INTRODUCTION

Preeclampsia (PE) is one of the hypertensive pregnancy disorders, which affects from 3 to 5% of pregnant women. It is the most important cause of maternal morbidity and perinatal mortality. On a global scale, PE is responsible for approximately 50, 000 maternal deaths annually ***(Duley et al., 2004)***. In addition, PE frequently coexists with intrauterine growth restriction (IUGR), placental abruption, and the need for iatrogenic preterm delivery, which are additional major causes of adverse outcome ***(Thilaganathan et al., 2010).***

PE is characterized by hypertension and proteinuria existing after 20 weeks of pregnancy. Shallow placentation is associated with abnormal invasion of cytotrophoblasts, leading to incomplete remodeling of maternal uterine spiral arterioles, which supply blood to the developing placenta ***(Harris et al., 2006 and Keogh et al., 2007).***

The ensuing hypoxic stress in the placenta is associated with the release of endothelial damaging factors into the maternal circulation ***(Maynard et al., 2003.and Burton et al., 2009).***

PE can be classified into early and late onset, and it is widely accepted that these subtypes of PE represent different forms of the disease. Early-onset PE, requiring delivery before 34 weeks' gestation, is commonly associated with intrauterine growth retardation (IUGR), abnormal uterine and umbilical artery Doppler waveforms, and adverse maternal and neonatal outcomes. In contrast, late-onset PE, with delivery at or after 34 weeks, is mostly associated with mild maternal disease and a low rate of fetal involvement. The perinatal outcomes of late-onset PE are usually favorable ***(Park et al., 2015).***

Early detection of PE would allow for planning the appropriate monitoring and for clinical management, following the early identification of disease complications. Although trials of prophylactic intervention for PE from mid-gestation have not been efficacious, it has been suggested that a very early prediction of PE in gestation may make early prophylactic strategies more effective **(*Park et al., 2015*)**.

Three-dimensional (3D) ultrasound can provide improved imaging of fetal anatomy compared with conventional 2D ultrasound. Specifically, novel assessment of the placenta by 3D ultrasound is more available than 2D ultrasound, including surface-rendering imaging and volume measurement. With the recent advances in 3D power Doppler ultrasound, as well as quantitative 3D Power Doppler histogram analysis, quantitative and qualitative assessments of the vascularization and blood flow of the placenta have become feasible ***(Hata et al., 2011).***

3D power Doppler ultrasound can depict internal placental vessel characteristics such as density of vessels, branching, caliber changes, and tortuosity ***(Hata et al., 2011).***

Several small studies have suggested that parameters derived from 3D-power Doppler evaluation of the placenta in the first trimester can predict adverse pregnancy outcomes including preeclampsia (PE) and fetal growth restriction ***(Rizzo et al., 2009).***

3D ultrasound will be done for all cases including 3D power Doppler indices of placental bed.Indices measured are placental vascularization index (VI), flow index (FI) and vascularization flow index (VFI) and found that the mean vascular indices were lower in pregnancies that subsequently developed pre-eclampsia compared to pregnancies who did not develop pre-eclampsia ***(Obido et al., 2011)***.

AIM OF THE WORK

The aim of this study was to assess the role of 3 dimensional power Doppler (3 PDP) of the uteroplacental circulation in early pregnancy as a screening tool for prediction of preeclampsia.

Placental Development and Imaging

The placenta, also called (the afterbirth) is an organ that develops in the uterus during pregnancy. It is a complete organ which is very firmly connected to the mother and loosely connected to the developing fetus through the umbilical cord. The life of the fetus depends upon the welfare of the placenta and the life of placenta depends on the welfare of the mother to whom it is attached. Hence this triad of mother-placenta-fetus becomes very important in the whole process of development of the fetus and birth ***(Nagi, 2011).***

The placenta is responsible for the nutritive, respiratory and excretory function of the fetus. As the fetus begins the ninth week of development, its demand for nutritional and other factors increase, causing major changes in the placenta. Among these is an increase in surface area between maternal and fetal components to facilitate exchange ***(Sadler, 2015) (figure1).***

