.Chapter One

Introduction and literature Review

1.1 Introduction

Pregnancy elicits a reorientation of physiologic prior pities of the woman's body optimal development of the maternal fetus. Specific alterations occur in the hematologic system during pregnancy as the mother provides the nutrients for fetal hematopoiesis and her body prepares for the hemostatic challenge of childbirth (Thomas*et al.*, 2004).

The hematologic profile significantly affected during pregnancy. And approach to recognition and management of hematologic problems during this staterequires a reorientation and expansion of the physician's focus to include the fetus and its specific need. Complete Blood count (CBC) determination during pregnancy is very important to follow up pregnant women (Thomas*et al.*, 2004).

Approximately 830 women every day die from preventable cause's related pregnancy and childbirth. 99% of all maternal deaths occur in developing countries. While higher in women living in rural areas and among poorer communities and young adolescent's faces a higher risk of complications and death as a result of pregnancy than other women. Good care before, during and after childbirth can save the lives of women and new born babies. Between 1990 and 2015, maternal mortality worldwide dropped by about 44%. Between 2016 and 2030, as part of the sustainable development agenda, the target is to reduce the global maternal mortality ratio to less than 70 per 100.000 live births (WHO, 2016).

1.2 Literature Review

1.2.1 Pregnancy

physician's customarily divide pregnancy into three time intervals called trimesters each of which is slightly longer Than 13 week.by convention (Carel *et al.*, 2008).

1.2.1.1 Pregnancy Trimester

1.2.1.1.1 First Trimester

The events that lead to pregnancy begin with conception, in which the sperm penetrates the egg produced by an ovary. The zygote (fertilized egg) then travels through the woman's fallopian tube to the uterus, where it implants itself in the uterine wall. The zygote is made up of a cluster of cells formed from the egg and sperm. These cells form the fetus and the placenta. The placenta provides nutrients and oxygen to the fetus (Pregnancy condition information, 2016).

1.2.1.1.2 Second Trimester

The second trimester is for many women the easiest three month of pregnancy in it feel better and the energy is up to start planning for baby arrival. During the second trimester the baby is growing quickly between 18 and 22 week of pregnancy, mother can see the baby progressing uses ultrasound. Also can see the sex of baby, Vernix and lanugo keep the fetus skin from chapping in the amniotic fluid. Most of the Brain neurons present by 24 weeks and the fetus react to sound; the fetus becomes 30 cm in length and 820gm in weight (Berk, 2011).

1.2.1.1.3 Third Trimester

The 26 to 40 weeks of third trimester is the period in which fetal organs complete their prenatal maturation, during it, the growth rate decelerates 3200g and is about 50 cm long term is the interval from 37 to 42 weeks normal labor, rhythmic uterine contraction, and birth occurring during this period (Carel *et al.*, 2008).

1.2.1.2 Maternal Adaptation

1.2.1.2.1 Physiological Change during Pregnancy

After conception, the corpus luteum, placenta, and developing embryo release hormones, growth factors, and other substances into the maternal circulation. These substances trigger a cascade of events that transform the functioning of the maternal cardiovascular, respiratory, and renal systems, which in turn alter the physicochemical determinants of $[H^+]$. Increased availability of substrates and precursors for fetal placental metabolism and hormone production is mediated by increases in dietary intake, as well as endocrine changes that increase the availability of glucose and low-density lipoprotein (LDL) cholesterol (Weissgerber and Wolf, 2006).

1.2.1.2.2 Hematological Change during Pregnancy

The major hematological changes during pregnancy are physiologic anemia, neutrophilia, mild thrombocytopenia, increased procoagulant factors, and diminished fibrinolysis. Plasma volume increases by 10 to 15 percent at 6 to 12 weeks of gestation, and then expands rapidly until 30 to 34 weeks, after which there is only a modest rise. Red blood cell mass begins to increase at 8 to 10 weeks of gestation and steadily risen by 20 to 30 percent (250 to 450

mL) above non-pregnant levels by the end of pregnancy (Michael and Nazli, 2011).

1.2.1.2.2.1 Anemia during pregnancy

Anemia is a major public health problem associated with maternal morbidity and mortality, especially in developing countries, it is important that there should be a firm diagnosis of anemia to unravel its possible cause(s) before the prescription of an appropriate therapeutic approach. A use of hemoglobin (HGB) level alone appears insufficient in determining the status of anemia in pregnancy. It is hypothesized that a combination of biochemical and hematological parameters could enhance the diagnosis (Benjamin, 2015).

1.2.1.2.2.1.1 Physiological anemia:

A greater expansion of plasma volume relative to the increase in hemoglobin mass and erythrocyte volume is responsible for the modest fall in hemoglobin levels. Physiological or dilutional anemia of pregnancy observed in healthy pregnant women. The greatest disproportion between the rates at which plasma and erythrocytes are added to the maternal circulation occurs during the late second to early third trimester. (Lowest hematocrit is typically measured at 28–36 weeks) Nearer to term, hemoglobin concentration increases due to cessation of plasma expansion and continuing increase in hemoglobin mass. Conversely, the absence of physiologic anemia appears to be a risk factor for stillbirth(Michael and Nazli,2011).

1.2.1.2.2.1.2 Iron Deficiency Anemia

Many women get pregnancy with low iron stores resulting from heavy menstrual periods, previous pregnancies, breast feeding, or poor nutrition. It is difficult to meet the increased requirement for iron through diet, and anemia often develops unless iron supplements are given. Red cells may not become hypochromic and microcytic until the hematocrit has fallen significantly. When this occurs, serum iron level below 40 mg/dL and transferrin saturation less than 10% are consistent with iron deficiency anemia (Stephen *et al.*, 2008).

1.2.1.2.2.1.3 Folic Acid Deficiency Anemia

Folic acid deficiency anemia is the main cause of macrocytic anemia in pregnancy, since vitamin B_{12} deficiency anemia is rare in the childbearing years. The daily requirement of folic acid doubles from 0.4 mg to 0.8 mg in pregnancy. Twin pregnancies, infections, malabsorption, and use of anticonvulsant drugs such as phenytoin can precipitate folic acid deficiency (Stephen *et al*., 2008).

1.2.1.2.2.2 Thrombocytopenia during pregnancy

Thrombocytopenia complicates up to 10% of all pregnancies, some of these are unique to pregnancy, while others may occur with increased frequency during gestation and still others bear no relationship to pregnancy present. While some thrombocytopenic disorders are not associated with adverse pregnancy outcomes, others are associated with significant maternal and/or neonatal morbidity and mortality. The time of onset of these disorders during pregnancy and their clinical manifestations often overlap, making the

diagnosis challenging. Immune thrombocytopenia (ITP) is one of the thrombocytopenic disorders that may complicate pregnancy and it management. ITP is the most common cause of isolated thrombocytopenia in the first and early second trimesters the pathophysiology of ITP has been classically believed to reflect the accelerated clearance of platelets coated by IgG antiplatelet autoantibodies (Evi*et al*., 2010).

1.2.1.2.2.3 Hemostasis and thrombosis during pregnancy

Pregnancy leads to a hypercoarguable state with consequent increased risks of thromboembolism and disseminated intra vascular coagulation (DIC). There is an increase in plasma factors VII, VIII, X and fibrinogen and fibrinolysis is suppressed. These changes last for up to 2 months into the puerperal period and the incidence of thrombosis during this period is increased. There is an association between thrombophilia conditions in the mother and with recurrent fetal loss, thisdue to placental Thrombosis and infarction(Hoffbrand*et al*., 2006).

1.2.1.2.3 Renal Function change during pregnancy

Substantial structural, functional and hemodynamic changes take place during normal pregnancy. Because of changes in the vascular and interstitial spaces, kidneys normally increase in size by up to 30%, with a 1–1. 5cm increase in length. Hydronephrosis, mainly secondary to ureteric mechanical obstruction, is common during pregnancy and may further enlarge the kidneys. The right ureter is more commonly affected because of the angle at which it crosses the iliac and ovarian vessels at its entry to the pelvis. Hormonal changes during pregnancy allow for increased blood flow to the kidneys and altered auto regulation such that glomerular filtration rate

(GFR) increases significantly through reductions in net glomerular oncotic pressure and increased renal size (Wael and Richard, 2014).

