Eco. Env. & Cons. 28 (February Suppl. Issue) : 2022; pp. (S340-S343)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i02s.055

Effect of Air Pollution and Oxidative Stress in Development of Cataract- A Study in Rural Regions of West Bengal

Somnath Ghosh, Sayani Pal Choudhury[1], Gopeswar Mukherjee[2] and Animesh Dey[3]*

Department of Allied Health Sciences, Brainware University, Kolkata 700 125, India

(Received 19 July, 2021; Accepted 2 August, 2021)

ABSTRACT

Oxidative stress induced by air pollution has been directly correlated to the pathogenesis of cataract. Cataract is the change of opacity of the ocular lens and one of the important causes behind visual loss. Free radicals induce lens damage by generating membrane lipid peroxidation, protein aggregation, protein inactivation, and subsequent lens opacification. The main aim of this present study to investigate the association between air pollutants, oxidative stress and cataracts in the adult population aged between 45-72 years. Malondialdehyde (MDA), the end product of lipid peroxidation may be used as a biomarker for the measurement of oxidative stress. In this present cross-sectional study blood sample of 24 cataract patients (Age limit 45-72 years) from Barasat village area of North 24 Pargana, West Bengal, India have been taken for measurement of MDA level i.e lipid peroxidation product. A control study has been conducted on 16 people from same age group. From statistical analysis of t score data it can be interpreted that the serum lipid peroxidation product (LPP) concentration (nmol/ml) is significantly higher in the cataract cases ($p< 0.001$) as compared to that in the control cases. From this study it is clear there is a direct relationship between lipid peroxidation, oxidative stress and Cataract although the above study cannot confirm the mechanism of the cataract formation.

Key words: *Oxidative stress, LPP, Cataract, MDA, Free radicals*

Introduction

Cataract is the opacification of the ocular lens and its one of the major factor for visual loss (Asbell P. A *et al.,* 2005). The past study showed that the people with a severe visual impairment from cataract would be approximately 220 million in 2020 (Apple D.J *et al.,* 2000). The blindness due to cataracts has been found to be 42.0% in Southeast Asia (Lee C.M *et al.,* 2017). Blindness and Cataract is very much related condition. Due to cataract now blindness has been increased from 10.9 million to about 12.6 million in last 25 years (Flaxman S.R *et al.,* 2017). As a leading public health issue, cataract now becomes more problematic as the population increases. Natural air pollution products, like particulate matter (PM) < 10 µm in size (PM10) to<2.5 µm (PM2.5), carbon monoxide (CO), nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), and ozone (O_3), can cause most serious health issues worldwide. Exposure to these pollutants particles may impact eye health which is the leading cause of allergic conjunctivitis and age-related macular degeneration (Mimura. T *et al.,* 2014). In India, older persons aged in between 60-65 years have an increased risk of blindness due to cataract and after intense study it is cleared that this tendency of risk has been increased due to exposure to biomass fuels ((Ravilla, T.D *et al.,* 2016). There are

several facts that Cataract can be triggered by a variety of means, and in most cases, the mediators underlying the pathological process are free radicals (Varma *et al.*, 1984). Free radicals induce lens damage by generating membrane lipid peroxidation, protein aggregation, protein inactivation, and subsequent lens opacification. When free radicals accumulate in the eye lens, the polyunsaturated fatty acids in the lens are targeted leading to the initiation of cataract. Malon-dialdehyde, the endproduct of lipid peroxidation, is also considered to be very toxic due its high cross-linking ability. In addition, protein – SH groups are also oxidized (in the case of lens crystalline proteins) that could result in cataractogenesis (Esterbauer *et al.*, 1985). Though cataract surgery is recognized as one of the safest, there is a greater chance of irreversible blind eyes due to surgery associated complications. Therefore, evaluating the association between exposure to ambient oxidative stress and Cataract is very important now a day. Among the biological molecules, lipids are most susceptible to the attack of reactive oxygen species and nitrogen species. Lipid peroxidation is described as a process in which oxidants like free radicals or nonradical species attacks containing carbon-carbon double bonds especially in polyunsaturated fatty acids (Huiyong Yin *et al.*, 2011). In this present study we have showed that lipid peroxidation induces alterations in the properties of the biological membranes such as disturbance of fine structure, functional loss and permeability of ocular lens. The levels of lipid peroxidation products (LPP) may be used as a biomarker for the measurement of oxidative stress status *in viv*o (R. Thiagarajan *et al*., 2013).

