



ANATOMICAL ASPECT OF KALA

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ABSTRACT-

The word *Kala* has been used in various meanings in Sanskrit, Vedic and Ayurvedic literature e.g. art, skill, ingenuity, a small part of anything, division of time, interest on a capital etc. Sushrut was the first to describe *Kala Sharira* under *Sharir Sankhya Vyakarana Adhyay* of *Shushruta Samhita*; however, the description is in very much brevity. He has explained seven types of *Kalas* along with their short, but very significant definition. *Kala* is explained as an interface between *Dhatu* and *Ashaya* that provides a barrier between the two. *Kalas* are covering of layer of *Shleshma* (mucosa) or like sheets of a *Snayu* (membranous structure), or amniotic membrane (mucus). This means that *Kalas* are pliable structures. All the three structures (examples) may or may not necessarily be present in each and every *Kala*, even one or two of the above-mentioned structures may be found existing in the *Kalas*.

KEYWORDS-*Ayurveda, Concept Of Kala, Kalasharir, Modern Anatomy*

INTRODUCTION-

Kala is described in *Garbhavyakaran* chapter of *Sharirasthan* in *Sushrut Samhita*.

गर्भावकान्तिशारीरान्तरमवकान्तस्य गर्भस्य व्याकरणार्हत्वाद्गर्भव्याकरणं वक्तुं युज्यत

इत्याह-अथेत्यादि । गर्भव्याकरणं गर्भविवरणमित्यर्थः ।

(सु. शा. 4/1-2 पद डल्हण)

In other words, the description is in the chapter related to embryogenesis. Some of the points described in embryology include organogenesis by induction through interaction between various tissues, organs and organ-system, and specific *Bija*, *Bijabhaga* and *Bijabhagavaya* mentioned for various anatomical and functional abnormalities, etc. So it is quite intriguing that at one end of the spectrum such topics are described in much detail while at another end, the features of body tissues and organs in terms of basic anatomy are missing. Maximal books of ancient libraries were destroyed by humans, but presently available ancient texts such as *Vriksha Ayurveda*, *Hasti Ayurveda*, *Ashwa Ayurveda* etc. throw a lot of light on the kind of knowledge existed at that time. Genetic manipulation of plants such as changing the color of *japa* flower, treatment of mammalian species and genetic manipulation to get the desired gender of mammalian young are some of the examples. So the disturbing question really remains why basic anatomy is missing.

Review-Based appraisal of *Kala* -

Only few views are available about what structure the *Kala* is.

Prof. Dr. D.G. Thatte has explained that the anatomical description of seven *Kala* is mostly of inner linings of the body cavities and not about outer serous, parietal or visceral covering having *Mamsadhara Kala*. Some are endothelial linings whereas some are facial sheaths between a particular tissue like *Mamsa Dhatu*. Many of these *Kala* give origin to muscle tissue like cremasteric fascia to cremasteric muscle or thoracolumbar fascia to muscles of posterior abdominal wall¹.

Acharya Sudarshana Shastri has stated that as per description found in *Sushrut Samhita* formation of all *Kalas* originally occurs from three primordial structures viz snayu praticchhanna kala (fibrous membrane), jarayusantata kala (serous membrane) and *Shleshma veshtita Kala* (mucus membrane)².

Prof. Dr.Sumati S. Khot has explained *kala* in an article titled “Basic Concept of *Kala* (Membrane)” in the following manner. *Kalas* are minute particles present in the body which are concerned with the process of formation of the *Dhatus* and *Malas*. One of the meanings of *Kala* is quality and biologically active quality of one *Dhatu* giving birth to another type is termed as *Kala* by acharyas. These are membranes with special functions. We can correlate the *Kalas* structurally with fascia, septum, fibrous membrane; mucous membrane or serous membrane but functionally, we can correlate them with cells or formative elements³.

Considering the ancient literatures and some opinions of modern *Ayurvedic* views there is a need to understand the basic types of tissues and tissue membrane.

Modern views about *Kala*^{4,5,6} -

Basic types of tissues and tissue membrane

To understand *Kala* in relation to modern anatomy one need to start with basic definition. *Kala* is a barrier spreading like a sheet, covering *Dhatu* and thus separating it from *Ashaya*; in other words, *Kala* separates two different types of tissues. Thus it would be appropriate to start with the understanding of tissue membrane, which is thin sheets of tissues that covers body cavities, organs within body cavities and lastly entire body also. A tissue is a group of cells having similar structure and function. These cells work together as a single unit. Epithelial, connective, muscular and nervous tissues are primary types of tissue (Figure 2.1).

