Conceptual study of Hematopoiesis (*Raktotpatti*)

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**ABSTRACT**

Ayurveda is an ancient and broad source of fundamental principles related to medical science. Many more principles of modern science are influenced by Ayurveda. *Sushrut Samhita* is one of the oldest treatises in the world dealing with surgery while *Charak samhita* deals in medicine. In *Ayurveda*, the process of formation of *Raktadhatu* was explained many years ago. Modern science has given almost same concept but hematopoietic organs are described differently in foetal life and after birth.

*Acharya Sushrut* says that *Raktadhatu* (blood) itself is a *jeev* (life) because loss of blood mostly leads to death. The blood plays a very important role in our body. All the nutritional elements reach entire parts in the body through blood and keeping us at an abeyance from diseases. So, it is important to know the concept of the formation of the *Raktadhatu* in *Ayurveda* as well as the concept of hematopoiesis in modern science in parallel. While diagnosis and making prognosis of any *Raktaj vyadhi*, one can perform some RBCs related investigations may prove very helpful. Therefore, the study of these two concepts is very essential.

**KEYWORDS**

*Raktadhatu*, *Ranjak pitta*, *Raktagni*, *Srotas*, *Moolasthan*, *Yakrit*, *Pleeha*, *SaraktaMeda*
INTRODUCTION

According to Ayurveda, the body is a combination of seven Dhatus’. Raktadhatu is second Dhatu in the body which is formed after the formation of Rasadhatu in Dhatuposhan kram. It performs many vital functions and is quite essential for Dehadharan. Its vitiation as well as imbalance causes various sign and diseases that hamper normal health of the body. According to modern science RBC are red cells present in the blood. Function and properties of RBC are very much similar to Raktadhatu.

In Ayurveda, Yakrit and Pleeha are mentioned as organs of hematopoiesasis. Almost all the Acharyas have same opinions about the formation of Raktadhatu. Tejo Dravyatmak Ahar, Ranjak pitta and Raktagni are the essential substances responsible for the formation of Raktadhatu. Modern science also accepts that liver and spleen are the hematopoietic organs in the foetal life but after birth liver and spleen are replaced for the hematopoiesis by red bone marrow of long and flat bones.

RAKTADHATU: All Acharyas of Ayurveda have mentioned that seven Dhatus are present in the body. Raktadhatu is one of them which is formed after the formation of Rasadhatu in Dhatuposhan Kram. Raktadhatu is also mentioned under the group of Dasha Pranayatana (seats of life). Raktadhatu should be regarded as pure when it has colour like that of heated gold, red velvet mite, red lotus, lac and gunja (abrus seed).

According to Ayurveda the Raktadhatu is also named as Rudhir, Lohit, Shonit, Ashrik, Kshataj which indicate the red colour. Total amount of Raktadhatu in the body is eight Anjali. Acharya Sushrut has stated about the importance or Raktadhatu that it is a Moola of the body because it provides nutrients so that, the body is maintained by Raktadhatu. Therefore it should be protected by all efforts. Raktadhatu itself is a life because loss of Rakta mostly leads to death. The Raktadhatu enhances the tone and complexion of skin. The whole physiology of the body is totally dependent on Raktadhatu because it strengthens the body and keeps it healthy. So that the Raktadhatu increases life span and keeps the person active.

RAKTAVAHA SROTAS: The word Srotas has originated from Sanskrit root which means to flow or to circulate. Srotas is a hollow transporting channel through which some vital substances like Prana, Udaka, Anna, Dosha, Dhatu, Mala etc are transported from one place to another.
Acharya Charak has mentioned 13 Srotas while Acharya Sushrut has mentioned 11 paires. They have described their specific Moolasthan (roots). The organ whose proper functioning is very important and needful for healthy status of Srotas and any abnormality or disease occurring in that organ will produce symptoms of Srotodushti in concern Srotas, is called as a Moolasthan (root) of that Srotas. Acharyas stated that Yakrit (liver), Pleeha (spleen) and Raktavahi Dhamani are the roots of Raktavaha Srotas. So, any abnormality in these organs will cause alteration in function of the Raktavaha Srotas and many symptoms are produced due to Raktavaha Srotodushti and finally affected by many Raktaj vyadhi (blood related diseases).

Raktavaha Srotas are the channels which carry Raktadhatu from one place to another place in the body. Therefore they may be compared with blood circulatory system of the body. So, the microscopic, macroscopic, large, small or rounded structures which carry the blood within it are called Raktavaha Srotas. RohiniSira (artery) and NeelaSira (vein) should be included under the term Raktavaha Srotas and capillaries of these Sira may be taken under the term microscopic structure.

RANJAK PITTA :- Ranjak pitta is one of five pitas which present in the body. Ranjak means coloring agent that gives specific color to the tissue by the process of Ranjan. Pittashave their specific sites in the body. Almost all Acharyas of Ayurveda have same opinions about the site of Ranjak Pitta that are Yakrit (liver) and Pleeha (spleen) but Acharya Vagbhat has described the Amashaya (stomach) as the site of Ranjak Pitta.

