# Chapter 12
# Characteristics of Healthy Blood

**Geetika Garg, Sandeep Singh, Abhishek Kumar Singh, and Syed Ibrahim Rizvi**

**Abstract** Blood is a specialized fluid consisting of plasma and cells that circulate through the entire body. Blood also contains essential nutrients, oxygen, and hormones in adequate quantity that makes the blood healthy. Some infections in the blood affect its overall health. These are bacteria and blood borne viruses that make the blood infected. Healthy blood is free from all kind of such infections. Blood plays an important role in regulating the body's systems and in maintaining the dynamic homeostasis. It carries oxygen, nutrients and hormones to living cells and takes away their waste products. Blood delivers immune cells to fight infections and contains platelets that can form a plug in a damaged blood vessel to prevent blood loss. Clinical markers associated with blood are used for the diagnosis of various health issues or pathological conditions. Biomarkers of oxidative stress in erythrocytes and plasma are extensively used to study physiological and metabolic processes. During the course of their natural aging erythrocytes can undergo an apoptosis-like cell death, termed eryptosis. This chapter provides an account of the composition and markers of healthy blood and its role in the maintenance of overall health.

**Keywords** Blood · Plasma · Erythrocytes · WBC · Health

## 12.1 Introduction

Blood is a specialized fluid connective tissue and a lifesaving liquid organ. Blood plays an important role in regulating the body's systems and maintaining homeostasis. It carries oxygen, nutrients and hormones to living cells and takes away their waste

G. Garg · S. Singh · S. I. Rizvi (✉)
Department of Biochemistry, University of Allahabad, Allahabad 211002, India
e-mail: sirizvi@gmail.com

G. Garg
Department of Zoology, Savitribai Phule Pune University, Pune 411007, India

A. K. Singh
Amity Institute of Neuropsychology and Neurosciences, Amity University Uttar Pradesh, Noida, India



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products. Blood delivers immune cells to fight infections and contains platelets that can form a plug in a damaged blood vessel to prevent blood loss. The blood that runs through the veins, arteries, and capillaries is known as whole blood. Whole blood is a mixture of cellular elements, colloids and crystalloids. Blood is circulated around the body through blood vessels by the pumping action of the heart. The arteries deliver oxygenated blood, glucose and other nutrients to the brain and the veins carry deoxygenated blood back to the heart, removing carbon dioxide, lactic acid, and other metabolic products.

The average human adult has more than 5 L of blood in their body, which is composed of plasma and several kinds of cells. Some of the most common blood tests determine which substances are present within blood and in what quantities. Other blood tests check for the composition of the blood itself, including the quantities and types of formed elements.

## 12.2 Characteristics of Healthy Blood

The first characteristic of blood is its colour. Blood that has taken up oxygen in the lungs is bright red, and blood that has released oxygen in the tissues is a dusky red or dark red. This is because of binding capacity of hemoglobin to oxygen. Another characteristic of blood is its viscosity which is five times greater than water. It is a measure of fluid's thickness and is influenced by the presence of plasma proteins and formed elements. Viscosity affects the blood pressure and blood flow. The pH of blood also determines its quality, and it ranges from 7.35 to 7.45 in a healthy person. Buffers present in the blood help to regulate pH.

### *12.2.1 Components of the Blood*

Blood has four major components: plasma, red blood cells (RBCs), white blood cells (WBCs), and platelets. A brief description of the constituents of normal healthy blood is given below, and are listed in Table 12.1.

***Plasma***: Blood plasma is the yellowish liquid part of the blood that carries cells and proteins throughout the body. It makes up about 55% of the body's total blood volume. Plasma serves as a transport medium for delivering nutrients to the cells of the various organs of the body and for transporting waste products derived from cellular metabolism to the kidneys, liver, and lungs for excretion. Plasma contains proteins that help blood to clot, transport blood cells throughout the body along with nutrients, antibodies, hormones and proteins that help to maintain homoeostasis. Blood plasma also contains glucose and other dissolved nutrients that makes the blood healthy. Clinical diagnostic markers in plasma and serum are listed in Table 12.2.

