بسم الله الرحمن الرحيم

Shendi University

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Establishment of Umbilical Cord Haematological Parameters References Range in Shendi Locality

A thesis submitted for partial fulfillment for the requirement of M.Sc

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الآية

بسم الله الرحمن الرحيم

قال تعالي:

﴿الْحَمْدُ لِلَّهِ الَّذِي لَهُ مَا فِي السَّمَاوَاتِ وَمَا فِي الأرضِ وَلَهُ الْحَمْدُ فِي الآخِرَةِ وَهُوَ الْحَكِيمُ الْخَبِيرُ﴾

صدق الله العظيم

سورة سبأ الآية(1)

Dedication

To those who give me best of life without payment

To my mother

&

To my dear friends

To those help me to complete this research.

Acknowledgment

First of all I thank Allah for giving me the strength and patience to do this work and pray for Prophet Mohammed peace be up on him. I would like to thank my supervisor Dr.Mohammed osman Ali. Also grateful thanks go to my teacher Dr. Hamza Ahmed for their cooperation and guidance. I would like to thank the staff for Almak Nimr hospital for their endless encouragement and help in the collection of specimens. I would like to thank my colleagues for their great help valuable comments. Finally I would like to thank all people who helped me to perform this work.

List of abbreviation

ATP	Adenosine triphosphate
CLL	Chronic lymphocytic leukemia
CBC	Complete blood count
EDTA	Ethylenediamine tetraacetic acid
FBE	Full blood exam
Hb	Hemoglobin
LDC	Leukocyte differential count
MCH	Mean corpuscular hemoglobin
MCHC	Mean corpuscular hemoglobin concentration
MCV	Mean corpuscular volume
MPV	Mean platelet volume
NRBCS	Nucleated red blood cell
PCV	Packed cell volume
RBCs	Red blood cells
RDW	Red cell distribution width
RNA	Ribonucleic acid
SPSS	Statistical Package for Social Sciences
WBCs	White blood cells

ملخص البحث

تم إجراء هذه الدراسة الوصفية القطعية لقياس الدم الكامل في حديثي الولادة في شندي في الفترة مابين 2018/3/1 - 2018/8/15 بهدف تحديد المعدل الطبيعي لمكونات الدم في حديثي الولادة .

تم أخذ 70 عينة من الحبل السري بمقدار 2.5 مل في مضاد تجلط دم EDTA وتم إرسال العينة تحت ظروف مثالية لحمايتها من التلوث ليتم تحليلها بواسطة جهازفحص الدم الكامل . أثبتت الدراسة بعد تحليل النتائج إحصائيا بواسطة برنامج الحزم الإحصائية للعلوم الإجتماعية SPSS أن الوسط الحسابي والإنحراف المعياري لكريات الدم البيضاء (10.5*\l$10^{9}$\l±9.1) وكريات الدم الحمراء (4,2*\l$10^{12}$\l ±0.54) ، والهيموغلوبين (15.1g/dl±1.4) والهيموتكريت (48.4%±5) ومتوسط حجم الخلية الحمراء (113,27fl±4.09) ومتوسط هيموغلوبين الخاية الحمراء (35,5pg±2,6) ، ومتوسط تركيز هيموغلوبين الخلية السمراء (31.3 %±1.9) والخلايا الليمفاوية (41,3%±6,6) والخلايا العدلة (45,99%±4,5) حجم الصفائح الدموية (8,6±0.49) توزيع خلايا الدم الحمراء (17,76%±1,2)والصفائح الدموية (220*l10^{9}l±24,3) .

أظهرت نتيجة التحليل تشابه حديثي الولادة في شندي مع أقرانهم في الأقطار الأخرى مع اختلاف في الهيموغلوبين وكريات الدم البيضاء والصفائح الدموية ويرجع ذلك لإختلاف البيئة والعامل الإقتصادي والثقافي وعليه يجب علي الأمهات الإهتمام بالتغذية في فترة الحمل ومراجعة الطبيب لقياس الهيموغلوبين.

Abstract

This is a cross sectional descriptive study conducted in Shendi locality during the period from,1/3/2018 to15/8/2018.The study aimed to establish a reference value of hematological parameters in the newborns.

A total number of 70 cord blood samples were collected in EDTA anticoagulant containers, then mix well and transferred to the laboratory , following standard procedures to prevent contamination, then analyzed using Hematological analyzer (Sysmex).

Statistical analysis by SPSS showed a hematological parameters(mean± SD) in the cord blood as follows: WBCS ($10,5*10^{9}$±1,9), RBCS($4,2*10^{12}$\L±0,54),HGB(15,1g/dl±1,3),HCT(48,4%±5),MCV(113,27fl±4,09)MCH(35,5pg±2,6),MCHC(31,3±1,9),LYM(41,3±6,6)NEUT(45,99±4,5),Mid(12,7%±5,31)RDW(17,76±1,2),MPV(8,6±0,49)andPLT($220*10^{9}$\L±24,3).

The study concluded that, the hematological parameters in newborns in Shendi are similar to other countries and there is a little pit significant difference in Hb, WBCs and platelet which might be due to environmental, economic and cultural differenence.We conclude that good nutrition and Hb estimation are important to women during pregnancy.

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1.1. Introduction

The development of human starts in the uterus after fertilization and during pregnancy which named prenatal development After delivery many stages model of development have been proposed such as newborn, infancy, childhood, adolescence and adulthood that characterize by biological and physical change.

A study was done which revealed that various blood indices vary in the newborns as compared to older children or adults. It depends on the gestational age, day of life, maternal factors, and mode of delivery and site of blood collection. [1] The first study on the haematology of the newborns was published in 1924 and since then many studies have been conducted that have examined babies at different gestational ages and of varying birth weights [2] Furthermore, determination of reference range of healthy, term neonate is clinically important in terms of various complete blood count parameters for example, haemoglobin concentration which is an important clinical measurement used in decisions regarding clinical diagnosis, treatment and public health interventions for anaemia . [3]

Haemoglobin and haematocrit have been used routinely in the diagnosis of neonatal anaemia and polycythaemia . [4] White blood cells and platelet count have proved helpful in the assessment of neonatal sepsis and haemostatic status of the infant respectively . [5] Manroe et al showed that the use of absolute blood neutrophils count has improved the sensitivity in screening for neonatal bacterial diseases. [6]

