A study of anatomy and physiology of movement of upper limb

Science, Anatomy

The procedure in lifting the hand to drink water is a complex one which involves a huge amount oftechnologyinter-transfer between the brain and the eventual skeletal muscle.

There is initiation of the movement at the brain which is transmitted via specialized white fibre tracts to the hip flexors via the intermediate spinal cord, involving a very complex mechanism at the cellular level

The initiation of the process is at the motor cortex (Ms I) of the brain. The primary motor area is located at the precentral gyrus of the frontal lobe. The area controlling the motion of the lower limbs lies towards the superior surface of the brain. Within this area lies the cell body of the primary neuron. These neurons are known as upper motor neurons (UMN).

These UMNs receive modulating impulse from the inputs from the cerebellum and the basal ganglia via the extrapyramidal pathways. These tracts modulate the gross movement initiated at the frontal cortex. In turn these areas are modulated by afferent signals from ascending spino cerebellar, and spino-thalamic pathways. The signal initiated at the nucleus of the cell body is transmitted electronically via the axon of the myelinated neuron via the mode of salutatory conduction.

The myelin sheath which surrounds the axon of nerves that involve fast transport, breaks at intermediate regions known as Nodes of Ranvier. The electrical impulse moves in a jumping manner at these nodes nerve transmission as a neural impulse, generated by the formation of a nerve action potential. Like all excitable tissue, nerves maintain a resting

membrane potential that is the difference of voltage across the membrane of the neuron. In neurons this value is - 70 mV.

This voltage difference is maintained by the Na/K pump on the membranes. This impulse generated at the axon hillock is transmitted via the depolarizing phase which allows sodium ions ingress into cells via opening of the Na channels. This entry of Na in one portion allows activation of other Na channels, causing depolarization of the adjacent region of the neuron. Subsequently repolarization occurs via the opening of K channels, which restores the membrane potential.

Thus this process continues which allows the transmission of impulse. Many such nerves together descend as the descending cortico spinal tract in the pyramidal system, which travels through the midbrain into the spinal cord, decussating at the level of midbrain(90% of the fibres decussating and forming the lateral spinothalamic tract) and again at the level of spinal cord (the other 10%, forming the anterior spinothalamic tract) .

It is the former which is responsible for the upper limb movements. The cortico-spinal tract travels in the anterior horn cell of the spinal cord till the brachial plexus where they synapse with the spinal ventral root neuron (lower motor neuron). A single post-synaptic neuron receives signals from many neurons. At the axon terminal, the propagation of impulses leads to release of neurotransmitters, which are stored in specialized vesicles.

The released Ach diffuses into the synaptic cleft and binds with receptors on the post synaptic membrane to produce excitatory post synaptic potentials. This leads to generation and propagation of impulse in nerves which are

destined to innervate the neuro-muscular junction. At the neuro-muscular junction, Ach is released, which diffuses into the synovial cleft and binds to receptors in the motor end plate, and triggers a muscle action potential.

The released Ach is destroyed by the acetylcholinestrase. At the level of the sarcolemma of the muscles, the muscle AP travels along T-tubules, opening Ca release channels in the sarcoplasmic reticulum. Ca binds to troponin-tropomysin complex, which releases the myosin heads, these then bind to the actin thin filaments, and draws them closer to the M line. Meanwhile bringing the Z disc closer.

This leads to muscle fibre contraction. This is a self propagating sequence eventually leading to the contraction muscles involved in the movement. Each nerve fibre innervates many musle fibres (about 150). This is the motor unit.

The greater the number of motor units recruited by the nerve action potential, the greater the force of contraction of the muscles. In the spinal cord, nerve impulse travels along the brachial plexus (C5 – T1) to innervate the Pectoralis major (Arm adduction and flexion – reaching out to hold the glass), Flexor digitorum superficialis and profundii of all fingers, the interossei and the lumbricals of all digits, opponens pollicis, flexor pollicis brevis , adducor pollicis and abductor pollicis brevis (gripping of the glass by the fingers flexion at metacarpophalangeal.

Proximal interphalangeal and the distal interphalangeal joint of the fingers; the carpometqcarpal joint, metacarpophalangeal and the interphalangeal joint of the thumb); then contraction of the biceps brachii (elbow flexion)

and the supinator (supination at the elbow joint); finally the contraction of the triceps muscle (elbow extension, to put the glass back).

This excitatory impulse is also associated with the production of inhibitory action potential (hyperpolarizing impulse) in the antagonists (eg triceps during elbow flexion, and biceps during elbow extension)