Acharya Sushrut says when the Ahar Rasa passes through Yakrit and Pleeha, it gets converted into Raktavarna (red color) due to the process of Ranjan by the heat of Ranjakagni which is situated there. So, it is clear that Ranjak Pitta is also called Ranjakagni and it bestows Raktavarna to Rasadhatu.

RAKTOTPATTI :- In Ayurveda, four Nyayas of Dhatuposhan are explained through which we can understand the formation of Raktadhatu. First, Ksheeradadhi nyaya (Transformation theory) explains that Ahar Rasa completely converts into Rasadhatu and then Rasadhatu transforms into the Raktadhatu. Before the formation of Raktadhatu, only Rasadhatu circulates into the body. Second, Kedarikulya nyaya (Transportation theory) explains that different Dhatus of the body
get nutrition one by one in sequence through vessels. So, *Rasadhatu* gets nutrition from *Ahar Rasa* then *Raktadhatu* from the rest part of *Ahar Rasa* and likewise till the last *Shukradhatu*\(^2\). Third, *Khalekapota nyaya* (Selectivity theory) explains that all *Dhatus* are directly nourished by *Ahar Rasa* without considering the sequence of nutrition. The *Ahar Rasa* circulates to the different *Dhatus* through different channels. In the beginning, the nearby *Dhatu* gets nourishment from *Ahar Rasa* and the distant one gets nourished later. This theory believes that each *Dhatu* has its specific nutrient called *Poshakamsha*\(^3\). Fourth, *Ek Kaala Dhatuposhan nyaya* (Simultaneous nourishment theory) has been introduced by the commentator *Arun Datta* and he says that the *Ahar Rasa* nourishes all the *Dhatus* simultaneously through the respective *Srotasa* of that *Dhatu*\(^4\).

All *Acharyas* of *Ayurveda* have mentioned that *Tejo dravya* (blood forming elements) of *Ahar Rasa* (digested food) are converted into the *Raktadhatu* by the action of *Ranjak Pitta* and *Raktagni*. The quantity and quality of *Raktadhatu* mostly depends upon the intake of *Tejo Dravyatmak Ahar*. Intake food must first be digested by the *Jatharagni* and produces *Ahar Rasa* which is then digested by *Rasagni* to produce *Rasadhatu* and its related tissues. Some part of *Rasadhatu* is then digested by *Raktagni* and at the time *Ranjak Pitta* gives red color to *Rasadhatu*. This produces red colored specific substance called *Raktadhatu*. When *Raktagni* is functioning properly and has received adequate *Rasa* for transformation, the *Rakta* produced will be of an ideal quantity and of better quality. So, according to *Ayurveda* the essential substances for the formation of *Rakta* are the *Tejo Dravyatmaka Ahar*, *Ranjak pitta* and the *Raktagni*. Absence of any one of them, it is not possible to form *Raktadhatu*.

**HEMATOPOIESIS**: In human life, production of the blood starts from 3\(^{rd}\) week of intrauterine life. Between the 3\(^{rd}\) week till 3\(^{rd}\) month of intrauterine life, erythropoiesis occurs within the blood vessels in the mesoderm of yolk sac. It is called intravascular erythropoiesis. Between 3\(^{rd}\) to 5\(^{th}\) month, erythropoiesis occurs principally in the liver and partly in the spleen. After 5\(^{th}\) month of intrauterine life and after birth erythropoiesis occurs in the red bone marrow. When there is extreme necessity of producing RBCs in some diseases after birth, erythropoiesis can occur in the liver and spleen also. In the red bone marrow, hematopoietic stem cell (HSC) is formed from totipotent stem cell and from
HSC; committed stem cells (progenitor cells) are formed. From progenitor cells, the pronormoblast cells then early normoblast develops. Early normoblast produces intermediate normoblast. Intermediate normoblast gives rise to late normoblast. From late normoblast, reticulocyte develops and reticulocyte gives rise to matured RBCs\textsuperscript{15}. Some factors which influence the erythropoiesis are (1) Hematopoietic Growth Factors (HGF) which includes erythropoietin, myeloid growth factors and thrombopoietin. HGF stimulate the production of different blood cells. Erythropoietin is a glycoprotein which is mainly (90\%) produced by the kidney and partly (10\%) by the liver. (2) Vitamines include vitamin B\textsubscript{12}, folic acid, pyridoxine and vitamin C. (3) Iron\textsuperscript{16}. Vit B\textsubscript{12} is not synthesized by human beings, so they depend on food or medicine for this vitamin. Vit B\textsubscript{12} combines with intrinsic factor which is secreted by parietal cells of the stomach then it travels down to the terminal intestine. After absorption from the ileum, Vit B\textsubscript{12} being bound with transcobalamine-2 and reach to the liver where it is stored. From the liver, Vit B\textsubscript{12} goes to red bone marrow and other organs. Folic acid is mainly found in vegetable foods. In the human intestine, it is absorbed from the upper part of small intestine then it enters the blood stream. In the blood, it converts into methyl tetrahydrofolate (CH\textsubscript{3}FH\textsubscript{4}). Methyl radical (CH\textsubscript{3}) is captured by cobalamin (Vit B\textsubscript{12}) which thus becomes methyl cobalamin and free FH\textsubscript{4} is the active form of folic acid. If free FH\textsubscript{4} is not formed, no maturation and cell division of primitive erythroblast can occur. This means, in total absence of Vit B\textsubscript{12}, folic acid is useless. Pyridoxine and Vit C also play important roles in erythropoiesis. Iron is required for the synthesis of Hb, myoglobin and cytochrome oxidase. Food iron is of two types - (1) Heme iron which present in food (2) Non-heme iron which is inorganic iron. Usually, the bulk of food iron is non-heme iron and these are in ferric (Fe\textsuperscript{3+}) state. It is absorbed mostly from 2\textsuperscript{nd} part of duodenum then it converts into ferrous (Fe\textsuperscript{2+}) state by iron reductase enzyme. Ferrous iron is absorbable. Iron is extracted from heme during formation of bilirubin in the liver and ultimately sent to bone marrow for reutilization\textsuperscript{17}.

