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“Conceptual study of *vyana vayu* (vata) w.s.r. to Action potential.”

Metake Ajit Dattatraya^{*1}, Patil Mahesh², Patil Ashok³

1. Associate Professor, Rognidan Department, Sant Gajanan Ayurveda Medical College, Mahagaon.
2. Professor, Samhita Siddhant Department, Sant Gajanan Ayurveda Medical College, Mahagaon.
3. Associate Professor, Rognidan Department, Yashwant Ayurved College, Kodoli

*Corresponding author: drajitmetake@yahoo.com, 9850074987

Abstract:

Background: Aim of this study, is to correlate the ayurvedic concept of *vyana vayu* with action potential. Methods: analysis of *vyana vayu* according to ayurvedic literature and comparing or correlating it with generation and propagation of action potential with the help of modern science literature. *Vyana vayu* is type of *vata* who is responsible for *rasa-rakta sanvahan* & locomotion of human body. Discussion: After analysing both ayurvedic and modern science literature the action of *vyana vayu* stated in ayurvedic texts can be correlated to development and propagation of action potential. Conclusion: *Vyana vayu* is action potential. Development and propagation of action potential correlates with the functions and characteristics of *vyana vayu*.

Keyword: (*Vyana vayu*, *Mahajav*, Action potential, Contraction, Neuro-transmitters)

Introduction:

Ayurveda is ancient science majorly based on observations. Modern science is majorly based on experiments. On many instances we came across, the similarity in principles of both medical sciences. By comparing or correlating similar principles from both medical sciences, those principles could be better understood. This can facilitate a perfect base for further fundamental & experimental research on those particular principles. *Vyana vayu* is type of *vayu* which is responsible for *rasa-rakta sanvahan* (circulation of blood) & the locomotive functions of the human body. By understanding concept of *vyana vayu* and action potential, further the role of *vata dosha* in etio-pathogenesis of various disorders can be better understood.

Aims :

- To study concept of *vyana vayu*.
- To study concept of action potential.
- To correlate *vyana vayu* with action potential.

Objects :

- To review ayurvedic literature about vyan vayu and related terminologies.
- To review related modern science literature about action potential.

Literature Review:

Vyan vayu –

- Vyan vayu is one of the 5 types of vata dosha- [1][2][3]
- **Charaka samhita chikitsa sthana** 28/9 – [4]
 - ✓ Location – location of vyana is whole body
 - ✓ Functions – all type of movements are caused due vyana vayu. *Gati, prasarana, akshepa, nimesha*, etc movements are carried out by vyana vayu.
- **Ashtang Hridayam – sutra sthana** 12/6-7.[5]
 - ✓ Location – It resides in all body, but specifically hridaya (heart) is its main location.
 - ✓ Characteristics – “mahajav”= it’s speed is very fast.
 - ✓ Functions – *prakshepan, akshepa, nimesha, unmeshagati* are carried out by vyana vayu. All major body movements are dependent on vyana vayu.
- **Sushrut samhita nidana sthan** 1/17-18.[6]
 - ✓ Location – whole body
 - ✓ Functions – *rasa sanvahan, sveda asruka sravan* i.e circulation of plasma & blood; secretions of blood & sweat, *panchadha cheshta* (i.e.

prasaran, akunchan, unmvinman, unnaman, tiryak gaman)

- **Ashtang Hridayam nidana sthan** 16/23-25 – [7]

Etiological factors causing vyana vayu dushti – *ati-gamana* (excessive walking), *ati-dhyana* (excessive anxiety), *ati-krida* (excessive physical exercise), *ati-visham cheshta* (excessive uneven movement of body parts); *Virodhi-ahar Sevan* (excessive eating of incompatible food combinations), *ati-ruksha ahar sevan* (excessive eating of), *ati-abhiharsha* (excessive happiness), *ati-vishad* (excessive depression) & similar conditions may lead to *vyana vayu dushti* (imbalance).

Symptoms and diseases caused due to vyana vayu dushti – *punsatva bhramsha* (reduced vigour, fertility), *utsaha bhramsha* (reduced energy), *bala bhramsha* (reduced energy); *shopha* (swelling), *chittotplava* (disturbed mental status), *jvara* (fever), *sarvang roga* (diseases affecting whole body), *nistoda* (pricking sensation), *romharsha* (goosebumps / shivering), *angasuptata* (numbness), *kustha* (skin diseases), *visarp* (herpes disorders), *sarvang gada* (disorders affecting whole body).

