Biochemical and Biophysical Research Communications xxx (2018) 1–5

Contents lists available at ScienceDirect

Biochemical and Biophysical Research Communications

journal homepage: www.elsevier.com/locate/ybbrc

Alteration of the nucleus basalis of Meynert afferents to vibrissae-related sensory cortex in de-whiskered adolescent congenital hypothyroid rats

Gila Behzadi [a], Mohammad Reza Afarinesh [b, *], Tahereh Haghpanah [c]

[a] Functional Neuroanatomy Lab, NPRC, Physiology Dept., Fac. Med, Shahid Beheshti Med. Sci. Univ, Tehran, Iran
[b] Kerman Cognitive Research Center and Kerman Neuroscience Research Center, Institute of Neuropharmachology, Kerman University of Medical Sciences, Kerman, Iran
[c] Department of Anatomy, Afzalipour Faculty of Medicine, Kerman University of Medical Sciences, Kerman, Iran

ARTICLE INFO

Article history:
Received 26 May 2018
Accepted 1 July 2018
Available online xxx

Keywords:
Hypothyroidism
Nucleus basalis of meynert (NBM)
Barrel cortex
Afferent
Plasticity
Whisker deprivation
Tract-tracing

ABSTRACT

Introduction: Thyroid hypofunction during early development results in anatomical alterations in the cerebellum, cerebrum, hippocampus and other brain structures. The plastic organization of the nucleus basalis of Meynert (nBM) projections to the whiskers-related somatosensory (wS1) cortex in adolescent pups with maternal thyroid hypofunction and sensory deprivation was assessed through retrograde WGA-HRP labeling.
Methods: Congenital hypothyroidism induced by adding PTU (25 ppm) to the drinking water from embryonic day 16 to postnatal day (PND) 60. Pregnant rats were divided to intact and congenital hypothyroid groups. In each group, the total whiskers of pups (4 of 8) were trimmed continuously from PND 0 to PND 60.
Results: Following separately WGA-HRP injections into wS1, retrogradely labeled neurons were observed in nBM. The number of labeled neurons in nBM were higher in the congenital hypothyroid and whisker deprived groups compared to their controls ($P < 0.05$).
Conclusion: Based on our results both congenital hypothyroidism and sensory deprivation may disturb normal development of cortical circuits in of nBM afferents to the wS1 cortex.
© 2018 Published by Elsevier Inc.

1. Introduction

Sensory cortical maps are dynamic representations whose developmental refinement depend on sensory experience [1]. The whisker part of primary somatosensory cortex (wS1) of the rodents, known as barrel cortex, is a useful model system for studying experience-dependent cortical development, because there is a simple mapping of individual whiskers to the corresponding barrel columns in the cortex [2]. Barrels receive catcolaminergic, serotonergic and cholinergic nerves more than thalamic afferents but we have a little knowledge about role of these nerves in processing sensory information [3].

The nucleus basalis meynert (nBM) is a term which is used for frontal areas of the brain basalis mainly refering to places along and in front of interior capsule margins and along globus pallidus middle margins. While acetylcholine (ACh) release is facilitated by Electrical stimulation of NBM in different areas of the cortex [4], it should be noted that ACh itself plays a crucial role in functional modulation based in the central nervous system such as: arousal, attention, learning and memory [5,6]. For the past 20 years, multiple studies have demonstrated the effect of acethylcholine on the functions of brain cortex with regards to the fact that a direct relation has been observed in many recent studies. ACh release occurs by the help of cortex cholinergic neurons (20%) or cholinergic neurons of nBM (80%) [5]. There is no hmogeneity in the distribution of ACh input from NBM; it is because greater amounts of ACh fibers are found in layers III and V [7].

