Investigation on the correlations between vitreoretinal disorders and atmospheric particulate matter in individuals working in Taranto

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Abstract

Introduction: several epidemiological studies have already highlighted the effects that fine atmospheric particulate matter has on health in terms of increasing mortality, hospital admissions and also respiratory diseases in the cardiovascular system.

The purpose of this study is to assess the possible correlation between inhalation of fine fraction of particulate matter missing in the air and disease outbreaks in vitreoretinal tract in the workplace of ILVA steel plant in Taranto.

Materials and methods: from June 2013 to December 2014 were examined both 57 male individuals aged between 25 and 58 years, working at the ILVA steel plant in Taranto and 52 male individuals aged between 25 and 58 who were just residents in the city of Taranto.

For each of them a complete eye examination was performed with particular reference to the posterior segment of the eye (indirect ophthalmoscopy with Schepens unit). All the examined individuals had visual acuity perfectly normal and no optic nerve lesion. All the general and ocular medical history revealed no pre-existing conditions worthy of note.

It was then conducted a statistical analysis of the data obtained by means of a chi-squared test by applying the correction according to Yates, which is appropriately used when the number of observations is less than 500. The significance level considered was 5%. Therefore, they were considered statistically significant values of \( p <0.05 \).

Results: during this work, statistical significance were highlighted between the two groups examined. The workers examined in 84% of cases have retinal disorders; 27% individuals had retinal disorders among residents examined in the city of Taranto.

Discussion: from the resulting data can be assumed that micro-respiratory bronchiole blockages can lead to gridlock and consequent retinal venous congestion.

KEY WORDS: air pollution, health, vitreoretinal disorders, worker.

Introduction

Epidemiological studies conducted in recent years have shown that there is a correlation between the presence of particulates in the atmosphere and both an increased level of mortality and/or hospitalisation and it was shown that there is a threshold level below which there are no effects observable on health (1). Several studies have highlighted the importance of the size of airborne particulates, focusing their attention on the ultrafine particles (2-4). The ultrafine particulate (PUF, size <0.1μm) is of particular relevance in urban areas, mostly because emitted in combustion processes. The ultrafine particles are the most dangerous particles for health, because it can deposit in the pulmonary alveoli and, because of their size, to be carried by the blood in the external respiratory organs. It
has recently been hypothesized that hyperfine particles are deposited on the olfactory mucosa spreading along the olfactory nerve to the brain (5).

Epidemiological studies show a statistically significant relationship between toxicity and/or mortality and the increase of the particulates of smaller size (6). The toxicological mechanism, though still unknown, appears to be due to the ultra-fine particles (7, 8). In this regard it has been observed that the surface area of the particles is likely to be an important parameter in terms of its dose, especially when comparing the effects of different size particles (9). In fact, the cells interact with the surface of the particles rather than with their volume. The fine and ultrafine particles can escape phagocytosis of macrophages of the pulmonary alveoli, gaining access to the epithelial tissue and the interstices of the lungs causing injury. Moreover, the fact that the particles carry adsorbed materials on their surface is important because they can deposit reactive or toxic compounds on cells (10).

The more contaminated system is the respiratory one. The size of the particles depends on their level of penetration in the respiratory tract; before they reach the lungs, they must overcome the natural barriers prepared by the defense system of our body. The particles larger than 1 micron are easily intercepted and deposited in the nose and throat which are then expelled; those of greater than 100 nm can be deposited in the respiratory bronchioles and be subsequently conveyed towards the throat and, finally, removed after about two hours. Thanks to its small size, fine particles are not retained by the nasal or bronchial mucosa, but penetrates into the alveoli, and is therefore eliminated in a less rapid and complete, causing inflammation and preventing gas exchange in the blood (11). Fine particulate matter is therefore the main responsible for the aggravation of cardiac respiratory diseases. Recent studies conducted at the University of Rochester, NY (12), by using hyperfine particles traced with radioactive isotopes have shown that such particulate can directly interact with the central nervous system. In fact it has been found that although most of the nanometric particles do not settle on the olfactory mucosa because of their low size, some of them have been found in correspondence of the olfactory nerve endings, which can spread to the brain. Considering that these particles can accumulate over the years in the central nervous system they can induce very severe neurotoxic effects.

Object of this investigation was the observation if other devices, such as the retina, being characterized by a rich vasculature, can be affected by fine particles that escaped the phagocytosis of macrophages in the lung alveoli, may cause possible microcirculatory alterations district uveal and vitreoretinal, since the intracocular pressure changes affected by changes in districts uveal capillaries and nerve (13). The retina is the most inner portion of the coat of the eye. It is typically found on the surface of the uvea which covers the papillary edge up to the small brink of the iris. Main retinal features are: transparent, fragile, havimg variable thickness (1 to 3 mm) depending on the examined regions, pink colouration (Fig. 1).

Figure 1 - Normal posterior segment examination of the ocular fundus.

The vitreous is a vascular tissue with fibril structure, enclosed within membranes of the eye, and occupies about 2/3 of the eye (Fig. 2).

The vitreous structural system is composed, in addition to specific cells, by a plot of collagen fibrils delimiting spaces in which hyaluronic acid is present. There are also within, proteins its ascorbic acid, glutathione, sugars, electrolytes, calcium, lactic acid. The posterior choroid, being located between the sclera and the retina, performs primary metabolic functions against retinal pigmented epithelium and neuroepithelium.

