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A Tail Plethysmograph for Measuring Arterial Blood Pressure in Dogs.

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A successful and satisfactory method of determining the blood pressure without cannulating, puncturing or exteriorizing an artery has not been available for use on dogs. Because hematomas frequently developed after the blood pressure of hypertensive dogs had been taken by the method of Hamilton, we were stimulated to explore the possibilities of measuring the blood pressure of dogs indirectly by means of volume changes in the tail.

The tail plethysmograph developed for use on the rat by Byrom and Wilson,[1] and subsequently modified by Williams, Harrison and Grollman,[2] Friedman,[3] and Kempf and Page[4] was adapted for use on the dog. In suiting this apparatus to the dog it was necessary to compensate for certain differences between the tails of rats and dogs. The tails of rats are quite uniform in shape whereas those of dogs vary greatly in length, conformation at the base and degree of tapering from base to tip. Consequently it was not merely a matter of enlarging the apparatus used for the rat to the size necessary for the tails of dogs, but redesigning of the apparatus was necessary. Instead of a rubber-lined glass cuff as used on the tail of the rat, a latex bag (3 by 20 cm) with a cloth cover was wrapped around the base of the tail as is done with the arm in clinical sphygmomanometry. The cuff is likewise connected to a mercury manometer.

To accommodate tails of different lengths, a series of glass chambers or plethysmographs 18 to 22 cm long fashioned from glass tubing 22 mm in diameter was prepared. A 2 mm lipping of the proximal end of the plethysmograph allows the anchoring of a latex sleeve which when fitted to the tail prevents escape of water from the plethysmograph. The sleeves are easily made by dipping standard 15 cc centrifuge tubes in liquid latex a sufficient number of times to give the desired thickness.

At the closed distal end of the plethysmograph above and below are two offset outlets. To the one above is attached the water manometer, which is a 2 to 3 mm L shaped glass tube about 20 cm long. In order to reduce the inertia of the column of water the long arm of the L is placed horizontal to the long axis of the plethysmograph. The capacity of the plethysmograph is about 50 cc. By suspending the apparatus from an adjustable ringstand by a rubber sling the fluctuations of the water manometer caused by respiratory and other movements of the animal are greatly reduced (Fig. 1.).

The tail is prepared by clipping and shaving to allow a more effective seal at the proximal end. To prevent the skin of the tail from becoming watersoaked, which diminishes the sensitivity of the readings, the tail was rubbed with petrolatum. To aid further in this respect the tail was kept in the apparatus only when necessary for taking readings. Care was exercised to obtain the proper placement of the tail in the apparatus. The lip of the plethysmograph should engage the tail with a minimum of pressure so as to avoid venous stasis. Shaving soap lather or brushless shaving cream aids in making the latex sleeve into which the tail is inserted watertight.

Like the plethysmograph, the blood pressure cuff is suspended by a rubber sling. Best results were obtained by applying the cuff each time a series of readings was taken. The proximity of the cuff with reference to the chamber appeared to be inconsequential but the cuff should be wide enough to avoid a

