J. Physiol. (1955) 130, 467–473

THE EFFECT OF BODY POSTURE ON THE HAND BLOOD FLOW

By P. BEACONSFIELD and JEAN GINSBURG

From the Sherrington School of Physiology, St Thomas's Hospital, London

(*Received* 16 *May* 1955)

Alteration in posture from the supine to the erect normally involves a series of changes affecting many systems of the body (Hellebrandt & Franseen, 1943). The cardiovascular responses are twofold, a decreased venous return due to the direct effect of gravity on the circulating blood, and reflex vasoconstriction which operates against the effect of gravity to maintain the blood pressure (Brigden, Howarth & Sharpey-Schafer, 1950; McMichael & Sharpey-Schafer, 1944; Wald, Guernsey & Scott, 1937). Measurements of cerebral (Scheinberg & Stead, 1949), hepatic (Culbertson, Wilkins, Ingelfinger & Bradley, 1951), renal (Kattus, Sinclair-Smith, Genest & Newman, 1949; White & Rolf, 1948), and forearm (Brigden *et al.* 1950) blood flow have shown that a decreased flow occurs in these areas when the upright posture is assumed. The present investigation was undertaken to determine the effect of passive change of body posture on the blood flow through the hand. The direct effect of gravity on the circulation through the hand was eliminated by maintaining it at the same level relative to the heart throughout the experiment, tilting being applied only to the body.

METHODS

Six normal subjects and six patients who had recently undergone a cervical sympathectomy were studied. Heat tests (Landis & Gibbon, 1933) were performed post-operatively and showed that the sympathectomy was complete in all cases.

The experiments were performed in a room where the temperature was maintained at 22° C. The subject lay comfortably on a table which could be tilted rapidly from the horizontal to the vertical. He was astride a small bicycle-saddle type of seat, thus obviating the necessity of any active leg movements in the vertical position. After he had been placed on the table, with a blanket around his legs, his left arm was comfortably supported in a horizontal position at 90° to the body, the elbow being slightly flexed and the hand partially internally rotated. This position does not exercise any stretch on the blood vessels, and ensures a good venous return. Moreover, the hand is thus maintained at a constant level above the heart, whatever the position of the subject. The left hand was used in ten experiments and the right in the remaining three. Hand blood flows were measured by venous occlusion plethysmography (Barcroft & Swan, 1953), the plethysmographs being filled with water kept at 32–33° C. After the subject had been lying on the table for 15 min, and had been tilted a number of times so as to become accustomed to the procedure, recordings were started. These were made at 30 sec intervals for 4 min in the horizontal position. The table was then tilted in 3 sec to an almost vertical position (80°), and readings taken immediately, at 15 sec intervals for the first 2 min, and at 30 sec intervals for the next 2 min. The table was then returned to the horizontal and recordings of the hand flow made for a further 4 min. This procedure was repeated three or four times during each experiment, and each subject was studied at least twice on different days.

A control experiment was devised to investigate any vascular reactions which might result from the psychological effect of tilting. Recordings were made with the subject horizontal, the table was then tilted vertically and immediately returned to the horizontal, when further readings were taken and continued for 4 min.

In three subjects, the venous pressure in the veins on the back of the hand and in the antecubital fossa, was measured with either a saline or a capacitance manometer, during the process of tilting.

RESULTS

The results of forty-eight tilts from the horizontal to the vertical recorded in thirteen experiments on six subjects are shown in Table 1 and in Fig. 1. The mean flow before tilting was 12·9 ml. per 100 ml. tissue per min (Table 1, column H). One minute after the table had been tilted to the vertical, there was a fall in flow to a mean of 7·5 ml./100 ml./min (Table 1, column V_e). After this, a rise in flow occurred over the next 3 min, to a mean value of 10·5 ml./100 ml./min (Table 1, column V_l).

The effect of tilting the body from the vertical to the horizontal was tested forty-four times in twelve experiments on the six subjects. Table 2 and Fig. 2 show that the mean flow in the vertical position was 10·9 ml./100 ml./min (Table 2, column V). One minute after returning to the horizontal the flow increased to a mean of 15·0 ml./100 ml./min (Table 2, column H_e), and then it decreased, with a final value of 11·5 ml./100 ml./min (Table 2, H_l).