Epithelial tissues: They cover body cavities, hollow organs and entire surface of the body. They are major components of the glands. They are composed of epithelial tissue and connective tissue to which it is attached. Their functions include protection, secretion, absorption, excretion, filtration, diffusion, and sensory reception. Epithelial cells may be squamous, cuboidal, or columnar in shape and may be arranged in single or multiple layers. Majority of connective tissues have blood supply. Epithelia layer of skin, cornea, lens and cartilages are some of the avascular connective tissues. Three types of epithelial tissues are mucus membranes (also called mucosae), serous membranes and cutaneous membrane (skin).

- Mucosae line the body cavities that open outside viz GIT, respiratory, urinary and reproductive systems. Mucus membranes are involved mainly in the functions of various types of secretion and absorption.
- Serous membranes: The body cavities that do not open outside are lined by this tissue. Also, the organs lying within such cavities are covered by this. A thin layer of serous fluid

secreted by the epithelium covers the serous membrane. Serous fluid lubricates the membrane and reduces friction and abrasion when the adjacent organs in closed cavities move against each other or the cavity wall. Pleura, pericardium and peritoneum are the examples of serous membranes.

Connective tissues: As the name implies, they bind body cells, organs and structures of the body together, form a framework and support the organs and body as a whole. Their functions include providing protection, support, and integration of all parts of the body. They also store fat, transport substances, provide protection against diseases and help repair tissue damage. Blood and lymph are liquid connective tissues. Synovial membranes and meninges are also the examples of connective tissues. Synovial membrane is a soft tissue found between joint capsule and joint cavity of synovial joints. It secretes synovial fluid, which lubricates the joint allowing smooth movements of the joint. The meninges are composed of three layers viz dura mater, arachnoid mater and pia mater. It covers the central nervous system. Dura mater is attached to internal surface of skull bones and bones of vertebral canal. Wharton jelly is a gelatinous substance around the umbilical cord is the example of mucus connective tissue. It is also found in pulp of young teeth. It is a rich source of stem cells.

Muscle tissue: Contain excitable cells that expand and contract in response to stimulation, and produce movement e.g. opening of an orifice, movement of limbs etc. This tissue is richly supplied with blood vessels. Muscle cells are arranged in bundles or layers. Connective tissue surrounds these bundles and layers.

Nervous tissue: Coordinates and controls many body functions.

