Elucidation of Taste Disorders Caused by Central Lesions

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Keiko ONODA* and Minoru IKEDA**

Assistant and Associate Professor**, Department of Otorhinolaryngology, Nihon University School of Medicine*

Abstract: Central taste disorder is clinically found in 1–2% of all taste disorders. Cerebral infarction, cerebral hemorrhage, and brain tumor are some of the causes of the disease. Since cases with central taste disorder often accompany symptoms that are specific to the responsible lesion, it is important to ask the patient about his condition in detail. Also, diagnostic imaging such as CT and MRI are essential for accurate determination of the lesion site and scope. For taste examination, we use electrogustometry and the filter-paper disk method, by which the right and left taste nerves can be evaluated separately. Basic research of the gustatory center in humans has shown that taste stimulation from peripheral taste nerves is projected onto the cerebral cortex on both sides. On the other hand, based on clinical examination of 36 cases of central taste disorder, which has been reported in the past, it is surmised that taste stimulation from peripheral taste nerves ipsilaterally ascends after entering into the solitary nucleus of the medulla, crosses over to the other side at the midbrain level, and contralaterally projects to the cerebral cortex after passing through the thalamus, internal capsule, and the radiate crown.

Key words: Taste disorder; Central lesion; Taste center

Introduction

There is a sense that taste disorder has not been given much significance because it is not a syndrome that usually has a direct impact on life. Recently, however, it has been drawing attention from the perspective of quality of life, and gaining significance even in daily clinical practice.

In most cases, the cause of taste disorder is found in a disorder at the peripheral level, and the mechanism of onset has been gradually understood. In some cases, on the other hand, the disorder occurs as a symptom caused by a central lesion. There are still many unclear points concerning the mechanism of onset for this type of taste disorder. Since such cases tend to manifest other symptoms, the patients tend to visit internists and neurosurgeons.

The diagnosis of taste disorder caused by a

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Table 1 Cause and Incidence of Taste Disorder

Cause	Incidence (%)
Drug-induced	495 (21.7)
Idiopathic	341 (15.0)
Zinc deficiency	330 (14.5)
Psychogenic	243 (10.7)
Flavor disorder	171 (7.5)
Systemic disease	169 (7.4)
Oral disease	146 (6.4)
Concurrent taste/smell disorder	60 (2.6)
Peripheral pathway disorder	59 (2.6)
Central pathway disorder	38 (1.7)
Endocrine	23 (1.0)
Other	203 (8.9)
Total	2,278 (100)

The most common types are drug-induced, idiopathic, and zinc deficiency types in this order, and central taste disorder has been found in 1.7% of all taste disorders.

(Excerpted from Norinaga Hamada, *et al.*: Clinical analysis of 2,278 cases examined at a gustatory clinical over a 10-year period. *Nihon University Medical Journal* 1995; 54(8): 529–535)

central lesion and known facts concerning the central neural pathway of taste will be herein discussed.

Taste Disorder Caused by a Central Lesion

1. Cause of taste disorder

There are many causes of taste disorder. The most common types of taste disorders are drug-induced, idiopathic, and zinc deficiency types in this order, and central taste disorder has been found in 1.7% of all taste disorders according to a report in 1995 (Table 1).[1] Central lesions include cerebral infarction, cerebral hemorrhage, multiple sclerosis, brain tumor, and head injuries.

2. Diagnosis

(1) **History taking**

Since central taste disorder often accompanies symptoms specific to the responsible lesion, it is important to ask the patient about his condition in detail. If the condition started with sudden headache, vomiting, or disturbance of consciousness, it can easily be diagnosed as cerebral hemorrhage, but one must be careful because the patient may not be aware of symptoms if it is cerebral infarction or a neurological disorder that occurs gradually.

Accompanying symptoms may be facial nerve palsy, hemiplegia, or dysarthria when the lesion includes a motor component, and hypoesthesia or tingling in the face or hand/foot when the lesion includes a sensory component.

(2) **Tests**

(a) Blood test

Central lesions often occur in patients with underlying diseases like hypertension, diabetes, and hyperlipidemia. The presence and severity of underlying diseases must be verified when treating the patient.

