International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

The Patophysiology of Age Related Macular Degeneration after Blue Light Exposure: A Literature Review

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Abstract: ***Age related macular degeneration (AMD) related blue light remains controversial yet some research suggest that blue light play a role in the patophysiology of AMD. Exposure of blue light can damage retina in long exposure but the exact patophysiology is still on research. Here we discuss the role of blue light in AMD occurance in literature review context.***

Keywords: AMD, Retina, Blue Light, Patophysiology

1. Introduction

Age related macular degeneration (AMD) is the commonest pathological problem related untreatable loss of vision in aged person who lives in developed country. Age related macular disease or AMD become the major reason of visual loss that can't be treated. The risk factor that already known from the newest scientific resourch such as genetic and environmental factor including age, female and smokies, from the data available, 15 years incidence rate around the world are 15.1% for early AMD and 4.1% for late AMD in white women aged 55 years and over. (1) Epidemiological data in the USA shows that AMD causes a sharp loss of vision by 54% in caucasian, 14% in Hispanic and 4% in black, the prevalence increasing along aging. (2)

The precise patophysiology of AMD is not clear, but AMD has a sign of material deposit under RPE called drusen. histopathologycally, this deposit can form a broad subretinal deposit as a basal laminer deposit or linear basal deposit. There is a possibility of interference such as oxidative stress, inflammation, hypoxia, and changes in the cellular matrix to the surface retinalcoroid induce atrophy of the RPE by accelerating the degeneration process. (1)

Several epidemiology studies show that exposure to light for a long time triggers the incidence of AMD (3-6), UV light with a strength below 400 nm can still be overcome by the cornea and lens so there is no retinal damage (7). The blue light spectrum (400-500 nm) is strong enough to penetrate and damage retinal tissue (8-12). To the best of our knowledge, the blue light role in retinal disease remains unknown and study about the role ot the light is still minimal. This literature review will discuss abour the blue light role in the pathophysiology of AMD.

Patophysiology Of AMD

The exact mechanism of the pathophysiology of AMD is still unknown, yet two proposed mechanism are oxidative stress and inflammation contribute to RPE cells degeneration. Apoptosis and necrosis are found in AMD related caspase dependent and independent pathway. The population of cells affected by AMD mostly are RPE cells, choriocappilaries, and neurons which all of the cells are related by photoreceptors sensitive to some spectrum of lights (13).

The mitcohondria become the important element in AMD related apoptosis pathway and inflammatory response. (14, 15). Pyroptosis is associated with inflammation withous NLRP3 inflammasome signaling which results in autophagy in AMD development. Hence, the hypothetical lipofucinogen inside RPE cells after induction of blue light can trigger the photooxidation process which accelerate the AMD process itself which explained in **Figure (1)** (13).

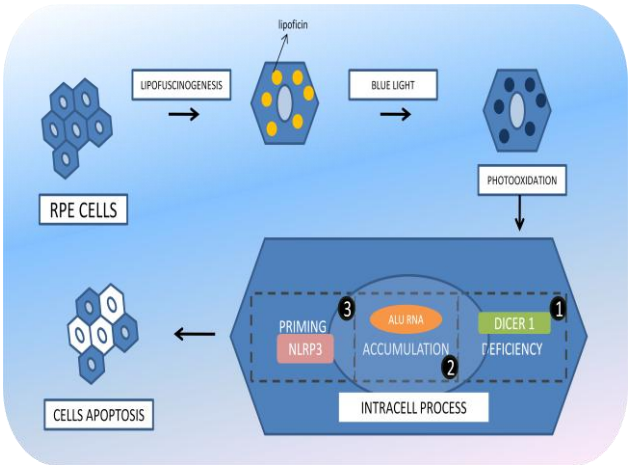

Figure 1: Apoptosis and pyroptosis are the main cause in AMD. Both of these are part of inflammation mentioned in patophysiology in AMD. Blue light itself plays important role in photooxidation induce oxidative stress and inflammation. The figure has been reproduced (13).

