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BRAIN RESEARCH

Short Communication

Brain-derived neurotrophic factor-immunoreactive neurons in the rat vagal and glossopharyngeal sensory ganglia; co-expression with other neurochemical substances

H. Ichikawa, R. Terayama, T. Yamaai, Z. Yan, T. Sugimoto*

Department of Oral Function and Anatomy, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, 2-5-1 Shikata-cho, Okayama 700-8525, Japan

ARTICLE INFO

Article history:
Accepted 8 November 2006
Available online 21 May 2007

Keywords:
Brain-derived neurotrophic factor
Jugular ganglion
Nodose ganglion
Petrosal ganglion
Immunohistochemistry
Rat

ABSTRACT

Immunohistochemistry for brain-derived neurotrophic factor (BDNF) was performed on the rat vagal and glossopharyngeal sensory ganglia. In the jugular, petrosal and nodose ganglia, 56.1±5.5%, 52.4±9.4% and 80.0±3.0% of sensory neurons, respectively, were immunoreactive for BDNF. These neurons were small- to medium-sized and observed throughout the ganglia. In the solitary tract nucleus, the neuropil showed BDNF immunoreactivity. A double immunofluorescence method demonstrated that BDNF-immunoreactive neurons were also immunoreactive for calcitonin gene-related peptide (CGRP), P2X3 receptor, the capsaicin receptor (VR1) or vanilloid receptor 1-like receptor (VRL-1) in the jugular (CGRP, 43.5%; P2X3 receptor, 51.1%; VR1, 71.7%; VRL-1, 0.5%), petrosal (CGRP, 33.2%; P2X3 receptor, 58.4%; VR1, 54.2%; VRL-1, 23.3%) and nodose ganglia (CGRP, 1.8%; P2X3 receptor, 49.1%; VR1, 70.7%; VRL-1, 11.5%). The co-expression with tyrosine hydroxylase was also detected in the petrosal (2.9%) and nodose ganglia (2.2%). However, BDNF-immunoreactive neurons were devoid of parvalbumin in these ganglia. The present findings suggest that BDNF-containing vagal and glossopharyngeal sensory neurons have nociceptive and chemoreceptive functions.

Somatic and visceral sensory neurons of the vagus nerve are located in the jugular and nodose ganglia, respectively. In addition, visceral sensory neurons of the glossopharyngeal nerve are present in the petrosal ganglion. These neurons convey sensory information from the tongue, larynx, pharynx, thorax and abdomen to the brainstem. Previous studies have classified vagal and glossopharyngeal sensory primary neurons into several subpopulations on the basis of their neurochemical substances. Calcitonin gene-related peptide (CGRP) is localized to small- to medium-sized nociceptors in the petrosal, jugular and nodose ganglia (Helke and Hill, 1988; Helke and Niederer, 1990). The capsaicin (vanilloid) receptor VR1 is an ion channel which can be activated by vanilloid compounds, protons and heat (>43 °C), whereas vanilloid receptor 1-like receptor (VRL-1) is activated by high temperatures with a threshold >52 °C (Caterina et al., 1997, 1999). P2X3 receptor is one of ligand-gated ion channels which is activated by extracellular ATP (Cook et al., 1997). These ion channels are predominantly expressed by nociceptors throughout the rat vagal and glossopharyngeal sensory ganglia (Ichikawa and Sugimoto, 2002, 2003; Ichikawa et al., 2006a). Tyrosine hydroxylase (TH) is a rate limiting enzyme of catecholamine synthesis. This enzyme is localized to chemoreceptors in the petrosal and nodose

* *Corresponding author*. Fax: +81 86 235 6612.
E-mail address: hiroichi@md.okayama-u.ac.jp (H. Ichikawa).

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doi:10.1016/j.brainres.2006.11.024

ganglia of the mouse and rat (Katz and Black, 1986; Helke and Hill, 1988; Helke and Niederer, 1990; Ichikawa et al., 1993; Ichikawa, 2002). On the other hand, parvalbumin (PV), a member of the calcium-binding protein family, is expressed by vagal and glossopharyngeal sensory neurons which include low-threshold mechanoreceptors (Ichikawa and Helke, 1995; Iino et al., 1998).

