

# STUDIES ON COLLATERAL CIRCULATION. I. THERMIC CHANGES AFTER ARTERIAL LIGATION AND GANGLIONECTOMY

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The temperature of a part of the body depends largely upon its blood supply. Under certain conditions, the temperature may therefore be a fair measure of the circulation. With this in view, a series of experiments was planned to approach the problem of collateral circulation and eventually the mechanism of vasomotor action. The group of experiments here presented deals with the thermic changes occurring in the hind feet of the dog: (a) following ligation of the external iliac artery, and (b) following ligation of both external iliac arteries and unilateral removal of the tributary sympathetic ganglia.

## METHOD

The animal was given sodium amytal [Lilly] (50 to 75 mgm., i.e., 0.5 to 0.75 cc. of a 10 per cent solution per kilogram of body weight) intraperitoneally and was attached by thermopiles to a Leeds and Northrup potentiometer temperature recorder<sup>1</sup> about half an hour later. The four leads of the recorder were connected to register subcutaneous temperatures of the right foot (1), and of the left foot (2), temperatures of the rectum (3), and of the room (4) respectively, once every four minutes. After an equilibrium had been established, one or both external iliac arteries were exposed retroperitoneally and doubly ligated as close to the aorta as was practicable. In experiments (b) both external iliac arteries were similarly ligated and in one group of experiments the rami communicantes of the tributary sympathetic ganglia of one limb were severed and the ganglia removed after the temperature of both feet had decreased to room temperature and had remained there for some time; in another group the tributary sympa-

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<sup>1</sup> The authors are indebted to the Leeds and Northrup Co., North Philadelphia, Pa., for the use of this instrument.

