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Comparative study between the evolutionary history of development of blood vessels in various species *(Brahmanda or Srushti)* and the Human Embryo (*Pinda*) to evaluate '*Yata Pindam Tata Brahmandam*'

Saurabh Jain[1], Prof. Sunil Kumar[2], Rashi Sharma[3]

[1]*Ph.D, Dept. of Sharir Rachana, Poornayu Ayurveda Chikitasalya Evam Anusandhan Vidyapeeth, Jabalpur, Madhya Pradesh, India.*

[2]*Professor, Dept. of Sharir Rachana, NIA Jaipur, Rajasthan, India.*

[3]*Post Graduate Scholar, Dept. of Sharir Rachana, NIA Jaipur, Rajasthan, India.*

ABSTRACT

Introduction: Embryology is considered to provide evidence for evolution and is a way to link various species on the phylogenetic tree of life. To higher recognize the evolutionary embryology in the back of the blood vascular device and endothelium recognition of the taxonomy is very essential. By this we came to know that different species achieve the goals of reproduction, nutrition and survival by different means. These changes diverge due to change in body size and variation in structural complexity. The same way vascular system in mammals develops. **Materials and Methods:** From various published articles through google search, texts of *Ayurveda* mainly *Charaka Samhita* and modern embryology texts and internet media. **Aim & Objective:** To compare the process of evolution of blood vessels in *Garbha* with that of evolution of various species on phylogenetic tree on basis of their functional requirements. **Result and Discussion:** Before the formation of placenta there is histotrophic nutrition in which embryo gets its nutrition through diffusion from uterine glands. This diffusion state is the *Srotas* in *Ayurveda* mentioned as *Sravanatsrotansi*. This diffusion can provide nutrition to small area or cell group only. With the beginning of formation of placenta, the histotrophic nutrition is replaced by the hemotrophic nutrition. As embryo further grows, the nutrition demand increases so to balance, tube circulation (vasculature) develops in embryo in order to increase the flow. This vasculature is the state of *Sira* in *Ayurveda* mentioned as *Sarnatsira*. Similarly, development of vessels from *Srotas* to *Dhamani* occurs in Fetus due to change in functional requirements. This occurs in human body. Thus, in this paper "*Yata Pinde Tata Brahmande" Nyaya* of *Yajurveda* which is very much similar to *Ayurveda "Lok Purusha Samya Siddhanth"* is justified in context of taxonomical circulatory system evolution and development.

Key words: *Ayurveda, Dhamani, Embryology, Sira, Srotas, Taxonomy, Vascular system.*

INTRODUCTION

Embryology is a vital branch of biological studies because an understanding of the growth and development of a species before birth can shed light on how it evolved and how various species are related.[1] Embryology is considered to provide evidence for evolution and is a way to link various species on the phylogenetic tree of life. The best-known example of embryology supporting the idea of evolution of species is the work of scientist Ernst Haeckel who proposed new ideas about of the evolutionary descent of human beings.[2] His infamous illustration of several vertebrate species ranging from humans to chickens and tortoises showed how closely all life is related based on major developmental milestones of embryos.[3] Looking at every level of organization in living systems, biologists see the signature of past and present evolution.[4] Embryology is a science that deals with development of an organism from its cellular stage to its adult form. Reviewing this evolution process definitely provides

Address for correspondence:
Dr. Saurabh Jain
Ph.D, Dept. of Sharir Rachana, Poornayu Ayurveda Chikitasalya Evam Anusandhan Vidyapeeth, Jabalpur, Madhya Pradesh, India.
E-mail: dr.jainsaurabh65@gmail.com

