Calcium dynamics during fertilization in C. elegans

ABSTRACT

Development of a technique to study fertilization induced calcium transients opens several experimental possibilities, e.g., identification of the signaling events intervening sperm binding and calcium elevation, identifying the possible roles of the calcium elevation such as the completion of meiosis, the formation of the eggshell, and the establishing of the embryo's axis of symmetry.

INTRODUCTION

Introduction In all animals, fertilization generates a pattern of intracellular calcium dynamics within the oocyte that constitutes an essential trigger for normal development. The spatiotemporal properties of the calcium dynamics differ among animals, e.g., echinoderms, fish, and frogs have single calcium transients whereas ascidians, nemerteans, and mammals have multiple calcium oscillations. Fertilization-induced calcium dynamics are mediated by release of internal calcium stores by inositol 1,4,5-triphosphate (IP3). In echinoderms and ascidians, the signaling pathway between sperm-egg fusion and the production of IP3 requires phospholipase Cγ and a Src family kinase, but little is known about the earliest events in this pathway. In the C. elegans hermaphrodite, oocytes are formed by budding from a syncytium. Afterwards, they undergo maturation, ovulation, and are fertilized internally in a single-file, assembly-line-like process. An oocyte arrests at diakinesis of prophase I upon reaching the entrance to the spermatheca. The nuclear envelope breaks down ~ 6 min before the mature oocyte enters the spermatheca where its leading edge engulfs a single sperm. Eggshell formation is initiated and meiosis I and II and completed immediately follow fertilization. The newly fertilized egg remains in the spermatheca ~ 3-5 min before it is pushed out of the spermatheca and into the uterus. The first cleavage in embryonic development occurs ~ 40 min after fertilization. Figure 1 is a DIC image of the posterior arm of the gonad showing the syncytial gonad, developing oocytes, spermatheca, and fertilized eggs within the uterus. Here, we describe fertilization-induced calcium dynamics in the nematode C. elegans (see for a description of an earlier study of the same). The benefit of continued use of C. elegans to study fertilization-induced calcium dynamics is the existence of powerful genetic tools, e.g., techniques for forward and reverse genetics, and an entirely sequenced genome. Molecular genetic analysis of the signaling pathway mediating fertilization-induced calcium dynamics may be possible using C. elegans.

CONCLUSION

This technique for measuring fertilization induced calcium transients provides a new experimental method in the study of C. elegans. A large number of existing mutants with fertilization defects can now be assayed for possible defects in the calcium transient. Forward genetic (gene knockout and RNAi) methods available in C. elegans should permit testing proteins hypothesized to be involved in this critical step in embryogenesis.