Materials and Methods

This present cross-sectional study has been conducted onsenile cataract in persons aged (Age limit 45-72 years) and they are exposed to air pollutants at Barasat village area of North 24 Parganas,West Bengal, India. An informed consent was obtained from all the subjects and the institutional ethics committee approved the study. The serum Lipid peroxidation product (LPP) i.e. malondialdehyde (MDA) level has been measured by using tricholoroacetic acid and thiobarbituric acid reagents and absorbance has been measured in spectrophotometer at 530 nm wavelengths. The determined wave length has been incorporated in the formula to detect the final value. (Sinnhubar *et al.*, 1958)
LPP level (nmol/ml) = Absorbance of the test/ Volume of sample in test× 6.41× volume of solution

Study Cases

The cases were divided in two groups:
Group-I: Cataract cases (n-24)
Group-II: Control group (n-16)

Results

Data has been presented as mean ± standard deviation. The p valuehas been obtained by t-test between the group I (cataract group) and group II (no cataract group). The estimated LPP mean value (nmol/ml)in Group I (Cataract patients) was 6.85375±1.088 and in Group II (Control), it was 2.676875 ± 0.56 ($p<0.0001$). Standard error of mean for Group I sample is 0.22 whereas for Group II is 0.14. The estimated't' score is 30.87for Group I sample whereas't' score in Group II is 19.12.

So from above t score data it can be said that the serum lipid peroxidation product (LPP) concentration (nmol/ml) is significantly higher in the cataract

Table 1. Average level of LPP (N-No of subjects, SD-Standard deviation, t- Critical values of t score, p value

	Group I (Cataract cases)	Group II (Control)
N	24	16
Mean age	72	70
Mean LPP level	6.854	2.677
SD	±1.088	±0.5601
SE	0.22	0.14
't'	t=30.87, df=23	t=19.12, df=15
P	<0.001	

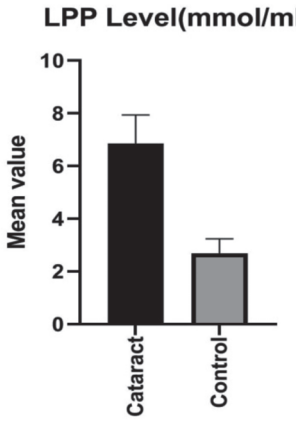

Fig. 1. Mean value of LPP level (nmol/ml)

cases ($p < 0.001$) as compared to that in the control cases.

So from the above data it can be inferred that patients with a history of cataract had higher levels of LPP than normal subjects with same age group.

Discussion

Cataract is one of the leading causes of blindness in India. In worldwide study it accounts for more than 50% of the blindness cases. Although a significant progress has been made towards the identification of the risk factors for cataract, there is no such primary preventivemeasurement or medical treatment for this condition. The removal of the cataract by surgical procedure is the only therapeutic approach. The ocular lens which is always exposed to sun light and free oxygen radicals is at a highest risk of photoxidative damage which results in cataract formation. The oxygen free radicals are responsible for impairment of the lens crystal lines. This abnormal aggregation, form the opacities. Also there is a destruction of proteolytic enzymes whose normal function is to discard the damaged proteins from the lens. Apart from an enzymatic defense system which consists of catalase, superoxide dismutase, glutathione peroxidase and hydrogen peroxidase against the reactive oxygen species, the lens also contains some antioxidants vitamins C and E and beta-carotene as next line of defense (David *et al.,* 1989). Cataract can be also developed from various causes like nutritional abnormalities, metabolic diseases and environmental factors, temperature, radiation (UV), (Choi *et al.,* 2018). From the above data it is clear there is a direct relationship between lipid peroxidation, oxidative stress and Cataract although the above study cannot confirm the mechanism of the cataract formation. The long-term exposure to air pollutants may damage the lens membrane luminal and secretary proteins by oxidative stress by reaction with reactive oxygen and nitrogen species. Additionally, with the increase of the age lens is modified the protective mechanisms against stress also decreased. These all factors are responsible for the development of cataract (Periyasamy *et al.,* 2017). Several experimental studies have been performed worldwide on this topic. A study in South Korea identified that exposure to air pollutants and particulate matters associated with cataract development in Korean adult's ≥50 year's age (Jinyoung *et al.,* 2020). It has also been found that exposure to biomass fuels in village during adult lifetime was associated with cataract in older women. Several studies in India have reported the adverse effects of particles on physiological measures compared to women using LPG, women who are cooking with biomass fuels exposed to three times the levels of particulate matters (PM10 and PM2.5), a 37% increase in reactive oxygen species (ROS) and a 40% depletion of the antioxidant enzymes superoxide dismutase (SOD) (Ravilla, *et al.,* 2016*)*. Our study does not confirm this report, further studies will be required to collect case history from those adult female patients regarding household cooking process and other chances of exposure to air pollutants.

Conclusion

The above result provides significant evidence for the association of oxidative stress with cataract in older persons. Our study, took place in rural areas of West Bengal. The association between air pollutants and cataract incidence differed according to age. This information may be helpful for understanding eye health and policymaking to control air pollution.

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