General sensory pathways of the trunk and limbs – ascending tracts

Notes :

- all the slides are included in the sheet so you don’t have to go back to them except for the figures.
- The doctor didn’t add much on the slides even though he said that this topic is very high yield on the final exam, so we tried our best to collect information from different resources hoping it will be helpful.
- the slides + what the doctor said are in black.
  any extra information we added is in purple.
  good luck

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Lecture objectives

Describe gracile and cuneate tracts and pathways for conscious proprioception, touch, pressure and vibration from the limbs and trunk.

Describe dorsal and ventral spinocerebellar tracts and pathways for unconscious proprioception from the limbs and trunk.

Describe lateral spinothalamic tract and pathways for pain and temperature from the limbs and trunk.

Describe ventral spinothalamic tract and pathways for simple touch from the limbs and trunk.
Now what do we mean by ascending tracts? They are groups of neurons that deliver whatever stimuli from the peripheral receptors to the CNS. In another words, we can define ascending tracts as the neural pathways by which sensory information from the peripheral nerves is transmitted to the cerebral cortex.

On their way of transmitting those sensory information, there will be neurons which will give the sensory information to another neurons until it reaches the CNS and that’s what we call it first-order neuron, second-order neuron and so on.

So first-order neurons sense stimuli (such as pain or touch) from receptors and transmit this information to second-order neurons that carry information to third-order neurons until it reaches the cortex.

Most of the ascending tracts pass on the thalamus before reaching the cerebrum so they have a relay station there or in the spinal cord/brain stem.

Now let's start with the first tract

**Dorsal Column or Medial Lemniscal System**

The dorsal column pathway function in carrying these types of sensation:

1- **Touch**, specifically the **Discriminative touch** (*calipers*) and **Fine touch** which is the sensation of a cotton ball on your hand.

2- **Vibration** (*tuning fork*)

3- **Conscious proprioception** (with eyes closed, patient reports position of limbs as they are moved by examiner). Notice that there is conscious proprioception and unconscious one.

Proprioception has a conscious and an unconscious component. The conscious pathway goes to the thalamus and cerebral cortex, enabling one to describe the position of a limb. The unconscious pathway (spinocerebellar tract) connects with the cerebellum, which is considered an unconscious organ, and enables one to walk and perform other complex acts without
having to think about which joints to flex and extend.

وحدات قياس لأصغر مسافة بين جزئين يمكن للجسم الاحساس بها

**Neural components of dorsal column:**

**Receptors** – encapsulated receptors & hair shafts, mostly transmitted by beta large fibers

1\(^{st}\) order neuron's cell body is in the dorsal root ganglion DRG

central Axon fibers from

- **Lower body** – fasciculus gracilis (those are the longest fibers in the body)

Upper body (above T6) – fasciculus cuneatus which is lateral to nucleus gracilis

- **Upper body (above T6)** – fasciculus cuneatus which is lateral to nucleus gracilis

Below T6 the nucleus cuneatus is absent, above T6 the two fasciculus present.

2\(^{nd}\) order neuron's cell body is in Posterior column nuclei (gracilis & cuneatus) in medulla oblongata.

And its Axons will Decussate to form internal arcuate fibers and then ascend as medial lemniscus which ascend to thalamus.

3\(^{rd}\) order neuron's cell body – ventral posterolateral nucleus of the thalamus (VPL)

*Axon goes through Internal capsule (posterior limb) to the Corona radiate to Somatosensory cortex – Postcentral gyrus*

The first order neurons carry sensory information regarding touch, proprioception or vibration from the peripheral nerves to the medulla oblongata. There are two different pathways which the first order neurons take:

- **Signals from the upper limb** (T6 and above) – travel in the fasciculus cuneatus (the lateral part of the dorsal column). They then synapse in the nucleus cuneatus of the medulla oblongata.

- **Signals from the lower limb** (below T6) – travel in the fasciculus gracilis (the medial part of the dorsal column). They then synapse in the nucleus gracilis of the medulla oblongata.

