



### UNDERSTANDING THE ACTIONS OF QUALITIES OF VATA IN PERSPECTIVE TO TRANSMISSION OF ACETYLCHOLINE FOR CONTRACTION OF MUSCLE - A CONCEPTUAL STUDY

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#### ABSTRACT

*Vata* is the most important functional component mentioned in Ayurveda. It initiates and control the functions of the *dosa* like *kapha*, *pitta*, the *dhatu* and the *mala*. *Vata* itself is *asanghata*, *anavasthita* and *syambhu* but help the body to perform different physiological activities because of the *guna* (qualities) like *ruksha*, *sita*, *laghu*, *suksma*, *cala*, *visada* and *khara*. The *guna* causes definite karma (actions) like *sosana*, *stambhana*, *langhana*, *vivarana*, *prerana* and *kshalana* respectively. The combined actions of different qualities of *vata* together produces *gati* (movements) in the body. Movements are voluntary and involuntary types caused by contractions of skeletal and smooth muscle fibers present in the body to carry out different physiological functions. Skeletal muscle contraction is produced by transmission of a neurotransmitter called acetylcholine. The transmission occurs from nerve fiber to muscle fiber through neuromuscular junctions. The whole process of transmission is facilitated by development of action potential. *Vata*, its qualities and their actions are substantiated with the conceptual reference transmission of acetylcholine for skeletal muscle contraction.

**Key words:** vata, pancha mahabhuta, action potential, guna, acetylcholine.

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## INTRODUCTION

*Tridosha* is the concept concerned to physiology in Ayurveda. It consists of *vata*, *pitta* and *kapha* which control the functional mechanism of human body. *Vata* is the most important component among the trio and acts in coordination with *kapha* and *pitta*. They maintain the functions of *saptadhatu* (seven structural components) and *mala* (excretory products) present in the body. As any other factors of the body, *vata* is made of *panchamahabhuta* (five proto- elements) *kshiti*, *apa*, *teja*, *vayu* and *akasha*. *Vata* has predominance of *akasa* and *vayu*. Each of the five *mahabhuta* is characterized by some specific *guna* (qualities). The qualities of *akasa* and *vayu maha bhuta* are therefore present in *vata*. The qualities are *ruksha*, *sita*, *laghu*, *suksma*, *chala*, *visada* and *khara*. These qualities cause definite *karma* (action) like *sosana*, *stambhana*, *langhana*, *vivarana*, *prerana* and *kshalana*. The *karma* generates *gati* (movements). The movements are voluntary and involuntary in nature, cause physiological functions by contraction of skeletal and smooth muscles. The voluntary movement like locomotion is caused by contractions of skeletal muscles. Transmission of a neurotransmitter, acetylcholine by series of events from nerve fiber to muscle fiber causes skeletal muscle contraction. The process of transmission of acetylcholine is

aided by development of action potential. In Ayurveda the *vata* which is *swayambhu*, *chala* and *asamghata* is stated to produce all types of voluntary and involuntary movement of the body. *Vata*, its qualities and their actions are substantiated with the conceptual reference transmission of acetylcholine for skeletal muscle contraction.

The concept of *vata*.

The *tridosha* (the functional component of the body) are *vata*, *pitta* and *kapha*. Each component has its own specific functions to perform in the body. It is evident from the root of origin of the three words. The word *vata* is derived from the verbal root “*va*” that means *gati* (movement).<sup>1</sup> While *pitta* is derived from the verbal root *tap* meaning *santapa* (to create heat) and *kapha* is derived from the root *slis* meaning *alingana* (to adhere).<sup>2</sup> *Vata* causes *gati* and bears supremacy over *pitta* and *kapha* as well as control *saptadhatu* (the seven structural components of the body) and *mala* (waste products of the body) which is reflected by its functions in the body.<sup>3</sup> It maintains and regulates the human machinery in proper order and controls body, mind and speech.<sup>4</sup> Some of the general functions of *vata* are *utshaha* (enthusiasm), *ucchasa* (inspiration), *nivasha* (expiration), *chesta* (different types of movement in the body) like *prasarana* (extention), *aksepa* (tremour), *vega pravartan*

