Pain, sleep, and temperature regulation
Advanced Pathophysiology
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Pain pathophysiology

- 2 types of peripheral pain fibers transmit to the spinal cord
  - A-delta fibers and C fibers
- 2 pathways transmit from the spinal cord to the supraspinal areas:
  - the sensory pathway from lamina V in the dorsal horn of the spinal cord to the hypothalamus and somatosensory cortex, and the affective pathway from lamina I in the dorsal horn of the spinal cord to the hypothalamus, amygdala and cingulate area.
- Pain can be modulated at the level of the periphery or spinal cord, or from higher supraspinal areas

Neurotransmitters and Pain

Acetylcholine
Histamine
Serotonin
D-serine
Nitric oxide
GABA
Glutamate

Types of Pain

1. Central pain arises from a lesion in the CNS, usually involving the spinothalamic cortical pathways (eg, thalamic infarct). The pain is usually constant with a burning, electrical quality. It is exacerbated by activity or changes in the weather. Hyperesthesia and hyperpathia and/or allodynia are invariably present, and the pain is highly resistant to treatment
2. Referred pain often originates from a visceral organ. It may be felt in body regions remote from the site of pathology. The mechanism may be the spinal convergence of visceral and somatic afferent fibers on spinothalamic neurons. Common manifestations are cutaneous and deep hyperalgesia, autonomic hyperactivity, tenderness, and muscular contractions
3. Nociceptive pain arises from activation of nociceptors
   a. Nociceptors are found in all tissues except the central nervous system (CNS)
   b. pain is clinically proportional to the degree of activation of afferent pain fibers and can be acute or chronic (ie. somatic pain, cancer pain, postoperative pain)
4. Sympathetically mediated pain is accompanied by evidence of edema, changes in skin blood flow, abnormal pseudo motor activity in the region of pain, allodynia, hyperalgesia, or hyperpathia

5. Deafferentation pain is chronic and results from loss of afferent input to the CNS. The pain may arise in the periphery (peripheral nerve avulsion) or in the CNS (spinal cord lesions, multiple sclerosis)
6. Neuralgia pain is lancinating and associated with nerve damage or irritation along the distribution of a single nerve (trigeminal) or nerves
7. Radicular pain is evoked by stimulation of nociceptive afferent fibers in spinal nerves, their roots, or ganglia, or by ectopic impulse generation. It is distinct from radiculopathy, but the two often arise together.
8. Psychogenic pain is inconsistent with the likely anatomic distribution of the presumed generator, or it exists with no apparent organic pathology despite extensive evaluation

Pain in children

- In children, the caregiver must be aware of the developmental stage of the child to best determine the assessment tool.
- Limited cognitive or language skills may influence pain measures, as well as the positive or negative consequences a child's pain reports, or behaviors produce. A child sleeping more than usual, for example, may actually be in significant pain without any crying or whimpering
- 2 tools used to assess CRIES (crying, requires oxygen, increased vital signs, expression, sleeplessness) uses the five variables on a 0–2 point scale to assess neonatal postoperative pain. The Modified Behavioral Pain Scale uses three factors (facial expression, cry, and movements) and has been validated for 2- to 6-month-old children
- In children older than 3-4 years, self-report measures may be used. However, children may underreport their pain to avoid future injections or other procedures aimed at alleviating the pain.

Pain in elderly

- assessment and reporting of pain is the most problematic area in this population
- One contributing factor is possible underreporting of discomfort because the patient does not want to complain
- Other patients may use pain to mask other newly developing physical or cognitive disabilities

Theories of pain

1. Specificity theory+
2. Pattern theory +
3. Gate control theory +
4. Neuromatrix theory+

Gate control theory of pain

- Pain sensation before it can reach the brain these pain messages encounter "nerve gates" in the spinal cord that open or close depending upon a number of factors
- possibly including instructions coming down from the brain
- When the gates are opening, pain messages "get through" more or less easily and pain can be intense
- When the gates close, pain messages are prevented from reaching the brain and may not even be experienced

Chronic pain syndromes

- Myofascial
- Musculoskeletal (mechanical)
- Neuropathic
- Fibromyalgia
- Chronic headaches

- 1 in 3 pts over age 65 are affected by pain

Myofascial

- skeletal muscle and fascia/connective tissue surrounding muscle pain:
- Lateral epicondylitis (tennis elbow)
- Quadratus lumborum syndrome (a common cause of nonradicular low back pain)
- Piriformis syndrome (a common cause of buttock and hip pain).