1.2.1.2.4 Endocrine change during pregnancy

Pregnancy alters the function of most endocrine glands, partly because the placenta produces hormones and partly because most hormones circulate in protein-bound forms and protein binding increases during pregnancy. The placenta produces the beta subunit of human chorionic gonadotropin (beta-hCG), a trophic hormone that, like follicle-stimulating and luteinizing hormones, maintains the corpus luteum and thereby prevents ovulation. Levels of estrogen and progesterone increase early during pregnancy because beta-hCG stimulates the ovaries to continuously produce them. After 9 to 10 week of pregnancy, the placenta itself produces large amounts of estrogen and progesterone to help maintain the pregnancy (Haywood, 2016).

1.2.1.2.5 Biochemical changes during pregnancy

During pregnancy, the electrolytes show little change, but there is an approximately 40%, increase in serum, triglycerides cholesterol, phospholipids, and free fatty acids, plasma albumin is decreased to an average of (3.4g/dl). In late pregnancy, plasma globulin concentration increase slightly. Several late pregnancies, plasma globulin concentration increase slightly. Several of the plasma transports protein increase significantly, including Thyroxin, binding globulin (CBG), and sex hormone binding globulin (SHBG) (Carel *et al.*, 2008)

1.2.2 Blood

Blood is a fluid inside the body. Transports oxygen and nutrients to the cells and takes out carbon dioxide and other wastes. Blood pumps out of the heart and goes to all parts of the body and then goes to all back to the heart to do it all over again. Blood is both a tissue and fluid. It is a tissue because of groups of cells being put together and blood is a fluid because the cells are in a liquid matrix. Blood is a need in the body (Shelby and Tiller, 2011).

Blood consists of formed elements that are suspended and carried in fluid calledplasma. The formed elements erythrocytes, leukocytes, and platelets. Functionrespectively in oxygen transport immune defense, and blood clotting. Plasmacontains different types of protein and many water soluble molecules (Fox, 2006).

1.2.2.1 Hemopoiesis

Hematopoiesis is defined as the production, development, differentiation, and maturation of all blood cells. Within these four functions is cellular machinery that outstrips most high-scale manufacturers in terms of production quotas, customs specifications, and quality of final product. When one considers that the bone marrow is able to produce 3 billion red cells, 1.5 billion white cells, and 2.5 billion platelets per day per body weight (Ciesla, 2007).

Site of hemopoiesis in the first few weeks of gestation: the yolk sac is the main site of hemopoiesis, and 6 week until6-7months of fetal life. The liver and spleen is the major hempotic organ and continue to produce blood cells until about 2 weeks after birth. The bone marrow is the most important site from 6-7 months of fetal life. During normal childhood and adult life the

marrow is the only source of new blood cells. The developing cells are situated outside the bone marrow sinuses and mature cells are released into the sinus spaces. In infancy all the bone marrow is hemopoietic but during childhood there is a progressive fatty replacement of marrow throughout the long bones so that in adult life hemopoietic marrow is confined to central skeleton and proximal end of the femurs and humerus. Moreover, the liver and spleen can resume their fetal hemopoietic role (extra medullary hemopoiesis). In fetus main site 0-2 months in yolk sac, 2-7months in liver and spleen 5-9months in bone marrow (Hoffbrand *et al., 2*006).

Regulation of hemopoiesis byhemopoietic growth factors which glycoprotein hormones that regulate the proliferation and differentiation of hemopoietic progenitor cells and the function of mature cells (Hoffbrand*et al., 2*006).

1.2.2.1.1 Erythropoiesis

Theerythronis the sum of all erythroid cells, including circulating red blood cells (RBCs) and marrow erythroid precursors. Erythroid precursors are derived from the colony forming unit- granulocyte, erythroid, monocyte, and megakaryocyte (CFU.GEMM). The earliest progenitor committed exclusively to erythroid lineage is the burst-forming unit–erythroid (BFU-E); this is followed by the colony-forming unit–erythroid (CFU-E).The earliest recognizable erythrocyte precursor is the pro-erythroblas**t**, which is characterized by a fine nuclear chromatin and intensely blue cytoplasm. The last nucleated RBC precursor is matophilic erythroblast, which ischaracterized by a well-hemoglobinzed cytoplasm; the nucleus is then lost producing the reticulocy**te**. Reticulocytes are identified using supravital stains such as new methylene blue; they cannot be definitively identified

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with routine Wright-Giemsa stains. Reticulocytes contain ribonucleic acid (RNA) for 4 days, normally; the first 3 days are spent in the marrow and fourth in the blood (Kern, 2002).

1.2.2.1.1.1 Red Blood cell (Erythrocyte)

Erythrocytes are anucleate cells containing few organelles; a large proportion of their cytoplasm consists of the iron containing oxygen approximately7 - 8 mm in diameter. The biconcave disk shape gives red blood cells (RBCs) the flexibility to squeezetheir way through capillaries and other small blood vessels. Viewed under the microscope, RBCs look like a circle with a central hole, or central pallor, which is approximately (one-third), the diameter of the cell. The normalRBCs count is approximately 4.5 to 6 million cells per microliter. They have a life span of approximately 120 days therefore; approximately 1% of red cells are replaced each day (Kern, 2002).

1.2.2.1.1.2 Hemoglobin

Human hemoglobin is formed from two pairs of globin chains each with a hemegroup attached. Normal adult hemoglobin (hemoglobin A) consists of four hemegroups and four polypeptide chains with a total of 574 amino acids. Thepolypeptide chains areorganized into two alpha chains and two beta chains. Eachof the chains has an attached heme group. Normal adult hemoglobin has 141 amino acids in each of the alpha chains and 146 amino acids in each of the beta chains. The specific sequence of these amino acids is known and is important in the identification of abnormal hemoglobin involving substitutions of specific amino acids (Turgeon, 2010).The iron group of home is able to combine with oxygen in the lungs and release

oxygen in the tissues. The heme iron recycled from senescent (old) red blood cells in the liver and spleen. This iron travel in the blood to bone marrow attach to protein carrier called transferrin. This recycledheme iron supplies most of the body need for iron. The balance of the requirement for iron, though relativelysmall must be made up for in the diet. Dietary iron is absorbed mostly in the duodenum and transported from the intestine bound to transferrin in blood. Transferrin is taken out of the blood when the transferrin molecule binds to receptor proteins on the plasma membranes of cells, triggering endocytosis (Fox, 2006)

1.2.2.1.1.3 Packed cell volume (Hematocrit)

The packet cell volume (PCV) can be used as a simple screening test for anemia as a reference method for calibrating automated blood count systems and as a rough practical hematology guide to the accuracy of hemoglobin measurement. The PCV is about three times ofHb which expressed in g/l. In conjunction with estimations of Hb and RBC, it can be used in the calculation of red cells indices. However it uses in under-resourced laboratories may be limited by the need for a specialized centrifuge and a reliable supply of capillary tubes (Daci and Lewis, 2011).

1.2.2.1.1.4 Red cells indices

Provide information about the hemoglobin content and size of red blood cell. Abnormal values indicate the presence of anemia and which type of anemia is it? (Henry, 2011)

1.2.2.1.1.4.1 The Mean red cell volume (MCV)

MCV is average size of a red blood cell and is calculated by dividing the PCV by the red blood cell count: MCV=PCV/RBC×10 (Henry, 2011).

MCV provides information on red cell size. Measured in femtolitters (fL) and is determined from the PCV an electronically obtained RBC count. There is some variation in reference ranges for MCV depending on the method used. Guideline reference range is 80–98fL. Values: low MCV are found in microcytic anemiaparticularly iron deficiency, anemia of chronic disease and thalassemia. It is low in infancy (about 70 fL at 1 year of age). RaiseMCVvalues: are found in macrocytic anemia, marked Reticulocytosis, and chronic Alcoholism, and is raised in new born infants (Monica, 2006).

1.2.2.1.1.4.2 Means corpuscular hemoglobin (MCH)

MCH is a measure of the average hemoglobin content per red cell. It may be calculated manually or by automated methods using the following formula**.**MCH=HB g/dl÷RBCs count $\times$ 10^{12} /LMCH is expressed in pictograms (pg) or (10–12 g). Thus, the MCH is a reflection of hemoglobin mass. In anemia secondary to impaired hemoglobin synthesis, such as iron deficiency anemia, hemoglobin mass per red cell decreases, resulting in a lower MCH value (John*et al.*, 2014).

1.2.2.1.1.4.3 Means Corpuscular Hemoglobin Concentration

MCHC gives the concentration of hemoglobin in 1 liter of packedred cells. MCHC (g/dl) = Hb (g/dl) ÷ PCV (Monica, 2006).

It is calculated from the hemoglobin and PCV. Low MCH values are found in microcytic hypochromic anemia and also when red cells are microcytic

and normochromic. In thalassemia minor the MCHC is low even when anemia is mild (MCHC is often normal) Raised MCHC value are found in microcytic hypochromic (Monica, 2006).

