EMBRYOLOGICAL CONCEPT OF KALA SHARIR

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Abstract:

Kala Sharir is a unique subject as well as difficult to understand. *Acharya Sushruta* was the first to explain about *Kala* in "Garbha Vyakran Shareer", 4th chapter of *Sharir Sthana* . *Acharya Sushruta* has defined the *Kala* as a barrier or interface between *Dhatu* and its *Ashaya* by giving examples of pith of wood, *Snayu* and *Jarayu* (amniotic membrane). These are extremely minute structures which are invisible to the naked eye, similar to a cell. They can be perceived by their functions in the body. There are seven *Kala* in our body - *Mamsdhara, Raktadhara, Medodhara, Shleshmadhara, Purishdhara, Pittadhara, Shukradhara kala*. It can be correlated with structures as Membrane, Fascia, Covering etc, in contemporary science. Membranes may be fibrous, serous and mucous in nature. Membrane are formed during the embryonic period. Hence an attempt is made to understand the formation of *Kala* on the basis of Ayurveda and Modern view.

Keywords: *Kala, Kala Sharir*, Membrane, Epithelium

Introduction:

Kala is one of the most difficult topics to understand scientifically. Its importance lies in the fact that its integrity plays a crucial role for normal development from the time of conception to a fetus at term and then for normal growth and development from neonatal stage to adult human form and also keeping the individual healthy throughout the life. This means that it is required for nourishment of all cells of the body, controlled growth of various *Dhatus* (body tissues) and *Ashayas* (organs) and replacement of senile cells.

It is also important for repair in case of damage to specific parts of the body. However, the individual's genome, and its interaction with environment (*ahar, vihar* and *aushadh*) exert continuous influence on maintaining the harmony between *dosha*, *dhatu* and *mala*. Successful interaction results in healthy state while abnormal interaction results in initiation of pathophysiology. Healthy interaction between adjacent cells and later adjacent and/or distant tissues and organs results in formation of healthy cells of various types, tissues, organs and organs-system. *Kala* also need to remain in healthy form to keep the entire body healthy. However, when one or more of them deviates from their normal state the body suffers. Treating its pathology to bring the

body back to normal state is very important, but the successful clinical application depends on the proper understanding of *Kala*.

Sushruta was the first to describe *Kala*. He has explained *Kala* as a barrier or interface between *Dhatu* and its *Ashaya* by giving examples of pith of wood, *Snayu* and *Jarayu* (amniotic membrane). With very brief, but very important description of this basic criterion he gave one criterion separately for each *Dhatu*. The nomenclature is different for each *Dhatu* and not in the usual order of *Rasa* etc. *Dhatus*.*Vagbhat* has then added the embryological development of *Kala*. This is also very brief. So the questions arise as to why *Sushruta* has not given detailed description; or why *Vagbhata*, despite being able to explain the embryological origin of *Kala*, did not add further to the existing knowledge of *Kala*.

DESCRIPTION OF *KALA* IN *SUSHRUTA SAMHITA SHARIR STHANA*:

Kala are seven in number and are the limiting or lining substances inside the *Ashaya* of the *Dhatu*.[i]*AcharyaDalhana* comments on above quotation and says that which does *Dharana Karma* is *Dhatu* like *Rasa*, *Rakta*, *Mamsa*. *Kapha*, *Pitta*, *Purisha* all these in there *PrakrutaAvastha* does *SharirDharana*, hence considered as *Dhatu*. *Ashaya* means the residing place[ii] The covering present in between the *Dhatvashaya*is called as *Kala*. *Ashaya* means an empty space. Whatever the matter stored in that empty space based on that its nomemclature is done. Like *Mutrashaya*, *Amashaya* etc. There are seven *Dhatu*inthe body. *Ashaya*are formed from these *Dhatu* only. *DhatuAshayaMaryada* means that which covers the internal aspect of that particular *Dhatu*. Like endocardium, endometrium, mucosa etc. In the context of *Kala* a simile is explained, when the transverse section of the wooden log is taken, the underlying structures are visible (like phloem, xyloem), similarly when the transverse section of *MamsaDhatu* is taken then the underlying *Rasa RaktadiDravya* is visualised. The different parts of the body are covered by *Snayu*, *Jarayu* and *Shleshma* are called as *Kalabhaga*.[iii] *AcharyaDalhana* comments on the above quotation as *Kala* is *Santata* that which is uniformly present.That which is covered by *Kapha*,from which certain creatures take birth.

