Simultaneous Determination of Temperatures of Skin and Muscle before and after Lumbar Sympathectomy

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A CONTROVERSY has existed for many years as to whether sympathetic denervation of the lower extremities increases the circulation in the skin by shunting the flow of blood from the muscle to the skin. This action was suggested by Bierman in 1941 after studies of the temperature of muscles in the lower extremities after lumbar sympathectomy. Under these circumstances one might postulate that a sympathectomy would not effectively increase the flow of blood* in an extremity or aid in the development of collateral circulation.

This study was undertaken to investigate, under rigid measures of control, simultaneous changes in the temperature of skin and muscle before and after sympathectomy, together with the sweating patterns of patients who have peripheral arterial disease.

Method

Skin Temperatures

All drugs were withheld for at least 12 hours before the test. The procedures used in determining temperatures of the skin and muscle were as follows. The patient fasted for 15 hours before the test. During the test he wore lightweight short pajamas and was in a supine position on a comfortable bed in a room with a constant air temperature of 25°C and a relative humidity of 40 percent. The basal blood pressure, pulse rate, and metabolic rate were determined.

Muscle and Skin Temperatures

The patient, previously lying on his back, turned on his stomach for 10 to 15 minutes and a thermo-electric needle† 5 cm. long and 1.2 mm. in diameter was inserted into the calf muscle of the extremity. The depth of the tip of the needle from the surface of the skin was at least 2.5 to 3 cm. A skin thermocouple was placed over the region adjacent to the thermo-electric needle. Simultaneous measurements of the temperature of the skin, meaning that of the calf, as well as the intramuscular temperature of the gastrocnemius muscle, were recorded at intervals of 2 minutes over a period of 20 minutes. The pulse rate and blood pressure were observed every 5 minutes.

Sweating Test

The cobaltous chloride procedure of one of us (Roth, 1935) was employed to determine sweating activity. Cobaltous chloride in a saturated solution of 95 per cent ethyl alcohol is deep blue, but changes to a bright pink in the presence of water. This solution was applied in stripes on the anterior and lateral aspects of the head, trunk, and extremities. An aluminum heating cabinet containing a series of incandescent light bulbs to maintain a temperature of about 140°F, and large enough to cover the entire body except for the head, was placed over the patient. After 10 to 20 minutes of heating in this cabinet, thermoregulatory sweating was induced, and the stripes of cobaltous chloride were transformed to the characteristic bright pink in the presence of perspiration. The relative change in color of the stripes indicated the varying degrees of sweating with a considerable degree of accuracy. Anhidrosis of course was indicated by the persistence of deep blue. In the normal person sweating is fairly even and diffuse over all portions of the body.

Results

Twenty-six patients were studied before and after unilateral lumbar sympathectomy. Fourteen patients had undergone chemical sympathectomy (injection of 3 or 4 ml. of absolute alcohol in the sympathetic chain at the level of the bodies of the second and third lumbar vertebrae) and 12 patients had undergone surgical removal of the first, second and third or second and third lumbar ganglia on one side.

The average age of the 26 patients was 59 years, and the range was 21 to 78 years. If the two patients 21 and 30 years old are
excluded, the average age of the group was 62 years. Thus, the studies were carried out on older persons.

Studies of the patients after performance of unilateral lumbar sympathectomy were divided into two groups: (1) 17 patients who had elevation of the temperature of the gastrocnemius muscle and the skin of the sural region; and (2) nine patients who had no increase in the temperature of the gastrocnemius muscle and the skin of the sural region.

The sweating patterns of all of these patients were divided into two groups: (1) anhidrosis of the entire lower extremity, from the inguinal region down, and (2) anhidrosis from the knee down. Anhidrosis of the entire extremity represents removal of the upper three lumbar ganglia, and anhidrosis of the leg from the knee down represents sympathetic denervation of the second and third lumbar sympathetic ganglia and rami.

Patients who had areas of spotty sweating
over the entire extremity or irregular hydrotic areas were excluded, since no effect of the sympathetic denervation could be anticipated.

Members of group 1 (table 1) are patients who had elevation of the temperature of the gastrocnemius muscle and of the skin of the sural region after unilateral lumbar sympathectomy. The average postoperative increase in temperature of the gastrocnemius muscle in 17 patients was 1.2 C., with a range from 1 to 2 C.* Also, the increase in the skin of the sural area averaged 1.2 C., with a range from 0 to 2 C. Figure 1 depicts the effects of lumbar ganglionectionomy in a typical patient of this group. About 15 minutes was considered to be an adaptation period, and therefore the last, or most stable, temperature reading after a period of 20 minutes represents the temperature recorded in all tables. The average age of these 17 patients (excluding the 21-year-old woman and the 30-year-old man) was 61 years. Two patients had ulcers on their feet. There was a constant increase in the temperature of the muscle and sural region.

*In normal persons the gradient of temperature from the internal temperature of 37 C. is 33 to 35 C. for muscle temperature and 30 to 34 C. for skin temperature; thus the changes are not great and an increase of 1 to 2 C. indicates a significant change in temperature.

