Ayurvedic Perspectives on Physiology of Blood (Rasa-Rakta Dhatu) and its Applied Aspects

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INTRODUCTION

Dosha (biological functional entity), Dhatu (tissue) and Mala (waste products) are said to be foundation of the body. Rasa (plasma) and Rakta (formed elements of blood) both are liquid, as their measurement is described in terms of Anjali Praman (measurement of liquid by joining both the hands) and both are in continuous circulation. Rasa is the first Dhatu formed after complete digestion of food and due to its continuous circulation is called as Rasa. The function of Rasa Dhatu is Preenana (nutrition). Rakta Dhatu has been considered to be most vital amongst the seven tissues, since it is mentioned as Pranayatana (seat of life) among the ten seats of Prana (life). Rakta plays an important role in sustenance of life, viz. acute blood loss of more than 10% leads to conditions like hypovolemic shock, which may be fatal. It is also responsible for increase or decrease in other Dhatus, because blood supplies nutrition to all the tissues and if it is itself deficient, it will lead to improper nutrition to other tissues, ischemia and hypoxia which ultimately leads to tissue death. Hence nutritional status of all the tissues will depend on the status of Rakta Dhatu.

Considering such a great physiological importance of Rakta, Sushruta designated it as fourth Dosha, apart from the three Doshas Vata, Pitta, Kapha. The scholars of ancient Greek medicine have also considered that the regulators of all physiological processes in body are the four humors- 1) blood, 2) phlegm, 3) yellow bile and 4) black bile. Unani medicine has also accepted blood (Dam) as a humor. Thus, different disciplines of ancient medicine have recognized the importance of blood in maintenance of homeostasis of body. For assessing the functional adequacy of Rasa-Rakta Dhatu in an individual, certain physiological, psychological, somatic features related to these Dhatu have been described under the examination of Dhatu Sarata (excellence of tissues).

Aims and Objectives of this study
To study and critically analyze the physiology of blood and its applied aspect described in Ayurveda.

MATERIALS AND METHODS
A comprehensive study was done on Rakta and Rasa Dhatu and their respective Srotas. Descriptions were collected from standard Ayurvedic literatures (Samhitas) and recent research papers related to it. Research papers and articles were searched online from scientific electronic databases as PubMed, Google scholar etc. and were analyzed in view of modern physiology, so as to understand the physiology of blood and its applied aspect described in Ayurveda.

REVIEW AND DISCUSSION
What is blood in Ayurveda?
Blood is a connective tissue which is in fluid form. Rasa and Rakta Dhatu altogether can be considered as blood, as both are liquid and circulating in intravascular compartment. While describing the circulation of Rasa by the action of Vyana Vayu (a subtype of Vata.
Dosha), Chakrapani has explained the term Rasa as “Rasateeti raso dravadhatuachyate taenurdhirraadinaamapi dravasnam grahamam bhavati”, where the term Rasa stands for intravascular circulating fluid (Drava) i.e. plasma including the blood cells. Bhela has also used word Rasa while describing the circulation of Rasa in heart and blood vessels. Again, the term Rasa-Rakta has been used for the completely digested essential and minutest material (nutrients absorbed in blood). Rasa is clear and colourless, so it refers to plasma; Rakta can be taken as Red Blood Cells (RBCs), as it is said to be of red color like Gunjiaphala (fruits of Abruus precatorius) and Padma (Nelumbo nucifera); whereas the White blood cells (WBCs) can be considered as Shonitarupi Oja.

After complete digestion of food, Aahara Rasa (nutrient rich extract) is formed, which gets absorbed into Dhamani (arteries) and is circulated into whole body by action of Vyana Vata. The above references signify that in Ayurveda, the term Rasa has been used for the fluid which is pumped by heart into blood vessels and that fluid is blood as per modern physiology. Charaka has described that the Oja (component of blood which provides immunity) gets circulated from the Mahata (heart) through Rasavaha Dhamani (blood vessels). Hemadri has described different types of Ojas, among which the Rasatmaka Oja can be considered as substances of complement system, antibodies; Dhatutejorupi-Oja can be considered as he tissue macrophages or all WBCs present in tissues; and Shonita rupi Oja as the WBCs in blood. Thus the Rasa-Rakta Dhatu, Rasatmaka Oja, Shonitarupi Oja altogether which is continuously circulating in the intravascular compartment could be considered as components of blood.