Haematological values are also frequently determined in the newborns for diagnostic purposes in suspected infections and in bleeding disorders. [7] It is now widely accepted that there are no universal or international standard haematological parameters and all reference values are affected

to some extent by factors such as age, race, diet, drug intake, method employed for determination etc. It is thus important that standard reference values of local population should be established. [8] However, haematological reference values which are in use in Sudan are derived from studies done on world populations and to the best of our knowledge, there is no reference value of neonatal haematological parameters available in Sudan, using umbilical cord blood. After a baby is born and the umbilical cord is cut, some blood remains in the blood vessels of the placenta and the portion of the umbilical cord that remains attached to it. The umbilical cord is a narrow tube-like structure that connects the fetus to the placenta. [9] Umbilical cord consists of one vein, which carries oxygenated, nutrient-rich blood to the fetus and two arteries that carry deoxygenated, nutrient depleted blood away from fetus blood circulation. Although umbilical vein carries blood towards the fetus's heart, while the umbilical arteries carry blood away. [10] The umbilical the umbilical cord contains remnants of the yolk sac and allantoids. It forms by the fifth week of development, replacing the yolk sac as the source of nutrients for the embryo. The cord is not directly connected to the mother's circulatory system, but instead joins the placenta, which transfers materials to and from the maternal blood without allowing direct mixing. The length of the umbilical cord is approximately equal to the crown-rump length of the fetus throughout pregnancy. The umbilical cord in a full term neonate is usually about 50 centimeters (20 in) long and about 2 centimeters (0.75 in) in diameter. This diameter decreases rapidly within the placenta. The fully patent umbilical artery has two main layers: an outer layer consisting of circularly arranged smooth muscle cells and an inner layer which shows rather irregularly and loosely arranged cells embedded in abundant ground substance stainingmetachromatic The smooth muscle cells of the layer are rather poorly differentiated, contain only a few tiny

myofilaments and are thereby unlikely to contribute actively to the process of post-natal closure. The umbilical cord contains Wharton's jelly, a gelatinous substance made largely from mucopolysaccharides which protects the blood vessels inside. [11] Hematology of newborn recently represented as area of study that focusing in study of umbilical cord blood and its elements in general. [12] Umbilical cord blood count at birth shows that there is an increased in hemoglobin, haematocrit, mean corpuscular volume, leukocyte count, reticulocyte count and nucleated red blood cells with presence of occasional immature white blood cells or left-shifted in peripheral blood of healthy infants, After birth, the baby no longer needs this extra blood. This blood is called placental blood or umbilical cord blood: "cord blood". The objective of this study was to establish reference haematological values (complete blood count) in healthy full term newborns using umbilical cord blood, either after deliver by normal labor or elective caesarean section. [9]

1.2. Rationale

The haematological parameters are very importance in medicine because they help in diagnosis of diseases and monitor response to treatment. Interpretation of values obtained in an individual baby depends on the knowledge of the normal values for the locality. Most studies in Sudan were carried out in adult people and ignored the newborn at birth (Cord Blood Sample), in this study we attempt to start base line information to establish the haematological reference range in the cord blood and to compare it with the international reference value. The importance of this study, its result could be very valuable in establishment of a new protocol for the diagnosis of the haematological inherited disorders in newborn.

Objectives .1.3

: 1.3.1. General Objective

To establish a local reference range for full blood count parameters of newborns using cord blood.

1.3.2. Specific objectives:

1. To determine Hb, PCV, RBCs, RDW and WBCs count in cord blood.

2. To calculate RBCs indices in cord blood

3. To determine platelets count and mean platelet volume in cord blood.

Literature Review

2.1. Characteristics of blood:

Blood is a body fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells. [13]

In vertebrates, it is composed of blood cells suspended in blood plasma. Plasma, which constitutes 55% of blood fluid, is mostly water (92% by volume), [14] and contains proteins, glucose, mineral ions, hormones, carbon dioxide (plasma being the main medium for excretory product transportation), and blood cells themselves. [14] Albumin is the main protein in plasma, and it functions to regulate the colloidal osmotic pressure of blood. The blood cells are mainly red blood cells (also called RBCs or erythrocytes), white blood cells (also called WBCs or leukocytes) and platelets (also called thrombocytes). The most abundant cells in vertebrate blood are red blood cells. These contain hemoglobin, an iron-containing protein, which facilitates oxygen transport by reversibly binding to this respiratory gas and greatly increasing its solubility in blood. In contrast, carbon dioxide is mostly transported extracellularly as bicarbonate ion transported in plasma. Blood is bright red when its hemoglobin is oxygenated and dark red when it is deoxygenated. , it is composed of blood cells suspended in blood plasma. Plasma, which constitutes 55% of blood fluid, is mostly water (92% by volume),[14] and contains proteins, glucose, mineral ions, hormones, carbon dioxide (plasma being the main medium for excretory product transportation), and blood cells themselves. Albumin is the main protein in plasma, and it functions to regulate the colloidal osmotic pressure of blood. The blood cells are mainly red blood cells (also called RBCs or

erythrocytes), white blood cells (also called WBCs or leukocytes) and platelets (also called thrombocytes). Blood is circulated around the body through blood vessels by the pumping action of the heart. In animals with lungs, arterial blood carries oxygen from inhaled air to the tissues of the body, and venous blood carries carbon dioxide, a waste product of metabolism produced by cells, from the tissues to the lungs to be exhaled. [16]

Medical terms related to blood often begin with hemo- or hemato- (also spelled haemo-and haemato-) from the Greek word αἷμα (haima) for "blood". In terms of anatomy and histology, [16] blood is considered a specialized form of connective tissue, given its origin in the bones and the presence of potential molecular fibers in the form of fibrinogen Blood performs many important functions within the body, including Supply of oxygen to tissues (bound to hemoglobin, which is carried in red cells)Supply of nutrients such as glucose, amino acids, and fatty acids (dissolved in the blood or bound to plasma proteins (e.g., blood lipids) Removal of waste such as carbon dioxide, urea, and lactic acid. Immunological functions, including circulation of white blood cells, and detection of foreign material by antibodies Coagulation, the response to a broken blood vessel, the conversion of blood from a liquid to a semisolid gel to stop bleeding Messenger functions, including the transport of hormones and the signaling of tissue damage Regulation of core body temperature Hydraulic functions. [16]

Blood accounts for 7% of the human body weight, [15] with an average density around 1060 kg/m3, very close to pure water's density of 1000 kg/m3. The average adult has a blood volume of roughly 5 litres (11 US pt), [16] which is composed of plasma and several kinds of cells. These blood cells (which are also called corpuscles or "formed elements")

consist of erythrocytes (red blood cells, RBCs), leukocytes (white blood cells), and thrombocytes (platelets). By volume, the red blood cells constitute about 45% of whole blood, the plasma about 54.3%, and white cells about 0.7%.

Whole blood (plasma and cells) exhibits non-Newtonian fluid dynamics. If all human hemoglobin were free in the plasma rather than being contained in RBCs, the circulatory fluid would be too viscous for the cardiovascular system to function effectively.

Microliter of blood contains 4.7 to 6.1 million (male), 4.2 to 5.4 million (female) erythrocytes:

Red blood cells contain the blood's hemoglobin and distribute oxygen. Mature red blood cells lack a nucleus and organelles in mammals. The red blood cells (together with endothelial vessel cells and other cells) are also marked by glycoprotein's that define the different blood types. The proportion of blood occupied by red blood cells is referred to as the haematocrit, and is normally about 45%. The combined surface area of all red blood cells of the human body would be roughly 2,000 times as great as the body's exterior surface [17] 4,000-11,000 leukocytes.