The second order neurons begin in the cuneate nucleus or gracilis. The fibers receive the information from the preceding neurons, and delivers it to the third order neurons in the thalamus.

Within the medulla oblongata, these fibers decussate (cross to the other side of the CNS). They then travel in the contralateral medial lemniscus to reach the thalamus.

Lastly, the third order neurons transmit the sensory signals from the thalamus to the ipsilateral primary sensory cortex of the brain. They ascend from the ventral
posterolateral nucleus of the thalamus, travel through the internal capsule and terminate at the sensory cortex.

Lesions

In the posterior column?

Above the decussation?

A lesion of the DCML pathway causes a loss of proprioception and fine touch. However, a small number of tactile fibers travel within the anterolateral system, and so the patient is still able to perform tasks requiring tactile information processing.

If the lesion occurs in the spinal cord (which is most common), the sensory loss will be ipsilateral – decussation occurs in the medulla oblongata.

**Anterolateral (spinothalamic) System**

mostly transmit fast pain

**Free nerve ending**, small size fibers

Its function is transmitting:

1. **Pain**

   Mostly Aδ fibers (small myelinated)

   **Fast pain** (sharp, will localized stabbing pain)
C fibers (unmyelinated)

*Slow pain (dull aching or burning pain* due to pathological condition)

Via spinoreticular tract

2-Temperature

**Crude touch**, you cannot discriminate the touch or identify its exact location.

**Poorly localized & poorly identified**

**DO NOT compensate damage to dorsal column**. If a damage or a lesion occurred to dorsal column, this system cannot compensate the lost sensations.

**Neural components**

1<sup>st</sup>

**Cell body – DRG**

**Axon**

Branches ascend & descend in the Lissauer’s tract for 1-2 segments

It means that second-order neuron is 2 segments above the entry of first-order neuron. So if the fibers enter at T3 the synapse will be at T1 ... if a lesion occurred at T1, the injury will be on the nerve inter at T3.

2<sup>nd</sup>

These neurons will form the tract, unlike the dorsal column which the tract is formed by first-order neuron

**Cell body – posterior horn** of gray matter (**substantia gelatinosa**)

**Axons – cross midline at anterior** directly at **white commissure**

3<sup>rd</sup> – **VPL** – **somatosensory cortex** the same as dorsal column

The first order neurons arise from the sensory receptors in the periphery. They enter the spinal cord, ascend 1-2 vertebral levels, and synapse at the tip of the dorsal horn – an area known as the substantia gelatinosa. The second order neurons carry the sensory information from the substantia gelatinosa to the thalamus, they decussate at the anterior white commissure. The third order neurons carry the sensory signals from the thalamus to the ipsilateral primary sensory cortex of the brain. They ascend from the ventral posterolateral nucleus of the thalamus, travel through the internal capsule and terminate at the sensory cortex.

**Somatotopic Organization of Anterolateral System**

At upper cervical level

**Sensory modalities**
- **Anterior** – crude touch
- **Lateral**
  - **Medial** – temperature most medial
  - **Lateral** – pain most lateral and superficial

So if the injury was at the medial side, it will affect the temperature sensation, but if it was superficial on the lateral side it will affect the pain sensation.

- **Area**
  - **Lower limb** – most lateral anteriorly
  - **Cervical** – most medial

**Lesions**

**Segment sparing (lesion at T1 – deficit up to T2 or T3 dermatomes)?**

**Partial lesion – effect of somatotopic organization?**

**Lesion at anterior white commissure?** It will affect the same segment only not the whole tract

لأوه الfibers بعملىا أول بأول لأنه آل decussation

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**Spinoreticular (Spinoreticulothalamic) Tract**

( the 2nd pain pathway)

It seems to be part of the spinothalamic tract. It is considered a slow pain pathway.

**1st order neurons are found in the dorsal root ganglion.**

slow pain is transmitted c fibers.

**2nd order neurons are mostly at substantia gelatinosa,**

2nd motor neurons sends out fibers that cross the midline toward 3rd order neuron in the thalamus.