Blue light role in retinal disease

Light exposure below 400 nm is not harmfull against retina beause it has a protection mechanism. This mechanism are conducted by cornea and the lens by absorbing the light, but the visible light is an exception. Blue light which is a part of visible spetrum that cover range 400-500 nm can penetrate the RPE cells lead to retinal damage. (8-12)

Many animal study with exposure of visible light show a long term changes that are similar to those seen in patient with AMD, and are thought to result from photo damage that induced by photohemial and photooxidative mehanisms. (16,17) Other study shows that retina is more sensitive to damage caused by UV or blue light.(18) This fact supported by epidemiology study perform by Taylor et al. The subjet are 838 watermen, the data acquired by direct interviewed and ophthalmologi examination, performed after pupilary dilatation. Stereocopic fundus and photograps were taken to assess the severity of AMD (19). The severity divided into some criteria, will be explained on table 1.

Table 1. Grading of AMD (4)
Grade 1. 5 or more small drusen in central 1500 µm; 10 or more small drussen between 1500 and 3000 µm
Grade 2. 20 or more small drusen in central 1500 µm
Grade 3. Large or confluent drusen, focal hyperpigmentation
Grade 4. Exudative disease, geographic atrophy

Table 1 Grading of AMD used by Taylor et al to determined the severity of AMD (19)

Ocular exposure was estimated using model computations of ambient irradiance and estimates of the ratio of ocular to ambient exposure. The result of this study showed that subjects exposed to long-term high doses of blue light were found to have a higher incidence of advanced AMD compared with age matched controls (OR 1.36; 95% CI 1.00–1.85). These data suggest that high levels of exposure to blue and visible light late in life may be important in causing AMD. (4)

Systematic review and meta-analysis about sunlight exposure as a risk factor for age-related macular degeneration conducted by Sui et all by including 14 eligible studies including, indicates that blue light which was included in the solar light spectrum led to a significant increase in the incidence of AMD.

Other Study of Blue light exposure contribute to AMD

From the in vitro study by Cora et al, the effect of non lethal dose blue light to RPE cells is evaluated. The human retinal pigment epithelial cell line ARPE-19 was cultured and exposed with blue light. This exposure was given by LED based for 24,48,72 hours. The output power of either 0,3 mW/cm^2 or 1 mW/cm^2. The cellular changes that was evaluated including metabolic activity, apoptosis, ROS production, mitochondrial membrane potential (MMP), ultrastructural changes of mitochondria; production of advanced glycation end products (AGEs); and stress-related cellular proteins. The result are there is no cell death, but the metabolic activity is decreased, decreased of MMP, and increased of intracellular ROS. The exposure for 3-24 H with output power 1 mW/cm^2, and 0,3 mW/cm^2 for 24 H will start the metabolism delayed. ROS production increase after 24 hours exposure, and the MMP start to decreased after 24 H exposure.(21) Blue light exposure in the systme mentioned caused significant ROS production in ARPE-19 cells. These findings are consistent with other studies that demonstrated blue light could trigger intracellular ROS production (17-19). Mostly the focus of pathogenesis study of AMD is apoptosis cell, but the actual number of apoptotic findings on AMD are only 10%-15%. (20) This study can show the stress signaling in RPE cells after blue light exposure. Cell abnormalities still occur even though apoptosis does not occur. This is what might be related to AMD (21). Further study with strong design are needed to prove this relationship.

2. Conclusion

AMD is an emerging cause of irreversible decrease of vision which impair the quality of life especially in active person. The exact mechanism of blue light induces AMD still need further research. Most of studies relating long term blue light exposure with photooxidative process which contribute to AMD acceleartion in RPE cells. Further studies are needed to confirm this mechanism which so guideline with bluelight exposure can be established.

