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Sperm membrane physiology and relevance for fertilization☆

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Abstract

This paper aims to overview recent insights in sperm surface remodelling pertinent to fertilization. A basic understanding of this remodelling is required to interpret the high amount of data appearing from high-throughput identification techniques for proteins presently applied in reproductive biology. From the extensive lists of protein candidates identified by proteomics, only a few are recognized to be directly involved in fertilization. Others are indirectly involved, but many are not yet considered to be involved in fertilization. Some of these newly identified and unexpected proteins may shed new light in the current molecular models for fertilization. However, the gathered lists of sperm proteins possibly involved in fertilization do only tell a part of the story regarding how fertilization is accomplished. When considering the identification of proteins involved in fertilization, one also needs to take into account the fundamental mechanisms involved in the redistribution of sperm surface proteins in membrane protein complexes and the involvement of cell signalling events that regulate their post-translational modification status. Both processes are likely requisite for protein configuration and grouping into functional membrane protein complexes necessary to elicit their delicate roles in fertilization. This paper emphasizes biochemical models for membrane surface modelling and their potential involvement for remodelling the sperm surface in the above described processes.

Keywords: Sperm capacitation; Sperm–zona binding; Acrosome reaction; Oolemma binding; Fertilization; Membrane protein complexes

1. Introduction

It is still not clear how sperm fertilize the oocyte, although it is clear that only functionally intact sperm can fertilize the egg and that this is somehow accomplished at the surface of the

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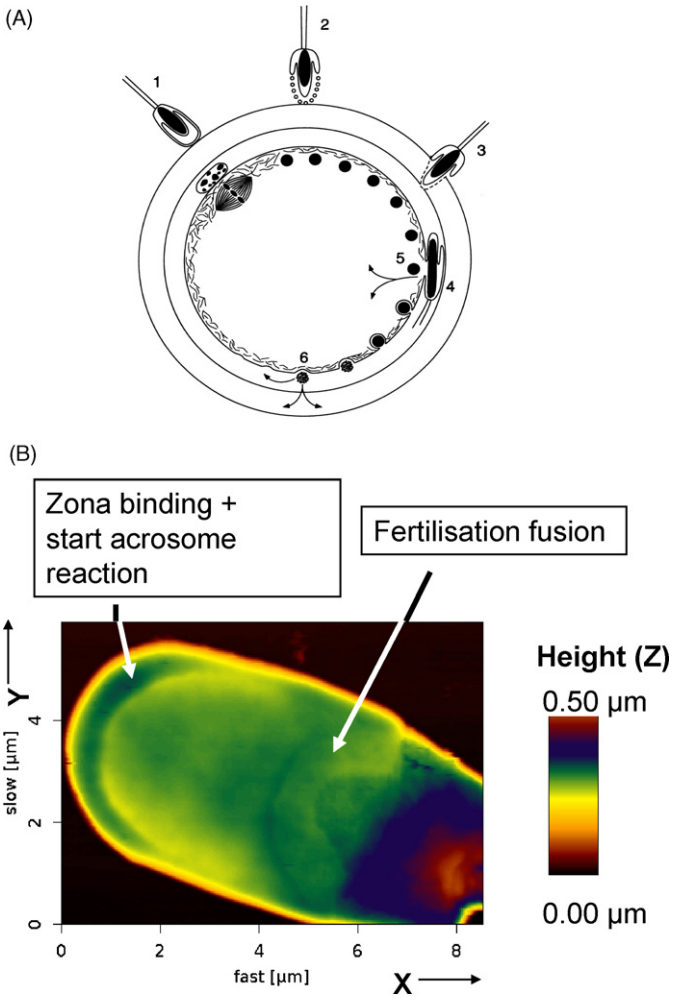

Fig. 1. (Panel A) Schematic representation of the sequence of interactions between the male and female gamete leading to fertilization. 1, Sperm binding to the zona pellucida (restricted to the apical ridge subdomain area); 2, the acrosome reaction (fusions restricted to the apical ridge and pre-equatorial subdomain areas); 3, the penetration of the zona pellucida note that the equatorial membranes remain intact and that the mixed vesicles resulting from the acrosome reaction are shed of the penetrating sperm; 4, binding and fusion with the oolemma (restricted to the equatorial subdomain area); 5, activation of the fertilized oocyte by a soluble sperm factors; 6, polyspermy block by the cortical reaction. (Panel B) The surface height of a living porcine sperm cell measured with atomic force microscopy. The apical ridge area is specifically involved in zona binding and is the site were the acrosome reaction is initiated, the equatorial segment is the specific area of the sperm head involved in oolemma binding and in the fertilization fusion.

sperm head (Yanagimachi, 1994). The sperm head surface is heterogeneous and diverse surface regions can be observed microscopically (Fig. 1). From previous studies we know that sperm surface molecules exhibit lateral diffusion properties but remain entrapped into specific surface regions (Phelps et al., 1988; Gadella et al., 1995). A reordering of this mosaic sperm surface takes place when sperm reside in the proximity of the egg at the same time when sperm becomes competent to fertilize.