In pathology can be observed dilatation and congestion of the venous vessels from various cases: diabetes, hypertension, hypercholesterolemia, lung disease, right heart diseases, blood diseases, etc. (14-16) (Fig. 3).

The source of retinal nutritional is twofold: one is dependent on the central artery, the other from the choroid-capillary. The central artery compensates for the metabolic needs of the most inner layers of the fibers, to the inner nuclear state (17, 18). The choriocapillaris provides the nutritional needs of outer retinal layers: pigment epithelium, rods and cones.

The retinal circulation is ensured only by the central retinal artery. The retinal arteries are two, one on the upper bound and one lower. Each of them is divided into a temporal branch and in a nasal one.

The central retinal vein is originated by the confluence of the retinal veins. It presides over the entire district venous circulation. In each quadrant the veins converge to form both the superior-nasal vein and superior-temporal once and respectively the veins nasal inferior and temporal-inferior.

The two upper retinal veins give rise to the upper reti-
nal vein and inferior to the lower retinal vein. The examination of the ocular fundus with ophthalmoscopy has been able to benefit in a time of many improvements that have led to the gradual creation of a series of equipments, but they do not differ substantially from the original models (19, 20). The Schepens binocular indirect ophthalmoscope-BIO (Fig. 4), widespread today, enables clear binocular vision to the examiner and therefore increases the possibility of a more precise evaluation of semeiological findings (21).

Materials and methods

This study was carried out within the project INAIL P20, L07. From June 2013 to December 2014, a number of 109 selected patients was examined: both a number of 57 males between 25 and 58 years old working for the industrial plant ILVA in Taranto and 52 male residents in the town of Taranto aged also between 25 and 58 years old.

For each individual a comprehensive eye examination, with particular reference to the posterior segment of the eye (indirect ophthalmoscopy with Schepens unit) was performed. All the examined subjects had perfectly normal visual acuity and no optic nerve lesion. The indirect ophthalmoscopy, performed by the Schepens equipment requires, after pupil dilation with 1% tropicamide eye drops, to explore a wide area of the retina, also providing images of its periphery. It is a tool that allows stereoscopic observation.
They excluded those who had pre-existing conditions or in progress, or that you were subjected to ocular surgeries.

The results emerged from the experimental investigation were analyzed by using the statistical significant test of \( \chi^2 \). As zero hypothesis (or null hypothesis), it was assumed that there was no difference between the two groups regarding the predisposition to retinal disease, and for any differences observed were to be attributed to chance. The statistical analysis was completed by applying the correction, according to Yates that is suitably used for a number of less than 500 observations.

They are considered statistically significant values of \( p < 0.05 \) (22).

**Results**

The workers analyzed had:
- visual in OU 10/10;
- objective examination: standard results in OU;
- fundus oculi: pink papillary on determined margins, stressed venous retinal congestion, macula and margin unscathed.

The individuals analyzed had:
- virus in OU 10/10;
- objective examination: within the limits of OU;
- fundus oculi: standard results in OU.

Table 1 shows the survey data conducted on the two sample groups, made up of both 57 individuals employed in the steel plant ILVA in Taranto and 52 individuals residents in Taranto but not employed in this company.

In this phase it was revealed the statistical significance between the two groups examined. In the group formed by workers ILVA steel plant about 84% of the individuals had vitreoretinal disorders. Within the other group, the individuals who presented positive results amounted to about 27%. Statistical analysis of the data, with a probability \( p < 0.05 \), suggests that the difference in the results of ophthalmologic examinations is not just a coincidence (Tab. 2).

**Table 1 - Summary Table showing the number of patients seen in reference to their chronological age.**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age ± S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILVA workers</td>
<td>57</td>
</tr>
<tr>
<td>Taranto City</td>
<td>52</td>
</tr>
<tr>
<td>Totals</td>
<td>109</td>
</tr>
</tbody>
</table>

\( \chi^2 = 43,55 \)
\( P = 0,0000 \)

Statistical significance (\( p < 0.05 \))

\( \chi^2 = 41,04 \)
\( P = 0,0000 \)

Correlation according to Yates

Statistical significance (\( p < 0.05 \))

**Table 2 - Summary table on the analysis of statistical data related to the research sample.**

<table>
<thead>
<tr>
<th></th>
<th>Pathological data</th>
<th>Standard Data</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILVA workers</td>
<td>48</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td>Taranto City</td>
<td>11</td>
<td>41</td>
<td>52</td>
</tr>
<tr>
<td>Totals</td>
<td>59</td>
<td>50</td>
<td>109</td>
</tr>
</tbody>
</table>

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Correlation according to Yates

Statistical significance (\( p < 0.05 \))
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Discussion

In large cities the issue concerning air pollution is highly topical and related to industrial problems, in addition to urban traffic and sources related to home heating. The environmental impact is not a concern just for the population as whole but also for those working in direct contact with particulate matter missing. In the city of Taranto it was investigated the incidence of pollutants in individuals working at the mill plant ILVA (23).

The aim of this study is to identify possible correlations between vitreoretinal disorders and inhalation of particles in those who are in direct contact with them. Implications of pulmonary nature have already been documented, in relation to various factors (asbestos, PM10 and smaller fractions). Emerging data suggest a higher incidence of microbronchiolopulmonary obstructions in individuals employed in the ILVA steel plant in Taranto. This can lead to gridlock and consequent retinal venous congestion (microinjection in high levels). Statistical significance are revealed by examining the two groups. It seems appropriate to deepen and broaden the object of study samples, with the possible need for additional diagnostic tests.

References