Progress of sperm Izumo relocailization during spontaneous acrosome reaction in the field mouse

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Introduction

It has been recently shown in mice that sperm undergo acrosome reaction (AR) by passing through cumulus cells, furthermore the acrosome-reacted sperm can bind to zona pellucida, and consequently fertilize the egg. However, up to date it has not been determined what is the fate of the massive population of sperm released from the male after attempting to fertilize an egg. There is a high rate of spontaneous acrosomal reaction in rodents, with up to 60% in promiscuous species. Izumo is a member of an immunoglobulin superfamily protein type I, it is transmembrane protein with an extracellular immunoglobulin domain and is essential for sperm-egg interaction and fusion. It is predicted that sperm bind through the primary fusion protein Izumo, located in the equatorial segment, to CD9 protein in an egg oolema. During AR, the primary fusion protein Izumo is relocated into the equatorial segment of the sperm head were the sperm-egg membrane fusion happens. The aim was to find out, whether the relocation of Izumo happens during the physiological spontaneous AR, or whether it occurs only in sperm with induced AR with further correlation to species-specific mating behaviour. Immunofluorescent detection of the Izumo protein at specific times of sperm capacitation in vitro during spontaneous, calcium ionophore and progesterone induced AR was monitored. In our experimental setup we used promiscuous species of field mice Apodemus sylvaticus and Apodemus microps, which exhibit a more rapid spontaneous AR in comparison to the laboratory strain of BALB/c mice used as a control.

Results

Izumo relocation during spontaneous AR with correlation to promiscuity behaviour

Izumo relocation during Ca(II) induced AR with correlation to promiscuity behaviour

Izumo relocation during progesterone induced AR with correlation to promiscuity behaviour

Conclusion

Our results show that during spontaneous AR there is a gradual Izumo relocation from the acrosomal membrane to the equatorial and post-acrosomal segment of the sperm head. Izumo relocation may not be related to acrosome stability. Izumo relocation is more dependent on ongoing capacitation rather than AR and is independent to the acrosome integrity in mice. The actual time needed for completing the relocation process remains faster only in the highly promiscuous species of A. Sylactus. The difference in final Izumo relocation between species is not as distinct and might depend on the time needed for completing of sperm capacitation rather than the acrosome reaction. There were no particular differences between the Izumo relocation in the spontaneous and calcium ionophore induced AR. The process of the Izumo dynamics was speed up when sperm were exposed to the parallel progesterone stimuli. Therefore, spontaneously acrosome reacted sperm have the same fertilizing potential as those after induced AR. Moreover, the beginning and progress of Izumo relocation positively correlates with the level of promiscuity and the acrosome instability in Apodemus species. Indisputably, the spontaneous AR is a fast event and for this reason, it might be usual in species with a promiscuous behaviour that being faster means succeeding over a competitor. The findings that crucial molecular changes essential for sperm-egg fusion represented by dynamic movements of Izumo also happen during spontaneous AR are vital for novel understanding of fertilization in mice. Moreover, this may represent a unique mechanism of accelerating the fertilizing process in a highly promiscuous environment under selective pressure of intra-specific sperm competition.

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