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evidence for evolution. It conserves the path of evolution in various divergent group of organisms. Sometimes some organs become vestigial by the time adult form is reached and they often appear in functional form in their embryonic stage.[5] Molecular phylogenetic analyses have yielded interesting, though limited insights into evolutionarily conserved mechanisms of heart development and tube formation.[6] According to Yajurveda all that exist in *Pinda* (individual) also exist in *Brahamanda* (universe) - *Yat Pinde Tat Bramhande*".[7] Due to this resemblance between the *Lok* (universe) and the *Purush* (individual) the individual can be understood well based upon knowledge of universe. Similarly, due to change in requirements there are certain structural developments that occur in various species like in fishes and amphibians, the yolk sac does not have its own vasculature, and is instead supplied by systemic arteries and veins. As body size grows and requirements change in mammals, birds, and reptiles, however, the yolk sac evolves its separate drainage, thus forming the vitelline arteries and veins. Then in vertebrates when liver develops as large abdominal structure the vitelline veins are divided into smaller hepatic sinusoids as they traverse the liver towards the heart. After that all gut veins start converging in the liver first thus forming the hepatic portal system common to all vertebrates. Similarly, such processes lead to evolution from Porifera to mammals. This occurs in our ecosystem. Similarly, development of vessels from Srotas to Dhamani occurs in Fetus due to change in functional requirements. This occurs in human body. *Acharya Charaka* narrated "*purushoyamloksammitam*" *Siddhant*. According to this *siddhant*, human body resembles to universe. Whatsoever formed entities (*murtimant*) are in human (*purush*) are present in the universe. Also, whatsoever formed entities (*murtimant*) are in universe (outside world) are the same in human body.[8] The goal of this review is to employ a comparative approach to review the phylogenetic history of the blood vascular system and endothelium with the development of human embryo as "*Yata Pinde Tata Brahmande".*

Taxonomy

Taxonomy with inside the extensive experience is the technological know-how of category of dwelling and extinct organisms.[9] To higher recognize the evolutionary embryology in the back of the blood vascular device and endothelium we ought to first recognize the taxonomy. Eukaryotes are further classified in two kingdoms Protozoa and Metazoans. Metazoans are multicellular eukaryotes and hence choice for the further consideration. Metazoans are further classified as Diploblasts and Triploblasts.[10] The most primitive diploblasts are - Porifera (sponges), Cnidaria (corals and jelly fish) and Ctenophora (comb jellies). Between 600-700 million years ago there aroused another body plan that demonstrated bilateral symmetry and a third germ layer so called as triploblasts. They give rise to Protostomes and Deuterostomes.[10] The Deuterostomes give rise to Chordates, hemichordates and Echinoderms.[10] The Protostomes give rise to the Ecdysozoans (including the arthropods and nematodes) and the Lophotrochozoans (including the mollusks and annelids).[9]

Requirement of different body plans

All animals have evolved to survive and reproduce and to do so they intake nutrients and excrete out metabolic wastes.[11] Different species use different strategies to achieve these goals. Such strategies diverge with changes in body size and complexity.[12]

Relation between size and structural modification[13]

Changes in size mandate changes in structural design. All unicellular and simple multicellular animals depend on diffusion nutrients and excretion due to small body size. Diffusion, while energetically inexpensive, is a very slow process and works only over small distances (diffusion path < 1 mm). However, these strategies restricted to certain limits on body size. To achieve further three-dimensional increases in size, it is necessary to employ internal transport and exchange systems (i.e., circulatory systems) to provide bulk flow delivery of substances (e.g., gases, nutrients, wastes) to and from each cell in the body. The process of Angiogenesis clearly shows the evidence that if size

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increases, hence increase in demand by peripheral cells, thereby new vessels develop to combat the demand.

In Ayurveda it is clearly mentioned that our body is mirror image of world outside. So whatever evolution and adaptability occurs to combat the demand in outside world, similarly, our body also evolves, and development occurs according to various needs of body.

Circulatory System[14]

A circulatory system is meant to reduce the functional diffusion distance. In diploblasts, they involve circulation of seawater into a body cavity that is open to the environment. In some triploblasts, however, circulatory fluid is an internal, extracellular and distributed either through body cavities or through integrated networks of vessels, sinuses and pumping organs. There are two internal circulatory systems: coelomic and blood vascular.

Coelomic Circulatory Systems[14]

Some triploblastic animals called *Acoelomates* (e.g., flatworms) obtain all of their oxygen and food by simple diffusion across the skin and gut and throughout the intercellular medium.

However, most triploblastic animals have a fluid-filled body cavity between the outer body wall (ectoderm) and the digestive tube (endoderm), termed the *coelom*. The coelom is lined by *mesothelium*. Coelomic cavities function in the local circulation of fluid.