White blood cells are part of the body's immune system , they destroy and remove old or aberrant cells and cellular debris, as well as attack infectious agents (pathogens) and foreign substances. The cancer of leukocytes is called leukemia.200, 000–500,000 thrombocytes: Also called platelets, they take part in blood clotting (coagulation). Fibrin from the coagulation cascade creates a mesh over the platelet plug. [8]

Constitution of normal blood Parameter Value Haematocrit 45 ± 7 (38–52%) for males42 ± 5 (37–47%) for females pH7.35–7.45base excess−3

to +3PO210–13 kPa (80–100 mm Hg)PCO24.8–5.8 kPa (35–45 mm Hg)HCO3−21–27 mM Oxygen saturation Oxygenated: 98–99%Deoxygenated: 75% . [18]

About 55% of blood is blood plasma, a fluid that is the blood's liquid medium, which by itself is straw-yellow in color. The blood plasma volume totals of 2.7–3.0 liters (2.8–3.2 quarts) in an average human. It is essentially an aqueous solution containing 92% water, 8% blood plasma proteins, and trace amounts of other materials. Plasma circulates dissolved nutrients, such as glucose, amino acids, and fatty acids (dissolved in the blood or bound to plasma proteins), and removes waste products, such as carbon dioxide, urea, and lactic acid. [18]

Other important components include

Serum albumin Blood-clotting factors (to facilitate coagulation) Immunoglobulin’s (antibodies) lipoprotein particles various other proteins various electrolytes (mainly sodium and chloride).

The term serum refers to plasma from which the clotting proteins have been removed. Most of the proteins remaining are albumin and immunoglobulins.

Blood pH is regulated to stay within the narrow range of 7.35 to 7.45, making it slightly basic. [18] Blood that has a pH below 7.35 is too acidic, whereas blood pH above 7.45 is too basic. Blood pH, partial pressure of oxygen (pO_2), partial pressure of carbon dioxide (pCO_2), and bicarbonate ($HCO3^-$) are carefully regulated by number of homeostatic mechanisms, which exert their influence principally through the respiratory system and the urinary system to control the acid-base balance and respiration. An arterial blood gas test measures these. Plasma also circulates hormones transmitting their messages to various tissues. [42]

2.2. Erythropoiesis

Erythropoiesis (from Greek 'erythro' meaning "red" and 'poiesis' meaning "to make") is the process which produces red blood cells(erythrocytes). It is stimulated by decreased O2 in circulation, which is detected by the kidneys, which then secrete the hormone erythropoietin [42] This hormone stimulates proliferation and differentiation of red cell. precursors, which activates increased erythropoiesis in the hemopoietic tissues, ultimately producing red blood cells(erythrocytes). In postnatal birds and mammals (including humans), this usually occurs within the red bone marrow. In the early fetus, erythropoiesis takes place in the mesodermal cells of the yolk sac. By the third or fourth month, erythropoiesis moves to the liver. [43] After seven months, erythropoiesis occurs in the bone marrow. Increased level of physical activity can cause an increase in erythropoiesis. However, in humans with certain diseases and in some animals, erythropoiesis also occurs outside the bone marrow, within the spleen or liver. This is termed extramedullary erythropoiesis. [44]

The bone marrow of essentially all the bones produces red blood cells until a person is around five years old. The tibia and femur cease to be important sites of hematopoiesis by about age 25 ,the vertebrae, sternum, pelvis and ribs, and cranial bones continue to produce red blood cells throughout life. [44]

.1.1.Erythrocyte differentiation2

In the process of red blood corpuscle maturation, a cell undergoes a series of differentiations. The following stages of development all occur within the bone marrow:

A hemocytoblast, a multipotent hematopoietic stem cell, become as common myeloid progenitor or a multipotent stem cell, and then a unipotent stem cell, then a pronormoblast, also commonly called proerythroblast or a rubriblast. This becomes a basophilic or early normoblast, also commonly called an erythroblast, then a polychromatophilic or intermediate normoblast, then an orthochromatic or late normoblast. At this stage the nucleus is expelled before the cell becomes a reticulocyte. [44]

The cell is released from the bone marrow after Stage 7, and so in newly circulating red blood cells there are about 1% reticulocytes. After one to two days, these ultimately become "erythrocytes" or mature red blood cells.

These stages correspond to specific appearances of the cell when stained with Wright's stain and examined by light microscopy, and correspond to other biochemical changes. [44]

In the process of maturation, a basophilic pronormoblast is converted from a cell with a large nucleus and a volume of 900 fL to an enucleated disc with a volume of 95 fL. By the reticulocyte stage, the cell has extruded its nucleus, but is still capable of producing hemoglobin.

Essential for the maturation of red blood cells are Vitamin B12 (cobalamin) and Vitamin B9 (Folic acid). Lack of either causes maturation failure in the process of erythropoiesis, which manifests clinically as reticulocytopenia, an abnormally low amount of reticulocytes. [44]

2.1.1.1.Characteristics seen in erythrocytes during erythropoiesis

As they mature, a number of erythrocyte characteristics change: The overall size of the erythroid precursor cell reduces with the cytoplasmic to nucleus (C:N) ratio increasing. The nuclear diameter decreases and chromatin condenses with the staining reaction progressing from purplish red to dark blue at the final nuclear stage of orthochromatic erythroblast, prior to nuclear ejection. The color of the cytoplasm changes from blue at proerythroblast and basophilic stages to a pinkish red as a result of the increasing expression of haemoglobin as the cell develops. Initially, the nucleus is large in size and contains open chromatin. But, as red blood cells mature, the size of the nucleus decreases, until it finally disappears with the condensation of the chromatin material . [44]

2.1.2. Regulation of erythropoiesis

A feedback loop involving erythropoietinhelps regulate the process of erythropoiesis so that, in non-disease states, the production of red blood cells is equal to the destruction of red blood cells and the red blood cell number is sufficient to sustain adequate tissue oxygen levels but not so high as to cause sludging, thrombosis, or stroke. Erythropoietin is produced in the kidney and liver in response to low oxygen levels. In addition, erythropoietin is bound by circulating red blood cells; low circulating numbers lead to a relatively high level of unbound erythropoietin, which stimulates production in the bone marrow. [45]

Recent studies have also shown that the peptide hormone hepcidin may play a role in the regulation of hemoglobin production, and thus affect erythropoiesis. The liver produces hepcidin. Hepcidin controls iron absorption in the gastrointestinal tract and iron release from reticuloendothelial tissue. Iron must be released from macrophages in the

bone marrow to be incorporated into the heme group of hemoglobin in erythrocytes. There are colony forming units that the cells follow during their formation. These cells are referred to as the committed cells including the granulocyte monocyte colony forming units. [45]

The secretion of hepcidin is inhibited by another hormone, erythroferrone, produced by erythroblasts in response to erythropoietin, and identified in 2014. [45][46] It appears that this links erythropoietin-driven erythropoiesis with the iron mobilization needed for hemoglobin synthesis.

Loss of function of the erythropoietin receptor or JAK2 in mice cells causes failure in erythropoiesis, so production of red blood cells in embryos and growth is disrupted. If there is no systemic feedback inhibition, for example, the diminishment or absence of suppressors of cytokine signaling proteins, giantism may result as shown in mice models. [47][48]

2.1.3. Hemoglobin

Hemoglobin (American) or haemoglobin (British) [49] abbreviated Hb or Hgb, is the iron-containing oxygen-transport metalloprotein in the red blood cells of all vertebrates [50] (with the exception of the fish family Channichthyidae [51] as well as the tissues of some invertebrates. Hemoglobin in the blood carries oxygen from the lungs orgills to the rest of the body (i.e. the tissues). There it releases the oxygen to permit aerobic respiration to provide energy to power the functions of the organism in the process called metabolism. A healthy individual has "12 to 16" grams of haemoglobin in every 100 ml of blood.

