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Acoustic Cavitation in Sclerotherapy

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Extended Abstract

Varicose veins are enlarged and tortuous vessels that commonly affect the lower limbs. Sclerotherapy has represented a minimally invasive treatment in the cure of varicose veins for many years. It consists of introducing a liquid drug into the pathological vessel which causes an inflammation at the endothelial level and the definitive closure of the vein. The dilution of the drug in the blood is the main limitation of this therapeutic method. The treatment of a wide gamma of varicose veins does require elevated amounts of sclerosant, increasing the risk of local and systemic side effects.

Recently the problem of dilution in traditional sclerotherapy has been overcome through the use of a foam obtained from sclerosant liquid. The expansion of the foam inside the blood vessel increases both the area that can be treated and the contact time between the chemical agent and the endothelial wall. Side effects are therefore greatly reduced because of the necessity for decreased drug doses.

This foam is most commonly produced using the Tessari method, which is based on hydrodynamic cavitation induced by a local increase of flow velocity and a consequent pressure reduction. Cavitation concerns generation, growth and collapse of vapour and gas bubbles in a liquid medium. Hydrodynamic cavitation is achieved by manually mixing air and a sclerosant drug through the use of two disposable syringes, connected by a three-way valve, as previously reported in literature (Tessari, 2000).

The manual method lacks sterility because of the use of environmental air. It has several other drawbacks such as repeatability and reproducibility of foam homogeneity, as well as low solubility of the gaseous component in the blood. Optical investigation demonstrates that the foam produced using the manual technique is polydispersed, with bubble diameter dimensions in the range from several tenths up to hundreds of micrometers, which could be the cause of microvascular obstruction and neurological events as highlighted recently by Regan et al. (2011) and Morrison et al. (2008).

The aim of our work is to present a new method for the preparation of the sclerosant foam using cavitation through the application of an acoustic field. A pulse-width-modulation power circuit was built to drive a piezoelectric transducer at low frequency. A vial, clamped with the ultrasound source, contains the sclerosant drug and a highly soluble physiological fluid (carbon dioxide) pre-charged in a sterile environment with a purging pressure reactor. After tuning the frequency and the driving amplitude of the circuit, a sclerosant foam is produced.

Experimental results demonstrate that our system, based on acoustic cavitation in a sterile environment, allows the production of a monodyspersed foam made up of microbubbles having diameters of tenths of micrometers in order to limit microcirculatory obstructions. Our future intent would be to define a protocol for the standardization of the foam production in order to make the sclerosing treatment safer for patients.

References

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