Diabetes - Laser Doppler Monitoring And Imaging

Introduction

Diabetes mellitus is a chronic condition in which a person has hyperglycaemia as a result of the pancreas not producing sufficient quantities of insulin, or an inappropriate response of the cells of the body to the insulin which is produced. In either case poor control of diabetes leads to a wide range of long term complications, some of which involve the blood vessels, leading to problems such as non-healing wounds (ulcers), endothelial dysfunction, peripheral vascular disease, and in severe cases leads to limb amputation when neuropathy of the feet is combined with reduced blood flow. According to the World Health Organization (2010), at least 220 million people worldwide suffer from diabetes, with this number projected to double between 2005 and 2030.

Laser Doppler studies of microvascular blood flow in diabetic patients – monitoring or imaging?

Moor Instruments designs and manufactures laser Doppler systems and accessories to investigate blood flow in the microcirculation. The laser Doppler technique is well established as the most convenient means of assessing tissue blood flow non-invasively and continuously. Both Monitoring and Imaging systems are available, each of which is particularly suited to a range of studies and applications. Monitoring allows continuous assessment of flow at one or more sites with the use of optic probes in contact with the tissue. Laser Doppler imaging is a non contact technique and a laser beam is used rather than transmitting light with optic probes. Accessories are also available to investigate the effect of thermal, drug and pressure stimulation on the microcirculation.

Peripheral vascular disease (PVD), including peripheral arterial occlusive disease (PAOD) and peripheral artery disease (PAD), is a common complication in Diabetes patients ultimately resulting in impaired skin microcirculation for example of the leg and foot. The use of laser Doppler for the study of microvascular blood flow in diabetic patients is used in a wide range of studies of PVD – for which different laser Doppler techniques are recommended. In the following sections a brief overview of commonly studied conditions are described and the appropriate laser Doppler technology indicated.

For further details of any these applications and the laser Doppler technology used, please contact your Moor Instruments representative who will be happy to help and advise you regarding your specific application.

Post-occlusive reactive hyperaemia (PORH)

The increase in microvascular blood flow following arterial occlusion, post occlusion reactive hyperaemia (PORH), can be assessed using the non-invasive laser Doppler technique. Following release of the arterial occlusion there is a marked transient increase in microvascular blood flow to the ischaemic tissues, referred to as post-occlusive reactive hyperaemia (PORH). Analysis of the PORH response in diabetes patients has been reported to provide an indication of the presence of microangiopathy (Strain et al, 2005. Yamamoto-Suganuma & Aso, 2009). PORH measurements can be simply and reproducibly performed using the moorVMS-LDF monitor combined with the automated pressure cuff controller, the moorVMS-PRES, teamed with the powerful PC software for analysis of the PORH response curve.

Diabetic foot/ulcers/non-healing wounds

We recommend: the moorLDI2 or the moorLDLS2

Diabetic foot ulcers are a chronic, severe and common complication in diabetic patients’ often resulting in limb amputation and increasing the death rate. The combination of poor nutritional blood flow, endothelial dysfunction and neuropathy etc. all render the diabetic foot vulnerable to the formation of non-healing ulcers. Studies aiming to correct cellular defects/abnormalities often require the monitoring of microvascular blood flow, and in some cases indicate that increased perfusion at the base of diabetic foot ulcers is linked to increased healing (Newton et al, 2002), and that control of inflammation can aid diabetic ulcer healing rate (Lau et al, 2009). The laser Doppler imaging system, moorLD2-IR, enables the user to image changes in blood flow over the entire wound surface, providing the user with a full colour 2-dimensional map of microvascular flow.

ULCERS/NON-HEALING WOUNDS - ask us about laser Doppler imaging with the moorLD2-IR or the moorLDLS2.

Endothelial Function/Dysfunction

We recommend: moorVMS-LDF and Iontophoresis with the MIC2

Endothelial dysfunction is a pathological state of the lining of the blood vessels (the endothelium) and is known to contribute to, or result from, several disease states including diabetes. Laser Doppler methods which have been described in the literature for the monitoring of endothelial function/dysfunction vary depending upon the experimental set-up.

Cohen et al, 2008, investigated the effect of a long-term exercise program on endothelial function (EF). EF was measured using laser Doppler monitoring of blood flow in response to vasoactive compounds. The group used iontophoresis to deliver the vasoactive drugs acetylcholine (Ach) and Sodium Nitroprusside (NaNP) into the skin.
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PORH - ask us about automatic pressure cuff control with the moorVMS-PRES and laser Doppler monitoring with the moorVMS-LDF.