**DISCUSSION**

According to *Ayurveda* three essential substances are required for the formation of
blood that are *Tejo Dravyatmak Ahar*, *Ranjak Pitta* and *Raktagni*. *Tejo Dravyatmak Ahar* means dietary requirements of hematopoietic elements like iron, copper, cobalt, folic acid, vitamins etc. These elements accelerate the process of hematopoiesis. The quality and quantity of *Raktadhatus* depends upon the intake of the *Tejo* elements. Food must first be digested by the *Jatharagni* (digestive enzymes). This produces *Ahar Rasa* which is then digested by own *Agni* of *Dhatu* to produce corresponding *Dhatu*. In this sequence, when *Rasadhatu* is digested by *Raktagni*, the *Raktadhatus* and its related tissues produced.

The substance which gives red color to blood is *Ranjak Pitta*. The red color of blood is attributed by hemoglobin (Hb) which present in RBCs. Hb is a red, oxygen carrying pigment of blood. It consists of the protein globin united with the pigment heme. Heme is an iron containing porphyrin called ironprotoporphyrinIX and the iron in heme is in the ferrous (Fe^{2+}) form. According to *Ayurveda*, *Ranjak Pitta* is located in *Yakrit* and *Pleeha*. In human body, iron is stored as ferritin and hemosiderin. 30% of iron is stored in liver, 30% in red bone marrow and rest in spleen and muscles. So, we can say that ferritin and hemosiderin form of iron is the coloring agent of blood and is similar to *Ranjak Pitta*.

*Acharya Vagbhat* has stated that *Ranjak Pitta* is located in *Amashaya* (stomach). In the stomach, parietal cells secret a type of glycoprotein called castle’s intrinsic factor (CIF). The CIF is essential for the absorption of VitB_{12}. Vit B_{12} combines with CIF and travels down to the terminal intestine. After absorption from the ilium, combined vit B_{12} is reaches to the liver and stored there. From the liver, vit B_{12} goes to red bone marrow to participate the hematopoiesis. Therefore, the castle’s intrinsic factor may represent *Vagbhat’s Ranjak Pitta*.

*Ayurveda* mentioned the *Raktagni* as an important factor for the formation of blood. Modern science has also accepted an another factor besides vitamins and iron that is Hematopoietic Growth Factor (HGF) which includes erythropoietin, myeloid growth factor, thrombopoietin and interleukins. The HGF are the regulatory proteins which stimulate the production of different blood cells. Functions of HGF are much similar to the function of *Raktagni*.

*Ayurveda* says that the *Yakrit* and *Pleeha* are the organs where *Raktadhatus* is formed. In the intrauterine life, from 3rd week to 3rd month hematopoiesis occurs in the blood
vessels of yolk sac. From 3rd month, hematopoiesis occurs mainly in the liver and partly in the spleen. Liver also produce various hematopoietic growth factor. After birth the formation of blood is processed in red bone marrow of long and flat bones. Ayurveda has not given any reference of that. Liver and spleen are not involved directly but some substances which come from these organs to red bone marrow, are participate the hematopoiesis.

According to Ayurveda SaraktaMeda is present in small bones. Though the hematopoietic function of SaraktaMeda is not described in Ayurveda, yet it may be red bone marrow.

**CONCLUSION**

After this conceptual and correlative study we found out some important facts about hematopoiesis. Ayurveda and modern science have almost same opinions about hematopoiesis in intrauterine life. After birth hematopoiesis takes place in red bone marrow but Ayurveda has not given any reference of that. In Ayurveda, liver and spleen are described as hematopoietic organs because many hematopoietic substances come to red bone marrow from liver and spleen. So, these organs are indirectly involved in hematopoiesis. Sarakta Meda can be compared with red bone marrow. Ranjak Pitta is a main coloring agent of Raktadhatu which is similar to iron and castle’s intrinsic factor. Concept of Raktagni can be much similar to the function of various HGF.
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