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Research Article

Pineal Gland and Its Secretion

Prof. Toshima Mishra

Zoology dept.

Abstract

The pineal gland was described as the "Seat of the Soul" by Renee Descartes and it is located in the center of the brain. The main function of the pineal gland is to receive information about the state of the light-dark cycle from the environment and convey this information to produce and secrete the hormone melatonin. The rhythmic production of melatonin, secreted only during the dark period of the day, is extensively used as a marker of the phase of the internal circadian clock. Melatonin itself is used as a therapy for certain sleep disorders related to circadian rhythm abnormalities and for the alleviation of jet lag. It might have more extensive therapeutic applications in the future, since multiple physiological roles have been attributed to melatonin. It exerts physiologic immediate effects during night or darkness and prospective effects at daytime when melatonin levels are undetectable. In addition to its role in regulating the circadian system and sleep patterns, melatonin is involved in cell protection, neuroprotection, and the reproductive system, among other functions. Pineal gland function and melatonin secretion can be impaired due to accidental and developmental conditions, such as pineal tumors, craniopharyngiomas, injuries affecting the sympathetic innervation of the pineal gland, and rare congenital disorders that alter melatonin secretion.

Pineal Anatomy and Structure

The pineal gland in humans is a small (100-150mg), highly vascularized, and a secretory neuroendocrine organ. It is located in the mid-line of the brain, outside the blood-brain barrier and attached to the roof of the third ventricle by a short stalk. In humans, the pineal gland usually shows a degree of calcification with age providing a good imaging marker (1). The principal innervation is sympathetic, arising from the superior cervical ganglia (2). Arterial vascularization of the pineal gland is supplied by both the anterior and posterior circulation, being the main artery supplying the lateral pineal artery, which originates from the posterior circulation (3). In mammals, the main cell type are pinealocytes (95%) followed by scattered glial cells (astrocytic and phagocytic subtypes) (4). Pinealocytes are responsible for the synthesis and secretion of melatonin.

Main Function of the Pineal Gland

The main function of the pineal gland is to receive and convey information about the current light-dark cycle from the environment and, consequently produce and secrete melatonin cyclically at night (dark period). Although in cold-blooded vertebrates (lower-vertebrate species), the pineal gland is photosensitive, this property is lost in higher vertebrates. In higher vertebrates, light is sensed by the inner retina (retinal ganglion cells) that send neural signals to the visual areas of the brain. However, a few retinal ganglion cells contain melanopsin and have intrinsic photoreceptor capability that send neural signals to non-image forming areas of the brain, including the pineal gland through complex neuronal connections. The photic information from the retina is sent to the suprachiasmatic nucleus (SCN), the major rhythm-generating system or "clock" in mammals, and from there to the hypothalamus. When the light signal is positive, the SCN secretes gamma-amino butyric acid, responsible for the inhibition of the neurons that synapse in the paraventricular nucleus (PVN) of the hypothalamus, consequently the signal to the pineal gland is interrupted and melatonin is not synthesized. On the contrary, when there is no light (darkness), the SCN secretes glutamate, responsible for the PVN transmission of the signal along the pathway to the pineal gland. The PVN nucleus communicates with higher thoracic segments of spinal column, conveying information to the superior cervical ganglion that transmits the final signal to the pineal gland through sympathetic postsynaptic fibers by releasing norepinephrine (NE). NE is the trigger for the pinealocytes to produce melatonin by activating the transcription of the mRNA encoding the enzyme arylalkylamine N-acetyltransferase (AA-NAT), the first molecular step for melatonin synthesis.

Pineal gland and its secretion

Secretions of Pineal Gland:

Melatonin:

Melatonin is a hormone made by a part of the brain called the pineal gland. Melatonin helps regulate your sleep cycle. It tells your body when it's time to go to sleep and when it's time to wake up.

Melatonin is available as a supplement in pill form. There are two types: natural and synthetic (manmade). Natural melatonin is made from the pineal gland of animals. This form could be contaminated with a virus so it's not recommended. The synthetic form of melatonin doesn't carry this risk. The label on the pill bottle should list the type. If you're not sure, ask a pharmacist or doctor before you take it.

