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Mammalian Spermatozoa: Physiological, Biochemical and Biotechnological Aspects

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Editorial
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Editorial

Fertilization, an important phase of reproduction, is physiologically the union of the male and female gamete. This succession involves the fusion of an oocyte with a sperm, leading to generation of a single diploid cell, the zygote, from which a new individual organism develops. The elucidation of the physiological, biochemical and molecular mechanisms of fertilization has enthralled researchers of relevance for several years. This editorial embodies this fascinating succession at physiological, biochemical and molecular level.

Spermatogenesis is a process in which testicular stem cells develop into mature spermatozoa, having subcategories as: (a) spermatocytogenesis (mitosis), (b) meiosis and (c) spermiogenesis. These developmental events occur in the seminiferous tubules of the testes. Spermatocytogenesis is a series of mitotic divisions that starts with diploid (2n) spermatogonia (A1) cells, which are the most immature male germ cells. Abnormal sperm were purposefully created and were never meant to partake in the act of fertilizing an ovum, but rather, they were constructed for the purpose of sperm competition and to hinder other male's sperm from achieving fertilization in instances when a female mates with multiple males during estrus [1].

The epididymis performs various major functions necessary for the reproduction of most mammalian species. First, the epididymis serves as a passage way for sperm to travel into the vas deferens. The epididymis also concentrates the sperm, provides the environment and fluids necessary for sperm maturation and acts as a storage unit for immature sperm that are ready for ejaculation. As sperm leaves the testicle it is accompanied by rete testis fluid, which is a diluent that makes ductile transport of the sperm easier. Upon reaching the epididymis, epithelial cells absorb rete testis fluid and secrete epididymal fluid, which concentrates the sperm and allows for more storage space [2]. While the sperm travel from the caput to the cauda epididymidis they continue to go through maturation. This maturation involves the migration of the cytoplasmic droplet, located on the mid-piece to travel from the proximal position to the distal position. Also while moving through the epididymal duct; rat sperm acquire the ability of increased progressive motility [3,4]. Maturation of sperm predominantly takes place while sperm move from caput to the corpus sections of the epididymis.

The ultimate goal in reproduction is to produce pregnancies and the method that will produce the best results is always going to be natural mating or at least the use of ejaculated semen. However, in many cases natural mating is not an option and ejaculated semen is unavailable, due to difficulty of handling the animal, death prior to collection or obstructive azoospermia preventing ejaculation [3]. Whether or not seminal plasma is beneficial to sperm, it does apparently serve a physiological purpose. It has been demonstrated in the bull that seminal plasma indirectly assists in the initiation of sperm capacitation, which is necessary to complete fertilization Nanda S, et al. [4] reported that exposure of Murrah buffalo epididymal sperm to isolated seminal plasma proteins (heparin and gelatin binding) assisted the sperm in mucous penetration and protected sperm membranes in vitro.

Even with some success in the field of assisted reproduction, epididymal sperm has limitations that include: methods for harvesting sperm from the epididymis, techniques for freezing epididymal sperm, the cytoplasmic droplet and in most cases, collection of epididymal sperm is from a postmortem animal. There are three main methods being used to collect epididymal sperm [5]. However depending on the laboratory there are subtle variations in these methods. With each method the epididymides along with the vas deferens are dissected away from the testicle. Due to the lack of difference between the two methods, it has ultimately been preferred the flotation technique because it is easy to work on [5].

Studies conducted during last two decades report the detection of increased ROS levels in the semen of 25% to 40% of infertile men [6] documented that in men with spinal cord injury, elevated seminal ROS levels are associated with poor sperm motility and morphology. These associations are independent of both ejaculation method and specimen type. The role of ROS in varicocele has been successfully reported by our center and others [6]. ROS in the human ejaculate originate principally from seminal leukocytes. Leukocytospermia is characterized by abnormally high seminal leukocyte, polymorphonuclear neutrophils, and macrophages [5,6]. During GU infection, the presence of leukocytes in semen has been associated with decreased sperm motility and fertilization capacity [6]. This dilemma may be partially due to the different techniques used to determine leukocyte concentration in semen as well as the lack of agreement on the lower leukocyte concentration responsible for sperm damage [5]. An association between cigarette smoking and reduced seminal quality has been identified. In a prospective study Agarwal, et al. [5], it has been compared infertile men who smoked cigarettes with nonsmoker infertile men. Spermatozoa produce small amounts of ROS that must be continuously inactivated to keep only the necessary amount to maintain normal physiologic cell function. The pathologic levels of ROS detected in the semen of infertile men are more likely caused by increased ROS production than by reduced antioxidant capacity of the seminal plasma [5].