Action Potential – [8][9][10]

Every cell possesses some positively charged and negatively charged ions inside the cell (i.e. Na^+ , K^+ , Cl^- , etc.). Similarly some positively & negatively charged Ions are also present outside the cell. Outside environment and inside environment is differentiated by cell membrane. Thus there will be some positive or negative charge inside and outside of the cell across the cell

membrane due to presence of respectively charged Ions. If we measure this electric charge, we will get a difference between the electrical charge inside the cell and outside the cell across the cell membrane, that is called as **membrane potential**. When these cell are at rest or not transferring any impulse there is a steady potential difference across the cell membrane that difference is called as **Resting membrane potential**.

Resting membrane potential is different for different type of cells.

For example –

1. **Skeletal muscle cells:** -95 mV ($\text{mV} = \text{milivolt} = 1/1000 \text{ volt}$)
2. **Smooth muscle cells:** -50 mV
3. **Astrocytes:** $-80/-90 \text{ mV}$
4. **Neurons:** -70 mV
5. **Erythrocytes:** -12 mV
6. **Cardiac contractile muscle fibres:** -90 mV .

How Resting Membrane Potential develops ? – It is developed due to uneven distribution of ions on both side of cell membrane due to changes in membrane permeability for potassium, sodium, calcium, and chloride, which results from the movement of these ions across it. This uneven distribution of ions is governed by different ion channels. Thus at a resting condition there will a difference between ionic charge inside the cell and outside the cell, this difference is called as resting membrane potential. Resting Membrane potential is always negative, that means the charge inside the cell is always negative than that of outside the cell. It is not the net charge inside the cell or

outside the cell. It is the difference in ionic charge across the cell membrane between inside & outside of the cell. From above examples resting membrane potential of Neurons is -70 mV means inside charge of neurons is more negative than outside of neuron, the difference between inside & outside is 70 mV .

What is Action Potential ?–

when a cell receives a stimulus, which can be mechanical or chemical, there will be opening of ion channels leading to movement of specific ions across the cell membrane according to their electrochemical gradient i.e. a concentration (chemical) difference plus an electrical difference. Due to this Ionic movement across the membrane, there will be change in **resting membrane potential**. This change in Resting membrane potential is called as impulse generation. Prior negative resting membrane potential changes in positive potential i.e more positively charged ions moves inside the cell and thus generating more positive charge inside the cell in comparison with outside the cell. This development of positive membrane potential is called as **depolarization**.

Events in Depolarization –

When membrane potential of axon reaches threshold, the Na^+ channel activation gates open. As Na^+ ions move through these channels into the neuron, a buildup of positive charges forms along inside surface of membrane and the membrane becomes depolarized.

After depolarization again specific ion channels open and close, thus permitting the positive charged ions to move outside the cell creating more negative charge

inside the cell in comparison with outside of cell. This change in membrane potential is called **Repolarization**.

Events in Repolarization – Na⁺ channel inactivation gates close and K⁺ channels open. The membrane starts to become repolarized as some K⁺ ions leave the cell and a few negative charges begin to build up along the inside surface of the membrane. K⁺ outflow continues. As more K⁺ ions leave the cell, more negative charges build up along inside surface of membrane. K⁺ outflow eventually restores resting membrane potential. Na⁺ channel activation gates close and inactivation gates open. Return to resting state when K⁺ gates close.

Sometimes this repolarization continues for a greater extent, thus creating more negative membrane potential than resting membrane potential, then it is called as **hyperpolarization**.

At the end of these changes, again resting membrane potential is achieved. This process of changing resting membrane potential due to depolarization and again restoring resting membrane potential due to repolarization is either called as graded potential or action potential.

Graded potential are the potential which are generated but not carried or propagated to longer distances.

And when this graded potential crosses specific threshold level due to summation of multiple graded potentials that is converted into action potential. Action potential is also called as a impulse, by means of which nerves and muscle cells communicate with each others.

How it propagates ? –

When action potential is developed in one cell it usually excites adjacent cell or portion of membrane resulting in propagation of action potential. It propagates away from the origin in unidirectional way. That means it propagates in any direction away from its origin but can't be propagated back to its origin, because when one cell is excited depolarization happens and after that repolarization follows, then there is a refractory period, in which the same cell can't be excited again thus propagation of action potential only happens forward it can't be transmitted backwards.

Speed of propagation of Action potential – It is very fast. The speed of propagation of an action potential is affected by three major factors: amount of myelination, axon diameter, and temperature. It is different in different types of cells. For example –

1. Velocity in small unmyelinated nerve fiber – 0.25meter/second.
2. Velocity in large myelinated nerve fibre – 100meter/second.
3. Cardiac Atrial muscle fibers : 0.3 meter/second.
4. Cardiac Internodal fibers : 1.0 meter/second.
5. Cardiac AV node : 0.05 meter/second.
6. Cardiac Bundle of His : 0.12 meter/second.
7. Cardiac Purkinje fibers : 4.0 meter/second.
8. Cardiac Ventricular muscle fibers : 0.5 meter/second .