***Red blood cells (RBC)***: The percentage of whole blood volume that is made up of red blood cells is called the hematocrit and is a common measure of red blood cell

**Table 12.1** Constituents of normal blood

| S. No. | Blood component | Reference range | |
|---|---|---|---|
| | | Male | Female |
| 1. | Red blood cells (RBC) | 4.3–5.9 million/mm$^3$ | 3.5–5.5 million/mm$^3$ |
| 2. | Hemoglobin (HGB) | 13.5–17.5 g/dL | 12.0–16.0 g/dL |
| 3. | Hematocrit (HT) | 41–53% | 36–46% |
| 4. | White blood cells (WBC) | 4500–11,000/mm3 | 4500–11,000/mm3 |
| 5. | Mean corpuscular volume (MCV) | 80–100 μm$^3$ | |
| 6. | Mean corpuscular haemoglobin (MCH) | 25.4–34.6 pg/cell | |
| 7. | Mean corpuscular hemoglobin concentration (MCHC) | 31–36% Hb/cell | |
| 8. | Platelets | 150,000–400,000/mm$^3$ | |

levels. Production of red blood cells takes place in the bone marrow under the control of the hormone erythropoietin and after approximately seven days of maturation they are released into the bloodstream. The morphology of RBC is essentially based on the size which varies in different animals. Generally, erythrocytes have a diameter of 4–10 μm. All non-mammalian (birds, reptiles, amphibians and fish) erythrocytes with a few isolated exceptions are nucleated and contain organelles in their cytoplasm. In humans, the mature form of healthy erythrocyte is normally a non-nucleated, yellowish and biconcave disk shaped (discocyte) when not subjected to external stress (Hillman and Finch 1996). The biconcave shape provides a large surface-to-volume ratio for oxygen delivery and better flexibility in narrow capillaries, and thereby RBCs can easily change their shape, which help them to fit through the various blood vessels in the body. However, while the lack of a nucleus makes a red blood cell more flexible, it also limits the life of the cell as it travels through the smallest blood vessels, damaging its cell membrane and depleting its energy supplies (Diez-Silva et al. 2010; Kuhn et al. 2017). Erythrocyte longevity varies across the major vertebrate groups, in humans the cellular half-life of erythrocytes is about 120 days, and is about 40, 600–800, 300–1400 and 80–500 days in birds, reptiles, amphibians and fish, respectively. These characteristics of RBC are essential for biological functions and can be affected by genetic or acquired pathological conditions. Healthy blood meets all these conditions to maintain fluidity and elasticity of membrane.

***White Blood Cells (WBCs or Leukocytes)***: The WBCs (also called leukocytes) are of two types (Greek "leukos" meaning "white" and "kytos," meaning "cell"). The granular leukocytes (eosinophils, neutrophils, and basophils) are named for the granules in their cytoplasm; the agranular leukocytes include monocytes and lymphocytes which lack cytoplasmic granules (Feher 2012). Pluripotent stem cells in the bone marrow produce myeloid and lymphoid progenitors. The myeloid progenitor differentiates further into a granulocyte/macrophage progenitor that further differentiates into the granulocytes and the monocytes while lymphoid progenitor produces

