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Clinical and Morphological Aspects of Male Germ Cells

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Annotation: The sperm is the male germ cell, which plays an important role in sexual reproduction. Without this cell, the process of fertilization and combinative variability is impossible, therefore, it is necessary to know the features of the stages of maturation of the sperm, the variants of the pathological structure of the cells of the spermatogenic series, its life cycle both in the body of a man and in the body of a woman.

Keywords: spermatozoon; spermatogenesis; acrosome; fertilization.

The human sperm cell is a reproductive cell in men and survives only in a warm environment; as soon as it leaves the man's body, the probability of sperm survival decreases and it can die, thereby impairing the overall quality of sperm. There are two types of sperm: "female" and "male". Spermatozoa, which after fertilization give rise to female (XX) offspring, differ in that they carry the X chromosome, and spermatozoa, which give rise to male (XY) offspring, carry the Y chromosome.

The human sperm consists of a flat disc-shaped head measuring 5.1 microns by 3.1 microns and a tail known as a flagellum 50 microns long. The flagellum sets the sperm in motion (at a speed of about 1-3 mm/min in humans), rotating in the form of an elliptical cone. Spermatozoa have an olfactory orientation mechanism and after entering the fallopian tubes, they must undergo a period of capacitation before entering the egg.

Head: has a compact nucleus containing only chromatin and is surrounded by only a thin layer of cytoplasm. Above the nucleus there is a cap-like structure called an acrosome, which is formed as a result of modification of the Golgi body and secretes the enzyme spermolysin (hyaluronidase, an enzyme penetrating the cortical zone, lysine zones or acrosine) necessary for fertilization. When the sperm approaches the egg, it enters into an acrosome reaction, in which the membrane surrounding the acrosome merges with the plasma membrane of the sperm head, exposing the contents of the acrosome.

Neck: this is the smallest part (0.03 microns), which has a proximal centriole located parallel to the base of the nucleus and a distal centriole located perpendicular to the previous one. The

proximal centriole is also present in the mature sperm; the distal centriole disappears after the assembly of the axoneme. The proximal centriole penetrates the egg during fertilization and triggers the first division of the egg, which does not have a centriole. The distal centriole gives rise to an axial filament, which forms a tail and has a structure (9+2). In the middle part there is a temporary membrane called a cuff.

Middle part: contains 10-14 mitochondrial spirals surrounding the axial fiber in the cytoplasm. It provides mobility and is therefore called the "energy plant" of the sperm. It also contains an annular centriole (annulus), which forms a diffusion barrier between the middle part and the main part and serves as a stabilizing structure to ensure the rigidity of the tail.

Tail: The flagellum is the longest part (50 microns), having an axial filament surrounded by cytoplasm and plasma membrane, but at the posterior end the axial filament is exposed. The flagellum gives movement to the cell.

Sperm is alkaline in nature, and spermatozoa do not achieve full mobility (hypermovability) until they enter the vagina, where the alkaline pH is neutralized by acidic vaginal secretions. This gradual process takes 20-30 minutes. During this time, fibrinogen from the seminal vesicles forms a clot that protects the sperm. As soon as they become hyper-mobile, fibrinolysin from the prostate gland dissolves the clot, allowing the sperm to move in an optimal way.

The sperm is characterized by the minimum amount of cytoplasm and the densest DNA packing known in eukaryotes. Compared with mitotic chromosomes in somatic cells, sperm DNA is at least six times more condensed.[9]

The sample contains DNA/chromatin, a centriole, and possibly also an ovocyte-activating factor (OAF). It may also contain paternal matrix RNA (mRNA), which also contributes to the development of the embryo.

The effectiveness of spermatogenesis varies from species to species, but appears to be relatively constant in humans. The differentiation of spermatogony into a mature sperm takes 70 ± 4 days. Compared to the animal world, human spermatogenesis is less effective. The daily formation of spermatozoa in humans is 3-4 million per 1 g of testicular tissue. According to WHO criteria, the number of spermatozoa in 1 ml of ejaculate should exceed 20 million. Most of the cells formed (more than 75%) die as a result of apoptosis or degeneration; of the remaining, more than half are defective. Thus, only about 12% of spermatozoa are potentially suitable for fertilization. In addition, sperm production decreases with age, which is associated with the loss of Sertoli cells. The reasons for this decrease are an increase in degenerative disorders of germ cells during meiosis prophase or loss of primary spermatocytes, as well as a decrease in the number of Leydig cells, non—Leydig interstitial cells, myoid cells and Sertoli cells.