Retrograde labeling studies in the rat and non-human primate brain have demonstrated that the nBM, situated in the substantia innominata in the basal forebrain provides the major source of the cholinergic projections to virtually all areas of the cerebral cortex

* Corresponding author. Kerman Neuroscience Research Center, Kerman University of Medical Sciences, Kerman, P.O.Box:76198-13159, Iran.
E-mail addresses: r.afarinesh@kmu.ac.ir, reza.afarinesh@gmail.com (M.R. Afarinesh).

https://doi.org/10.1016/j.bbrc.2018.07.001
0006-291X/© 2018 Published by Elsevier Inc.

Please cite this article in press as: G. Behzadi, et al., Alteration of the nucleus basalis of Meynert afferents to vibrissae-related sensory cortex in de-whiskered adolescent congenital hypothyroid rats, Biochemical and Biophysical Research Communications (2018), https://doi.org/10.1016/j.bbrc.2018.07.001

[8]. The nBM has an important modulatory effects on the vibrissal sensory-motor neural plasticity, information processing and integration [9]. It has been reported that depletion of cholinergic fibers in newborn rats did not change the size of barrels in wS1 cortex [10], while no significant plasticity response was observed in the absence of cholinergic input from the nBM to wS1 cortex [11]. Moreover, it has been shown that cholinergic system plays a permissive role in activity-dependent modifications of neuronal connections in the somatosensory and visual cortex [9].

Maternal and fetal thyroid hormones have an important role on the normal development of sensory systems [12]. Thyroid hormones (THs) are major regulators for normal developing of central nervous system [13]. Different parts of the brain structures vary in sensitivity to THs during developmental events [14]. Our previous study has shown that both chronic whisker deprivation and congenital thyroid hypofunction alter quantitative patterns of cortical and sub-cortical afferents from thalamus, locus coeruleus and dorsal raphe nuclei to primary sensory and motor cortices [15]. Since overall functions of the cholinergic systems could also be modified by hypothyroidism [16] and sensory deprivation [9], we quantitatively and comparatively evaluate nBM projections to vibrissae sensory cortex. To this aim, discrete injections of retrograde tracer; wheat germ agglutinin-horseradish peroxidase (WGA-HRP); was performed in wS1 cortex of hypothyroid rats following chronic whisker deprivation.

2. Materials and methods

2.1. Animals and experimental procedures

The Wistar rats were housed in a 12-h light/12-h dark controlled room at a constant temperature (22–24 °C) conditions with free access to food and water. All of the experimental procedures were performed in accordance with guidelines for caring and using of laboratory animals set forth by the research council at Shahid Beheshti University of Medical Sciences (Tehran–Iran). The present study was conducted with 16 pups derived from sixteen breeding pairs (weighing 250–300 g). Under sterile conditions, the first day of pregnancy was defined by first sight of a vaginal plug.

According our previous study [15,17], congenital hypothyroidism (CH) was induced by adding propylthiouracil (PTU, 25 mg/l, Iran hormone) to the drinking water of eight pregnant dams beginning at embryonic day 16 (E16) to assure that thyroid hormone levels were suppressed from the onset of the fetal thyroid gland function in E17 [18]. The PTU treatment was continued after birth to postnatal day 60 (PND60). A fresh PTU solution was prepared at weekly intervals. Similar to our previous studies, the symptoms of hypothyroidism e.g. growth impairment (weekly) and multiple morphological alterations were recorded to confirm congenital thyroid hormone deficiency.

After delivery of pregnant congenital hypothyroid rats, the pups were placed with their mother and were randomly divided into two groups in each cage: 1-Hypothyroid + whisker deprived group (Hypo + WD), all of whiskers were trimmed bilaterally every other day to a length of 1 mm from PND 0 until PND 60 (n = 4). 2-Hypothyroid pups (Hypo) who had been kept with intact whiskers (n = 4). Each rats per groups was selected from a pair parent. The second group was composed of one control pregnant dams who received tap water. Similarly, the offspring of eight pregnant dams was divided into two groups: the whisker deprived group (Ctl + WD), which were subjected to whisker trimming as explained (n = 4) before and intact pups used as the control group (Ctl) (n = 4). Blood samplings was obtained from the 3 rats per each group on the PND 60 to evaluate free thyroxine hormone (T4) determination. Then, plasma of samples was extracted by centrifuge apparatus at 3000 rpm × 15 min, and was stored in a microtube. T4 concentrations were determined using the T4 kit (DiaPlus Inc Co., Canada).