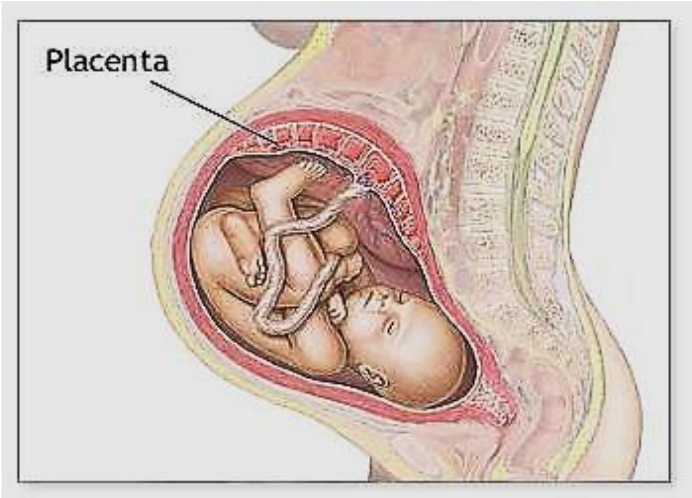

Fig. (1): Placenta **(Quoted from Baptiste-Roberts et al, 2009).**

Development of the placenta

Implantation of the ovum: *(figure* 2)

It is a process by which the embryo is embedded and fixed with the endometrium of the uterus. At the time of implantation, the embryo is in the form of blastocyst. It usually occurs during 6-10 days after ovulation ***(Singh, 2012).***

The intimate contact of fetal and maternal tissues occurs by implantation of the embryo. The blastocyst surrounded by zona pellucida enters the uterus on sixth day. The zona pellucida prevents it from sticking to the wall of the uterus.

As the blastocyst enlarges, the zona pellucida covering it becomes stretched and ultimately disappears. Consequently the trophoblast is exposed. The trophoblast has the property of attaching itself to any tissue with which it comes in contact with the trophoblast sticks to the uterine endometrium. The cells of trophoblast divide mitotically and form new cells that lose their cell membranes and form a mass of cells called syncytiotrophoblast. The syncytiotrophoblast invades the endometrium with the help of proteolytic enzymes secreted by its cells. The blastocyst goes deeper and deeper until it completely lies within the endometrium ***(Singh, 2012).***

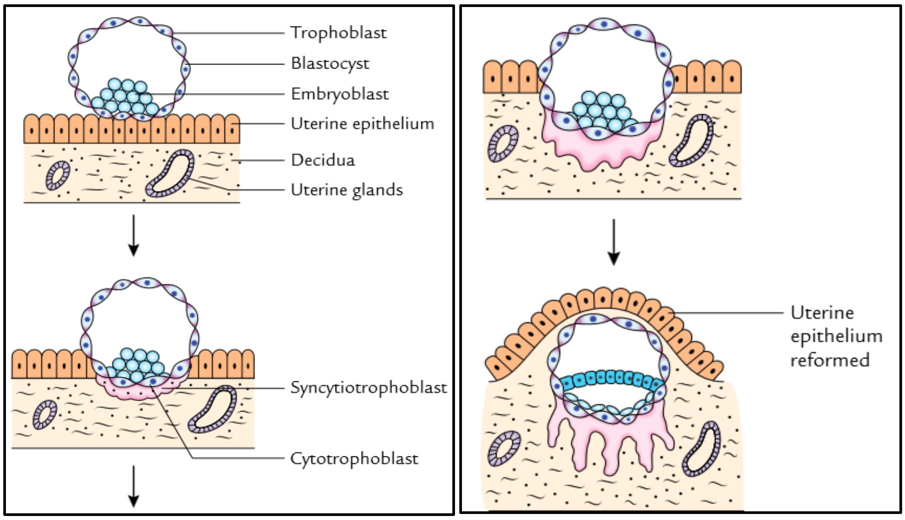

Fig. (2): Steps of implantation ***(Quoted from Singh, 2012).***

The Decidua:

Before the fertilized ovum reaches the uterus, the mucous membrane of the body of the uterus undergoes important changes and is then known as the **decidua**. The vascularity and thickness of the mucous membrane are increased; its glands are elongated and open on its free surface by funnel-shaped orifices, while their deeper portions are tortuous and dilated into irregular spaces. The inter glandular tissue is also increased in quantity, and is crowded with alarge round or oval cells, termed as **decidual cells**. These changes are advanced by the second month of pregnancy ***(Collins, 2008).***

