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ANATOMY AND PHYSIOLOGY OF THE UTERUS

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ABSTRACT

This article analyzes the anatomical and physiological features of the uterus based on modern scientific views. It describes the macroscopic and microscopic structure of the uterus, its blood supply, innervation, and functional significance in the female reproductive system. In addition, the morphofunctional changes occurring in the endometrium and myometrium during the menstrual cycle, the process of implantation, adaptive mechanisms during pregnancy, and the main stages of labor physiology are scientifically characterized. The article also discusses the clinical significance of the uterus, its pathological conditions, diagnostic methods, and aspects related to reproductive technologies. The findings indicate that a deep understanding of the complex anatomical and functional organization of the uterus as the central reproductive organ of the female body is of great importance in gynecology, obstetrics, and reproductive medicine.

Keywords: uterus, endometrium, myometrium, perimetrium, menstrual cycle, implantation, decidua, hormones, reproductive system, uterine blood circulation.

INTRODUCTION

The uterus is the central organ of the female reproductive system and plays a decisive role in the implantation of the fertilized ovum, the development of the embryo and fetus, the physiological course of pregnancy, and the process of childbirth. This organ is not only anatomically complex but also represents a highly coordinated functional system closely associated with hormonal, neural, and immune regulatory mechanisms.

A thorough study of the normal structure and function of the uterus provides an important theoretical and practical basis for understanding the pathogenesis of gynecological diseases, identifying the causes of infertility, monitoring pregnancy, and effectively applying modern reproductive technologies.

Modern anatomy, histology, physiology, and clinical medicine pay particular attention to the study of the uterus, since structural and functional changes in this organ are directly related to women’s reproductive health. In particular, endometrial receptivity, myometrial contractile activity, cervical protective mechanisms, and the characteristics of uteroplacental circulation are among the priority areas of current scientific research. Therefore, a comprehensive study of the anatomy and physiology of the uterus is considered scientifically and practically relevant.

Anatomical Structure of the Uterus

The uterus is located in the pelvic cavity and is bordered anteriorly by the urinary bladder and posteriorly by the rectum. Its upper part is connected with the uterine tubes and forms a single functional complex with the internal organs of the female reproductive system. In its normal anatomical position, the uterus is situated in an anteverted and anteflexed position, meaning that it is tilted and bent forward. This topographical position creates favorable conditions for the normal functional activity of the uterus.

Macroscopically, the uterus consists of several main parts. Its upper dome-shaped portion is called the fundus uteri. The middle part, which forms the main volume of the organ, is the corpus

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uteri. The narrow portion connecting the body of the uterus with the cervix is known as the isthmus uteri, while the lower cylindrical part is the cervix uteri. The cervix, in turn, consists of an external portion facing the vaginal cavity and an internal portion connected with the uterine cavity. Each of these structures has distinct anatomical and physiological significance.

The uterus is maintained in a certain anatomical position within the pelvic cavity by a number of supporting ligaments. The broad ligament, round ligament, cardinal ligament, and uterosacral ligaments hold the uterus in its anatomical position and maintain its physiological mobility within normal limits. Weakening or injury of these ligaments may lead to pathological conditions such as uterine malposition or prolapse.

Microscopic Structure of the Uterus

Histologically, the uterine wall consists of three main layers: the endometrium, myometrium, and perimetrium. The endometrium is the inner mucous layer of the uterus and undergoes continuous morphofunctional changes during the menstrual cycle. It consists of basal and functional layers. The basal layer remains constant and serves as a source for regeneration of the functional layer after menstruation. The functional layer is highly sensitive to hormonal influence; it thickens during the menstrual cycle, undergoes secretory changes, and, if fertilization does not occur, is shed during menstruation.