In contrast to the findings in the patients after sympathectomy, 10 patients similar to those in group 1 were given 5 mg. of nyildrin hydrochloride (arilidin) intramuscularly and intra-arterially. No change in skin or muscle temperature occurred. If sympathetic denervation of the lower extremities increased the circulation in the skin by shunting the flow of blood from the muscle to the skin, then a lowered or an unchanged temperature of the muscle should result, but instead, the temperatures of both the skin and muscle increased.

In these patients with severe arteriosclerosis, sympathectomy is carried out only to prevent impending gangrene or for the relief of pain; thus it was not possible to exercise these patients.

There remain some challenging problems to be attacked in this field, but at present the methods are not adequate for study of the circulation in man. The new electronic methods for the measurement of blood flow necessitate cutting down on an artery, an action which is not justifiable in man to determine the blood flow.

Data from patient in group 1. Elevation of the temperature of the gastrocnemius muscle and sural skin area after left lumbar ganglionectionomy is parallel. The area of anhidrosis (dark shaded) of the left lower extremity after sympathectomy corresponds to the effects of removal of the first, second, and third lumbar sympathetic ganglia.

The Sural Muscle and Skin Temperatures

The patients in group 1 were again divided into two groups on the basis of the type of sympathetic denervation performed: (1) surgical sympathectomy, and (2) chemical sympathectomy. No significant change in the increase in the temperature of the gastrocnemius muscle and sural skin after adequate surgical sympathectomy as opposed to a similar change after adequate chemical sympathectomy could be noted.

Members of group 2 (table 2) were nine patients who had no increase of temperature in the gastrocnemius muscle and skin of the sural region after unilateral lumbar sympathetic denervation. Three patients had ischemic ulcers on the toes. Figure 2 depicts the effects of lumbar ganglionectionomy in this group.

Discussion

Frequently it has been said that sympathetic denervation of the skin decreases the flow of blood through the underlying muscle. Various factors have been concerned with such observations. First, different methods
The symmetric difference between temperatures of the skin and in deep tissues in the extremities under normal conditions was found to be very small. Lippros3-5 found an average temperature difference in normal persons of symmetric points of only 0.2 C. He also could demonstrate in a large series of cases that the temperature in repeated examinations within days or weeks under basal conditions in the same person, without marked progressive occlusive arterial disease, remained within the same range.

In the 26 patients who had diffuse occlusive arterial disease studied in this series, lumbar sympathectomy was thought to be the treatment of choice. The separation into two groups was based on temperatures of the skin and muscle in the sural region after performance of unilateral lumbar sympathectomy. In group 1, which consisted of 17 patients, a parallel increase in the temperature of the gastrocnemius muscle and sural skin after unilateral lumbar sympathetic denervation could be observed. This postoperative elevation of temperature, which represents an increase in the flow of blood in the measured area under basal conditions, presumably is based on the release of vasoconstriction superimposed upon diffuse organic disease.*

Group 2 was composed of the remaining nine patients who had what clinically was the same diffuse occlusive arterial disease; however, their condition probably was more advanced.† These patients obtained no benefit

*The exact nature of this action has not been determined in the human being.

†If measurements of the skin temperature of the lower extremities of patients with peripheral arterial disease are made before and after the oral ingestion of cobaltous chloride in a saturated solution of 90 per cent ethyl alcohol, the increase in the temperatures of the skin of the extremities, in spite of the absence of peripheral pulsations, would indicate that vasodilatation of the collateral circulation took place. On the other hand, in the absence of peripheral pulsations, if there were no increase in the skin temperatures of the lower extremities, this would indicate that the collateral circulation was not adequate and that, often, impending gangrene or even gangrene was present. Patients in group 2 had the latter condition.
from unilateral lumbar sympathectomy so far as the postoperative temperature in the gastrocnemius muscle of the sural skin is concerned. No change from preoperative values could be observed. The temperatures remained stable. Moreover, clinically no improvement was noted in comparison with the preoperative condition. No acute exacerbation of the disease was noted. It would appear that these nine patients had organic changes of the arteries without the presence of a significant vasospastic component. Thus, no effect from sympathetic denervation could be observed.

**Summary**

A group of 26 patients who had peripheral occlusive arterial disease of the lower extremity were studied before and after chemical or surgical unilateral lumbar sympathectomy. The temperatures of the gastrocnemius muscle and of the skin of the sural area were determined simultaneously preoperatively and postoperatively. Only patients who had undergone successful unilateral lumbar sympathetic denervation based on the postoperative area of anhidrosis were included. The data were obtained under basal conditions among the 26 patients, and the persons studied were divided into two groups. Group 1 was composed of 17 patients (65 per cent) who had a definite parallel increase of 1.2 C. in the temperature of the gastrocnemius muscle and the skin after unilateral sympathectomy. In group 2 (nine patients or 35 per cent) the temperature of the gastrocnemius muscle and the skin of the sural area was unchanged after unilateral sympathectomy. Since none of these patients were suitable for surgical bypass arterial-grafting procedures and all were in the older age group, not too much could be expected from the standpoint of an increase in temperature. However, when the temperature of the skin after operation increased, the temperature of the gastrocnemius muscle also increased.

**References**


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