1 Byrom, F. B., and Wilson, C., *J. Physiol.*, 1938, **93**, 301.

2 Williams, J. R., Jr., Harrison, T. R., and Grollman, A., *J. Clin. Invest.*, 1939, **18**, 373.

3 Friedman, S. M., *J. Lab. and Clin. Med.*, 1941, **27**, 240.

4 Kempf, G. F., and Page, I. H., *J. Lab. and Clin. Med.*, 1942, **27**, 1192.

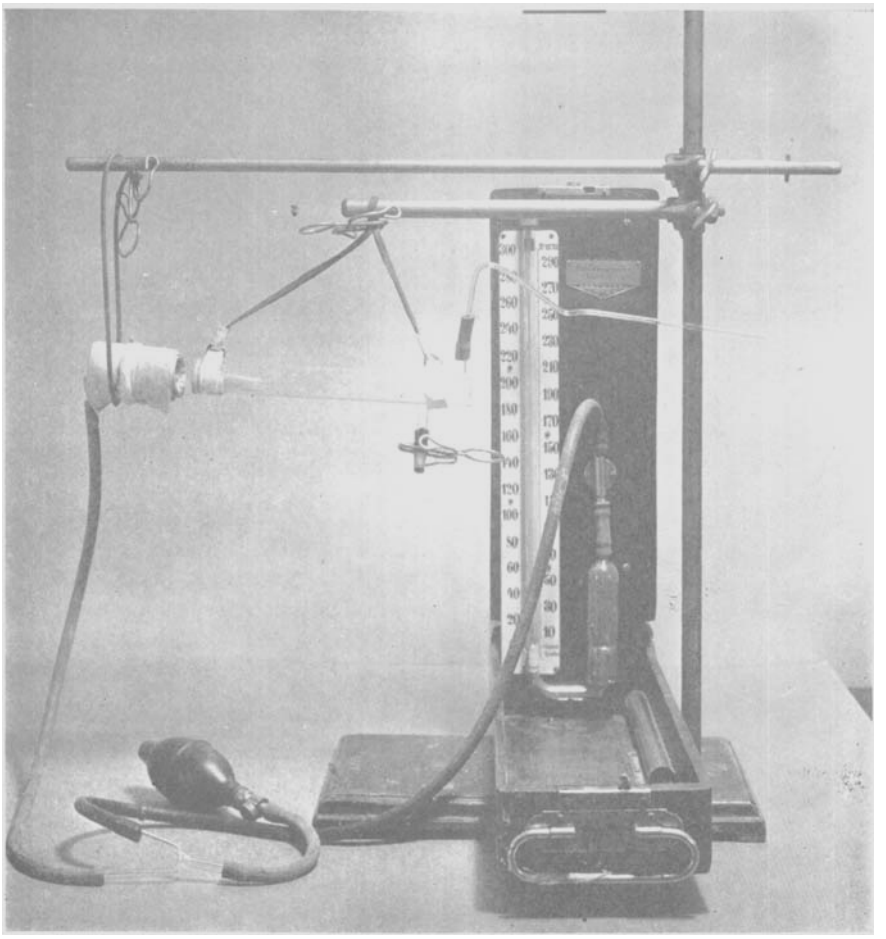

FIG. 1.
The tail plethysmograph.

narrow band of occlusion on inflation.

To measure the blood pressure, the chamber is slowly filled with water at room temperature or above and all bubbles of air are excluded. Water is forced up into the manometer tube for a distance of about 5 cm. There is at once a fluctuation of the water level of 4 to 6 mm due to the pulse. The tail cuff is then rapidly inflated to a level about 20 mm of mercury above an occlusive pressure. The cuff is then slowly deflated. If the sphygmomanometer scale and the water manometer are properly aligned, both can be observed simultaneously. At the first sign of a pulsating rise of the water in the manometer the level of the mercury is noted and this reading is taken as the systolic blood pressure. A satisfactory index of diastolic blood pressure was not found. Friedman's end point, the change of a pulsating rise in the water manometer to a slower steady rise, is not applicable to the dog since a marked pulsation is present even with no inflation of the cuff. After an observation of the systolic blood pressure the cuff should be rapidly deflated and a rest of 5 to 15 seconds given before repeating the procedure. The most satisfactory results were obtained when 4 or 5 readings were taken in rapid succession and the chamber was emptied until the next observation. If considerable time was to intervene, the tail was removed from the apparatus and again replaced just before the next observations were made.

Results. The apparatus gave constant and accurate values of blood pressure in anesthetized (pentobarbital sodium, 25 mg per kg)

TABLE I.
Data on Blood Pressures of Anesthetized, Trained and Untrained Dogs, Obtained by Direct (Arterial Puncture) and Indirect (Tail Plethysmograph) Means.

Dog	Anesthesia	Trained	Blood pressure, mm of mercury		
			Plethysmograph	Femoral artery	Difference
1	+	+	140	135	5
	—	+	140	130	10
	—	+	146	136	10
	+	+	132	126	6
	+	+	132	126	6
2	+	—	175	168	7
3	+	—	170	162	8
	+	—	138	132	6
	—	—	175	132	43
4	—	—	185	145	40
	+	—	142	134	8
5	+	—	118	110	8
	+	—	146	140	6
	+	—	118	112	6

and in well-trained dogs. It was found that inflation of the cuff sometimes caused certain dogs to contract the caudal muscles enough to give blood pressure values that were too high. In such animals local caudal or spinal block prevented this from occurring. The data obtained with the tail plethysmograph were simultaneously checked against values obtained with pressures taken by direct arterial puncture and mercury manometer. Representative data on the blood pressure obtained from trained and untrained dogs, with and without anesthesia, are given in Table I. The blood pressure of the anesthetized dog taken by the plethysmograph agreed very well with that obtained by direct arterial puncture but was, on an average, 6 to 8 mm of mercury higher, while in the unanesthetized trained dog the blood pressure was about 10 mm higher. In the unanesthetized untrained animal differences of as much as 40 mm of mercury were observed. One must, however, keep in mind the rapid vasomotor alterations of such animals to outside stimuli and recognize that changes of this magnitude may occur normally. A comparison in anesthetized animals of the response of the blood pressure obtained simultaneously with the tail plethysmograph and a mercury manometer following intravenous injections of sodium nitrite, ephedrine and pitressin showed values that differed by only a few millimeters of mercury.

Summary. The tail plethysmograph as used on the rat has been modified for use on the dog. When properly applied, it affords an easy and repeatable measure of arterial blood pressure in close agreement with values obtained by the mercury manometer.

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Nucleic Acid Derivatives as Growth Factors for Certain Group A Hemolytic Streptococci.*

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The development of a satisfactory test for the *in vitro* resistance of Group A (Lancefield) streptococci to sulfonamides has been hampered by the lack of a medium which would support adequate growth of freshly isolated strains and would, at the same time, contain little or no sulfonamide antagonists. It was

* The opinions expressed in this paper are those of the author and do not necessarily represent those of the Navy Department.