EFFECTIVE INSTRUMENT FOR CRYOABLATION

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Introduction

The technology of destructive cryotherapy is based on local hypothermia of pathological tissue to the temperature at which irreversible damage occurs in the cells.

After successfully destroying the cryotherapy exposure in the pathological process develops on cryonecrosis.

Cryonecrosis provides natural rejection and removal of pathological tissue without the use of traditional surgical techniques.

Local supercooling of the patient's body tissue for the formation of zones of cryonecrosis received international designation cryoablation (CA).

This name more accurately reflects the essence of the cryomedical technology, because during the CA operation only the destruction of pathological cells is achieved.

Replacing the definition of "cryosurgery" with the term CA is important to prevent such excesses.
Introduction

The determining influence on the efficiency of the use of CA has the choice of equipment for the organization of local hypothermia.

**nitrogen cooling system (NCS) VS throttling cooling system (TCS)**

**the greatest heat dissipation capacity**

The heat of vaporization of liquid nitrogen is 199 kJ/kg. Evaporation of 1 kg of liquid nitrogen allows to chill out to a temperature of CN about 1 kg of pathological tissue.

don’t have so massive communications like NCS, so can be used in minimally invasive operations

heat dissipation capacity more less than NCS

So we need to find new technological solutions that can compensate this defect of NCS devices
COOLING SYSTEM OF DEVICES FOR CRYOABLATION

The power of the heat flow removed by from the cooling system:
\[ q_{SC} = g'(1 - x) \cdot r' \]

The flow rate of working substance:
\[ g' = f \omega' \rho' \]

Minimum dryness degree of the compressed gas flow in the TCS:
\[ x_{min} = \frac{q_T}{r'}, \quad x_{min} \geq 0,63. \]

Dryness degree for LN: \( x \rightarrow 0 \)

\[ q_{SC} = (1 - x) \cdot r', \quad q_{NSC} = 199 \frac{kJ}{kg \cdot s}, \quad q_{TSC} = 60 \frac{kJ}{kg \cdot s}. \]
THE RESEARCHING OF THE LIQUID NITROGEN TRANSPORT PROCESS THROUGH A PIPELINE

The mathematical model of the object is based on a system of equations describing the movement of cryogenic liquid along the line.

The equations of motion and continuity:

\[
\frac{\partial (f \rho \omega)}{\partial \tau} + \omega \frac{\partial (f \rho \omega)}{\partial z} + (1 + \delta) \frac{\partial p}{\partial z} = 0
\]

\[
\frac{\partial (f \rho)}{\partial \tau} + \frac{\partial (f \rho \omega)}{\partial z} = 0
\]

The energy equation

\[
\rho \frac{\partial h}{\partial \tau} + \omega \rho \frac{\partial h}{\partial z} + q_v = 0
\]

Equations for the calculation of thermophysical properties of cryogenic liquid:

\[
p v = zRT
\]
THE RESEARCHING OF THE LIQUID NITROGEN TRANSPORT PROCESS THROUGH A PIPELINE

Figure 2. The physical model of the pipeline supplying liquid nitrogen

\[ p_i = p_{i-1} - \Delta \psi_i \quad T_i = T_{i-1} + \Delta T_i \quad \rho_i, c_{pi}, \Delta E_{1i}, \Delta E_{2i} \]
THE HEAT LOAD ON THE COOLING SYSTEM OF THE HEAT- REMOVING DEVICES OF THE INSTRUMENT FOR CA

1. Supercooling from the initial state to the phase transition temperature 271<T_i<305 K, h_i=f(T_i);

2. The freezing of biological tissues T_i≈271K, Δh_i=-q*

3. Hypothermia of tissues from the defrosting temperature to cryonecrosis temperature T_{necr}<T_i<271 K, h_i=f(T_i);

4. Hypothermia of tissues from the cryonecrosis temperature to the temperature of the heat removal device T”’<T_i<T_{nec} 271 K, h_i=f(T_i).

\[ Q_{NCS} = Q_1 + Q_2 + Q_3 + Q_4 = \int_{r_{min}}^{r_{max}} (h_i^{305} - h_i^\tau) \rho_i \Delta V_i \partial r. \]
THE TRANSFER OF LIQUID NITROGEN IN UNDERHEATED CONDITION

The saturation temperature of the liquid depends on the pressure in the vapor space

\[ T'' = f(P'') \]

At \( P_4 = 2.0 \) MPa saturation temperature of the liquid nitrogen will rise to

\[ T'' = 115 \]

The underheating heat of the flow

\[ Q_{un} = c_{LN} \cdot (T'' - T'), \quad Q_{un} = 74.4 \frac{J}{kg} \]

Figure 3. Compression of liquid nitrogen by a plunger pump
CONCLUSIONS

Supplying NCS devices for CA with liquid nitrogen compressed to a pressure of at least 2 MPa allows to remove traditional disadvantages of surgical devices using liquid nitrogen.

The supply pipeline diameter of the compressed liquid nitrogen can be reduced to 1,0·10⁻³ m, this allows to use devices with NCS for minimally invasive CA operations.

The technology based on the use of underheated liquid nitrogen will return to the devices with NCS their competitive benefits and will allow to increase the scope of application of such devices during the CA.
THANK YOU

Questions?

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