Melatonin function

Melatonin, the hormone produced by the pineal gland at night, serves as a time cue to the biological clock and promotes sleep anticipation in the brain default mode network (DMN); these effects may explain the increase in sleep propensity in circadian rhythm sleep disorders and the enhanced restorative sleep in older patients with insomnia. With age and certain diseases, the robustness of the circadian system decreases and melatonin production is diminished or shifted. Deviant circadian rhythms and poor sleep quality are associated with increased risks of cardiovascular, metabolic and cognitive diseases, poor quality of life and mortality. Exogenously administered melatonin improves non-restorative sleep and circadian rhythm amplitudes and misalignments. The ability of melatonin to reduce activation of the DMN (precuneus) may explain the enhancement of the restorative value of sleep (sleep quality) in insomnia patients, and its beneficial effects on cardiovascular health and cognitive decline in patients with AD. The ability of exogenously administered melatonin to mitigate the loss of the endogenous night signal and improve the restorative value of sleep represents a promising investigational route for early intervention to promote healthy physical and mental ageing.

Across the animal spectrum, there is evidence of circadian time-keeping activity, dating back hundreds of millions of years, attesting to the fundamental importance of synchrony with the environment to the survival of each organism. A key molecule responsible for this, melatonin, was discovered less than 50 years ago and is now produced biosynthetically. Although just as valid as other biosynthetically produced hormones such as growth hormone or oestrogen, its relatively recent discovery means that many of its actions remain obscure.

Serotonin:

Serotonin (also known as 5-hydroxytryptamine or 5-HT) is a naturally occurring substance that functions as a neurotransmitter to carry signals between nerve cells (called neurons) throughout your body.[1] Most commonly, people are aware of serotonin's role in the central nervous system (CNS).

Serotonin functions: Serotonin impacts every part of your body, from your emotions to your motor skills. Serotonin is considered a natural mood stabilizer. It's the chemical that helps with sleeping, eating, and digesting. Serotonin also helps:

- reduce depression
- regulate anxiety
- heal wounds
- stimulate nausea
- maintain bone health

Here's how serotonin acts in various functions across your body:

Bowel movements: Serotonin is found primarily in the body's stomach and intestines. It helps control your bowel movements and function.

Mood: Serotonin in the brain is thought to regulate anxiety, happiness, and mood. Low levels of the chemical have been associated with depression, and increased serotonin levels brought on by medication are thought to decrease arousal.

Nausea: Serotonin is part of the reason why you become nauseated. Production of serotonin rises to push out noxious or upsetting food more quickly in diarrhoea. The chemical also increases in the blood, which stimulates the part of the brain that controls nausea.

Sleep: This chemical is responsible for stimulating the parts of the brain that control sleep and waking. Whether you sleep or wake depends on what area is stimulated and which serotonin receptor is used.

Blood clotting: Blood platelets release serotonin to help heal wounds. The serotonin causes tiny arteries to narrow, helping form blood clots.

Bone health: Serotonin plays a role in bone health. Significantly high levels of serotonin in the bones can lead to osteoporosis, which makes the bones weaker.

Sexual function: Low levels of serotonin are associated with increased libido, while increased serotonin levels are associated with reduced libido.

Serotonin and mental health

Serotonin helps regulate your mood naturally. When your serotonin levels are normal, you feel:

- happier
- calmer
- more focused
- less anxious
- more emotionally stable

Serotonin is much more than a neurotransmitter essential for the modulation of mood. It regulates a wide range of physiologic and pathophysiologic processes in most human organs. This explains why serotonergic drugs modulate phenomena ranging from ejaculatory latency to hemostatic function in addition to their more commonly appreciated effects on mood and cognition.Serotonin typically regulates a given physiologic process (such as digestion, pain perception, or energy balance) at multiple steps through different and frequently opposing mechanisms. For example, serotonin is not simply pro- or antianalgesic; instead, it both potentiates and inhibits nociceptive processing at various levels of the nervous system.