SPERM HYPERACTIVATION

The process resulting in specific behaviour of a sperm cell ensuring its increased speed and force in movement.

♀ Reproductive functions ♂ Male

About Sperm hyperactivation

For a successful fertilization there are several basic conditions that the sperm cell must to accomplish. One of the basic and important conditions is the acquisition of a specific type of behaviour, called the sperm hyperactivation. The sperm hyperactivation is necessary for a successful migration of the sperm cell through fluids (the oviductal mucous) present in female reproductive tract (oviducts) and the penetration of the layers surrounding the oocyte. Hyperactivation is generally characterized as high amplitude flagellar bending (Pic. 1), a reduction in beat frequency and a beat asymmetry. These changes in the tail movement convey the enhanced thrust of the sperm cell. Hyperactivated sperm cells swim faster and their tail movements become more forceful. Hyperactivation is closely related to the sperm capacitation. These two conditions are most important for the sperm cell capacity to penetrate the protective layer surrounding the oocyte (zona pellucida).

Ca2+ and sperm hyperactivation

There are several chemical factors known to induce the sperm hyperactivation. It is well known the great influence of Ca2+ ions on the induction of sperm hyperactivation. An increased concentration of Ca2+ ions in the sperm tail is necessary for hyperactivation to happen. The transportation of Ca2+ into the sperm cell is provided by specific ion channels incorporated in the sperm cell membrane. There are various types of ion channels known to allow specifically the Ca2+ cations to transport into the sperm cell; the most familiar type of such channels is the CatSper ion channel. Calcium cations received through this kind of channels interacts in the signalling cascade resulting in the sperm hyperactivation (Pic. 2). The complete or partial absence of single or multiple Ca2+ channels is responsible for infertility or subfertility. Regarding the very close relationship of sperm hyperactivation and sperm capacitation, it is worth mentioning that the specific protein modulation (tyrosine phosphorylation) associated with sperm capacitation was observed to happen in the sperm tail, so it is obvious, that it has an influence on the sperm cell hyperactivation.

Energy management

The sperm hyperactivation is a condition requiring an increased supply of energy. One of the energy resources in a cell is glucose. The main pathway of glucose utilization is represented by glycolysis occurring in the intracellular fluid called cytosol, both in somatic and sperm cells. A great part of energy is also provided by mitochondria, specific organelle that can be found in the neck of sperm cell and it is often called as „the cellular power plant“ . Main substrates to process in mitochondrÌa are pyruvate and lactate, the products of glycolysis (Pic. 3). These two substances can be found in high concentrations, along with glucose, in oviductal fluid. The disruption of proper energetic metabolism can lead to a male infertility. Therefore, new strategies for treatment of such disruptions in cell energetic metabolism are under investigation.
Pic. 1: Measurement of sperm tail bending amplitude
Comparison of sperm tail bending amplitude before (on the right) and after (on the left) hyperactivation.

Pic. 2: Activation of hyperactivation through CatSper ion channel
The activation of CatSper channels in the flagellum by diverse stimuli (including intracellular pH, membrane potential (Em), progesterone, prostaglandins and other organic molecules) leading to the hyperactivation.

Pic. 3: Sperm cell metabolism of pyruvate and lactate
Simple diagram of the energetic metabolism of a sperm cell.

Sources

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