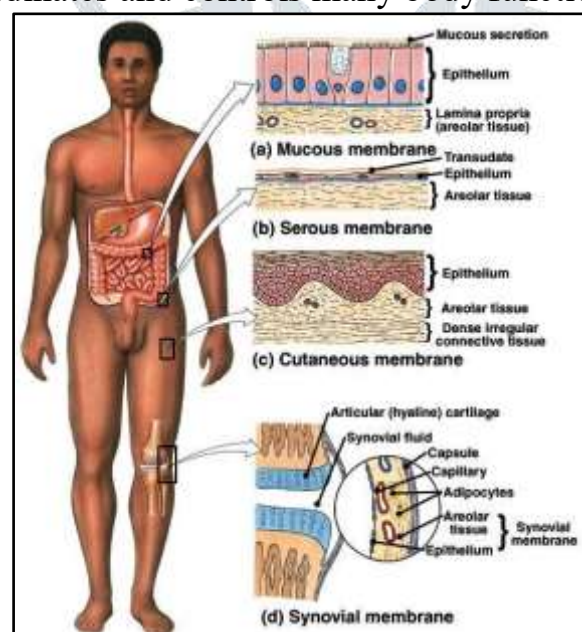


Figure 1: Different types of membranes

Dhatus described in *Ayurveda* represent major tissues described in modern anatomy. Analysis of this description and description of *Kala* reveals two major differences. First is in *Ayurvedic* classics it is difficult to correlate any structure with nervous tissue. Second, is the difference that *Ayurveda* has considered *Shukra* (entire hormonal orchestra related to reproductive system i.e. hypothalamus-pituitary-gonadal axis) as one of the *Dhatus* while modern anatomy does not consider it as any specific tissue or membrane. *Rasa* and *Rakta* get classified in liquid connective tissues. *Mamsa* may be considered under muscle tissue. *Kandara* and *Snayu* may be considered as dense regular connective tissue. *Meda* may fall under the classification of connective tissue; loose connective tissue, to be very precise. *Asthi* may be considered cartilage and bone tissue while some part of it may come under dense irregular connective tissue. *Meda* and *Asthi* both are types of mature connective tissue. *Shukra Dhatu* (7th *Dhatu*) may be considered as hypothalamus-pituitary-gonadal axis. Semen in adult male is the proof that *Shukra Dhatu* is normally functioning, while in adult female menstruation is the proof of normal functioning of 7th *Dhatu*. Both of these are not considered as any type of tissues in modern anatomy. However, their final pathway of exit from body is lined by epithelium. This is also a continuous sheet of cells and forms a lining in excretory pathway as explained earlier to act as a barrier to transfer excretory matter (or seminal fluid) out of the body.

Based on these understanding various *kalas* can be explained as given below.

***Mamsadhara Kala*:** It contains branches of *Sira* and *Dhamani* (blood vessels) and *Snayu* (Figure 2). This means that this is a vascular membrane. It supports *Mamsa*. The term is used in polysemantic manner. It could be muscle, tendon or ligament, so *Mamsadhara* could be epimysium. This generally extends beyond the fleshy part of the muscle, forming a tendon (a thick rope-like structure) or aponeurosis (a sheet-like structure)(Figure 3).

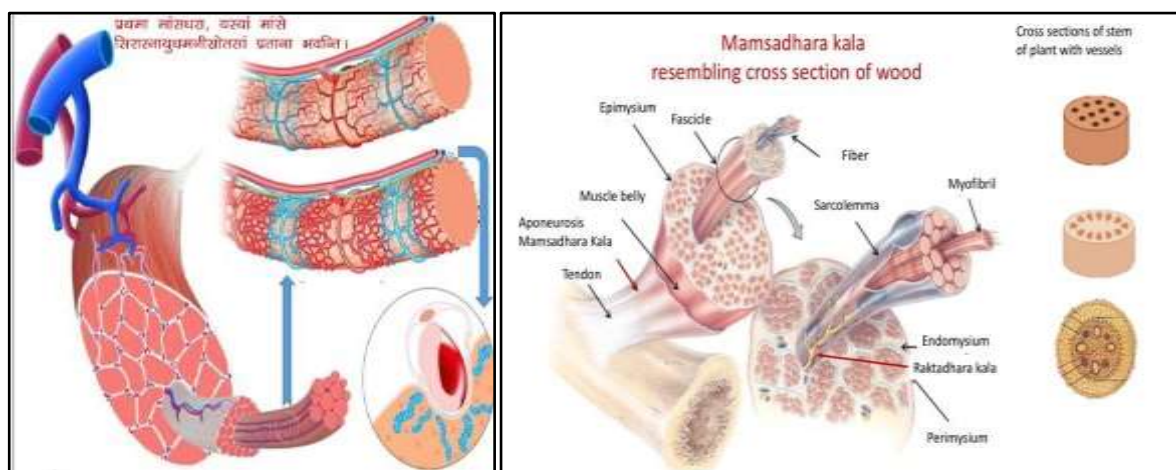
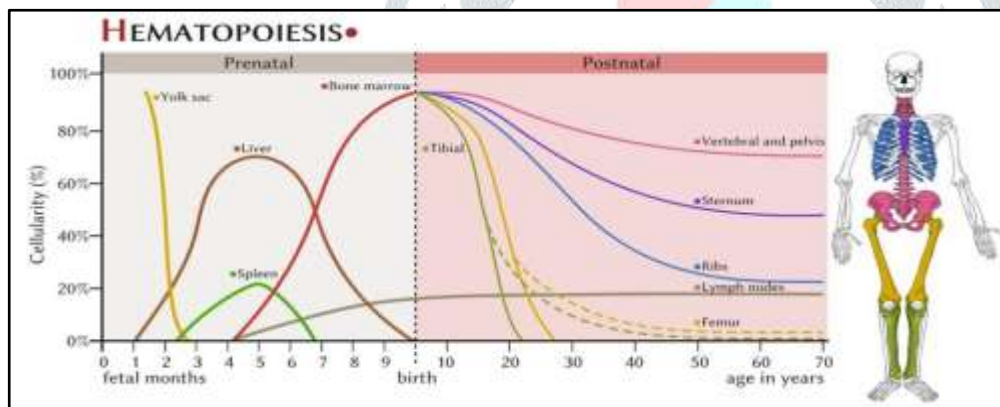