Role of neurotransmitters in Propagation of action potential –

On reaching the ends of an axon of the nerve fiber, these action potential

trigger the release of *neurotransmitters*, chemical messengers. Neurotransmitters are released at nerve ending terminals and bind to receptors on the surface of the target neuron. These receptors act as on and off switches for the next cell. Each receptor has a distinctly shaped part that exactly matches a particular chemical messenger. A neurotransmitter fits into this region in much the same way as a key fits into an automobile ignition. And when it does, it alters the neuron's outer membrane and triggers a change, such as the contraction of a muscle or increased activity of an enzyme in the cell or generation of action potential in adjacent neuron.

What is the use of action potential?

Action potential is a basic communication system of our body. When a stimulus is sensed by our sensory receptors, action potential is generated. This action potential then transferred to brain or central nervous system through afferent/sensory nerves. Then after reaching in brain the sense is finally experienced. After experiencing appropriate order given by brain is again transported to target organ in the form of action potential through efferent (motor) nerve. After reaching at the target organ concerned action is carried out by that organ. For example in case of muscle, when a impulse or action potential reaches the muscle, then there will be muscle contraction afterwards. If the impulse is not given to that specific muscle then it will relax.

Discussion & observation:

- **Functions of vyana vayu –**

Rasadi dhatu sanvahan – rasadi dhatu sanvahan means circulation of rasa and rakta dhatu i.e. blood circulation. According ayurvedic texts rasa, rakta sanvahan is carried out by hriday and dhamani i.e. heart and the blood vessels. According to modern sciences basic force behind the circulation of blood from heart to all body is contraction of left ventricle. Left ventricle contraction is due contraction of myometrium which occurs due to development of action potential in left ventricle cardiac muscle fibres. Due to development of action potential, there is influx of calcium ions inside the cardiac muscle fibres, which ultimately binds to troponin-s proteins which generates sliding movement in cardiac muscle fibres. This sliding movement in muscle fibre ultimately reduces the length of muscle fibre. Due to reduction in cardiac muscle length, contraction occurs. Thus basic force behind contraction of cardiac ventricles is development and propagation of action potential. Action potential is primarily generated by SA node cells, which then propagated to all over the heart through cardiac conductive system. As this action potential propagates in cardiac compartments, respective compartment contracts, which leads pumping of blood from heart to lungs in case of right ventricle; and pumping of blood in all body in case of left ventricle. Before pumping blood from ventricles there must be filling of blood in ventricles. That is done by opening atrio-ventricular valves and atrial contraction. Atrial contraction is due to propagation of action potential to atrium from SA node. This is only half story. Blood thus circulated from heart to all over the body, but to complete the circulatory cycle, it should be brought back to heart for

pumping again. This is called venous return. Specialised structure of veins makes this possible. Again wall of the vein is made up of smooth muscle. Venous return is dependent on venous tone, venous pressure, muscle pump and respiratory pump. In all these factors causing venous return, basic responsible force is contraction of smooth muscles of venules & veins due to which venous tone and venous pressure is maintained, which ultimately pushes blood towards heart. When skeletal muscles contract, underneath veins get compressed which also facilitate venous return. Contraction of smooth muscles from vein/venules wall & contraction of skeletal muscle is due to development of action potential in respective structures.

Thus the rasa sanvahan action of vyan vayu can be correlated to atrial and ventricle contraction due to development & propagation of “action potential” in cardiac muscle fibres + development of action potential in smooth muscles of venous structures + development of action potential in skeletal muscles.

Prakshepan, akshepan, unmesha, nimesh gati –

Prakshepan (extension), akshepan(flexion) unmesh & nimesh (eye lid opening & closing) all these above mention actions are due to muscle contraction and relaxation. Prakshepan and Akshepan is considered as gatra prakshepan and akshepan i.e. flexion and extension of limbs of the body. This extension and flexion of limbs is very important for locomotion. Extension and flexion of limbs are due to contraction of specific muscles related to that particular limb.

For example - Muscles of both the upper arm and forearm control movement of the forearm. The biceps brachii flex the forearm and work with the supinator of the forearm to rotate it so the palm faces upward. The triceps brachii extend the forearm. The pronator teres and quadratus control pronation, or rotation of the forearm so that the palm faces downward. Likewise other movements are carried out. Similarly the tone of muscle is responsible for the maintaining particular position of the limb. These all flexion and extension movement of limbs are dependent on muscle contraction and relaxation of related muscles. Contraction and relaxation of muscles are dependent on action potential of muscle fibre in addition to action potential of nerve fibers.