In mammals, the protein makes up about 96% of the red blood cells' dry content (by weight), and around 35% of the total content (including

water) . [52] Hemoglobin has an oxygen-binding capacity of 1.34 mL O_2 per gram, [53] which increases the total blood oxygen capacity seventy-fold compared to dissolved oxygen in blood. The mammalian hemoglobin molecule can bind (carry) up to four oxygen molecules. [54]

Hemoglobin is involved in the transport of other gases: It carries some of the body's respiratory carbon dioxide (about 20–25% of the total [55] as carbaminohemoglobin, in which CO2 is bound to the globin protein. The molecule also carries the important regulatory molecule nitric oxide bound to a globin protein thiol group, releasing it at the same time as oxygen. [56]

Hemoglobin is also found outside red blood cells and their progenitor lines. Other cells that contain hemoglobin include the A9 dopaminergic neurons in the substantianigra, macrophages, alveolar cells, lungs, retinal pigment epithelium, hepatocytes, mesangial cells in the kidney, endometrial cells, cervical cells and vaginal epithelial cells. [57] In these tissues, hemoglobin has a non-oxygen-carrying function as an antioxidant and a regulator of iron metabolism. [58]

Hemoglobin and hemoglobin-like molecules are also found in many invertebrates, fungi, and plants. [59] In these organisms, hemoglobin's may carry oxygen, or they may act to transport and regulate other small molecules and ions such as carbon dioxide, nitric oxide, hydrogen sulfide and sulfide. A variant of the molecule, called leghemoglobin, is used to scavenge oxygen away from anaerobic systems, such as the nitrogen-fixing nodules of leguminous plants, before the oxygen can poison (deactivate) the system.

Hemoglobin (Hb) is synthesized in a complex series of steps. The heme part is synthesized in a series of steps in the mitochondria and the

cytosol of immature red blood cells, while the globin protein parts are synthesized by ribosomes in the cytosol. [60] Production of Hb continues in the cell throughout its early development from the proerythroblast to the reticulocyte in the bone marrow. At this point, the nucleus is lost in mammalian red blood cells, but not in birds and many other species. Even after the loss of the nucleus in mammals, residual ribosomal RNA allows further synthesis of Hb until the reticulocyte loses its RNA soon after entering the vasculature (this hemoglobin-synthetic RNA in fact gives the reticulocyte its reticulated appearance and name). [61]

Hemoglobin has a quaternary structure characteristic of many multi-subunit globular proteins. [62] Most of the amino acids in hemoglobin form alpha helices, and these helices are connected by short non-helical segments. Hydrogen bonds stabilize the helical sections inside this protein, causing attractions within the molecule, which then causes each polypeptide chain to fold into a specific shape. [63] Hemoglobin's quaternary structure comes from its four subunits in roughly a tetrahedral arrangement. [62]

In most vertebrates, the hemoglobin molecule is an assembly of four globular protein subunits. Each subunit is composed of a protein chain tightly associated with a non-protein prosthetic heme group. Each protein chain arranges into a set of alpha-helixstructural segments connected together in a globin fold arrangement. Such a name is given because this arrangement is the same folding motif used in other heme/globin proteins such as myoglobin. [64][65] This folding pattern contains a pocket that strongly binds the heme group.

A heme group consists of an iron (Fe) ion (charged atom) held in a heterocyclic ring, known as a porphyrin. This porphyrin ring consists of

four pyrrole molecules cyclically linked together (by methine bridges) with the iron ion bound in the center . [66] The iron ion, which is the site of oxygen binding, coordinates with the four nitrogen atoms in the center of the ring, which all lie in one plane. The iron is bound strongly (covalently) to the globular protein via the N atoms of the imidazole ring of F8 histidine residue (also known as the proximal histidine) below the porphyrin ring. A sixth position can reversibly bind oxygen by a coordinate covalent bond, completing the octahedral group of six ligands. Oxygen binds in an "end-on bent" geometry where one oxygen atom binds to Fe and the other protrudes at an angle. When oxygen is not bound, a very weakly bonded water molecule fills the site, forming a distorted octahedron.

Even though carbon dioxide is carried by hemoglobin, it does not compete with oxygen for the iron-binding positions but is bound to the protein chains of the structure.

The iron ion may be either in the Fe^{+2} or in the Fe3+ state, but ferrihemoglobin (methemoglobin) (Fe^{+3}) cannot bind oxygen . [67] In binding, oxygen temporarily and reversibly oxidizes (Fe^{+2}) to (Fe^{+3}) while oxygen temporarily turns into the superoxideion, thus iron must exist in the +2 oxidation state to bind oxygen. If superoxide ion associated to Fe^{+3} is protonated, the hemoglobin iron will remain oxidized and incapable of binding oxygen. In such cases, the enzyme methemoglobin reductase will be able to eventually reactivate methemoglobin by reducing the iron center.

In adult humans, the most common hemoglobin type is a tetramer (which contains four subunit proteins) called hemoglobin A, consisting of two α and two β subunits non-covalently bound, each made of 141 and

146 amino acid residues, respectively. This is denoted as α2β2. The subunits are structurally similar and about the same size. Each subunit has a molecular weight of about 16,000 daltons, for a total molecular weight of the tetramer of about 64,000 daltons (64,458 g/mol) Thus, 1 g/dL = 0.1551 mmol/L. Hemoglobin A is the most intensively studied of the hemoglobin molecules.

In human infants, the hemoglobin molecule is made up of 2 α chains and 2 γ chains. The gamma chains are gradually replaced by β chains as the infant grows.

The four polypeptide chains are bound to each other by salt bridges, hydrogen bonds, and the hydrophobic effect.

Oxygen saturation In general, hemoglobin can be saturated with oxygen molecules (oxyhemoglobin), or desaturated with oxygen molecules (deoxyhemoglobin) . [50]

Oxyhemoglobin is formed during physiological respiration when oxygen binds to the heme component of the protein hemoglobin in red blood cells. This process occurs in the pulmonary capillaries adjacent to the alveoli of the lungs. The oxygen then travels through the blood stream to be dropped off at cells where it is utilized as a terminal electron acceptor in the production of ATP by the process of oxidative phosphorylation. It does not, however, help to counteract a decrease in blood pH. Ventilation, or breathing, may reverse this condition by removal of carbon dioxide, thus causing a shift up in pH . [68]

Hemoglobin exists in two forms, a taut (tense) form (T) and a relaxed form (R). Various factors such as low pH, high CO_2 and high 2,3 BPG at the level of the tissues favor the taut form, which has low oxygen affinity and releases oxygen in the tissues. Conversely, a high pH, low CO_2, or

low 2,3 BPG favors the relaxed form, which can better bind oxygen. The partial pressure of the system also affects O2 affinity where, at high partial pressures of oxygen (such as those present in the alveoli), the relaxed (high affinity, R) state is favoured. Inversely, at low partial pressures (such as those present in respiring tissues), the (low affinity, T) tense state is favoured Additionally, the binding of oxygen to the iron (II) heme pulls the iron into the plane of the porphyrin ring, causing a slight conformational shift. The shift encourages oxygen to bind to the three remaining heme units within hemoglobin (thus, oxygen binding is cooperative) . [68]

Deoxygenated hemoglobin is the form of hemoglobin without the bound oxygen. The absorption spectra of oxyhemoglobin and deoxyhemoglobin differ. The oxyhemoglobin has significantly lower absorption of the 660 nm wavelength than deoxyhemoglobin, while at 940 nm its absorption is slightly higher. This difference is used for the measurement of the amount of oxygen in a patient's blood by an instrument called a pulse oximeter. This difference also accounts for the presentation of cyanosis, the blue to purplish color that tissues develop during hypoxia. [68]

Deoxygenated hemoglobin is paramagnetic; it is weakly attracted to magnetic fields. [49][50] In contrast, oxygenated hemoglobin exhibit.