The spinoreticular tract is an ascending pathway in the white matter of the spinal cord, positioned closely to the lateral spinothalamic tract. The tract is from spinal cord—to
reticular formation— to thalamus. It is responsible for automatic responses to pain, such as in the case of injury.

The tract begins with first-order neurons, which immediately synapse with second-order neurons in the posterior horn of the spinal column. These neurons decussate to the opposite side (anterolateral), and travel up the spinal column. It terminates in the brainstem at the medullary-pontine reticular formation. Information is sent from there to the intradmedian nucleus of the thalamic intralaminar nuclei. The thalamic intralaminar nuclei project diffusely to entire cerebral cortex where pain reaches conscious level and promotes behavioral arousal.

Reticular formation (bilaterally) some parts are crossed and some are not.

Thalamus (intralaminar nuclei)

Cortex
- Postcentral gyrus – localization of pain
- Insula & anterior cingulate gyrus – affective (suffering) aspect of pain

Spinocerebellar Pathways

(although it is part of motor system, it is classified as ascending tract).

The spinocerebellar tract is a nerve tract originating in the spinal cord and terminating in the same side (ipsilateral) of the cerebellum.

- Function
  - Non-conscious proprioception it carries proprioception information to the cerebellum to help it in doing motor functions. You are not conscious to this information.

Such as when you walk, your cerebellum knows which leg to move up and which leg to stand still, without the need for you to be conscious about it, and that’s by this tract that carry non-conscious proprioception to the cerebellum.

- Essential for normal motor function
- Lesions lead to severe motor deficits
  - Ataxia (uncoordinated movements)
- Origin – muscle spindles, golgi tendon organs & joint receptors
  - All terminate in the cerebellum at the same side (ipsilateral)
As the spinocerebellar tract reach the cerebellum at ipsilateral side …..and then at the level of superior cerebellar peduncles they cross in way to reach cerebrum, so the right hemisphere from cerebellum is attached to the left cerebrum (that’s mean the right cerebral hemisphere attach to the left cerebellar hemisphere which attach the left side of the body.

Within the spinocerebellar tracts, there are four individual pathways:

**Posterior spinocerebellar tract** – Carries proprioceptive information from the lower limbs to the ipsilateral cerebellum.

**Cuneocerebellar tract** – Carries proprioceptive information from the upper limbs to the ipsilateral cerebellum.

**Anterior spinocerebellar tract** – Carries proprioceptive information from the lower limbs. The fibres decussate twice – and so terminate in the ipsilateral cerebellum.

**Rostral spinocerebellar tract** – Carries proprioceptive information from the upper limbs to the ipsilateral cerebellum.

**Posterior Spinocerebellar Tract**

From trunk and leg → where descending tracts present , most superficial lateral column

- 1st – DRG
- 2nd –

- Cell body - Clarke’s nucleus C8- L2

Most anterior part of posterior horn . notice that Clarke's nucleus isn’t at the whole length of the spinal cord , it is just from C8 to L2 , so fibers above C8 will go in another tract we will talk about in the coming slides

- fibers that are Below L2 – ascend in the fasciculus gracilis until they reach Clarke’s nucleus

- Axons – ascend in the same side they do not cross ,
  - until they reach Inferior cerebellar peduncles
From Wikipedia: It is part of the somatosensory system and runs in parallel with the ventral spinocerebellar tract. It carries proprioceptive information from muscle spindles and Golgi tendon organs of ipsilateral part of trunk and lower limb. Proprioceptive information is taken to the spinal cord via central processes of dorsal root ganglia (first order neurons). These central processes travel through the dorsal horn where they synapse with second order neurons of Clarke's nucleus. Axon fibers from Clarke's Nucleus convey this proprioceptive information in the spinal cord in the peripheral region of the funiculus posterior ipsilaterally. The fibers continue to course through the medulla oblongata of the brainstem, at which point they pass through the inferior cerebellar peduncle and into the cerebellum, where unconscious proprioceptive information is processed.

