A BLOODLESS METHOD OF DETERMINING THE SYSTOLIC ARTERIAL PRESSURE AND THE DEGREE OF VASODILATATION AND VASOCONSTRICTION IN WHITE RATS

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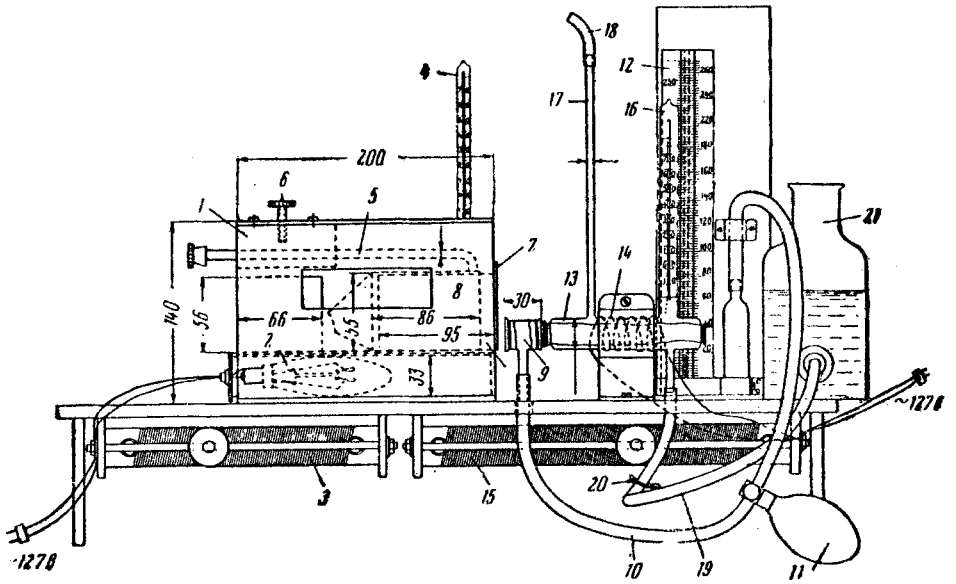
The apparatus suggested by [Williams, Harrison and Grollman (1939)] for determining the systolic arterial pressure in rats has been widely used in laboratory practice. This method has, however, the following essential faults: 1) an excessively high temperature (40-43°C) for the rats in the heated chamber (heated by an electric coil), which causes gross changes in the circulatory system, and 2) the level of the water temperature in the plethysmograph is not determined with accuracy.



Improved apparatus for the bloodless determination of the systolic arterial pressure and vascular tone in rats.

Chamber for the rat (1), electric lamp of specification 127 v, 25 w, Resk (2), rheostat (3), thermometer (4), rod for moving the chamber (5), screw for fixing the position of the chamber (6), door (7), movable part of the chamber (8). Compression chamber, diameter 18 mm (9), rubber tube (10), bulb (11), sphygmomanometer scale (12). Glass plethysmograph, 132 mm long, tube diameter 25.5 mm). Inlet diameter 18 mm, outlet diameter 9 mm (13), electric coil (14), rheostat (15), thermometer (16), water manometer (17) (internal diameter 2.5 mm), rubber connection (18). Rubber tube connecting the plethysmograph to the bottle (19). Clamp (20, water bottle (21).

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Repeated Measurements of the Systolic Arterial Pressure and the Vasodilatation and Vasoconstriction in Healthy Rats (temperature of the chamber for the rats 30-32°C; water temperature in the plethysmograph 40-42°C)

