Roles and mechanisms of Ca^{2+} oscillation in the process of fertilization

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During the process of fertilization, Ca^{2+} is involved in many events in sperm and egg. All steps of sperm for ensuring fertilization: initiation and activation of motility, chemotactic behavior, and acrosome reaction, requires increase in intracellular Ca^{2+}. On the other hand, sperm induces the egg transient or oscillatory Ca^{2+} increases, and the Ca^{2+} increase triggers events of egg activation. However, the precise roles and mechanisms of Ca^{2+} increase on these events of fertilization are still unknown. Therefore, I have studied on roles and mechanisms of Ca^{2+} in fertilization.

The acrosome reaction of sperm, which entails exocytosis of the acrosomal vesicles, is an indispensable step for sperm-egg binding. In mammalian sperm, the acrosome reaction can be induced by zona pellucida, the extracellular matrix of the egg, or progesterone included in follicular fluid. ZP3, a glycoprotein in zona pellucida, stimulates voltage-dependent Ca^{2+} channels and induces transient Ca^{2+} influx. It is followed by a slower and sustained Ca^{2+} increase and results in acrosome reaction. The sustained Ca^{2+} elevation seems to be cause by releasing Ca^{2+} from an IP_3-sensitive intracellular store and subsequent Ca^{2+} entry via store-operated Ca^{2+}-channel. However, only few studies have reported detailed spatio-temporal analysis of single sperm because of difficulties in observation. I have tried to study the role of Ca^{2+} in the acrosome reaction, and to make a Ca^{2+} imaging system in single sperm. Recently, we found that phospholipase Cd4 is an important enzyme for intracellular Ca^{2+} mobilization in the acrosome reaction and for sustained Ca^{2+} increase induced by zona pellucida in spermatozoa through the experiments on phospholipase Cd4 deficient mice. Furthermore, store-operated Ca^{2+}-channel seems to be localized on neck region of sperm head. Now we are trying to identify more precise signaling pathway in the acrosome reaction, especially roles of IP_3 receptor.

Publications: Yoshida et al. 203 122-133 1998, Fukami et al.Science 292 920-923 2001, Fukami et al. J. Cell. Biol. 151 79-88 2003