The myometrium is the thickest layer of the uterine wall and consists of smooth muscle fibers. It forms the main contractile apparatus of the uterus. The muscle fibers of the myometrium are arranged in different directions, which ensures strong and coordinated contractions during labor. During pregnancy, hyperplasia and hypertrophy occur in the myometrium, resulting in a several-fold increase in uterine size. The perimetrium is the outer serous layer of the uterus, formed by the continuation of the peritoneum, and covers the organ externally.

Blood Supply and Innervation

The blood supply of the uterus is provided mainly by the uterine artery. In addition, the ovarian artery also contributes to the uterine blood supply to some extent. Spiral arteries are especially important in the endometrium, as they undergo significant changes during different phases of the menstrual cycle. Spasm and subsequent damage to the spiral arteries are key components of the mechanism of menstrual bleeding. Venous drainage from the uterus occurs through venous plexuses.

From the point of view of innervation, the uterus is controlled by the autonomic nervous system. Sympathetic nerve fibers mainly participate in increasing the contractile activity of the uterine muscles, while parasympathetic nerves contribute to relaxation processes. The integration of neural and hormonal regulation coordinates uterine activity during the menstrual cycle, pregnancy, and labor.

Physiology of the Uterus

The physiology of the uterus is closely connected with the general reproductive cycle of the female body. The menstrual cycle lasts an average of 28 days and involves sequential changes in the endometrium and ovarian function. During the menstrual phase, the functional layer of the endometrium is shed, and bleeding occurs. In the proliferative phase, under the influence of estrogen, the endometrium regenerates, and the glands and stromal elements increase. In the secretory phase, due to the predominance of progesterone, the endometrium becomes ready for implantation. During this period, the glands acquire active secretory properties, stromal edema occurs, and the uterine mucosa creates a favorable environment for receiving the fertilized ovum.

Implantation is one of the most important stages of uterine physiology. After the fertilized ovum reaches the uterine cavity, it attaches to the receptive part of the endometrium. During this process, trophoblast cells develop actively, decidual changes occur, and the initial morphological

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basis of pregnancy is formed. Successful implantation is directly associated with the condition of the endometrium, hormonal background, immune tolerance, and uterine blood circulation.

During pregnancy, the uterus demonstrates a remarkable capacity for adaptation. Its size, mass, and blood supply increase significantly. Myometrial fibers stretch while maintaining their contractile capacity. The formation of the placenta in the uterus creates the necessary physiological conditions for the exchange of gases, nutrients, and metabolites between the mother and the fetus. During pregnancy, the cervix also performs an important protective function. The cervical canal becomes filled with mucus, forming a mucus plug, which helps prevent ascending infections.

Morphofunctional Changes of the Endometrium

The endometrium undergoes specific structural changes during each phase of the menstrual cycle. In the proliferative phase, its thickness increases, the glands are relatively straight, and mitotic activity in stromal cells intensifies. In the secretory phase, the glands become tortuous and spiral-shaped, their secretory activity increases, and an environment rich in glycogen and other substances is formed. This condition creates the most favorable period for implantation. In the menstrual phase, spasm of the spiral arteries, tissue ischemia, and necrobiotic changes lead to the shedding of the functional layer.

Endometrial receptivity has particular scientific and practical importance in modern reproductive medicine. The most favorable period for implantation is called the “window of receptivity” and usually corresponds to days 20-24 of the menstrual cycle. During this period, cell surface receptors, integrins, and other molecular factors become activated. Therefore, the functional maturity of the endometrium is an important indicator both in natural pregnancy and in assisted reproductive technologies.

Biophysical Properties of the Myometrium

The myometrium is a functional muscular system capable of independent contraction. Its main biophysical properties include automatism, extensibility, and the ability to contract synchronously. During pregnancy, the uterine wall expands significantly; however, during labor, it remains capable of active contraction. The increase in the number of gap junctions between myometrial cells is particularly important before labor, as it ensures coordinated and effective contractions. Labor activity is determined precisely by this property of the myometrium.