Saumi Datta, Arnab Ray. Understanding the actions of qualities of vata in perspective to transmission of acetylcholine for contraction of muscle - a conceptual study. Jour. of Ayurveda & Holistic Medicine, Volume-IX, Issue-IV (July-Aug.2021)

( proper development of urge for elimination of waste products from the body), *dhatu gati* (proper metabolic transformation), and maintain the normal functions of *indriya* (sense faculties).<sup>5</sup> Human body is a *karya dravya* and constitute of *dosa*, *dhatu* and *mala*.<sup>6</sup> Ayurveda states that all *karya dravya* (substances) that are present in the universe are made of *pancha mahabhuta* (five proto-elements).<sup>7</sup> The proto elements are, *kshiti* (earth) *apa* (water), *teja* (fire), *vayu* (air) and *akasha* (space). At the time of creation of the body and its different components, there is *anyonyanupravesh* (intermingling) of these proto-elements in respective and requisite combinations.<sup>8</sup> The protoelements are involved in the development of structural and functional components of the body and also carry out different functions within body by their specific attributes or qualities.<sup>9</sup> Like attributes of *akasa mahabhuta* are *laghu* (light), *mridu* (soft), *slaksna* (smooth), *sukshma* (penetrative) and *vivikta* (individualization of channels of the body).<sup>10</sup> *Vayu mahabhuta*, has attributes like *laghu* (light), *sita* (cold), *ruksha* (dry), *khara*(rough),*visada* (clear), *sukshma* (penetrative) and *spandana* (mobile).<sup>11</sup> Each attribute has a definite function to perform. *Vata*, has predominance of *vayu mahabhuta* and *akasa mahabhuta*. The qualities of these *mahabhuta* are predominant in *vata* such as *rukhsa* (dry), *sita* (cold), *laghu* (light), *sukshma* (penetrative), *chala* (mobile), *vishada* (clear) and *khara* (rough).<sup>12</sup>

The qualities of *vata* and their actions are like *laghu* causes *langhana* (the act of crossing over leaping,), *rukhsa* causes *sosana* (drying up, draining, perching, absorbing), *khara* causes *lekhsana* (coming in contact, scratching, scraping, touching,), *suskma* causes *vivarana* (hole, fissure, cleft, aperture of the body), *visada* causes *kshalana* (wiping off,washing of, cleaning), *sita* causes *stambhana* (arresting, stiffening, checking, stopping ) and *chala* causes *prerana* (setting into motion).<sup>13</sup> *Vata* is capable of performing the different functions in the body because of these qualities and their actions. However, *Vata* itself is characterized as *asanghatam* (invisible without shape and size), *chala* (instable, mobile), *swayambhu* (self existant).<sup>14</sup>

Action potential and its propagation through nerve fibers and muscle fibers.

The human body is made of cells. A non-stimulated cell is called a resting cell with a potential difference between a point inside and outside the cell membrane. The inside of a cell is negatively charged compared to outside and is called resting membrane potential. When the cells are adequately stimulated there is reversal of polarity and development of action potential.<sup>15</sup> Action potential originates in nerve cells and cells of skeletal

Saumi Datta, Arnab Ray. Understanding the actions of qualities of vata in perspective to transmission of acetylcholine for contraction of muscle - a conceptual study. *Jour. of Ayurveda & Holistic Medicine*, Volume-IX, Issue-IV (July-Aug.2021)

muscles, cardiac muscles and smooth muscles.<sup>16</sup> Action potential integrate afferent and efferent reflex for contractions of muscles and glands to produce desired physiological effect like- circulation of blood through blood vessels, cardiac output, respiration, mastication, deglutition, peristalsis, defecation, micturition as well as locomotion.<sup>17</sup> These functions are the results of formation of reflex arc.