2.3. Leukopoiesis

Leukopoiesis is a form of hematopoiesis in which white blood cells (WBC or leukocytes) are formed in bone marrow located in bones in adults and hematopoietic organs in the fetus. White blood cells, indeed all blood cells, are formed from the differentiation of pluripotent hematopoietic stem cells which give rise to several cell lines with

unlimited differentiation potential . [69] These immediate cell lines, or colonies, are progenitors of red blood cells (erythrocytes), platelets (megakaryocytes), and the two main groups of WBCs, myelocytes and lymphocytes. On the basis of the history of associated leukemic diseases, it's divided into two main groups: acute and chronic. The incidence of both chronic and acute leukaemias is higher in males than in females. [69]

In hematology, myelopoiesis in the broadestsense of the term is the production of bone marrow and of all cells that arise from it, namely, all blood cells. But in a narrower sense that is also commonly used, myelopoiesis is the regulated formation specifically of myeloid leukocytes (myelocytes), including eosinophilic granulocytes, basophilic granulocytes, neutrophilic granulocytes, and monocytes. [69]

The common myeloid progenitor can differentiate in the bone marrow into red blood cells and megakaryocytes (leading to platelets) as well as mast cells and myeloblasts, the latter leading to the myelocytic line (granulocytes) and to monocytes, macrophages, and dendritic cells of the innate immune system. The granulocytes, also called polymorphonuclear leukocytes because of their multilobed nuclei, are three short lived cell types including eosinophils, basophils, and neutrophils. A granulocyte differentiates into a distinct cell type by a process called granulopoiesis. In this process it first transforms from a common myeloblasts (myeloid progenitor) to a common promyelocyte. This promyelocyte gives rise to a unique myelocytes that for the first time can be classified as an eosinophil, basophil, or neutrophil progenitor based on the histological staining affinity (eosinophilic, basophilic, or neutral granules) . [69] The unique myelocyte next differentiates into a metamyelocyte and then a band cell, with a "C" shaped nucleus, before becoming a mature eosinophil, basophil, or neutrophil. Macrophages come from monoblast

progenitors that differentriate into monocytes, which mature into monocytes. Monocytes eventually enter the tissues and become macrophages. [69]

2.4.Lymphopoiesis

Lymphopoiesis (lĭm'fō-poi-ē'sĭs) (or lymphocytopoiesis) is the generation of lymphocytes, one of the five types of white blood cell (WBC) . [69] It is more formally known as lymphoid hematopoiesis.

Pathosis in lymphopoiesis leads to any of various lymphoproliferative disorders, such as the lymphomas and lymphoid leukemias.

2.4.1. Lymphopoiesis Glossary

antigen any molecule that can provoke an immune defense B cells lymphocytes that ultimately produce antibodies, bone marrow the center of bones capable of producing all red and white blood cells in the adult, cortex the outer portion of any organ ,cytoplasm the portion of a cell between the nucleus and the membrane differentiation permanent changes to a cell developing over time and with cell division granules grains found in many white blood cells, [71] composed of defensive chemicals hematopoietic that which gives rise to any blood cell type• lineage a type of cell and its descendants by division and differentiation lymphocytes a special 'lineage' of WBC macrophages myeloid descendants (some may be lymphoid) with 'eating' abilities, also cooperate with lymphocytes myeloid ancestors of WBCs with granules and also of macrophages T Cells "management" lymphocytes for immunity (WBC) White Blood Cell in contrast to the much more common Red Blood Cell; responsible for defense. [71]

2.5. Thrombopoiesis

Thrombopoiesis refers to the process of thrombocyte generation [71][72] Thromobocytes are ligations of the cytoplasm frommegakaryocytes.

A single megakaryocyte can give rise to thousands of thrombocytes.

The term "thrombocytopoiesis" is sometimes used to emphasize the cellular nature.

Thrombopoietin stimulates megakaryopoiesis, the process of megakaryocyte maturation and differentiation. Thrombopoietin, upon release, binds to its receptor, c-mpl, found onmegakaryocyte progenitor cells. Following binding, intracellular signalling leads to megakaryocyte growth, maturation, membrane stability, platelet granule formation and the demarcation of the cytoplasm into regions destined to fragment into mature platelets. [73] These "proplatelet processes" further fragment into platelets. This last step of proplatelet process and platelet formation, in vitro, has been shown to be independent of thrombopoietin.

2.6. Newborn:

A newborn is, in colloquial use, an infant who is only hours, days, or up to number month old. In medical contexts, newborn or neonate (from Latin, neonates, newborn) refers to an infant in the first 28 days after birth , [73] the term applies to premature, full term, and post mature infants; before birth

2.6.1 Physical characteristics of newborn

A newborn's shoulders and hips are wide, the abdomen protrudes slightly, and the arms and legs are relatively long with respect to the rest of their body. In first world nations, the average total body length of newborns is 35.6–50.8 cm (14.0–20.0 in), although premature newborns

may be much smaller. The score is a measure of a newborn's transition from the uterus during the first minutes after birth. [74]

2.6.2 Weight

In developed countries, the average birth weight of a full-term newborn is approximately 3.4 kg (7 1⁄2 lb), and is typically in the range of 2.7–4.6 kg (6.0–10.1 lb).

Over the first 5–7 days following birth, the body weight of a term neonate decreases by 3–7%, [74] and is largely a result of the resorption and urination of the fluid that initially fills the lungs, in addition to a delay of often a few days before breast feeding becomes effective. After the first week, healthy term neonates should gain 10–20 grams/day. [74]

2.7. Umbilical cord:

In placental mammals, the umbilical cord (also called the navel string, [10] birth cord or funiculars umbilical is a conduit between the developing embryo or fetus and the placenta. During prenatal development, the umbilical cord is physiologically and genetically part of the fetus and (in humans) normally contains two arteries (the umbilical arteries) and one vein (the umbilical vein), buried within Wharton's jelly. The umbilical vein supplies the fetus with oxygenated, nutrient-rich blood from the placenta. Conversely, the fetal heart pumps deoxygenated, nutrient-depleted blood through the umbilical arteries Cord blood, also called placental blood, is found in the umbilical cord and placenta of newborn babies. After a baby is born, and the umbilical cord cut, the baby has no more use for the blood that remains in these organs. Although cord blood is made up of the same components as any other blood, the plethora of hematopoietic cells present is what makes it special. [11]

Hematopoietic are immature, or primitive, cells which still have the potential to form into platelets, or red or white blood cells. With some scientific intervention, they may even be able to for into other cell types that make up your body back to the placenta. [11]

2.7.1. Structure and development:

The embryo is surrounded by the thin membranes of the amniotic sac, the umbilical cord is seen in the center, attaching the embryo to the placenta.

