McCance: Pathophysiology, 6th Edition

Chapter 15: Pain, Temperature Regulation, Sleep, and Sensory Function

Key Points – Print

SUMMARY REVIEW

Pain

1. Pain is protective and a complex phenomenon composed of sensory experiences (time, space, intensity) and emotion, cognition, and motivation.
2. The gate control theory of pain describes the modulation of pain in the dorsal horn of the spinal cord by sensory afferent stimulation and central descending impulses that influence the "pain gate" within the substantia gelatinosa of the spinal cord
3. The portions of the nervous system responsible for the sensation and perception of pain may be divided into three areas: (1) the afferent fibers, (2) the afferent pathways and (3) the CNS.
4. The afferent system is composed of nociceptors, Aδ and C fibers (first-order neurons), the dorsal horn of the spinal column (second-order neurons), and afferent neurons in the spinothalamic tract (third-order neurons).
5. Nociceptors detect a wide range of stimuli and respond to chemical, mechanical, and thermal stimulation.
6. Myelinated Aδ receptor transmission is fast and conveys mechanical and thermal sharp, localized pain. Unmyelinated polymodal C fiber transmission is slower and conveys diffuse burning and aching sensations. These primary-order neurons terminate on second-order neurons.
7. Three classes of second-order neurons modulate pain transmission: projection cells, excitatory interneurons, and inhibitory interneurons. The second-order neurons are located in the spinal cord laminae and function as a pain gate to regulate pain transmission.
8. Second-order neurons cross over the cord and ascend primarily in the lateral spinothalamic tract to projection centers including the thalamus reticular formation, and PAG matter.
9. Third-order neurons carry information to the sensory cortex and reticular and limbic systems for pain processing and interpretation.
10. Efferent pathways from the PAG are responsible for modulation or inhibition of afferent pain signals. The thalamus, cortex, and postcentral gyrus perceive, describe, and localize pain. The reticular formation and limbic system control the emotional and affective response to pain.
11. Pain can be modulated by segmental inhibition, which is the peripheral stimulation of nociceptors by touch, vibration, or pressure resulting in closure of the spinal cord pain gate. Higher brain center also can influence painful stimuli (heterosegmental control of nociception) as well as inhibition from the caudal medulla (diffuse noxious inhibitory controls). Thus pain

can be modulated with stimulation from the periphery or by descending impulses from the brain.

12. Pain neurotransmitters can be classified as inflammatory, excitatory, and inhibitory modulators of pain. Inflammatory neurotransmitters include prostaglandins, nitric oxide, bradykinins, and histamine. Glutamate, aspartate, and amino acid precursors are excitatory neurotransmitters. GABA and glycine are inhibitory neurotransmitters. Endogenous opioids including enkephalins, endorphins, dynorphins and endomorphins inhibit pain transmission and are present in varying concentrations in the neurons of the brain, spinal cord, and GI tract. Serotonin, norepinephrine aspartate, and glycine also can modulate pain processing.
13. Pain threshold is the point at which pain is perceived. Pain threshold does not vary significantly among people or within the same person over time.
14. Pain tolerance is the duration of time or the intensity of pain that an individual will endure before initiating overt pain response. Tolerance varies widely among individuals and in the same individual over time.
15. Classifications of pain include nociceptive pain (with a known physiologic cause), non-nociceptive pain (neuropathic pain), acute pain (signal to the person of a harmful stimulus), and chronic pain (persistence of pain of unknown cause or unusual response to therapy).
16. Acute pain may be (1) somatic (superficial), (2) visceral (internal), or (3) referred (present in an area distant from its origin).
17. Somatic pain arises from connective tissue, muscle, bone, and skin and is sharp and localized.
18. Visceral pain is transmitted by sympathetic afferents and is poorly localized.
19. Referred pain usually arises from the viscera and terminates in an area of the spinal cord that is conjoined with fibers originating in the skin and other areas and thereby produces the perception of pain at the referred site.
20. Physiologic responses to acute pain include increased heart rate, respiratory rate, and blood pressure; pallor or flushing; dilated pupils; and diaphoresis. Blood sugar is elevated; gastric secretion and motility are decreased; and blood flow to the viscera and skin is decreased.
21. Chronic pain generally lasts at least 3 months and may be persistent, for example, low back pain or intermittent migraine headache.
22. Chronic pain conditions include myofascial pain syndromes, chronic postoperative pain, low back pain, and chronic pain associated with cancer.
23. Neuropathic pain is usually chronic, results from nerve trauma or disease, and leads to abnormal peripheral and central pain processing. Types of neuropathic pain include deafferentation pain, sympathetically maintained pain, central pain, and phantom pain.
24. Newborns and young children have the anatomic and functional ability to perceive pain. Pain experienced by infants may have prolonged effects on brain organization and responses to pain.
25. Older individuals may or may not have an increased pain threshold. In all age groups, women appear to be more sensitive to pain than are men.