A reflex arc consists of afferent and efferent pathway for reflex actions. End organs, afferent path, Central nervous system (CNS), efferent path, junction with the target organs or effector are the components of reflex arc. The end organs receive the sensory stimulus. The stimulus produces a generator potential which develops into action potential in the afferent path formed by the sensory nerve and is carried to CNS.<sup>18</sup> It is from the CNS via the efferent path that the motor nerve carries impulse in the form of action potential to the effector organ. The efferent impulse is transferred to the target organ called the effector through myoneural junction or neuromuscular cleft by producing end plate potential (EPP). The effector muscles show the effect of the reflex action by muscle contraction and causing movement.

Propagation of action potential in the efferent pathway of reflex arc for skeletal muscle contraction.

An efferent (motor) nerve transmit impulse, action potential to the muscle of contraction. When a nerve is adequately stimulated, action potential develops and travel along the axon of the nerve and supplies several muscle fibers by splitting into many terminal branches. The terminal branches of the nerve forms bulb like expansion on reaching close to the muscle fiber. The cell membrane or sarcolemma of the muscle fiber underlying the bulbous expansion invaginates into the cytosol of muscle fiber. The space between the bulb of nerve terminal and sarcolemma is called the neuromuscular cleft or myoneural junction. The acetylcholine receptors are present on the sarcolemma at the cleft. During neuromuscular transmission of action potential, acetylcholine, a neurotransmitter stored in presynaptic vesicles of nerve terminals releases and combines with post synaptic receptors of sarcolemma at the neuromuscular junction. This is achieved when action potential reaches the bulbous expansion of the nerve terminals, it increases the permeability of calcium ions from the extracellular space to cytosol of nerve terminals causing bursting of the vesicles and releasing of acetylcholine. Acetylcholine crosses pre junctional membrane and attaches to post junction receptors after crossing the neuromuscular cleft. The binding of the acetylcholine with the receptors produces

Saumi Datta, Arnab Ray. Understanding the actions of qualities of vata in perspective to transmission of acetylcholine for contraction of muscle - a conceptual study. Jour. of Ayurveda & Holistic Medicine, Volume-IX, Issue-IV (July-Aug.2021)

local current called end plate potential (EPP). EPP when sufficiently highly develops to action potential which propagates over the muscle fiber to cause muscle contraction and voluntary movement is achieved.<sup>19</sup>

#### Discussion

The general functions of *vata* like *utshaha* (enthusiasm), *ucchasa* (inspiration), *nisvasha* (expiration) and *chesta* (different types of movement in the body) like *prasarana* (extention), *aksepa* (tremour), may be expressed under involuntary and voluntary motor actions of the body.

The term *gati* in context to *vata* implies that, it is the originator and executor of all types of movements in the body. Voluntary movement like contraction and relaxation of skeletal muscle and involuntary movement of cardiac muscle, and smooth muscles of viscera. The actions of *vata* are endowed to produce physiological effects. The physiological effect is enabled by reflex mechanism in which an afferent stimulus is converted to motor effect by the involvement of central nervous system. *Vata* is the supreme among the three *dosa*. It initiates, coordinate and control the functions of seven dhatu and mala. Its physiological existence is represented by three

characteristics like *asanghatam* (absence of corporeal form), *vata* has no physical form, quantity or measurement. *Chalatva* (mobility or instability) indicates movement in a direction without obstructions.<sup>20</sup> *Vata* itself is not only mobile but are capable of moving and exerting influence on components like dhatu and mala of the body. *Vata* is *swayambhu* (self-existing). Self-existing can be interpreted as uninterrupted self-propagating that execute different physiological functions.