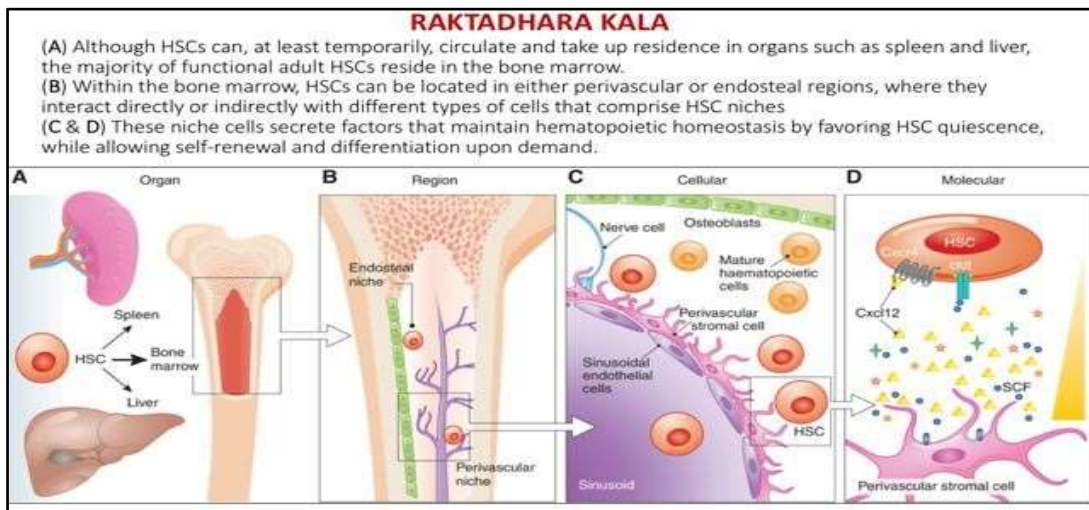
Figure 2 (left): *Mamsadhara Kala* showing branches of blood vessels

Figure 3 (Right): *Mamsadhara Kala* (aponeurosis)

***Raktadhara Kala*:** It supports blood within it. Blood is said to form in *Sira*, liver and spleen. Haematopoiesis in the beginning of embryonic life is extraembryonic in blood islets of yolk sac. Shortly thereafter the hematopoietic stem cells (HSCs) migrate to foetal liver, spleen and then finally to bone marrow (Figure 4). In the middle age about 30 years of age haematopoiesis is largely in small bones and in sternum as well as pelvis. Here in these bones the endosteum (Figure 5) forms the boundary between bone and HSCs. In *Sira*, blood is kept enclosed in blood vessel. So the endothelium could be considered as *Kala* in adults. Extramedullary (outside of bone marrow) haematopoiesis as a rule occurs in foetal life. However, it can occur in liver and spleen after birth as normal immune response to pathogens for production of antigen-presenting cells and phagocytes. Also, when microenvironment in bone marrow changes due to any pathology such as myelofibrosis then liver and spleen can revert back to their foetal function of haematopoiesis. HSCs are found in stroma of organs involved in haematopoiesis. So, the stroma (a kind of reticular connective tissue) also may be considered as *Raktadhara Kala*.



(Figure 4): Normal haematopoiesis in humans at different ages of life.



(Figure 5): *Raktadhara Kala* (endosteum) in relation to haematopoiesis, especially to bones

Medodhara kala: This kala could be interpreted as omental sacs in abdomen. In small bones this kala covers red bone marrow. The primary functions of bone marrow are of haematopoiesis (from HSCs), and formation of non-blood cell components from mesenchymal stem cells. Non-blood cell components include stromal cells (that support HSCs), fibrous connective tissue (found in tendons and ligaments), fat, cartilages and bone cells, and to store fat. Bone marrow is highly vascular for obvious reason of providing blood cells to the body and removing degenerated blood cells from the body. Thus, structure of bone marrow has two different sections viz vascular and non-vascular. Up to adolescence the majority of bone marrow is red, which is slowly replaced by yellow bone marrow. Yellow bone marrow mainly contains fat cells with very little blood supply and has inactive hematopoietic tissue. If the need arise this yellow bone marrow can resume the function of haematopoiesis. The marrow cavity is lined by a thin connective tissue called endosteum.