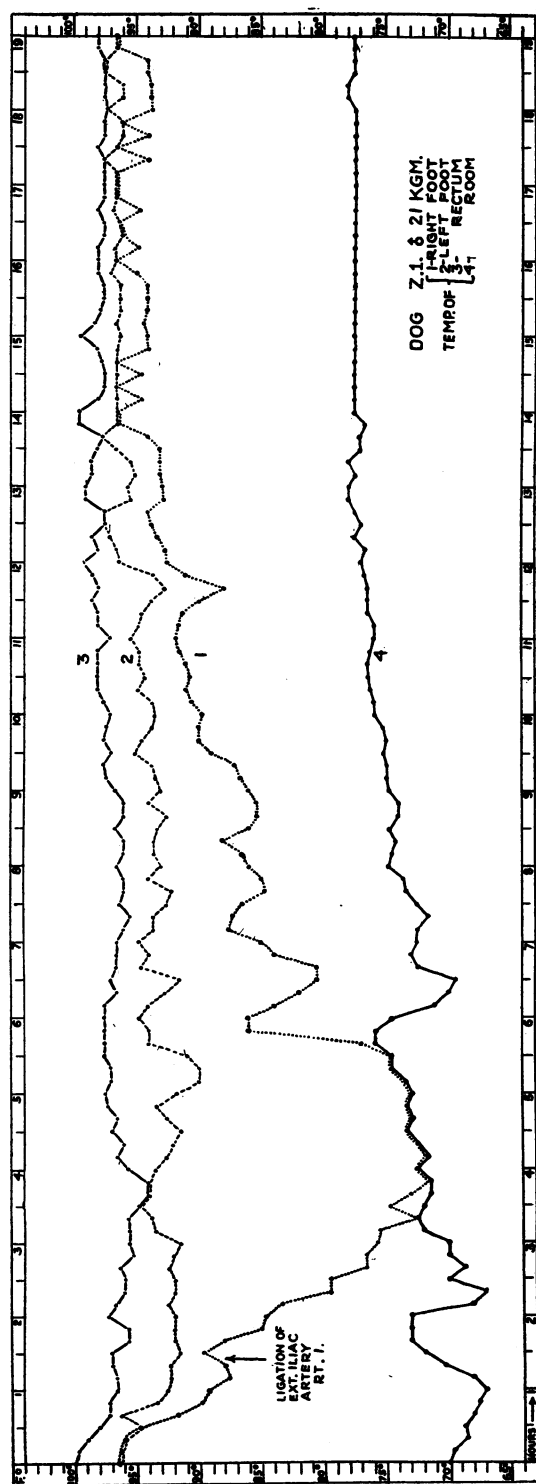


FIG. 1. DOUBLE LIGATION OF THE RIGHT EXTERNAL ILIAC ARTERY CLOSE TO THE AORTA WAS FOLLOWED BY A DECREASE OF THE TEMPERATURE OF THE CORRESPONDING FOOT TO ROOM TEMPERATURE, A DROP OF APPROXIMATELY 20° F., WHERE IT REMAINED FOR NEARLY 2 HOURS. After numerous fluctuations with a trend upward, it reached the temperature of the other leg at about the 13th hour following the ligation.

thetic ganglia were removed on one side immediately after ligation of the arteries.

#### EXPERIMENTAL DATA

Ligation of the external iliac artery proximal to the profunda femoris was always followed by a marked decrease of the temperature of the foot of the corresponding limb. The lowering of the temperature was either gradual or sudden and usually the temperature of the foot reached that of the room in approximately 2 to 6 hours after a drop of about 10° to 30° F. In the majority of the experiments a rise in temperature and a return to the previous level occurred in about 13 hours following the ligation. The experiments were usually carried out on one limb, using the other as a control (fig. 1). The phenomenon, however, was approximately the same when both external iliac arteries were ligated, i.e., the decrease in temperature was simultaneous in both feet and the return to previous level also occurred at about the same time (fig. 2).

In those experiments in which both external iliac arteries were ligated and the temperature of both feet had decreased to room temperature, cutting of the rami communicantes and removal of the tributary sympathetic ganglia of one limb caused a sudden rise in temperature of the corresponding foot. The change in temperature of the foot, from room temperature of about 70° F. to nearly that before ligation, usually occurred in about one hour and remained elevated until the end of the experiment several hours later, whereas the temperature of the other foot remained unchanged at room temperature (fig. 3). Transection of the rami communicantes and removal of the tributary sympathetic ganglia of one limb following ligation of its artery prevented the drop in temperature of the foot of the corresponding limb (fig. 4).

#### COMMENT

The reason for choosing the site of ligation as high as the origin of the external iliac artery from the aorta lies in the anatomic peculiarities of the blood supply of the lower extremities of the dog. The external iliac artery is a direct branch of the aorta in this animal and the profunda femoris leaves the external iliac artery within the pelvis. It was found that ligation of the femoral artery in Hunter's canal or of the external iliac artery distal to the origin of the profunda femoris led

