>
<td>1.97 ± 0.66</td>
<td>0.156 ± 0.189</td>
</tr>
<tr>
<td>Controls (n = 32)</td>
<td>1.32 ± 0.71</td>
<td>10.23 ± 5.9</td>
<td>1.94 ± 0.86</td>
<td>0.112 ± 0.152</td>
</tr>
<tr>
<td>Female subjects (n = 31)</td>
<td>1.06 ± 0.54</td>
<td>9.0 ± 1.46</td>
<td>2.0 ± 0.7</td>
<td>0.161 ± 0.206</td>
</tr>
<tr>
<td>Female controls (n = 20)</td>
<td>1.36 ± 0.81</td>
<td>11.0 ± 2.2</td>
<td>1.8 ± 0.8</td>
<td>0.102 ± 0.098</td>
</tr>
<tr>
<td>Male subjects (n = 10)</td>
<td>0.68 ± 0.32</td>
<td>8.3 ± 1.7</td>
<td>1.9 ± 0.6</td>
<td>0.141 ± 0.132</td>
</tr>
<tr>
<td>Male controls (n = 12)</td>
<td>1.25 ± 0.9</td>
<td>8.9 ± 2.3</td>
<td>2.2 ± 1.04</td>
<td>0.128 ± 0.219</td>
</tr>
<tr>
<td>Non-smoking subjects (n = 32)</td>
<td>0.95 ± 0.5</td>
<td>8.9 ± 1.5</td>
<td>2.1 ± 0.64</td>
<td>0.151 ± 0.187</td>
</tr>
<tr>
<td>Non-smoking controls (n = 22)</td>
<td>1.41 ± 0.9</td>
<td>10.4 ± 2.6</td>
<td>2.2 ± 1.0</td>
<td>0.118 ± 0.175</td>
</tr>
<tr>
<td>Smoking subjects (n = 9)</td>
<td>1.06 ± 0.6</td>
<td>8.6 ± 1.7</td>
<td>1.5 ± 0.5</td>
<td>0.173 ± 0.208</td>
</tr>
<tr>
<td>Smoking controls (n = 10)</td>
<td>1.1 ± 0.5</td>
<td>10.5 ± 2.1</td>
<td>1.5 ± 0.5</td>
<td>0.098 ± 0.086</td>
</tr>
<tr>
<td>Smoking subjects (n = 9)</td>
<td>1.06 ± 0.6</td>
<td>8.6 ± 1.7</td>
<td>1.5 ± 0.5</td>
<td>0.173 ± 0.208</td>
</tr>
<tr>
<td>Non-smoking subjects (n = 32)</td>
<td>0.95 ± 0.5</td>
<td>8.9 ± 1.5</td>
<td>2.1 ± 0.64</td>
<td>0.151 ± 0.187</td>
</tr>
</tbody>
</table>

* Statistically significant.
in the group of radiology workers and in the subgroup of women. Significantly lower IgA concentrations were noted in the smoking subjects than in non-smokers. In the non-smoking subgroup, IgG concentrations were significantly lower than in respective non-smoking controls. IgG concentrations were statistically significantly reduced in the subgroup of smoking subjects compared to controls. The remaining results of immunoglobulin and CRP determinations did not reach the level of statistical significance (Table 1).

DISCUSSION

Our results indicated significantly reduced IgG concentrations in the group of x-ray department workers and in the subgroup of female subjects. IgG concentrations were also significantly reduced in the subgroup of non-smoking subjects when compared with the respective control subgroup. It should be noted that the remaining results of immunoglobulin determinations in the study group and subgroups of subjects showed reduced concentrations, but the differences did not reach the level of statistical significance.

It seems reasonable to associate the observed differences with the effects of low-level exposures to ionizing radiation on the workers’ immune system. In the humoral antigen response, immunoglobulin IgG is made as second after IgM, whose production involves helper lymphocytes CD4 Th2 [10]. The observed reduction in IgG levels indicates that the mechanisms responsible for IgG synthesis are somewhat disturbed, which may be associated with the effect of ionizing radiation on lymphocytes B and Th2. The influence may be associated with the expression of the adhesion particles involved in the communication of those cells during IgG synthesis, in the production of Th2 cytokins at that stage of the humoral response, or may result from the direct effect on gene expression and IgG synthesis. As stated earlier, lymphocytes B are more sensitive to ionizing radiation than lymphocytes T [1,2]. In addition, lymphocytes Th2 responsible for class switching of produced immunoglobulins are more sensitive to radiation than population of Th1, whose role is mainly associated with cellular-type response [11]. The findings of an earlier study on radiology department workers showed elevated concentrations of IL-2 (produced by lymphocytes Th1) and reduced blood serum levels of IL-4 (produced by lymphocytes Th2), which may result from the reduced IgG production and concentration due to promotion of Th1 response non-associated with immunoglobulin synthesis [12]. IgM, IgG, and IgA concentrations lower in radiology workers than in controls were earlier reported by Godekmerdan et al. [13] and Serhatlioglu et al. [14]. Reduced IgA was observed in the subgroup of smoking subjects compared to non-smokers. In addition, IgG concentrations were also significantly reduced in smoking subjects compared to smokers of the control group, which may evidence the inhibitory effect of smoking combined with low-dose ionizing irradiation on antibody production.

Smoking exerts a suppressive effect on the immune system, manifested among others by lower immunoglobulin concentrations, in particularly IgG and IgA [15–17]. People exposed to low doses of ionizing radiation may experience the combined effect of radiation and smoking leading to the decreased concentration of immunoglobulin, already confirmed for IgG and IgA [13]. No significant changes in CRP concentrations were observed in radiology workers compared to controls in spite of some IgG level variations, which indicated that low ionizing radiation doses do not affect the concentration of that protein as a parameter of inflammatory processes. Earlier observations did not reveal changes in blood serum IL-6 concentrations in workers of x-ray departments, which is important in view of the fact that the most significant effect on the CRP production is attributed to IL-6 [9].

CONCLUSIONS

Our results may suggest a relationship between low doses of ionizing radiation and humoral immunity as manifested by reduced IgG concentrations in x-ray department workers. In addition, this relationship is evident in smoking subjects, which confirms the suppressive effect of tobacco smoking on immunoglobulin synthesis.
REFERENCES