BASAL FEEDBACK IN HUMAN THERMOREGULATION

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INTRODUCTION

Studies of the role of the circulation in heat-exchange and thermoregulation were begun from the study of brain and blood temperature dependence. Bazett [1] was among the firsts probably who paid attention to relationship of brain and blood temperature perfused it. Now this problem is investigated in man. While there is no full clearness. Some authors insist on existence of selective brain cooling [2]. Use of models showed that the only way cooling brain is circulation [3,4].

Transport of heat by circulating blood and countercurrent heat exchange between large blood vessels are studied by modeling and analytical description [5,6,7,8]. Development of mathematical models taking into account all complexity and details of heat transfer by blood in organism will increase the understanding of this process.

The objective of this study is to research functional physiological significance of heat transfer by blood at systemic level using whole body model of human thermoregulation.

METHODS

Class of mathematical dynamic models is developed using traditional approach involving passive and active parts of thermoregulatory system. Identification of models was performed in comparison with experimental results. Mathematical description is the system of differential equations, which corresponds to the definite approximation of object. Convective heat transfer by blood was performed according to well known formula including perfusion rate, arterial blood and tissue temperatures, density and specific heat capacity of blood [9]. Equation of mixed venous blood describes the process of mixing of heat flows transfered by blood from all i-compartments of body, taking into account the blood volume in large venous vessels, cardiac output, perfusion rates, physical constants and heat-exchange between upper respiratory ways and environment.

Transient and steady-state processes of passive and active systems under different environmental conditions were studied. There were provided computer experiments studying effect of stabilisation of arterial blood temperature on system, response of system to change of skin blood flow in opened loop system, regulation in closed loop system under resting condions in a neutral environment, heat-exchange processes in brain.

RESULTS

Modeling of opened loop system revealed important quantitative data. Passive system has high inertia. Transient processes depend on disturbance and get up to 9—10 hours under substantial deviations of ambient temperature from initial. Analysis of dynamics shows that time characteristics of transient processes, temperature changes of all organs and tissues are determined by integrative heat flow transfered by mixed venous blood.

Simulation of maintenance of initial meaning of arterial (mixed venous) blood temperature in response to disturbance at system revealed qualitative changes in dynamics. System behaved itself as it was controlled. Temperatures of brain and internal organs keeped their set meanings, shell temperatures changed little, transient processes ended in 30—40 min. On a whole stabilization of the arterial blood temperature provides practical invariability of core temperatures to environment.

Analysis of heat-exchange in brain showed that 70% of metabolic production is transfered by blood flow. It takes place under small temperature difference 0.1C between tissue and blood. It means that any change of conditions of heat transfer by blood effects on brain temperature.

Modeling is revealed high sensitivity of brain temperature to skin blood flow. Skin blood flow as effector response changes in different parts of the body. As an example 2-increase of skin blood flow in extremeties evokes decrease of brain temperature up to 0.17C. Quantitative analysis showed that changes are owing to convective heat flow but not by conduction.

Simulation of closed loop system in neutral environment where regulation is provided only by skin blood flow demonstrated efficiancy of regulation. Analysis of dynamic processes showed that substantial change of convective heat flow in skin takes place. It oscillates from initial 15 ccal per hour to 40 ccal per hour while conductive flow changes from 30 to 40 ccal per hour.

CONCLUSIONS

In conclusion, results of modeling allows to suggest that basal feed-back in thermoregulation goes through integrative heat flow transfered by mixed venous blood. It percepts all systemic disturbances by blood flows of organs and tissues. It transfers these changes to brain. Brain temperature follows arterial blood temperature. Brain evokes regulatory actions which are realized through convective integrative heat flow by blood.

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