![Fig.1: Schematic presentation of composition of blood](image)

**Functional similarities between blood and Rasa-Rakta**

Plasma carries all nutrients; RBCs are carrying oxygen (Prana Vayu) as indicated in Ayurveda too-“Praninama Pranah Shonitam Hiyanuvartate”. Modern physiology has also considered blood as ‘fluid of life’ because it carries oxygen (O2) from lungs to all parts of body and carbon dioxide (CO2) from all of the body to lungs. The Rasa Dhatu is said to serve functions of nourishment (Tarpayati), growth (Yardhyayati), Dhayayati (sustenance of tissues). Similarly, blood is also known as ‘fluid of growth’ as it carries nutritive substances (Rasa) absorbed from digestive system (Mahasrotasa) and hormones from endocrine glands to all the tissues. Blood is also called the ‘fluid of health’ because it protects body against diseases as it contains Oja (immunglobulins, i.e. Rasatmaka Oja and WBCs, i.e. Shonitarupi Oja).

**Formation of Rakta Dhatu**

Rakta is formed from the nutrient fraction of Rasa Dhatu in Rakavaha Srotomoola (root of channels related to haemopoiesis). Rasa which is clear like water, attains the red color after it reaches liver and spleen due to action of Ranjukaagni. The entire nutrient required for the synthesis of blood cells are taken from Rasa Dhatu. Liver synthesizes haem, clotting factors and proteins of plasma and some nutrients (Vitamin B12 and folic acid) are stored in liver also. Liver and spleen are considered as root of Rakavaha Srotas. because synthesis of blood cells occurs in liver and spleen during third to fifth month of intrauterine life and both the organs act as blood reservoir. Along with liver and spleen, Rakavaha Dhamani (blood vessels) has also been considered as root of Rakavaha Srotamsi. It means that Rakavaha Srotas includes both haemopoietic system and a part of cardiovascular system Rakavahi Dhamani (blood vessels). In third week of intrauterine life, blood cells and blood vessels are formed from the blood islands which are clusters of mesodermal cells in the wall of yolk sac near allantoic diverticulum. This blood island is later on converted to precursor cells haemangioblasts, the center of which forms haemopoietic stem cells and the periphery forms angioblasts. Embryologically both blood cells and blood vessels have same origin, so in Ayurveda, Sira (blood vessels) have been considered as Upadhatu (secondary tissue) of Rakta. Spleen has been considered as a root of Rakavaha Srotasa and site of haemopoiesis which may be due to its embryonic origin because it develops as a collection of mesenchymal cells in the dorsal mesogastrium. These mesenchymal cells differentiate to form lymphoblasts and other blood forming cells. According to Vagbhatta, the Rakta attains red colour in Aamashaya (stomach), which can be considered as gastric intrinsic factor of castle that is required for the absorption of vitamin B12, which in turn is needed for DNA synthesis of the RBC precursors in the bone marrow.

**Majja Dhatu** (bone marrow) also plays an important role in formation of Rakta Dhatu. Majja is present in the cavities of large bone, whereas Sarakta Meda (red bone marrow) is present in the cavities of small bones. Majja Vriddh produce heaviness in eye and body, and Rakta Gaurava. Again, the features of Majja Pradoshaja Vikara (disorders due to vitiation of Majja Dhatu) like Murchha (fainting), Bhrama (dizziness), Timir Darshana (perception of darkness) manifests in condition of anaemia due to blood disorders or decrease of blood volume. Also, there are some very important similarities between Ayurveda and ancient Greek theories of medicine proposed by Galen, regarding the
formation of blood and its circulation. Galen believed that the digested food called chyle, reaches the liver, from the intestines and it was then converted into blood there. Galen also described that the blood after reaching the heart, was carried to all the parts of body through veins, and was then converted into flesh. [32]

Sites of Rakta Dhatu

Rakta Dhatu is situated in whole body, [33] although the organs considered as the reservoir of Rakta Dhatu are Yakrita (liver), Pitla (spleen), [34,35] Hridaya (heart), [36] Raktadharana Kala, [37] and Asrigdhara Kala (layer of skin). [38] Raktaadi Dhatu circulates in the whole body, although main sites are Hridaya, [39] and blood vessels.

