Physiology of Pain

PAIN: Pain is defined as an unpleasant and emotional experience associated with or without actual tissue damage. The pain sensation is describe in many way like sharp, pricking, electric, dull ache, shooting, cutting, stabbing, etc. pain receptor in the skin and other tissue are all free nerve ending. They are wide spread in the superficial layer of the skin as well as in certain internal tissue, such as the periosteum, arterial wall, the joint surface, and the falx and tentorium in the vault. Most other deeper tissue are only sparsely supplied with pain ending; never less any wide spread tissue damage can summate to cause the slow chronic aching type of pain in most of the area.

NOCICEPTION:

Nociception is the detection of tissue damage by specialized receptor called nociceptors. "Noci" is derived from the Latin word which means "hurt". Although the term nociception is often used interchangeably with the term pain. It technically must be restricted to denote only transmission of nociceptive information.

BENEFIT OF PAIN SENSATION:

Pain is a important sensory symptom, though it is an unpleasant sensation, it has protective or survival benefits such as-

It gives warning signal about the existence of a problem or threat. It also creates the awareness of the injury.

It prevents further damage by causing reflux withdrawal of the body from the sources of injury.

It forces the person to rest or to minimize the activity, thus enabling the rapid healing of the injured part.

It urges the person to take required treatment to prevent major damage.

TYPE OF PAIN:

Pain has been classified into two major type:

Fast pain

Slow pain

Fast pain- it is also describe by many alternative names such as sharp pain, pricking pain, acute pain and electric pain. Pain is felt when needle struck in to skin, when skin cut with knife. Fast pain is not felt in deeper part of body.

Slow pain: alternate name to these are slow, burning, aching pain, throbbing pain, chronic pain. This type of pain is usually associated with tissue destruction. It can lead to prolonged, unbearable suffering. It can occur both in the skin and in almost any deeper tissue or organ.

TYPE OF SENSATION:

There are many type of the variation of sensation that stimulates the skin as well as internal organ.

Skin:

Mechanical- Nociception, contact.

Thermal- hot and cold.

Chemical- acid.

Internal organ

Digestive tract- pressure, distention, inflammation.

Joint and muscle-position and movement of joint, stretch and contraction of muscle.

Fast pain is elicited by the mechanical and thermal types of stimuli. Whereas slow pain can be elicited by all three types.

The chemical substances are especially important in stimulating the slow, suffering type of pain that occur after tissue injury. Some chemical that excite the chemical type of pain are bradykinin, serotonin, histamine, potassium ions, acids, acetylcholine and proteolytic enzymes. Prostaglandins and substance P enhance the sensitivity of pain.

CAUSE OF PAIN

CHEMICAL PAIN STIMULI-

Extract from damaged tissue causes intense pain when injected beneath the normal skin. Most of the chemical excite the chemical pain receptor can be found in these extracts. One chemical that seems to be more painful than other is bradykinin. Also, the intensity of the pain felt correlate with the local increase in potassium ion concentration or increase

in proteolytic enzymes that directly attach the nerve endings and excite pain by making the nerve membranes more permeable to ion.

TISSUE DAMAGE:

When blood flow to a tissue is blocked, the tissue often become very pain full within a few minutes one suggested cause of pain is accumulation of fare amount of lactic acid in tissue, formed as a consequence of anaerobic metabolism. It is also probable that other chemical agents such as bradykinin and proteolytic enzymes are formed in tissue because of cell damage and in additional to lactic acid stimulate the pain nerve ending.

MUSCLE SPASM:

It is also a common cause of pain. This pain probably result partially from the direct effect of muscle spasm in stimulating mechanosensitive pain receptor, but it might also result from the indirect effect of muscle spasm to compress the blood vessel and cause ischemia. Also, the spasm increases the rate of metabolism in muscle tissue that making the relative ischemia even greater, creating ideal; condition for the release of chemical pain-inducing substances.

RATE OF TISSUE DAMAGE:

The average person begins to perceive pain when the skin is heated above 45°C. This is also the temperature at which the tissues begin to be damaged by heat; indeed, the tissues are eventually destroyed if the temperature remains above this level indefinitely. Therefore, it is immediately apparent that pain resulting from heat is closely correlated with the rate at which damage to the tissues is occurring and not with the total damage that has already occurred.

NERVES:

Each nerve is segregated as

Sensory (afferent) nerve- caries a bundle of sensory nerve e.g. Ophthalmic(1), Optic(2), and Auditory(8) cranial nerves.

Motor (efferent) nerve- carries a bundle of axon or motor nerve fibers e.g. Oculomotor(3), Trochlear(4), Abducens(6) cranial nerves.

Mixed nerve- carries both sensory and motor nerve fiber. All spinal nerves are of mixed variety.

SENSORY NERVES

The sensory fibers in sensory nerve are of two types:

Mechanoreceptor fibers: sense body movement (proprioception) (A-alpha) and pressure (A-beta) placed against the body.

Nociceptor fibers: sense tissue injury.

NOCICEPTOR FIBERS

Inflammation by noxious and mediator associated with inflammation stimulates two varieties of nerve fibers.

