Morphological Characteristics of Tectal Neurons of Layer I Projecting to the Nucleus Geniculatus Lateralis Ventralis in Chick

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(Received 5 January 2004/Accepted 26 March 2004)

ABSTRACT. Some visual information is sent to the nucleus geniculatus lateralis ventralis (GLv) via the cells in layer I (I cells) of the tectum in birds and is used for color vision, papillary reflex, and kineoptic functions. To reveal the morphological features of 'I cells' projecting to the GLv, they were retrogradely labeled with DiI (1,1'-diiododecyl-3, 3', 3'-tetramethylindolyl-carbocyanine perchlorate) in chicks. Two different types of neurons, 'spear dendritic I cells' and 'forked dendritic I cells' were identified. The former had small spindle-like soma and an apical dendrite extending to the tectal surface, and the latter had somewhat larger triangular or polygonal soma and plural ascending dendrites. Most of the labeled dendritic endings bifurcated horizontally in layer F, and showed the ending patterns similar to the terminals of optic nerve fibers.

KEY WORDS: avian tectum, ventral lateral geniculate nucleus, vision.

J. Vet. Med. Sci. 66(8): 1015–1016, 2004

The tectum is a main visual center in birds and receives various visual information such as kineoptics, sight, and brightness via many types of retinal ganglion cells concerning with these respective information [12]. Some visual information is sent to the nucleus geniculatus lateralis ventralis (GLv) [2, 7, 8] and is used for visual functions of color vision [11], papillary reflex [4], and optomotor mechanisms [5, 14]. These output neurons are exclusively located in layer I of the stratum griseum et fibrosum superficiale [7]. However, morphological features of these neurons have been reported sporadically so far, as compared to the neurons in the stratum griseum centrale (SGC) that are main sources to the nucleus rotundus [1, 3, 6, 9].

Nineteen chicks (one- or two-day-old) supplied by incubation of fertilized eggs in our laboratory were cared in a brooder (38°C, natural light). All chicks were deeply anesthetized with pentobarbital sodium (0.06–0.12 ml, 32 mg/kg) through the peritoneum. Chicks received perfusion of 1% paraformaldehyde in 0.1 M phosphate buffer (pH 7.4, 4°C) through the left ventricle.

A small amount (0.8 μ l) of 0.5% suspending solution of DiI (1,1'-diiododecyl-3, 3', 3'-tetramethylindolyl-carbocyanine perchlorate, Molecular Probes, Eugene, OR) (0.8 mg DiI - 8 μ l dimethyl sulfoxide in 150 μ l physiological saline containing 0.1% Triton X-100) was injected into the GLv of 11 chicks by the use of the stereotaxic instrument (SR-60, Narishige, Japan). In 8 chicks, after perfusion of 1%

paraformaldehyde, the brain was transversally cut through the region of the GLv on the stereotaxic instrument. Small DiI crystals were implanted into the GLv. In all chicks, the brain was immersed into 1% paraformaldehyde in 0.1 M phosphate buffer (pH 7.4, 37°C) for 9 weeks in the dark. The brain was cut with a vibratome at 200 μ m in 0.1 M phosphate buffer (pH. 7.4). Sections were collected in 4% paraformaldehyde in 0.1 M phosphate buffer and were counterstained with 0.04% 4',6-diamidino-2-phenylindole dihydrochloride (DAPI) in 0.1 M phosphate buffer (pH. 7.4) for one min on glass slide to reveal the laminar structure of the tectum. Sections were rinsed with 0.1 M phosphate buffer (three times) on glass slide. The sections were covered with a slip of glass by polyvinyl alcohol. Cytoarchitectural classification of the chick brain was followed to the Kuenzel and Masson's atlas [10].

After an application of DiI into the GLv, two different types of neurons were identified in the tectal layer I (I cells) according to their dendritic arborization, 'spear dendritic I cells' and 'forked dendritic I cells'.

'Spear dendritic I cells': These neurons had small spindle-like soma and an apical dendrite extending perpendicularly toward the tectal surface and were found to be labeled often in layer I (Fig. 1a). An average of somal areas of 'spear dendritic I cells' was $149.9 \pm 55.7 \mu\text{m}^2$ (mean $\pm$ SD) (range: $87.1\text{--}335.9 \mu\text{m}^2$, $n=55$). An apical dendrite gave off short branches to some of layers A–H, but most of these dendrites including apical dendrites ended in layer F (approximately 60 %). The width of dendritic endings was $56.0 \pm 35.2 \mu\text{m}$ on average (range: $11.9\text{--}162.4 \mu\text{m}$, $n=42$).

