SHORT COMMUNICATION

Jaw-closing reflex elicited by water stimulation of oral mucosa in the frog

Hiromichi Nomura and Toshifumi Kumai

Department of Oral Physiology, Matsumoto Dental College, 1780 Hirooka-gobara, Shiojiri 399-07, Japan

[Accepted for publication: November 10, 1983]

Key words: jaw-closing reflex / chemoreflex / frog / water receptor

The frog is known to have a specific chemoreceptor sensitive to water which is generally called water receptor\(^1,6,7\)\(^{,7}\). In order to know the role of this chemoreceptor, we studied the reflex elicited by tap water stimulation of the tongue and found that tap water elicits reflex discharges in the submental and submaxillary muscles and brings about nostril closure by a lever mechanism. When the submental and submaxillary muscles contract, the mandible decreases in width and the prelingual tubercle moves forward. This protrudes the anterior end of the upper jaw forward and closes the nostril.

In this lever mechanism of nostril closure, elevation of the mandible should occur simultaneously because the prelingual tubercle is needed to fit into the medial subrostral fossa of the upper jaw and to move upward slightly. In a previous study\(^4\)\(^{,4}\), however, we were not able to obtain a jaw-closing reflex in so far as stimulation of the tongue with tap water was concerned. It is known that there are also water receptors in the palate\(^5,6\)\(^{,6}\). Thus, we studies the reflex elicited by tap water stimulation of the palate and buccal floor and found that such stimulation elicited a jaw-closing reflex due to activities of the pterygoid and masseter muscles.

Materials and Methods

Male frogs, *Rana nigromaculata* and *Rana japonica*, weighing 15–30 g, were used. Under anesthesia with ethyl ether, the brachial nerves were severed bilaterally and the caudal part of the vertebral canal was destroyed with a needle in order to prevent movement of the animals after recovery from the anesthesia; then, about 0.2 ml of 0.5% MS 222 was injected intraperitoneally. After the trigeminal, facial, and glossopharyngeal nerves were dissected according to need under anesthesia, the animals were mounted on a wooden stage and fixed with pins.

Reflex activities of the jaw- and nostril-closing muscles were examined by recording electromyograms (in cases of the temporal and pterygoid muscles) or by recording neural discharges (in cases of the masseter and submental muscles) with bipolar silver wire electrodes. Myograms and neural discharges were displayed on a cathode-ray oscilloscope and recorded with a camera.

Tap water as well as sapid solutions (1 M NaCl, 0.5 mM quinine-HCl and HCl at pH 2.5) were used as chemical stimuli. These solutions were applied to the palate, tongue, or buccal floor with a pipet for about 10 seconds. Each test was followed by rinsing with Ringer’s solution with no further stimulation for 2 minutes. Tactile stimuli were applied with a small brush. Experiments were carried out at room temperature (23–26°C) in a damp room.

Results

SENSORY INNERVATION: According to Gaupp (1896), the oral mucosa of the
frog is innervated by the trigeminal, facial, and glossopharyngeal nerves. But, when the sensory innervation of oral mucosa in frogs was examined by recording the afferent neural discharges, the chemoreceptors were found to be innervated by the facial nerve and the tactile receptors, by both the facial and trigeminal nerves. The glossopharyngeal nerve did not appear to innervate the palate and buccal floor. More precisely, chemoreceptors in the palate are innervated by the palatal division of the facial nerve and those in the buccal floor and the proximal part of the tongue by hyomandibular division. Tactile receptors in the palate are innervated by both the maxillary and ophthalmic divisions of the trigeminal nerve and the palatal division of the facial nerve; those in the buccal floor and the proximal part of the tongue, by both the mandibular division of the trigeminal nerve and the hyomandibular division of the facial nerve.

JAW REFLEX: When the palate was stimulated by tap water in animals having had two-thirds of their mandible removed, an elevation of the remaining part of the mandible was usually observed. Similar elevation of the mandible was obtained by tap water stimulation of the buccal floor and proximal part of the tongue. This indicates that activation of the water receptors in the palate or in the buccal floor, including the proximal part of the tongue, elicits a jaw-closing reflex in the frog.

The frog has three kinds of jaw-closing muscles—temporal, pterygoid, and masseter muscles—the latter of which is further divided into the major and minor masseter muscles. In order to know whether or not all these muscles participate in the jaw-closing reflex by tap water stimulation of the palate or buccal floor, reflex activities in these muscles were examined by recording myograms or neural discharges in each muscle.

Fig. 1A shows the myograms of the right temporal and left pterygoid muscles elicited reflexly by tactile and chemical stimuli of the buccal floor including the proximal part of the tongue. It was seen that a touch with a brush on the lower lip elicited a phasic discharge in the temporal muscle and a relatively tonic discharge in the pterygoid muscle unilaterally. Tap water stimulation of the oral mucosa always elicited a long-
lasting tonic discharge in the pterygoid and major masseter muscles (or its part) as seen in the third and sixth columns of Fig. 1A. 1 M NaCl usually elicited an appreciable discharge in the pterygoid muscle, but 0.5 mM quinine-HCl and HCl at pH 2.5 did not. It is to be noted in this figure that chemical stimuli elicited no reflex discharge in the temporal muscle. The jaw closing reflex elicited by chemical stimulation appeared to occur bilaterally.

Fig. 1B shows the reflex discharges of the nerve branches innervating the submental muscle (upper traces) and the major masseter muscle (lower traces) when the palate was stimulated tactilely and chemically. It is seen that tap water on the palate elicited pronounced tonic discharges in both nerve branches. This indicates that tap water stimulation of the palate elicits both the jaw- and nostril-closing reflexes simultaneously.

As the masseter muscle is innervated by several small nerve branches, we were not able to determine whether or not all the major masseter muscle fibers participate in the jaw-closing reflex elicited by chemical stimulation. The minor masseter muscle did not appear to participate in the reflex.

Discussion

The present study showed that the frog does not employ the temporal muscle in the jaw-closing reflex elicited by chemical stimulation, though it is used in the jaw-closing reflex elicited by tactile stimulation. This may be explained by the following reasons. The temporal muscle and the major part of the masseter muscle elevate the mandible backwards. Since nostril closure in the frog is caused by the forward movement of the anterior end of the upper jaw brought about by the protrusion of the prelingual tubercle of the mandible toward the medial subrostral fossa of the upper jaw, the backward movement of the mandible hampers the nostril-closing movement. On the contrary, the pterygoid muscle elevates the mandible forward and contributes to the nostril-closing movement. If this is the case, the role of the masseter muscle in the nostril-closing reflex should involve an antagonistic and compensating action against the forward movement of the lower jaw by the pterygoid muscle.

Another reason may be that the temporal muscle participates in a phasic movement of the lower jaw during prey capture, while the pterygoid and masseter muscles participate in a slow or tonic movement as during jaw closure at rest or in water. The finding that tactile stimulus on the lip elicited a more tonic reflex discharge in the pterygoid and masseter muscles than in the temporal muscle suggests this possibility.

References