Musculoskeletal (mechanical) pain:

- Osteoarthritis
- Rheumatoid arthritis
- Back pain
- Chronic or repetitive overuse
- Muscular strains
- Faulty posture
- Mechanical low back pain
- Osteomyelitis
- Osteoporosis
- Ankylosing spondylitis
- Myofascial diseases
- Polymyalgia rheumatica
- Polymyositis
- Fractures

Neuropathic pain:

- caused by nerve injury or disease, as well as by involvement of nerves in other disease processes (tumor, inflammation)
- Neuropathic pain may occur in the periphery or the CNS
    - Peripheral neuropathy
    - Postherpetic neuralgia (shingles)
    - Complex regional pain syndrome (formerly called causalgia, reflex sympathetic dystrophy or sympathetically maintained pain)
    - Central pain - post-stroke pain and multiple sclerosis pain

Fibromyalgia

Starting points

- Previous theory involved Chronic, widespread pain with multiple trigger points (this is now removed as diagnostic criteria)
    - there is often diffuse tenderness which is assessed by counting the number of tender points by palpating several areas of the body
- Centralized Pain syndrome
- Comorbid Symptoms such as memory difficulties sleep and mood difficulties and overwhelming fatigue

Etiology/Epidemiology

- strongly associated with families
- Co- aggregate w/ other disorders such as IBS, TMJ, interstitial cystitis, tension headaches and vulvodynia: all of these have central sensitization syndrome and chronic overlapping pain conditions
- Female>male (9/10 w/ FM are female)
- Overall prevalence 2%

Pathophysiology:

Clinical presentation

- chronic pain more than 3 months
- tenderness on examination, diffuse
- muscle stiffness
- sleep disturbances mood disturbances cognitive dysfunction paresthesias
- sensitivity to sensory stimuli such as noises, odors, or lights
- fatigue unrelieved by rest

Temperature regulation

- Hypothalamus controls Thermoregulation
  - Parasympathetic system controls sweating
  - Sympathetic system controls skin blood flow
- Vasodilation results in heat dissipation
- Core temp rises 1*C per 30* C ambient temperature
- Core temp rise 0.6 *C= raises basal metabolic rate 10%
- Cellular damage = >104 F (40* C)
- Cellular death =>107.6 F (42* C)
- Known as Thermal Maximum
- Cell death occurs at variable duration of exposure: 42 C (107.6 F) for 45 minutes to 8 hours

Temperature regulation: Children

- Physiology: Children and increased propensity for Heat Illness
- Greater surface area to body mass
- Slower sweat rates
- Sweating initiated at a higher temp set point
- Sweat is more dilute
- Slower acclimatization to hot environments
- Decreased thirst response

Physiology: Heat Dissipation Mechanisms

- Sweat evaporation (primary mechanism at >68F or 20C)
  - Optimally dissipates 600 kcal/hour
  - Sweat loss maximum 3 Liters/hour--Perspiration becomes less effective in humid environments
  - Endurance athletes lose up to 1.5 Liters/hour
  - Rate of perspiration in hot environments is almost exclusively responsible for heat loss

- Heat Conduction
  - Cold packs applied to skin
  - Cold water emersion is the most expedient way to dissipate heat

- Heat Convection (Air/wind flows over skin)
  - Body can dissipate heat with greater air circulation
  - Cooler air also dissipates heat by providing a larger gradient between body temp and air temp
  - Permeable clothing allows for greater heat dissipation

- Heat Radiation (Infrared dissipation)

- Radiant energy is resorbed or reflected
- Light-colored clothing reflects away heat

Fever

- Celsius >38 degrees OR >100.4 Fahrenheit

Fever without focus

- Age <36 months (Higher risk in younger infants)
- Fever without localizing signs
- Acute onset of fever persisting <1 week
- Assess for occult bacteremia

Fever of unknown origin (FUO)

- Fever exceeding 1-week duration
- Fever documented in the hospital
- All possible investigations performed during the week
- ADULT: infectious diseases remain the most common cause>> followed by malignancies> autoimmune diseases> and other
- CHILD: rare diseases, but also include common illnesses presenting unusually
- The vast majority of children have underlying bacterial or viral infections

