Mathematics to improve macular degeneration treatment

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Researchers from the Universidad Carlos III de Madrid (UC3M) have created a mathematical model and simulated numerically the progression of age-related macular degeneration, one of the main causes of blindness. This model can be used to better understand how this disease appears and assess the most effective treatments.

Age-related macular degeneration (AMD) is a degenerative disease of the macula, the central area of the retina. There is currently no cure for the disease and it is characterized by a gradual loss of central vision and is the leading cause of blindness in developed countries in people over the age of 65. It is estimated that AMD affects around 800,000 people in Spain. It is estimated that around 196 million people are affected worldwide and it is also estimated that this number will reach 288 million by 2040.

There are two types of AMD: the dry or atrophic phase, which is usually the first and most common phase which progresses slowly; the acute phase, known as the wet or exudative phase, which occurs less frequently but has a worse prognosis at a visual level. In this latter form of AMD, there is an angiogenesis under the retina, an abnormal growth of very fragile blood vessels that may lose fluid or bleed, which can knock off and destroy the photoreceptor cells needed to see.

In their research, scientists from the UC3M have created a computational model simulation of angiogenesis (the propagation of blood capillaries) that takes how this process occurs in the eye into account. "What happens in this case is that, with age, a barrier (called the Bruch's membrane) that separates the capillary vessels from the inner part of the retina becomes less permeable and, therefore, does not deliver enough oxygen or nutrients to the photoreceptors. They then emit a signaling protein (called a vessel endothelial growth factor) that diffuses, passes to the blood vessels, and triggers this angiogenesis, which is what causes the disease," explains Luis L. Bonilla from the UC3M's Gregorio MillánBarbany University Institute for Modeling and Simulation in Fluid Dynamics, Nanoscience and Industrial Mathematics, who recently published a scientific article with Rocío Vega and Manuel

Carretero in the Biomedicines journal.

In practice, relatively little is known about the evolution and appearance of this disease and researchers hope that using this mathematical modeling they will be able to better understand how this pathology is created, how long it takes to progress, and if there is a way to stop it using current therapies. "The model has several parameters that characterize the progression of the disease. One can change them and predict how the disease will progress according to values, so it can be used to control how the process happens," explains Professor Bonilla.

Numerical simulations of the model suggest that therapies based on decreasing growth factors and proteins that are crucial in angiogenesis may temporarily slow the disease down, while other therapies based on improving cell adhesion may be more effective in the long term. In addition to this, this model could be used to research other retinal diseases, scientists say, such as diabetic retinopathy or that associated with premature babies, as, in these cases, these diseases also occur due to abnormal blood vessel growth.

More information: Rocío Vega et al, Anomalous Angiogenesis in Retina, *Biomedicines* (2021). DOI: 10.3390/biomedicines9020224

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