1.2.2.1.1.5 Red cell distribution width(RDW)

Most instrument also produce a quantitative measurement of the variation in cell volume, an equivalent of the microscopic assessment of the degree of anisocytosis. This parameter has been named the red cell distribution width. RDW is derived from pulse height analysis and can be expressed either as the standard deviation (SD) in fl or as the coefficient of variation (CV) (%) of the measurements of the red cell volume. The RDW-SD is measured by calculating the width in fl at the 20% height level of the red cell size distribution histogram and the RDW-CV is calculated mathematically as the coefficient of variation

RDW-SD% = ISD/MCV×100%.

The normal reference range is in the order of 12.8 ± 1.2% as CV and 42.5 ± 3.5 fl as SD. However, widely different ranges have been reported. Therefore it is important for laboratories to determine their own reference ranges (Daci and Lewis, 2011).

1.2.2.1.2 Myelopoiesis

Under the influence of cytokines, myeloid progenitor cell is form, this cell then differentiate into morphologically recognizable myeloid precursors: myeloblasts, promyelocyte, myelocyte, and metamylocytes. Normally these cells do not appear in peripheral blood. Myeloblasts are rather large cells and have large nucleus with fine chromatin and several nucleoli. Cytoplasmic

granules are absent. The normal marrow contains up to 5% of myeloblast. Cell divisions of myeloblast result in the formation of promyelocyte slightly larger neutrophil precursors with granules in their cytoplasm. These cells in turn give rise by cell division to myelocyte, which have smaller granules (secondary or specific granules). At this stage, a differentiation of the myelocyte into the neutrophil, eosinophil, and basophil series can be recognized (Reinhold*et al.*, 2007).

1.2.2.1.2.1 White Blood cells (Leukocytes)

White blood cells (WBCs) are the cellular elements of the immune system in humans and other animals. Their primary function is to patrol the body for potential sources of infection and destroy invading pathogens, such as viruses, bacteria, fungi, and parasitic microorganisms. Leukocytes derive from pluripotent hematopoietic stem cells in the bone marrow and are specialized into four morphologically different cell types of myeloid lineage (neutrophils, eosinophils, basophils, and monocytes) and lymphoid cells that include natural killer (NK) cells and T- and B-lymphocytes. WBCs, also known as "leukocytes," migrate to the sites of infection to destroy pathogenic microorganisms (Damir, 2009).

The presentstudy was focused to the most cells were affected during pregnancy.

1.2.2.1.2.1.1 Neutrophils

Neutrophils have a nucleus which stains purple and is divided into two to five segments or lobes. The lobes are separated by a thin strand or filament of nuclearmaterial. The nuclear chromatin is heterogeneous with some clumping. Thecytoplasm of it is very pale blue and is packed with fine line

staining granules. Neutrophils are produced in the bone marrow. They spend 6–10 hours in the blood stream before moving from capillaries into tissues. The major function of neutrophils is as tissue phagocytes. They move preferentially to sites of infection or inflammation where they ingest, kill and break down bacteria. The process of moving to sites of infection or inflammations known as chemo taxis and occurs in response to activated complement components and chemical signals released by a variety of cells (Bain, 2004).

1.2.2.1.2.1.2 Lymphocytes

Lymphocyteshavetwo general sub populations, B Lymphocytes and T Lymphocytes. Appear morphologically similar on peripheral smear. Their derivation and function, however, are quite different. B lymphocytes comprise, 10 to 20% of the total lymphocyte population, whereas T lymphocytes comprise 60 to 80%. A third minor population, natural killer (NK) lymphocytes, constitutes less than 10% of the total lymphocyte population (Ciesla, 2007).

1.2.2.1.2.1.2.1Blymphocytes

B cells are the primary effectors of the humoral (antibody‑mediated) immune system.They develop in the bone marrow and are found in lymph nodes, the spleen and other organs, as well as in blood. After antigen stimulation, B cells may develop into plasma cells, which are the primary antibody-producing cells (Kern, 2002).

1.2.2.1.2.1.2.2 T lymphocytes

T cells are the main effectors of cell-mediated immunity. They are the command and control cells of the entire immune system they stimulate or inhibit the function of other cells of the immune system, including B cells, monocytes and macrophages, and other T cells. Their precursors originate in the bone marrow but develop and mature in the thymus. Normally, the majority of circulating lymphocytes are T cells. They are divided into two main subtypes: Thelper cells, which are the major regulatory cells of the immune system, usually express a surface antigen designated CD4. T suppressor (cytotoxic cells)is involved in the destruction of virally infected cells and rejection of transplanted organs. They usually express the CD8surface antigen. Unlike other leukocytes, which make a one-way trip between blood and tissues, lymphocytes can recirculate between blood, tissue, and lymph fluid (Kern, 2002).

1.2.2.1.3 Thrombopoiesis

Platelets drive from megakaryocytes, which are very large cells with a large, multi-lobulated nucleus. The dioxy nucleic acid (DNA) content of mega-karyocytes is at least eight times that of other somatic cells. One megakaryocyte can produce at least several thousand platelets. The formation and release of platelets is related to a preformed structure in the cytoplasm of megakaryocytes, the so-called (demarcation membrane system) megakaryocyte derive from megakaryocyte progenitors colony forming unit-megakaryocyte (CFU-Mega) which in turn originate in develops at hematopoietic stem cell. Megakaryocytes are mainly found in the bone marrow but can transit too many organs, including the lungs, where part of the platelets released. The maturation of megakaryocyte and the production

of platelets are occurs under the influence of thrombopoietin (TPO).Which act together with certain other cytokines like (IL6 and IL11), on early megakaryocyte progenitor as well as mature megakaryocyte. Under physiological conditions, the serum levels of (TPO) are low at normal orelevated platelets counts and high in individuals with low platelet count (Reinhold*et al.*, 2007)

1.2.2.1.3.1 Platelets (Thrombocytes)

Platelets are nucleate circulating blood particles. They circulate around the body in an inactive state until they come into contactwith areas of endothelial damage or activation of the coagulation cascade. Here they adhere to the endothelial defect, release their granules content, and stick together to form aggregates. Physiologically these processes help to limit blood loss, inappropriate or excessive platelet activation result in an acute obstruction of blood flow, as occurs, for example, in an acute myocardial infraction. However, activated platelet also express and release molecules that stimulate a localized inflammatory response the activation of leukocyte and endothelial cells, and it is now clear that platelet function is not merely limited to the prevention of blood loss. Indeed, platelets have been implicated in many pathological processes including host defense, inflammatory arthritis, adult respiratory distress syndrome, and tumor growth and metastasis (Martin and Desmond, 2005).

1.2.3 Complete blood count (CBC)

Complete blood count (CBC) is one of the most frequently ordered laboratory tests in the hematology laboratory.CBC gives important information about the kinds and number of cells in the blood, especially

redblood cells, white blood cells and platelets.This evaluation consists of nine components and offers the clinician a variety of hematological data to interpret and review that directly relate to the health of the bone marrow, represented by the numbers and types of cells in the peripheral circulation, the 17 components of the CBC are WBC count, RBC count, HB, PCV, MCV, MCH, MCHC, PLT count and RDW, DLC(Neutrophil, Lymphocyte, Monocyte, Eosinophil, Basophil), PMV, PDW depending on the type of automated instrumentation used (Ciesla , 2007).

1.2.3.1Clinical significant of CBC

The CBC is a basic screening test. Finding in the CBC gives valuable diagnostic information about the hematologic and other body system prognosis, response to treatment, and recovery. The CBC consists of a series of test that determine number, variety, percentage concentrations and quality of blood cells (Fox, 2006).

1.2.4 Previous Studies

1.2.4.1Previouse Study in world

Chandra S et al (2012) studied on physiological changes in hematological parameters during pregnancy. They found that pregnancy is a state characterized by many physiological hematological changes, which may appear to be pathological in the non-pregnant state. The review highlights most of these changes along with the scientific basis for the same, as per the current knowledge, with a special reference to the red blood and white blood cells, platelets and hemostatic profile.

1.2.4.2 Previous study in Africa

The study was conduct in Nigeria by Jacobs et al(2013)study found there was variation in some hematological indices during normal pregnancy. Also showed that there was a significant decreasedin the PCV, Hb, Granulocytes and platelets, while lymphocytes increase in study groups compared with control and concluded that pregnancy in women has the tendency to alter hematological indices.

