Journal of Contemporary Medical Education, 2023
VOL 13, NO. 04, PAGE 01

PERSPECTIVE

Open Access

Development of Paraventricular Nucleus Hypothalamus and its Components

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ARTICLE HISTORY
Received: 03-Apr-2023, Manuscript No. JCMEDU-23-96440; Editor assigned: 07-Apr-2023, Pre-QC No. JCMEDU-23-96440 (PQ); Reviewed: 21-Apr-2023, QC No. JCMEDU-23-96440; Revised: 28-Apr-2023, Manuscript No. JCMEDU-23-96440 (R); Published: 05-May-2023

Description

The paraventricular nucleus of the hypothalamus (PVH) is a largely conserved brain area. From zebrafish to humans, it is situated in the ventral diencephalon next to the third ventricle. Magnocellular, parvocellular, and long-projecting neurons, which make up the majority of the neurons in the PVH, are crucial to the control of energy balance and a number of endocrinological processes. This study focuses on recent findings regarding the PVH's role in modulating energy homeostasis and the hypothalamus-pituitary system, as well as human diseases like obesity, short stature, hypertension, and diabetes insipidus that are linked to the PVH. Therefore, research on the PVH will help us understand how the central nervous system develops as well as the causes of human diseases and how to treat them.

Development

Early in development, the anterior-most ventral portion of the neural tube gives rise to the hypothalamus. The partition of the anterior neural plate into the telencephalon, ocular field, and diencephalon may be programmed in response to the timing and intensity of Wingless/Integrated (WNT) Signaling. The telencephalon gives rise to the preoptic area, and the diencephalon produces other regions of the hypothalamus. Three subregions and one cell band can be identified in the early primordium of the hypothalamus based on the gene-expression profiles along the dorsal-ventral axis. Hypothalamus are referred to as the intrahypothalamic diagonal, floor plate, alar plate, and basal plate. Arx and *Gad67* are expressed in the intrahypothalamic diagonal, a parallel band of cells between the alar and basal plates. *Sim1* and *Pax6* expression are markers for the alar plate. The expression of *Nkx2.1*, *Tbx2*, and *Tbx3* defines the floor plate. The basal plate also expresses *Nkx2.1*. The supraoptic nucleus (SON) and PVH are produced by the alar plate, whereas the Arcuate Nucleus Hypothalamus (ARC), Dorsomedial Hypothalamus (DMH), and Ventromedial Hypothalamus (VMH) are produced by the basal plate. The development of different nuclei in the hypothalamus has an outside-in formation, in contrast to the cerebral cortex's inside-out layer pattern, as seen by the emergence of lateral neurons before medial neurons. The specific mechanisms behind the formation of the hypothalamus and PVH, however, remain poorly understood.

Components

The PVH, lateral hypothalamus, posterior hypothalamus, DMH, nucleus of the solitary tract (NTS), brainstem, and bed nucleus of stria terminalis (BNST) in the forebrain are only a few of the locations that the ARC has extensive reciprocal connections with. The PVH appears to be the melanocortin system's nucleus among them. Most glutamatergic PVH neurons that send signals to the brainstem's parabrachial nucleus (PBN) and dorsal motor nucleus of the vagus nerve (DMV) express melanocortin-4 receptor (MC4R). In general, signals that inhibit feeding are sent to the hindbrain by activated MC4R+ neurons, whereas signals that promote feeding are sent there by inhibited MC4R+ neurons. AgRP inhibits MC4R+ neurons whereas -melanocyte-stimulating hormone activates them. Additionally, Neuropeptide Y (NPY) receptors are expressed by MC4R+ neurons to transmit information that encourages feeding. The nucleus tractus solitarius (NTS) responds more strongly to satiety signals such cholecystokinin, which is released from the gut after eating, when it receives leptin signalling from Oxytocin (OXT)+ neurons in the PVH in addition to MC4R+ neurons. Additionally, agouti-related peptide (AgRP) inhibits OXT+ neurons. It's interesting to note that a recent study claimed OXT+ neuron projections just pass through the NTS and target the intermediolateral column (IML) in the thoracic spinal cord, which is crucial for energy consumption.

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