Acta Medica Okayama

Volume 3, *Issue* 4 1932 *Article* 1

AUGUST 1933

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The contracture of Tongue Muscle by the Stimulation of Lingual Nerve after the Degeneration of Hypoglossal Nerves.*

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Abstract

1. Stimulation of the peripheral stump of the lingual nerve after the degeneration of hypoglossal nerve causes the contracture of tongue. 2. This phenomenon is retained after the removal of the superior cervical ganglion, after the degeneration of sympathetic postganglional fibres in lingual nerves. 3. Acetylcholine (Vagusstoff) in most cases has no effect upon the tongue after the degeneration of hypoglossal nerve. 4. Curare prevents the contracture of tongue by the stimulation of lingual nerve.

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The contracture of Tongue Muscle by the Stimulation of Lingual Nerve after the Degeneration of Hypoglossal Nerves.

By

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Received for publication July 26, 1932.

Introduction:

In 1863, *Philippeaus* and *Vulpian* severed the hypoglossal nerves of a dog, and in spite of the complete degeneration of the motor nerve, they recognized a tongue movement when the fifth brain nerve was stimulated.

Since this report was published, the studies on this problem have often been undertaken by many men of fame. For example, *Cyon* reported in 1871 that this reaction also resulted from mechanical stimulus.

Eckhard in 1873 obtained the result from which he concluded that this reaction could be secured only by an electrical stimulus. *Vulpian* in the same year reported his experiments and stated as follows; At the end of 4 to 5 days after severing the hypoglossal nerve, the reaction was observed and in 20 to 30 days it occurred most markedly. The nerve which was stimulated in this reaction was not the fifth brain nerve but that originating from the chorda tympani*.

Schiff in 1878 recognized by severing the hypoglossal nerve, the phenomenon of quivering when the tongue was anaesthetised. He divided the course of observation into three periods that is, within 1 or 2 days after cutting the lingual nerves when stimulated would not produce any reaction at all; but after 8 or 10 days the quivering of the anaesthetised part of tongue appeared spontaneously, showed still nothing to the nerve stimulus; and after 15 or 18 days the quiver

* The reason for this is omitted here.

faded out completely and the tongue movement by the stimulation of the lingual nerve appeared as *Vulpian* observed. In 1878, *Bleuler* and *Lehmann* experimenting on the lingual nerves of a rabbit after severing the hypoglossal nerves found that the movement of the tongue appeared, but the quiver, contrary to *Schiff*'s observation, did not fade out.

In 1883, *Heidenhain* studied all the details in order to solve this problem. According to his studies, after the severing of hypoglossal nerves, the quiver in the denervated tongue was recognized and lasted for 6 weeks. By the stimulation of the lingual nerves, the contracture of the denervated tongue was observed within 4 days after the operation and lasted for a year. Furthermore, contracture by the stimulation differed entirely from that by hypoglossal stimulation i. e., after a certain period, the phenomenon became slower. This contracture was never observed in the motor nerve stimulation. At the beginning of denervation, a small amount of nicotine produced the contracture. He did not investigate the relation between the tongue muscle and the chorda tympani. *Boeke*, experimenting on a hedge-hog in 1913 and on a monkey in 1915, severed the hypoglossal nerves and after the degeneration of those nerves, he found in the tongue muscle the similar nerve endings which he regarded as the markless nerve fibres. He claimed that these fibres belong to the chorda tympani. *Rijinberk* also studying this problem, stated that this phenomenon of contracture could not be explaind as being of a sympathetic nature only.

Frank and others in 1922 repeated the experiment and reached the conclusion that was of a parasympathetic nature.

In order to settle the problem, the following experiment was carried out.

Method of Procedure:

1. Dogs only were used as subjects.

2. On cutting the hypoglossal nerves, the subjects in most cases were anaesthetised with morphine followed by ether. The animal was laid on its back, with the head on the table, and was kept in position by a cord. At a point between 2 and 3 cm from the corner of the lower jaw bone to the medial line, the skin was cut open and the wound was carried deeper. Parallel to the lingual artery, the hypoglossal nerve which runs from external back to internal front, can be recognized. Then the nerve of 1 – 2 cm long was cut away.