'Forked dendritic I cells': These cells had somewhat larger triangular or polygonal somata. The somal area was $282.9 \pm 98.7 \mu\text{m}^2$ on average (range: $112.5\text{--}513.3 \mu\text{m}^2$, $n=43$). Two to five ascending and basal dendrites gave off

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Fig. 1. Photomicrographs of two kinds of tectal I cells projecting to the nucleus geniculatus lateralis ventralis, 'spear dendritic I cell' with a spindle-like soma and a single apical dendrite (a) and 'forked dendritic I cell' with polygonal soma and plural ascending dendrites (b). Note that the dendrites bifurcate horizontally in layer F (a) or form bush-like endings (b) as shown in camera lucida. Arrow in a indicates the neuron shown in camera lucida. Scale bar in a is 50 μm for a and b.

secondary and tertiary branches (Fig. 1b). Dendritic endings were observed in some of layers A-H, particularly in layer F (approximately 65.1%). Some dendrites arising from the bottom surface of the soma or from the basal dendrite extended downwards to layer I, layer J, or SGC. The dendritic endings showed two different features, bush-like ending with small branches and bifurcated ending without any branches. Extension of ascending dendrites was $224.1 \pm 99.6 \mu\text{m}$ on average (range: 92.6–536.1 μm , $n=43$).

Two types of neurons demonstrated in this study, 'spear dendritic I cells' and 'forked dendritic I cells', seem to correspond to bipolar [13] or radial [15] cells and ganglionic [13] or nonradial cells [15] in tectal layer I cells demonstrated by Golgi impregnation method, respectively. Most of the ascending dendrites of labeled I cells bifurcated horizontally in layer F and formed the specialized dendritic endings. The shape of these dendritic endings in layer F is well consistent with that of the retinal axon terminals which formed a slab-like terminal system oriented horizontally in layer F [16]. It may be helpful to the transmission of some kinds of the visual information between retinal ganglion cells and tectal I cells which send axons to the GLv. Hunt and Kunzle [8] demonstrated inhibitory property on layer I cells by labeling with tritiated GABA. It suggests that the TO(tectum opticum)-GLv system would serve as the inhibitory system during the visual processes in the GLv.

REFERENCES

1. Benowitz, L. I. and Karten, H. J. 1976. *J. Comp. Neurol.* **167**: 503–520.
2. Crossland, W. J. and Uchwat, C. J. 1979. *J. Comp. Neurol.* **85**: 87–106.
3. Deng, C. and Rogers, L. J. 1998. *J. Comp. Neurol.* **394**: 171–185.
4. Gamlin, P. D., Reiner, A., Erichsen, J. T., Karten, H. J. and Cohen, D. H. 1984. *J. Comp. Neurol.* **226**: 523–543.
5. Gioanni, H., Palacios, A., Sansonetti, A. and Varela, F. 1991. *Exp. Brain Res.* **86**: 601–607.
6. Hu, M., Naito, J., Chen, Y., Ohmori, Y. and Fukuta, K. 2003. *Anat. Histol. Embryol.* **32**: 335–340.
7. Hu, M., Naito, J., Chen, Y., Ohmori, Y. and Fukuta, K. 2004. *Anat. Histol. Embryol.* (in press).
8. Hunt, S. P. and Kunzle, H. 1976. *J. Comp. Neurol.* **170**: 173–189.
9. Karten, H. J., Cox, K. and Mpodozis, J. 1997. *J. Comp. Neurol.* **387**: 449–465.
10. Kuenzel, W. J. and Masson, M. 1988. *A Stereotaxic Atlas of the Brain of Chick (Gallus domesticus)*. Johns Hopkins University Press, Baltimore and London.
11. Maturana, H. R. and Varela, F. J. 1982. *Brain Res.* **247**: 227–241.
12. Naito, J. and Chen, Y. 2004. *J. Comp. Neurol.* **469**: 360–376.
13. O'Flaherty, J. J. 1970. *J. Hirnforsch.* **12**: 389–404.
14. Pateromichelakis, S. 1979. *Brain Res.* **167**: 281–296.
15. Stone, J. and Freeman, J. A. 1971. *Brain Res.* **27**: 203–221.
16. Tombol, T. 1998. *Acta Anat.* **162**: 209–225.