Ultrasound Energy for Biomedicine

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Abstract – **For removing tissues and fragmenting stones, removing clots from blood vessels and other undesirable derivatives which can occur in a person's body, it is possible to use the ultrasound energy. Usually the energy generated to the environment by the waveguide is transmitted in the form of intensive acoustic waves of high frequency; tissues are destroyed under their influence, under the direct mechanical effect, or because of the phenomenon of cavitation. Within cavitation, in the liquid effect by the ultrasound frequency of big power, microscopic bubbles filled by vapours or cavities occur which expand fast and explode. These explosions are accompanied by intensive local hydraulic impacts which cause destruction of tissues.[1,2].**

Keywords – **ultrasound, vibration, waveguide, cavitations**

I. INTRODUCTION

Thrombolytic or mechanical recanalizations are much more efficient than conventional open surgery. However the recanalizations are not always technically successful in neglected cases. The most important difficulties occur at the moment of penetration of the occlusion with a guide wire. Inability to penetrate the occlusion may lead to unsuccessful balloon angioplasty, stenting or atherectomy. Therefore it is important to use the ultrasound energy to enhance the recanalization. The studies have been performed to estimate the auxiliary power consumption of various ultrasound effects in order to enhance the effectiveness of thrombolytic therapy. Moreover, the ultrasound energy has been considered for penetration of intravascular blockages due to both atherosclerotic plaque and intravascular blood clots (Omnisonic Inc., USA).

II.CAVITATION EFFECT FOR MEDICINE

Despite the clinical and technological advancement, vascular diseases such as acute myocardial infarction, stroke and peripheral arterial thrombosis remain a serious health problem, regarding unsatisfactory treatment outcomes (high, mortality, disability, significant economic costs). For example, mere in the United States the management of cardiovascular diseases, care and disability compensation costs are at $ 40 billion per year.

The main idea of our research work is to use the phenomenon of ultrasound cavitation for the endovascular therapy of blood vessel diseases and malignancies [4,5].

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III. METHOD

The ultrasonic blood – vessel recanalization system consists of reusable electronics (Generator 1 and Transducer 2) and the single use ultrasound wave wire 3 (Fig.1). The ultrasound wave wire is connected to the electronics by attaching the proximal hub of the to the distal end of the Transducer. The Generator converts AC line power into high frequency current. This current is then delivered to piezoelectric crystals contained within the transducer resulting in crystal expansion and contraction.

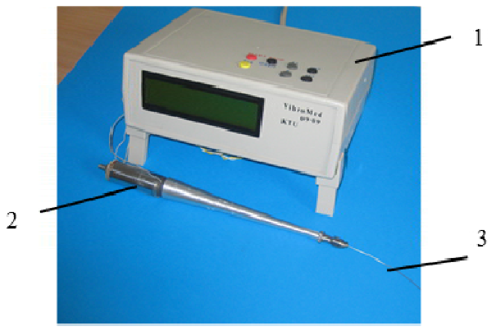

Fig.1 The ultrasonic blood- vessel recanalization system

The Transducer horn amplifies the rapid crystal expansion and contraction propagating high frequency mechanical vibration down a wave wire to its proximal tip at approximately 20 kHz or 20,000 cycles per second. This vibrational energy of the proximal tip provides mechanical and hydrodynamic impact which aids in the recanalization of an occluded artery.

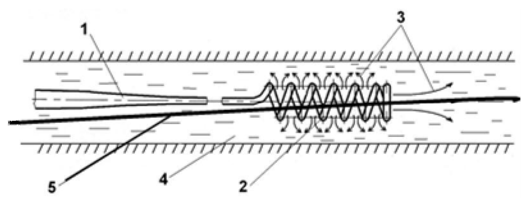

Fig.2 The structure of the ultrasound wave wire: 1 – conical-stepped-cylindrical sainless steel wave wire; 2 – spiral shaped proximal end of the wave wire;3-cavitation zone; 4-blood –vessel; 5-guide wire

The ultrasound wave wire used for the internal blood-vessel recanalization consists [5] of the combination of conical-stepped-cylindrical stainless steel waveguide 1 and proximal end 2, which is spiral shaped. It allows to significantly improving dynamic characteristics by existing various static loads. The flexible guide wire 5 may be entered through spiral internal part and it directs the ultrasound wave wire proximal end into the thrombus location in blood vessel (Fig.2).

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The process of ultrasound cavitation induced in liquid by the spiral shaped proximal end of the wave wire is presented in Fig.3.

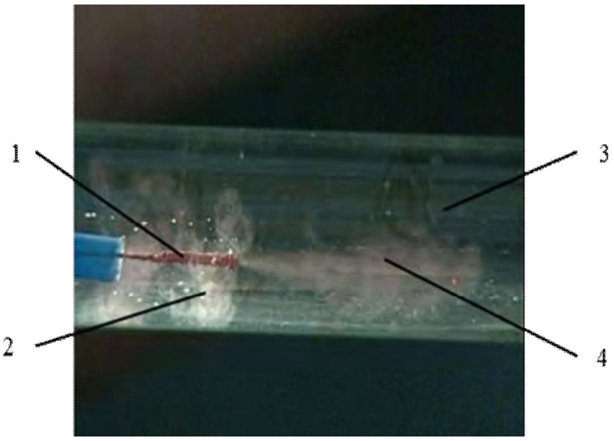

Fig.3 Image of the cavitation zone induced by the spiral shaped proximal end of the wave wire: 1 – spiral shaped proximal end of the wave wire; 2 – cavitation zone; 3 – tube which liquid; 4 – stream cavitation

IV. CONCLUSION

Introduction of new endovascular interventions into clinical practice in Lithuanian will expand treatment options for many diseases where other approaches, including operative, is impossible or too dangerous. This is particularly useful for specific treatment of serious medical conditions using the new above mentioned percutaneous intervention techniques. The successful application of this ultrasonic blood-vessel recanalization system should be crucial to wider usage of cost-effective endovascular interventions in Lithuania.

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