(b) Diagnostic imaging

When central taste disorder is suspected, the lesion site and scope must be accurately determined by diagnostic imaging such as CT and MRI.

(c) Gustometry[2,3]

There are various methods of gustometry including simple tests. Methods that make it possible to evaluate the right and left taste nerves separately should be used not only for taste disorders caused by peripheral neuropathy (e.g, facial nerve palsy) but also for central taste disorders. Of such methods, the most reliable methods are electrogustometry and the filter-paper disk method. By use of these methods, gustometry should be performed at a total of six sites based on where the taste nerves are distributed on the right and the left (chorda tympani nerve, glossopharyngeal nerve, and greater petrosal nerve).

An electrogustometer (TR-06, Rion Co., Ltd.) is used for electrogustometry. Each test site is stimulated with a stainless steel electrode 5 mm in diameter that is connected to direct-current electricity, and the minimum recognizable dB value is treated as the threshold. Abnormality is defined by at least a 6-dB difference between the right and the left.

A test kit (Taste Disk®, Sanwa Kagaku) is used for the filter-paper disk method. Filter-papers, which are 5 mm in diameter, are soaked in each flavored solution (sucrose, salt, tartaric acid, and quinine hydrochloride) and placed on the test site. The minimum recognizable concentration number is treated as the threshold. Clear abnormality is defined by at least a 2-grade difference between the right and the left.

(3) **Treatment**

Although zinc preparations, vitamins, and drugs used to improve peripheral circulation are used in the case of peripheral taste disorder, the central lesion as well as the underlying disease, when present, are treated in the case of central taste disorder.

Anti-hypertensive drugs, hypoglycemic drugs, and antilipemic drugs are used for underlying diseases such as hypertension, diabetes, and hyperlipidemia. Antithrombotic drugs and drugs that improve cerebral edema are used for cerebral infarction, and drugs that improve cerebral edema and surgical measures are used for cerebral hemorrhage. Steroids are used for neurological diseases.

Taste Center

1. Taste center in animals[4,5]

Taste nerves within facial nerves, glossopharyngeal nerves, and vagal nerves enter into the rostral side of the solitary nucleus of the medulla on the same side before connecting to a secondary neuron.

In monkeys, the secondary neuron from the rostral side of the solitary nucleus of the medulla ends directly at the small cell of the posteromedial ventral nucleus of thalamus on the same side, and the tertiary neuron projects to the transitional site from the cerebrocortical frontal opercular part to the insular cortex on the same side. In cats, the secondary neuron from the rostral side of the solitary nucleus of the medulla runs through the brachia conjunctiva nucleus of the dorsal side of the pons on the same side, and the tertiary neuron that starts here ends at the posteromedial ventral nucleus of thalamus on the same side. The quaternary neuron projects to an area near the frontal sylvian sulcus of the cerebral cortex and limbic cortex. In rats, the primary and secondary neurons follow the same pathway as cats, but the tertiary neuron ends at bilateral posteromedial ventral nuclei of thalamus, and the quaternary neuron projects to the bilateral insular cortex in the cerebral cortex. The neural pathways vary in such ways depending on the species among animals.

2. Taste center in humans

In humans, when the peripheral taste nerves (chorda tympani nerve, glossopharyngeal nerve, and greater petrosal nerve) enter into the solitary nucleus of the medulla and the neurons change, the pathway runs upward through the medial side of the medial lemniscus or the reticular formation on the same side, and reaches the pontine taste area (PTA) in the upper pons near the superior cerebellar peduncle.[6] Then, it reaches the thalamic subnucleus where the neuron is changed, and reaches the cortical side of the parietal operculum and the insular cortex. However, there is still no clear consensus concerning whether the pathway from PTA to the thalamic subnucleus is ipsilateral, contralateral, or bilateral.