1.2.4.3 Previous Studies in Sudan

Many researches were conducted in the Sudan University Science and Technology to evaluate hematological profile in normal pregnancy aimed to determine the CBC in Sudanese pregnant women in different state of Sudan:

Abd-Elsalam (2012) assessedCBCin pregnant women in Port Sudan in cross-sectional case control descriptive study aimed to determineCBC of Sudanese pregnant women and they were studied possible risk factors such as age, number of pregnancy, stage of trimester and history of

abortion,usesautomated hematological analyzer (Sysmex KXN-21) found that WBC and neutrophils significantly increased, while Hemoglobin, Platelets, eosinophils, basophils, MPV insignificantly decreased,while MCV, MCH and RDW increased insignificantly.

Elgari(2013) showed that there were significant decreased in RBCs count, Hb and PCVof pregnant women compared to non- pregnant women (*P value*<0.05) and significant decrease MCV, MCH and MCHC of pregnant women, while WBCs count was increased significantly in contrast to platelets count which was significantly lower than the normal control.

Abdelgaderet al (2014) measured Hemoglobinlevel, RBCs Indices, and iron status in pregnant females in Sudan, the results showed that out of 80 pregnant females, of them had low Hb level, and while 72 had normal Hb level. RBC indices showed 62 mothers had normal MCV, while 18 mothers had low MCV. 63 mothers had normal MCH, while 17 had low MCH, 78 had normal MCHC, while 2had low MCHC.

Nasor(2015) showed that RBCs, Hb, MCHC, lymphocyte count, lymphocyte percentage decreased significantly in pregnant women compared to non-pregnant womenWhile MCV, neutrophil count and neutrophil percentage increased significantly in pregnant womencompared to non- pregnant women and no significant differences in HCT, MCH, WBCs, and MXD of pregnant women when compare to non- pregnant women.The case control study done by

Albadri (2016) in Khartoum North to determine CBC of 80 Sudanese pregnant women at Second trimester as case and 40 non- pregnant women as matched age with control. The results showedsignificant decrease in

meansof HCT, TRBCs, Hb, and MCHC and lymphocytes percentagein pregnant women when compared withnon-pregnant women.WBCs count, PDW, MPV and neutrophils percentage significantly increase, while insignificant decrease in means of MCV, MXD percentage and platelets in pregnant women compared with non- pregnant women. Alsoinsignificant increased in means of MCH and RDW-sd.No significant difference in means of Hb, HCT, TRBCs count and indices and WBCs count and differential,platelets and their indices between with and without abortion .There was no statistical difference between means of Complete blood cell countin pregnant women who's had less or more than three children also no significant difference between means of Complete blood cell count in pregnant womenwhose age more or less than 30 years. The study concluded that HCT, TRBCs, Hb, MCHC and lymphocytes and neutrophil percentage,WBCs count, PDW, MPV significantly affected by pregnancy at second trimester.

1.3 Rationale

Pregnant women in rural area didn't receive enough maternal care due to socioeconomic causes and that leads to complication during pregnancy and increase in mortality.

Few studies were done about hematological profile of Sudanese pregnant women, especially in North Kordofan State.

This study is a part of a project to establish baseline data of CBC of pregnant women in El Obeid Teaching Hospital during pregnancy.

1.4 Objectives

1.4.1 General Objectives

To determine Complete Blood cell Count (CBC) of Sudanese pregnant women during pregnancy in El Obeid locality.

1.4.2 Specific Objectives

-To determine CBC of Sudanese pregnant women during pregnancy.

-To compare between means red blood cells count and its indices,platelets count, white blood cells count and its differential and Absolute in pregnant and non-pregnant women.

- To determine effect of different factor on CBC parameter in pregnant women.

-To determine possible correlation between CBC in different cases groups.

Chapter Two

Materials and Methods

2.1 Study design

This study was prospective and case control study conducted at El ObiedTeaching Hospital during the period from March to December(2016).

2.2 Sample size

One hundred eighty (180)women were enrolled in the study. Include One hundred twenty (120) pregnant women sub divided into three groups first, second and third trimester and sixty (60) non-pregnant women. With age group varies 18-40 years.

2.3 Study area

Samples were collected in North KordofanState (257 miles south west of Khartoum) at El Obeid Teaching Hospital.

2.4 Study population:

Sudanese pregnant women during pregnancy attended in ElObiedTeaching HospitalinNorthKordofan State and control group (non-pregnant) women. With age ranged between 18 and 40 years.

2.4.1 Inclusion criteria:

Include only healthy pregnant women around ElObied locality with age 18-40 years.

2.4.2 Exclusion criteria

Women who were subjected to blood transfusion in last three months and with history of diseases that may affect the result such as; malaria, liver diseases, renal diseases, hypertension, diabetes mellitus, were excluded from the study.

2.5 Tools of data collection

Data was collected using structural interviewing questionnaire data, clinical data was obtained for sample collection and clinical record.

2.6 Method of sample collection

2.5 ml venous blood was collected from individual under study and dispensed in EDTA container for CBC determination (Daci and Lewis, 2011).

2.7 Methods

2.7.1 Procedure of CBC

Automated methods may provide additional data describing cellular characteristics such as cell volume. However, the automated measurements describe average cellular characteristics but do not adequately describe the scatter of individual values around the average. Hence, a bimodal population of small (microcytic) and large (macrocytic) RBCs might be reported as

Normal cell size. Therefore, a thorough blood examination also requires microscopic evaluation of a stained blood film to complement hematology analyzer data, especially when new findings are identified (John*et al.*, 2014).

2.7.2 Hemoglobin concentration

Hemoglobin (Hb) is an intensely colored protein, allowing its measurement by spectrophotometric techniques. Hemoglobin is found in the blood in a variety of forms, including oxyhemoglobin, carboxyhemoglobin, met-hemoglobin, and other minor components. These may be converted to a single stable compound, cyanmethemoglobin, by mixing blood with Drabkin solution (containing potassium ferricyanide and potassium cyanide).Sulfhemoglobin is not converted but is rarely present in significant amounts. The absorbance of the cyanhemoglobin is measured in a spectrophotometer at 540 nm to determine Hb. This technique is used both in manual determinations and automated hematology analyzers. Hb is expressed in grams per deciliter (g/dl) of whole blood (John*et al.*, 2014).

2.7.3 Red Blood cell count and platelets count

Red cells and other blood cells were counted in systems based on aperture impedance technology. Platelets can be counted in whole blood using the same techniques of electrical detection as is used for counting red cells. An upper threshold is needed to separate platelets from red cells and a lower threshold is needed to separate platelets from debris and electronic noise. RBC normal range in women $4.3 \pm 0.5 \times 10^{12}$/L, and platelet normal range in women $280 \pm 130 \times 10^9$/L (Daci and Lewis, 2011).

2.7.4 Packet cells volume count

Automated blood cell counter was estimated PCV by technology that has little connection with packing red cells by centrifugation. The passage of a cell through the aperture of an impedance counter leads to the generation of an electrical pulse, the of which is proportional to cell volume. The number

of pulses generated allows the RBC to be determined. Women normal Range (0.41 ± 0.05 L/L) (Daci and Lewis, 2011).

2.7.5 Total white blood cells

The WBC is determined in whole blood in which red cells have been lysed. The lytic agent is required to destroy the red cells and reduce the red cell stroma to a residue that causes no detectable response in the counting system. The following fluid is satisfactory: Certified 20 g,10% formaldehyde (in 9 g/l NaCl) 2 ml, Glacial acetic acid 16 ml, NaCl 6 g, and water to 1 liter. Residual particles in a diluted blood sample are counted after red cell lysis, normal range 4 - 10 × 109 L (Daci and Lewis, 2011).

2.7.6 Automated differential leukocyte count

Automated leukocyte differentials markedly decrease the time and cost of performing routine examinations as well as increasing accuracy to a CV of 3 to 5%.However, automated analysis is incapable of accurately identifying and classifying all types of cells and is particularly insensitive to abnormal or immature cells. Therefore, most analyzers will flag possible abnormal white cell populations, indicating the need for examination by a skilled morphologist for identification.The capacity for performing automated leukocyte differentials is incorporated into hematology analyzers, which identify cells on the basis of cellular size, cell complexity, or staining characteristics as part of the complete blood count, allowing for generation of a five-part differential count that numerates neutrophils, monocytes, lymphocytes,eosinophils, and basophils.Most systems perform cell counts on specimens via continuous(John*et al.*, 2014).

2.8 Ethical Consideration

Ethical clearance was obtained from ElObied Teaching Hospital for Obstetric and women disease and Research council of the collage of Medical Laboratory Sciences and samples were collected. Named consents were taken from all the participations after they had been informedabout the procedure of blood collection and aims of study.