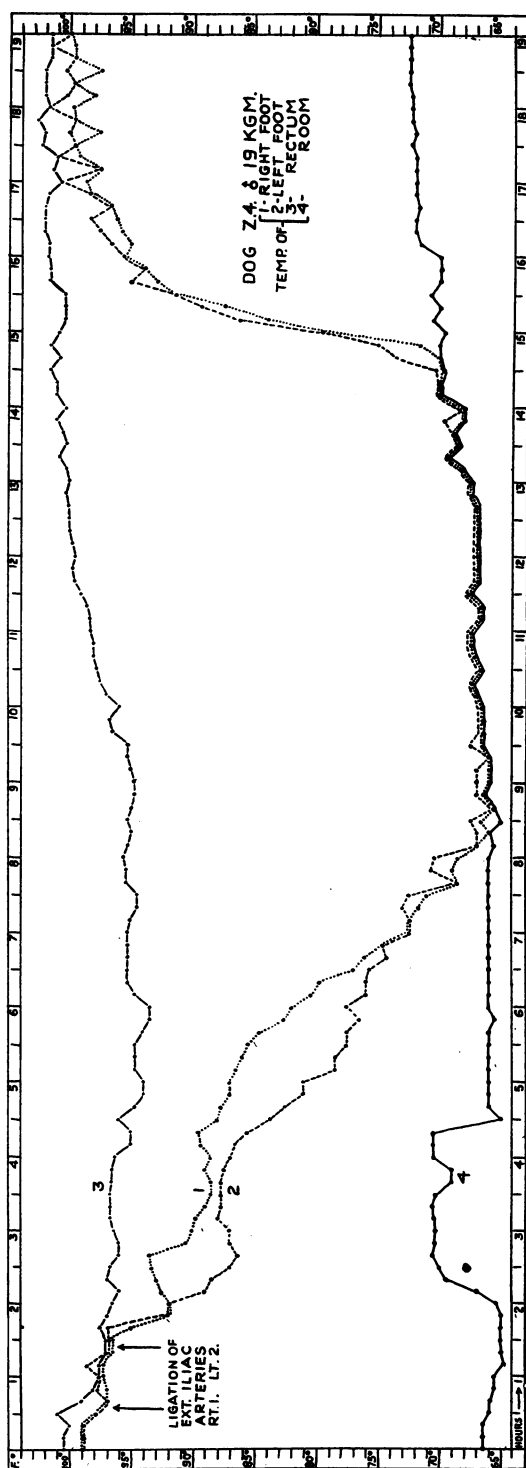


FIG 2. LIGATION OF BOTH EXTERNAL ILIAC ARTERIES CLOSE TO THE AORTA WAS FOLLOWED BY A GRADUAL DECREASE OF THE TEMPERATURE OF BOTH FEET OF NEARLY 30° F. TO ROOM TEMPERATURE. It remained there for almost 6 hours, then with a steady rise it returned to the level before ligation.

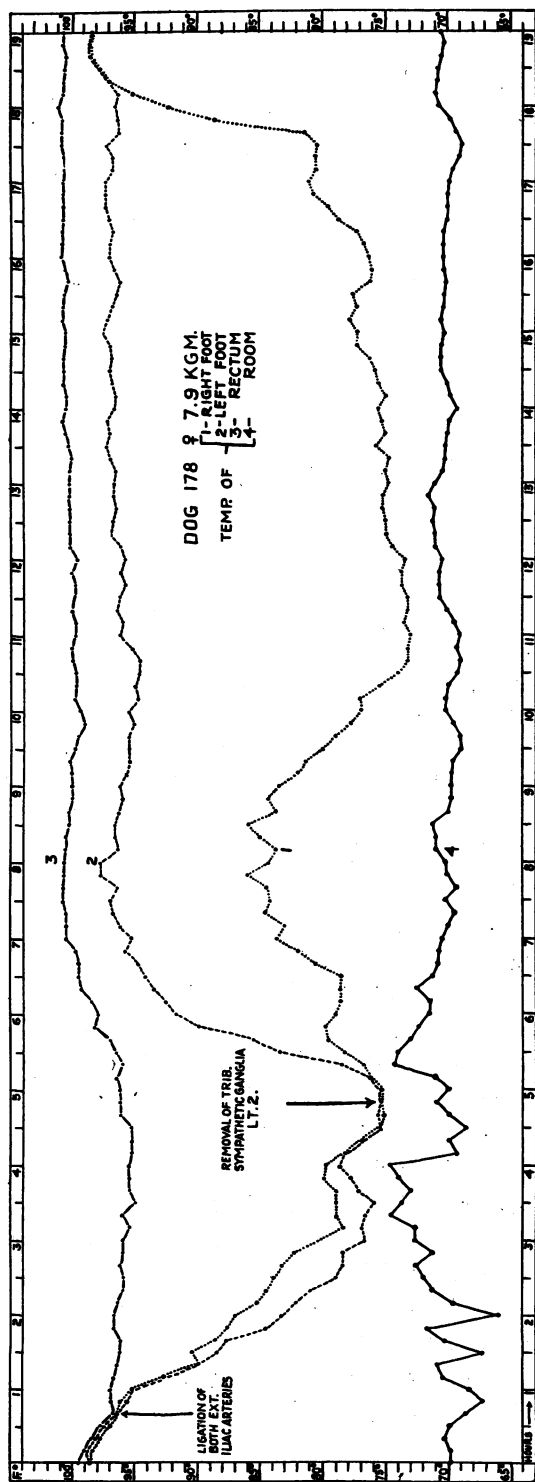


FIG. 3. DOUBLE LIGATION OF BOTH EXTERNAL ILIAC ARTERIES CLOSE TO THE AORTA WAS FOLLOWED BY A DECREASE OF ABOUT 20° F. IN THE TEMPERATURE OF BOTH FEET. Transection of the rami communicantes and removal of the tributary sympathetic ganglia of the left limb caused a rise in temperature of about 20° F. of the corresponding foot. This temperature difference was maintained for about 12 hours when a rise in temperature of the other foot abolished the difference.

