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Predicting patterns of retinal haemorrhage

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Retinal haemorrhage (bleeding of the blood vessels in the retina) is often observed following a traumatic brain injury, such as a sudden impact to the head or in Shaken Baby Syndrome, for which it is one of the clinical identifiers. However, it can be difficult to correlate the severity of the trauma to the particular pattern of bleeding.

The central retinal artery and corresponding vein supply the retinal circulation of the eye. They penetrate the eye via the Optic Nerve, which they enter a few centimetres back from the globe, immediately after passing through a region filled with cerebrospinal fluid (CSF) [1]. The CSF also surrounds the brain, so the CSF pressure will be directly influenced by pressure changes in the brain. Using a multi-compartment model, previously applied to explain the onset of retinal venous pulsation [2], we examine how the sudden change in CSF pressure drives flow along the blood vessels towards the retinal circulation; in some cases the accompanying pressure wave can steepen to form a shock. We use a sophisticated numerical method [3] to track the propagation of the shock waves through the blood vessels.

We focus attention on the retinal blood vessels immediately beyond the optic nerve, showing that the region directly upstream (where the vessels are strongly confined by the nerve fibres) significantly reduces the amplitude of the pressure wave transmitted into the eye, effectively protecting the eye from damage. We quantify the level of elevation in CSF pressure required for the onset of retinal haemorrhage using a simple bursting criterion. We further examine how these shock waves spread across blood vessel bifurcations in the retinal circulation to predict the pattern of vessel bursting across the entire retina.

REFERENCES

[1] S. S. Hayreh, The central artery of the retina its role in the blood supply of the optic nerve. *Br. J. Ophthalmol*, 47(11):651, 1963.

[2] P. S. Stewart, O. E. Jensen and A. J. E. Foss. A theoretical model to allow prediction of the CSF pressure from observations of the retinal venous pulse. *Invest. Ophthalmol. Vis. Sci.* 55(10):6319-6323, 2014.

[3] B. S. Brook, S. A. E. G. Falle and T. J. Pedley. Numerical solutions for unsteady gravity-driven flows in collapsible tubes: evolution and roll-wave instability of a steady state. *J. Fluid. Mech.* 396:223-256, 1999.