Distinctive names are applied to different portions of the deciduas:

- The part which covers the ovum is named the **decidua capsularis**
- The portion which intervenes between the ovum and the uterine wall is named as the **decidua basalis** (**decidua placentalis);** it is here that the placenta is subsequently developed.
- The part of the decidua which lines the remainder of the body of the uterus is known as the **decidua vera** (**decidua parietalis*) (Collins, 2008).***

Coincidently with the growth of the embryo, the decidua capsularis is thinned and extended ***(fig3)*** and the space between it and the decidua vera is obliterated gradually, and by the third month of pregnancy the two are in contact. By the fifth month of pregnancy the deciduas capsularis has practically disappeared, and during the succeeding months the decidua vera also undergoes atrophy, owing to the increased pressure ***(Collins, 2008).***

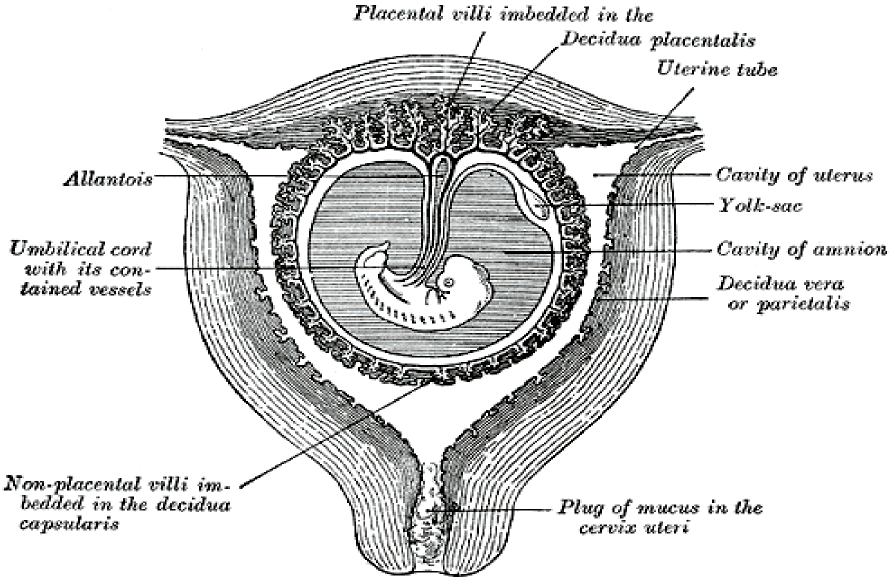

Fig. (3): Sectional plan of the gravid uterus in the third and fourth month **(Quoted from Healy, 2008).**

The Chorion: (*figs 4 to 8)*

The chorion consists of two layers: an outer layer formed by the primitive ectoderm or trophoblast, and an inner layer formed by the somatic mesoderm; with this latter the amnion is in contact. The trophoblast is made up of an internal layer of cubical cells, the **cytotrophoblast (layer of Langhans),** and an external layer of richly nucleated protoplasm devoid of cell boundaries, the **syncytiotrophoblast.** It undergoes rapid proliferation and forms numerous processes, the **chorionic villi**, which invade and destroy the uterine decidua and at the same time absorb from it nutritive materials for the growth of the embryo. The chorionic villi are at first small and non-vascular, and consist of trophoblast only, but they increase in size and ramify, while the mesoderm, carrying branches of the umbilical vessels, grows into them, and in this way they are vascularized ***(Collins, 2008).***

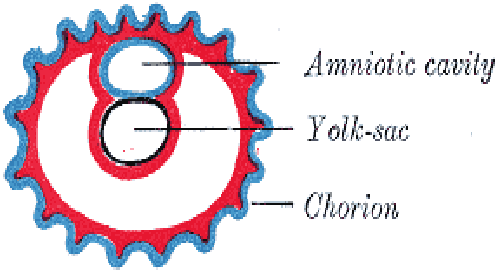

Fig. (4): Diagram showing earliest observed stage of human ovum **(Quoted from Healy, 2008).**