Formation of *Kala*[iv]:

AcharyaVagbhatta describes about the formation of *Kala* as

Kala is such redundant matter (*Kleda*) as exists between the *Ashayas* and the *Dhatus* and transformed by the *Swaushmana* into tissues pervaded with fibrous matter, serous and mucinious structures. It is like the heartwood of plants, the residual part of the essential *Dhatu* and is termed *Kala* on account of its structure.

Description of *Kala* in *AshtangaSangraha*:

Kala is such redundant matter (*Kleda*) as exists between the *Ashaya*and the *Dhatu* and transformed by the *Swaushmana* into tissues pervaded with fibrous matter, serous and mucinious structures. It is like the heartwood of plants, the residual part of the essential *Dhatu* and is termed *Kala* on account of its structure.[v]

Indu comments on the formation of *Kala* as, description of *Sapta Kala* is as follows: The *Kleda* which is present between *Raktadi Dhatu* or *Ashaya* or *Srotas* by the action of *Swadhatushma*, gets transformed into

Shleshmadi structure, which is known as *Kala*. Just as the xyloem, phloem essential parts of a wooden log are present inside it in the same manner the *Kala* is present with in the *Dhatu* and *Ashaya*.The *Kleda* transforms the *Dhatusara* into *Kala* and does not follow the *Dhatukrama* i.e. *PoorvaDhatu* into *UttaraDhatu*. It is based on specific functional activity.[vi]

Description of *Kala* in *Bhavaprakash*:

Bhavamishra's opinion about *Kala* is almost same as that of *AcharyaSushruta* and *AcharyaVagbhatta*, the only difference is the specificity made about *Kleda* and *Ushma*. He has deviated from his predecessors by specifically stating that the *Kleda* involved is of *Dhatu* (located in *Ashaya*) and its maturation to form *Kala* is achieved by the action of body heat.[vii]

Modern aspect of *Kala Sharir*:

1. EPITHELIA:

The term epithelium is applied to the layer or layers of cells that cover the body surfaces or line the body cavities that open on to it. Epithelia function generally as selective barriers that facilitate, or inhibit, the passage of substances across the surfaces they cover. In addition, they may: protect underlying tissues against dehydration, chemical or mechanical damage; synthesize and secrete products into the spaces that they line; and function as sensory surfaces. In this respect, many features of nervous tissue can be regarded as those of a modified epithelium and the two tissue types share an origin in embryonic ectoderm. Epithelia are predominantly cellular and the little extracellular material they possess is limited to the basal lamina. Intercellular junctions, which are usually numerous, maintain the mechanical cohesiveness of the epithelial sheet and contribute to its barrier functions. A series of three intercellular junctions forms a typical epithelial junctional complex: in sequence from the apical surface, this consists of a tight junctional zone, an adherent (intermediate) junctional zone and a region of discrete desmosome junctions. Epithelial cell shape is most usually polygonal and partly determined by cytoplasmic features such as secretory granules. The basal surface of an epithelium lies in contact with a thin layer of filamentous protein and proteoglycan termed thebasal lamina, which is synthesized predominantly by the epithelial cells.Epithelia can usually regenerate when injured. Indeed, many epithelia continuously replace their cells to offset cell loss caused by mechanical abrasion. Blood vessels do not penetrate typical epithelia and so cells receive their nutrition by diffusion from capillaries of neighbouring connective tissues. This arrangement limits the maximum thickness of living epithelial cell layers. Epithelia, together with their supporting connective tissue, can often be removed surgically as one layer, which is collectively known as a membrane. Where the surface of a membrane is moistened by mucous glands it is called a mucous membrane or mucosa, whereas a similar layer of connective tissue covered by mesothelium is called a serous membrane or serosa.

