

INFLUENCE OF CYCLOPROPANE UPON PERIPHERAL BLOOD FLOW IN MAN * †

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LITTLE is known concerning the peripheral vascular responses in man to the administration of the various inhalation anesthetics. According to Waters (1), cyclopropane in anesthetic concentration relaxes peripheral blood vessels, with the result that the oxygen saturation of the venous blood becomes equal to that of arterial blood even when the inspired oxygen is 21 per cent. Associated with this is an apparent increase in capillary bleeding, which is considered by Marshall (2) to be due in part to the absence of compensatory sympatheticotonia and hyperadrenia.

Mann and his associates (3), using a modification of Rein's thermomastromuhr (4), studied the effect of ether in dogs and found that under light surgical anesthesia there was an average increase in flow in the peripheral arteries of approximately 64 per cent. as compared to the flow under local anesthesia. With profound anesthesia, the increase in flow rarely amounted to more than 20 per cent. These authors concluded that the findings with light ether anesthesia could be attributed to a decrease in vasomotor tone without effect upon blood pressure, thus causing an increase in the flow of blood. Under deep anesthesia both the vasomotor tone and general blood pressure were depressed, causing flow of peripheral blood to diminish.

Since the peripheral vascular responses to the administration of a general anesthetic agent may play an important role in the post-anesthetic status of the patient, it was thought worth while to investigate the changes produced by cyclopropane in man by means of the venous occlusion plethysmographic method.

METHOD

The study was performed upon 12 subjects who were suffering from various conditions necessitating surgical intervention. The peripheral vascular system, however, was normal in each case. The procedure generally followed consisted first of obtaining a control level of blood flow immediately before the anesthetic was begun; in a number of instances, however, basal readings were taken either a few days before or after the operation. During the administration of the anesthetic, determina-

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tions of blood flow were generally made in the periods before and after the actual surgical procedure, in order to minimize the reflex effect upon peripheral blood flow of the associated irritation and trauma of tissues. All of the subjects had preoperative medication consisting of either $\frac{1}{6}$ to $\frac{1}{4}$ grain morphine sulphate with atropine sulphate, or $1\frac{1}{2}$ to 3 grains of nembutal, or both.

Blood flow readings were obtained in the following manner: A hand or a forearm was placed in an appropriately shaped plethysmograph and the system was made water-tight by stretching a rubber diaphragm through which the extremity passed, over the opening or openings in the apparatus. The diaphragm was held in place with a ring and reinforced by a felt pad and two leaves of an iris diaphragm. A rubber cuff, an extension of the rubber diaphragm, was attached to the skin with rubber cement. The plethysmograph was then filled with water at 32 C. and connected to a recording system consisting of a Brodie's bellows and pen writing lever; the latter recording changes in limb volume on a fast moving drum. The actual blood flow determination was obtained by suddenly applying a pressure of about 70 mm. Hg to the extremity, proximal to its insertion into the plethysmograph. Since this was sufficient to stop venous outflow without interfering with arterial inflow—at least for the first few seconds of application—the extremity increased in size. The rate of increase depended upon the rate at which the blood entered the limb. This change in volume was recorded on the drum, and by means of water calibration of the plethysmograph, the quantity of blood entering the extremity in the first second was determined. From this figure the number of cubic centimeters of blood flow per minute per 100 cc. of limb volume was calculated. In studying blood flow in the forearm, a pressure of 300 mm. Hg was maintained at the wrist during the actual determination, to prevent venous return from the hand. The temperature of the operating room was generally 25 C. (For further details as to technique reference can be made to previous work (5).)

RESULTS

The hand was studied six times, and in every instance a significant increase in blood flow was observed during the period of surgical anesthesia. The average maximal increase was four times the control resting level of blood flow. No correlation, however, could be observed between the several planes of surgical anesthesia and the magnitude of the increase in flow. The response depicted in Figure 1 is typical of the results for the hand.

The forearm was studied six times and in every instance but one there was a significant increase in blood flow during the period of surgical anesthesia. In the one exception, the control level of blood

flow was unusually high, being 2.6 cc. per min. per 100 cc. of limb volume (instead of the normal average of 1.8 cc.), and the flow during the period of anesthesia did not rise above this level. In the remaining cases, the average maximal increase was four times the control flow of resting blood. Again, as in the hand, no correlation was observed between the depth of the anesthesia and the height of the increased flow. The graph in Figure 1 is typical of the results for the forearm.

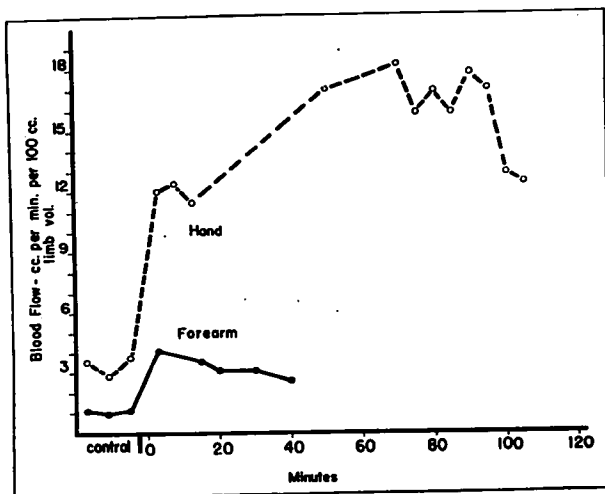


FIG. 1. Typical responses in hand and forearm to the administration of cyclopropane anesthesia. Hand-average control flow of 3.1 cc. per min. per 100 cc. limb vol. With onset of anesthesia, flow immediately increases, reaching a maximal level of 18 cc. Forearm—average control flow of 1 cc. With onset of anesthesia, flow increases to a maximal level of 4 cc. Bath temperature—32 C.