26. Pain in older adults is influenced by liver and renal function, including alterations in metabolism of drugs and metabolites.

Temperature Regulation

1. Temperature regulation is achieved through precise balancing of heat production, heat conservation, and heat loss. Body temperature is maintained around 37° C (98.6° F).
2. Temperature regulation is mediated by the hypothalamus. Peripheral thermoreceptors in the skin and central thermoreceptors in the hypothalamus, spinal cord, and abdominal organs provide the hypothalamus with information about skin and core temperatures.
3. Heat is produced through chemical reactions of metabolism, skeletal muscle contraction (shivering), and chemical thermogenesis.
4. Heat is lost through radiation, conduction, convection, vasodilation, decreased muscle tone, evaporation of sweat, increased ventilation, and voluntary mechanisms.
5. Heat conservation is accomplished through vasoconstriction and voluntary mechanisms.
6. Fever is triggered by the release of pyrogens from leukocytes and other cells involved in the immune response (endogenous pyrogens) and bacteria (exogenous pyrogens). Fever is both a symptom of a disease and a normal immunologic mechanism.
7. Fever involves resetting the hypothalamic thermostat to a higher level. When a fever breaks, the set point is returned to normal.
8. Fever production aids responses to infectious processes. Higher temperatures kill many microorganisms and decrease serum levels of iron, zinc, and copper that are needed for bacterial replication.
9. Infants and older adults require special attention to maintenance of body temperature. Because of their greater body surface:mass ratio and decreased subcutaneous fat, infants do not conserve heat well. Older individuals have poor responses to environmental temperature extremes as a result of slowed blood circulation, structural and functional changes in skin, and an overall decrease in heat-producing activities.
10. Hyperthermia (marked warming of core temperature) can produce nerve damage, coagulation of cell proteins, and death. Forms of accidental hyperthermia include heat cramps, heat exhaustion, heat stroke, and malignant hyperthermia. Heat stroke and malignant hyperthermia are potentially lethal developments.
11. Hypothermia (marked cooling of core temperature) slows the rate of chemical reaction (tissue metabolism), increases the viscosity of the blood, slows blood flow through the microcirculation, facilitates blood coagulation, and stimulates profound vasoconstriction. Hypothermia may be accidental or therapeutic.

Sleep

1. Sleep may be divided into REM and NREM stages, each of which has its own series of stages. While asleep, an individual progresses through REM and NREM (slow-wave) sleep in a predictable cycle.
2. NREM sleep is initiated by the withdrawal of neurotransmitters from the afferent formation and by the inhibition of arousal mechanisms in the cerebral cortex. REM sleep is controlled by mechanisms in the hypothalamus and pontine reticular formation.
3. During sleep the body is actively engaged in restoring and repairing itself. Sleep deprivation can cause profound changes in personality and functioning.
4. The restorative, reparative, and growth processes occur during slow-wave sleep.
5. The sleep patterns of the newborn and young child vary from those of the adult in total sleep time, cycle length, and percentage of time spent in each sleep cycle. Older adults experience a total decrease in sleep time.
6. Sleep disorders include (1) dyssomnias (2) parasomnias, (3) sleep disorders associated with mental, neurologic or other medical disorder, and (4) proposed sleep disorders.
7. Common dyssomnias include insomnia, OSAS, RLS, circadian rhythm disorder, and hypersomnia.
8. Common parasomnias include arousal disorders, sleep-wake transition disorder, and disorders associated with REM sleep.
9. Sleep and disease are interrelated. Some diseases may produce alterations in the quantity and quality of sleep or affect sleep stages. These are referred to as *secondary sleep disorders.* In some instances sleep stages produce alterations in certain disease states. These are referred to as *sleep-provoked disorders.*