The first study on the taste center in humans was reported by Penfield *et al.*[7] who performed electrical stimulation in various sites in the brain during craniotomy under local anesthesia and had patients answer what type of sensation they experienced. Later, Funakoshi *et al.*[8] and Plattig[9] recorded the cerebrocortical evoked potential by use of flavored solutions. Kida[10] also conducted similar recording, and recorded evoked potential on both sides of the head, although he reported that the response on the same side was particularly marked. More recently, Kobayakawa *et al.*[11] measured the magnetic field in the brain that occurs in response to stimulation with flavored solutions, and reported that the primary gustatory field is

Table 2 Cases with Taste Disorders Caused by Central Lesions

Reporter	Year of report	Age	Sex	Disease	Lesion site	Taste disorder
Fujikane *et al.*	1999	66	F	Infarction of the radiate crown	Behind the left radiate crown	Contralateral
	1999	72	M	Infarction of the radiate crown	Behind the left radiate crown	Contralateral
	1999	59	M	Infarction of the radiate crown	Behind the left radiate crown	Contralateral
	1999	70	F	Infarction of the posterior limb of internal capsule	Posterior limb of the right internal capsule	Contralateral
Onoda *et al.*	1999	68	M	Infarction of the posterior limb of internal capsule	Posterior limb of the left internal capsule	Contralateral
Adler	1934	20	F	Thalamic tumor	Left thalamus	Contralateral
Gänshirt	1950	N.A.	M	Thalamic tumor	Right thalamus	Contralateral
Stockert	1951	57	M	Thalamic hemorrhage	Thalamus	Contralateral
Onoda *et al.*	1999	65	M	Thalamic infarction	Left thalamus	Contralateral
Fujikane *et al.*	1999	58	M	Thalamic infarction	Right thalamus	Contralateral
	1999	70	M	Thalamic infarction	Right thalamus	Contralateral
	1999	62	F	Thalamic infarction	Left thalamus	Contralateral
	1999	57	F	Thalamic infarction	Right thalamus	Contralateral
Ito *et al.*	1993	35	M	Thalamic hemorrhage	Right thalamus	Ipsilateral
Combarros *et al.*	1994	39	F	Multiple sclerosis	Right thalamus	Ipsilateral
Hisahara *et al.*	1994	37	M	Multiple sclerosis	Right upper midbrain	Contralateral
Lee *et al.*	1998	64	M	Midbrain infarction	Right upper midbrain	Contralateral
Johnson	1996	22	M	Midbrain injury	Left lower midbrain	Ipsilateral
Shikama *et al.*	1996	37	F	Cerebral arteriovenous malformation	Left lower midbrain	Ipsilateral
	1996	65	F	Midbrain infarction	Right lower midbrain	Ipsilateral
Fujikane *et al.*	1998	67	M	Pontine infarction	Left upper pontine tegmentum	Contralateral
Goto *et al.*	1983	38	F	Pontine hemorrhage	Left upper pontine tegmentum	Ipsilateral
	1983	56	M	Pontine hemorrhage	Left upper pontine tegmentum	Ipsilateral
	1983	53	F	Pontine hemorrhage	Left upper pontine tegmentum	Ipsilateral
Nakajima *et al.*	1983	60	M	Pontine hemorrhage	Right upper pontine tegmentum	Ipsilateral
Joichi *et al.*	1985	60	M	Pontine infarction	Right upper pontine tegmentum	Ipsilateral
Uesaka *et al.*	1998	21	F	Multiple sclerosis	Right upper pontine tegmentum	Ipsilateral
Lee *et al.*	1998	58	M	Pontine infarction	Right upper pontine tegmentum	Ipsilateral
Hoshino *et al.*	1999	17	F	Multiple sclerosis	Right middle pontine tegmentum	Ipsilateral
Sunada *et al.*	1995	28	M	Pontine hemorrhage	Right middle pontine tegmentum	Contralateral
Kojima *et al.*	1999	71	F	Pontine hemorrhage	Right middle pontine tegmentum	Ipsilateral
Sato *et al.*	2000	58	F	Multiple sclerosis	Right middle pontine tegmentum	Ipsilateral
Pascual-Leone *et al.*	1991	25	M	Multiple sclerosis	Right lower pontine tegmentum	Ipsilateral
Yabe *et al.*	1995	51	M	Multiple sclerosis	Right lower pontine tegmentum	Ipsilateral
Lee *et al.*	1998	58	F	Pontine infarction	Left lower pontine tegmentum	Ipsilateral
Onoda *et al.*	1999	29	F	Pontine infarction	Right lower pontine tegmentum	Ipsilateral

