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Oocyte–somatic cell–endocrine interactions in pigs

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Abstract

Oocyte–somatic cell communication is bi-directional and essential for both oocyte and follicular granulosa and theca cell function and development. We have shown that the oocyte secretes factors that stimulate porcine granulosa cell proliferation in serum-free culture, and suppress progesterone production, thereby preventing premature luteinisation. Possible candidates for mediating some of these effects are the bone morphogenetic proteins (BMPs) that belong to the transforming growth factor β family. They are emerging as a family of proteins critical for fertility and ovulation rate in several mammals, and they are expressed in various cell types in the ovary. We have evidence for a functional BMP system in the porcine ovary and BMP receptors are present in the egg nests in the fetal ovary and in the granulosa cells, oocytes and occasional theca cells throughout subsequent development. In addition to paracrine interactions in the ovary, the porcine oocyte and its developmental potential can also be influenced by nutritional manipulation in vivo. We have demonstrated that feeding a high plane of nutrition to gilts for 19 days prior to ovulation increased oocyte quality compared to control animals fed a maintenance diet, as determined by oocyte maturation in vitro. This was associated with a number of changes in circulating reproductive and metabolic hormones and also in the follicular fluid in which the oocyte is nurtured. Further studies showed a similar increase in prenatal survival on Day 30 of gestation, demonstrating a direct link between oocyte quality/maturation and embryo survival. Collectively, these studies emphasise the importance of the interactions that occur between the oocyte

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and somatic cells and also with endocrine hormones for ovarian development, and ultimately for the production of oocytes with optimal developmental potential.

Keywords: Oocyte; Somatic cell; Pigs; Oocyte quality

1. Oocyte–somatic cell interactions

1.1. Oocyte secreted factors

Within the mammalian ovarian follicle, oocyte growth and differentiation depends upon an intimate association between the somatic follicular cells and the developing germ cells [1]. Studies have demonstrated that various aspects of follicular development are dependent upon and/or are influenced by the presence of the oocyte, including granulosa cell proliferation and cumulus expansion [2]. Thus it is clear that oocyte–granulosa cell communication is bi-directional and essential for both oocyte and follicular somatic cell function and development [3]. Paracrine factors secreted by both granulosa and theca cells, in addition to FSH, regulate individual follicle development. However, the oocyte may play a dominant role in controlling follicle development [4].

1.2. Regulation of somatic cell function by the oocyte

Recent research on oocyte-secreted factors has focussed on murine systems and has shown that oocytes are capable of modulating steroid synthesis by murine cumulus cells in vitro, particularly by inhibiting progesterone production [5]. Furthermore, the oocyte plays a role in the control of granulosa cell proliferation and morphology [3,6,7]. We have extended these findings to the pig and have shown using serum-free culture systems, where the follicular phenotype is maintained in vitro [8–10], that the porcine oocyte modulates both granulosa and theca cell growth and function. This is particularly interesting because there is a paucity of information on the effect the oocyte has on ovarian somatic cells in large polyovulatory species such as the pig, and little is known about effects on theca cell function in any species.

Both porcine granulosa and theca cells cultured with either oocyte-conditioned medium or co-cultured with denuded oocytes, showed an increase in viable cell numbers. Oocyte secreted factors also suppressed progesterone but stimulated oestradiol synthesis by granulosa cells throughout a 6-day culture period (Fig. 1). Furthermore, oocyte-derived suppression of progesterone was also observed in cultured theca cells. Interestingly, both theca androstenedione and oestradiol synthesis were modulated by oocyte-derived factors [10].

These findings support the proposal that the porcine oocyte secrete(s) a factor that modulates both cell proliferation and steroidogenesis by ovarian somatic cells in physiologically relevant, serum-free systems and oocyte secreted factors interact with LR3 IGF-1 in potentiating these effects. In particular, these studies confirm that porcine oocyte secreted factors are active inhibitors of luteinisation. The effects of oocyte secreted factors appear to be