Panchabhautika composition of blood

Rakta Dhatu is Panchabhatu (five basic elements) in nature, so it possess the attributes of each Mahabhuta (elements)- the typical smell is due to Pritvi (earth), fluidity (Dravata) is due to Jala (water), redness (Raga) is due to Agni (biofire), pulsation and motion (Spandanana) is due to Vayu (air) and lightness (Laghata) is due to Aakasha (space). [40]

Physical characteristics of Rakta Dhatu

Quantity of Rakta is 8 Anjali. [41] It is neither too cold nor too hot, sweet and salty in taste, unctuous, red coloured, and heavy. It is Asamhata (loose), which means which is neither too thick nor too thin; due to this property, blood does not clot in the intravascular compartment. It’s being Avirvana means that pure blood does not stain the cloth, while impure blood stains the cloth in such a way that it does not get clean even after washing. [42,43]

Colour Index: Oxygenated blood is of scarlet red colour, but as per description in Ayurveda, red colour index varies among different individuals as per Prakriti (psychosomatic constitutions). Ayurveda describes different similres for blood’s red colour index, such as molten gold, Indragopa (cochineal insect), lotus flower, laksha, berry of Ganja (Abrus precatorius Linn), blood of sheep and rabbit; they all are of red colour but of different shades. [44,45,46] A study in 2008, “whole genome expression and biochemical correlation of extreme constitutional type defined in Ayurveda”, has reported that there is difference in hematological parameters like Haemoglobin concentration, packed cell volume (PCV), RBCs count in individuals of different Prakriti. These values tend to be higher in Pitta Prakriti as compared to Vata and Kapha. [47] Another study in 2012 showed that Adenosine diphasphate (ADP) induced maximal platelet aggregation was found high in Vata Pitta Prakriti individuals. [48]

Factors affecting formation of Shuddha Rakta

Charaka has described various factors that affect formation of Shuddha Rakta Dhatu (best quality blood cells) like diet and regimen, Deshasatmya, Kalasatmya and Okasatmya (respectively meaning, aclimation to habitat, seasons and habits). [49] Diet: Use of foods which are neither too hot nor too cold, light and Deepana (digestive power stimulant) are good for the formation of blood. [50] Use of diet opposite to constitution ; excessive hot, sour, salty substances; alcoholic beverages; use of Kadathya (Dolichus biflorus Linn), Tila (Sesamum indicum Linn), Malaka (Raphanus sativus Linn); meat of animals living in water, marshy regions, burrows and Prasaha (beast or bird of prey) kind; use of sour curd, scum of curd, Shukta (fermented guel), Sara (beet) and Sauvrika (variety of beer); food which are incompatible, soaked in water and decomposed, they all lead to vitiation of Rakta Dhatu. [51] Also, if our diet is deficient of iron or Vitamin B12 and folic acid, it will lead to iron deficiency anemia and megaloblastic anemia respectively. [52]

Code of conduct: Not only the type of Ahara (diet) we ingest affects the quality of blood, but also the type of Vihara (actions and behaviour) does the same. Sleeping during daytime after meal, excessive anger and exposure to sun, bloodletting not done at proper time, suppression of urges like vomiting, exertion, and injury can all lead to vitiation of Dosha. [53]

Ayurveda also considers excessive exposure to sun as an etiological factor for vitiation of blood and production of its disorders. Recently many researchers have found significant association of various good and bad effects related to excessive sun exposure. A study in 2014 showed that excessive exposure to sunrays is associated with decreased serum folate status in women of child bearing age, whereas as an in-vitro study in 2007, the folate and its synthetic derivative, folic acid are both vulnerable to degradation by ultraviolet (UV) B radiation. [54,55] Lucas RM (2006) has suggested the consequences of excessive exposure to UV radiations, such as skin cancer, cataract and other eye diseases, and viral infections caused by UV-induced immunosuppression. [56] Radiation suppresses bone marrow, leading to disorders of blood cells as in aplastic anemia. [57]

Desha Satmya: It is also a determinant of the quality of blood. Diet and regimen which are opposite to the inherent nature of a Desha (habitat) , are often beneficial for body. [58] It determines attributes due to procreation or movement of food substances in a particular locality or their aclimation to that region. [59] The individuals living in high altitude area of 14,000-17,000 feet have physiological polycythemia. Similarly, deep sea diving leads to O2 toxicity, CO2 toxicity and decompression sickness. [60]