The results in sympathetomized limbs were very different (Fig. 3). The mean blood flow of 4·4 ml. recorded in the horizontal position was practically unchanged immediately after tilting to the vertical. Subsequently within 2–3 min, a slight decrease in blood flow occurred. This level was then maintained until the patient was tilted back to the supine, when the blood flow reached the original pre-tilting level.

In the control experiment (Fig. 4), tilting from the horizontal to the vertical, and immediately back to the horizontal position caused no significant change in hand flow, in the adapted subject. The venous pressure tracings showed little change on tilting: the collecting pressures used (70 mm Hg) were therefore adequate.

TABLE 1. Effect of tilting the body from the horizontal to the vertical on the hand blood flow (ml./100 ml. tissue/min) of six normal subjects

Expt. no.	Side	H	V_e	V_l	$H - V_e$	$H - V_l$
1	L	13·9	7·3	14·6	6·6	-0·7
2	L	15·0	6·4	11·7	8·6	3·3
3	L	9·1	3·6	5·4	5·5	3·7
4	L	11·2	8·1	9·9	3·0	1·2
5	R	9·2	3·7	7·2	5·5	2·0
6	L	15·4	8·4	13·3	7·0	2·1
7	L	17·5	14·7	16·7	2·8	0·8
8	L	9·9	6·4	7·5	3·5	2·4
9	L	11·4	8·4	15·5	3·0	-0·9
10	L	20·3	16·5	14·8	3·8	5·5
11	R	7·6	3·8	5·0	3·8	2·6
12	L	14·6	5·7	7·9	8·9	6·7
13	R	13·1	4·9	6·9	8·2	6·2
Mean value		12·9	7·5	10·5	5·4	2·68
					S.E. = 0·63	S.E. = 0·66
					$t = 8{\cdot}6$	$t = 4{\cdot}1$

H, average hand blood flow in the horizontal position for the 3 min immediately before tilting upright. V_e, average hand blood flow recorded 10–60 sec after tilting upright. V_l, average hand blood flow recorded 1–4 min after tilting upright. $H - V_e$, difference between mean flows in horizontal and early vertical phase. $H - V_l$, difference between mean flows in horizontal and late vertical phase.

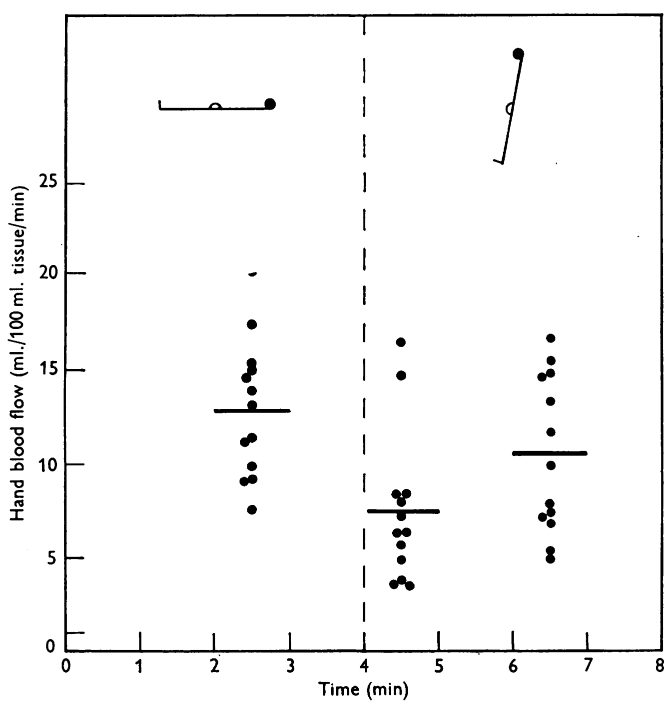

Fig. 1. Effect of tilting the body from the horizontal to the vertical in normal subjects.

TABLE 2. Effect of tilting the body from the vertical to the horizontal on the hand blood flow (ml./100 ml. tissue/min) of six normal subjects

Expt. no.	Side	V	H_e	H_l	$H_e - V$	$H_l - V$
1	L	11·7	17·1	14·9	5·4	3·2
2	L	5·4	8·9	8·0	3·5	2·6
3	L	10·1	14·2	11·7	4·1	1·6
4	R	7·2	12·6	6·5	5·4	−0·7
5	L	13·3	14·5	14·7	1·2	1·4
6	L	14·6	15·0	12·2	0·4	−2·4
7	L	16·7	21·6	14·7	4·9	−2·0
8	L	7·2	11·0	10·1	3·8	2·9
9	L	18·5	23·3	15·9	4·8	−2·6
10	L	14·8	22·1	20·0	7·3	5·2
11	R	5·0	6·9	4·8	1·9	−0·2
12	R	6·7	13·1	4·8	6·4	−1·9
Mean value		10·9	15·0	11·5	4·09	0·6
					S.E. = 0·60	S.E. = 0·74
					$t = 6·84$	$t = 0·83$

