THE EFFECT OF VARIATIONS IN BLOOD-PRESSURE ON PULSE WAVE VELOCITY IN THE BRACHIAL ARTERY IN MAN.

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PULSE wave velocity, as measured by means of the hot wire sphygmograph, has been shown to vary with the pressure within the artery, and with the extensibility of the arterial wall in experiments performed upon the excised carotid artery from animals and human subjects (2, 4). By means of a hot wire sphygmograph similar to that used for experiments on the excised artery, the pulse wave velocity can be ascertained in the living subject (6), and it has been shown that the velocity increases with advancing age, closely following the rise in blood-pressure which occurs as one grows older (1). In cases where the extensibility of the arteries is identical one would expect to find a rise in pulse wave velocity with a rise in blood-pressure, as the velocity appears to vary with the pressure within the walls, apart from the consideration of external factors, such as arterial contraction.

The effect of variation of the blood-pressure upon the extensibility of an artery in the living subject has been worked out previously (3) by compressing a known length of the artery under a sphygmomanometer bandage at different pressures and estimating the pulse wave velocity in each case. This yielded a series of results showing that the increased pressure was accompanied by an increase of velocity in the affected part; but since the whole of the arm under the bandage was subjected to pressure, it was thought possible that factors, other than pressure changes within the artery, might have contributed to this result. To eliminate these external factors and to obtain a localised change of blood-pressure in one artery, our subject has remained in the same position throughout the experiment, the right arm being passively raised or lowered. In all cases we found a fall in systolic blood-pressure of 20 to 30 mm. Hg, when the arm was raised above the head from the horizontal position. The blood-pressure was read also in the left arm, first when both arms were horizontal, and secondly with the left arm in

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the same position after the right arm had been raised to the vertical position. The blood-pressure in the left arm did not vary whatever position the right arm assumed.

It has been shown previously (5) that the pulse wave velocity varies with respiratory changes, the velocity being higher during expiration than inspiration, corresponding with the higher blood-pressure in the peripheral arteries. These measurements agree with the majority of those tabulated by Wiggers (7). To obtain comparable points for measurement in similar phases of respiration, a respiratory curve was taken from the subject simultaneously with the carotid radial tracings.

Method. In making these investigations we have worked with normal subjects between the ages of 20 and 30, and have estimated the pulse wave velocity by means of two hot wire sphymographs, the one connected with the carotid artery by means of a cup-shaped receiver, and the other by the armlet of a Pachon oscillometer to the radial artery at the wrist. The instrument, which has been fully described in a previous paper (1), consists of a Wheatstone's bridge, the hot wire forming one of the arms. The sphygmographs were connected with fine copper fibres suspended between the poles of an Einthoven string galvanometer, the deflections of which, recording simultaneous carotid and radial pulsations were photographed on long strips of bromide paper. To record the respiratory curve an apex beat tambour was applied to the chest wall by an elastic bandage, and connected by rubber tubing to a second tambour with a light lever placed in the beam of light from the galvanometer. Movements of the chest wall caused a deflection of the writing point, the movements of the shadow being recorded on the same strip

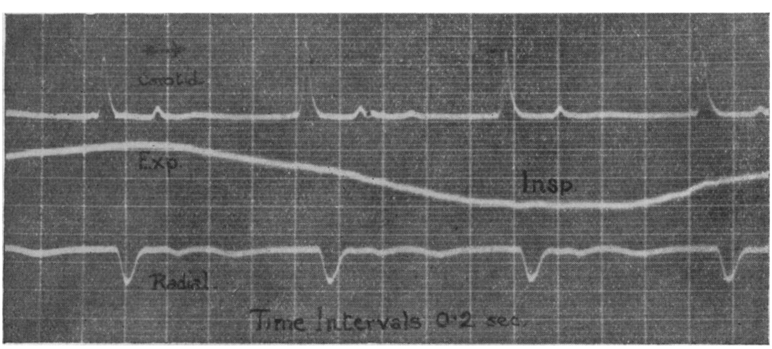

Fig. 1. Read from left to right. Curves from above downward—carotid artery, respiration, radial artery. Time in 0·2 sec.

of paper as the carotid radial tracing. A time marker cutting off the light every 0·2 sec. was employed.