Our research has shown that 36 cases with taste disorders have been reported.
(Added to reference 12 Onoda, K. *et al.*: *Laryngoscope* 1999; 109(1): 123–128)

Table 3 Relationship between Lesion Site and the Side of Taste Disorder
Figures in ( ) shows the %

Location	Taste disorder			Total
	Ipsilateral	Contralateral	Bilateral	
Radiate crown	0	3 (100%)	0	3
Posterior limb of internal capsule	0	2 (100%)	0	2
Thalamus	2 (20%)	8 (80%)	0	10
Upper midbrain	0	2 (100%)	0	2
Lower midbrain	3 (100%)	0	0	3
Upper pons	7 (87.5%)	1 (12.5%)	0	8
Middle pons	3 (75%)	1 (25%)	0	4
Lower pons	4 (100%)	0	0	4
Total	19	17	0	36

Ipsilateral taste disorders are common from lower pons to lower midbrain, and contralateral taste disorders are common from upper midbrain to radiate crown.
(Added to reference 12 Onoda, K. *et al.*: *Laryngoscope* 1999; 109(1): 123–128)

located in the transitional area of the bilateral insular cortex and the opercular part. Studies in the past have led many to believe that taste stimulation that has reached the brain is projected onto the cerebral cortex on both sides.

Examination of Cases with Central Taste Disorders

As mentioned earlier, the central neural pathway for taste in humans needs to be further investigated. We examined cases with taste disorders caused by a central lesion from a clinical perspective. So far, 36 cases with taste disorders caused by a central lesion have been reported (Table 2). Classification by the lesion site showed that there were 16 cases of pontine lesions, 5 cases of midbrain lesions, 10 cases of thalamic lesions, 2 cases of lesions in the internal capsule, and 3 cases of lesions in the radiate crown. The relationship between the lesion site and the side of taste disorder was ipsilateral in 14 out of 16 cases (87.5%) for pontine lesions, ipsilateral in 3 out of 5 cases (60%) for midbrain lesions, contralateral in 8 out of 10 cases (80%) in thalamic lesions, contralateral in 2 cases (100%) of lesions in the internal capsule, and contralateral in 3 cases (100%) of lesions in the radiate crown (Table 3).

Based on these results, it is surmised that the central neural pathway for taste ipsilaterally ascends from the solitary nucleus of the medulla to the midbrain through the pons, crosses over to the other side within the midbrain, and contralaterally projects to the cerebral cortex after passing through the thalamus, internal capsule, and the radiate crown. However, contralateral and ipsilateral taste disorders have been reported in the pontine and thalamic lesions, respectively, although in small numbers, which cannot be explained by the aforementioned hypothesis. Hence, further examinations need to be conducted with a larger sample size.

Next, re-examination of the lesion sites based on the diagnostic imaging and subjective symptoms in each report showed that pontine lesions were located in the medial lemniscus or the lateral side of the reticular formation, which suggested that the pathway may be running

through a more dorsolateral location than conventionally speculated. Lesions were located in an area ranging from the red nucleus to the medial lemniscus in the midbrain, an area ranging from the ventral posteromedial nucleus to the ventral posterolateral nucleus in the thalamus, the posterior limb in the internal capsule, and the posterior area in the radiate crown. These sites are likely to be involved in the central neural pathway of taste.

Thus, studies in the past showed that the center of taste runs bilaterally, and examination of cases showed that it crosses over to the other side at the midbrain level, running unilaterally and contralaterally. However, as for the opinion that it runs bilaterally, as stated in past studies, there is a possibility that taste information is communicated through the corpus callosum similarly to how other sensory fibers and motor fibers run to the cerebral hemisphere on the other side through the corpus callosum. Further examination is, therefore, needed.

Conclusion

Based on our examination of cases in the past, it seems that the central neural pathway of taste crosses over to the other side at the midbrain level, running unilaterally and contralaterally. However, there are still many aspects that have not been determined concerning the taste center. In the future, we need to collect more cases, and examine the taste pathway by using new methods.

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