**Table 12.2** Clinical diagnostic markers in plasma and serum

| S. No. | Markers | Clinical significance | Reference range | Reference |
|---|---|---|---|---|
| 1. | Blood glucose | Supply energy to all cells in the body. Blood glucose higher than that of normal level indicate hyperglycemia and lower level indicates the hypoglycaemia | 70–90 mg/dL fasting, 140 mg/dL 2 h after eating | (Duckworth 2001; Kalra et al. 2013) |
| 2. | Total cholesterol | Used to build the structure of cell membrane and hormones. Help the metabolism to work efficiently | <200 mg/dL | (Lin et al. 2015) |
| 3. | Triglyceride | Stored in fat cells. Contribute to measure the heart health. Harden the artery wall, which increases risk for stroke, heart attack, and cardiovascular disease. High triglycerides are a sign of other conditions such as obesity, diabetes, hypothyroidism, and liver or kidney disease | <150 mg/dL or < 1.7 mmol/L | (Teixeira et al. 2019) |
| 4. | HDL | Helps to remove LDL from blood | 60 mg/dL | (Després et al. 2000) |
| 5. | LDL | Indicate the risk of heart attack, stroke, and atherosclerosis | <100 mg/dL | (Ivanova et al. 2017) |
| 6. | Troponin | Used to detect chest pain or heart attack | 0–0.4 ng/mL | (Al-Otaiby et al. 2011) |
| 7. | Total protein | Necessary for body's growth, evelopment, and health. Level indicated about disease status in different organs | 6–8 g/dL | (Krisko and Radman 2019) |
| 8. | Albumin | Help to diagnose liver and kidney dysfunction | 3.5–5.0 g/dL | (Chien et al. 2017) |

(continued)

**Table 12.2** (continued)

| S. No. | Markers | Clinical significance | Reference range | Reference |
|---|---|---|---|---|
| 9. | Bilirubin | Used to assess liver function. It helps to determine the cause of jaundice and diagnose conditions such as liver disease, hemolyticanemia, and blockage of the bile ducts | 0.2–1.2 mg/dL | (Vítek 2017) |
| 10. | SGPT (ALT) | Specific indicator of liver inflammation. Elevated level indicates the medical problems such as viral hepatitis, diabetes, congestive heart failure, liver damage, bile duct problems, infectious mononucleosis, or myopathy | 7–56 U/Liter of serum | (Ramaty et al. 2014) |
| 11. | SGOT (AST) | Commonly measured as a part of liver function test. Its level elevated also in diseases such as myocardial infarction, acute pancreatitis, acute hemolyticanemia, severe burns, renal disease, muscular dystrophyand trauma | 5–40 U/Liter of serum | (Mavis and Alonso 2015) |
| 12. | Urea | Serum urea concentration reflects the balance between urea production in the liver and urea elimination by the kidneys | 5–20 mg/dL or 1.8–7.1 mmol urea/liter | (Bowker et al. 1992; Vanholder et al. 2018), |
| 13. | Creatinine | Level elevated when there is a significant reduction in the glomerular filtration rate or when urine elimination is obstructed | 0.6–1.2 mg/dL in adult male and 0.5–1.1 mg/dL in adult female | (Winnett et al. 2011), |

(continued)

**Table 12.2** (continued)

| S. No. | Markers | Clinical significance | Reference range | Reference |
|---|---|---|---|---|
| 14. | Uric acid | High blood concentrations of uric acid can lead to gout and are associated with other medical conditions, including diabetes and the formation of ammonium acid urate kidney stones | 2.4–6.0 mg/dL (female) and 3.4–7.0 mg/dL (male) | (Jin et al. 2012; MacFarlane and Kim 2014) |
| 15. | Creatine kinase | Used to detect muscle dystrophy and myocardial infarction | 22–198 U/L | (Blanke et al. 1984) |
| 16. | Sodium | Sodium concentration on mortality in patients hospitalized with heart failure and hyponatremia | 135–145 mEq/L | (Madan et al. 2011) |
| 17. | Chloride | Hyperchloremia, hypochloremia is more closely associated with increased mortality and should certainly be considered by intensive care physicians | 96–106 mEq/L | (Pfortmueller et al. 2018) |
| 18. | Phosphorus | Risk factor for cardiovascular disease | 2.5–4.5 mg/dL | (Gutiérrez 2013) |
| 19. | Lactate dehydrogenase | Lactate dehydrogenase and lactate dehydrogenase isoenzyme measurements in serum in the following main clinical fields: cardiology, hepatology, haematology and oncology | 140–280 U/L | (Huijgen et al. 1997) |

(continued)