2.9 Data analysis

Data was checked and analysis using Statistical Package of Social Sciences (SPSS) software program (version 16), one sample T-test were used to obtain P-value significant level was set at ≤ 0.05

Results

This study was carried at Kordofan North State at ElObied Teaching Hospital for Obstetric and women Diseases during the period from March to December 2016 to measure CBC of pregnant women.

3.1Demographic Results:

Distribution of study volunteers According toageshowed that most frequent group in study volunteers was (21-30) year 68/120 (56%) in pregnant women and was 30/60 (50%) in non-pregnant women while the least frequent groups in study volunteers was(18-20) and (31-40) year 26/120 (22%) in pregnant women and was (18-20) year 10/60 (17%) in non-pregnant women.Table- (1) and Figure (1)

Table – (1): Age distributions among study volunteers

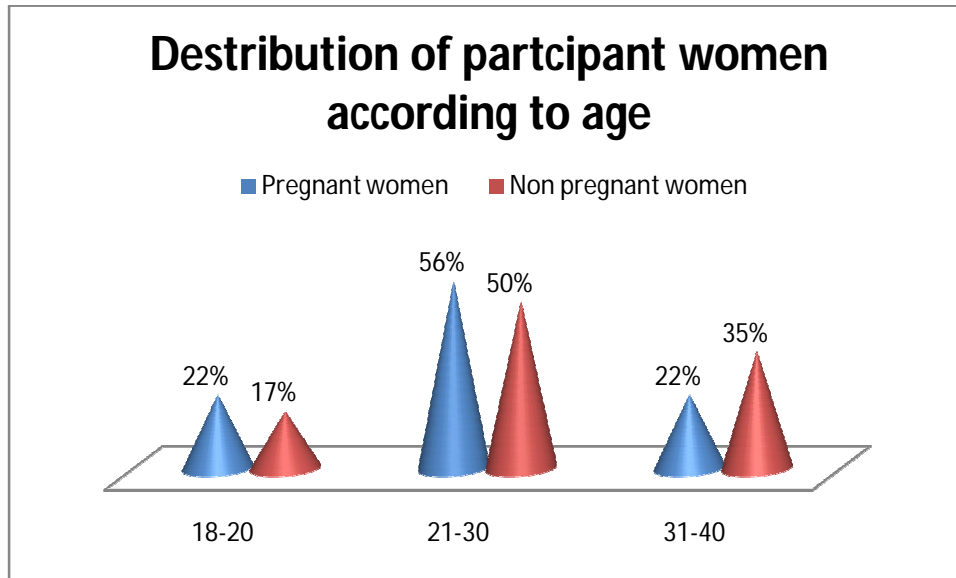| Age group Year	Pregnant Women	Non-pregnant Women
18-20	(26/120),22%	(10/60),17%
21-30	(68/120),56	(30/60),50%
31-40	(26/120),22%	(20/60),35%
Total	**120**	**60**

Figure (1): Distribution of participant women according to age

Distribution of possible risk factors in pregnant women:

Distribution of pregnant women according to history of miscarriage showed thatonly 30/120 (25%) of pregnant women has a history of it. AndMultigravidiae was most frequent group 48/120 (40%) followed by primigravidiae37/120 (31%) and then secondarygravidiae group 35 /120 (29%). Majority of women in third trimester 84/120 (70%) followed bysecond 19/120 (16%) and first trimester 17/120 (14%).Socioeconomic status and education level were showed that the most frequent women were poor 100/120 (83%), while the least frequent was high Socioeconomic 8/120 (7%), and illiterate had high frequent 52/120 (40%) compared with primary35/120 (29%), secondary 23/120 (20%) and high education 10/120 (11%). Only 27% of women had anemia and 50% of pregnant women were residence in rural areas. Table - (2), Figure (2) and Figure(3)

Table- (2): Distribution of possible risk factors in pregnant women

| Variables	Frequents	Percentages
Miscarriage		
Yes	30/120	25%
No	90/120	75%
Gravidiae		
Primgravidiae	37/120	31%
Secondrygravidiae	35/120	29%
Multigravidiae	48/120	40%
Trimesters		
First trimester	17/120	14%
Second trimester	19/120	16%
Third trimester	84/120	70%
Socioeconomic		
Poor	100/120	83%
Good	12/120	10%
High	8/120	7%
Education level		
Illiterate	52/120	40%
Primary	35/120	29%
Secondary	23/120	20%
High	10/120	11%
Anemia		
Anemic	32/120	27%
Non anemic	88/120	73%
Residence		
Rural area	60/120	50%
In El Obied	60/120	50%
Total	**120**	**100%**
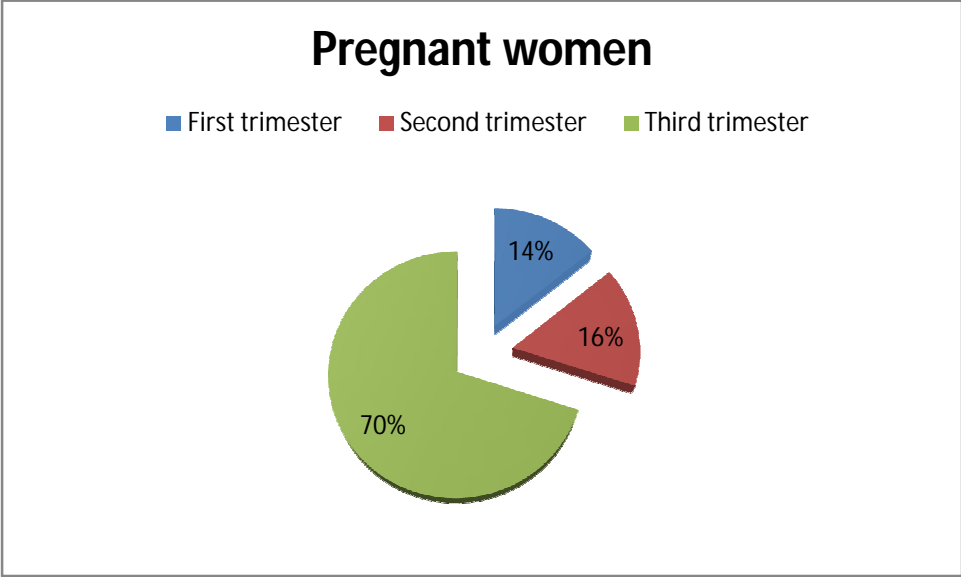
Figure (2):Distribution of pregnant women according to Trimester
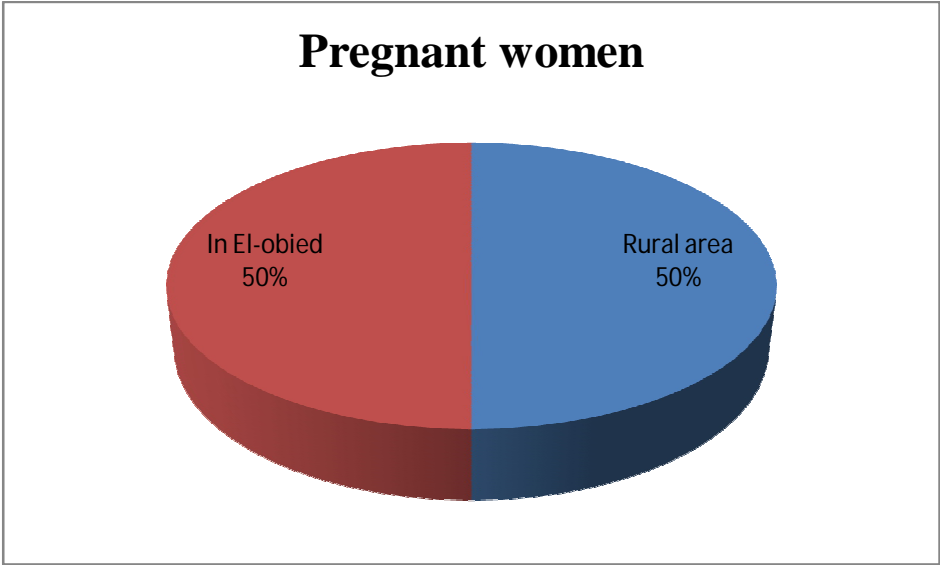

Figure (3):Distribution of pregnant women according to residence

3.2 Comparison of results:

Hb content, RBC and MCH of study population were showed significantly decrease (*p.value*<0.05) in pregnant women compared to non-pregnant women, while Hematocrit, MCV and MCHC of the study population showed there was no statistical correlation among study subject (*p .value>0.05*).Table - (3)