Kala Satmya: Kala stands for both, the time form of day and night, seasons (nityaga) and the age of an individual (Aumastika). [61] Practice of diet and regimen according to seasons (Ritucharya) is beneficial to health. [62] Rakta Dhatu gets vitiated in Sharada Ritu (autumn season) by its virtue. In females, the blood indices vary according to her physiological state like menstruation, pregnancy etc. Concentration of Hb varies with human age, like at birth it is 23 gm/dl, at the end of three month it is 10.5gm/dl and after that it increases steadily to become 15.5gm/dl in adult males and 14 gm/dl in adult females. [63]
Characteristics of impure or vitiated *Rakta Dhatu* [64, 65]

*Rakta Dhatu* vitiated by *Vata Dosha* becomes slightly reddish or black, non-slimy, thin, flowing quickly and non-clotting; by *Pitta Dosha*, colour becomes bluish-yellow, green or black, red, unpleasant smelling, not liked by ants and flies, and non-clotting; by *Kapha Dosha*, causes colour similar to solution of Gairika (red ochre), slightly white, slimy, unctuous, cold, thick flowing slowly, has threads and resembling a muscle; by Tridosha, resembles to Kanjika (rice gruel), foul smelling.

**Role of Rakta Dhatu in embryogenesis**

*Rakta Dhatu* along with other *Dosha* and *Dhatu* plays an important role in formation of organs like *Yakrita* (liver), *Plitha* (spleen), *Phupphusa* (lungs), *Undaka* (appendix), *Guda* (anus), *Basti* (bladder), *Jivha* (tongue), *Vrikka* (kidney), *Vrishana* (testes), *Hridaya* (heart) and *Pranavaha Dhammies* (vessels carrying Prana Vata). [66] All these organs derived with the help of *Rakta*, have high vascularity and some organs like liver, spleen, lungs, heart also act as reservoirs of blood.

**Metabolism of Rakta Dhatu**

During the metabolism of *Rakta Dhatu*, the nutrient part of *Rakta Dhatu* nourishes the next *Dhatu* i.e., *Mamsa Dhatu* and *Malarupi* (similar to waste) *Pitta* is formed as *Mala* (waste), and *Kundra* (tendon), *Sira* (blood vessels) are produced as *Updhatu*. [67] *Malarupi Pitta* may be considered bilirubin which is formed as breakdown by product of RBCs in liver. [68] The possible explanation regarding the *Siras* as *Updhatu* (subsidiary tissue) of *Rakta Dhatu* is that the *Rakta Kshaya* (decreased quantity of blood) or *Rakta vyrriddhi* (increased quantity of blood) are directly reflected through the condition of the *Siras*. Looseness of *Siras* in case of *Rakta Kshaya* and fullness of *Siras* in case of *Rakta Vridhdi* is found.

**Features of Raktasarara Purusha**

It reflects the status of *Rakta* in an individual, i.e. whether it is *Pravara*, *Madhyama* or *Avara* (high, moderate and minimal level of excellence of *Dhatu*). Raktasarara individuals have reddish, unctuous and bright ears, eyes, mouth, tongue, nose, lips, palm and planter aspects, nails forehead and penis. The mentioned sites can be observed to be the most superficial and exposed parts of the body. These sites are clinically useful, such as in examination of anemia, jaundice. Along with it, the psychological traits of such people have also been mentioned such as being happy, aggressive, intelligent, tender and intolerant to strain and warm environment. [69, 70]

*Bhelu* has described certain features of a healthy person on the basis of redness present over face, eyes, body, palm and soles. [71] In a study in 2014, “Study of *Dhatu Sarata* and its association with blood indices”, a positive correlation was found between blood indices and Raktasarara, especially *MCHC* and *Rakta sarara*. [72] In 2015, a study on *Dhatusarata* reported that the healthy male individuals have more RBC count, HB%, HCT, MCHC and Platelet count than the female subjects. [73]

**Features of Rakta Kshaya**

Signs and symptoms of *Rakta Kshaya* are often manifested through the changes in quality and complexion of skin. A healthy smooth skin with luster is an indicator of good status of *Rakta Dhatu*. The individuals suffering from *Rakta Kshaya* have rough, cracked and dry skin, loss of luster, crave for sour and cold substances and have looseness of the vessels. [74, 75] *Dalhana* has explained that the desire for sour substances is due to aggravation of *Vata Dosha*, as sour substances will suppress this aggravated *Vata*. Again due to *Rakta Kshaya*, there is a loss of fluid content of the body and the resultant increase in hotness leads to enhanced desire of cold substances. Looseness of veins may be due to hypovolemia in case of blood loss. All these features of *Rakta Kshaya* are very similar to those characteristics which are found in an anaemic state of body.

