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Mathematical models of retinitis pigmentosa: the oxygen toxicity hypothesis. (English)

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Summary: The group of genetically mediated diseases, known collectively as retinitis pigmentosa (RP), cause retinal degeneration and, hence, loss of vision. The most common inherited retinal degeneration, RP is currently untreatable. The retina detects light using cells known as photoreceptors, of which there are two types: rods and cones. In RP, genetic mutations cause patches of photoreceptors to degenerate and typically directly affect either rods or cones, but not both. During disease progression, degenerate patches spread and the unaffected photoreceptor type also begins to degenerate. The cause underlying these phenomena is currently unknown. The oxygen toxicity hypothesis proposes that secondary photoreceptor loss is due to hyperoxia (toxically high oxygen levels), which results from the decrease in oxygen uptake following the initial loss of photoreceptors. In this paper, we construct mathematical models, formulated as 1D systems of partial differential equations, to investigate this hypothesis. Using a combination of numerical simulations, asymptotic analysis and travelling wave analysis, we find that degeneration may spread due to hyperoxia, and generate spatio-temporal patterns of degeneration similar to those seen *in vivo*. We determine the conditions under which a degenerate patch will spread and show that the wave speed of degeneration is a monotone decreasing function of the local photoreceptor density. Lastly, the effects of treatment with antioxidants and trophic factors, and of capillary loss, upon the dynamics of photoreceptor loss and recovery are considered.

MSC:

92C50 Medical applications (general)
35Q92 PDEs in connection with biology, chemistry and other natural sciences

Keywords:

asymptotic analysis; retina; photoreceptors; hyperoxia

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