Thus omental sac (Figures 6 and 7) and endosteum (Figures 8) may be considered as *Medodhara Kala*. Quite interestingly *Vagbhat* in *Ashtangsamgraha* has stated the function of *Medodhara Kala* as formation of blood. Another significant statement made by him is that the same *Kala* in skull bone cause genesis of *Mastulunga* (brain)(Figures 9). This means that this *Kala* in skull may be called as meninges.

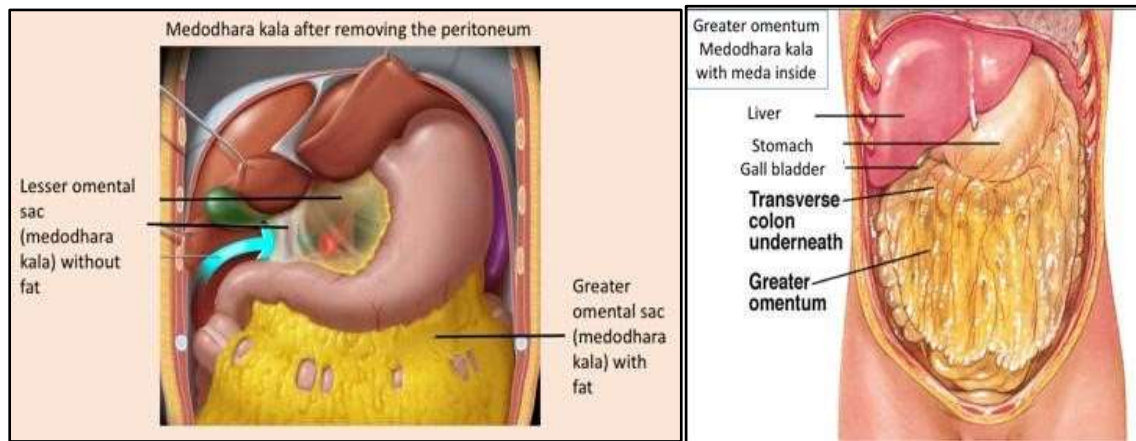
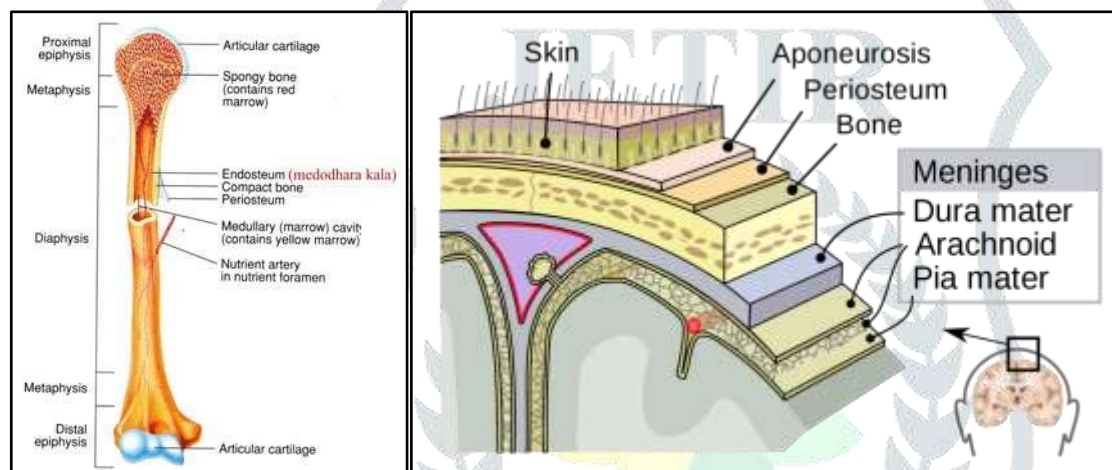


Figure 6 (left): Lesser omentum and greater omentum (after removal of peritoneal layer)

Figure 7 (right): After removal of medodhara kala (omental sac) the greater omentum shows blood vessels



Figures 8(left): *Medodhara Kala* (with red bone and yellow bone marrow)

Figures 9(right): Meninges (with subarachnoid blood vessels) considered as either *Medodhara Kala* or *Shleshmadhara Kala*

Shleshmadhara Kala: This *Kala* clearly is synovial membrane. *Sushrut* and both *Vagbhat* are of same opinion in this regard. However, *Arunadatta* in *Ashtangahridaya* has also considered covering of brain and in bones also as *Shleshmadhara Kala*. So meninges (figure 9) also might be considered here. Since synovial membrane occurs as inner surface of synovial joints and tendon sheath location of bones may not be a true deviation.