V, average hand blood flow in the vertical position for the 3 min immediately before returning to the horizontal. H_e, average hand blood flow recorded 10–60 sec after returning to the horizontal. H_l, average hand blood flow recorded 1–4 min after returning to the horizontal. $H_e - V$, difference between mean flows in vertical and early horizontal phase. $H_l - V$, difference between mean flows in vertical and late horizontal phase.

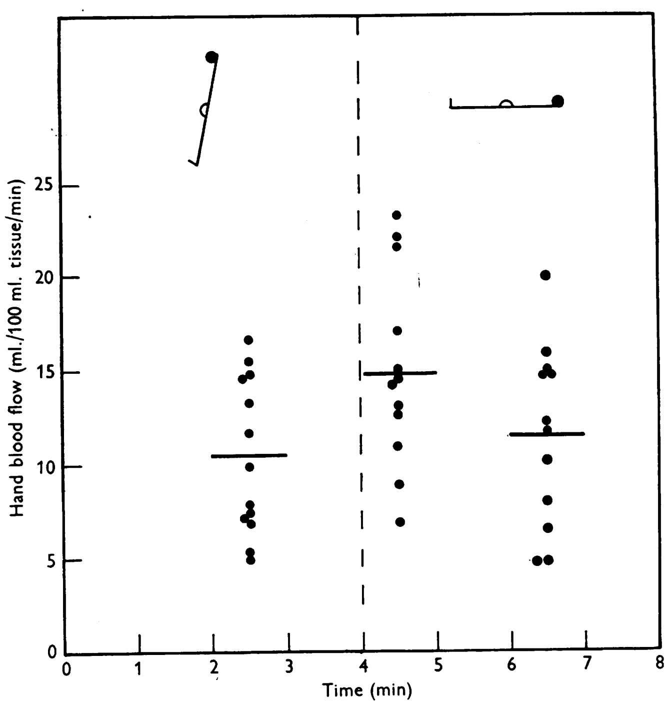

Fig. 2. Effect of tilting the body from the vertical to the horizontal in normal subjects.

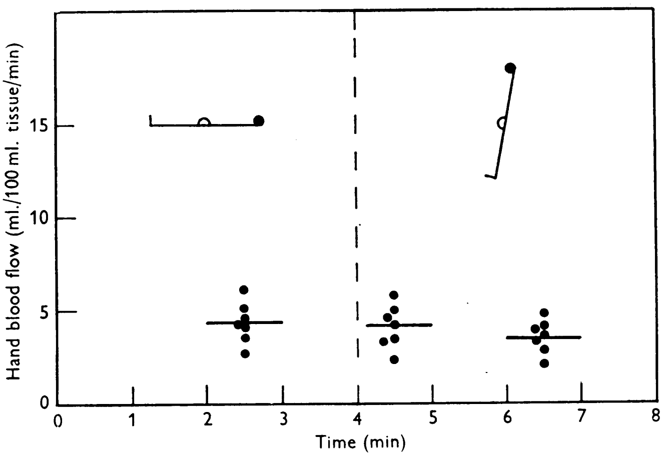

Fig. 3. Effect of tilting the body from the horizontal to the vertical in recently sympathectomized subjects.

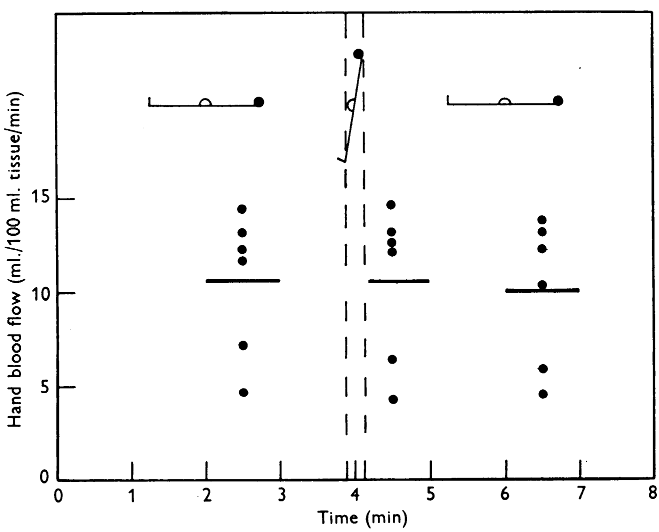

Fig. 4. Effect of tilting the body from the horizontal to the vertical and back again to the horizontal, in normal subjects.

