On the Descending Spinal Pathways Subserving the Sweating of the Plantar Sweat Glands in Rats

By

Chikamasa Ninagawa

From the Department of Physiology, Nagasaki University School of Medicine, Nagasaki

(Received for publication, July 20, 1955)

It is not long since the evidences of secretion in the plantar sweat glands of rats were given.

Ring and Randall1) were the first to study histologically the plantar sweat glands in rats. Further, they found that the sweating was causable by the prolonged continuous stimulation of the sciatic nerve of the corresponding side. They failed, however, to induce sweating by raising the body temperature.

Nakagawa2) reported that in the plantar surface of non-anesthetized albino rats a spontaneous sweating was always observed, which was completely abolished by ether anesthesia or by the section of the sciatic nerve on the same side.

It is the purpose of the present investigation to elucidate the spinal pathways subserving this spontaneous sweating of the plantar sweat glands in rats.

Experimental

Methods

Adult albino rats, regardless of sex, were experimented on. Under ether anesthesia the lesion of the spinal cord was made with the tip of a needle or a knife.

In the first series of experiments, the total section of the spinal cord was made at various levels of the thoracic or lumbar segments. In the second series, the hemisection was performed at the thoracic or lumbar level. And, in the third series, the spinal cord was sectioned on one side partially at the thoracic level, the extent of lesion being verified after finishing the experiments by microscopic examination.

The animals were allowed to survive after operation for several weeks and during this period the observations on sweating were made almost every day.
The method used in the present experiments for detecting the sweating was that devised by Wada and Takagaki\(^3\); that is, the area of the plantar surface to be examined was painted with an iodine alcohol solution and after drying completely the area was painted with a mixture of starch powder and castor oil. Sweating was evidenced by the appearance of black dots at the openings of the sweat ducts.

Before experiments the spontaneous sweating at the plantar surface of each rat was examined and only those rats were chosen, whose sweating on the left and right hind feet was almost equal in degree.

Results

(1) *Total section of spinal cord at thoracic or lumbar level*

In 9 animals, the total section of the thoracic segment was made at the levels varying from D\(_1\) to D\(_9\). In one of them, whose spinal cord was transected at the level of D\(_6\), the spontaneous sweating in a small degree was observed in the plantar surface of both hind feet. In other 2 rats, which died on the 4th and the 5th day after the total section of the spinal cord at D\(_1\), respectively, a faint sweating was found after section in both plantar surface. In 6 others with totally transected spinal cord at the level of D\(_5\)-D\(_9\), spontaneous sweating in both plantar surfaces was completely abolished.

In 2 animals the total section of the spinal cord was made at the level of D\(_10\). In one of them sweating was scarcely observed on both plantar surfaces and in the 2nd rat a faint sweating was found.

In 4 animals the total sections were made at the levels varying from D\(_11\) to L\(_1\). In them, it was noticed that the more caudal was the level of the total section the more profuse was the sweating.

In 2 rats the section was performed at the level of L\(_2\) and L\(_3\), respectively. In these cases, no effect of section was observed. Further, a profuse sweating was observed in another rat, whose spinal cord was destroyed below the level of L\(_2\).

From these experiments it may be concluded that centres for the spontaneous sweating of the plantar surface in rats are situated at somewhere above the thoracic level and that the secretory fibres descend the thoracic segments and leave the spinal cord at levels of D\(_11\)-L\(_1\).

(2) *Hemisection of spinal cord at thoracic or lumbar level*

In 8 animals the left lateral half of the spinal cord was sectioned at the levels varying from D\(_1\) to D\(_9\).

There, spontaneous sweating of the ipsilateral plantar surface was found to be significantly reduced.

In 5 rats the left hemisection of the spinal cord was made at the levels varying from D\(_10\) to L\(_1\). In them, the more caudal was the hemisection
level the more insignificant was the difference between the right and left hind feet in the intensity of the plantar sweating.

In 2 others the left hemisection of the spinal cord was performed at the level of L2 or L3. No change was observed in these cases.