**Features of Rakta Vridhdi**

Vitiated *Rakta Dhatu* leads to reddish discolouration of body and eyes, fullness of veins, [76] and production of skin diseases like *Vidradhi* (abscess), *Visrapa* (erysipelas), *Kushta* (skin disorder), *Vyaanga* (depigmentation), diseases of spleen, *Vatarakta* (gout), *Galma* (abdominal tumour), *Upkusha* (disease of gums), *Kamala*, loss of *Agni* and red colouration of urine too. [77] Excessive sleep, excessive thirst, anorexia, belching of bitter and sour material, profound debility, excessive sweating and bad smell of body also manifests due to vitiation of *Rakta Dhatu*. [78] In *Rakta Pradoshaja Vikara* (diseases due to vitiated *Rakta*) like *Kamala* and in other disorders, the *Srotomoola*, *Yakrita* and *Plitha* are affected.

Chakrapani explained *Srotomoola* as “mulamitiprabhavasthanam”, meaning that *Moola* of a *Srotas* may be the anatomical seat of the respective *Srotas*, the primary seat of pathology of that *Srotas* or may be the site of manifestation of disease. So in *Rakta Pradoshaja Vikara*, involvement of liver and spleen is found, which are clearly identified in Ayurveda as the *moola* of Raktavaha Srotas. [79]

**Preventive measures for Rakta Doshaja Vikara**

In *Ritucharya* of *Sharada Ritu*, *Raktamokshana* (blood-letting) should be adopted to relieve the impurities in *Rakta Dhatu*. *Raktamokshana* is also indicated in treatment of *Rakta Pradoshaja Vikara*. Bloodletting should be done in accordance with the strength of body and *Dosha*, until pure blood remains in the body. [80]

**Methods of blood clotting**

There are four methods to stop bleeding- Sandhana (union), Skandana (clotting), Pachana (styptic for closing wound) and *Dahana* (cauterization). *Sandhana* means union and is done with the help of astringent substances; *Skandana* is done by using cold substances; *Pachana* is done by using ash; and *Dahana* is done by cauterization, which causes constriction of blood vessels. *Skandana*, *Sandhana*, *Pachana* and *Dahana* are used in a sequential manner. [81]
Introduction of whole blood in management of blood loss

In case of extreme blood loss, consumption of blood with honey or consumption of raw liver with its content is advised. Livers are a rich source of all the nutrients required for synthesis of blood and clotting factors. In case of Jivadana (bleeding) which can occur as a complication of improper purgation technique, as a life supporting measure the person is even advised to drink the fresh blood of deer, cow, buffalo or goat because of the belief that it gets immediately transformed into live blood. Enema can also be given with a mixture of this blood with Darbha (Desmostachya bipinnata) powder. In case of excessive haemorrhage, enema of mixtures of milk of cow, sheep, goat or buffalo with the paste of Jivaniya groups of drug and fresh blood of rabbit, deer, cock, cat, buffalo, sheep or goat is recommended. Use of Rakta as nasal drop is indicated in the treatment of Krimija Shiroroga (disorders of brain caused by worms).

CONCLUSION

On the basis of above discussion, the Rasa and Rakta Dhatu can be considered as blood because they both are in liquid (Drava) state, which gets circulated in intravascular compartment (heart and blood vessels) and have functional similarities. It is distributed to all throughout the body due to action of Vyana Vata on heart and blood vessels (cardiovascular system), which is similar to blood and there are great similarities at functional level too. The Rasa- Rakta Dhatu carries all the nutrients along with Oja and nourishes and protects all the tissues. Characteristics of the best quality of Rasa and Rakta Dhatu and Dhatusarara have been described in order to clinically assess the functional status of a particular Dhatu. Various factors like diet and regimen, Deshasatmya, Kalasatmya and Oakasatmya have been described, that affects the formation of Shuddha Rakta Dhatu and may produce various disorders related to blood. Various measures for blood loss and blood clotting have been also described. These descriptions show that a very detailed physiology of blood and its applied aspect have been discussed by the ancient Ayurvedic scholars, and the scientific explanations in this article may be helpful in its understanding.

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