DISCUSSION

Analysis of the results has been simplified by dividing the reaction to tilting into an immediate phase and a late phase. The immediate phase comprises the first 10–60 sec after the change in position, and the late one the succeeding 3 min. Our results show clearly that the immediate response of the circulation in the hand, maintained in an unchanged horizontal position, whilst the body is tilted from the horizontal to the vertical, is a marked vasoconstriction, of short duration. This vasoconstriction is of nervous origin and is absent in the recently sympathectomized limb (Fig. 3).

The control experiments (Fig. 4) show that the vasoconstriction is a true response to passive change of body posture (at least in the subject adapted to the conditions of our experiments), and not a general response to sensory stimulation of a similar nature to that observed following a loud noise, the application of ice to the skin, mental arithmetic, etc. Further evidence for this is suggested by the changes observed on tilting from the vertical to the horizontal position. One would expect the psychological effect of tilting, if important as a factor in our experiments, to operate similarly when the subject was moved from the vertical to the horizontal, and thus cause, at least in the immediate phase, a vasoconstriction. Table 2 and Fig. 2 show that this is not so, a definite vasodilation occurring in all our normal subjects.

As shown in Table 1 the initial vasoconstriction is not maintained and during the late vertical phase, a rise in blood flow occurs, to a level only slightly less than that observed with the body horizontal. The difference between the mean values in the horizontal and late vertical phases is still statistically significant ($t=4{\cdot}1$). The sympathectomized hand in the late phase, shows a similar decrease in flow (a mean of 3·5 ml./100 ml./min compared with the mean of 4·4 in the horizontal). It would appear, therefore, that the decreased flow which is observed in the late vertical phase, and which occurs in both normal and sympathectomized limbs, is not of nervous origin, but may be a mechanical effect, resulting either from the decreased pulse pressure in the vertical position, or possibly from a slight alteration in hydrostatic pressure.

One might therefore conclude, that, in the long run, the vessels of the hand do not participate in the vasoconstriction which maintains the blood pressure in the vertical position. We would like to point out, however, that these results, although constant and clearcut, refer to changes in hand blood flow occurring in strictly defined conditions, and in subjects thoroughly used to the procedures involved. The applicability of these results to more normal conditions, must, therefore, be accepted with certain reservations. Normally the erect posture is not achieved by passive movement: muscular activity is considerable, sensory stimulation may be marked, and the position of the hand frequently altered. These factors will undoubtedly alter the circulation through the hand and may prolong and reinforce the vasoconstriction which we have demonstrated occurs in the completely passive subject.

The reflex nature of the early vasoconstriction, and its dependence on an intact sympathetic system is established: the exact afferent and efferent pathways are however not clear. In the late phase, the carotid sinus, which in animals was thought to be vital for the maintenance of the circulation during postural change (Heymans, Bouckaert & Dautrebande, 1931) would not appear to exert a significant influence on the blood vessels of the hand in the conditions of our experiments.

SUMMARY

1. The reaction of the circulation in the hand to a passive change in body posture has been studied in normal and sympathectomized subjects by means of venous occlusion plethysmography.

2. The immediate response of the circulation in the hand (maintained in an unchanged horizontal position) to a change in body posture from the horizontal to the vertical is a vasoconstriction of short duration which is absent in the recently sympathectomized limb.

3. The immediate vasoconstriction is followed by a rise in flow to a mean level only slightly less than that recorded in the horizontal position.

The authors have pleasure in expressing their indebtedness to Prof. H. Barcroft for his constant encouragement and advice, to Prof. E. P. Sharpey-Schafer for the loan of apparatus, and to Miss Harrill of the Physiotherapy School of St Thomas's Hospital for assistance in providing subjects. Prof. C. G. Rob and Prof. I. Aird very kindly allowed us to study their patients. Mr G. T. Hales gave efficient technical assistance.

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