Table-**(3):**Comparison of Hb content, Hematocrit and RBCs count and its Indices between pregnant women and non-pregnant women

Parameter	Mean Pregnant	Mean non pregnant	*P.value*
Hb g/dl	11.8 ± 1.6	$12.7 \pm 1.o$	0.00
RBCs$\times 10^6$ µl	4.18 ± 0.5	4.33 ± 0.4	0.05
HCT%	35.7 ± 4.5	36.7 ± 3.3	0.09
MCV fl	85.2 ± 6.6	85.6 ± 3.3	0.06
MCH pg	28.3 ± 2.5	29.2 ± 1.2	0.01
MCHC%	33.4 ± 4.6	33.9 ± 1.7	0.34

WBCs count and granulocytes (percentage and absolute) of the study population were show significantly increased (*p.value*< 0.05) in pregnant women compared to non-pregnant women. On the other hand the

lymphocytes percentage and mid percentage showed significant decrease, while platelets showed insignificant decrease when compared between non-pregnant women. (*p.value*>0.05).Table - (4)

Table- (**4**):Comparison of Platelets count, WBCs count and its Differential and Absolutes between pregnant and non-pregnant women

Parameter	Mean Pregnant	Mean non-pregnant	*P.value*
WBC×10^3 µl	8.8±3.9	6.9 ± 2.4	0.00
Gran%	67.6 ± 8.7	61.9 ± 12.2	0.00
Lym%	24.3 ± 8.2	29.7 ± 9.9	0.00
Mid%	8.0 ± 2.5	9.3 ± 2.9	0.00
Gran#	6.2 ± 3.7	4.4 ± 2.2	0.00
Lym#	1.9 ± 0.6	1.9 ± 0.7	0.80
Mid #	0.8 ± 0.6	0.6 ± 0.2	0.20
Plt×10^3 µl	234± 7.0	252 ± 68.7	0.09

3.3 Effected of different factors on CBC parameter:

3.3.1 Effect of the gestational age:

Result showed there was no statistical correlation between first and second Trimester while there was statistical significant between second and third trimester *P.value* (>0.05*) (*<0.05) respectively. Table- (5)

Table - (5): The effect of the gestational age onHb, HCT, RBCs count andits indices, platelets and WBCs and its differential and absolute

Parameter	Mean First Trimester	Mean Second Trimester	Mean Third Trimester	*P value* 1st+2nd	*P value* 1st+3rd	*P value* 2nd+3rd
Hb g/dl	12.0 ±1.3	11.2 1.8	11.8 ± 1.5	0.75	0.00	0.00
RBCs×10^{6} µl	4.43 ±o.5	3.85 ± 0.6	4.20 ± 0.5	0.06	0.00	0.00
HCT%	36.6 ±3.7	33.9 ± 5.2	35.8 ± 4.5	0.06	0.00	0.02
MCV f/l	81.5 ±7.9	88 ± 5.7	85.7± 6.2	0.93	0.00	0.00
MCH p/g	27.2 ±2.7	28.5 ± 2.4	28.3 ±2.5	0.86	0.00	0.00
MCHC%	32.7 ±1.2	33.1 ± 0.8	33.5± 5.5	0.84	0.00	0.00
WBCs×10^{3} µl	8.9 ± 7.2	8.6 ± 2.6	8.8 ± 3.1	0.85	0.00	0.00
Gran%	64.3 ±1.2	68.6 ±5.9	68.2 ± 8.4	0.89	0.00	0.00
Lym%	26.7 ±1.1	22.6 ± 5.5	23.9 ± 8.0	0.52	0.00	0.00
Mid%	9.0 ± 1.0	8.8 ± 2.3	7.7 ±2.3	0.84	0.00	0.01
Pl.t×10^{3}µl	278.6±1.2	243.3±6.2	222,7±5.5	0.47	0.00	0.00

3.3.2 Effect of Miscarriage:

Result showed that history of miscarriage among pregnant womenhadno effected on HCT, RBC and WBC (*pvalue*<0.05), whileHb, platelet may be affected by history of miscarriage (*P value* = 0.05). Table - (6)

Table - (6): The effect of Miscarriage on Hb,HCT, RBC, WBCs and Platelets

Parameter	Number	Means	*P. value*
Hb yes	30	11.7 ±1.3	
No	90	11.8 ± 1.6	0.05
HCT yes	30	35.4 ± 3.9	0.70
No	90	35.7 ± 4.6	
RBC yes	30	4.19 ± 0.59	0.97
No	90	4.18 ±0 .51	
WBC yes	30	8.70±5.7	0.88
No	90	8.80 ± 3.1	
Plt yes	30	262 ± 98.3	0.05
No	90	224 ± 56.0	

3.3.3 Effect of anemia:

Result showed that anemia was statistical correlation effectedon Hb, HCT and RBC, while there was no statistical correlation effected on WBC and Plt. Table - (7)

Table – (7): Effect of anemia on Hb, HCT, RBC, WBC and plt in pregnant women.

Parameter	Number	Means	*P. value*
Hb Anemic	32	9.8 ± 1.0	0.00
no anemic	88	12.5 ± 0.9	
HCT Anemic	32	30.3 ± 3.2	0.00
no anemic	88	37.6 ± 2.9	
RBC Anemic	32	3.70 ± 0.57	0.00
no anemic	88	4.35 ± 3.9	
WBC Anemic	32	8.7 ± 3.7	0.79
no anemic	88	8.7 ± 3.9	
Pl.t Anemic	32	236 ± 87	0.81
no anemic	88	233 ± 69	

3.3.4 Effect of number of pregnancy:

Result showed thatnumber of pregnancy was significant effected on platelets*(p. value > 0.05)*, while there were no affected on Hb, HCT, RBC and WBC*(p. value < 0.05)*. Table - (8)

Table - **(8):** Effect of number of pregnancy on Hb, HCT, RBC, WBC and platelets in pregnant women uses Independent sample t test.

Parameter	n=1	n>1	*P value*
Hb g/dl	11 ± 1.6	11 ± 1.5	0.29
HCT %	35.1 ± 4.6	35.9 ± 4.3	0.39
$RBC10^6 \times \mu l$	4.12 ± 0.1	4.21 ± 0.1	0.41
$WBC \times 10^3 \mu l$	9.0 ± 5.3	8.7 ± 3.1	0.71
$Plt \times 10^3 \mu l$	265 ± 50	220 ± 50	0.00

Key word: n= number of pregnant

3.3.5 Effect of Socioeconomic, Education and Residence

Result showed that the Socioeconomic, education and Residence had no statistical effected on Hb, HCT, RBC, WBC and platelets. Table – (9)

Table - **(9):** Effect of Socioeconomic, Education and Residence on Hb, HCT, RBC, WBC and platelets uses one way Anova test.

Parameter	P value Socioeconomic	P value Education	P value Residence
Hb g/dl	0.33	0.75	0.82
HCT %	0.65	0.88	0.81
RBC$\times10^6$ µl	0.44	0.67	0.73
WBC$10^3\times$µl	0.33	0.06	0.73
Plt$10^3\times$µl	0.35	0.06	0.06

3.4 Correlation Results

3.4.1 Correlation ofgestational age to Hb level

Distribution of Hb level and correlation of gestational age to Hb level in pregnant women showed that there were 88/120 (73%) had normal hemoglobin level, while 27/120 (23%) had mild anemia,4/120 (3.3%) had moderate anemia and only one women 1/120 (0.8%) was suffering from severe anemia in second trimester. Table- (10) and Figure (4)

