Available online at http://www.ijims.com
ISSN - (Print): 2519 – 7908 ; ISSN - (Electronic): 2348 – 0343
IF:4.335; IC Value: 60.59

Role of Basal Ganglia in the Regulation of Motor Activities by the help of Direct, Indirect, and Hyperdirect pathways: A Review

Roan Mukherjee

Associate Professor and Head, Department of Human Physiology,
Hazaribag College of Dental Sciences and Hospital, Demotand, Hazaribag, Jharkhand, India

A group of subcortical nuclei referred as basal ganglia significantly modulates the voluntary motor activities and has a well established link with movement disorders like ***Parkinsonism, Chorea/ Huntington's chorea, and hemiballismus***. Basal ganglia consists of corpus striatum, subthalamic nucleus and substantia nigra. Corpus straitum comprises of the caudate nucleus, putamen and globus pallidus (globus pallidus external segment (GPe), globus pallidus internal segment (GPi)).

Below is described the role of basal ganglia in the regulation of motor activities by the help of direct, indirect, and hyperdirect pathways (Boscha et. al., 2012; Beurrier et. al., 2006; Nambu et. al., 2002).

The onset of voluntary motor activity takes place under the influence of cerebral cortex. The basal ganglia is capable of controlling these motor activities due to the presence of ***neuronal circuits*** between the basal ganglia and the motor cortex and supplementary motor area. This neuronal circuit includes the direct, indirect and hyperdirect pathways.

Direct pathway: Cerebral cortex (premotor and supplementary motor cortex) project to the striatum (putamen). The striatum inhibits the internal globus pallidus (GPi) or medial globus pallidus by the help of gamma- aminobutyric acid (GABA) and substance P. Due to this inhibition of the medial globus pallidus, it will not lead to the inhibition of the thalamus and the thalamus can cause excitation of the motor cortex to result in the promotion of movement. At rest, the medial globus pallidus releases GABA to inhibit thalamic input to the motor cortex thereby causing supression of movements.

Indirect pathway: Cerebral cortex (premotor and supplementary motor cortex) project to the striatum (putamen). Neurons meant for the indirect pathway project to the external globus pallidus (GPe) or lateral globus pallidus and inhibit it by the help of GABA and enkephalin.

Otherwise the lateral globus pallidus would inhibit the subthalamic nucleus (STN). Due to the inhibition of the lateral globus pallidus, it will not be able to inhibit the subthalamic nucleus and the subthalamic nucleus will stimulate and cause excitation of the medial globus pallidus which in turn will inhibit the thalamus and thereby suppress unwanted movements.

Hyperdirect pathway: It bypass the corpus striatum (where the projections from the cerebral cortex enters in the direct and indirect pathways) after arising from the motor cortex and directly projects to the subthalamic nucleus. From the later, excitatory inputs enter the Gpi. The hyperdirect pathway functions to inhibit incorrect motor activities / movements. Lesions in this pathway (such as in case of ***stroke***) results in the inability to inhibit incorrect / unwanted patterns of movements leading to hemiballismus which is marked by unilateral, voilent motor restlessness of the body, especially in the upper limbs which shows flailing (throwing with force) undesired movements.

To explore the detailed ***pathophysiology*** of movement disorders there is a necessity to further the knowledge of the normal physiology of direct , indirect and hyperdirect pathways of basal ganglia. Hence ,more studies should be conducted involving the slice preparation of basal ganglia, especially by developing a hyperdirect connection brain slice.

References

Beurrier ,C., Ben-Ari, Y., Hammond C. (2006). Preservation of the direct and indirect pathways in an in-vitro preparation of the mouse basal ganglia. *Neuroscience,*140(1):77-86.

Boscha, C., Maillya, P., Degosa, B., Deniaua, J.-M., Venance, L. (2012). Preservation of the hyperdirect pathway of basal ganglia in a rodent brain slice. *Neuroscience*, 215, 31–41.

Nambu, A. , Tokuno, H. , Takada, M. (2002). Functional significance of the cortico–subthalamo–pallidal ‘hyperdirect’ pathway. *Neuroscience Research*, 43 (2)111–117.