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A PLETHYSMOGRAPHIC METHOD FOR MEASURING SYSTOLIC BLOOD PRESSURE IN THE INTACT RAT

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By means of the technique described in this paper it is possible to make repeated measurements of the systolic blood pressure of the rat without injury to the animal.

Principle. The circulation through the tail is arrested by suddenly inflating a cuff on the root to a pressure well above the systolic level. The pressure is then gradually reduced. When the systolic level is reached, blood can enter but cannot leave the tail. The resulting increase in the volume of the tail is detected by a simple water plethysmograph.

Apparatus. The cuff (Fig. 1) consists of an outer cylindrical casing of celluloid (X-ray film) about 2·5 cm. long by 2 cm. diameter, and an inner tubular sheath of very thin condom rubber which closely invests the tail. The sheath is held at each end between an inner collar of glass tubing (0·5 mm. thick) and an outer disc of cork, the periphery of which is fixed to the outer casing. The glass collars and the rubber sheath have the same internal diameter. The length of sheath in contact with the tail should be at least 1·5 cm. An air inlet tube of narrow glass tubing is cemented into the outer casing and is attached by bicycle valve tubing to a three-way tap, through which the cuff can be connected with the outside air or with a pressure reserve bottle of about 500 c.c. capacity. The bottle is also connected with a mercury manometer and with a sphymomanometer bulb and release valve. Several cuffs must be constructed to fit tails of different thickness. They should be stored in a refrigerator and discarded as soon as the rubber begins to perish.

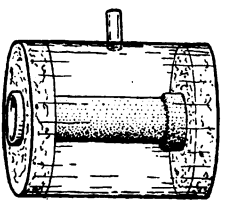

Fig. 1. The cuff.

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The plethysmograph (Fig. 2) is a glass tube about 12 cm. long and about 1 cm. internal diameter, terminating in a capillary tube of about 0·5 mm. bore, and bearing a side tube for filling and for adjusting the level of fluid in the capillary. Junction between the tail and the plethysmograph is made by green soft soap contained in a screw-capped metal gland.[1] This junction is watertight, but does not obstruct the venous return unless the soap is too hard.

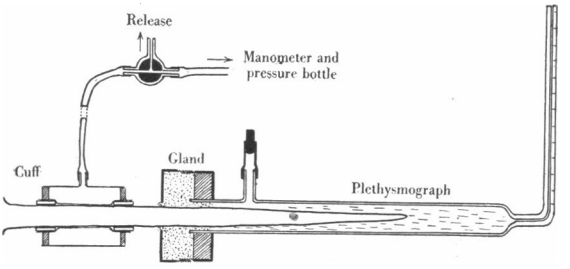

Fig. 2. The plethysmograph and cuff mounted on the rat's tail.

Procedure. A suitable cuff is fitted on the tail about 1 cm. distal to the root. The accuracy of the method depends mainly on the fit of the rubber sheath, which should be just loose enough to allow free rotation of the cuff round the tail. The cap of the plethysmograph gland is removed, packed with soft soap and replaced with the thread lightly engaged. A central core of soap is removed by a narrow bladed knife and the tail is inserted through the hole to within about 2 cm. of the cuff. The cap is screwed down until the tail is felt to be lightly gripped by the soap. The plethysmograph is filled with lukewarm distilled water, coloured with phenol red, and the level in the capillary adjusted to a convenient point. The column rises and falls slightly with respiration and finer and more rapid pulse waves are often visible. Before attempting a reading it is desirable to make sure that the venous return from the tail is not obstructed by the gland or the cuff. The venous pressure in the tail is normally so low that inflation of the cuff to a pressure of 10–20 mm. Hg is enough to compress the main veins and cause a steady rise of the meniscus in the capillary tube. If a greater pressure is needed either the cuff is too tight, the soap is too hard, or the cap has been screwed down too tightly.

[1] The brass case supplied with a microscope objective can readily be converted for this purpose.

