Short Communication

Japanese Journal of Physiology, **30**, 305–307, 1980

Water Fibers in the Superior Laryngeal Nerve of the Rat

Tomio SHINGAI*

Department of Physiology, Akita University
School of Medicine, Akita, 010 Japan

Summary Water responses elicited by application of water on the laryngeal mucosa were observed in the superior laryngeal nerve fibers in the rat. The response was augmented by K^+ ions and was depressed by Na^+ ions, while anions (Cl^-, F^-, SO_4^{2-}, benzoate) showed no noticeable effect.

Water fibers in the superior laryngeal nerve (SLN) which are excited by water application on the laryngeal mucosa have been found in several animals. These include the cat (STOREY, 1968; BOUSHEY *et al.*, 1974), lamb (STOREY and JOHNSON, 1975; HARDING *et al.*, 1976), rabbit (SHINGAI, 1977) and monkey (HARDING *et al.*, 1978). In the rat, water fibers have not yet been identified in the SLN, although fibers chemosensitive to NaCl have been found in the nerve (ANDREW and OLIVER, 1951; ANDREW, 1956). This paper describes water fibers in the SLN of the rat, and its properties in response to various electrolyte solutions.

Wistar rats, weighing 250–350 g, were used. The laryngeal mucosa of the animal anesthetized with urethane (1.0 g/kg, i.p.) was exposed by a midline incision in the thyroid cartilage, and the edges of the incision were held apart by threads to expose the laryngeal surface of the epiglottis. After surgical procedure, the animals were immobilized with gallamine triethiodide (Teikoku Kagaku Indust. Co.) and artificially ventilated.

Recordings of neural activity were performed with a bipolar platinum electrode from single fibers or thin strands dissected from the SLN. Test solutions were dropped onto the laryngeal surface of the epiglottis using a syringe equipped with a fine needle. Between periods of stimulation the mucosa was rinsed with 160 mM NaCl solution. Unitary or multiunit responses were recorded on a magnetic tape and were displayed on a pen-recorder through an integrator having a time constant of 0.3 sec.

Figure 1a illustrates a typical response of a single water fiber in the SLN induced by water application. One droplet (about 10 μl) of distilled water was enough to excite water units, but a droplet of liquid paraffin did not evoke any

Received for publication September 17, 1979

* Present address: Department of Physiology, Niigata University School of Dentistry, Niigata, 951 Japan

真貝富夫

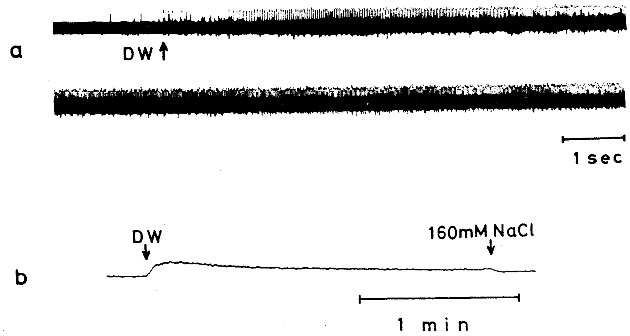

Fig. 1. Response of a single water unit in the superior laryngeal nerve of the rat to distilled water. One droplet of water was applied to the laryngeal surface of the epiglottis. (a) A unitary response of a water unit. (b) The integrated response. Arrows indicate the times of application of distilled water (DW) and 160 mM NaCl solution.

response. Therefore, effectiveness of water stimulation is not mechanical, but chemical. The impulse frequency of the water response gradually increased in the early phase of the response, reaching a maximum firing level within several seconds (Fig. 1a). The maximum frequency of the discharge ranged from 60–80 impulses/sec. After then, the discharge frequency decreased very slowly (Fig. 1b). Application of 160 mM NaCl solution rapidly suppressed the response (Fig. 1b). When water was dropped successively, the unit continued to discharge for a few minutes.