Special Senses

Vision

1. The eyelids, conjunctivae, and lacrimal apparatus protect the eye. Infections are the most common disorders; they include blepharitis, conjunctivitis, chalazion, and hordeolum.
2. Conjunctivitis can be acute or chronic, bacterial, viral, or allergic. Redness, edema, pain, and lacrimation are common symptoms. Trachoma (chlamydial conjunctivitis) is the leading cause of blindness in the world and is associated with poor sanitary conditions.
3. Keratitis is a bacterial or viral infection of the cornea that can lead to corneal ulceration. Photophobia, pain, and tearing are common symptoms.
4. The wall of the eye has three layers: sclera, choroid, and retina. The retina contains millions of photoreceptors known as rods and cones that receive light through the lens and then convey signals to the optic nerve and subsequently to the visual cortex of the brain.
5. The eye is filled with vitreous and aqueous humor, which prevent it from collapsing.
6. Structural eye changes caused by aging or chronic disease result in decreased visual acuity.

7. The major alterations in ocular movement include strabismus, nystagmus, and paralysis of the extraocular muscles.
8. Alterations in visual acuity can be caused by amblyopia, scotoma, cataracts, papilledema, macular degeneration, retinal detachment, glaucoma, and macular degeneration.
9. Alterations in accommodation develop with increased intraocular pressure, inflammation, and disease of the oculomotor nerve. Presbyopia is loss of accommodation caused by loss of lens elasticity with aging.
10. Alterations in refraction, including myopia, hyperopia, and astigmatism, are the most common visual disorders.
11. Alterations in color vision occur with disorders of the cornea and the inherited trait of color blindness.
12. Trauma or disease of the optic nerve pathways or optic radiations, can cause blindness in the visual fields. Homonymous hemianopsia is caused by damage of one optic tract.

Hearing

1. The ear is composed of external, middle, and inner structures. The external structures are the pinna, auditory canal, and tympanic membrane. The tympanic cavity (containing three bones: malleus, incus, and stapes), oval window, eustachian tube, and fluid comprise the middle ear and transmit sound vibrations to the inner ear.
2. The inner ear includes the bony and membranous labyrinths that transmit sound waves through the cochlea to the division of the eighth cranial nerve. The semicircular canals and vestibule help maintain balance through the equilibrium receptors.
3. Approximately one third of all people older than 65 years have hearing loss.
4. Otitis externa is an infection of the outer ear. Otitis media, an infection of the middle ear, is common in children and can be acute or chronic.
5. Hearing loss can be classified as conductive, sensorineural, mixed, or functional.
6. Conductive hearing loss occurs when sound waves cannot be conducted through the middle ear.
7. Sensorineural hearing loss develops with impairment of the organ of Corti or its central connections. . Presbycusis is age-related hearing loss and is the most common form of sensorineural hearing loss.
8. A combination of conductive and sensorineural loss is a mixed hearing loss.
9. Loss of hearing with no known organic cause is a functional hearing loss.

Olfaction and Taste

1. The perception of flavor is altered if olfaction or taste dysfunctions occur. Sensitivity to odor and taste decreases with aging.
2. Hyposmia is a decrease in the sense of smell, and anosmia is the complete loss of smell. Inflammation of the nasal mucosa and trauma or tumors of the olfactory nerve lead to a diminished sense of smell.

3. Hypogeusia is a decrease in taste sensation, and ageusia is the absence of taste. Loss of taste buds or trauma to the facial or glossopharyngeal nerves decreases taste sensation.

Somatosensory Function

1. The sensation of touch involves the fusion of several qualities, including modality, intensity, location, and duration of the sensory stimulus.
2. Receptors sensitive to touch are present in the skin; these include Meissner and pacinian corpuscles and Merkel disks and Ruffini endings. The sensory response is conducted to the brain through the dorsal column and anterior spinothalamic tract.
3. Abnormal tactile perception may be caused by alterations at any level of the nervous system, from the receptor to the cerebral cortex.
4. Proprioception is the position and location of the body and its parts. Proprioceptors are located in the inner ear, joints, and ligaments. Proprioceptive stimuli are necessary for balance, coordinated movement, and grading of muscular contraction.
5. Disorders of proprioception can be caused by alterations at any level of the nervous system. Two common causes of proprioceptive dysfunction are vestibular dysfunction and neuropathy.