Confocal scanning laser Doppler flowmetry in retinovascular disease

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Ophthalmologists are now able to assess by non-invasive means the retinal and choroidal circulation in patients in greater detail than ever before. How this may help our understanding of disease is well illustrated by glaucoma researchers, who have been quick to embrace these new techniques. For retinovascular diseases the ability to measure blood flow directly in the retinal circulation is an exciting development, but as Squirrell *et al.*[1] from Sheffield show in this issue of *Eye*, new techniques require careful appraisal before they can be accepted.

Techniques now available to study blood flow in retinovascular disease clinically include fundus fluorescein angiography, pulsatile ocular blood flow (POBF), colour Doppler imaging (CDI) and confocal scanning laser Doppler flowmetry (cSLDF).

Fundus fluorescein angiography is the investigation most familiar to ophthalmologists: it gives dynamic information about the anatomy and morphology of the retinal (and some choroidal) circulation and is easy to perform, albeit it is an invasive procedure.

POBF is an ingenious technique based on the Langham pneumotonometer[2] which measures the pulsatile blood flow in the eye indirectly by sampling the intraocular pressure 200 times per second. It is likely that the POBF is largely a measure of the choroidal circulation, with a small component from the retinal circulation.

CDI is based on the Doppler Principle described by Christian Doppler (1803–1853), by which changes in the frequency of reflected sound waves are used to measure the velocity of a moving object. CDI utilises ultrasonic imaging of the blood flow in larger vessels, and makes use of colour pixels to represent direction and images of blood flow. In retinovascular disease CDI has been used for the investigation of central retinal vein occlusion, ocular ischaemic syndrome and anterior ischaemic optic neuropathy.[3]

Laser Doppler flowmetry (LDF) was described by Riva *et al.*[4] and is also based on the Doppler Principle. cSLDF is a promising new tool for investigating retinal or optic nerve head blood flow measurement. It is non-invasive, using low laser light intensities, and generates results in seconds.[5] The Heidelberg Retinal Flowmeter (HRF) is an example of cSLDF that combines laser Doppler flowmetry with scanning laser technology, and is a modification of the Heidelberg Retinal Tomogram, a confocal scanning laser ophthalmoscope. LDF allows the measurement of blood flow indices at a single retinal location. By incorporating scanning laser technology the HRF enables multiple LDF measurements over a given scan area, which build up into a colour-coded two-dimensional perfusion map.

Squirrell and co-workers[1] used the HRF to investigate 10 cases of macular branch retinal vein occlusion with defined ischaemic areas on fluorescein angiography. Ten healthy volunteers were similarly investigated as controls. The results of this study showed that HRF was a poor detector of retinal ischaemia, as defined by fluorescein angiography, with HRF recording a significant reduction in blood flow in only 7 of 10 patients with macular ischaemia. In addition the authors found that the HRF detected differences in blood flow between the superior and inferior retina in 3 of 10 healthy controls.

Why has such a new high-technology investigation performed so badly? The authors have postulated that the scanning laser beam is penetrating the retinal pigment epithelium and inadvertently picking up choroidal blood flow as well. This is one possibility but the answer is likely to be a combination of factors because the HRF is such a sensitive instrument. Several factors affect its performance: eye movements, cardiac rhythm, camera–eye distance, level of illumination, the zero offset effect and finally the size of measurement frame are all variables that can affect the results obtained. The size and position of the measuring frame is largely dependent on the operator because placing it in the same anatomical position for each perfusion image poses a problem. Recent developments in

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software now allow the whole perfusion image to be analysed and this has been shown to reduce the inter-session variability.[5]

The sensitivity of the HRF is therefore its main weakness but equally its strength. For example the differences between blood flow in superior and inferior retinal vessels that were detected by Squirrell *et al*. may in fact be true physiological differences in flow that represent a difference in the autoregulation of blood flow in the superior and inferior retina. Why normal patients should have these differences is unclear, but it may be a gravitational phenomenon and it has been observed in other normal controls.[6]

Where the HRF and related instruments may have a clinical role is in serial measurements of the retinal circulation of patients with retinovascular disease by the same technician over a period of time. Such measurements might allow ophthalmologists for the first time to use laser photocoagulation dynamically when changes in retinal blood flow indicate it, rather than by planning treatment by morphological changes only.

References

1. Squirrell DM, Watts A, Evans D, Mody C, Talbot JF. A prospective evaluation of the Heidelberg retina flowmeter in diagnosing ischaemia following branch retinal vein occlusion: a masked, controlled comparison with fluorescein angiography. Eye 2001;15:261–6.
2. Langham ME, McCarthy E. A rapid pneumatic applanation tonometer: comparative findings and evaluation. Arch Ophthalmol 1968;79:389–99.
3. Williamson TH, Harris A. Colour Doppler ultrasound imaging of the eye and orbit. Surv Ophthalmol 1996;40:255–67.
4. Riva CE, Grunwald JE, Petrig BL. Autoregulation of human retinal blood flow: an investigation with laser Doppler velocimetry. Invest Ophthalmol Vis Sci 1986;27:1706–12.
5. Kagemann LE, Harris A, Chung HS, Evans D, Buck S, Martin BJ. Heidelberg retinal flowmetry: factors affecting blood flow measurement. Br J Ophthalmol 1998;82:131–6.
6. Chung HS, Harris A, Halter PJ, Roff EJ, Kagemann LE, Garzozi HJ, *et al*. Regional differences in retinal vascular reactivity. Invest Ophthalmol Vis Sci 1999;40:2448–53.