THE ABSENCE OF VASOCONSTRICTOR REFLEXES IN THE FOREHEAD CIRCULATION. EFFECTS OF COLD

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Plethysmographic data were presented in earlier publications (1, 2, 3) to illustrate the selective character of vasomotor activity in the skin. These plethysmograms indicated the absence of vasoconstrictor reflexes in head skin (with the exception of the ear). It has been suggested that these results “may be due rather to relative vasomotor inactivity of certain vessels than to an independence of rhythmic activity” (4).

It is possible that vasoconstrictor fibers do not reach the forehead skin. There are many observations which so suggest: the constancy of the forehead temperature and its failure to fall during prolonged constriction of the fingers and toes; the throbbing of the temporal artery during excitement; the frequent increase in forehead volume pulses during vasoconstrictor discharges (1); the relative constancy of the blood supply of head skin during massive disturbances of the circulation by drugs (5); the failure of unilateral cervical sympathectomy to increase the temperature of the forehead skin on that side (6)—the effects are also very small on the cheek, upper lip, nose and chin.

The present communication reports data which extend this list and further deny the existence of vasoconstrictor reflexes in the forehead skin. The reactions of the minute arteries in the forehead skin were studied by recording their volume pulses with the photoelectric technique which has been described elsewhere (7).

RESULTS. Spontaneous arterial constrictions which are seen so commonly in plethysmograms of the extremities and which are generally considered as due to vasomotor activity, have not been observed in the forehead skin. A striking illustration is provided in figure 1 obtained from a normal male while he rested, slept, and awakened. The frequent vasomotor discharges to the finger are wholly absent in the forehead. Reduction in finger flow (third record), probably due to increased vasomotor tone, occurred without evident change in the forehead circulation.

Startle due to loud unexpected noises, immersion of the hand in ice water, or a deep breath, are known to elicit vasoconstrictor reflexes which not only affect both the upper and lower extremity, but also are often sufficiently extensive to increase the arterial blood pressure. If these stimuli are effective, the finger’s

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vessels are always constricted in the normal subject. At times, the vasoconstrictor reflexes so elicited may include the vascular areas in the calf and forearm (8), but the constrictor effects here are weak compared to those in the hand and foot. We have seen no instance of arterial constriction in the forehead in response to these stimuli, irrespective of how intense the effects may have been in the finger. Figure 2 illustrates. The stimuli of a loud noise, of immersion of the opposite hand in ice water and of a deep breath were supplied in succession. The effect of awakening the sleeping subject by the observers' cough is also shown. Decisive constriction occurred in the finger in each case. If there had been a weak constriction in the forehead skin, there would have been at least a slight decrease in the volume pulse here. But there is no indication whatever in these records of a vasoconstrictor action on the forehead arteries.

An effective method of eliciting constriction in cutaneous vessels is the local application of cold. Effective chilling of the forehead skin in such a manner as to permit simultaneous and continuous recording of the volume pulses of the chilled skin proved to be fairly difficult. We tried various applicators made of rubber dam through which cold water could be circulated. These were large enough to cover most of the forehead. A hole cut in the center permitted the
plethysmograph to reach the small skin area which was surrounded by skin in contact with the cold surface of the applicator. Dissatisfied with the small fall in temperature so induced in the skin directly beneath the plethysmograph,

we constructed an applicator of segments of copper sheeting which were soldered to short pieces of copper tubing. The latter were connected closely together by rubber tubing. This arrangement provided an excellent broad comfortable

Fig. 2. Absence of vasoconstrictor reflexes in forehead skin. At 1, the sleeping subject was awakened by the observer’s cough. At 2, a loud noise. At 3, immersion of the opposite hand in ice water. At 4, a deep breath. Upper volume pulse record from finger pad, lower from forehead. Respiration. Time: 5 sec.

Fig. 3. Effects of moderate cold applied to the forehead by means of cold water circulated through a hollow rubber applicator which was in contact with the forehead. The cold was applied between the vertical signals. Upper volume pulse record from the finger pad, lower from the forehead. Respiration. Time: 5 sec.

Fig. 4. Effects of more prolonged application of more intense cold than that applied in figure 3. The cold was applied at the break in the forehead temperature curve. Recovery of the forehead circulation was incomplete at the end of the observational period. No pain was experienced. The time intervals between the sections of the figure are: between sections 1 and 2, 12 minutes: between sections 2 and 3, 21.5 minutes. The records from above, downwards: finger pad temperature, finger pad volume pulse, forehead temperature, forehead volume pulse, time (5 sec.), respiration.
contact with the forehead skin. A gap in its middle provided for the application of the plethysmograph, as with the rubber applicator. Despite the excellent contact with the skin and the high thermal conductivity of copper, this device was not much more successful than the rubber applicator in lowering the temperature of the skin either directly under it or under the plethysmograph. The

cold applicator and the plethysmograph were suspended from a plaster of Paris cast of the subject's cranium as illustrated elsewhere (9). This device is comfortable and permits prolonged observations.