CLASSIFICATION:

Epithelia can be classified as unilaminar (single-layered, simple), in which a single layer of cells rests on a basal lamina; or multilaminar, in which the layer is more than one cell thick. The latter includes: stratified

squamous epithelia, in which flattened superficial cells are constantly replaced from the basal layers; urothelium (transitional epithelium), which serves special functions in the urinary tract; and other multilaminar epithelia such as those lining the largest ducts of some exocrine glands, which, like urothelium, are replaced only very slowly under normal conditions. Seminiferous epithelium is a specialized multilaminar tissue found only in the testis.

2. CONNECTIVE AND SUPPORTING TISSUES:

The connective tissues are defined as those composed predominantly of intercellular material, the extracellular matrix, which is secreted mainly by the connective tissue cells. The cells are therefore usually widely separated by their matrix, which is composed of fibrous proteins and a relatively amorphous ground substance. Many of the special properties of connective tissues are determined by the composition of the matrix, and their classification is also largely based on its characteristics. In some types of connective tissue, the cellular component eventually dominates the tissue, even though the tissue originally has a high matrix : cell ratio, e.g. adipose tissue. Connective tissues are derived from embryonic mesenchyme or, in the head region, largely from neural crest. Connective tissues have several essential roles in the body. These may be subdivided into structural roles, which largely reflect the special mechanical properties of the extracellular matrix components, and defensive roles, in which the cellular component has the dominant role. Connective tissues often also play important trophic and morphogenetic parts in organizing and influencing the growth and differentiation of surrounding tissues, e.g. in the development of glands from an epithelial surface. Structural connective tissues are divided into ordinary (or general) types, which are widely distributed, and special skeletal types, i.e. cartilage and bone. A third type, haemo- lymphoid tissues, consists of peripheral blood cells, lymphoid tissues and their precursors; They are often grouped with other types of connective tissue because of their similar mesenchymal origins and because the various defensive cells of the blood also form part of a typical connective tissue cell population. They reach connective tissues via the blood circulation and migrate into them through the endothelial walls of vessels.

CLASSIFICATION OF CONNECTIVE TISSUES:

Connective and supporting tissues differ considerably in appearance, consistency and composition in different regions. These differences reflect local functional requirements and are related to the predominance of the cell types; the concentration, arrangement and types of fibre; and the characteristics of the interfibrillar matrix. On these bases, general connective tissues can be classified into irregular and regular types, according to the degree of orientation of their fibrous components.

3. MUCOSA (MUCOUS MEMBRANE):

A mucosa or mucous membrane lines many internal hollow organs in which the inner surfaces are moistened by mucus, such as the intestines, conducting portions of the airway, and the genital and urinary tracts. A mucosa proper consists of an epithelial lining, which may have the ducts of mucosal, submucosal or extrinsic glands opening on to its surface, an underlying loose connective tissue, the lamina propria, and a thin layer of

smooth muscle, the muscularis mucosae. This last layer either may be absent from some mucosae, or may be replaced by a layer of elastic fibres. The term mucous membrane reflects the fact that these tissues can all be peeled away as a sheet or membrane from underlying structures; the plane of separation occurs along the muscularis mucosae. Submucosa is a layer of supporting connective tissue that usually lies below the muscularis mucosae. It may contain mucous or seromucous submucosal glands. Inflammation of the viscera involves, primarily, the connective tissues of the submucosa and lamina propria, and is characterised by dilated vessels, oedema, and accumulations of extravasated immune defence cells. Most mucosae are also supported by one or more layers of smooth muscle, the muscularis externa. Contraction of this muscle may constrict the mucosal lumen (e.g. in the airway) or, where there are two or more muscle layers orientated in opposing directions (e.g. in the intestines), cause peristaltic movement of the viscus and the contents of its lumen. The outer surface of the muscle may be covered by a serosa or, where the structure is retroperitoneal or passes through the pelvic floor, by a connective tissue adventitia.

