Instrumentation for Blood Parameters Measurement in Gravitational Physiology Experiments Using Remote Control

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Abstract. *For space biology a new electro-mechanical equipment for multiple blood withdrawal from small experimental animals applied to a centrifuge with maximal 6g gravitational overloading has been developed and tested. The equipment consists of a transmitter and receiver equipped by microcomputers. Active rotor stepping motors are driving four pairs of syringes. It is also possible to measure the instantaneous gravitational force using an accelerometric transducer [1, 3]. This telemetrically regulated blood sampling allows studying selective effects of hypergravity during centrifugation. It can be also used for study of microgravity effects in the animal organism during space flights for the understanding of the mechanism of the changes of the activity of neuroendocrine system and metabolic processes. This instrumentation is also applicable for shifting of small measured samples in the case of imaging using CT or NMR scanners.*

1. Introduction

Biotelemetry is a transmission of biologically important information from an animal to a receiver without the use of connecting wires. The used signals are generally carried by radio waves [2]. Specific claims are necessary when telemetric control of a mechanical operation is needed, e.g. for movement of rods of blood syringes.

In space biology the project relating to changes of functions of neuroendocrine system during exposure to simulated microgravity and hypergravity is performed. Observations are proposed for the group of animals exposed for a short time to hypergravity by using centrifuge device simulating a gravity load at start or landing of space satellite up to 6g, $g = 9.80665\ m\ s^{-2}$.

Also the studies of adaptation to hypergravity of 2g for the period of two weeks, simulating the process of postflight readaptation, are proposed. Results of these experiments are important for the understanding of the mechanism of the changes of the activity of neuroendocrine system and metabolic processes observed in human subjects and experimental animals after space flights, and also to distinguish between specific effects of microgravity, hypergravity during the landing and postflight readaptation to gravity conditions on Earth.

2. Technical equipment

For these studies an equipment for multiple blood withdrawal from small experimental animals with telemetric control has been developed and tested. A pair of rats is placed in a cabin rotating in a centrifuge with max. 6g gravitational overloading, Fig.1.

Fig. 1 A cabin of the centrifuge for testing of 2 experimental animals (rats). Each animal is connected to four syringes driven by two stepping motor. 10 cabins are placed on the centrifuge arms with a length of 3 meters.

The equipment consists of a telemetric transmitter (placed outside the room of the centrifuge) and receiver. Both transmitter and receiver are equipped by microcomputers.

The instantaneous gravitational force is also measured using an accelerometric transducer (Analog Devices ADXL210) placed near the testing box (left upper corner) with telemetric data transmission. For gravitational force calculation for our centrifuge the following formula was applied:

$$g = 1.117 \,.\, r \,.\, n^2 \,.\, 10^{-3}$$

where: r - radius in [m], n – number of revolutions per minute.

2.1 Transmitter

The transmitter, Fig. 2, (placed outside the room of the centrifuge) and receiver, Fig. 3, are working on frequency (UHF range) f = 433.92 MHz, pulse code modulation, output power 5 mW, coverage within 100 m. Both transmitter and receiver are constructed on hybrid modules AUREL: TX-SAW 433s and STD 433 DIL.