2.2. Surgery and tracer injections

According our previous study [15], on the 58 days after birth, each animal was anesthetized by an intraperitoneal injection of ketamine (80 mg/kg)/xylazine (10 mg/kg) mixture. Using a 5 μl Hamilton syringe, ipsilateral (right hemisphere) pressure injection of 0.5 μl WGA-HRP (Sigma, St. Louis, MO; 1% in distilled water) was performed separately into the wS1 cortex (2 mm caudal to the bregma, 5 mm lateral from the midline and 1–1.5 mm deep) [19]. When the needle was removed, the injection sites were cleaned with sterile saline, and the scalp incision was sutured. After 48 h of survival time, the pups were deeply re-anesthetized and perfused transcardially with 150 ml saline (37 °C) followed by 150–250 ml of fixative (1.25% glutaraldehydeand 1% paraformaldehyde in 0.1 M phosphate buffer at pH 7.4,4 °C). Following perfusion and fixation, the brain was removed and crioprotected in 20% solution (sucrose + phosphate-buffered saline) for overnight at 4 °C. The blocks of tissue were cut serially into 50-μm-thick coronal sections using a cryostat. The tetra-methybenzidine method was used for the WGA-HRP reaction procedure [20]. For better structural illustration, the sections were counterstained with0.1% neutral red.

2.3. Counting procedure and image analysis

The WGA-HRP-labeled neurons were localized by examining the sections under a light microscope. A computer based Image Analysis System (Olympus BX60 and DP12; Olysia soft imaging system, Japan) was employed to determined the number of WGA-HRP positive neurons. The positioning of the structures (forebrain, diencephalic and brain stem nuclei) was achieved according to atlas of rats [19]. For each brain, labeled structures were counted and the mean neuron count was obtained by pooling the number of WGA-HRP positive perikaria in 6–8 corresponding tissue sections for each nucleus.

2.4. Data analysis

Statistical differences between labeled cells in different groups were determined by One-way ANOVA followed by post-hoc Tukey-Kramer. The level of significance was set at $P < 0.05$.

3. Results

3.1. Thalamic labeling and injection sites confirmation

Among a total of 16 offspring pups of both sexes only rats (n = 4, in each group) with specific thalamic (VPM) projections to wS1 cortex were analyzed in this study. The accuracy of individual injection sites in wS1 targets were confirmed with the presence of ipsilateral labeled neurons in the thalamic VPM nucleus [21,22]. The injection sites for each cortical area are schematically shown in Fig. 1.

3.2. Experimental hypothyroidism

PTU is frequently used to induce chemical hypothyroidism in our laboratory [23–26]. According to our previous study [24], PTU (50 mg/l) caused a severe mortality (>90%) of the offspring after PND 25. To keep the longevity up to PND 60, we reduced the dose of PTU down to 25 mg/l [15,17]. This dose reduced the rate of mortality to <10%. The body weight gain of Hypothyroid groups (Hypo and Hypo + WD) reduced significantly compared to control groups

Please cite this article in press as: G. Behzadi, et al., Alteration of the nucleus basalis of Meynert afferents to vibrissae-related sensory cortex in de-whiskered adolescent congenital hypothyroid rats, Biochemical and Biophysical Research Communications (2018), https://doi.org/10.1016/j.bbrc.2018.07.001

Download English Version:

https://daneshyari.com/en/article/8961812

Download Persian Version:

https://daneshyari.com/article/8961812

Daneshyari.com