The experimental results above mentioned show that the secretory fibres for the plantar sweat glands descend the spinal cord and run predominantly without crossing to the ipsilateral hind foot. And the partial decussation of secretory fibres located close to the level of preganglionic outflow is also indicated by a slight spontaneous sweating remaining after the hemisection in the ipsilateral plantar surface.

(3) Partial lesion of the spinal cord at the thoracic level

Unilateral section of the ventral quadrant at the level of D8 was made in 2 rats. Spontaneous sweating in the ipsilateral plantar surface was in these rats obviously reduced. The effect of unilateral section of the dorsal quadrant which was made at D7-D8 in 5 rats, resembled that of the ventral quadrant section.

In 4 rats, the lesion was made on the left lateral column at the level of D7-D8. In them, spontaneous sweating of the ipsilateral plantar surface was markedly reduced, except for one rat in which the lesion was restricted within the outer portion of the lateral column. Further, it was found that even by the section of the ventral portion of lateral column spontaneous sweating of the plantar surface of the ipsilateral side was definitely reduced.

On the other hand, it was observed in 2 rats that the section of ventral or dorsal column produced no effect on spontaneous sweating in the plantar surface.

From these experimental results it may reasonably be assumed that the pathways of the secretory fibres to the plantar sweat glands are located in the lateral or ventro-lateral column.

Discussion

Descending spinal pathways to the plantar sweat glands in cats were traced by Ott.41 In the cats, in which various columns of the spinal cord were damaged at the level between D6 and D7, spontaneous sweating was induced by the faradization of the medulla. After the hemisection of the spinal cord, sweating was elicited only in the plantar sweat glands of the contralateral foot. The unilateral section of the lateral column abolished the sweating of the ipsilateral plantar surface, whereas no effect was observed of the section of the posterior column. From these experimental results he inferred that the secretory fibres descended the lateral column of cord without crossing.

Quite different evidences were given by Beaton and Leininger5) as
to the spinal pathways for sweating in monkeys. By the unilateral section of the lateral or ventrolateral column of the spinal cord at the midthoracic level, sweating in the contralateral foot was found to be wholly impaired. Thereby they concluded that descending spinal pathways for sweating of the lower extremity in monkeys were located in the lateral or ventrolateral column, having a complete or almost complete decussation below the midthoracic level.

In human beings it was proved by Foerster⁶ and List and Peet⁷ that the unilateral section of the lateral column of the spinal cord at the cervical level caused an ipsilateral hemihypohidrosis, suggesting that most of the secretory fibres descend the lateral column of the spinal cord without crossing.

Thus it has been elucidated by the present investigation that the descending spinal pathways for sweating of the plantar surface in rats are similar in their course to those in cats and in human beings and are quite different from those in monkeys.

It may be added here that spontaneous sweating of the plantar sweat gland is also observable in mice. Therefore, it will be of interest to study in mice the spinal descending pathways for sweating.

**Summary**

The present investigation has been undertaken to elucidate the spinal pathways for spontaneous sweating of plantar sweat glands in albino rats.

Total section, hemisection or unilateral partial section of the spinal cord were made at various levels and the effects of these sections on spontaneous sweating in the plantar surface were examined.

Experiments of the total section of the spinal cord indicated that secretory fibres for the plantar sweat glands in rats descended the thoracic segments of the spinal cord, leaving the spinal cord at the levels from D₁₁ to L₁.

Experiments involving the hemisection or partial section of the spinal cord indicated that the descending spinal pathways subserving spontaneous sweating in the plantar surface ran in the lateral or ventrolateral column and mostly without crossing.

I wish to express my gratitude to Prof. T. Suzuki, who suggested this problem to me, for his encouragement and advice.

**References**

2) Nakagawa, J. Physiol. Soc. Jap., (Japanese), 1950, 12, 104 P.
4) Ott, J. Physiol., 1879–80, 2, 42.
6) Foerster, Bumke u. Foerster's Handb. Neurol., V. 232 f.