Endovascular laser treatment and optical coherence tomography

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Endovenous laser therapy (ELT) was introduced in clinical practice as a therapy for incompetent veins about ten years ago. One characteristic of ELT is the broad spectrum of different treatment protocols by means of a variety of laser systems as well as manifold application forms and dosimetry concepts which are under investigations.

Clinical results with effective, relatively pain-free occlusion of incompetent varicosis veins have been observed, as well as undesired side effects such as ecchymosis, phlebitis and recanalization. In recent years systematic experimental investigations and the analysis of clinical results have increased the understanding of the interrelation between the clinical and physical aspects, followed to a continuous optimization of ELT. The use of IR wavelengths and radial irradiation concepts, together with continuous moving of the optical fiber seem to reduce possible side effects. This way ELT treatment becomes a more standardized effective method for the treatment of varicose veins.

The physiological consequences of ELT, such as venous wall thickening, a reduction in luminal diameter, thrombus formation or obliteration are currently assessed either clinically, based on duplex ultrasound findings, or on phlebography. The methods in routine clinical use are not capable of differentiating between the different layers of the venous wall. Moreover, effects of ELT cannot be visualized directly during the procedure.

In a further investigation the potential of OCT to characterize the structure of the normal venous wall and to distinguish it from alterations after ELT had been performed. Differentiation of the type of change in the venous wall following RFA or ELT at different energy levels can directly influence clinical and therapeutic management. The experimental method was based on a standardized bovine hind limb model, with both untreated, normal venous segments and segments that had been exposed to energy of either RFA or ELT. Findings were compared with the results of histopathology as the reference standard.

Although technical improvements and certain laser parameters are nowadays available there is demand to improve the clinical situation by developing feedback-systems, thus getting on-line information for the clinical outcome and preventing for under- and over-treatment.

By means of Monte-Carlo simulation the potential of detecting signals due to heat induced shrinkage of the vessel was investigated. Remission spectra of native and coagulated vein tissue were compared to identify potential parameters for signalling the physiological change of the tissue due to the heating process. A miniaturized temperature sensor was developed for intraluminal measurements during laser energy application.

Monte Carlo simulations show that the detection of remitted light from the vessels wall is possible for small vessel calibres of less than 6mm in diameter. Remission spectra of native compared to coagulated vein tissue differ. While native tissue relates more to the content of deoxy-hemoglobin, the spectra of coagulated tissue relates more to the oxy-hemoglobin state. Based on the principle of temperature dependent fluorescence emission a miniaturized sensor was developed which can be used in the light field of radial emitting fibres.

Several optical changes for on-line-monitoring of signals during ELT showed potential to serve as feedback mechanism. Up to now, only the measurement of the endoluminal temperature could be realized. Further investigations are needed to find suitable technical realization to prevent for under- or overheating during ELT.