Immunology of the Uterus

From an immunological point of view, the uterus is a unique organ. Although the fetus is genetically a partially foreign structure to the maternal organism, immune rejection does not occur during normal pregnancy. T-regulatory cells, cytokines, and mechanisms of local immune tolerance play an important role in this process. The immune environment of the uterine mucosa supports implantation and helps maintain pregnancy. Therefore, immunological balance is considered one of the important factors in reproductive success.

Features of Uterine Blood Circulation

The uterine blood circulation system is highly adaptive and changes dramatically, especially during pregnancy. Spiral arteries dilate, uteroplacental blood flow increases, and exchange between the mother and fetus through the placenta intensifies. If disturbances occur in this circulatory system, complications such as fetal growth restriction, placental insufficiency, or preeclampsia may develop. Therefore, understanding the normal physiology of uterine blood circulation is of great importance in obstetric practice.

Physiological Significance of the Cervix

The cervix is not only an anatomical transition zone but also a structure that performs important physiological and protective functions. During ovulation, cervical mucus becomes more

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fluid, facilitating the passage of spermatozoa into the uterine cavity. During pregnancy, this mucus thickens and forms a mucus plug, preventing microorganisms from ascending. Before labor, the cervix undergoes softening, shortening, and dilation, creating conditions for the passage of the fetus through the birth canal.

Physiology of Labor

Labor is the final and most active stage of uterine physiology. It is regulated by complex hormonal and neural mechanisms. At the onset of labor, an increase in the number of oxytocin receptors, enhanced synthesis of prostaglandins, and cervical maturation play an important role. Uterine contractions are initially irregular but later become rhythmic and strong. The cervix gradually dilates, the fetus moves through the birth canal, and the placenta is delivered in the third stage of labor. Each stage of this process is based on the close coordination of the myometrium, cervix, and hormonal regulatory system.

Clinical Significance of the Uterus

The uterus has great practical importance in clinical medicine. Its various pathologies can seriously affect female reproductive health. Uterine myoma is a benign tumor that develops from the muscular layer of the uterus and is often manifested by menstrual disorders, pain, or infertility. Endometriosis is characterized by the growth of endometrium-like tissue outside the uterus and may cause chronic pain and infertility. Endometritis is inflammation of the inner uterine layer and is often associated with infectious factors. Cervical erosion and uterine shape anomalies may also negatively affect reproductive function.

Ultrasound examination, hysteroscopy, biopsy, magnetic resonance imaging, and laboratory methods play an important role in diagnosing uterine pathologies. In recent years, special attention has been paid to assessing the functional state of the uterus in assisted reproductive technologies, including in vitro fertilization. Endometrial thickness, receptivity, and determining the optimal period for embryo transfer directly influence reproductive outcomes.

Modern Scientific Approaches

Currently, molecular and genetic approaches are widely used in the study of uterine physiology and pathology. Tests aimed at determining endometrial receptivity, 3D ultrasound diagnostics, molecular markers, particularly the study of HOXA10 gene activity, as well as stem-cell-based therapeutic methods, are considered promising areas. According to modern scientific views, the normal function of the uterus is the result of a multistage integrated regulatory system in which anatomical, hormonal, immunological, and molecular mechanisms operate in close interconnection.

CONCLUSION

The uterus is the central organ of the female reproductive system, and its anatomical and physiological characteristics are extremely complex and multifaceted. The macro- and microstructure of this organ, its blood supply, innervation, hormonal regulation, and immunological features collectively ensure its reproductive function. Physiological processes such as the menstrual cycle, implantation, pregnancy, and labor are all closely associated with uterine activity.

A thorough study of the normal anatomical and functional state of the uterus has important scientific and practical significance in the early detection of gynecological and obstetric pathologies, their effective treatment, and the protection of reproductive health. Therefore, enriching knowledge about the uterus on the basis of modern scientific approaches remains one of the most relevant areas of medicine.

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