Motor Cortex & Descending Tracts

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Descending Tracts

- Various brain regions send signals via descending pathway and regulate spinal control of movement.
- Descending signals end on alpha and gamma motor neurons (lower motor neuron) or the interneurons that affect them.
- Descenging tracts could end interneuron that function in reflex arcs.
- So descending signals are fully integrated with local control.

Descending Tracts

- Descending pathways are consist of two types:
  - Lateral pathways
  - Ventromedial pathways

Lateral Pathways

- Experimental lesions in lateral pathways in monkey rendered them unable to move their arms and hands properly.
- Lateral pathways fibers provide control of voluntary movements of the distal extremities.
- Lateral pathways could be divided into two different tract:
  - Corticospinal tract: Main component
  - Rubrospinal tract: Smaller component

Lateral Pathways

Corticospinal Tract

- Most important component of the lateral pathways.
- Originating in neocortex; mainly originate in areas 4 and 6 of frontal lobe (motor cortex)
- Cross section of tract is triangular, so this tract is also called **pyramidal tract**
- At the junction of medulla and spinal cord, corticospinal tract decussates

Lateral Pathways

Corticospinal Tract

- After crossing, big part of it go down in lateral column.
  - This is called lateral corticospinal tract.
  - It terminates on ventral horn and make synapse with lower motor neuron that control distal muscles.
- (Anterior corticospinal tract small part of corticospinal tract. It assists with motor control)

Lateral Pathways

Rubrospinal Tract

- Much smaller component of lateral pathways
- Originates in the red nucleus (nucleus ruber) in the midbrain; decussates in the pons.
- Major source of input is frontal cortex which also contributes corticospinal tract.
- Rubrospinal tract has been replaced by corticospinal tract over the course of evolution. In humans most of its function subsumed by corticospinal tract

Lateral Pathways

- Corticospinal tract
- Rubrospinal tract

Lateral Pathways

Lesions

- Lateral pathway lesion;
  - Monkeys could not do fractionated arm and hand movements.
  - Voluntary movements were slower and less accurate
  - They could sit and stand upright.
- Only corticospinal tract lesion;
  - Same deficit
  - Many function recover over time.
  - But subsequent lesion in rubraspinal tract reversed this recovery

➢ *Rubrospinal pathway compansate for function of the corticospinal tract over time.*

Ventromedial Pathways

- Originate in the brain stem and terminate in spinal cord
- Contain 4 descending tracts:
  1. Vestibulospinal tract
  2. Tectospinal tract
  3. Pontine Reticulospinal tract
  4. Medullary reticulospinal tract
- Ventromedial pathways controls proximal and axial muscles to maintain balance and posture
- Always use sensory information from proprioception and vision.

Ventromedial Pathways

Vestibulospinal Tracts

- Keeping head balanced as the body moves and turn the head to new stimuli.
- Originate in vestibular nuclei which relay information from vestibular labyrinth (balance organ).
  - One component projects down to cervical segment of spinal cord; control neck muscle
  - Other component projects down to lumbar segments to helps us maintain balance

Ventromedial Pathways

Tectospinal Tracts

- Responsible for moving head and eyes to appropriate point in space to fixate the image on our fovea.
- Originates in superior colliculus which receives direct input from retina and cortex.
- Axons project to cervical regions of spinal cord to help control muscles of neck and upper trunk

Ventromedial Pathways

- Reticular formation is a complex network of neurons in brain stem.

Pontin Reticulospinal Tract

- Enhances the antigravity reflexes
- Activity in this pathway facilitate the extensors and help maintain standing posture

Medullary Reticulospinal Tract

- Opposite functions.
- Liberates the antigravity muscles from reflex control

Ventromedial Pathways

- Vestibulospinal tract
- Tectospinal tract
- Pontin reticulospinal tract
- Medullary reticulospinal tract

Brain Control of Movement

- Cortical areas 4 and 6 are called «motor cortex» but control of movement engages large part of cortex.

- Different aspects of motor control are localized to different regions of the cerebral cortex

Brain Control of Movement

Penfield Experiments

- From 1930s through the 1950s
- He used direct cortical stimulation during open brain surgeries
- Electrical stimulation to spesific part of brain could create spesific response
- Cortical map

Motor Cortex

Area 4

- Electrical stimulation of area 4 in the precentral gyrus elicit a twitch of a particular muscles on the contralateral side.
- This area is called «*primary motor cortex*»
- There is a somatotopic organization in primary motor cortex.

Motor Cortex

Area 6

- Just anterior to area 4 and specialized for voluntary movements
- Electrical simulation to area 6 evokes complex movements of either side of the body.
- «Higher» motor areas
- There are two somatotopically organized motor maps in area 6

1. Premotor area
2. Supplementary motor area (SMA)

Motor Cortex

Area 6

- Premotor area and SMA plays an important role in «motor planning»
  - ➢the planning of complex movement sequences
- These areas activate about a second before the execution of the movement = planning

- SMA activated for the movement of either side.
  - SMAs ot two hemispheres are closely linked via corpus callosum.
  - SMA lesion in one side cause distortion of movements that required both hands (buttoning a shirt)

Posterior Parietal Cortex

- This area responsible for *spatial perception* which is a ability that allows us to aware our body and environment (space).
- Obtain somatosensory, proprioceptive and visiual information for this function

- This information is crucial for motor function
- There are two areas within posterior parietal cortex
  - Area 5 obtain somatosensory informaton from area 3 1 2
  - Area 7 obtain visiual information from visiual cortex

Prefrontal Cortex

- Related to executive control and planning ability
- «Highest level of motor control hierarchy»
- Responsible for making decisions according to goal

- Prefrontal cortex and parietal cortex both send axons that converge on cortical area 6.

Neuronal Coding of Movement

- Descending pathways originates in cortical layer V, pyramidal neurons.
- Some of this cell excite lower motor monosynaptically; some of them brancjes and excite local inhibitory interneuron.
- A single neuron may generated movements with recprocal inhibiton.

Neuronal Coding of Movement

- Researchers previously thought the motor cortex send signal to contract individual muscles.
- But recent sudies showed us, individual pyramidal cells send signals to innervate different muscles for a moving of a limb.
- Motor cortex do not code individual muscles;

➢ Motor cortex codes movements (force and direction) and descending pathways innervate every muscle for this spesific movement.

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