**Table 12.2** (continued)

| S. No. | Markers | Clinical significance | Reference range | Reference |
|---|---|---|---|---|
| 20. | C-Reactive protein | Acute-phase marker in tissue injury, infection and inflammation and atherosclerosis. It now has a distinct status of a disease marker in cardiovascular diseases and is well known of its clinical and pathological significance | <3.0 mg/L | (Ansar and Ghosh 2013) |
| 21. | Thyroid hormone | Potent regulators of multiple physiological activities, including cellular metabolic rate, heart and digestive functions, muscle function, brain development, and bone maintenance | Adult: 2–10 μ U/mL<br>Newborn: 3–18 μ U/mL | (Premachandra and Walfish 1982) |
| 22. | Steroid hormone | Help control metabolism, inflammation, immune functions, salt and water balance, development of sexual characteristics, and the ability to withstand illness and injury | NA | (Holst et al. 2004) |

lymphocytes. WBCs are an important part of the body's defense against infectious organisms and foreign substances. To defend the body adequately, a sufficient number of WBC receive a message that an infectious organism or foreign substance has invaded the body, and that they should get to where they are needed, and then kill and digest the harmful organism or substance. Adequate defense include different blood cells having different functions: some fight intruders such as bacteria, viruses, parasites or fungi themselves and render them harmless. Others produce antibodies, which specifically target foreign objects or viruses. Certain lymphocytes can also kill cancerous cells that have been produced elsewhere in the body. There are five types of WBC:

1. Neutrophils: each $mm^3$ of blood contains 4000 to 11000 WBCs of which neutrophils comprise of 50–70% of the white cell count. The neutrophils are the most numerous type of the leukocytes. During tissue injury, they leave the circulatory system early in the inflammatory response to bacterial invasions.
2. Basophils: These are the least in number comprising <1% of total WBCs. Structurally and functionally they resemble mast cells. However, basophils originate in the marrow whereas mast cells originate from precursor cells in the connective tissue. Both basophils and mast cells contain secretory granules that store histamine and heparin, among other chemicals.
3. Eosinophils: These cells make 4% of total WBCs but are readily identifiable in blood smears because their cytoplasmic granules take on an orange-red to bright yellow color when stained with eosin. They have roles in hypersensitivity and allergy and their number increases during allergic conditions such as hay fever and asthma.
4. Monocytes: These have several functions, including bacterial removal, are active in inflammation and in repair of damaged tissues, and are the largest of the leukocytes. They are released into the blood from the marrow in an immature form with little phagocytic ability. They circulate in the blood until they find a suitable home in the tissues, where they greatly enlarge to become tissue macrophages. Their life span varies from months to years, depending on their activity.
5. Lymphocytes: These are the second most common WBC (approximately 20–25% of the white cell count), and are divided into two major types: B lymphocytes, which make antibodies, and T lymphocytes, which destroy cells infected with viruses. All three cell types derive from a single lymphoid stem cell. The thymus modifies the cells that become T-lymphocytes and these cells promote cell-mediated immunity. The bone marrow influences the cells that become B cells, and these cells differentiate to form plasma cells which produce circulating antibodies that comprise humoral immunity. These cells work together to defend the body against foreign substances, such as bacteria, viruses, and cancer cells.

***Platelets***: These are small enucleate cell fragments that circulate in blood and play a crucial role in managing vascular integrity and regulating homeostasis. Primarily they are associated with hemostasis, which is to initiate blood coagulation. Although very dynamic, they usually remain in an inactive state and get activated only when a blood vessel is damaged. Hemostasis or blood coagulation is not the sole function of platelets; rather it is employed in several multifunctional attributes monitoring the homeostasis of the body.

## 12.3 Clinical Markers for Health Associated with Blood

Blood is continuously exposed to plenty of metabolites and free radicals. The overall health of organisms and a wide range of disorders associated with blood can be detected by complete blood count (CBC). A CBC test measures several components and features of the blood, including RBCs, WBCs, hemoglobin, hematocrit and platelets. Abnormal increases or decreases in cell counts may indicate that a person has some kind of ailment that calls for further evaluation. The disorders of RBC can be divided into those of decreased RBC mass (anemias) and those of increased RBC mass (erythrocytoses). The excess RBC usually create no problems but may cause blood clots in some people.