Umbilical artery, bottom: umbilical vein, middle: remnant of allantoises.

The umbilical cord develops from and contains remnants of the yolk sac and allantoises. It forms by the fifth week of development, replacing the yolk sac as the source of nutrients for the embryo. [11]

2.8. Complete blood count:

A complete blood count (CBC), also known as a complete blood cell count, full blood count(FBC), or full blood exam (FBE), is a blood panel requested by a doctor or other medical professional that gives information about the cells in a patient's blood, such as the cell count for each blood cell type and the concentrations of hemoglobin. A scientist or lab technician performs the requested testing and provides the requesting medical professional with the results of the CBC. Blood counts of various types have been used for clinical purposes since the 19th century. Automated equipment to carry out complete blood counts was developed in the 1950s and 1960s [75] Most blood counts today include a CBC count (i.e.: complete blood count) and leukocyte differential count (LDC) that gives the percentage of each WBC type, such as neutrophils, eosinophils, basophils, monocytes, and lymphocytes) . [76]

The cells that circulate in the bloodstream are generally divided into three types: white blood cells (leukocytes), red blood cells (erythrocytes), and platelets (thrombocytes). Abnormally high or low counts may indicate the presence of many forms of disease, and hence blood counts are among the most commonly performed blood tests in medicine, as they can provide an overview of a patient's general health status. A CBC is routinely performed during annual physical examinations in some jurisdictions. [77]

2.8.1. Medical uses

Complete blood counts are done to monitor overall health, to screen for some diseases, to confirm a diagnosis of some medical conditions, to monitor a medical condition, and to monitor changes in the body caused by medical treatments. [77]

For patients who need blood transfusion, a blood count may be used to get data which would help plan an amount of treatment. [78] In such cases, the person should have only one blood count for the day, and the transfusion of red blood cells or platelets should be planned based on that. [78] Multiple blood draws and counts throughout the day are an excessive use of phlebotomy and can lead to unnecessary additional transfusions, and the extra unnecessary treatment would be outside of medical guidelines. [78]

Typically, analysis begins when a well mixed whole blood sample is placed on a rack in the analyzer. The instrument utilizes flow cells, photometers and apertures in order to analyze different elements in the blood. The cell counting component counts the numbers and types of different cells within the blood. A special photometer called a hemoglobin meter measures the amount of hemoglobin. This is done by

adding a diluents that lyses the red blood cells which is then pumped into a spectro-photometric measuring cuvette. The change in color of the lysate equates to the hemoglobin content of the blood. This information can be very helpful to a physician who, for example, is trying to identify the cause of a patient's anemia. The results are printed out or sent to a computer for review. [76]

Blood cell counting occurs by flow cytometry when a very small amount of the specimen is aspirated, diluted and passes through an aperture and a laser flow cell. Sensors count and identify the number of cells passing through the aperture. The two main types sensors used are laser light detectors and electrical impedance. The instrument determines the type of blood cell by analyzing data about the size and aspects of light as they pass through the cells. Some instruments measuring different characteristics of the cells in order to categorize them. [76]

Because an automated hematology cell counter samples and counts so many cells, the results are very precise. However, certain abnormal cells in the blood may not be identified correctly, requiring manual review of the instrument's results and identification by other means (such as microscopy) of any abnormal cells the instrument could not categorize. Sophisticated modern analyzers can provide extended WBC differential counts, which include hematopoietic progenitor cells, immature granulocytes, and erythroblasts. [76]

Various Red blood cell indices (parameters calculated from other CBC results) are often reported in addition to cell counts and hemoglobin. Automated hematology analyzers calculate the average amount (MCH) and concentration (MCHC) of hemoglobin within each red blood cell. Average RBC size (MCV) and shape (RDW) are also calculated to

provide additional diagnostic information. For example, if the red cells are smaller or larger than normal, or if there is a lot of variation in the size of the red cells, this data can help guide the direction of further testing and expedite the diagnostic process so patients can get the treatment they need quickly. [79]

Manual Hemocytometers (counting chambers that hold a specified volume of diluted blood to enable enumeration with a Microscope) are used to calculate the number of red and white cells per liter of blood. (The dilution and scaled grid lines on the hemocytometer are used because there are far too many cells without those aids.)

To identify the numbers of different white cells, a blood film is made on a slide, and a large number of white blood cells (at least 100) are counted using a microscope. This gives the percentage of cells that are of each type. By multiplying these percentages by the total number of white blood cells, the absolute number of each type of white cell can be obtained.

Manual microscopic counting is useful in cases where automated analyzers cannot reliably count abnormal cells, such as those immature or atypical cells (that are not present in normal patients) and are only seen in peripheral blood with certain haematological conditions. Manual counting is subject to sampling error because so few cells are counted compared with automated analysis.

Medical technologists examine blood film via a microscope for some CBCs, not only to find abnormal white cells but also because variation in the shape of red cells is an important diagnostic tool. Although automated analyzers give fast, reliable results regarding the number, average size, and variation in size of red blood cells, they do not identify specific

shapes. Also, some normal patients' platelets will clump in EDTA anticoagulated blood, which causes automatic analyses to give a falsely low platelet count. The person viewing the slide in these cases will see clumps of platelets and can estimate if there are low, normal, or high numbers of platelets. [80]

2.8.2.Complete Blood Count Components:

2.8.2.1.White cells

Total white blood cells are reported, and a differential reports all the white cell types as a percentage and as an absolute number per unit volume. [81] A high WBC may indicate an infection, leukemia or some other hematological disorder.

2.8.2.2.Neutrophils:

May indicate bacterial infection, and are seen in leukaemias. They may also be raised in acute viral infections. Because of the segmented appearance of the nucleus, more mature neutrophils are sometimes referred to as "segs". The nucleus of less mature neutrophils is not segmented, but has a band or rod-like shape. Less mature neutrophils are known as "bands" or "stabs".Stab is a German term for rod. [8]

2.8.2.3.Lymphocytes:

Higher with some viral infections such as glandular fever. Raised in chronic lymphocytic leukemia (CLL) and other lymphocytic leukaemias. Counts may be decreased by HIV infection. In adults, lymphocytes are the second most common WBC type after neutrophils. In young children under age 8, lymphocytes are more common than neutrophils. [82]

2.8.2.4.Monocytes:

May be raised in bacterial infection, tuberculosis, malaria, Rocky Mountain spotted fever, monocytes leukemia, chronic ulcerative colitis and regional enteritis. [82]

2.8.2.5.Eosinophils:

Increased in parasitic infections, asthma, or allergic reaction.

2.8.2.6.Basophils:

May be increased in bone marrow related conditions such as leukemia or lymphoma. [82]

2.8.2.7.Red cells

Total red blood cells: The number of red cells is given as an absolute number per liter. [81] Iron deficiency anemia is one condition that shows up as a Low RBC count.

2.8.2.8.Hemoglobin

Hemoglobin: The amount of hemoglobin in the blood, expressed in grams per deciliter. [81] A low level of hemoglobin is a sign of anemia.