The changes in the blood pressure and pulse rate with cyclopropane anesthesia were similar to those previously reported by other authors (6). In most instances no significant increase in blood pressure was observed. The pulse rate either remained unchanged or even decreased somewhat as compared with control resting level.

DISCUSSION

The reported data definitely indicate that during surgical anesthesia produced by cyclopropane there is a significant increase in peripheral blood flow through at least the upper extremities. The findings in the hand can probably be explained on the basis of a diminution in tone of the vasomotor system, with a resulting vasodilatation of skin vessels.

This explanation, however, does not apply to the findings in the forearm, since it has been shown that the blood vessels in this portion of the upper extremity are not under the control of the vasomotor center under ordinary environmental conditions (7). The possibility that there is an increase in cardiac output, and hence a passive vasodilatation of the forearm blood vessels during cyclopropane anesthesia, is largely negated by the finding of only insignificant changes in blood pressure and pulse rate. The remaining possibility, therefore, that cyclopropane produces an active vasodilatation of blood vessels in the forearm, either directly or by stimulation of vasodilator nerves, must be seriously considered.

Since all the patients in the series had received various types of preoperative medication, the question arises as to whether the drugs played any role in the increase in flow observed during the anesthetic stage. Since the medications were given at least one-half hour before anesthesia was begun, it is quite probable that sufficient time was present for any peripheral vascular responses that might have been elicited by them to manifest themselves and thus influence the level of the control flow of resting blood. It therefore seems reasonable to assume that the change in flow observed within a few minutes after the administration of cyclopropane (Fig. 1) was due primarily to the effect of the anesthetic.

SUMMARY AND CONCLUSIONS

The effect of cyclopropane anesthesia upon the rate of flow of peripheral blood was studied in a series of 12 subjects by means of the venous occlusion plethysmographic method. Because of the known differences in the response of the blood vessels in the hand and forearm, each of these blood beds was observed separately.

In all cases but one there was a significant increase in peripheral blood flow through both the hand and forearm during surgical anesthesia. The average maximal response was four times greater than that observed during the control period.

The increase in blood flow through the hand can probably be explained upon the basis of a diminution of vasomotor tonus with a resulting vasodilatation of blood vessels. The increase in blood flow in the forearm may be due to an active vasodilatation of blood vessels.

The reported findings are in accord with, and add to, the previous observations concerning the peripheral vascular responses to cyclopropane anesthesia.

REFERENCES

1. Waters, R. M.: Present Status of Cyclopropane, *Brit. M. J.* 2: 1013 (Nov. 21) 1936.
2. Marshall, S. V.: Cyclopropane Anesthesia: A Preliminary Survey, *M. J. Australia* 2: 138 (July 24) 1937.
3. Mann, F. C.; Essex, H. E.; Herrick, J. F., and Baldes, E. J.: The Flow of Blood in Relation to Anesthesia and Operation, *West. J. Surg.* 43: 177 (April) 1935.

4. Rein, H.: Die Thermo-Stromuhr. Ein Verfahren zur fortlaufender Messung der mittleren absoluten Durchflussmengen in uneröffniten Gefäßen in situ, Ztschr. f. Biol. 87: 395 (June) 1928.
5. (a) Abramson, D. L.; Zazecela, H., and Marrus, J.: Plethysmographic Studies of Peripheral Blood Flow in Man. I. Criteria for Obtaining Accurate Plethysmographic Data, Am. Heart J. 17: 194 (Feb.) 1939. II. Physiologic Factors Affecting Resting Blood Flow in the Extremities, Am. Heart J. 17: 206 (Feb.) 1939. (b) Ferris, E. B., Jr., and Abramson, D. I.: Description of a New Plethysmograph, Am. Heart J. 19: 223 (Feb.) 1940.
6. Seevers, M. H., and Waters, R. M.: Pharmacology of the Anesthetic Gases, Physiol. Rev. 18: 447 (July) 1938.
7. Abramson, D. I., and Ferris, E. B., Jr.: Responses of Blood Vessels in the Resting Hand and Forearm to Various Stimuli, Am. Heart J. 19: 541 (May) 1940.

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STOUFFER'S RESTAURNT, 3 E. 57TH STREET, NEW YORK CITY

APRIL 10, 1941—7:30 P.M. DINNER—6:00 P.M.

1. Misuse of Adrenalin During Anesthesia; a Case Report.
By Mary Lou Byrd, M.D., Senior Resident in Anesthesia at Bellevue Hospital, New York City. (Lantern Demonstration.)
2. Cyclopropane Anesthesia with a Statistical Report of 40,000 Cases.
By Ivan B. Taylor, M.D., Director of Anesthesia, Hospital of the University of Pennsylvania, Philadelphia, Pa.
3. Effects of Narcotics and Other Chemical Agents on Nerve.
By Detlev W. Bronk, M.D., Professor of Physiology and Chairman of the Department of Physiology and Bio-Physics, Cornell University Medical School, New York City.

COMING EXAMINATIONS

AMERICAN BOARD OF ANESTHESIOLOGY: *Oral*. Part II. Cleveland, Ohio, May 31–June 1, 1941. Final date for filing application is April 1, 1941. Sec., Dr. Paul M. Wood, 745 Fifth Ave., New York.