4. SEROSA (SEROUS MEMBRANE):

Serosa consists of a single layer of squamous mesothelial cells, expressing keratin intermediate filaments, supported by an underlying layer of loose connective tissue that contains numerous blood and lymphatic vessels. Serosa lines the pleural, pericardial and peritoneal cavities, and covers the external surfaces of organs lying within those cavities and, in the abdomen, the mesenteries that envelop them. A potential space, filled with a small amount of protein-containing serous fluid – largely an exudate of interstitial fluid – exists between the outer parietal and the inner visceral layers of the serosa.

5. FASCIA:

Fascia is a generic term applied to sheaths, sheets or other dissectible masses of connective tissue that are large enough to be visible to the unaided eye. Tela subcutanea, hypodermis and subcutaneous tissue are the recommended synonymous terms that replace superficial fascia. Deeper-lying condensations of connective tissue have been defined according to their location, e.g. investing muscles (fascia musculorum) or viscera (fascia visceralis). Loosely packed connective tissue surrounds peripheral nerves, blood and lymph vessels as they pass between other structures, often linking them together as neurovascular bundles. Some large vessels, e.g. the common carotid and femoral arteries, are invested by a dense connective tissue sheath that may be functionally significant, aiding venous return by approximating large veins to pulsating arteries.[viii]

Derivatives of Germ Layers [ix]:

1. ECTODREM:
    1. Lining Epithelia of:
        i. Skin
        ii. Lips, cheeks, gums, part of floor of mouth
        iii. Parts of palate, nasal cavities and paranasal sinuses
        iv. Lower part of anal canal

v. Terminal part of male urethera

vi. Labia majora and outer surface of labia minora

vii. Epithelium of cornea, conjuctiva, ciliary body, iris

viii. Outer layer of tympanic membrane and membranous labyrinth E

2. Glands – Exocrine – Sweat glands, sebaceous glands Parotid, Mammary and lacrimal

3. Other derivatives:

i. Hair

ii. Nails

iii. Enamel of teeth

iv. Lens of eye; musculature of iris

v. Nervous system

2. MESODERM:

All connective tissue including loose areolar tissue, superficial and deep fascia, ligaments, tendons, aponeuroses and the dermis of the skin.

• Specialised connective tissue like adipose tissue, reticular tissue, cartilage and bone

• All muscles – smooth, striated and cardiac – except the musculature of iris.

• Heart, all blood vessels and lymphatics, blood cells.

• Kidneys, ureters, trigone of bladder, parts of male and female urethera, inner prostatic glands.

• Ovary, uterus, uterine tubes, upper part of vagina.

• Testis, epidydimis, ductus deferens, seminal vesicle ejaculatory duct.

• Lining mesothelium of pleural, pericardial and peritoneal cavities; and of tunica vaginalis. • Lining mesothelium of bursae and joints.

• Substance of cornea, sclera, choroid, ciliary body and iris.

3.ENDODERM:

1. Lining Epithelia of :

i. Part of mouth, palate, tongue, tonsil, pharynx.

ii. Oesophagus, stomach, small and large intestines, anal canal (upper part)

iii. Pharyngo – tympanic tube, middle ear, inner layer of tympanic membrane, mastoid antrum, air cells.

iv. Respiratory tract

v. Gall bladder, extrahepatic duct system, pancreatic ducts

vi. Urinary bladder except trigone

vii. Female urethera except part of its posterior wall

viii. Male urethera except part of posterior wall of prostatic part

ix. Greater part of vagina, vestibule and inner surface of labia minora

2. Glands:

i. Endocrine: Thyroid, parathyroid, thymus, islets of Langerhans

ii. Exocrine: Liver, pancreas, glands in G.I.T., prostatic glands and its female homologues