Sertoli cells play an important role in the development of male gametes, which are connected to blocks of spermatogenic cells by processes and depressions. There is close contact between Sertoli cells, which forms a special histological barrier for the development of male germ cells, limiting them from the effects of the immune system [2]. Sertoli cells also phagocytize dead spermatogenic cells and secrete liquid into the lumen of the tubule, into which the spermatozoa are immersed after detaching from the spermatogenic epithelium.

Thus, Sertoli cells control the development of spermatozoa. On the periphery there are the youngest, undifferentiated germ cells – spermatogonia. Closer to the center and lumen of the tubule are spermatocytes of the first order, then there are spermatocytes of the second order, oval spermatids are located near the lumen, and mature spermatozoa are located in the tubule itself. In spermatogenesis, there are 4 stages: reproduction, growth, maturation and formation.

After that, the spermatozoa sequentially pass through the straight seminal tubules, the testicular network and through the outflow tubules enter the head of the epididymis, where most of the liquid in which the spermatozoa were transported is absorbed, increasing their concentration by 10-100

times. The epithelium of the appendage secretes a liquid in which the spermatozoa are suspended [1; 6]. As newly formed spermatozoa pass through the appendage of the testicle (body and tail), they undergo various modifications, including changes in surface charge, membrane protein composition, immunoreactivity, phospholipid and fatty acid content, adenylate cyclase activity, etc. The main energy substrate of the sperm at this stage is acetylcarnitine, which is part of the secretion of the epididymis. Many of these changes seem to be designed to improve the structural integration of the sperm membrane and their fertilizing ability.

Disorders in the structure of the sperm tail have a strong effect on its mobility. In many cases, spermatozoa with short and thin flagella have a pronounced violation of the structure of the fibrous layer covering the tail, or its dysplasia.

As shown by the analysis of a number of testicular biopsies, this disease develops as a result of impaired development of the fibrous layer and cytoskeleton of the tail during the late phase of spermatogenesis [9]. At the molecular level, this disorder is caused by a lack of dynein "handles" in the sperm. The disease is systemic and also develops by a similar mechanism in the respiratory epithelium. Possible genes that may be responsible for the development of the disease have been identified, such as the signal transducers AKAP3 and AKAP4, which are among the most numerous proteins of the fibrous layer, or the Dnah8 protein (heavy chain of dynein). At the moment, it remains unclear whether this disease is inherited [1; 4].

The second stage in the life cycle of a sperm can take place in the female body. During ejaculation, sperm is ejaculated into the area of the external opening of the cervical canal and the posterior arch of the vagina. At the same time, at this moment, spermatozoa do not yet have the fertilizing ability. This is achieved as a result of the process of capacitation under the influence of the secrets of the female genital tract.

Due to the high acidity of the vaginal contents (pH=4.0), most male gametes, including pathological ones, die at this time and are phagocytized [3; 11]. The remaining spermatozoa quickly penetrate the mucus, which is released from the cervical canal during sexual intercourse under the influence of contractions of the muscles of the cervix. The slightly alkaline reaction of cervical mucus contributes to an increase in the motor activity of spermatozoa [1; 4]. They penetrate through the cervical canal into her body at a rate of 3-4 mm per minute, after which they are dosed into the fallopian tubes. Prostaglandins contained in sperm activate the contractile activity of the myometrium and smooth muscle cells of the fallopian tubes, which is also important for the adequate promotion of gametes [7; 12]. Movements of the cilia of the epithelium of the fallopian tubes, as well as positive rheotaxis – the ability to move against the current of the secretion of the genital tract - play an essential role in the promotion of spermatozoa. The further the sperm moves in the female body, the less it comes into contact with the sperm plasma, which prepares it for a possible meeting with the egg [8]. It is known that spermatozoa are capacitated in portions for a period of 1-4 hours, due to which there is a constant change in the pool of gametes ready for fertilization of the egg [9; 12].

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