Animal No.	Time of investigation	Time of investigation (in minutes) 1	2	3	4	5
		pulsation / systolic arterial pressure (in mm) / dilatation (in mm) / constriction (in mm)	pulsation / systolic arterial pressure (in mm) / dilatation (in mm) / constriction (in mm)	pulsation / systolic arterial pressure (in mm) / dilatation (in mm) / constriction (in mm)	pulsation / systolic arterial pressure (in mm) / dilatation (in mm) / constriction (in mm)	pulsation / systolic arterial pressure (in mm) / dilatation (in mm) / constriction (in mm)
1	10 hr 10 min	| 60 0.005 0.005	+ 90 0.01 0.01	+ 114 0.02 0.03	+ 124 0.02 0.03	+ 124 0.02 0.04
2	10 " 17 "	| 54 — —	| 78 0.005 0.005	| 80 0.05 0.05	+ 94 0.01 0.05	+ 94 0.01 0.01
3	10 " 23 "	| 50 — —	| 70 0.005 0.005	+ 100 0.01 0.01	+ 100 0.01 0.01	— — —
4	10 " 33 "	| 48 — —	| 80 0.01 0.005	— 82 0.01 0.01	+ 100 0.02 0.02	+ 106 0.02 0.04
5	10 " 38 "	| 96 0.01 0.01	| 90 0.01 0.01	+ 104 0.01 0.01	+ 106 0.01 0.02	+ 110 0.01 0.02
6	10 " 50 "	| 102 0.01 0.01	+ 108 0.01 0.03	+ 110 0.01 0.03	+ 110 0.01 0.03	+ 112 0.01 0.03
7	11 " 04 "	| 70 0.01 0.005	| 96 0.02 0.02	+ 110 0.02 0.04	+ 114 0.01 0.03	+ 110 0.01 0.03
8	11 " 19 "	| 62 0.01 0.01	| 82 0.03 0.03	| 96 0.02 0.04	| 106 0.02 0.05	| 108 0.02 0.04
9	13 " 23 "	| 80 — —	| 84 0.01 0.01	| 92 0.01 0.02	| 96 0.02 0.02	+ 118 0.02 0.04
10	13 " 30 "	| 82 0.02 0.01	+ 96 — —	+ 106 0.02 0.01	+ 106 0.02 0.01	

In the course of our work, at the instigation of N. I. Arinchin we have introduced the following modifications into Williams' apparatus: a more suitable double-walled chamber has been constructed; in order to increase its thermal resistance its internal surface is covered with asbestos, and an evenly distributed form of electric heating has been introduced by means of two small electric lamps (25-30 w), the emission of heat from their filaments being controlled by a rheostat. This enables the temperature of the chamber to be kept constant (30-32°C); the metal plug separating the plethysmograph from the compression cuff has been removed as superfluous. A thermometer has been introduced into the plethysmograph for recording the water temperature. Electric heating has been introduced into the plethysmograph, as described by S. K. Krasnov [4], and its temperature is regulated by a rheostat. This allows the water temperature in the plethysmograph to be maintained at a constant level (40-42°C). The manometer has been transferred from the end portion of the plethysmograph to the point on the apparatus corresponding to the beginning of the animal's tail, where larger vascular trunks are to be found. The capillary tube is replaced by a manometer with an internal diameter of 2-2½ mm. Instead of injecting water into the plethysmograph with a syringe, a siphon system has been introduced.

So that the tail can be introduced more conveniently into the plethysmograph, the rubber tube which is fixed to the free end of the manometer is clamped and the bottle of water is lowered below the level of the plethysmograph. Enlarging the lumen of the cuff allows the tail to be introduced freely into the plethysmograph. The modifications which have been carried out enable the experiments to be conducted at a constant temperature, which is essential, and they make the apparatus much easier to use. The details of the apparatus are shown in the Figure.

The constant temperature conditions in the apparatus allows observations to be made on the level of the systolic arterial pressure for 15-30 minutes.

The value of the systolic arterial pressure is determined numerically by the level of the mercury in the Riva-Rocci apparatus in the period of decompression, at the beginning of the rise of the fluid in the plethysmograph. The results of our investigations of the level of the systolic arterial pressure in healthy white rats are shown in the table.