A higher than normal count of WBC leads to a condition known as leukocytosis, which is usually caused by bacterial infection, tissue damage, and inflammatory diseases (Wahed and Dasgupta 2015). A lower count, a condition known as leukopenia, is often associated with bone marrow deficiency, certain viral infection, and severe bacterial infection. Platelets are also involved in the fundamental biological process of chronic inflammation associated with disease pathology. Primarily, platelet activity is associated with the initiation of coagulation cascades. The decrease in the number of platelets in the blood is known as thrombocytopenia. An increase in platelet count in which the platelets do not work properly is the condition known as thrombocythemia.

## 12.4 Blood Components as Markers of Health

Blood provides the necessary biological information for the diagnosis of various pathological conditions. In these conditions, biomarkers are used as indicators of a biological factor that represents the health status.

### *12.4.1 Role of RBC in the Maintenance of Health*

The most important and well-known function of erythrocytes is the transport of oxygen from lungs to tissues. Erythrocytes are also essential in maintaining blood pH and carbon dioxide transport. In addition, RBCs are well equipped with antioxidant systems, which essentially contribute to their function and integrity. Damage of red cell integrity, defined as hemolysis, has been shown to significantly contribute to severe pathologies, including endothelial dysfunction (Crawford et al. 2004). Erythrocytes are also involved in tissue protection and the regulation of cardiovascular homeostasis through NO metabolism and release of bioactive molecules (Cortese-Krott et al. 2012). RBCs contain numerous sources of oxygen along with high levels of iron, which in its free form acts as a catalyst of ROS production. RBCs also have limited capacity to restore damaged elements due to loss of protein expression during erythropoietic maturation (Zivot et al. 2018). The combined action of all endogenous antioxidant systems makes RBCs very resistant against oxidation as well as an efficient systemic redox buffering system. These properties help to keep RBC healthy and well functioned. The malfunction of antioxidant defense or conditions of increased oxidant production have severe consequences for RBCs at subcellular level. This includes the degradation of Hb and other proteins, disturbance of ionic homeostasis, hindered RBC deformation, interference with erythropoiesis and enhanced exposure of phosphatidylserine (Mohanty et al. 2014). Furthermore, RBC membranes consist of high concentration of PUFA that make them susceptible to lipid peroxidation leading to loss of membrane integrity and decreased activity of enzymes associated with erythrocyte membrane (Kaestner and Minetti 2017).

### *12.4.2 Role of WBC in Maintenance of Health*

Normal WBC count is important for determining health status as it helps to understand what is going on inside the body during a variety of health situations. Besides acting as an indicator of current health status, white blood cell count has also been suggested as a predictive and prognostic marker for a number of chronic diseases (Madjid and Fatemi 2013; Wang et al. 2018). As the WBC count goes up, it could mean inflammation somewhere in the body. The role of white blood cell count in pathogenesis of various diseases such as diabetes, cardiovascular disease, and obesity-related disorders has been reported (Twig et al. 2012; Veronelli et al. 2004). Recent studies reveal that higher WBC contributes to atherosclerotic progression and impaired fasting glucose. Most white blood cell disorders are either a type of cancer or proliferative disorder.

### *12.4.3 Role of Platelets in the Maintenance of Health*

Platelet activity is associated with coagulation cascades. Blood vessel damage causes the sub-endothelial surface to be the primary target site for platelet action. Pro-aggregatory stimuli (platelet agonists) promote the action of platelet adhesion to the sub-endothelial surfaces. During this process, platelets change their shape, release their granule contents, and gradually form aggregates by adhering with each other (Vinik et al. 2001). Thus, platelets primarily function to minimize blood loss. Platelets are also involved in the fundamental biological process of chronic inflammation associated with disease pathology (Ghoshal and Bhattacharyya 2014). Platelets are actively involved in secretion of molecules like GPIIb, IIIa, fibrinogen, catecholamine, serotonin, calcium, ATP, ADP, which are involved in aggregation. Differential expressions of surface receptors like CD36, CD41, CD61 have also been measured in several diseases. Platelet activation and dysfunction have been implicated in diabetes, renal diseases, tumorigenesis, Alzheimer's, and CVD.