A-delta (δ) fibers: transmit information in acute pain.

C-fiber: transmit information in chronic pain.

The A fibers are myelinated, while the C-fiber are unmyelinated.

Table No 10: Types of fibres

AXON TYPE	**Aα**	**Aβ**	**Aδ**	**C**
DIAMETER (μm)	13-20	6-12	1-5	0.2-1.5
SPEED(m/s)	80-120	35-75	5-35	0.5-2

The thicker the nerve the faster the information travels within it.

NOCICEPTORS Nociceptors are of various subtypes:A (δ) receptors-

These are of two type

Mechanosensitive receptors

Mechanothermal receptors-stimulate by temperature >450C or <50C.

The mechanoreceptors are mildly myelinated. It have cluster of sensitive spots. As a result, A-δ nociceptors respond to dangerously intense mechanical or to mechanothermal stimuli.

Polymodal receptor-C receptor:

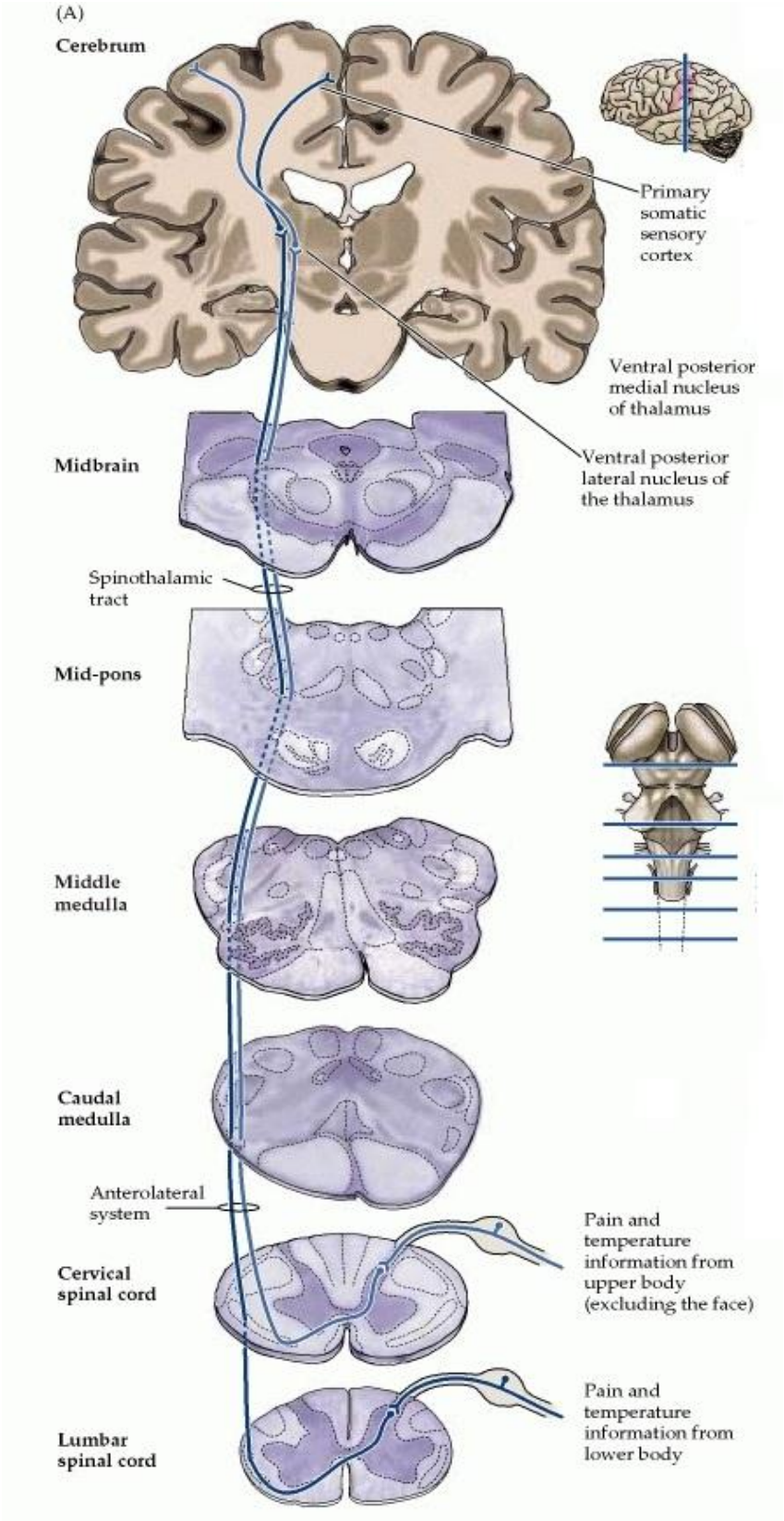
The unmyelinated polymodal nociceptors are responsive to thermal, mechanical as well as chemical stimuli.