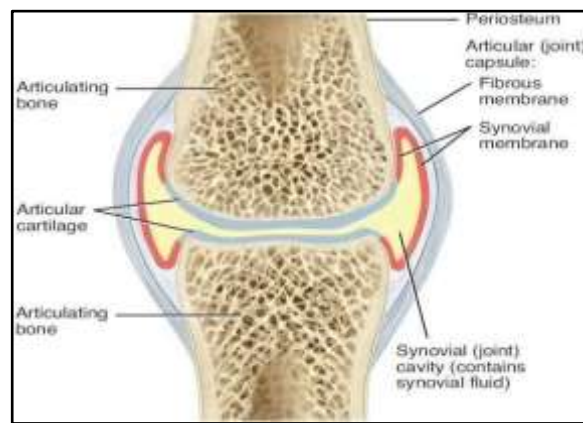
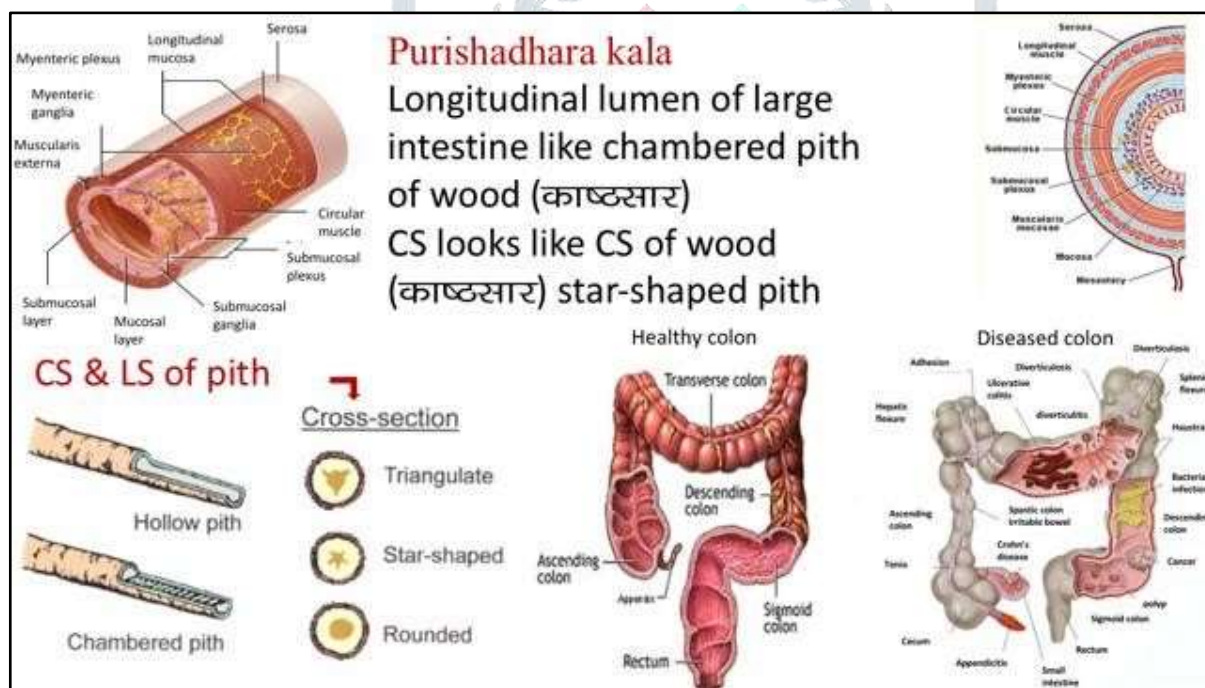


Figure 10: *Shlshmadhara Kala* in synovial joint

Purishadhara Kala: This could be mucosa of large colon and rectum (figure 11). Its function is to separate waste products from nutrients, water, electrolytes etc. However, entire small intestine (from pyloric end of stomach to ileocecal valve) and large intestine contain it but due to specific function of separation of waste products it is considered to be located in large colon along with cecum and rectum.



(Figure 11): *Purishadhara Kala* (mucosa of large colon, sigmoid colon and rectum)

Pittadhara Kala: This *Kala* forcefully retains the food (partly digested) which is heading towards *Pakwashaya*, digests it and desiccates by the action of (*Teja* of) *Pitta* and then propels it further. This description is sufficient to understand that this could be mucosa of duodenum, jejunum and ileum (figures 3.1.11 to 3.1.13). Two types of movement are observed in small intestine viz segmentation (bidirectional movement i.e. simultaneous

forward and backward movement by cutting method) and propulsion in unidirectional i.e. forward movement. Forceful retention appears to be segmentation, which mechanically aids in digestion by way of cutting and mixing.

