JOURNAL OF RESEARCH IN TRADITIONAL MEDICINE

TITLE

Histological validation of *Pleeha* (Spleen) as one of the *Mulasthana* (Origin) of *Rakta Vaha Srotas* (Circulatory System)

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QR CODE

Received: 9/5/17 Revised:2/6/17 Accepted: 22/6/17

DOI: **http://.dx.doi.org/10.21276/jrtm.2017/510**

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ABSTRACT

BACKGROUND: Living physical body is comprised of numerous channels intended as an internal transport system for divergent functions (*Srotomayam hi Shariram*). *Yakrit* (liver) and *Pleeha* (spleen) are described as the *Mulasthana* (origin) of *Rakta Vaha Srotas* which play significant role in the formation and obliteration of *Rakta Dhatu*. **AIM:** The present review study is based on concepts of *Srotas* especially *Rakta Vaha Srotas* and intends to interpret their role, *Mulasthana* and analyze them with the help of current scientific knowledge specially histology. **MATERIALS & METHODS:** *Brihattrayee* (the basic three classical books) and other relevant contemporary literature were critically reviewed to dig out the hidden core of *Srotas Sharir* & their *Mulasthana*. **RESULTS:** One can consider *Mulasthana* on basis of *Utpatti* (place of production), *Sangraha* (storage area), *Vahana Sthana* (conduction area) & *Naidanic Drishtikon* (in diagnostic purview) likewise inference can be drawn that *Pleeha* is one of the *Mula Sthana* of *Rakta Vaha Srotas* with the help of histological study**.** **CONCLUSION:** Even though the concepts of *Rakta Vaha Srotas* & its *Mulasthana* i.e. *Pleeha* is described in Ayurveda dates back to centuries; they are still relevant in the current scientific world provided suitable approach is applied to interpret them.

KEYWORDS: *Histology, Mulasthana, Pleeha (Spleen), Rakta Vaha Srotas (Circulatory System)*

Introduction

Ayurvedic classical texts describes "*Srotomayam hi Shariram*" meaning that the human body as a channel organization or is comprised of numerous channels designed as an internal transport system for different functions, both gross and subtle.[1] *Srotas* is the arrangement that carries or circulates the *Doshas* and *Dhatu* to the various body organs. Understanding *Srotas* is an important topic as per anatomy, because these are related with the nourishment of the different parts of the body and on other hand is important in the pathological understanding of the diseases. *Srotas* is a representative of its structural composition regarding its storage capacity and its extensibility when it matters. *Acharya* has elaborated this concept with respect to complete and thoughtful knowledge of its *Vyakhya* (definition), *Sankhya* (number), *Bheda* (classification), *Strotodushti Lakshans* (systemic pathological signs/symptoms) and their *Mulasthana* (origin). Inspite of the existence of numerous *Srotas*, Charak has categorised 13 numbers of *Srotas* [2] and Sushrut has described 11 pairs of *Srotas*. [3]

Srotomula is the 'area of influence'. *Chakradutta* the commentator of *Charaka* [4], describes *Srotomula* as the area from which *Srotas* evolves or arises (similar to root of the tree). Any infection of the root of *Srotas* affects the functioning and health of the entire *Srotas*. Same reason can't be given for *Mulasthana* of all *Srotas* but any organ / structure can be considered as its *Mulasthana* on following basis, [5]

- *Utpatti sthan* (origin point of view)
- *Sangraha sthan* (storage)
- *Vahana sthan* (conduction)
- *Naidanic drishtikon* (diagnostic point of view)
- *Chikitsatmak drishtikon* (clinical point of view)

Among these the *Mulasthana* can act in combination of above mentioned effects or may act alone.

Materials & Methods

Brihat-Trayee (three classical lexicon of Ayurveda) with their commentaries, particularly from Charaka Samhita *Vimana Sthana* & Sushruta Samhita *Sharirsthana*, where there is description of *Srotas Sharir* with explanation and supportive texts of contemporary science specially Grays Anatomy along with references from internet and journals were assessed for this study.

Observations

Thorough review of Ayurveda literature on *Rakta Vaha Srotas Sharir* with *Pleeha* as *Mulasthana* & comparative micro structural study of spleen, it is revealed that *Pleeha* i.e. spleen can be aptly considered as *Mulasthana* of *Rakta Vaha Srotas*.