The blood-pressure having been determined by the auscultatory method, over the brachial artery at the bend of the elbow, with the arm in the vertical position, records were taken of the carotid and radial pulsations. The right arm was then supported vertically upwards, to eliminate the effect of extraneous muscular contraction on the artery, and the blood-pressure was again read in a similar manner. A second record of the carotid and radial deflections was then obtained. The distance from the centre of the cup on the carotid artery to the right sterno-clavicular joint was measured, together with the length of the radial and brachial arteries from the proximal border of the radial bandage to the sterno-clavicular joint, the difference between the two being the distance traversed by the pulse wave in the time between the carotid and radial oscillations on the record.

The long paper records were measured in two ways: (*a*) by means of a Lucas Comparator, (*b*) with a glass ruler etched in millimetres. The Lucas Comparator is the more accurate method, but the majority of our measurements were taken with the glass ruler as being sufficiently accurate for the purpose. The calculation was estimated by the time lines occurring on the record every 0·2 sec., an accuracy of ·001 sec. being obtained.

Carotid-radial intervals were taken at similar points on the respiratory curve, and all these deflections were measured unless malformation of the curve was evident.

		Arm down			Arm up			
Exp.	Distance in cms.	B.P. in mm. Hg	Time in secs.	Velocity in metres per sec.	B.P. in mm. Hg	Time in secs.	Velocity in metres per sec.	Difference in vel. m. per sec.
1	52	113/65	Insp. ·0955	5·5	98/60	Insp. ·1153	4·5	1·0
			Exp. ·0885	5·9		Exp. ·1080	4·8	1·1
2	51·5	140/65	Insp. ·0972	5·3	115/60	Insp. ·1375	3·7	1·6
			Exp. ·0953	5·4		Exp. ·1334	3·9	1·5
3	47·5	130/80	Insp. ·0772	6·2	100/55	Insp. ·1115	4·3	1·9
			Exp. ·0720	6·6		Exp. ·1030	4·6	2·0
4	50·5	110/70	Insp. ·0943	5·4	85/55	Insp. ·1373	3·7	1·7
			Exp. ·0902	5·6		Exp. ·1329	3·8	1·8
5	50	115/75	Insp. ·1170	4·3	84/45	Insp. ·1456	3·4	·9
			Exp. ·1115	4·5		Exp. ·1332	3·8	·7
6	51	120/70	Insp. ·0816	6·2	100/55	Insp. ·1124	4·5	1·7
			Exp. ·0782	6·5		Exp. ·1001	5·1	1·4

The figures given for time in this table are the mean of the four or five time intervals which were measured in each case.

The velocity was worked out by estimating d/t where d is the distance between the length of the radial-brachial and carotid arteries in centimetres and t the time interval between the upstrokes of the carotid and radial deflections in seconds. The velocity was estimated in metres per second.

CONCLUSIONS.

In all our cases where a fall in blood-pressure was noted on raising the arm to a vertical position, the lengthening of the carotid-radial time interval was observed, with an appreciable slowing of the pulse wave velocity, as will be seen from the table. This postural variation in blood-pressure is considerable and must be accounted for when estimating the pulse wave velocity in arteries such as the femoral. In timing the arrival of the pulse wave at the wrist, asynchrony may be found if there is a difference between the position of the arms, the fact being of importance in certain clinical cases, such as aneurysm of the arch of the aorta. Thus asynchrony of the two pulses in cases where the external conditions are identical, indicates alteration in pressure in one artery, with delayed transmission of the pulse wave.

These variations in pulse wave velocity with small changes of blood-pressure are important as indications that constant modification of blood-pressure is occurring independently of permanent alteration of arterial elasticity.

The Expenses of this investigation were in part defrayed out of a grant from the Government Grants Committee of the Royal Society to one of us (B. A. McS.).

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