## 12.5 RBC and Aging

The aging process of RBC is considered an issue of special scientific and clinical interest. It represents a total of unidirectional, time-dependent but not-necessarily linear series of molecular events that finally lead to cell clearance (Aminoff et al. 1992). Under normal circumstances, human RBCs live approximately 120 $\pm$ 4 days in blood circulation, implying the existence of tightly regulated molecular mechanism(s), responsible for the programming of the lifespan and the nonrandom removal of senescent RBCs (Badior and Casey 2018; Franco 2009; Walsh et al. 2002). RBC is a favorite subject of investigation of cellular senescence (Clark 1988; Singh et al. 2016b). Although RBCs lose their subcellular organelles, they maintain a plethora of cellular functions like anaerobic glycolysis, the pentose phosphate shunt, cellular signaling and possibly even a variant of programmed cell death called eryptosis (Lang et al. 2005; Minetti and Low 1997). RBCs are maintained in a functional state until the very end of their life and go back to the bone marrow to die (Bernhardt and Ellory 2003). RBCs experience a range of continuous metabolic and physical damages as they age, such as membrane vesiculation, haemoglobin (Hb) modifications and progressive failure of both, cellular homeostasis and antioxidant defenses (Piomelli and Seaman 1993; Willekens et al. 2003). The increase in RBCs density, the nonenzymatic glycation of Hb and the deamidation of protein 4.1b to 4.1a have been widely used as sensitive RBC age markers (Bosch et al. 1992; Lutz et al. 1992; Mueller et al. 1987).

## 12.6 Markers of Oxidative Stress in Erythrocytes and Plasma

RBC and their membrane have always been important media for study due to the important role they play in various physiological and metabolic processes. Erythrocytes have been increasingly studied as they are the easiest available human cell type. Throughout its entire life, the organism is confronted with oxidative stress due to the production of ROS and reactive nitrogen species (RNS). ROS are normally generated as by-products of oxygen metabolism and generate free radical chain reaction. High levels of oxidative stress have been linked with the increased incidence of a variety of health issues. At moderate concentration ROS play several beneficial physiological roles in cell signaling and induce mitogenic response (Genestra 2007). They are needed to synthesize some cellular structures and to be used by the host defense system to fight pathogens.

Various markers of oxidative stress in erythrocytes and plasma are listed in Table 12.3. One of the most putative markers of oxidative stress is the measure of total antioxidant status. Total antioxidant status is measured in terms of 1,1-diphenyl-2-picrylhydrazyl free radical (DPPH) assay, 2,2-azobis-3-ethylbenzthiazoline-6-sulfonic acid (ABTS) assay and ferric reducing ability of plasma (FRAP) assay.

**Table 12.3** Oxidative stress biomarkers in erythrocytes and plasma

| S.No. | Biomarkers | Clinical significance | Reference |
|---|---|---|---|
| 1. | Protein Carbonyls | Marker of plasma and membrane protein oxidation. Formed due to the protein-pro cross linking and oxidation of protein backbone | (Sangeetha et al. 2005; Singh et al. 2016a) |
| 2. | Advanced oxidation of protein products | Dityrosine-containing cross-linked protein products Plasma level of AOPP elevated during various diseases | (Garg et al. 2017) |
| 3. | Total thiols | Product of S-thiolation reaction, act as an antioxidant. Alteration in thiol-disulphide redox status has been observed in specific groups of diseases such as cardiovascular, cancer, and neurodegenerative | (Oliveira and Laurindo 2018; Singh et al. 2019) |
| 4. | Reduced Glutathione | Most abundant non protein thiol helps in maintaining intracellular redox environment. Erythrocyte GSH level get reduced during oxidative stress | (Singh et al. 2017, 2018) |
| 5. | Plasma Membrane Redox system | Oxidoreductase system, tranfers electron from intracellular donor to extracellular acceptor and provide antioxidant protection against induced oxidative stress | (Adlard and Bush 2011; Hyun et al. 2006; Rodríguez-Aguilera et al. n.d.; Singh et al. 2017) |
| 6. | Malondialdehyde | Byproduct of lipid peroxidation, play an important role in the pathogenesis and progression of several diseases. Affects the variety of membrane related functions, alteration in membrane fluidity, permeability and loss of function | (Garg et al. 2017; Singh et al. 2016a) |

