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Pathways for the Secretory Fibers of the Salivary Glands in Man.

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The innervation and mechanism of salivary secretion has been studied by many investigators, but completely satisfactory explanations of the various observations have not been reached partly because the innervations of the parotid, sublingual and submaxillary glands are not constant in different species of experimental animals or even in a single species. Furthermore, the fact that the innervation is not a simple one makes it all the more difficult to arrive at a definite and satisfactory understanding.

Howell,[1] speaking of the salivary glands of the dog, states as follows: "These glands receive their nerve supply from 2 general sources—namely, the bulbar autonomics (or cerebral fibers) and the sympathetic autonomics. The parotid gland receives its bulbar fibers from the glossopharyngeal or ninth cranial nerve; they pass into a branch of this nerve, known as the tympanic branch or nerve of Jacobson, thence to the small superficial petrosal nerve, through which they reach the otic ganglion. From this ganglion they pass (postganglionic fibers) by way of the auriculotemporal branch of the inferior division of the fifth cranial nerve to the parotid gland. The sympathetic autonomics pass to the superior cervical ganglion by way of the cervical sympathetic, and thence as postganglionic fibers in branches which accompany the arteries distributed to the gland. The bulbar autonomic supply for the submaxillary and sublingual glands arises from the brain in the facial nerve and passes out in the chorda tympani. This latter nerve, after emerging from the tympanic cavity through the Glaserian fissure, joins the lingual nerve. After running with this nerve for a short distance, the secretory (and vasodilator) nerve fibers destined for the submaxillary and sublingual glands branch off and pass to the glands, following the course of the ducts. The supply of sympathetic autonomics has the same general course as those for the parotid."

This is given as quite definite for the dog, but the arrangement is admittedly different for other species, and so might be far from true in man. There are probably 3 distinct sets of nerves to the sali-

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[1] Howell, W. H., 1926, IX ed., 755; W. B. Saunders Co., Phila.

vary glands; the sympathetic, parasympathetic, and trophic fibers of Heidenhain. Therefore it would be quite normal to expect that these fibers entered the organs by different routes.

In this investigation the rates of secretion of the parotid and submaxillary glands have been studied. The secretions were collected from human subjects in whom either the chorda tympani had been severed during mastoidectomy (sometimes with the facial nerve) or the ninth nerve had been cut intracranially. The secretions were collected by placing tared tampons over the duct openings of the glands, the tongue stimulated with lemon juice, and the tampons with the absorbed secretions reweighed.[2]

When the glossopharyngeal or ninth nerve is sectioned intracranially for tic douloureux there results unilateral anesthesia of the nasopharynx, soft palate, posterior pharyngeal wall and tonsillar region, loss of taste and sensation over the unilateral posterior third of the tongue. The only muscle innervated by this nerve is the stylopharyngeus, the paralysis of which cannot be detected.

Some authors[3, 4] have reported salivation during the paroxymal attacks of pain, and Hesse[5] has noted increased parotid secretion on the affected side, markedly decreased following section of the nerve. In 3 patients tested, who had one glossopharyngeal nerve cut intracranially where it is isolated from the other cranial nerves and readily divided without trauma to adjacent nerves, shortly after operation the collection of parotid secretion from the operated side was markedly diminished. This difference became smaller the longer the interval after operation.

Similar observations were obtained in the secretions of the submaxillary and sublingual glands, although the actual measurements were made of the submaxillary glands only. Starting with a ratio of 1 to 10 on the tenth postoperative day, it changed to 1 to 5 in 3 months.

It was surprising to find a markedly diminished submaxillary secretion shortly after section of the ninth nerve as the accepted theory has been that the secretory fibers pass from the brain in the seventh nerve and through the chorda tympani to the glands.

Through the courtesy of Drs. Sewall, Bacher, Cowan and Borden of the Department of Otolaryngology, the salivary secretions were collected from patients having radical mastoidectomies. In the cases

[2] Poth, E. J., PROC. SOC. EXP. BIOL. AND MED., 1933, **30**, 977.

[3] Dandy, W. E., *Arch. Surg.*, 1927, **15**, 198.

[4] Reichert, F. L., *Surg. Clin., N. A.*, 1933, **13**, 193.

[5] Hesse, E., *Internat. Abst. S. G. and O.*, 1931, **52**, 114.

examined the tympanic nerve (Jacobson's nerve), which is a branch of the ninth coursing in the middle ear and over the promontory, was believed not to be injured but almost invariably the chorda tympani was avulsed when the malleus and incus were removed. These patients not only showed a loss of taste on the ipsolateral anterior half of the tongue since it has been shown[6] that taste to the anterior half of the tongue courses through the chorda tympani, then through the seventh nerve to the brain.

Four patients having loss of taste on the anterior ⅔ of the tongue following radical mastoidectomy had their salivary secretions collected 3 days to 4 months after operation. Not only was the submaxillary secretion markedly diminished (1 to 10 or 12) throughout the whole period without any change in the ratio but the parotid secretion was markedly diminished as well (1 to 3 or 5) and remained so for 4 months after operation.