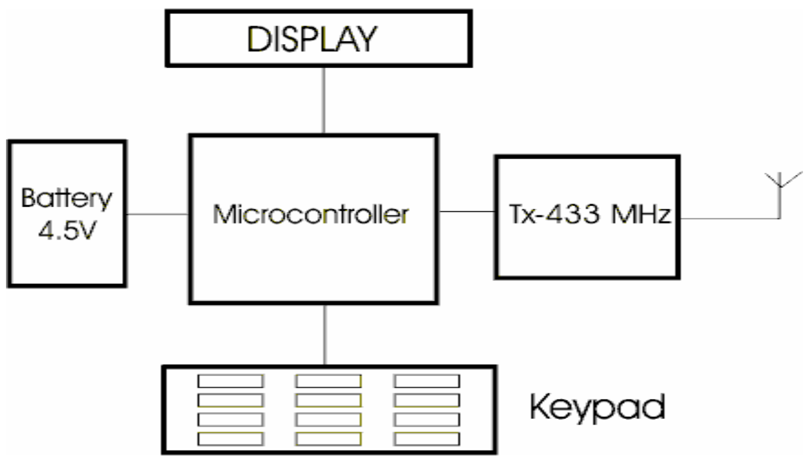

Fig. 2 Transmitter controlled by a microcontroller. Using a keypad it is possible to pre-program the time sequences for suction and exhaustion of particular pairs of syringes.

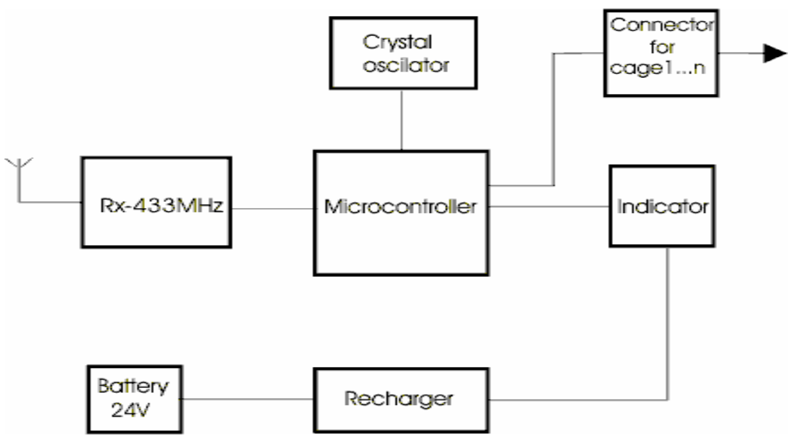

Fig. 3 Receiver controlled by a microcontroller placed in the room of the centrifuge. Through a cable it is connected with step motors placed in every cabine driving the syringes.

2.2 Receiver

After switching on the receiver, it is waiting for a radiofrequency signal comprising pre-programmed sequence. After a LED diode is confirming the successful receiving, the count down is starting and the applied sequence is starting. The receiver is switching on the selected driving rods of syringes in precise time moments. After sequence is finishing the syringes are removed and using manual control (pushing button) the driving rods are returned to the initial position.

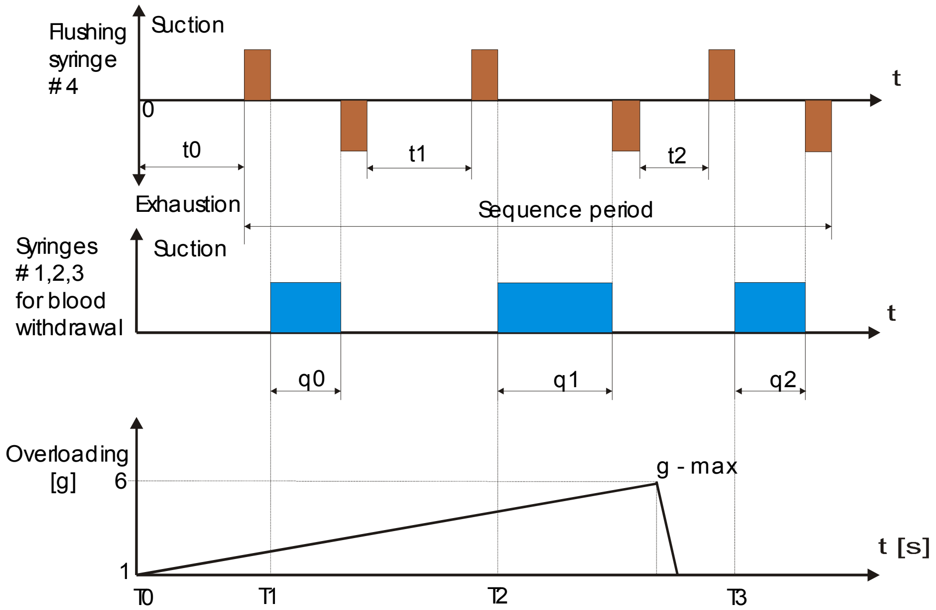

Fig. 4 Programmable sequences.