- Clinical Cues:
  - Fever, chills, weight loss, night sweats, malaise, pain
  - ? recent surgery
  - ? any travel

Malignant hyperthermia

Rare: related rapid rise in body temp, muscle rigidity, HTN and tachypnea
Ryanodine receptor gene (RYR1) defect effects the calcium release channel in muscle
Results in an unregulated increase in skeletal muscle oxidative metabolism

Usual etiology: inhaled anesthetics or succinylcholine

Heat stroke

- Classic Heatstroke
  - Gradual environmental exposure (usually seen in elderly and debilitated)
- Exertional Heatstroke
  - Rapid onset over hours (Usually seen in young patients and in athletes)
- s/sx
  - Hyperpyrexia (Use rectal probe)
  - Core temps exceeds 40 C (104 F) for Heat Stroke diagnosis
  - Core temps may range as high as 44 C (111 F) Reports of temps up to 47 C (116.6 F)

- ALOC (delerium or coma), Anhidrosis, tachycardia, hypotension, tachypnea

Hypothermia

- Core temp <95 F (35 C)
  - Radiative heat loss (50% of heat loss)
  - Majority of radiative via head (60%)
  - Conductive heat loss (2-3% of heat loss)
  - Wet clothing: Heat loss increases x5
  - Cold water immersion: Heat loss increases x25
  - Convective heat loss (10%)
  - Important in windy conditions
  - Convective loss increases with shivering
  - Evaporative heat loss (Up to 27%)
  - Respiratory heat loss (Up to 9%)
- Clinical Presentation
  - AMS
  - Shivering
  - flushing
  - Facial edema
  - Initial tachycardia progresses to bradycardia
  - hypotension
  - Paradoxical undressing
  - Respiratory depression
  - ataxia
  - Decreased corneal reflex

Sleep

- Sleep cycles begin to normalize after 6 months of age
  - Newborns enter REM immediately after falling asleep
  - 1 y/o @ 50-50 split of NREM and REM
  - @3-5 years enters adult sleep pattern

- Average sleep per day
  - Infants and children: 16 to 20 hours per day
  - Young Adults: 7 to 8 hours per day
  - Adults over age 60 years: 6.5 hours per day

Sleep cycles –adult

Awake

- Wakefulness w/ eyes closed
- Alpha waves

NREM 1

- Sleep Onset (Drowsy Phase)
- Lowest threshold for arousal
- Time spent in Stage I increases with age
- Accounts for more brief awakenings
- Accounts for fragmented sleep

NREM 2

- Light Sleep w/ sleep spindles

NREM 3 (Non-REM Sleep)

- Delta waves
- No eye movement
- REM sleep
- Deepest, most refreshing, and restorative sleep type
- Diminishes with age
- Highest threshold for arousal
- Associated with diffuse dreams
    - Dream about color or emotion
- Associated Conditions
    - Night/sleep terrors
    - Sleep walking
    - Confusion on arousal

Non-REM sleep

- Inhibition from hypothalamus
- Tone: Sympathetic decreased/parasympathetic increased
- BMR falls 10-15%
- Temp = decreases 0.5-1.0 *C
- HR, BP, RESP, muscle tone all decreases
- Pupils constricted

Rapid Eye Movement Sleep (REM Sleep)

- Timing
- REM occurs cyclically every 90 minutes of sleep
- Infants spend 50% of sleep time in REM Sleep

- Adults spend 20% of sleep time in REM Sleep
- Dream Characteristics
- Most recallable dreams during this stage
- Bizarre and detailed dreams during this stage

- Signs
    - Suppressed voluntary motor activity ("paralyzed")
    - Rapid eye movements
- Associated Sleep Conditions
    - Nightmares and frightful dreams
    - Sleep-related painful erections
- Provocation of Medical Symptoms
    - CAD (angina)
    - COPD(Apnea)
    - PUD (abd pain)
    - GERD (abd pain)
    - Migraine and cluster headache

Dyssomnias

- Insomnia
- OSAS (obstructive sleep apnea syndrome)
- Obesity hypoventilation syndrome
- Restless leg syndrome
- Hypersomnia
- Narcolepsy
- Circadian rhythm sleep disorders