PATHWAY FOR TRANSMISSION OF PAIN

Even though all pain receptors are free nerve ending, these nerve ending have two different pathways for transmitting pain signals into the central nervous system

FAST-SHARP PAIN PATHWAY

SLOW-CHRONIC PAIN PATHWAY



TRANSMISSION OF PAIN

FAST-SHARP PAIN PATHWAY: The fast-sharp pain signals are elicited by either mechanical or thermal pain stimuli; they are transmitted in the peripheral nerves to the spinal cord by small type Aδ fibers at velocities between 6 and 30 m/sec.

FIRST ORDER NEURON: these are the cell in the posterior nerve root ganglia which receive the impulse of pain sensation from pain receptor through there dendrites. These impulse are transmitted to spinal cord through the axons of these neurons. Fast pain sensation is carried by Aδ type afferent fibers. They terminate mainly in lamina 1(lamina marginalis) of the dorsal horn.

SECOND ORDER NEURON: Neuron of arginal nucleus forms the second order neuron. These form the neospinothalamic tract. This gibe rise to long fiber that crosses immediately to the opposite side of the cord through the anterior commissure and then turned upward, passing to the brain in the anterolateral columns.

A few fiber of neospinothalamic tract terminate in the reticular area of the brain stem, but most pass all the way to the thalamus without interruption, terminating in the ventrobasalcomplex. A few fibers also terminate in the posterior nucleus group of the thalamus.

THIRD ORDER NEURON: third order neuron of pain pathway are the neuron in

Thalamic nucleus

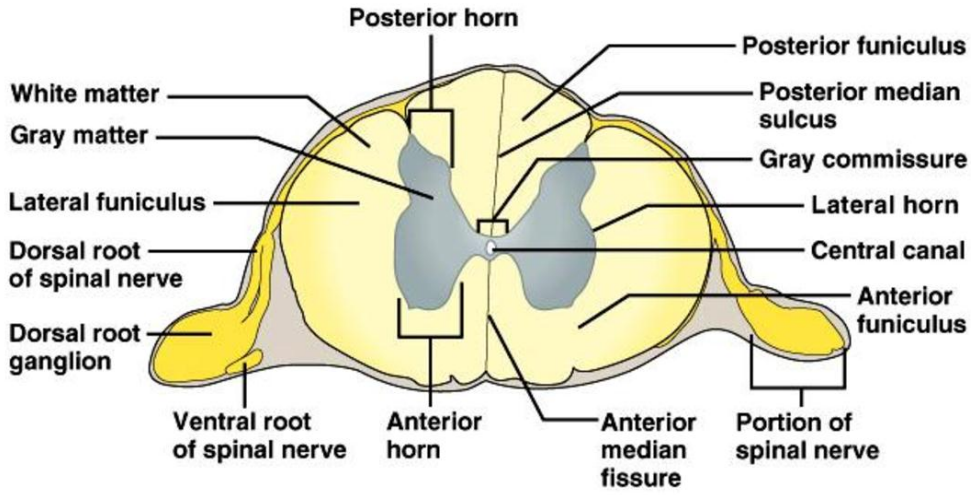
Reticular formation

Tectum

Graymatter around aqueduct of sylvius

Axons from these neurons reach the sensory area of cerebral cortex. Some fiber from reticular formation reaches hypothalamus. From these thalamic areas, the signals are transmitted to the other basal areas of the brain as well as to the somatosensory cortex.

NEUROTRANSMITTER: it is believed that glutamate neurotransmitter substance secreted in the spinal cord at the type Aδ pain nerve fibers ending, it action lasting for only a few millisecond.



SPINAL CORD

SLOW CHRONIC PAIN PATHWAY- Slow chronic type of pain is elicited mostly by chemical type of pain stimuli but some time by persisting mechanical or thermal stimuli. This sow-chronic pain is transmitted to the spinal cord by type C fibers at velocities of between 0.5-2 m/sec.

FIRST ORDER NEURON- pain sensation from pain receptor is carried by C type afferent fibers which synapse with substantia gelatinosa in dorsal horn. Although it does transmit some signal from Aδ fibers as well. In this fiber terminate in lamina 1and 3 of the dorsal horn which together called substantia gelitinosa. Most of the signal then passes through one or more additional short fibers entering mainly in the lamina 5 also in the dorsal horn.

SECOND ORDER NEURON: the fiber of slow pain which arises from neuron of substantia gelatinosa, cross the midline and run along the fiber of fast pain as paleospinothalamic fiber in lateral spinothalamic tract. One-fifth of these fiber terminate in ventral posteriolateral nucleus of the following area:

Nuclei of reticular formation in brain stem

Tectum of mid brain

Gray matter surrounding aqueduct of sylvius

THIRD ORDER NEURON:

Thalamic nucleus

Reticular formation

Tectum

Gray matter surrounding aqueduct of sylvius

Axon from these neurons reaches the sensory area of the cerebral cortex. Some fiber from reticular formation reaches hypothalamus.

NEUROTRANSMITTER:

Research experiments suggest that type C pain fiber terminals entering the spinal cord secrete both glutamate transmitter and substance P transmitter.

CENTER FOR PAIN SENSATION

The center for pain sensation is in the postcentral gyrus of parietal cortex. Fiber reaching hypothalamus is concerned with arousal mechanism due to pain.