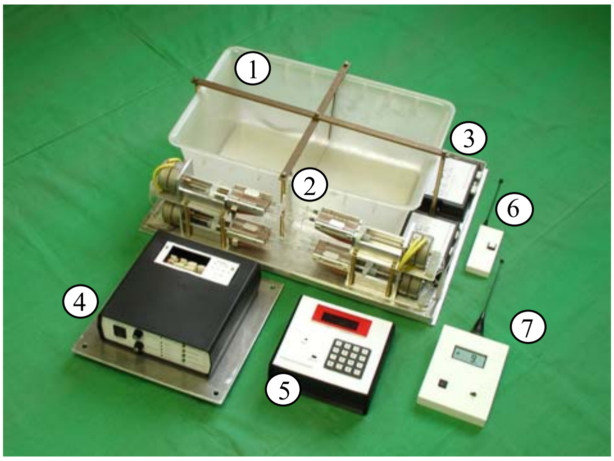

Fig. 5 Equipment for multiple blood withdrawal with telemetric control – 4 channels, for 2 animals.

In the Fig.5 one can find: 1 - box for 2 experimental animals, 2 - four pairs of syringes controlled by step motors, 3 - modules for step motors driving, 4 - receiving module controlled by a microcomputer, 5 - transmitting module, frequency: 433.92 MHz, modulation PCM, 6 - transmitting module of an accelerometric transducer, 7 - receiving module of an accelerometric transducer.

2.3 Programming unit

After switching on the transmitting unit it is possible to pre-program sequences t0, q0, t1, q1, t2, q2, Fig 3. It is possible to set up width of pulses, their time schedule and blood volume typing t and q values. For the blood volume selection q it is necessary to type the keyboard in steps 1, 2, 3. Number 1 means 0.33 ml, 2 – 0.66 ml and 3 – 0.99 ml.
The programmer automatically controls the input values. After typing a number bigger than the pre-programmed step the procedure is returned back. After typing t and q the programmer confirms acceptation by two short blinks. After typing all the values and confirming the acceptation it is possible to switch of the programmer.

3. Conclusion

The aim the investigations in proposed project is realization of series of the experiments with rats exposed to hypokinesia (tail-suspension hypokinesia, restriction of mobility) for various time period with the blood sampling during the hypokinesia by using a canula and determination of plasma levels of hormones, neurotransmitters and metabolites. In selected time intervals it is proposed to measure in isolated organs and tissues the content of neurotransmitters, hormones, production of hormones, activity of enzymes involved in the production of neurotransmitters, expression of genes for coding these enzymes. The response of neuroendocrine system (changes of catecholamine, corticosterone, prolactine, growth hormone) will be determined. The results will be used for evaluation of the capacity of the organism to overcome several stress loads. Similar protocol of observations is proposed for the group of animals exposed for a short time to hypergravity (by using centrifuge device simulating a gravity load at start or landing of space satellite (6g-8g), $g = 9.80665\ m\ s^{-2}$.
Electro-mechanical equipment, Fig. 5, has been tested on a centrifuge placed in a laboratory of The Institute of Animal Biochemistry and Genetics, SAS. In the centrifuge there is possible to place 10 boxes with 20 experimental animals, plus 1 control box with two animals rotating in the centre of the centrifuge where $g= 9.80665\ m\ s^{-2}$.

This telemetrically regulated blood sampling allows to study selective effects of hypergravity during centrifugation. It can be also used for study of microgravity effects in the animal organism during space flights.

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