Rakta Vaha Srotas in Ayurveda

In Ayurveda the channels transporting the *Rakta Dhatu* from its sites of origin to the pumping place of greater circulation and from there to each and every part of the body appear to come under the heading of

Rakta Vaha Srotas. *Yakrit* and *Pleeha* have been considered as *Mulasthana* of *Rakta Vaha Srotas* [4] with *Raktavahi Dhamani* (blood vessels). [3] During embryonic development origin of *Yakrit* and *Pleeha* takes place from *Shonita* (*Rakta*)[6]and after intra uterine life, during second trimester haematopoiesis takes place in *Yakrit* & *Pleeha* and *Pleeha*. Hence on the basis of *Gunasamanya Ashraya-Ashrayi* (quality wise interdependence between abode & resident) the relation between *Yakrit-Pleeha* and *Shonita Dhatu* gets proven successfully. After attaining *Rakta Varna* (red colour) in *Yakrit- Pleeha*, it is conducted to different parts of body by *Raktavahi Dhamani*. [7]

Pleeha

Yakrit and *Pleeha* are maximally mentioned in same context everywhere but location wise there is a difference mentioned. *Pleeha* is located in left of *Hridaya* (heart) along with *Phupphusa* (lungs) where as *Yakrit* in the right side [8]. In Susrutha Samhita, the site of *Siravedhya* (venesection) in *Plihodara* (splenomegaly) is *Vama Kurpara* (left elbow joint) whereas right elbow joint is the location for venesection for *Yakrutodara* (hepatomegaly). [9]

Spleen

Spleen is located in left hypochondrium of abdominal cavity, which is a wedge shaped organ & roughly corresponds to fist of the person; measuring 1, 3, 5 inches in thickness, breadth & length respectively. It is behind 9th, 10th & 11th rib; which makes it un-palpable until abnormally enlarged. [10]

In first trimester of intra uterine life, hematopoiesis takes place in yolk sac. During the middle trimester of gestation, the liver is the main organ for hematopoiesis along with spleen & lymph node. The spleen filters blood by segregating worn-out RBCs & microbial agents & provides immunity by producing immunoglobulin M (IgM). Old red blood cells are recycled in the spleen, and platelets as well as white blood cells are stored there.

Microstructure

Microscopically, the parenchymal tissue of the spleen consists of two major components, white pulp and red pulp, named on the basis of their appearance when a fresh spleen is transected. [11] The white pulp is composed of lymphoid tissue in which B and T lymphocytes mature and proliferate under antigenic stimulation. The red pulp is a unique filtration device that enables the spleen to clear particulate material from the blood as it perfuse the spleen.

White pulp

In the spleen parenchyma, branches of the splenic artery radiate out from the hilum within trabeculae, ramifying and narrowing to arterioles. In their terminal few millimetres, their connective tissue adventitia is replaced by a sheath of T-lymphocytes, the periarteriolar lymphatic sheath (PALS). This sheath is enlarged in places by lymphoid follicles, which are aggregations of B-lymphocytes, 0.25–1 mm in diameter. Follicles are usually situated near the terminal branches of arterioles and typically protrude to one side of a vessel, which consequently appears eccentrically placed within the follicle. Arterioles branch laterally within follicles to form a series of parallel terminal arterioles, called penicilli, or penicillar arterioles, from their resemblance to the penicillium mould. [12]

Red pulp

The red pulp constitutes the majority (75%) of the total splenic volume. It contains large numbers of venous sinusoids that ultimately drain into tributaries of the major splenic veins. The sinusoids are separated from each other by a fibro-cellular network consisting of small bundles of delicate collagen type III fibres, the reticulum, and numerous reticular fibroblasts and splenic macrophages. Seen in two-dimensional sections, these inter-sinusoidal regions appear as strips of tissue, the splenic cords, which alternate with splenic sinuses. In reality, they form a three-dimensional continuum around the venous spaces. [1,12]

Venous sinusoids

Venous sinusoids are elongated ovoid vessels approximately 50 µm in diameter, lined by a characteristic, 'incomplete' endothelium that is unique to the spleen. Their endothelial cells are long and narrow, and aligned with the long axis of the sinusoid; they are often called stave cells, because they are reminiscent of planks in a barrel. Stave cells are attached to their neighbours at intervals along their length by short stretches of intercellular junctions. These junctions alternate with intercellular slits which allow blood cells to squeeze into the lumen of the sinusoid from the surrounding splenic cords.

Reticular tissue of the splenic cords

Large, stellate fibroblasts called reticular cells lie around the sinusoids. They synthesis the matrix components of the reticulum, including collagen and proteoglycans, and their cytoplasmic processes compartmentalise the reticular space. Blood is released from the ends of capillaries originating from penicillar arterioles and percolates through the reticular spaces within the splenic cords.