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Hind limb ischaemia/Angiogenesis

We recommend: the moorLDI2-HR

The formation of new blood vessels, angiogenesis, is a normal physiological response to tissue ischaemia. The literature suggests that Diabetes patients have endothelial dysfunction and also impaired angiogenesis in response to ischaemia (Huang et al, 2008). The moorLDI2-HR, high resolution laser Doppler imaging system, enables non-invasive assessment of global perfusion in the ischaemic hind limb of mice and rats without the need for tracer dyes. Measurements can be performed over a number of days resulting in a sequence of full colour 2-dimensional maps of microvascular flow of re-perfusion of the ischaemic limb following development of collateral vessels.

Hind Limb Ischaemia and Angiogenesis - ask us about laser Doppler imaging with the moorLDI2-HR.

Diabetic Peripheral Neuropathy

We recommend: the moorVMS-LDF and MIC2

Diabetic peripheral neuropathy (DPN) is a serious complication of diabetes, which can ultimately lead to gangrene and amputation of the foot/lower limb. Symptoms of DPN in the foot/lower limb include; numbness and tingling, loss of sensation and muscle weakness. The exact mechanisms of DPN are not completely understood however considerable evidence indicates that abnormalities in the microvasculature contribute to nerve hypoxia (Malik et al, 2006).

Diabetic Peripheral Neuropathy - ask us about laser Doppler monitoring with the moorVMS-LDF and Iontophoresis with the MIC2.

References

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DIABETIC PERIPHERAL NEUROPATHY - ask us about laser Doppler monitoring with the moorVMS-LDF and Iontophoresis with the MIC2.

References


Forst et al., 2005, investigated the impact of insulin on EF and microvascular flow in the postprandial state. Blood flow was monitored in the dorsum of the foot using a laser Doppler monitor, with vasoactive challenge performed via the iontophoresis of Ach.

ENDOTHELIAL FUNCTION - ask us about laser Doppler monitoring with the moorVMS-LDF and iontophoresis with the MIC2.

Skin perfusion pressure (SPP)

We recommend: the moorVMS-LDF and moorVMS-PRES

Skin Perfusion Pressure (SPP) is the pressure required for restoring microcirculatory blood flow following release of carefully controlled occlusion. The measurement of SPP with laser Doppler is a non-invasive test. It has proved useful in the assessment of peripheral arterial disease (PAD) for both critical ischaemia (Castronuovo, 1997, Castronuovo et al., 1997), and also for the determination of optimal levels for amputation (Tsujii et al., 2008). There are also indications in the literature that SPP measurements are useful indicators for wound healing potential (Yamada et al., 2008). The combined moorVMS-PRES and moorVMS-LDF systems enable simple, rapid and reproducible measurement of SPP. The user friendly PC software enables protocols to be written which exactly match user requirements for individual experimental conditions – the user is in no way limited to pre-defined protocols.

LIMB/TOE/ANKLE & FOOT PRESSURE - ask us about automatic pressure cuff control with the moorVMS-PRES and laser Doppler monitoring with the moorVMS-LDF.

Toe pressure

We recommend: the moorVMS-LDF and moorVMS-PRES

Toe Blood Pressure (TBP) is the measurement of distal limb systolic blood pressure at the toe. TBP is particularly useful in patients with noncompressible tibial arteries, for example those suffering long-standing diabetes, renal failure or other disorders where vascular calcification is present (Clement, TASC II, 2008). TBP can be used in patients with peripheral artery disease (PAD) to assess the severity of ischaemia (Ubbink, 2004) and ultimately lead to early treatment and/or prevention of the formation of ischaemic ulcers in the lower limb. Routine measurements of TBP can be performed simply and rapidly using the moorVMS-LDF and moorVMS-PRES systems with the default protocol. The user-friendly software enables user defined protocols as required for research – the user is not limited to pre-defined protocols.

LIMB/TOE/ANKLE & FOOT PRESSURE - ask us about automatic pressure cuff control with the moorVMS-PRES and laser Doppler monitoring with the moorVMS-LDF.

Clement D. 2008  Diagnosis and evaluation of peripheral artery disease – non invasive vascular laboratory and imaging techniques. Based on the Inter-Society Consensus.  www.tasc-2-pad.org