Table - **(10):** Correlation of gestational age to Hb level

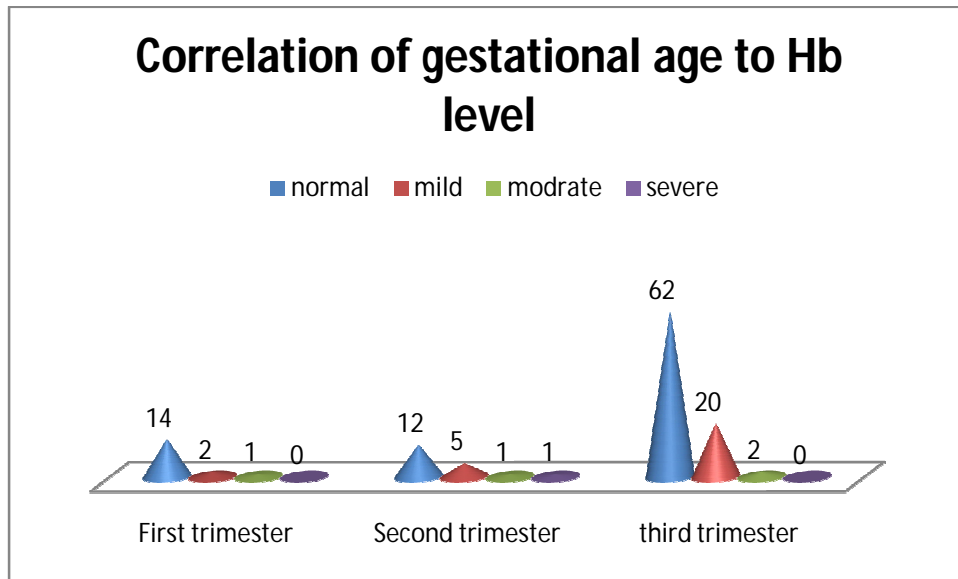| pregnant women trimester	Normal >11.og/dl	Mild anemia 9.0-10.9/dl	Moderate anemia 7.0-8.9g/dl	Severe anemia <7.0 g/dl
First	14	2	1	-
Second	12	5	1	1
Third	62	20	2	-
Total	88 73%	27 23%	4 3.3%	1 0.8%

Figure (4): Correlation of gestational age to Hb level and anemia

Chapter four

Discussion, conclusion and recommendation

4.1 Discussion

This study designed to provide means and difference between pregnant women during pregnancy and control(healthy women without pregnancy) in North KordofanState attending at ElObied Teaching Hospital.

In present study theHb concentration showedsignificant decrease in pregnant women compared with non-pregnant women, similar result was documented in Sudan in differences of trimester with (Elgari, 2013;Nasor, 2015; Hassan, 2015;AlBadri, 2016)Also this study agrees with study conducted in India by Smendraet al(2016) who reported that decline in Hbmay be due to an increased demand for iron and nutrients as pregnancy progresses. The result disagreed with(Khalil, 2012) observed that Hb concentration of pregnant women did not vary significantly from that of non- pregnant women.

In present study the HCT values were show insignificantly decreased in pregnant women when compared to non-pregnant women. This result agrees with study conducted in Elgatarefby (Mohamed, 2015), the study was disagreed with study conduct in Nigeria by Jacobs et al(2013) they found a significant decrease in Hb and HCT.In the present study there are significant decrease in means of RBCs count in pregnant women compared to non-pregnant women, similar result were documented in Nigeria by(Akinbami*et al.,*2013).

In present study MCV and MCHC showed insignificant decrease, while MCH was show significant decrease in pregnant women compared to non-

pregnant womenthis result was disagreed with previous study conducted by Milman et al (2000) who foundall hematologic indices were significantly lower in placebo-treated than in iron-treated women. The result agrees with (Jacobs *et al.*, 2013) who reported this variation in indices was might be attributed to variation in supportive supplementation during pregnancy and or nutritional habits.

In present study was found significant increase in the WBCs count compared to non-pregnant women. The result agree with (Pughikumo*et al.,* 2015) who reported ThatWBCs count increases steadily in pregnancy from the first to the third trimester. It was not an indication for the diagnosis of infection in these women.

In this study the granulocyte (percentage and absolute) showed significant increase in pregnant women when compared to non-pregnant women, this result similar to result documented by (Jessica *et al.,*2007) who reported thatNeutrophil increased due to Neutrophil chemo taxis and phagocytic activity are depressed, especially due to inhibitory factors present in the serum of pregnant women.

In present study the lymphocyte (percentages) and Mid percentage is significant decrease in pregnant women compared to non-pregnant women. In present study the platelets was show insignificant decrease this result was disagree with previous study conduct by (Akinbami*et al*., 2013) who found significant decrease in pregnant women when compare with non-pregnant women.This gradual reduction in PLT count as pregnancy advance may be due to hemodilution secondary to expansion of the plasma volume. The history of miscarriage, anemia and number of pregnancies effected the some parameter of CBC, this result disagree with (Nasor, 2015) who report that no

significant effect of abortion, number of children and age on CBC of pregnant women.In present study when classified the study population to groups according the gestational age the CBC parameter showed no statistical correlation between first and second Trimester while there was statistical significant between second and third trimester.

4.2 Conclusion

1- Significant decrease (*p value*<o.o5) inHb, RBCs count, MCH, Mid percentage and lymphocyte percentage in pregnant women compared to non-pregnant women, whileinsignificant decrease (*p value*>0.05) in HCT, MCV, MCHC and plate lets count in pregnant women compared to non-pregnant women.

2- Significant increase (*p value*<0.05) inWBCs count, Granulocyte (percentage and absolute) in pregnant women compared to non-pregnant women.

3-No statistical correlation between first and second Trimester while there was statistical significant between second and third trimester.

4- History of miscarriage, anemia, and number of pregnancies had significantaffected to someparameter of CBC.

5. Socioeconomic, education and Residence had no significant effected CBC parameter.

4.3 Recommendation

1-Receive enough maternal care in rural area and that leads to reduce the complication during pregnancy and mortality.

2- Another studies about hematological profile of Sudanese pregnant womenshould be done especially in North Kordofan State to assess Reference range.

3- Regular follow up of pregnant women.

References

AbbassA.K.,LichtmanA.,and PillaiS. (2012). Cellular and Molecular Immunology, 8 [th]Editions,Printed in Canada.

Abdelgader E. A., Diab T. A., Kordofani A., Sana E., and Abdalla S. E. (2014). Hemoglobin level, RBCs Indices, and iron status in pregnant females in Sudan. *Basic Research Journal of Medicine and Clinical Sciences*, 3 (2):8-13.

Abd-Elsalam R.K. (2012). Assessment of Complete Blood Count of Pregnant women in Port Sudan City, M.Sc. Thesis, Sudan University Of Science & Technology.USA

AlbadriaM. B. (2016). Determination of Complete Blood Count of Sudanese Pregnant women at Second Trimester Khartoum North Hospital, M.Sc. Thesis Sudan University of Science & Technology.

Aknibami A.A., Ajibola S.O., Rabiu K.A., Adewunmi A.A., Dosunum A.O.,Adediran A., Osunkalu V.O., Osikomaiya B.I and Ismail K.A. (2013). Hematological profile of normal pregnant women in Lagos: Nigeria. *International. Journal Women Health,* 5(3):227-232

Bain B. (2004). Beginners Guide to blood cell, 2[th]Edition.by Black well publishing Ltd London.

Benjamin A. (2015). Biochemical and hematological profiles of anemic pregnant women attending antenatal clinic at the Bolgatanga regional Hospital,M.S.C Thesis,KwameNkumah Universityofscienceand TechnologycollegeofScience

Berk L.E. (2011) .Infants and children, 7 [th] editions. USA Published by Pearson.

Carel A. B., Eduard R. A., David E. B and Barbara G**.** (2008). Fundamentals of Clinical chemistry, 6th edition, Saunders an imprint of Elsevier Inc

Chandra S., Tripathi A.K., andAmzarul M. (2012). *Indian Journal Hematology BloodTransfusion*, 28 (3):144-146.

CieslaB. (2007).Hematology in practice, 2End Edition, PhiladelphiaCopyright © Davis Company.

DaciJ and LewisM. (2011). Practical Hematology, 11th editions. London,Elsevier Limited.

DamirK. (2009). Cytoskeleton and deformability of white blood Cells.*Current Topics in Membranes,* 64:47-111

Elgari M.(2013). Evaluation of Hematological parameters of Sudanese Pregnant women attending at Omdurman Al Saudi Maternity Hospital, M.S.C Thesis, Sudan University Of Science & Technology.

EvistavrouM . **A.**, Keith R., and McCrae M.D.(2010). Thrombocytopeniain Pregnancy. American Society of hematology.

Fischbach FandDunning B. (2009). Manual laboratory and Diagnostic test 8[th]edition, Walters Kluwer Health.

FoxI. (2006). Blood Composition, Human physiology, 9[th]Edition, published by. New York America

Haywood L.B. (2016). Physiology of pregnancy,DukeUniversity Medical Center© Merck Sharp &Dohme

Corp., a subsidiary of Merck & Co., Inc., Kenilworth*, National Journal, US*

Henry J.B. (2011). Clinical diagnosis and management by laboratory method. 22 ᵀʰeditions, Elsevier publisher.

Hoffbrand A.V., Mossp. A., and Pettit J.E. (2006). Essential Hematology, 5ᵗʰEdition, London Blackwell Publishing.