2.8.2.9.Haematocrit

Haematocrit or packed cell volume (PCV): This is the fraction of whole blood volume that consists of red blood cells. [81]

2.8.2.10.Red Blood Cell Indices

RBC Indices are typically calculated from other measured RBC parameters. They include the MHC, MCHC, MCV and RDW. Automated

analyzers measure MCV directly, and use it and the RBC to calculate the Haematocrit. [83]

A- MCV

Mean corpuscular volume (MCV): the average volume of the red cells, measured in femtolitres. [81] Anemia is classified as microcytic or macrocytic if the MCV value is above or below the expected normal range, anemias are classified as normocytic if the MCV is within the expected range. Other conditions that can affect MCV include thalassemia, reticulocytosis, alcoholism, chemotherapy, vitamin B12 deficiency, and/or folic acid deficiency.

B- MCH

Mean corpuscular hemoglobin (MCH): the average amount of hemoglobin per red blood cell, in picograms. [81]

C- MCHC

Mean corpuscular hemoglobin concentration (MCHC): the average concentration of hemoglobin in red blood cells. In Hypo chromic anemia, such as caused by an iron deficiency, the MCHC is decreased.

D- RDW

Red cell distribution width (RDW): reflects the degree of variation in size and shape of red blood cells as calculated by automated analyzers. RDW determination, in conjunction with RBC count and MCV, is useful in the interpretation of several hematological disorders. The RDW is measured as a coefficient of variation of red cell size distribution

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2.8.2.11. Platelets

Platelet numbers are given, as well as information about their size and the range of sizes in the blood. [81]

Mean platelet volume (MPV): a measurement of the average size of platelets.

2.9. Previous Study

Assessment of hematological parameters of neonatal cord blood in anemic and non anemic mothers in Khartoum state 2013.

.9.1Hematologic values in umbilical cord blood obtained from babies 2 non-anemic (n=208) mothers born to anemic (n=292) and

Parameter	Sample	Mean± SD
Hemoglobin	Non anemic	144.5 ± 15.5
	Anemic	143.4 ± 14.6
Haematocrit	Non anemic	0.44 ± 5.10
	Anemic	0.44 ± 5.14
M C V	Non anemic	105.5 ± 5.14
	Anemic	105.3 ± 5.12
MCH	Non anemic	33.5 ±1.99
	Anemic	33.2 ±1.96
MCHC	Non anemic	331±11.9
	Anemic	332 ±11.4
Platelet x 10^9/L	Non anemic	251 x 10^9/L ± 92
	Anemic	257 x 10^9/L ± 91
White Blood Cells x 10^9/L	Non anemic	12.5x 10^9/L ± 8
	Anemic	12 x 10^9/L ± 4

2.9.2. Before this research were done few studies in some countries of world and results show in table [7]

ıeter	Pakistan	Italy	East Africa	India	Argentina	Cote D'ivoire	Nigeria
HGB	14.1±1.5	16.1±2	16±1.7	16.3±1.7	15.5±1.1	15±1.7	14
RBCs	4.3±0.4	4.5±0.6		5.07±0.4	4.7±0.3	4.4±0.5	
HCT		48.9	47±6	51.8±3.3	49±4.3	43.6±5.5	42
MCV	105.8±6.2	108.2±4.3	112.6±8.9	102.4±7.1	105.1±5.3	100±6.2	
MCH	34.1±2.11	35.7±1.8	31.9±5.5	32.01±3.5	33.3±1.2	34.5±2.4	
MCHC	32.5±2.12	-	33.5±2.8	31.3±2.7		34.2±1	
TWBCs	13.6±4.2	14.4±4.3	12.3±4.8			13.7±5.4	9.5±6.5
N	50.1±12.4		62.6			54.4±15.4	67
LYM	39.1±12.2		37.4			36.5±12.3	30
PLT	256.3±76.5	292.8±72.6	269.9±72.6			161±45	173±138

Materials and methods

3.1. Study design:

This is a cross sectional study design based on cord blood sample of 70 newborns deliver in Almak nimer university hospital to establishment the Haematological parameters in the newborns.

3.2. Study area:

The study was conducted in Shendi city in Sudan, during the period between 1/3/2018 to 15/8/2018 Shendi city is located in northern Sudan, situated on the east bank of the Nile 150 km northeast of Khartoum. Shendi is also about 45 km southwest of the ancient city of Meroe. Located in the River Nile state, Shendi is the center of the Ja'aliin tribe and an important historic trading center. Its principal suburb on the west bank is Al-Matamma. A major traditional trade route across the Bayuda desert connects Al-Matamma to Marawi and Napata, 250 km to the northwest.

3.3. Ethical considerations:

Procedure of cord blood sampling was explained to the mother. All participants were informed about the research objectives and procedures during the interview period. A written valid consent was obtained from all participants before Data and Cord Blood Sample Collection.

3.4. Study population:

A total of 70 cord blood samples were collected from the umbilical vein during normal delivery or caesarean section

3.5. Inclusion Criteria

Mother

 Pregnant woman. (Booked cases)

 Uneventful pregnancy.

 Haemoglobin ≥10 g/dl

Neonates

Full term (37 to 42 weeks) with normal birth weight (2.5–4.0 Kg)

3.6.1. Exclusion Criteria for mother:

Diseases complicating pregnancy (anaemia, haemorrhage, pregnancy induced hypertension, eclampsia, diabetes (gestational or insulin dependent), heart, kidney or lung disease, malaria, disseminated intravascular coagulation), Thalassaemia/Sickle cell disease, Drug or alcohol abuse, Immediate shock like state after post partum period and emergency caesarean section.

3.6.2. Exclusion criteria for the neonate:

Abnormal partogram, Perinatal blood loss, Hydropsfetalis, Birth asphyxia, Low Apgar score <8 at 5minutes, Obvious congenital/chromosomal abnormality and Pathologic jaundice (within 24 hours of birth).

3.7. Blood Sampling:

After delivery of the baby, the umbilical cord was clamped immediately. Then 2.5 ml of cord blood was taken from umbilical vein and transferred into an EDTA container. The sample was then sent as early as possible (maximum 3 to 6 hours) to Modern Medical Analysis Centre for analysis. the haematological parameters was done by the Sysmex Counter (automated haemalogical analyzer). The differential leukocyte count was counted by light microscopy using Leishmans

stained smears. Recording of nucleated RBCs was done as per 100 leukocytes using Leishmans stained smear and expressed the WBC count as corrected for the presence of nucleated RBCs if its number was 10 or more.

3.8. Data collection tools:

The primary data will be collected by using questionnaire and observation of the laboratory results.

3.9. Data analysis:

The data were compared by using Statistical analysis performed with Statistical Package for Social sciences (SPSS-s) software version 12. To compare means and standard deviation of haematological values, between normal vaginal delivery and caesarean section, maternal age, and parity Students t-test was used. In all statistical analysis, only $p<0.05$ were considered significant.

3.10. Methods:

Complete blood count (CBC):

Principle of sysmex:

The SysmxXE_2100 is haematology automated analyzer used to quickly perform full blood counts and it made by Sysmex Corporation Principles of measurement (Japan).

Diluted blood is pass through a tube which thin enough that can pass cells by one at a time, Characteristic about the cell are measured using lasers or electrical impedance.