(continued)

**Table 12.3** (continued)

| S.No. | Biomarkers | Clinical significance | Reference |
|---|---|---|---|
| 7. | Lipid hydroperoxides | Formed from lipid autooxidation and photooxidation. Plama and membrane level of LHP get elevated during diseases associated with oxidative stress | (Gönenç et al. 2006; Peña-Bautista et al. 2019; Singh et al. 2018) |
| 8. | Acetylcholine esterase | Maintains the erythrocyte membrane potential. Marker of erythrocyte aging and RBC membrane integrity | (Suhail and Rizvi 1989) |
| 9. | Sodium potassium ATPase ($Na^+/K^+$-ATPase) and Plasma membrane calcium ATPase (PMCA) | Maintains the intracellular ionic homeostasis and electrochemical gradients across the membrane. The activity of NKApump is considerably impaired during the alteration in homeostasis mediated by oxidative stress | (Marchesi 2008) |
| 10. | Sodium Hydrogen exchanger (NHE) | NHE activity contributes to overall cell damage. Play vital housekeeping roles in the maintenanceof intracellular ionic homeostasis | (Dubyak 2004; Singh et al. 2016b; Várady et al. 2015) |

There is a strong correlation between antioxidant capacity and oxidative damage during aging (Pandey and Rizvi 2010).

Under physiological aerobic conditions, erythrocytes are continuously exposed to oxidants derived from endogenous as well as exogenous sources. Exposure of erythrocytes to physiological oxidative stress leads to lipid peroxidation that could change the membrane composition, inducing conformational changes and protein cross-linking in membrane proteins and, these changes may lead to abnormal cell morphology and hemolysis (Garg et al. 2019; Berzosa et al. 2011; Ciccoli et al. 2013; Freikman et al. 2011; Pytel et al. 2013). Lipid peroxidation is usually measured in terms of malondialdehyde (MDA) and lipid hydroperoxides (LHP). RBCs have also been reported to be associated with a number of biomarkers for age and senescence, these include reduced glutathione (GSH), the plasma membrane redox system (PMRS), rate of cysteine influx and antioxidant enzymatic activity. Due to these robust and reproducible age biomarkers, erythrocytes have become a suitable model for aging research (Kumar and Rizvi 2014; Rizvi et al. 2006, 2009; Rizvi and Maurya 2008). PMRS is an oxidoreductase system that transfers electrons from intracellular donors to extracellular acceptors such as ascorbate free radical and convert it into ascorbate. Erythrocyte PMRS provides antioxidant protection against oxidative stress. RBCs possess effective enzymatic antioxidant systems that neutralize the ROS into non/less reactive species. Superoxide dismutase (SOD), glutathione peroxidase (GPx), glutathione reductase (GR) and catalase (CAT) are some of the endogenous enzymatic defense systems in all aerobic cells which get affected by advancing age (Finkel and Holbrook 2000; Wojciech et al. 2010). They give protection by directly scavenging superoxide radicals and hydrogen peroxide (Pandey and Rizvi 2010; Scandalios 2005). These antioxidants counteract oxidative stress and mitigate its effects on individuals' health as they are free from important side effects. On the other hand, some prooxidants can be as well useful to human health particularly in cancer (Pizzino et al. 2017). Thus oxidative stress, although being one of the major harms to individual's wellness and health, can also be exploited as a treatment monitoring tool when finely tuned inside human organism.

## 12.7 Conclusion

In this chapter, we have reviewed the basic components of blood, including the different factors that can be used to determine the health status of the blood. Various clinical and oxidative stress biomarkers in the blood help to understand the dynamic homeostasis at the physiological level. Furthermore, blood analysis provides an array of the minimal-invasive procedures that can be used to assess important clinical biomarkers of health and deviations from it.

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