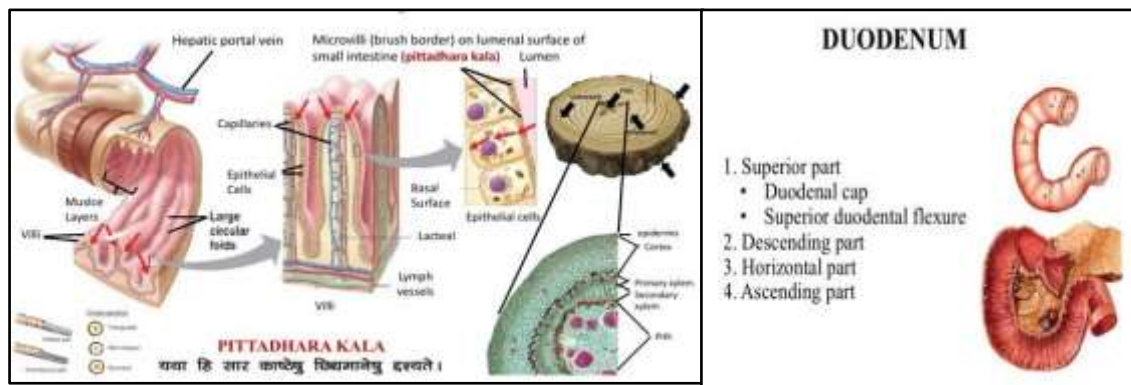
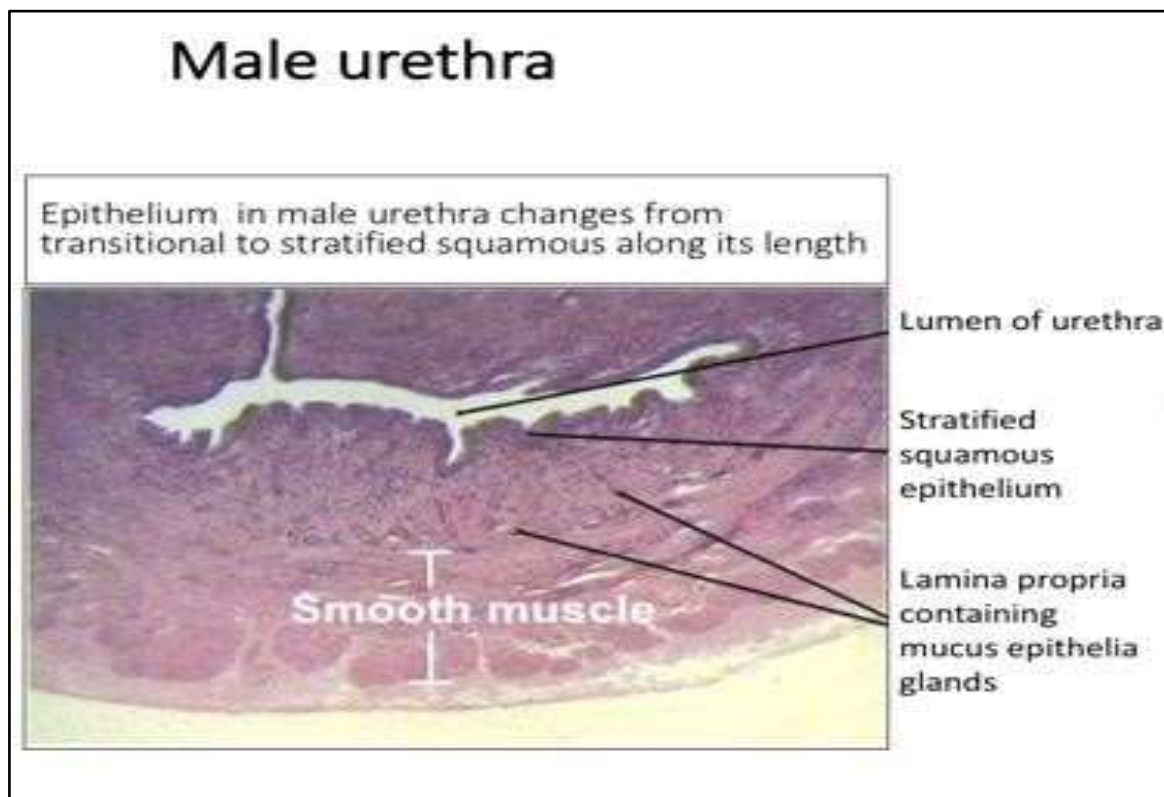