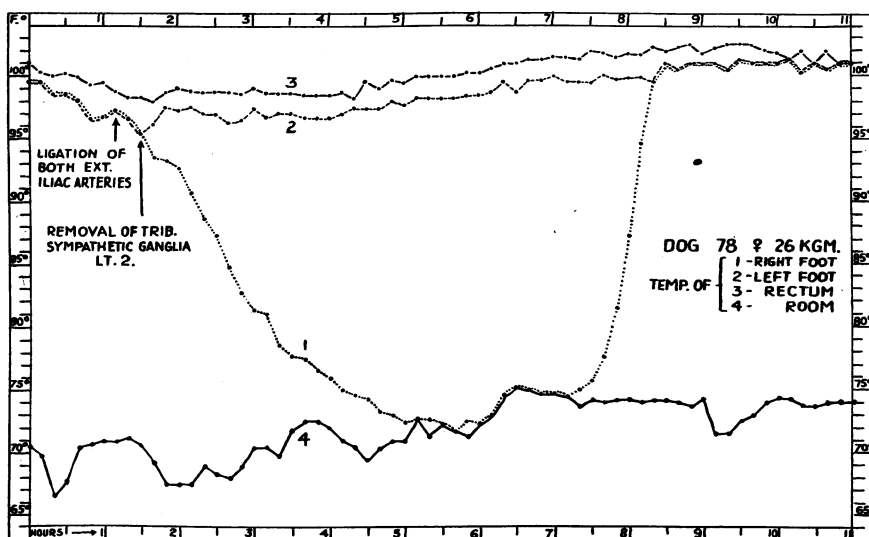


FIG. 4. DOUBLE LIGATION OF BOTH EXTERNAL ILIAC ARTERIES CLOSE TO THE AORTA WAS FOLLOWED BY AN INITIAL DECREASE IN TEMPERATURE IN BOTH FEET. Transection of the rami communicantes and removal of the tributary sympathetic ganglia of the left limb prevented a further drop in temperature in the corresponding foot while that of the other fell about 25° F. The temperature of the right foot returned to the previous level about 6 hours after ligation.

to no, or only slight and transient, change in temperature of the foot of the corresponding limb (1).

The above experiments show that after ligation of the external iliac artery the circulation in the corresponding limb is insufficient to maintain its normal temperature. The circulation, however, as indicated by the temperature rise of the limb to the level of that before ligation, returns in about 13 hours. This seems to indicate the presence of anatomical channels which are sufficient to care for the circulation after ligation and suggests that the reestablishment of former conditions by collateral circulation is a vasomotor phenomenon.

This is further substantiated by the fact that the temperature of a limb which has dropped to room temperature after ligation of its external iliac artery can at any time be raised to the normal level by removal of the tributary sympathetic ganglia. Not only that, but removal of the tributary sympathetic ganglia simultaneously with

ligation of the artery prevents the lowering of the temperature of that limb.

#### SUMMARY AND CONCLUSIONS

In the dog ligation of one or both external iliac arteries close to the aorta was always followed by a decrease of temperature in the corresponding foot varying from about 10° to 30° F. In the majority of the experiments a rise in temperature with a return to its previous level occurred about 13 hours after ligation. This, in the writers' opinion, seems to indicate the presence of anatomical channels sufficient to care for the circulation after ligation and suggests that the reestablishment of former conditions by collateral circulation is a vasomotor phenomenon.

This is further substantiated by the fact that the temperature of a limb which had dropped to room temperature after ligation of its external iliac artery rose to normal soon after removal of the tributary sympathetic ganglia and that simultaneous removal of the tributary sympathetic ganglia with ligation of the artery prevented the lowering of the temperature of that limb.

#### BIBLIOGRAPHY

1. Ferris, Henry W., and Harvey, Samuel C., *Proc. Soc. Exp. Biol. and Med.*, 1925, xxii, 383. A Physiological Study of the Development of the Collateral Circulation in the Leg of the Dog.