Neuroscience of Pain

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Conflict of Interest
Disclosure Statement
I have no financial relationships with any commercial interest related to the content of this activity.

I will not discuss off-label use during my presentation.

Objectives
- Define Pain and differentiate between acute and chronic pain
- Review the anatomy and physiology of the neurotransmission of pain
- Describe the components of the Gate Control Theory of Pain
- Discuss sensitization of pain

Introduction
Chronic pain affects about 100 million American adults—more than the total affected by heart disease, cancer, and diabetes combined.

Pain also costs the nation up to $635 billion each year in medical treatment and lost productivity.

Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research. Institute of Medicine 2011.

Defining Pain
An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage. Pain is always subjective. It is unquestionably a sensation in a part or parts of the body, but it is also always unpleasant and therefore also an emotional experience.

The International Association for the Study of Pain (IASP), 1994.

Acute Pain
Sudden onset and expected to last a short time. It usually can be linked clearly to a specific event, injury, or illness—a muscle strain, a severe sunburn, a kidney stone, or pleurisy, for example.

Acute pain also can be a recurrent problem, with episodes being interspersed with pain-free periods, as in the case of dysmenorrhea, migraine, and sickle-cell disease.
Common Sources of Acute Pain

- infectious diseases (e.g., food poisoning with related gastrointestinal manifestations)
- wound infections
- untreated dental conditions
- burns
- trauma (broken bones, lacerations and other wounds)
- appendicitis
- surgery
- medical procedures
- childbirth

Chronic Pain

Pain lasting for several months (3-6 months), and can be caused by an underlying medical condition, injury, or medical treatment

The role of Inflammation:

- Peripheral sensitization when local nociceptors become highly sensitive even to normal stimuli, such as touch.
- Central sensitization is overexcitement of neurons in the central nervous system.

Common Sources of Chronic Pain

- migraine and other serious headaches
- arthritis and other joint pain
- fibromyalgia
- endometriosis
- irritable bowel syndrome
- chronic interstitial cystitis
- vulvodynia
- trauma or postsurgical pain
- low back pain
- other musculoskeletal disorders
- temporomandibular joint disorder
- shingles
- sickle cell disease
- heart disease (angina)
- cancer
- stroke
- diabetes

The Pseudounipolar Neuron

The cell bodies of these neurons are located in either the dorsal root ganglia or the trigeminal ganglia.

Nociceptors and Pain
Primary Afferent Neurons and the Spinal Cord

Rexed Laminae of the spinal cord

Ascending pathway

Central Projections of Nociceptors

Neurotransmitters and Neuromodulators of Pain

<table>
<thead>
<tr>
<th>Neurotransmitters</th>
<th>Receptor</th>
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<tbody>
<tr>
<td>Excitatory Neurotransmitter</td>
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<tr>
<td>Substance P</td>
<td>Neurokinin (NK)-1, NK2</td>
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<tr>
<td>Glutamate</td>
<td>NMDA, AMPA, kainate</td>
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<td>Inhibitory Neurotransmitter</td>
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</tr>
<tr>
<td>Glycine</td>
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<td>GABA</td>
<td>GABA_A, GABA_B, GABA_C</td>
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<tr>
<td>Enkephalin</td>
<td>Mu, delta kappa</td>
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<tr>
<td>Norepinephrine</td>
<td>Alpha, adrenergic</td>
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Adapted from Nagelhout and Plaus, Nurse Anesthesia, 5th Ed., 2014, page 1247

Acute vs Chronic Pain

Neuroplasticity and Pain

Pain is a dynamic sensation and the symptoms associated with hyperalgesia are the consequence of plastic changes along the entire pain system, from the peripheral nociceptors, to spinal and supraspinal neurons and the higher centers of the brain.

This process of sensitization is key to the understanding of chronic pain and of many clinically relevant conditions.


Gate Control Theory of Pain

Ronald Melzack and Patrick Wall introduced their “gate control” theory of pain in 1965.

The gate control theory of pain asserts that non-painful input closes the “gates” to painful input, which prevents pain sensation from traveling to the central nervous system. This theory was the first to incorporate both physiological and psychological aspects of pain.


Gate Control Theory of Pain

Firing of the Aβ fibers activates the inhibitory interneuron, reducing the chances that the projection neuron will fire, even in the presence of a firing nociceptive fiber.
Chronic Pain

"Chronic pain can be a disease in itself. Chronic pain has a distinct pathology, causing changes throughout the nervous system that often worsen over time. It has significant psychological and cognitive correlates and can constitute a serious, separate disease entity."

Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research. Institute of Medicine 2011.

Peripheral Sensitization

Peripheral sensitization is a reduction in threshold and an increase in responsiveness of the peripheral ends of nociceptors.

Central Sensitization

Neuropathic Pain

A disease of the peripheral or central nervous system that arises when a person's nerves, spinal cord, or brain is damaged or fails to function properly for any of a large number of reasons.

The cause may be an underlying disease process (as in diabetes) or injury (e.g., stroke, spinal cord damage), but neuropathic pain may not have an observable cause and can be considered maladaptive "in the sense that the pain neither protects nor supports healing and repair". (Costigan et al., 2009, p. 3).

Unknown Causes of Pain

Pain arises without a defined cause or injury. Examples of such chronic pain conditions are irritable bowel syndrome, fibromyalgia, vulvodynia, chronic headaches, and temporomandibular disorders. For some disorders, research points to impaired central pain sensitivity and responses in these conditions, but their complex mechanisms have not yet been unraveled.

(Kindler et al., 2011)

References