DISCUSSION:

The term "*Kala*" denotes a tiny piece, particularly a sixteenth part, of anything, as well as any single part or portion of a total. (Rigveda 7,47,17). This shows that *Kala* are minute structures in the body which does the *Dharana Karma* based on their location. They are classified as *Snayu-Pratichhanna, Jarayu –Santata* and *Shleshma-Veshtit*, which correspond to the fibrous, serous and mucous membranes, respectively. The word tendinous sheath is used for *Snayu-pratichhanna* in certain books. Tendons are fibrous parts of muscles found throughout the body. The fibrous membrane is a particular kind of membrane that covers various bodily tissues in several places. The deep fascia is a layer of thick, fibrous connective tissue that separates groups of muscles into fascial compartments and covers individual muscles. This fascia is quite similar to the *Mamsadhara Kala* mentioned in our classics. As a result, the phrase *Snayu-pratichhanna* used in reference to *Kala* should be interpreted as fibrous membrane. Similarly in case of *Jarayu-Santata, Jarayu* is the chorionic membrane; it is actually a component of embryonic life that is descended from the chorion. Chorion takes part in the formation of placenta. Amnion is another tissue which is generated from extraembryonic mesoderm and amniogenic cells. It creates the amniotic membrane that can be associated with *Jarayu*. As *Jarayu* is said to be one of the form of *Kala*, it is present in post embryonic life also. Serous membrane is a similar type of membrane that is found in the body and secretes a little amount of fluid to reduce friction. Serous membranes are the internal coverings mostly associated with body cavities. As a result, the name *Jarayu* in *Kala Sharir* should be associated with the serous membrane rather than the chorionic membrane. The other is shlemana-Veshtita, although *Shleshma* is associated to *Kapha*, it is a subtype of *Kapha* that is responsible for lubrication. The *Shleshmadhara Kala*, which is located in all synovial joints,has a primary role of lubricating. The mucous membrane described by modern science is similar to the *Shlemana-Veshtita* type of *Kala* described by our Acharya, because the functions are mostly similar. In contemporary terms, the development of Kala can be

explained by the production of tissue. In the Material & Method section, information about bodily tissues and their derivatives from diverse epithelia is gathered. The Kala mentioned in Ayurveda literature is similar to the Epithelia described in embryology. Previous writers have already compared *Sapta Kala* to contemporary anatomical structures. The following table provides an overview of these structures by comparing them to their embryological development.

Table: *Sapta Kala* and Modern Anatomy Correlation

S.N	. *Kala*	Anatomical Structures	Embryological Derivation
1	*Mamsadhara Kala*	Deep fascia, Intermuscular septa	Mesenchyme
2	*Raktadhara Kala*	Endothelial lining of the blood vessels and sinuses in the liver & spleen	Endothelium of Mesoderm
3	*Medodhara Kala*	Subcutaneous fascia, Omentum, mesentery	Mesothelium of Mesoderm
4	*Shleshmadhara Kala*	Synovial membrane	Mesothelium of Mesoderm
5	*Purishdhara Kala*	Mucous membrane of large intestine	Epithelium of Endoderm
6	*Pittadhara Kala*	Mucous membrane of stomach & small intestine	Epithelium of Endoderm
7	*Shukradhara Kala*	Mucous membrane of testes, semeniferous tubules, Epidedymus, vas deferens	Epithelium of Mesoderm

Conclusion:

The *Sapta Kala* can be compared to the bodily membranes. The Formation of Kala is caused by a liquid component that is present between body tissue and the hollow space. The liquid component may be *Kleda*, or essence of *Dhatus*. The main factor in the development of *Kala* is *Kapha* or the essence of *Kapha* and based on the influence of *Vata* and *Pitta*, it is classified as *Snayu-pratichhanna*, *Jarayu-santata*, and *Shleshma-Veshtita*. Kala can be classified as epithelium, mesothelium or endothelium coverings of predominantly mesodermal and endodermal origin.

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