A novel method for analysing Doppler blood velocity waveforms may reveal early microvascular disease. Studies of the retrobulbar circulation in type 1 diabetes and grade 1 hypertension.

Paul Hamilton¹, Aaron McCann², Christina Agnew², Vivienne McClanaghan¹, Auleen Millar¹, Canice McGivern², Gary McVeigh¹

¹Queen’s University Belfast, Department of Therapeutics and Pharmacology, BT5 7EG, Belfast, United Kingdom, ²Northern Ireland Regional Medical Physics Agency, BT5 7EG, Belfast, United Kingdom

Patients with hypertension and diabetes who develop microvascular disease are at high risk of a future cardiovascular event. If microvascular dysfunction could be detected at a pre-clinical stage, patients could be selected for early therapeutic intervention and intensive monitoring. Detailed analysis of Doppler blood velocity waveforms should help characterise microvessels since their morphology is partly determined by wave reflection. The wavelet transform is a mathematical tool that is ideal for analysing these waveforms.

39 subjects with well-controlled type 1 diabetes and 39 controls underwent ultrasound examinations of the common carotid (CCA), ophthalmic (OA) and central retinal artery (CRA) arteries, as did 25 subjects with grade 1 hypertension and 33 matched controls. No subjects had apparent microvascular complications. Waveforms were characterised using the discrete wavelet transform. Frequency data were categorized into eleven bands.

In the CCA, amplitude was higher for subjects with diabetes than controls in band seven (median 0.42 (IQR 0.28-0.62) vs 0.38 (0.26-0.63) cm/s, p=0.032), and lower in band eleven (mean 46.61 (SE 1.48) vs 52.88 (1.73) cm/s, p=0.007). In the OA, the amplitude was higher for subjects with diabetes in bands one (median 0.24 (IQR 0.20-0.29) vs 0.19 (0.16-0.24) cm/s, p=0.007), two (0.62 (0.45-0.74) vs 0.53 (0.40-0.62) cm/s, p=0.025) and four (2.30 (1.55 - 2.88) vs 1.76 (1.38 - 2.18) cm/s, p=0.022), and lower in band seven (0.55 (0.36-0.79) vs 0.73 (0.54-1.13) cm/s, p=0.020). In the CRA, the amplitude was higher for subjects with diabetes in bands one (0.18 (0.16-0.25) vs 0.16 (0.13-0.21) cm/s, p=0.020), two (0.38 (0.30-0.51) vs 0.31 (0.26-0.41) cm/s, p=0.012), three (0.70 (0.56-0.84) vs 0.49 (0.45-0.61) cm/s, p=0.000) and five (1.37 (1.08-1.89) vs 1.25 (0.97-1.40) cm/s, p=0.028).

In the CCA, the amplitude was lower for subjects with hypertension than controls in bands one (mean 0.54 (SE 0.02) cm/s vs 0.64 (0.25) cm/s, p=0.010), four (4.94 (0.36) cm/s vs 6.46 (0.39) cm/s, p=0.008), five (7.25 (0.47) cm/s vs 8.85 (0.42) cm/s, p=0.015), seven (median 0.92 (interquartile range 0.76-1.40) cm/s vs 1.73 (1.22-3.44) cm/s, p=0.000), nine (1.41 (0.96-1.66) cm/s vs 2.01 (1.44-2.80) cm/s, p=0.008) and eleven (44.60 (39.63, 48.06) cm/s vs 52.42 (45.90-59.67) cm/s, p=0.002). In the OA, the amplitude was lower for subjects with hypertension in band seven (median 0.54 (interquartile range 0.25-0.80) cm/s vs 0.76 (0.57-1.26) cm/s, p=0.017). In the CRA, the amplitude was lower for subjects with hypertension in band four (mean 0.63 (standard error 0.04) cm/s vs 0.75 (0.05) cm/s, p=0.048), but higher in band 11 (median 7.52 (interquartile range 5.63-8.83) cm/s vs 2.22 (1.28-5.53) cm/s, p=0.000).

Differences in waveforms between groups should either be due to a difference in the incident or reflected wave components. In the diabetes study, incident components would be expected to be similar. This, and the fact that abnormalities were most pronounced when signals were captured close to the microvasculature, suggests that the abnormalities detected are due to microvascular alterations. In the hypertension study, both incident and reflected wave components would be expected to be different. This might explain why abnormalities were detected in more proximal locations.