From these observations it has been shown that after section of the glossopharyngeal nerve there is an immediate and marked diminution in secretion which, however, approaches that of the normal side by the third post-operative month. When the chorda tympani has been sectioned just distal to its exit from the facial canal and facial nerve, salivary secretion is markedly and permanently diminished.

One must conclude, therefore, that secretory fibers to the salivary glands leaving the brain by the glossopharyngeal nerve following its tympanic branch (Jacobson's nerve) into the middle ear where they cross in the region of the greater superficial petrosal

TABLE I.

Rates of salivary secretion following intracranial section of the glossopharyngeal nerve.

Patient	Operative Procedure	Time Postoperative	Parotid		Submaxillary	
			Operated side	Normal side	Operated side	Normal side
			gm.	gm.	gm.	gm.
R. S.	Section N IX intracranially left. 12-10-32	10 da.	0.25	2.20	—	—
		10 wk.	2.7	4.5	0.10	0.90
		13 "	1.05	1.20	0.10	0.55
E. H.	Section N IX intracranially left. 11-10-31	1 yr. 4 mo.	0.25	0.70	0.50	0.45
					0.10	0.15
J. M. S.	Section N IX intracranially right. 7-3-30	2 yr. 6 mo.	0.60	0.90	0.20	0.25

[6] Lewis, D., and Dandy, W. E., *Arch. Surg.*, 1930, **21**, 249.

nerve to join the fibers of the seventh nerve in the region of the geniculate ganglion. Or, these fibers might be found to leave the ninth nerve via the anastomotic or communicating branch of the auricular branch of the glossopharyngeal to enter the seventh nerve distal to the chorda tympani because of the findings in Table II, Case E. In this case of peripheral Bell's Palsy with taste intact, a decrease of salivary secretion on the affected side is found.

Also, there is evidence that other secretory fibers course out from the brain through the seventh nerve. Thus the fibers as described from the ninth as well as those from the seventh are collected in the chorda tympani to be distributed to the parotid by way of the Otic ganglion and thence via the auriculo temporal branch of the fifth

TABLE II.
Rates of salivary secretion following section of chorda tympani in the tympanic membrane, and a case of peripheral Bell's palsy.

Patient	Operative Procedure	Post Operative	Parotid		Submaxillary	
			Operated side	Normal side	Operated side	Normal side
			gm.	gm.	gm.	gm.
A	Right Radical Mastoidectomy 11-24-32 Taste: Rt. Ant. 2/3 tongue gone	4 mo.	0.60 0.80	1.95 2.25	0.03	0.13
B	Bilateral Simple Mastoidectomy. Rt. facial palsy, not complete. Taste normal 2-20-33	11 days	1.45(Rt.) 1.50(Lt.)		0.05(Rt.) 1.00(Lt.)	
	Rt. Radical Mastoidectomy 3-8-33 Taste: Rt. Ant. 2/3 tongue gone	3 "	0.50(Rt.)	1.25(Lt.)	0.20(Rt.)	0.65(Lt.)
C	Rt. Radical Mastoidectomy 2-28-33 Taste: Rt. Ant. 2/3 tongue gone	4 "	1.0	3.60	None*	Abundant*
D	Rt. Radical Mastoidectomy 3-7-33 Taste: Rt. Ant. 2/3 tongue gone	5 "	0.55 0.50	1.00 1.10	0.05 0.03	0.25 0.25
E	Bell's Palsy Right Taste intact	5 wk.	0.60(Rt.) 0.50(Rt.)	1.10(Lt.) 0.95(Lt.)	0.15(Rt.) 0.10(Rt.)	0.25(Lt.) 0.50(Lt.)

* Gross observation. Not collected and weighed.

and to the submaxillary gland by way of the lingual branch of the fifth.

Summary. 1. The rates of secretion of the salivary glands in man after unilateral section of the ninth nerve and chorda tympani indicate peripheral pathways for secretory fibers to these glands other than those accepted. 2. Section of the ninth nerve intracranially causes marked temporary diminution of salivation with partial recovery involving parotid, sublingual and submaxillary glands. 3. Section of the chorda tympani in the tympanic membrane causes marked permanent diminution of salivation involving the parotid, sublingual and submaxillary glands. 4. Therefore, it is concluded that the salivary glands receive their secretory fibers from both the seventh and ninth nerves.

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A Simplified Technique for Quantitative Collection of Salivary Secretions of Man.

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Several methods have been devised for the collection of the salivary secretions of man, but most of them are either troublesome or inaccurate. The method presented here is applicable to the collection of the secretions of the parotid, sublingual, and submaxillary glands separately and simultaneously on both sides.

The method consists of applying pieces of tared absorbent material to the various duct openings, absorbing the secretions for the desired length of time, and then reweighing to nearest .05 gm. The quantity collected is given by difference. It is simpler to collect the secretions from the 3 pairs of glands separately, and the nasal tampons marketed by Johnson and Johnson are found to be the most satisfactory absorbent material.

To collect the secretions of the parotid glands, the floor of the mouth is packed off with dental rolls, and strips of tared nasal tampons about 4 cm. long are placed over the openings of Stenson's ducts. The strips will remain in place without support. They may be left in place until their thickness has doubled. This will require

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