As it does so, macrophages within the reticulum remove blood-borne particulate material damaged erythrocytes. When numbers of damaged erythrocytes increase, the reticular cells proliferate and the size of the red pulp increases considerably: this causes enlargement of the whole spleen, and in extreme cases, Splenomegaly. [1, 12]

Splenic microcirculation

The segmental splenic arteries enter the hilum and ramify in the trabeculae throughout the organ. Small arteries tapering to arterioles pass through the white pulp then turn abruptly to form penicillar branches which, after a course of approximately 0.5 mm, pass out of the white pulp into the marginal zone and red pulp. The passage of blood through the vascular compartments between the arterioles and splenic veins is referred to collectively as the intermediate circulation of the spleen. Ultimately, blood is passed to the venous sinusoids from which it enters venules leading to small veins that run within trabeculae, and thence into larger veins that drain the spleen at its hilum.

Open and closed splenic circulations

Views on the intermediate circulation of the spleen differ on whether blood passes from the arterioles (or their terminal capillaries) directly into the venous sinuses (a closed circulation), or is instead discharged into a network of spaces in the splenic cords before entering the sinuses through the minute slits in their walls (an open circulation). In humans, evidence favours the presence of an anatomically and physiologically open circulation, in which blood percolates slowly through the reticular tissue of the splenic cords and filters through slits in the sinus walls before joining the majority of the blood flow. [12]

Splenomegaly

Splenomegaly is defined as enlargement of the spleen. [13] The spleen enlarges as it performs its normal functions. The four most important normal functions of the spleen are as follows:

- Clearance of microorganisms and particulate antigens from the blood stream,
- Synthesis of immunoglobulin G (IgG)
- Removal of abnormal red blood cells (RBCs)
- Extra-medullary hematopoiesis in certain diseases

Also, there are certain pathological causes under which Splenomegaly can be seen performing there aforesaid normal functions like lympho-proliferative disease, the resumption of extra-medullary hematopoiesis in myelo-proliferative disease, enhanced reticulo-endothelial activity in autoimmune hemolysis, expansion of the lymphoid tissue in response to infections or vascular congestion as a result of portal hypertension. [14]

Discussion

Spleen is composed of two primary regions namely, red pulp and white pulp. The red pulp makes up for little more than three-fourth of the spleen. Red pulp is red because it has many small cavities (sinusoids) where the spleen stores blood in case of injury or other situations where the body needs extra blood. This blood reserve has a high count of platelets, an essential component for blood coagulation to help stop bleeding. Red pulp also removes and recycles components of old, damaged and dead red blood cells. White pulp is associated with the lymphatic function of the spleen. Most of this tissue consists of lymph-related nodules, called Malphighian corpuscles. It also produces and stores white blood cells (lymphocytes).

Certain portions of the circulatory system are so extensive and so compliant that they are called "specific blood reservoirs." The spleen, sometimes can decrease in size sufficiently to release as much as 100 milliliters of blood into other areas of the circulation. [15]

The sinuses can swell the same as any other part of the venous system and store whole blood. These can then be expelled into the general circulation whenever the sympathetic nervous system becomes excited and causes the spleen and its vessels to contract. As much as 50 millilitres of concentrated red blood cells can be released into the circulation, raising the hematocrit level 1 to 2 per cent. In other areas of the splenic pulp are islands of white blood cells, which collectively are called the white pulp.

During embryonic development the origin of *Yakrit* and *Pleeha* takes place from *Shonita* (*Rakta*) and post IUL during second trimester haematopoiesis takes in liver & spleen. Hence on the basis of *Guna-Samanya, Ashraya-Ashrayi* relation between *Yakrit-Pleeha* and *Shonita Dhatu* gets proven successfully.

Histological study gives clear cut explanation of functions; same is in context of spleen. On the following basis *Pleeha* as *Mulasthana* of *Rakthavaha Srotas* can be considered as per following criteria,

Utpatti Sthana - In intra-uterine life & post-natal period is extra medullary hematopoiesis. *Sangraha Sthana* is at red pulp, sinusoids of spleen. *Vahana Sthana* is micro circulation through the channels and by *Naidanic Drishtikon* it is splenomegaly (cause).

Conclusion

One can draw the inference that the *Pleeha* is one of the *Mula Stana* of *Rakta Vaha Srotas*. Hence there is a requirement to elaborate the knowledge of the *Rakta Vaha Srotas* and its *Moolsthana* with scientific way in context to *Rakta Pradoshaj Vyadhi* for the management.

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How to Cite the article:

Gaurav Soni and Neelam. Histological validation of *Pleeha* (Spleen) as one of the *Mulasthana* (Origin) of *Rakta Vaha Srotas* (Circulatory System). J. Res. Tradit. Med 2017; 3(1): 18-22

http:dx.doi.org/10.21276/jrtm.2017/510

Source of Support: NIL

Conflict of Interest: NIL