*Asanghatam, chalatva and swayambhu* help to draw a similarity between *vata* and action potential. An action potential (AP) develops due to sequential change in a membrane potential when a threshold stimulus is applied at a point in nerve or muscle fiber. It starts at the site of stimulus and moves along the membrane at a constant speed and amplitude under standard condition in respect to ion concentration and temperature.<sup>21</sup> It has no shape and size of its own and assumes the shape and size in muscle or nerve fibers where it develops.<sup>22</sup> From the point of stimulus it propagates along the cell membrane in a particular direction with undiminished strength till the end of cell membrane is reached.

23

**Table: 1 Similarities between characteristics of Vata and Action potential**

Sl. No	Characteristics of <i>Vata</i>	Characteristics of Action Potential (AP)
1	<i>Asanghatam</i> (No physical form)	AP takes the shape and size of the of the nerve fiber or muscle fiber where it develops. It does not have

		shape or size of its own.
2	<i>Chalatva</i> (Movement in a direction without obstruction)	AP originates from the point of an adequate stimulus in muscle or nerve fiber and propagates without obstruction along their cell membrane
3	<i>Swayambhu</i> (Self-existing, uninterrupted self-propagating)	Unaltered propagation of AP continues from the point of stimulus to the end of cell membrane at a constant speed and amplitude.

The characteristic similarities between vata and action potential justifies that *vata* like action potential initiates all physiological action of the body.

*Rukhsa, sita, laghu, sukshma, chala, vishada* and *khara* are called the physical qualities of *vata*. Each *guna* is responsible for producing a particular effect. It is known that the quality of a substance is determined by its action, similarly each of the qualities of *vata* causes specific effect or actions.<sup>24</sup> Like 1) *laghu* causes *langhana*, means the act of crossing over, leaping 2) *rukhsa* causes *sosana* means drying up, absorbing, 3) *khara* causes *lekhana* means coming in contact, touching, 4) *suskma* causes *vivarana* meaning hole, fissure, cleft, aperture of the body), 5) *visada* causes *kshalana* means wiping off, washing off, cleaning, 6) *sita* causes *stambhana* means arresting, checking, stopping) and 7) *chala* causes *prerana* meaning setting into motion.<sup>25</sup>

The resultant of all these actions when taken together produces *gati prasarana* (movement like extension). *Prasarana* is a type of *cheta* that involves skeletal muscle contraction for extension of body part. The muscle contraction is caused by transmission of a neurotransmitter, acetylcholine. Acetylcholine is one among the many neurotransmitters present in the body. It is a chemical substance that the motor neurons of the nervous system releases in order to activate skeletal muscles fiber to cause contraction and produce voluntary movements.

Definite action of *rukhsa* and the other six physical qualities of *vata* produces *prasarana*, a type of voluntary movement. The action of each of the qualities of *vata* may be compared with the sequence of actions or events that takes place for transmission of acetylcholine from the nerve cell body to the cell membrane (sarcolemma) of muscle fiber via the neuro muscular junction. So that it finally

Saumi Datta, Arnab Ray. Understanding the actions of qualities of vata in perspective to transmission of acetylcholine for contraction of muscle - a conceptual study. Jour. of Ayurveda & Holistic Medicine, Volume-IX, Issue-IV (July-Aug.2021)

causes muscle contraction and produce voluntary movement like *prasarana*.

Action potential develops in the nerve cell body and reaches the bulbous expansion of nerve terminal, it increases the permeability of nerve terminals for entry of calcium ions from the extracellular fluid to the cytosol of nerve terminal. The increase of permeability for calcium ion may be compared to the action of *vivarana*. *Vivarana* means aperture or gap in the structures of the body which is due to the *suskma* (penetrative) quality of *vata*.

The calcium ions cause bursting of the vesicles containing acetylcholine in the nerve terminals. The bursting of vesicles can be compared to the action of *sosana* which means drying up or withering causing bursting. This action is be due to *ruksha* (dry) quality of *vata*.

The vesicles releases acetylcholine. The action of release may be is compared to *kshalana* that means washing off, wiping off and is due to the *visada* (clearing) quality of *vata*.