Sperm DNA damage is critical in the context of success of assisted reproductive techniques Oxidative Stress and Sperm Chromatin Damage in Male Infertility [7]. The main nuisance of ART is that they bypass the natural defense barrier present throughout female reproductive tract responsible for selecting the best spermatozoa for oocyte fertilization. Normally oocytes are capable of repairing partial DNA damage. Infertility is a growing problem among couples trying to conceive; in the past the female partner was singled out as the primary reason for being unable to bear a child. Research now reveals that male infertility may contribute in up to two thirds of all couples who seek treatment for infertility. It is thought that these nicks exist naturally and serve to relieve torsional stress.

Genetic Lesions Genetic lesions are another possible means of attack through which nDNA can influence male infertility; these lesions create insults or gaps within the genome and may yield effects ranging from minimal to catastrophic. They can be divided into 3 classes based on the type of impact they present [7]. In this context, the most important function of the sperm mitochondria is to manufacture ATP. The mitochondria itself is composed of 2 distinct membranes, an inner membrane and an outer membrane. The outer membrane is relatively permissive and allows the transit of large molecules through nonspecific porin channels; the inner membrane is much more discriminatory. There is an ongoing debate over the cause and effect of apoptotic signaling in mitochondria. In other words, does the sperm mitochondria respiratory system contribute to the ROS environment, causing apoptosis, or does the increased ROS environment cause mitochondrial respiratory failure?. Chromosomal disomies are said to be reduced between fourfold and fivefold in HA-selected sperm compared with semen sperm [7]. Further, it indicates that HA preferentially selects for chromosomally normal sperm. Because of such promising results, a kit for this assay has become commercially available. The sperm-hyaluronan binding assay (HBA) has been marketed for routine testing of sperm motility and fertility [7].

Furthermore, diet is also directly associated with the integrity of spermatozoa and play vital roles to maintaining the proper functions. There are reports that food groups like dark green, leafy vegetables, fruits rich in vitamin C, walnuts rich in omega-3 fatty acids and arginine and whole cereals, antioxidants, liver, fatty fish, seafood, low-fat dairy products, coenzyme Q10 (CoQ10) and oysters contain the high level of zinc, vitamin B12, vitamin D, and Selenium have been positively play crucial roles in quality of sperm [8]. According to the available research studies suggest that consuming certain foods may harm the integrity of sperm such as high fat dietary products, trans fats, processed meat, soy products, coffee, sweet drinks, high level of carbohydrates are concern with structure and function of sperm cells. High intakes of trans-fat, saturated fatty acids and other dietary components are related to higher oxidative stress that triggers inflammation via nuclear factor-kappa B (NF-*k*B) mediated cell signaling pathway together with the decrease in antioxidant activity which constitutes the underlying cause of decreased sperm quality and a higher risk of infertility due to deterioration of sperm morphology, as well as hormonal and immunological disorders. Also, oxidative stress may impair sperm axonemal and mitochondrial function, as well as DNA integrity, RNA and protein synthesis. Consequently, change of lifestyle, mostly with regard to the antioxidant rich diet, low calorie foods seems to be crucial with regard to integrity of spermatozoa associated with male infertility.

Conclusion and Future Perspectives

Conclusively, *in-silico* studies based research using certain specific tools, overviewed by Saxena et al. [9], is mandatory to bring in appropriate application of certain specific techniques in view of improving the quality of spermatozoa that are selected for use in all ART techniques to improve reproductive outcomes like sperm count, sperm volume, sperm viability and male fertility. Nevertheless, these may provide new insights into development of novel male contraceptives.

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