Review of variation in blood vascular systems

The blood vascular system consists of vessels, sinuses, hemocoels, and/or pumping organs and is continuous all around the tissues in the body. The spaces are lined only by matrix in Invertebrates while in Vertebrates a secondary cell lining has evolved which is termed as endothelium. By contraction of specialized mesothelial cells, the transport of fluids is made possible. Blood vascular systems is of two possible designs: one is open vascular system and other is closed vascular system. Due to diversity in phenotypes the Invertebrates display blood vascular system varying from open to closed type. In contrast, all vertebrates have a closed cardiovascular system.[15]

Open circulatory system occurs in arthropods (insects) and non-cephalopod mollusks (snails). It is considered open because the blood (called *hemolymph*) empties from a contractile heart into the body cavity (termed a *hemocoel*), where it directly bathes the organs.

Closed circulatory systems occur in a wide variety of invertebrates cephalopods (e.g., octopus and squid) and in vertebrates. In closed systems, the blood remains inside boundaries made of distinct channels or chambers, where it is physically separated from the intercellular fluid, body cells and coelom. In vertebrates, the closed vascular system consists of a series of closed vessels with an endothelial lining, invested with smooth muscle cells or pericytes. Conversely, the closed system of vertebrates contains vascular beds, such as the sinusoids of the liver, spleen and bone marrow, where there is direct contact between blood and the interstitial space. In haemochorial placentation (e.g., in primates), the maternal spiral arteries become open ended, and blood is released into a placental labyrinth where it bathes the chorionic villi and is drained by the spiral veins. Such an arrangement is highly reminiscent of an open system.

What causes blood vascular system to evolve and update

Circulatory systems evolved to overcome the problem of time and distance achieved by diffusion, thus permitting proper functioning even in increased body size and metabolic rates (Metazoans). Although the primitive coelom provided bulk flow delivery of substances, but these structures never developed an efficient pumping mechanism to combat the requirements of increased and more developed body size. The movement of fluid in blood vascular systems was originally mediated by the peristaltic motion of certain blood vessels, (earthworm and amphioxus). However, peristaltic pumps lack effective coordination between the fluid that is entering the contractile region and the fluid that is leaving it. This

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makes a way for evolution of true heart which can work on pressure gradient system thus managing the inflow and outflow strictly. This leads to development of chambers, nodes for electrical connection between myocytes for simultaneous stimulation and valves for maintain one way flow.

Pathways of circulating nutrients

Histiotrophic and Haemotrophic are two principal ways to provide nutrition from mother to fetus in eutherian mammals. In Histiotrophic method the extracellular material derived from the endometrium and the uterine glands accumulates in the space between the maternal and fetal tissues and thereby provides nutrition to fetus. It is phagocytosed initially by the trophectoderm of the blastocyst, and later by the trophoblast of the placenta or the endoderm of the yolk sac.[15]

In contrast, the exchange of nutrition via blood as medium between maternal and fetal circulations is called Haemotrophic nutrition. This is made possible by the vast and very close apposition of the maternal and fetal tissues that occurs within placenta.[15]

Until the end of the first trimester, even after implantation and establishment of the chorioallantoic placenta there is a transition phase where maternal supply to placenta is not established completely. In this period, the uterine glands discharge secretions into the intervillous space which are taken up by the syncitiotrophoblast cells. Also, during early pregnancy selected maternal proteins accumulate within the fluid of the coelomic cavity, from which they may be transported to the fetus by the secondary yolk sac.[15] An isotrophic nutrition may be advantageous to the fetus during the first trimester as it provides nutrition under a low oxygen concentration. Once this is complete, and fetal oxygen requirements rise, there is a transition to haemotrophic nutrition at the start of the second trimester, when the maternal placental circulation is fully established.[15]

DISCUSSION

Analysis of molecular phylogenetics have yielded interesting, although limited exposure into evolutionarily conserved mechanisms of heart development and tube formation. Extra organismic circulation is observed in Diploblasts like canal system in porifera, water vascular system in echinoderms, gastrovascular system in coelenterates. Some triploblastic animals called Acoelomates (e.g., flatworms) obtain all of their oxygen and food by simple diffusion across the skin and gut and throughout the intercellular medium. However, most triploblastic animals have a fluid-filled body cavity between the outer body wall (ectoderm) and the digestive tube (endoderm), termed the coelom.[14] The coelom is lined by mesothelium. Coelomic cavities function in the local circulation of fluid. That is similar to *Sravanat Srotansi.*[16] The blood vascular system consists of blood-filled spaces (vessels, sinuses, hemocoels,) which is continuous around and between all tissues in the body which is similar to *Sarnat Sira.*[17] Along with the closed vascular system heart beats and the contraction of arteries facilitate the simultaneous circulation which is similar to *Dhamnat Dhamanyaha.*[18] As in platyhelminths, the fluid filled spaces present in the mesodermal parenchyma tissue between body wall and internal organs are used in the distribution of substances likewise, in all mammalian species nutrition of the conceptus is initially histotrophic. The uterine glands discharge secretions into the intervillous space until at least 8 weeks of pregnancy, and that these are taken up by the syncitiotrophoblast.[19]