Figure 12 (left): *Pittadhara Kala* where the lumen on dissection looks like longitudinal section of a stem of plant as shown in left lower corner

Figure 13 (right): The image shows different parts of duodenum with lumen in both the ends resembling cross section of a stem of a plant

Shukradhara Kala : The description exclusively relates to male as it describes ejaculation of *Shukra* (semen). However, *Shukra* is stated to be spread throughout the body. Ejaculation is controlled by hypothalamus-pituitary-testicular axis. So, the spread of *Shukra* in the form of reproductive system hormones can be understood. Ejaculation is a local movement. The sperm are released from testes. Seminal fluid, prostatic fluid and secretions of bulbourethral gland along with spermatozoa make the semen. As per description of its location this could be epithelium of penile urethra. However, as per the definition if the barrier between *Ashaya* and *Dhatu* is *Kala* then *Ashaya* of sperm is epididymis (where it is stored) so lining of seminiferous tubules till the prepuce should be considered as *Shukradhara kala*.



Shukradhara kala

Figure 15: *Shukradhara Kala*. Though the classical reference is for *Shukradhara Kala* in male only, but it has to be represented in female by corresponding part. So the location of seventh *Kala* in female is also shown here.

DISCUSSION-

Understanding of *Kala* in perspective of modern anatomy -

With much brevity in the description, it is not easy to understand the anatomy of *Kala*. The available description in ancient classical texts reflects not true anatomy, but physiologic anatomy. Whatever functions of *Kala* are described very specific and that quite significantly contribute in understanding anatomy of *Kala* and reaching somewhere close to what ancient might have meant by *Kala*.

Functional Anatomy of *Kala*

- The description of *Kala* very minimal, but by no means very vague considering the time of evolution of *Ayurveda* and facilities available in those times. Help of modern anatomy and physiology makes the subject matter easier; and then by analyzing the description of physiologic anatomy following functions of *Kala* emerge.
- Providing support to the *Ashayas* (organs)
- Providing barrier between *Dhatus* and their *Ashayas* and thereby providing protection to the *Ashayas* as is found with *Kala* in *Ama-Pakwashaya*. For example, digestive system digests the muscles in mutton, but does not digest the muscles of gastrointestinal tract.

- Resemblance of *Pittadhara* and *Purishadhara Kala* with star-shaped lumen means that the surface area of *Kalas* increases and that enables them to function more efficiently in relation to digestion, absorption and production of waste (by absorbing the nutrients, water and electrolytes).
- Barrier function is extended to brain as well as foetus also.
- Simile to pith of plant (on section) means that *Kala* provides nutrition (including water and electrolytes) to the tissue where it is located
- Simile for oozing from *Kala* on injury like oozing from the incision on the lactiferous plant also means that *Kala* helps in repairing the tissue damage.
- Meninges (*Medodhara Kala*) protect the brain and spinal cord from mechanical injury, provide blood supply to the brain and skull and space for movement of cerebrospinal fluid.
- Digestion of food e.g. *Pittadhara Kala*
- Absorption (of nutrient from the gastrointestinal tract) after digestion of food
- Propulsion of chyme in *Pittadhara* and *Purishadhara Kalas*
- Providing nourishment to the relevant part of the body or whole body e.g. *Pittadhara Kala* provides nutrition to the body after absorption of nutrients, water and electrolytes etc.
- Providing strength (and cushion-effect) to adjacent structure such as *Shleshmadhara Kala* in bone joints
- Facilitation of ejaculation of *Shukra* (spread in whole body of a male) ultimately from penile urethra to exterior (of male body). Analysis of this statement with the help of modern anatomy and physiology reveals that this function is controlled by hypothalamus-pituitary-testicular axis. Since females also have seventh *Dhatu* i.e. *Shukra* for them it is hypothalamus-pituitary-ovarian axis. In other words, the endocrine hormones related to reproductive system function reaching the reproductive system also need *Kala*. Albeit, this *Kala* is already explained as *Raktadhara Kala*.

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