References

[1] Raeba Mathew, Sobha Sivaprasad, James J. *Vaughan asburys general ophtalmology 19th edition.* united states : McGraw-Hill Education, Inc., 2018. ISBN: 978-0-07-184354-6.
[2] Bowling, brad**.** *Kanski's Clinical Ophthalmology 8th edition.* s.l. : elsevier, 2016. ISBN: 978-0-7020-5572-0.
[3] Mainster MA. Light and macular degeneration: a biophysical and clinical perspective. Eye 1987; 1:304-10. [PMID: 3308530]
[4] Taylor HR, West S, Munoz B, Rosenthal FS, Bressler SB, Bressler NM. The long-term effects of visible light on the eye. Arch Ophthalmol 1992; 110:99-104. [PMID: 1731731]
[5] Margrain TH, Boulton M, Marshall J, Sliney DH. Do blue light filters confer protection against age-related macular degeneration? Prog Retin Eye Res 2004; 23:523-31. [PMID: 15302349]
[6] Klein R, Meuer SM, Knudtson MD, Iyengar SK, Klein BE. The epidemiology of retinal reticular drusen. Am J Ophthalmol 2008; 145:317-26. [PMID: 18045568]
[7] Boulton M, Rozanowska M, Rozanowski B. Retinal photodamage. J Photochem Photobiol B 2001; 64:144-61. [PMID: 11744401]
[8] Smith BT, Belani S, Ho AC. Ultraviolet and near-blue light effects on the eye. Int Ophthalmol Clin 2005; 45:107-15. [PMID: 15632529]
[9] Putting BJ, Zweypfenning RC, Vrensen GF, Oosterhuis JA, van Best JA. Blood-retinal barrier dysfunction at the pigment epithelium induced by blue light. Invest Ophthalmol Vis Sci 1992; 33:3385-93. [PMID: 1428711]
[10] Grimm C, Wenzel A, Williams T, Rol P, Hafezi F, Reme C. Rhodopsin-mediated blue-light damage to the rat retina: effect of photoreversal of bleaching. Invest Ophthalmol Vis Sci 2001; 42:497-505. [PMID: 11157889]
[11] Wenzel A, Grimm C, Samardzija M, Reme CE. Molecular mechanisms of light-induced photoreceptor apoptosis and neuroprotection for retinal degeneration. Prog Retin Eye Res 2005; 24:275-306. [PMID: 15610977]
[12] Algvere PV, Marshall J, Seregard S. Age-related maculopathy and the impact of blue light hazard. Acta Ophthalmol Scand 2006; 84:4-15. [PMID: 16445433]

[13] Kaarniranta K, Tokarz P, Koskela A, Paterno J, Blasiak J. Autophagy Regulates Death of Retinal Pigment Epithelium Cells in Age-Related Macular Degeneration. *Cell Biol Toxicol*. 2016; DOI 10.1007/s10565-016-9371-8
[14] Zhou Q, Li H, Xue D. Elimination of paternal mitochondria through the lysosomal degradation pathway in C. elegans. Cell Res. 2011;21:1662–9.
[15] Criollo A, Galluzzi L, Maiuri MC, Tasdemir E, Lavandero S, Kroemer G. Mitochondrial control of cell death induced by hyperosmotic stress. Apoptosis. 2007;12:3–18.
[16] Tso MOM: Retinal photic injury in normal scorbutic monkeys. Trans Am Ophthalmol Soc 1987; 85:498.
[17] Lawwill T: Three major pathologic processes caused by light in the primate retina: A search for mechanisms. Trans Am Ophthalmol Soc 1982; 80:517.
[18] Hamm WT Jr, Mueller HA, Sliney DH: Retinal sensitivity to damage from short wavelength light. Nature 1976; 260:153.
[19] Taylor HR: Ultraviolet radiation and the eye: An epidemiologic study. Trans Am Ophthalmol Soc 1989; 87:802-853.
[20] Sui GY, Liu GC, Liu GY, Gao YY, Deng Y, *et al*. Is sunlight exposure a risk factor for age-related macular degeneration? A systematic review and meta-analysis. *Br J Ophthalmol*. 2013 Apr;97(4):389-94. doi: 10.1136/bjophthalmol-2012-302281.
[21] Cora Roehlecke,Annette Schaller, Lilla Knels,1 Richard H.W. Funk. The influence of sublethal blue light exposure on human RPE cells. *Molecular Vision* 2009; 15:1929-1938

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