Procedure:

Cord blood was collected in EDTA container and analyzed for different haematological parameters (Hb, PCV, RBCs, WBCs, platelet count, RBCs indices and differential WBCs count). The data entry and analysis was done on computer package SPSS (Statistical Packages of Social Sciences) version 12.0. The results were given in the text as mean, standard deviation and 95% confidence intervals of haematological values (complete blood count).

Result interpretation:

All quality control measures were adopted during specimen collection and processing.

Results

This Prospective descriptive cross sectional study which conducted in Shendi City and aimed to evaluate blood cell parameter in cord blood A total of 70 neonates were included in the study.

The mean haemoglobin, TWBCs, RBCs count, platelet count, haematocrit, MCV, MCH, MCHC, RDW, neutrophil %, lymphocytes % , mid% and MPV of the newborns were (15.11 g/dl, 10.54 $x10^9$/L , 4.27 x1012/L , 220.28 $x10^9$/L, 48.46%, 113.27 fl, 35.5 pg, 31.31g/dl, 17.76, 45.99%, 41.3%, 12.7% and 8.6 fl) respectively, as demonstrated in (table 4-1).

Table (4.1) Show the mean of blood cell parameter in newborn:

Parameters	**Mean**	**±SD**
WBCS $x10^9$/L	10.54	1.9
RBCS $x10^{12}$/L	4.27	0.54
HGB g/dl	15.11	1.26
HCT %	48.46	6.6
MCV fl	113.27	4.09
MCH pg	35.5	2.58
MCHC g/dl	31.31	1.9
RDW	17.76	1.2
LYM %	41.3	6.62
NEUT %	45.99	4.56
Mid %	12.7	5.31
PLT $x10^9$/L	220.28	24.31
MPV	8.6	0.49

5.1. Discussion

This study was conducted to determine the complete blood count of term, healthy newborns. It observed that the mean haemoglobin of the study population agreed with the figures of Cote D'ivoire (Africa) , but lower than the European and Indian values, probably due to the low number of newborns included in the study, low socioeconomic status, poor nutrition, maternal factors such as low iron , high gravidity and time between birth .

Mean Corpuscular Volume (MCV) value was similar to the international one. The Total leukocyte count was higher in the Italian study (mean was 14.4) than rest of the studies including the current results.

In all previous studies, the neutrophils were the predominant cells followed by lymphocytes. The wide range of leukocyte count was observed in all studies.

The mean of Platelet count in this study showed inconsistency values in different countries, such as Cote D'ivoire, Nigeria, Italy and Malawi, high possibly because of the following four reasons. This variation could be due to environmental factors such as medicinal herbs widely used in Africa, acute or chronic malaria and poverty with malnutrition in African countries. [7]

RBCs count showed similarity to the international parameters except India. The mean of Hematocrit in this study was lower than international parameters except Abidjan. The MCH was higher than others except in Italy. MCHC was lower in this study than international parameters but was similar in Indians.

Hence, this study may help in developing a reference range in Shendi population.

5.2. Conclusion

- The mean of haemoglobin is 15.1 g/dl, RBCs is 4.2 $x10^{12}$/L, PCV is 48.4%, MCV is 113.01fl, MCH is 35.5pg, MCHC is 31.3g/dl, TWBCs is 10.5 $x10^{9}$/L and platelet is 220 $x10^{9}$/L.
- The hematological parameters in newborn in Africa were similar to this study except in haemoglobin and WBCs count and platelet.

5.3.Recommendations

-Full care for pregnant women including nutrition and routine follow up till delivery.

-Large sample size research should be conducted in Shendi to establish the reference hematological values.

-Similar type of studies should be conducted in rural areas of Shendi as well as other provinces of Sudan to fully comprehend the effect on CBC parameters of newborns of various other factors effecting delivery as diet, environment and methods used during delivery by traditional midwife especially in the rural population.

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Appendix I

بسم الله الرحمن الرحيم

Questionnaire

Establishment of Umbilical Cord Haematological Parameters Referance Range in Shendi Locality

Serial No ( ) ***date: / /***

1. Age of mother:……..

2. Weight of newborn:.....

3. Mode of delivery….....

4. Complication during pregnancy

yes ( ) No ( )

5. If yes, mention it ….....

6. State of the newborn.....

Appendix II

إقـرار بالموافقـة

الاسم :----------

العمر :---------- العنوان :----------

أوافق بمحض ارادتي بالمشاركة في البحث العلمي المتعلق بدراسة قياس مكونات الدم في عينة الحبل السري في حديثي الولادة في شندي .

اسم الباحث :ست النفر مصطفى بابكر

بعد أن شرح لى بأنه لا يترتب عليه أي أذى جسدى واعلم أن المشاركة في هذا البحث لن تؤثر بأي حال من الأحوال في الرعاية الطبية التي يتلقاها مولودي كما أنه يحق لي بدون ابداء أسباب الإنسحاب من هذا البحث في أي مرحلة من مراحله.

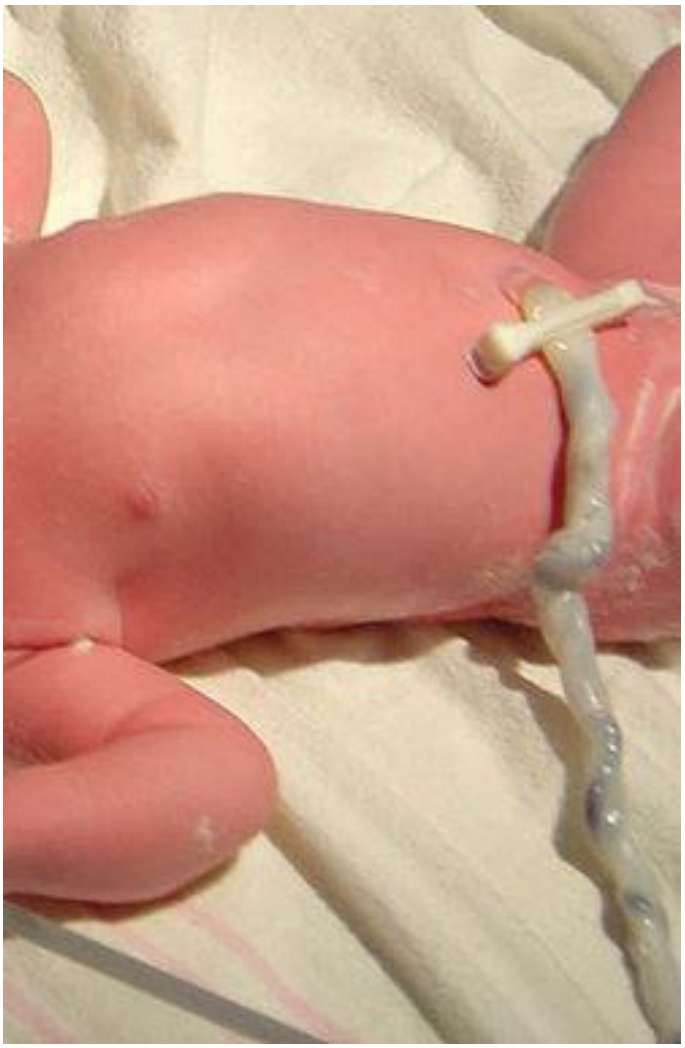
البحث بإشراف :

د.محمد عثمان علي

التوقيع : ----------

التاريخ :----------

Appendix III



Appendix IV