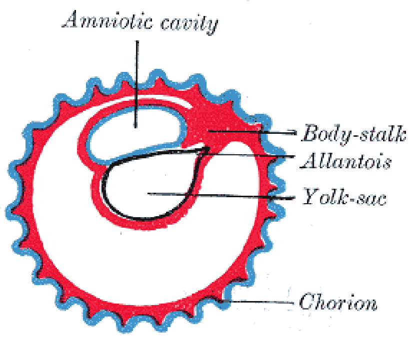

Fig. (5): Diagram illustrating early formation of allantois and differentiation of body-stalk **(Quoted from Healy, 2008).**

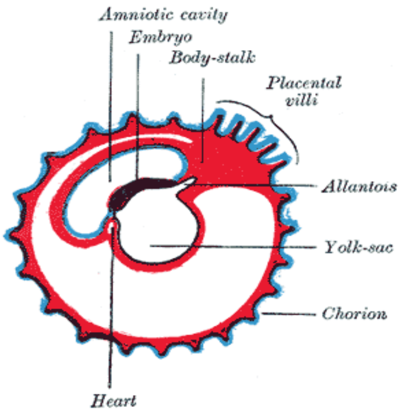

Fig. (6): Diagram showing later stage of allantoic development with commencing constriction of the yolk-sac ***(Quoted from Healy, 2008).***

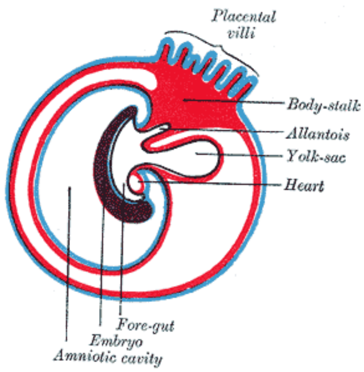

Fig. (7): Diagram showing the expansion of amnion and delimitation of the umbilicus ***(Quoted from Healy, 2008).***

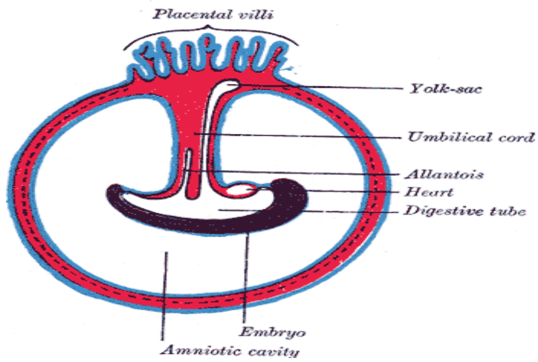

Fig. (8): Diagram illustrating a later stage in the development of the umbilical cord ***(Quoted from Healy, 2008).***

Blood is carried to the villi by the branches of the umbilical arteries, and after circulating through the capillaries of the villi, is returned to the embryo by the umbilical vein. Until about the end of the second month of pregnancy the villi cover the entire chorion, and are almost uniform in size ***(fig5)*** but after that they develop unequally. The greater part of the chorion is in contact with the decidua capsularis ***(fig3)*** and over this portion the villi, with their contained vessels, undergo atrophy, so that by the fourth month scarcely a trace of them is left, and hence this part of the chorion becomes smooth, and is named the **chorion leave**; as it takes no share in the formation of the placenta, it is also named the non-placental part of the chorion. On the other hand, the villi on that part of the chorion which is in contact with the decidua placentalis increase greatly in size and complexity, and hence this part is named the **chorion frondosum** ***(fig8) (Collins, 2008).***

The Placenta:

The placenta connects the fetus to the uterine wall, and is the organ by means of which the nutritive, respiratory, and excretory functions of the fetus are carried on. It is composed of **fetal** and **maternal** portions ***(Collins, 2008).***

Fetal Portion:

The fetal portion of the placenta consists of the villi of the chorion frondosum; these branch repeatedly, and increase in size. These greatly ramified villi are suspended in the intervillous space, and are bathed in maternal blood, which is conveyed to the space by the uterine arteries and carried away by the uterine veins. A branch of an umbilical artery enters by a tributary of the umbilical vein. The vessels of the villus are surrounded by a thin layer of mesoderm consisting of gelatinous connective tissue, which is covered by two strata of ectodermal cells derived from the trophoblast: the deeper stratum, next the mesodermic tissue, represents the cytotrophoblast or layer of Langhans; the superficial, in contact with the maternal blood, the syncytiotrophoblast ***(fig9)***. After the fifth month the two strata of cells are replaced by a single layer of somewhat flattened cells ***(Collins, 2008)***.