Further as evolution occurs, for e.g.in roundworms and haemolymph in Arthropods, the coelomic fluid plays the major role in transportation of nutrients and similarly in embryology, during early pregnancy selected maternal proteins accumulate within the fluid of the coelomic cavity, from which they may be transported to the fetus by the secondary yolk sac.[20] For the first 11 weeks of pregnancy, before the mother's nutrient-rich blood supply is plumbed in, all the materials and energy for building a baby are supplied by secretions from glands in the uterus lining.[21]

From open, lacunar, single circuit the blood vascular system in mammals evolves and develops as double circuit circulation.

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In Ayurveda classics, seers have said that whatever is there in outer world, similar is observed in our own body. Considering this as the principle we observed evolution in different phyla of animals along with evolution in their body systems. Likewise in development of embryo to adult form, there are various developments in their nutrition providing systems.

Thereby, at the start of the second trimester, when fetal oxygen requirements rise, there is a transition from histiotrophic to haemotrophic nutrition when the maternal placental circulation is fully established. The human placenta is hemochorionic which means that blood is not exchange between mother and fetus. Before the formation of placenta there is histotrophic nutrition in which embryo gets its nutrition through diffusion from uterine glands.[20] This diffusion state is the *Srotas* in *Ayurveda* mentioned as ***Sravanatsrotansi*.** This diffusion can provide nutrition to small area or cell group only. With the beginning of formation of placenta, the histotrophic nutrition is replaced by the hemotrophic nutrition. As embryo further grows, the nutrition demand increases so to balance, tube circulation (vasculature) develops in embryo in order to increase the flow. This vasculature is the state of *Sira* in *Ayurveda* mentioned as ***Sarnatsira***. Thereby, to balance the nutritional demand of the growing embryo, pressure flow is needed which is performed by the heart. As heart beats or contracts blood flows with pressure in the heart connected tubes (artery). This arterial system is the state of *Dhamani* in *Ayurveda* mentioned as ***Dhamanat Dhamani*.** Thus, *Acharya Vagbhatt* who is the follower of *Charak* and *Sushrut Samhita* may conclude that *Dhamani* is the specific *Sira* and *Sira* is the specific *Srotas* which can be understood by the following tabular form of lineage. (Table 1)

CONCLUSION

Cardiovascular system is highly diverse in their structure and function. The design of a given system is exquisitely matched to the needs of the animal. It continuously evolves according to requirement of evolved species. Similarly, we find the development of blood circulation process in mammals. Thus, we could say that many years back Yajurveda has given the theory of "*Yata Pinde Tata Brahmande"* which was very similar to *Ayurveda* "*Lok Purusha Samya Siddhanth"* which is justified in context of taxonomical circulatory system evolution and development.

Table 1: Indicating Development of nutritional circulation in *Garbha* and *Srushti*

↓	**Development of nutritional circulation in *Srushti***	**Development of nutritional circlulation in embryo**	**Reason of development**	**Development of nutritional circulation in *Garbha* according to *Ayurveda***	↓
Direction of development	Diplobl ast and some triplobl astic	Trophec toderm phagocy tosing-oviducta l	Nutrition by diffusion (small embryo get its nutrition)	***Srotas*** (*Sravan at Srotans i)*	**Histotr ophic nutriti on**
	Most triplobl astic	Uterine gland secretio ns	Coelomic circulatio n (local cir culation of fluid.)		
	Cephal opods (open) and vertebr ate (close)	Vasculo genesis	Circulati on develops to balance the nutrition al demand of growing fetus	***Sira*** *(Sarnat sira)*	**Hemot rophic nutriti on**
		By heart	Pressure	***Dhama***	

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		contraction	pumping needed to improve the circulation	***ni*** *(Dhamanat dhamani)*	

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