Sleep disorders

- A common complaints reported in primary care
- Unmanaged insomnia can cost over US $100 billion each year due to accidents and poor work productivity.
- Associated with anxiety, depression, and physical complaints
- Diagnosis is made primarily by patient interview. Sleep diaries, actigraphy, and polysomnography may assist in confirming diagnosis
- Identification of the correct etiology is essential, as interventions differ and may be harmful in some cases if the diagnosis is incorrect

Hypersomnia

- Unknown etiology
- Multiple theories of patho

- classic tetrad of narcolepsy (only 10% to 15% of cases) includes excessive daytime sleepiness, cataplexy, sleep paralysis, and hypnagogic/hypnopompic hallucinations
- The only clinical manifestation that is specific to narcolepsy is cataplexy

Obstructive sleep apnea

- Disorder of breathing during sleep related to upper airway obstruction
- Associated with reduced blood O2 saturation and hypercapnia
- Characterized by loud snoring, gasping, intervals of apnea lasting from 10s to 30s fragmented sleep, daytime sleepiness

- Caused by soft palate or base of tongue collapsing against pharyngeal walls because of decreased muscle tone during REM sleep

Restless leg syndrome

- Sensorimotor disorder characterized by a compulsive urge to move the legs.
- Accompanied by dysesthesias -prickling, tingling, crawling sensations causing restless legs at rest
- Treatment options include nonpharmacologic treatments, dopamine agonists, opioids, benzodiazepines, or neuroleptic agents.

Sensory functions

Vision

- Blepharitis
- Conjunctivitis
- Keratitis
- Strabismus
- Amblyopia
- Scotoma
- Cataract
- Glaucoma
- Presbyopia
- Myopia/hyperopia
- Visual dysfunction
    - Esotropia
    - Exotropia
    - Hypertropia
    - Hypotropia

Hearing

- Conductive hearing loss
- Acute otitis media
- Sensorineural hearing loss

Olfaction

- Hyposmia
- Parosmia
- Olfactory hallucinations

Taste

- Hypogeusia
- Ageusia
- Parageusia

Touch

- Any impairment can alter reception, transmission perception or interpretation of touch alter tactile sensation

Proprioception

- Any level of nervous system can manifest as alterations in perception and awareness
- Vertigo
- Meniere' disease
- Peripheral neuropathies

External eye

- Blepharitis
- Hordeolum
- Chalazion
- Conjunctivitis
- Keratitis

- Age related: presbyopia

Visual dysfunction

- Cataracts
- Incidence increases with age
- Etiology: infection, trauma, radiation, drugs, DM

- Surgery
- Lens replacement

Glaucoma

- 2nd leading cause of blindness
- Intraocular pressure >12-20 mmHg
- Primary open angle **
- Acute angle closure
- Optic disk cupping is diagnostic

Retinal detachment

- acute or progressive condition in which the neuroretina separates from the retinal pigment epithelium with accumulation of subretinal fluid and loss of retinal function
- loss or deterioration of central vision
- flashes of light
- loss of peripheral visual field
- Consequence of vitreoretinal traction

Macular degeneration

- Leading cause of adult blindness in industrialized nations
- Classically presentation: white people aged >55 years
- sudden-onset blurring or distortion of vision
- drusen
- macular pigmentary changes
- geographic atrophy
- choroidal neovascularization

Hearing

- Otitis externa
- Otitis media
- Conductive hearing loss
- Sensorineural
- Age related: presbycusis

Hearing loss

- Conductive = change in outer or middle ear conduction
- Sensorineural= corgi organ impairment
- Mixed = both types
- Functional= no reason

Ear infections

- Otitis externa
- Most commonly caused by Pseudomonas aeruginosa and Staphylococcus

- species
- Presents with rapid onset of ear pain, tenderness, itching, aural fullness, and hearing loss

Ear infections

- most common bacteria responsible for AOM are Streptococcus pneumoniae (~40%), nontypable Haemophiles influenzae (25% - 30%), and Moraxella catarrhalis (10% - 15%)
- otalgia, irritability, decreased hearing, anorexia, vomiting, or fever, usually in the presence of an ongoing viral respiratory infection

Olfaction & taste

- Olfaction :
  - Hyposmia-impaired smell
  - Anosmia – no smell
  - Parosmia-perverted /abnormal response to smell
- Taste:
  - Hypogeusia-decrease in taste sensation
  - Ageusia- absence of taste

References

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