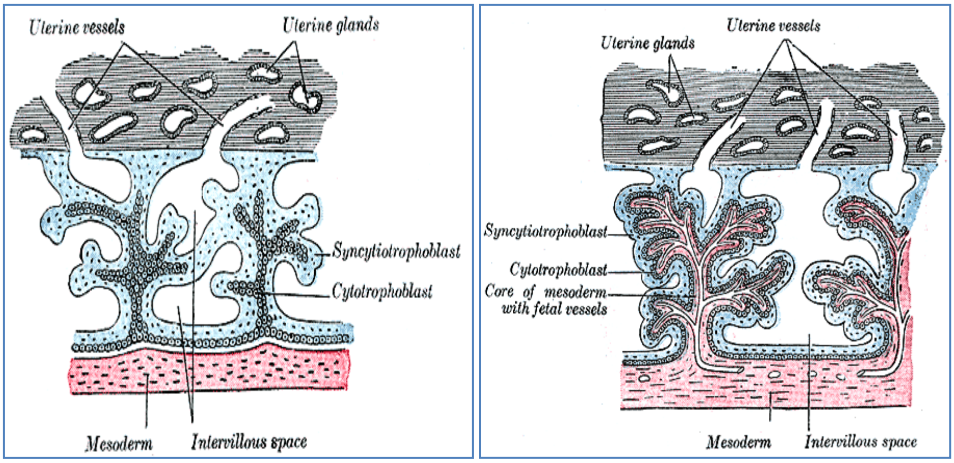

Fig. (9): Diagrammatic a. Primary b. Secondary chorionic villi ***(Quoted from Healy, 2008).***

Maternal Portion:

The maternal portion of the placenta is formed by the decidua placentalis containing the intervillous space. This space is produced by the enlargement and intercommunication of the spaces in the trophoblastic network. The changes involve the disappearance of the greater portion of the stratum compactum, but the deeper part of this layer persists and is condensed to form what is known as the **basal plate**. Between this plate and the uterine muscular fibers are the stratum spongiosum and the boundary layer; through these and the basal plate the uterine arteries and veins pass to and from the intervillous space. The endothelial lining of the uterine vessels ceases at the point where they terminate in the intervillous space which is lined by the syncytiotrophoblast. Portions of the stratum compactum persist and are condensed to form a series of septa, which extend from the basal plate through the thickness of the placenta and subdivide it into the lobules or **cotyledons** seen on the uterine surface of the detached placenta ***(Collins, 2008).***

At the end of pregnancy, a number of changes that occur in the placenta may indicate reduced exchange between the two circulations. These changes include:

- An increase in fibrous tissue in the core of the villus.

- Thickening of basement membranes in fetal capillaries
- Obliterative changes in small capillaries of the villi, and
- Deposition of fibrinoid on the surface of the villi in the junctional zone and in the chorionic plate. Excessive fibrinoid formation frequently causes infarction of an intervillous lake or sometimes of an entire cotyledon. The cotyledon then assumes a whitish appearance ***(Sadler, 2012).***

The placenta is usually attached near the fundus of the uterus and more frequently on the posterior than on the anterior wall of the uterus. It may, however, occupy a lower position and in rare cases, its site is close to the internal orifice of the uterus, which it may occlude, thus giving rise to the condition known as placenta previa ***(Collins, 2008).***

Separation of the Placenta:

After the child is born, the placenta and membranes are expelled from the uterus as the after-birth. The separation takes place through the stratum spongiosum, and necessarily causes rupture of the uterine vessels. The orifices of the torn vessels are, however, closed by the firm contraction of the uterine muscular fibers, and thus postpartum hemorrhage is controlled ***(Collins, 2008).***