To take a reading the air bottle is filled to a pressure of 200–250 mm. Hg and then connected with the cuff through the three-way tap. The meniscus rises abruptly as blood is milked backwards from beneath the sheath of the cuff and, if necessary, the level is readjusted. The pressure is next reduced in 10 mm. stages through the release valve. The meniscus remains stationary or falls slowly until the systolic level has been passed, when an abrupt and progressive rise is observed. The manometer reading is noted and the air in the cuff is released through the tap. The fluid column falls rapidly as blood leaves the tail. When equilibrium has been regained a second and more accurate reading is taken, the pressure being reduced in 2 mm. stages as the expected systolic level is approached. The end point is sharp.

Applications and limitations. The chief application of the technique is in experiments demanding serial readings of blood pressure at intervals over a period of weeks, e.g. in the study of experimental hypertension. For single experiments, such as testing fluids for pressor activity, direct cannulation of the carotid is more suitable. Since the slightest movement of the animal is transmitted to the plethysmograph, anæsthesia is essential. Ether has been found to be the most reliable anæsthetic provided that the concentration of vapour during induction is not excessive. Too strong an atmosphere of ether stimulates bronchial secretion which may obstruct respiration seriously enough to affect the blood pressure or even cause death. If such obstruction should occur it can generally be relieved by a suction tube inserted into the pharynx, but blood pressure readings are of little value until cyanosis has disappeared. Experience with a direct method of recording blood pressure through a carotid cannula has shown that with ether anæsthesia the pressure can be maintained within the normal range for two hours or more. Chloroform causes a pronounced fall in pressure. Diallylbarbituric acid ("Dial", Ciba) injected into the peritoneal cavity has also been used and has given results comparable to those obtained with ether. Dial anæsthesia, however, generally lasts for two hours or more, during which time the animal must be carefully observed for signs of respiratory obstruction.

Accuracy. In a series of 22 rats direct determination of systolic blood pressure was made by inserting into the carotid artery a No. 12 gauge needle connected with a mercury manometer [Rous & Drury, 1929], coagulation being prevented by preliminary intravenous injection of chlorazol fast pink [Huggett & Rowe, 1933]. Repeated readings of systolic pressure in the tail were then taken and compared with the carotid pressure. It was found that with badly fitting cuffs the two estimates

might differ by 20 mm. Hg or more. With properly fitting cuffs, however (18 out of 22 experiments), the present technique was found to give readings consistently lower than the carotid value by 10 mm. Hg or less.

Normal range. In Table I data obtained from 88 normal rats, mostly young adults, are collected, analysed, and compared with the estimates

TABLE I

Author	Method	Anæsthetic	No. of observations	Blood pressure		
				Mean	Range	Standard deviation
Durant [1927]	Direct	Ether and amytal	41	119	92–150	—
Rous & Drury [1929]	,,	Urethane	?	105	100–120	—
Chanutin & Ferris [1932]	,,	Ether	10	120	106–145	—
Leiter [1935]	,,	Sodium barbitol	69 p.c. of 131	—	101–140	—
Rubin & Rapoport [1937]	Indirect (leg)	Ether	117	119	78–154	19
Griffiths [1934]	Indirect (leg)	Nembutal	90 p.c. of more than 100	—	80–100	—
Present method	Indirect (tail)	Ether	70	106	78–132	13·0
,,	,,	Dial	18	105	87–122	11·4

of other writers. Taking three times the standard deviation from the mean value of 106 as a safe margin, readings consistently above 145 or below 65 mm. Hg may be regarded as abnormal.

SUMMARY

A method is described for measuring the systolic blood pressure of the intact, anæsthetized rat using an air pressure cuff and a plethysmograph on the tail. In normal rats anæsthetized with ether, the method gives results slightly lower than the carotid blood pressure, ranging from 78 to 132 mm. Hg with a mean value of 106 mm.

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