Brain-derived neurotrophic factor (BDNF) can support proliferation, differentiation and survival of neurons in the peripheral and central nervous systems during development (Klein, 1994). In addition, BDNF is expressed by many neurons in the sensory ganglia of adult rats (Zhou and Rush, 1996; Zhou et al., 1998; Thompson et al., 1999; Luo et al., 2001; Ichikawa et al., 2006b). In the dorsal root and trigeminal ganglia, BDNF-

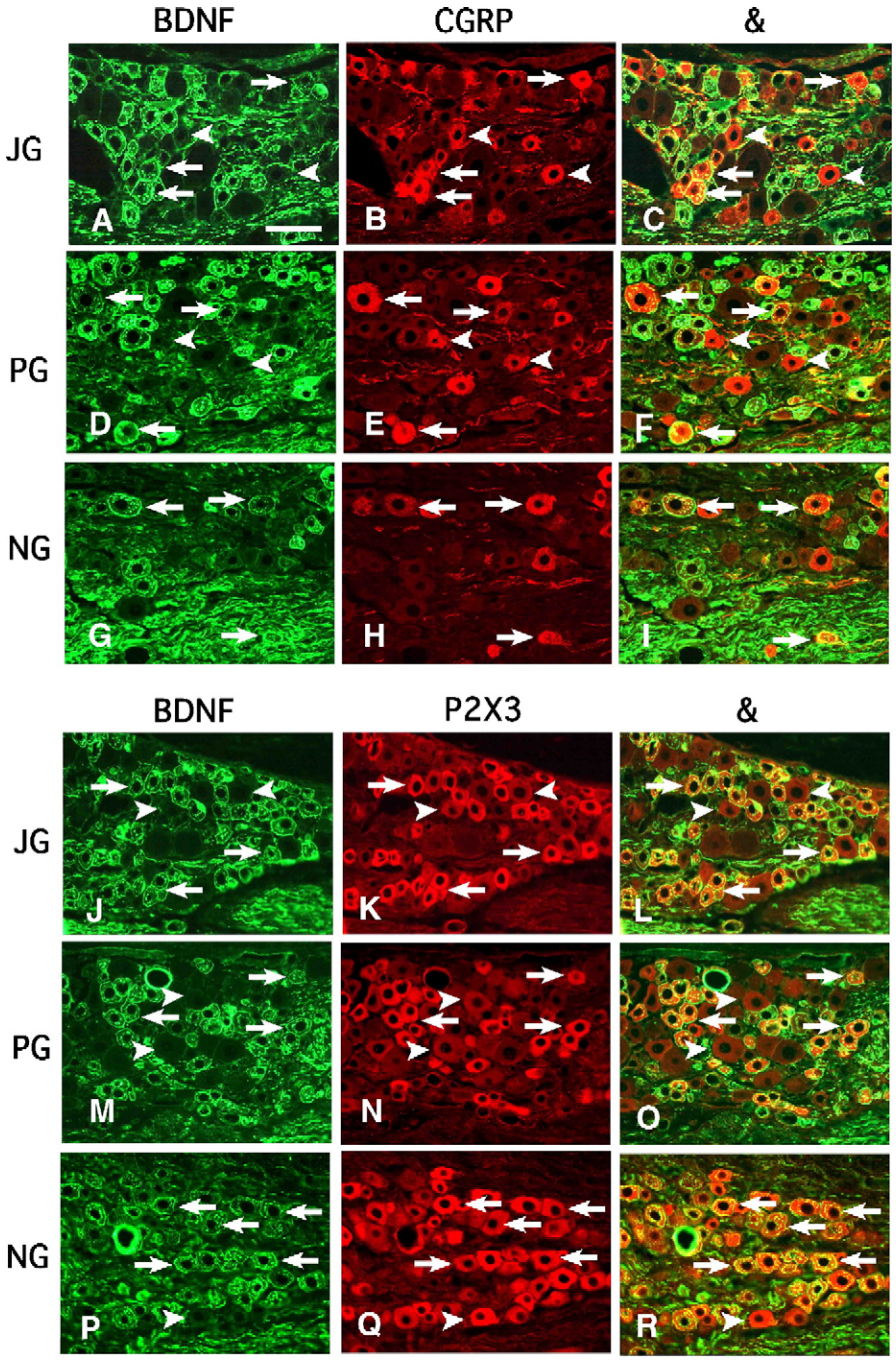

Fig. 1 – Double immunofluorescent microphotographs of BDNF-ir (A, D, G, J, M, P), CGRP-ir (B, E, H), BDNF- and CGRP-ir (C, F, I), P2X3 receptor-ir (K, N, Q) and BDNF- and P2X3 receptor-ir (L, O, R) in the jugular (JG; A–C, J–L), petrosal (PG; D–F, M–O) and nodose ganglia (NG; G–I, P–R). Panels A–R show the same fields of view, respectively. A double immunofluorescence method demonstrates that many BDNF-ir neurons co-express CGRP-ir (arrows in panels A–I) or P2X3 receptor-ir (arrows in panels J–R). Arrowheads in panels A–F and panels J–R point to CGRP- and P2X3 receptor-ir neurons, respectively, which are devoid of BDNF-ir. Scale bar=50 μm (A). All panels are at the same magnification.