Unmesha & nimesh gati means opening & closing of eyelids i.e. blinking of eye. The eyelid movements are mediated mainly by the orbicularis oculi (OO) and the levator palpebrae superioris (LPS) muscles. Closure of eyelid is due to contraction of OO and relaxation of LPS muscle. Opening of eyelid is due to contraction of LPS and relaxation of OO.

According to modern science muscle contractions and relaxation depends on action potential of muscle fibres. “Action potential is defined as a series of electrical changes that occur in the membrane potential when the muscle or nerve is stimulated. Action potential occurs in two phases –

1. Depolarization
2. Repolarization.

Depolarization brings the muscle contraction and repolarization brings the

muscle relaxation. Due to combination of muscle contraction and relaxation various actions like flexion, extension are carried out. All muscles follow this mechanism.

Sveda sravan –

Sveda sravan i.e. sweating, the main source of sweat in body is eccrine and apocrine sweat glands present in dermis of the skin. Sweat is produced in sweat glands but to reach on the top of the skin surface, sweat glands are surrounded by specialized cells called as mesoepithelial cells. These mesoepithelial cells contracts and presses the coiled portion of sweat glands and pumps out the sweat from sweat glands on the surface of skin through tubular ducts. Structure of mesoepithelial cells is similar to muscular cell structure. External stimulation of these cells are carried out by impulse generated by various factors such as temperature, hormones etc. that impulse is action potential. After stimulation from central centers or peripheral receptors, a signal or impulse in the form of action potential is carried towards these mesoepithelial cells and as a result of this impulse / propagation of action potential, mesoepithelial cells contracts.

Asruka sravan is bleeding. Mostly it is possible only after some injury or pathological conditions are present (some physiological conditions are there like menstrual bleeding). In any of these conditions whenever blood vasculature (arterial system, venous system, capillary system) is damaged or broken then there will be flow of blood unless hemostasis is achieved by body. The main driving force for this blood flow is in arterial system cardiac pumping and in venous system it is venous pressure developed due to

various muscular pumps acting on venous vasculature. We have already seen that for cardiac pumping and other muscular pumps are working because of contraction of respective musculature. Action potential is necessary for contraction of these musculature.

• **Characteristic** –

We have already seen characteristic of *vyan vayu* i.e. *Mahajav* = very fast. Propagation of action potential is also very fast.

• **Location** –

Location of *vyan vayu* is whole body. Similarly development & propagation of action potential in nerve cells, muscle cells and some other specialised cells can be seen in all parts of the body.

• **Symptoms and diseases caused by *vyan vayu*** –

Diseases mentioned in *vyan vayu dushti* are *sarvangaj* i.e. occupying whole body.

One of them is *punsatva bhramsha* – it can be reduced sexual interest or reduced fertility i.e. production of male/female gametes. Both these are mostly due to hormonal deficiency of imbalance. Release of hormones in blood is due to action potential acting on respective structure causing contraction of that structure giving rise to pumping action. Due to pumping action of respective structure, hormones are released in blood stream.

Utsaha bhramsha (reduced energy), *bala bhramsha* (reduced energy) – Blood circulation abnormality can cause *utsaha bhramsha* and muscular weakness can

cause *bala bhramsha*. In both conditions contraction of muscle fibres are the main forces behind action. Wherever contracting action is there, action potential is always present.

Shopha can be caused due to defective pumping of blood causing stagnant oedema especially in lower limbs or it can be generalised oedema due to electrolyte imbalance. Abnormality in action potentials can cause defective blood pumping. Electrolyte imbalance can lead to abnormal impulse (action potential) generations or abnormal impulse (action potential) conduction. As we already know for development of action potential, positively charged and negatively charged ions are necessary.

chittotplava (disturbed mental status) – in various mental disorders impulse signalling can be hampered.

kustha (skin diseases), *visarp* (herpes disorders) – these diseases are related to skin. Normal skin defense includes appropriate secretion of sweat. Due to abnormalities in sweating there is weakening of natural skin defence, this can attract many skin diseases.

Romharsha (goosebumps / shivering), *angasuptata* (numbness) – numbness is related to sensory nerve function and its perception at central level. This all depends on generation of impulse (action potential) at sensory receptors then conduction of that impulse to central higher centres for perception. Goosebumps is caused due to contraction of muscle arrector pili. Again for contraction of arrector pili action potential is necessary.

Conclusion:

Characteristic, functions & location of *vyana vayu* are similar with the characteristic, functions and location of action potential.

We have seen a connection between *vyana vayu dushti* & irregular action potential.

Thus we can conclude *vyana vayu* is nothing but development and propagation of action potential. Or we can say generation and conduction of action potential is nothing but the *vyana vayu karma*.

According to this theory we can elaborate on the role of *vata* (specifically *vyana vayu*) in etio-pathogenesis of various diseases.

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