3. Cutting away of sympathetic nerve ganglion:

Sympathetic nerve is enclosed in the tissue sheath along with the vagus nerve. This vago-sympathetic nerve lies along the carotid artery, and following upward the

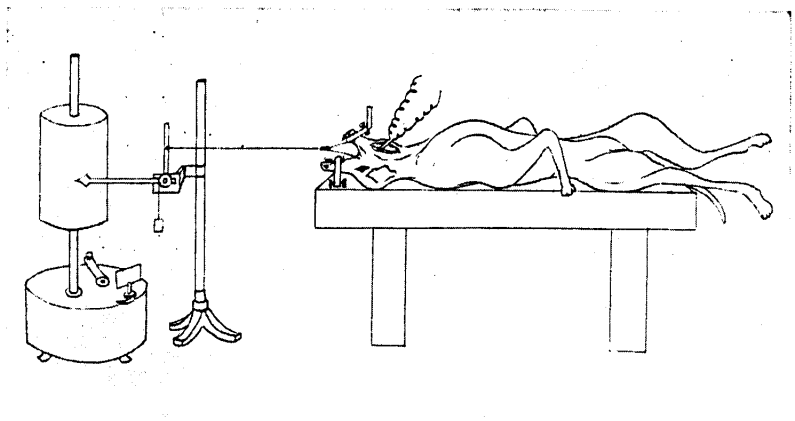
vago-sympathetic trunk, superior cervical ganglion of sympathetic can be easily reached. A dog with both hypoglossal nerves severed loses the control of its tongue. It was fed by the help of rubber tubing or if it is a quiet dog, well chopped meat was placed on the back of the tongue root, whence was easily swallowed. In the present experiment, the teeth were left as they were, but there was no danger of biting the tongue. Then after 10 to 14 days, hypoglossal and sympathetic nerves degenerated and the next experiment was carried out.

4. Experiment:

For the experiment on the reaction of a denervated tongue with a natural circulation, at the end of the degeneration period, the animal was anaesthetised with morphine-ether. The skin was opened at the place of the scar of the first operation. At the external front side of the hypoglossal nerves, under the tongue bone and mandibular artery, the lingual nerve was easily found. At the central point, it was cut off and its peripheral stump was stimulated. The dog was laid on the table for operation, the head being kept in position by a cord passing behind the upper canine teeth. The lower jaw was held wide open by a similar cord attached to a support. The tongue fell naturally on the roof of the mouth, and a fine thread, drawn through the tip, and connected it to one end of a light lever.

The experimental arrangement is shown in Fig. 1:

Fig. 1. Experimental arrangement.



One arm of the angular lever was connected by the aid of thread to the tip of tongue, and the writing point of the other arm marked the contracture of tongue on the smoked surface of the drum. A small weight attached to the lever near to the axis kept the thread tight and the tip of the tongue was just raised from the roof of the mouth.

It was so arranged that a contracture of the denervated half causes the whole tongue to rise from the roof of the mouth, and such movement was recorded by a rise of the writing point of the lever.

Nerve stimulation was made by platinum electrodes. These were usually fixed to a clamp, the nerve was laid across them and protected from drying, so that the successive stimulations were applied to the same stretch of nerve. Induction shocks

were used, obtained from the secondary induction, coil, the current in the primary, obtained from a single accumulater cell, being in most cases interrupted by the automatic spring hammer. The strength of the stimulus was adjusted to a degree just perceptible on the tip of the observer's tongue, and was applied at 16 cm distance of the secondary coil from the primary.

5. Histological examination:

Since the decided proof only could be obtained by the histological examination, the following observation was made. If some motor end plates are found in the tongue muscle after the complete degeneration of the cut hypoglossal nerve, it may be concluded that the tongue is still in connection with some motor nerves. Consequently the contracture of the tongue by the stimulation of the peripheral stump of the lingual nerve will be due to the mixing of the motor nerve in this trunk.

Under this hypothesis, the author examined the tongue muscle after staining with goldchloride*. No motor plate was found in the tongue muscle, after the complete degeneration of the cut hypoglossal nerves.

But still I hesitate to conclude that the contracture is due to the excitation of autonomic nerve, because it is quite possible some motor end plates escaped my search.

Results:

1. *First group of experiments* (Both hypoglossal nerves cut.):

First case: Dog 6,400 g.

Operated on Dec. 17, 1930.

Experimented on Jan. 15, 1931.

On the same day, the dog was put to death by asphyxiation.

Time between operation and experiment, 30 days.

Operation and its course: 5 cc of 2% morphine was injected under the skin. Under the narcosis, about 1 cm of the hypoglossal nerves, on both sides were removed. 3 to 4 days after the operation, a feeble quiver of the tongue was observed. On the following day about 600 cc of milk was given. At the end of 10 days 100–150 g of minched meat per day was fed, placing it on the back of the tongue, from where it was easily swallowed.

After 2 or 3 weeks, the operation wound was healed.

Experiment: Under the anaesthesia of morphia-chloroform-ether, the lingual nerve was exposed and cut. The peripheral stump of this nerve was stimulated by the Faradic current of a strength above

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* I followed exactly the description of *Langley* in his practical histology. His method always gave excellent results for the staining of motor plates in tongue of several animals.

mentioned. The injection of 5 cc of 1% curare abolishes the contracture of the tongue by the stimulation of the lingual nerve.