The Cuneocerebellar Tract

(same as post spinocerebellar, but above c8)

From the arm –& neck

• 1st

• Cell body – DRG

• Axon – ascend in the fasciculus cuneatus (not found below T6)

• 2nd

• Cell body – external (lateral or accessory) cuneate nucleus
• Axons – inferior cerebellar peduncle

The cuneocerebellar tract is similar to the dorsal spinocerebellar tract. Specifically, it conveys information related to the upper limbs. As Clarke’s nucleus is not present above the level of C8, the fibers entering form the upper limb pass to the medulla via the cuneate fasciculus, synapsing in the accessory cuneate nucleus before passing to the cerebellum. Again, this pathway conveys non-conscious proprioceptive information from muscle spindles and Golgi tendon organs from the upper limb musculature. It is an ipsilateral pathway.

Anterior (Ventral) Spinocerebellar Tract

1\textsuperscript{st} order neuron $\rightarrow$ DRG

• 2\textsuperscript{nd}

• Cell body – around the border of the ventral horn

• axons – mostly cross the midline

• Superior cerebellar peduncle

• Then cross back through middle cerebellar peduncle

Crossing over occurs twice, so they will continue as ipsilateral in cerebellum.

Information conveyed in the ventral spinocerebellar tract arises from Golgi tendon organs at the junction between the tendon and the muscle of the lower limbs. Initially the information passes from one side of the body then crosses over at the spinal cord ascending in the ventral spinocerebellar tract. At the level of the pons, these fibers then crossover again back to the same side the information had arisen from in the superior cerebellar peduncle. This then passes to the cerebellum. This tract conveys information about movement of the entire limb and adjustments to the posture. The information terminates on the ipsilateral side but crosses twice.

Rostral Spinocerebellar Tract –

Above the ventral spinocerebellar tract

• Same as ventral spinocerebellar tract except

• From cranial region

The rostral spinocerebellar tract is like the ventral spinocerebellar tract but the difference is that it conveys information about the upper limbs from the Golgi tendon organs. It is an ipsilateral pathway and the information passes to the cerebellum via the inferior cerebellar peduncles.
Other Ascending Tracts

- **Spinoreticular tract** (data affecting consciousness) function in reflexes, visceral sensation and pain
  - Mostly uncrossed
  - To reticular formation in medulla and pons
- **Spinotectal tract** important for visual motor sensation to complete the circuit by feedback
  - Crossed
  - To superior colliculus
  - Affect spinovisual reflexes
- **Spinoolivary tract**
  - Cross the midline
  - To the inferior olivary nuclei
  - Then cross to the cerebellum
- **Inferior cerebellar peduncle**

**Sensory Lesions**

- In spinal cord
  - **Anterior white commissure** – loss of pain & temperature sensation bilaterally (ring of body)

At the same segment on both sides, remember the sparing, if the cut is on T3 then the affected ring is on the level of T1.

- **Hemisection** – contralateral loss of pain and temperature & ipsilateral loss of discriminative touch
- In the medulla
  - **Medial lesions** – loss of discriminative touch for the contralateral body

After medial lemniscus
  - **Lateral lesions** – loss of pain & temperature for contralateral body
On anterolateral system

• In the pons and above
  • All sensory modalities travel together
  • Small lesions – hemianesthesia for the contralateral half
• Pain & the thalamus
• Ventral posterior thalamus

• Period (months) of analgesia followed by chronic pain (thalamic pain syndrome)
there is no loss of sensation

• Pain & the cortex
• Somatosensory cortex

• Reduce ability to localize pain but does not eliminate the ability to feel pain

Phantom Limb

• Results from loss of a limb, amputation
• Patient feels that the limb is still present
• Cortical representation stay intact for a period of time?
• Limb remain associated with the mental image
• Amputation could be followed by severe pain in the site of the limb
• Due pressure on the nerve stumps

A phantom limb is the sensation that an amputated or missing limb is still attached. Approximately 60 to 80% of individuals with an amputation experience phantom sensations in their amputated limb, and the majority of the sensations are painful.

Sorry for any mistake, Good luck