Acetylcholine crosses the prejunctional membrane and reaches the receptors at post junctional membrane after crossing the neuro muscular cleft. The act of crossing the neuro muscular cleft may be compared to action of *langhana* that means crossing over, this is attributed to the *laghu* (lightness) quality of *vata*.

Acetylcholine attaches to the post junction membrane. The attachment may be similar to the action *lekhana* which means coming in contact and is due to the *khara* (rough) quality of *vata*.

The binding of the two, acetylcholine to the receptor in the surface of sarcolemma produces local current called end plate potential. The binding is similar to *stambhana* which means to arrest and make immovable. This action occurs due to *sita* (cold) quality of *vata*.

The binding of acetylcholine and the receptor at sarcolemma produces end plate potential. When EPP is sufficiently high it develops into action potential and propagates along the muscle fiber and finally cause muscle contraction. The action of propagation may be compared to the act of *prerana* that means setting into motion and attributed to the *cala* quality of *vata*.

Action potential produces an arc for reflex action. Action potential generated in motor nerve of efferent path way help in transmission of acetylcholine from nerve terminal to sarcolemma and creates endplate potential. Again, action potential is generated by sufficient high end plate potential which propagates along cell membrane and cause muscle contraction producing movements like extension. Similarly, *vata* like action potential produces *gati* (movement) like *prasarana*.

Saumi Datta, Arnab Ray. Understanding the actions of qualities of vata in perspective to transmission of acetylcholine for contraction of muscle - a conceptual study. Jour. of Ayurveda & Holistic Medicine, Volume-IX, Issue-IV (July-Aug.2021)

Events in the transmission of acetylcholine through the neuromuscular junction plays pivot role for contraction followed by muscle extension. Similarly, *prasarana* is the outcome of the combined action of *ruksha* and the other six qualities of *vata*

**Table:2 Comparison between action of qualities of *vata* and events of transmission of acetylcholine by action potential**

Sl. No.	<i>Vata guna</i> (Qualities of <i>vata</i> )	<i>Guna karma</i> (Action of qualities of <i>vata</i> )	Events of transmission of Acetylcholine
1	<i>Sukshma</i> (penetrative)	<i>Vivarana</i> (gap or aperture)	permeability of the cell membrane of the nerve terminals increases for entry of calcium ions
2	<i>Ruksha</i> (dry)	<i>Sosana</i> (Withering and bursting)	the calcium ions burst the vesicles present in the cytoplasm of the nerve terminals.
3	<i>Visada</i> (clearing)	<i>Kshalana</i> (Wiping off)	vesicles release the acetylcholine in prejunctional membrane of nerve terminal
4	<i>Laghu</i> (light)	<i>Langhana</i> (Crossing over)	acetylcholine crosses the neuromuscular cleft to reach the post junctional membrane
5	<i>Khara</i> (rough)	<i>Lekhana</i> (Coming in contact)	acetylcholine comes in contact of the receptors in post junctional membrane of sarcolemma
6	<i>Sita</i> (cold)	<i>Stambhana</i> (Arresting, to stop)	acetylcholine binds with receptors at prejunctional membrane to produce EPP
7	<i>Chala</i> (mobile)	<i>Prerana</i> (Setting into)	sufficiently high EPP develops into AP that propagate along

Saumi Datta, Arnab Ray. Understanding the actions of qualities of vata in perspective to transmission of acetylcholine for contraction of muscle - a conceptual study. Jour. of Ayurveda & Holistic Medicine, Volume-IX, Issue-IV (July-Aug.2021)

		motion)	the sarcolemma to produce muscle contraction.
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## CONCLUSION

In Ayurveda *vata* is considered to be the most important biological factor of the body. This aroused the necessity to understand the actions of *ruksha* and other qualities of *vata* to produce movement in different parts of the body compared to the sequential events that takes place during transmission of acetylcholine for muscle contraction. Further comprehensive studies are necessary to establish this concept.

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