The tongue muscle was stained with gold chloride, but no end plates of motor nerve could be found.

Fig. 2.

↑—↓ Faradic stimulation.
5″

Second case: Dog 5,400 g.
Operated on Jan. 21, 1931.
Experimented on Feb. 10, 1931.
Time between operation and experiment, 21 days.

Operation and its course: Like the first case, the experiment was carried out under the anaesthesia with morphine-ether. The wound of operation healed quite well.

Experiment: A Faradic stimulation was given to the peripheral stump of the severed lingual nerve. The contracture of the tongue was observed. The acetylcholine was injected into the femoral vein. It caused no contracture of the tongue, nor any change in the effect of nerve stimulation was observed.

Bielschowsky's method was used for staining the end plates of motor nerve, but no end plate could be observed.

2. *Second group of experiments*:

First case: Dog 5,700 g.

Both the hypoglossal nerves were severed on Jan. 23, 1931.
Both the superior cervical ganglions were removed on Feb. 7, 1931.
Experimented on Feb. 25, 1931.
Time between operation and experiment, 34 days.

Under the anaesthesia of morphine, chloroform and ether, both the hypoglossal nerves were cut off about 1 cm in length. From the next day, the subject swallowed the meat given. The wound healed and then the second operation was performed.

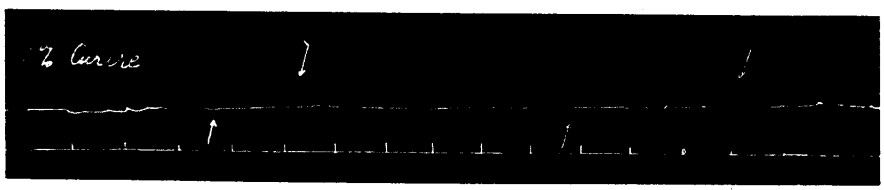
Under the anaesthesia, both the superior cervical ganglions were completely taken away. No loss of blood occured. On account of the severe operation, the dog recoverd slowly. The pupils of the animal after the operation were small.

Experiment: The stimulation of the lingual nerve caused the contracture of the tongue. Injection of acetylcholine gave no contracture of the tongue. Injection of curare relieved the contracture of the tongue by the stimulation of the lingual nerve.

The motor end plates were not found by means of the gold chloride method, but many tiny nerve fibres which are going to the muscle fibers were observed.

Fig. 3.

↑—↓ Faradic stimulation.
5″



Second case: Dog 15,200 g.
Operated on Mar. 9, 1931.
Experimented on Apr. 14. 1931.
Time between operation and experiment, 37 days.
Operation was performed like that of the first example.

Experiment: Stimulation of the hypoglossal nerves showed no contracture of tongue. Faradic stimulation of the peripheral stump of the lingual nerve caused the contracture of the tongue. Curare injection relieved the effect of the stimulation. Careful examination of the lingual nerves after death of animal showed the connection only to the tongue.

The histological examination did not reveal the existence of motor end plates in the tongue muscle.

Discussions:

Vulpian-Heidenhain phenomenon was mentioned in the introduction. Some investigators believe that the phenomenon is due to the excitation of the autonomic nerve which is mixed in the lingual nerves. But the foregoing experiment very probably indicates that it is due rather to the motor fibres mixed in the lingual nerves.

There is no doubt that the stimulation of the lingual nerve after the degeneration of hypoglossal nerves, causes a contracture of the tongue. The lack of effect of the acetylcholine (*Vagusstoff*) on the tongue probably indicates that the vagus does not innervate the tongue. The effect of the stimulation of the lingual nerves remains for a long time after the removal of the superior cervical ganglions. This fact strongly indicates that the sympathetic fibres do not take part in contracture of the tongue by the stimulation of the lingual nerve. The only possible explanation is the assumption of the mixture of some motor fibres in the lingual nerves. The experiments with curare support the above assumption. The decisive proof is the finding of some motor end plate in the tongue muscle after the degeneration of hypoglossal nerves.

In spite of the negative result of the search for the motor end plates on the tongue muscle, in which hypoglossal nerve completely degenerated, the author still doubts whether some end plates did escape his observation.

Summary:

1. Stimulation of the peripheral stump of the lingual nerve after

the degeneration of hypoglossal nerve causes the contracture of tongue.

2. This phenomenon is retained after the removal of the superior cervical ganglion, after the degeneration of sympathetic postganglionial fibres in lingual nerves.

3. Acetylcholine (*Vagusstoff*) in most cases has no effect upon the tongue after the degeneration of hypoglossal nerve.

4. Curare prevents the contracture of tongue by the stimulation of lingual nerve.

In closing, I wish to express my sincere thanks to Prof. Dr. *S. Oinuma* for his kind criticism and advice.

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