Methodology of multichannel study of cryoeffect in vitro

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Cryosurgery is a minimally invasive, effective and safe method, which is intended for targeted and controlled destruction of affected tissues by low temperatures. This method is indicated for the treatment of benign, precancerous and malignant neoplasms. Conducting experimental studies in biological tissues allows us to study the mechanisms of freeze-thawing processes that occur during cryosurgical treatment. The progress of cryosurgery is inextricably linked to understanding the freezing and thawing processes, because they are the main factors in the destruction of biological tissues. Assuming the serious ethical problems when performing the studies in animals, in vitro experiments are preferable, the data of which could be extrapolated to biological tissues *in vivo*.

To control the dynamics of the freezing zone parameters in a model system during in vitro cryogenic exposure, a technology has been developed that is based on the use of various information-retrieving channels.

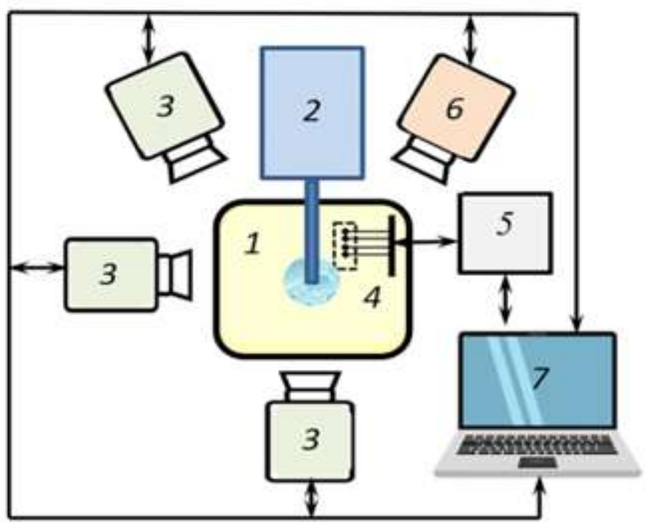

Fig. 1. Block diagram of the experimental setup:
1) model system, 2) cryoinstrument, 3) video cameras, 4) set of resistance thermometers, 5) multichannel analog-to-digital signal converter, 6) thermal imager, 7) computer for visualization and automatic data recording.

Fig. 2. The process of monitoring cryogenic exposure in vitro (external appearance of the experimental setup)

The methodology contains requirements for equipment and facilities as well as a step-by-step description of testing and preparing equipment, measuring using all components of the setup, quantitative analysis of the results obtained, etc. Due to multichanneling, the technology can be used for simultaneous and synchronous quantitative monitoring of the dynamics of the ice ball size and shape (three video surveillance channels), measuring temperature dynamics at specified points in the model system volume (up to 8 microthermometers), monitoring the freezing front movement on the surface and quantitative analysis of the dynamics of thermal fields on the model system entire surface (infrared thermal imaging channel), etc.

a **b** **c** **d** **f**

Fig. 3. Main components of the experimental setup: (a) container with model liquid is placed in an external container with coolant, (b) quasi-point nitrogen cryoapplicator, (c) fixation device with a set of microthermometers, (d) video camera, (f) thermal imager for measuring low-temperature thermal fields.

The technique is intended for carrying out the optimal procedure of low-temperature exposure, quantitative simultaneous and synchronous control of the dynamics of the parameters of the model system and subsequent analysis of the obtained data, and can be used in relevant scientific experiments in vitro. Algorithm of the proposed methodology is presented in Fig. 4.

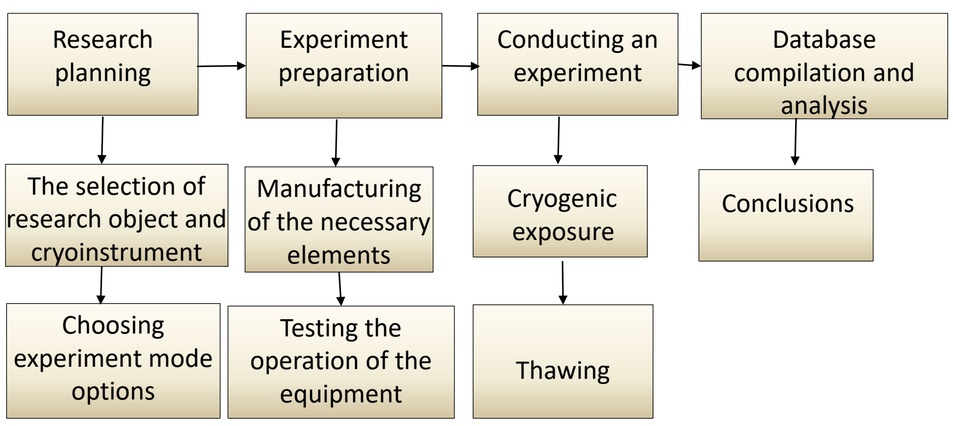

Fig. 4. Research algorithm.

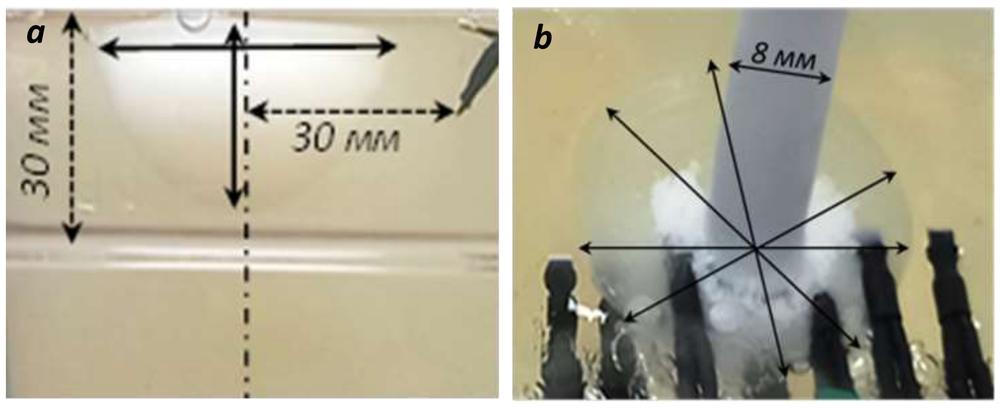

Fig. 5. Analysis of the size and shape of the ice ball: (a) frame from a side camera video using three microthermometers, (b) frame from the video of the upper camera using seven microthermometers.

Further research involves the use of various cryoinstruments and freeze-thawing modes, varying the composition and temperature of the model system, simulating the presence of blood vessels in the zone of cryoimpact, etc.

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