On starting the flow of cold water (chilled to 4–8°C.) through the applicator, constriction occurred at once in the control finger but not immediately in the forehead skin which was being cooled (figs. 3–6). The intensity and duration of the constriction in the finger varied with subjects; there was no obvious correla-
tion with the sensations. Constriction appeared gradually in the forehead skin as its temperature fell. Cooling took place rather slowly and its action on the forehead vessels required periods as long as twenty minutes to attain a maximal decrease in the volume pulse. The cooling was insufficient in all instances to secure complete constriction. The decrease in pulse amplitude varied in the individual experiments between 32 and 90 per cent of the control value. In no instance was there any indication of a vasoconstrictor reflex in the forehead skin, although in many trials the reduced volume pulses and the increased frequency of "spontaneous waves" in the finger during the cold application showed that the cold stimulus continued to be effective in eliciting vasoconstrictor reflexes.

The absence of the initial constriction to cold in the forehead skin is comparable to those rare cases described in a previous paper (10), in which chilling of the finger or toe results in gradual constriction when vasoconstrictor reflexes are not elicited by the cold. Also, the sympathectomized toe responds to cold as does the forehead skin (10). These analogies in responses strongly support our thesis that vasoconstrictor reflexes are wholly absent from the forehead skin.

In a few experiments (figs. 5 and 6), the forehead volume pulse was considerably increased during the cold application at the time of sharp constriction in the finger (fig. 6) or when pain in the forehead was experienced (fig. 5). This effect may have been due to an increase in pulse pressure or to a vasodilator reflex elicited in the forehead by the pain. There is evidence that vasodilator fibers reach the forehead by way of the cervical sympathetic (6). Thus, neither emotional flushing nor the flushing due to over-heating occur on the denervated side of the face and forehead after unilateral cervical sympathectomy (6).

The increase in amplitude of the forehead volume pulses (fig. 5) with the onset of pain, when constriction of the forehead vessels due to cold had already occurred, recalls the correlation between the amplitude of the temporal artery pulsations and the presence or absence of headache (11). However, none of the subjects confused the pain from the local cold application with headache. The pain was somewhat similar to a sharply localized headache but contrasted notably with the intense frontal ache produced by strong winds on a bitter cold day. The difference seemed to be primarily one of intensity and may well have been due to failure to cool adequately. Some subjects experienced only a sensation of cold.

The reactive dilatation which is so characteristic of the finger's reactions to cold was not observed in the forehead skin. This may have been due to inadequate cooling as we seldom succeeded in chilling to the point where the constriction was sufficient to eliminate the volume pulse. The lowest temperature reached in these experiments was 21°C. which is above that at which the reactive dilatation is usually induced in the finger. It is also possible that the arteriovenous anastomoses are too few in number in the forehead skin for a reactive dilatation to occur. Information is lacking on this point.

Recovery of the forehead circulation and of the forehead temperature after ending the cold applications proceeded slowly, thus contrasting sharply with the recovery in the finger (10) where the rise in temperature and the arterial dilata-
tion occurred rapidly. The slowness of recovery in the forehead may have been related to the absence of any indication of a reactive dilatation there. It may also have been affected by the thermal capacity of the cold applicator. Yet, recovery in the finger was also subject to the same delaying influence but proceeded swiftly.

SUMMARY

The absence of vasoconstrictor reflexes in the forehead is demonstrated by the following evidence:

1. The spontaneous rhythmic constrictions of vasomotor origin in the finger of the resting subject are absent from the forehead.

2. The vasoconstrictor reflexes elicited by startle, awakening, a deep breath, immersion of the hand in ice water or local cold to the forehead are wholly absent in the latter.

3. The vascular reactions of the forehead skin to local cold are like those of a sympathectomized digit. Constriction is gradual as the temperature of the skin falls and seems to be due to the direct effects of cold on the vessels.

The reactive dilatation to cold which occurs in the fingers, was not observed in the forehead skin.

Occasionally, there was indication of a vasodilator reflex in the forehead skin at the time of a powerful constriction in the finger.

REFERENCES

(1) HERTZMAN, A. B. AND J. B. DILLON. This Journal 127: 671, 1939; 130: 50, 1940.
(2) HERTZMAN, A. B. This Journal 134: 59, 1941.
(3) HERTZMAN, A. B. AND L. W. ROTH. This Journal in press.
(4) BURTON, A. C. AND R. M. TAYLOR. This Journal 129: 565, 1940.
(6) LEWIS, T. AND E. M. LANDIS. Heart 15: 151, 1930.
(7) HERTZMAN, A. B. AND J. B. DILLON. This Journal 130: 177, 1940.
(10) HERTZMAN, A. B. AND L. W. ROTH. This Journal, in press.