Jacobs J., Patrick C.,Ngozi R.,Ewrhe O. (2013). Change Hematological Indices in Normal Pregnancy,*Physiology Journal. V* (10): 283814.

Jessica M., Badger F., Hseih C.C., Troisi R., Lagiou P and PolischmanN.(2007). Plasma volume expantion in pregnancy. Implications for biomarkers in population studies. Cancer Epidemiol biomarkers;16:1720.

John P., Daniel A., ArberB. G., Alan F. L ., Robert T. M., Frixos P., and George M. (2014).Wintrobe's Clinical hematology; 13 ᵗʰ edition.

Kern W. (2002).PDQ Hematology. 1st Edition, Oklahoma City. B.C Decker.

Khalil R.K.A. (2012). Assessment of complete blood count of pregnant women in Port Sudan city, sustech.Edu / handle/ 123456789/1398.

NasorK.M. (2015) .DeterminationofComplete Blood Count of Sudanese Pregnant women at third trimesterKhartoum Teaching Hospital. M.S.C Thesis, Sudan University of Science & Technology.

Kumar and Clark. (2006). Clinical Medicine, 6 ᵗʰ editions. PublisherSaunders Ltd.

Mohamed M. A.(2015). Determination of Complete Blood Count of Sudanese Pregnant Women at different Trimester in Elgataref, M.S.C.Theseis, Sudan University of Science and Technology.

Martin Q and Desmond F.(2005). Platelets Function, Assessment, Diagnosis and Treatment, first Edition, Published in

Milman N.,Bergholt T., andByg K.E.(2007). Reference Intervals for hematological variables during normal pregnancy and postpartum in: 434 healthy Danish women, *European Journal of Hematology*, 79:39–46.

Michael J and NazliH. (2011). Hematologic Changes in Pregnancy, publication/227697211/viewer/AS:104464786657286@1401917755871/background/1.png**,** https://www.researchgate.net

Monica C. (2006). District Laboratory practice in Tropical countries part 2, second edition.Published in the United States of America by Cambridge University Press, New York www.cambridge.org

Pregnancy condition Information. (2016). 343w42y http//www.nichd.gov/

Pughikumo O. C.,Pughikumo D.T2 and Omunakwe H. E.(2015). White Blood Cell Counts In Pregnant Women in Port Harcourt, Nigeria*IOSR Journal of Dental and Medical Sciences*(14),. II PP 01.

Reinhold H., Jonathan G. P**.**Erhard Hiller., Ronald Paquette. (2007). Modern Hematology, 2 Editions, New Jersey., United States of America. Humana Press.

Hassan S. E. (2015).Determination of Complete Blood Count of Sudanese Pregnant women at third Trimester inKhartoum Hospital, M.Sc. Thesis Sudan University of Science & Technology.

Somendra K., SanjeevN., Arjun S., andShrikant.(2016).Evaluation of hematological indices, neutrophils and platelets in pregnant women

attending tertiary care center.*Indian Journal of Pathology and Oncology, 2;3(2);297-304*

Shelby Iand Tiller F. (2011).Blood is a component need in the body to live, senior project Research paper 2011, Published in Education, Health and medicineBusiness.

Stephen J., Maxine A., and Lawrence M. (2008).Current medicine diagnosis and treatment: McGraw-Hill professional (2)

Thomas P. D.,Gerard N., and Joshua A**.** (2004).Medical complication during Pregnancy, chapter four Hematologic Aspects of Pregnancy,6th EditionsCopyright ©2004 Elsevier Inc. All reserved

Turgeon M. L. (2010) Clinical Hematology Theory and Procedures, 5th Edition, Applied physiology, Nutrition and metabolism 31(1):1-11

WaelHand RichardA. (2014). Renal function in normal and disordered pregnancy, Published in final edited form.*Curr Opine Nephron Hypertension journal; 23(1): 46–53.*

Weissgerber L Tand Wolfe A. L. (2006). Physiological adaptation in early human Pregnancy: *Applied physiology, Nutrition, and Metabolism journal*.(31):1-11.

World   Health   Organization.   (WHO).   (2016). (http;//www.who.int/mediacenter/factheets/fs348/en/).

Appendix (1)

Informed consent

بسم الله الرحمن الرحيم

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا

براءة اخلاقية

الإسم:...

سوف يتم أخذ عينة من الدم (٣مل) من الوريد بواسطة حقنة طعن وذلك بعد مسح منطقة

العينةبواسطة مطهركل الأدوات المستخدمة لأخذ العينة معقمة و متبع فيها وسائل السلامة المعملية

وسوف يتم اخطاركبالنتيجة مع الألتزام بسرية المعلومات وان لا تستخدم الا لغرض البحث.

أوافق أنا المذكور اعلاه أخذ عينة لإجراء الدراسة

الإمضاء.....................................

التاريخ ... .

Appendix (2)

Sudan University of Science and Technology

College of Graduate Studies

Questionnaires to measure CBC of pregnant women in

NorthernKordofan State (ElObied)

No (......) Date: ....

Name: ……………………………………………………………….................

Age: …………………………………………Occupation: …………………………………..

Husband occupation: …………………………………………………………………………

Residence: ………………. ..………………………………………………………………

Month of pregnancy ☐   No of pregnancy ☐

Miscarriages:

No ☐   Yes   How many ☐   ☐

Suffer from disease:

Malaria ☐   Anemia ☐ Typhoid   ☐

Other: ………………………………………………………………………………..

Supplements: Iron ☐   Folic acid ☐

Previous blood transfusion:

Yes ☐   When ☐   No ☐

Result:

WBC…………………………..RBC………………………..HGB……………….….HCT……

MCV………................ MCH…………… MCHC……………………PL.T……………….

LYM%...............................NEUT%............................MXD%...............................LYM#.............

NEUT#...........................MXD..........................RDW..............................

Appendix (3)

Mindray(BC-3000 Plus)
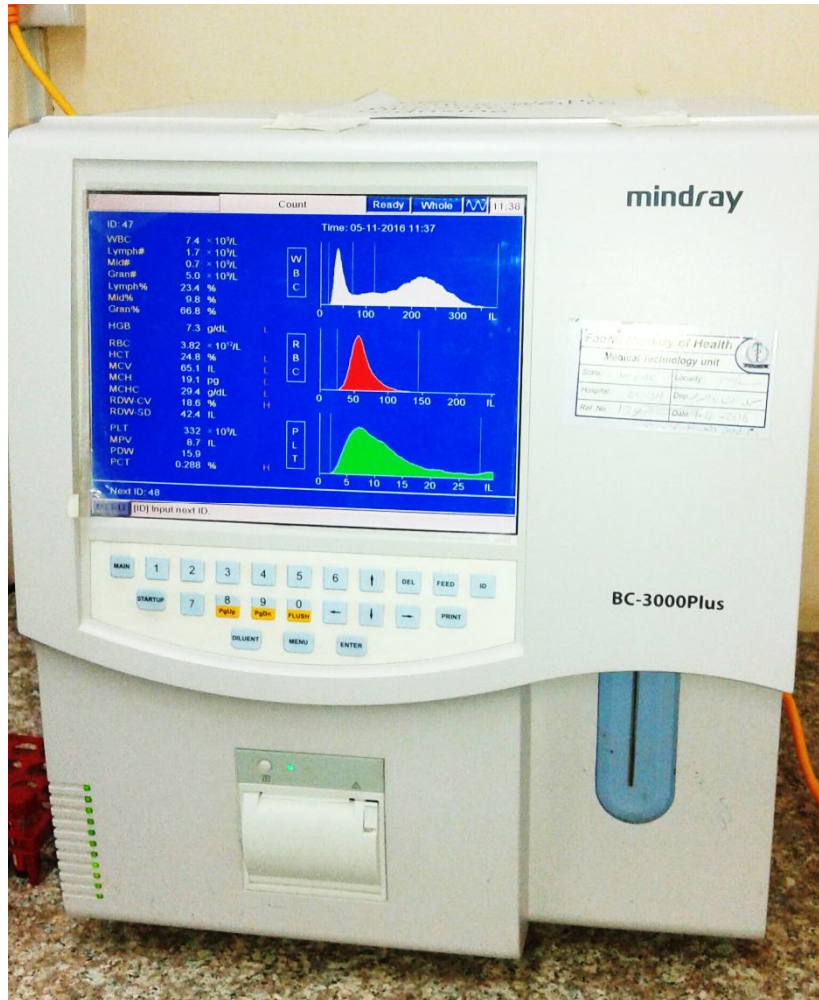
Appendix (4)

ElObied Teaching Hospital of Obstetric and Women Disease