These findings enable the trends of the systolic arterial pressure in healthy rats to be demonstrated under given temperature conditions. As a result of heating the rats, the level of their blood pressure rises. The first reading of the blood pressure approximates the natural value most closely, and may be compared with the initial values obtained from the first measurements under different experimental conditions. The tendency of the blood pressure to rise provides evidence of the state of the circulation when the body temperature rises. These readings may also be compared with those obtained during the action of various factors on the cardiovascular system, and thereby give an indication of the hyper-or hypotensive effect of different drugs. The average value of all the readings may also be taken. The appearance of a pulsating flow of blood during the investigation may indicate an increase in the propulsive power of the heart and, possibly, enlargement of the lumen of the caudal vessels.

Besides the more accurate bloodless determination of the level of the blood pressure, it is possible with this modified method to estimate at the same time the vascular tone by N. I. Arinchin's method [1, 2, 3]. The state of the vascular tone is expressed by the degree of vasodilatation and vasoconstriction of the caudal vessels, which is determined by the magnitude of the rise of the column of water in the manometer of the plethysmograph in the period of compression and decompression. Thanks to the introduction into the plethysmograph of a graduated manometric tube, 1 ml in volume and with divisions of 0.01 ml, the dilatation of the caudal vessels and their subsequent constriction can be measured with an accuracy of 0.01 ml by the rise and fall of the fluid level in the plethysmograph tube.

From the experience we have gained, the following method of investigation of the blood pressure and the vascular tone in white rats appears to be the most rational.

The chamber for the rat is heated to 25°C, after which the rat is placed inside and the electric heater switched off. After a few minutes the temperature of the chamber rises to 27°C and remains within these limits, with only slight variations for a period of many hours. Introduction of the rat into the chamber heated only to 21°C also causes the temperature of the chamber to rise gradually to 27°C. If the rat is placed in the chamber heated to 40-42°C, as recommended by Williams, the temperature of the chamber falls by 3-4°C. Thus by the method which we recommend it is not the chamber that heats the rat but the rat that heats the chamber to the temperature of its own body. Accordingly it is possible at the same time to study the process of thermoregulation (the intensity of heat emission, and the heat production, by measurement of the body temperature) in white rats under various experimental conditions. In the normal course of this work it is necessary to keep the rats at room temperature (20°C) outside the period of the investigation as well.

The frequency of measurement is of great importance. If the blood pressure is measured every minute for a long time, a reflex strengthening of the action of the heart takes place, leading to a rise in the blood pressure, while at the same time there is increased dilatation, and especially constriction of the vessels. It is therefore necessary to carry out the measurements at intervals of 3-5 minutes, and if the investigations are to last several hours this interval may be lengthened.

It is also important, if the tail is not removed, to release it from compression by the plethysmograph cuff, otherwise this causes distress to the animal, which alters its cardiac activity. It is therefore necessary, in the intervals between the individual measurements, to restore the normal blood supply to the caudal vessels without fail.

If these conditions are observed, the blood pressure is kept within limits of 80-90-110 mm of mercury in the course of observation for 4-6 hours, and the vasodilatation and vasoconstriction measure 0.02-0.04 mm of water. This is in agreement with the experimental results of Proskauer, Neumann and Graef [6]. Hence the values obtained by Williams' method vary significantly from the normal level of the blood pressure in white rats.

SUMMARY

The authors improved the Williams-Grollman-Harrison apparatus. A more convenient double-walled chamber was devised, covered by asbestos for maintaining the constant temperature. The temperature regimen of the chamber was changed. Instead of 40-42°C the investigations are carried out at 30-31°C which removes the thermal dyspnea and the thermal shock in experimental animals. The plethysmograph is filled with water by the syphon method. The temperature of the water is determined by the mounted thermometer and is regulated with the aid of a rheostat. The manometer is transferred from the caudal part of plethysmograph to its proximal part where

the large arteries of the tail pulsate. This gives more precise recordings. This apparatus permits determination of the vasoconstriction in the tail by N. I. Arinchin's method. The rise and fall of the manometric fluid level during the period of decompression is taken into consideration.

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