Effects of several ions on the excitability of the water units were examined. Figure 2 shows concentration-response curves for NaCl and KCl. In the ex-

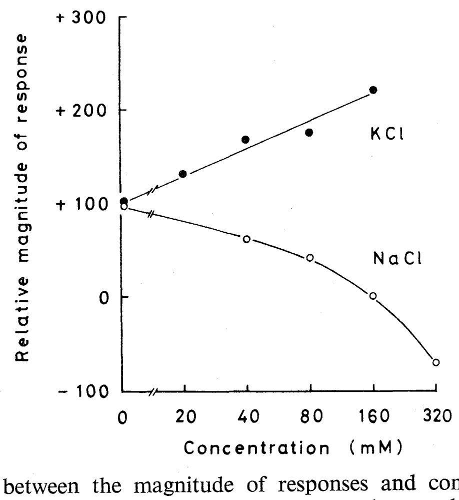

Fig. 2. Relations between the magnitude of responses and concentrations of KCl and NaCl. The magnitude of the response was expressed as a relative value of the area of the integrated response during initial 30 sec for test solutions to that for distilled water. The spontaneous level was expressed as zero.

periment of Fig. 2, the response were led from a thin bundle containing a few water units which had much spontaneous activity. The magnitude of the responses evoked by KCl solutions increased with increasing concentrations of KCl. On the other hand, the responses produced by NaCl solutions gradually decreased in magnitude as the concentrations were raised. When 320 mM NaCl solution was applied, the basal activity was rapidly depressed and then the discharge frequency gradually returned to the pre-stimulus level within 1 min. The augmentation of the water response by KCl and the depression of the response by NaCl were also observed in the experiments with a single water unit preparation.

NaF and Na_2SO_4 showed a depressing effect similar to that with NaCl. Effects of potassium benzoate and sodium benzoate were also examined, because benzoate ions have a strong inhibitory effect on the activity of taste fibers of the rat (BEIDLER, 1967) and of the water fibers of the frog (NOMURA and ISHIZAKI, 1972). Potassium benzoate produced copious discharges as did KCl, whereas sodium benzoate had a depressing effect similar to that of NaCl.

The results obtained in the present study suggest that the excitability of the water unit in the rat is not associated with anions but with cations. It is, therefore, considered that the augmentation of the water response by potassium salts is caused by K^+ ions and the depression of the response by sodium salts is due to Na^+ ions. The cation dependence of the water unit excitability in the rat is in contrast to the anion dependence of the excitability of water units in the SLN of the rabbit (SHINGAI, 1977).

REFERENCES

ANDREW, B. L. and OLIVER, J. (1951) The epiglottal taste buds of the rat. *J. Physiol. (Lond.)*, **114**: 48P–49P.

ANDREW, B. L. (1956) A functional analysis of the myelinated fibres of the superior laryngeal nerve of the rat. *J. Physiol. (Lond.)*, **133**: 420–432.

BEIDLER, L. M. (1967) Anion influences on taste receptor response. *In*: Olfaction and Taste, Vol. II, ed. by HAYASHI, T. Pergamon Press, Oxford, pp. 509–534.

BOUSHEY, H. A., RICHARDSON, P. S., WIDDICOMBE, J. G., and WISE, J. C. M. (1974) The response of laryngeal afferent fibres to mechanical and chemical stimuli. *J. Physiol. (Lond.)*, **240**: 153–175.

HARDING, R., JOHNSON, P., and MCCLELLAND, M. E. (1976) Water receptors in the larynx of the lamb. *J. Physiol. (Lond.)*, **256**: 104P–105P.

HARDING, R., JOHNSON, P., and MCCLELLAND, M. E. (1978) Liquid-sensitive laryngeal receptors in the developing sheep, cat and monkey. *J. Physiol. (Lond.)*, **277**: 409–422.

NOMURA, H. and ISHIZAKI, M. (1972) Stimulation mechanism of water response in the frog: Roles of anions in the activity of a chemoreceptor. *Bull. Tokyo Dent. Coll.*, **13**: 21–52.

SHINGAI, T. (1977) Ionic mechanism of water receptors in the laryngeal mucosa of the rabbit. *Jpn. J. Physiol.*, **27**: 27–42.

STOREY, A. T. (1968) A functional analysis of sensory units innervating epiglottis and larynx. *Exp. Neurol.*, **20**: 366–383.

STOREY, A. T. and JOHNSON, P. (1975) Laryngeal water receptors initiating apnea in the lamb. *Exp. Neurol.*, **47**: 42–55.