Animal Science 434

Lecture 10: The Follicular Phase of the Estrous Cycle

Tonic and Preovulatory Surge of GnRH

Hypothalamus

GnRH

Anterior Pituitary

LH, FSH

Inhibin

Estradiol

CL

Follicle

LH, FSH

Ovary

Progesterone

 Estradiol

(-)

Estradiol

(-)

Days Relative to the GnRH Surge

Follicular Phase
Fate of follicles and oocytes.

<table>
<thead>
<tr>
<th>Total # of follicles</th>
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<tbody>
<tr>
<td>At birth</td>
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<tr>
<td>12 months</td>
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<tr>
<td>4-6 years</td>
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<tr>
<td>Aged cow</td>
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Follicles grow to tertiary characteristic and degenerate.

Maximum number of oocytes ovulated for a cow

17 cycles/year x 8 year = 136 oocytes ovulated/lifespan

Follicles grow to tertiary characteristic and degenerate.

Maximum number of oocytes ovulated for a cow

17 cycles/year x 8 year = 136 oocytes ovulated/lifespan

Can increase with superovulation with FSH to stimulate the rescue of follicles which would have undergone atresia
Initial Follicular Growth

Small Antral Follicle

Gonadotropin Independent

FSH

Recruitment

50 - 60 days

Follicular Waves in Cattle

Follicular Size

Recruitment

Selection

Dominance

Atresia

Ovulation

Day After Ovulation

Progesterone

Follicular Waves in Cattle

Follicular Size

Recruitment

Selection

Dominance

Atresia

Ovulation

Day After Ovulation

FSH

estradiol

inhibin

(-)

Follicular Waves in Cattle

Follicular Size

Recruitment

Selection

Dominance

Atresia

Ovulation

Day After Ovulation

Progesterone
Species Variation in Follicular Waves
- Cattle - 2 or 3 / cycle
- Sheep - 4 or 5 / cycle
- Pigs - 1 / cycle
- Horses - 1 / cycle
- Human - 1 / cycle

Gonadotropin Action Within the Follicle
Antral Follicle

Theca Interna

Granulosa

Blood

Receptor

LH

cAMP

Cholesterol

Testosterone

PKA

FSH

Testosterone

FSH

Receptor

LH

Selection

Dominant Follicle Express LH Receptor

cAMP

Testosterone

PKA

cAMP

Estradiol

PKA

Ovulation

Blocking of these events in the follicle prevents ovulation.

- protein synthesis
- steroid synthesis
- prostaglandin synthesis
- plasminogen activator synthesis
Preovulatory LH Surge

- Increased Blood Flow to Ovary and Follicle
- Vascular Permeability
- Plasminogen
- Plasminogen Activator
- Progesterone
- Prostaglandin Synthesis
- Blood Flow to Ovary and Follicle

- Cumulus Expansion
- Oocyte Separates from Follicular Wall
- Collagenase (inactive)
- Collagenase (active)
- Follicular Wall Weakens
- Contraction of Smooth Muscle
- Ovulation

Types of Ovulators

- Spontaneous Ovulators
- Induced Ovulators

- Sensory Neurons
- Nerve endings sensing copulation
- Copulation
- Penis

- Blood LH
- Time (hr)
- Stimulation
- GnRH
- LH
- Anterior Pit.
- Posterior Pit.
- Hypothalamus
- Spinal Chord
Sensory Neurons

Nerve endings sensing copulation

Copulation

Penis

Sensory Neurons

Cats

- Induced Ovulators
- Single copulation
  - Only works 50% of the time
- Multiple copulations
  - Higher LH surge

Spontaneous Ovulators

- Retain some neural control of ovulation
  - heifers can alter the timing of the LH surge by clitoral stimulation
  - human rape cases result in higher than expected pregnancy rates

Oogenesis

Migration to germinal ridge
Meiotic divisions

Initiation of Meiosis
Interphase
DNA synthesis
Meiotic prophase begins

Primordial Germ Cells
Primordial Gonads
Primordial Oogonia
Primordial Oocyte
Primary Oocyte
Follicle Cells
Gonadotropin
Independent
Gonadotropin
Dependent

Prophase of Meiosis
Leptotene
Zygotene
Pachytene
Diplotene
Diplotene
Dictyotene
Meiotic Arrest

Fetal Oocyte Development

Mitosis
Meiosis

Fertilization
Birth

Cow

250 d

Sow

114 d

Mouse

19 d

Ovulation of Tertiary Follicle

Mouse

Fetal Oocyte Development

Mitosis
Meiosis

Fertilization
Birth

Cow

250 d

Sow

114 d

Mouse

19 d
Formation of the Zona Pellucida

Corona Radiata

Zona Pellucida

Oocyte

During Oocyte Growth and Before the LH Surge

• OMI - Oocyte Maturation Inhibitor
• MPF - Maturation promoting factor
• GV - germinal vesicle (nucleus)

Gap Junctions Allow Cell to Cell Communication!

The LH Surge

Gap Junctions are Destroyed!

The LH Surge

Resumption of Meiosis

Gap Junctions are Destroyed!

LH Surge → Resumption of Meiosis → First polar body emitted, arrest at metaphase II of meiosis → Zygote (pronucleate egg) → Ovulation (most species) → Sperm penetration → 4N → 2N → 2N

Primary Oocyte → Secondary Oocyte → Ovulation

Most species
LH Surge

Resumption of Meiosis

First polar body emitted, arrest at metaphase II of meiosis

Ovulation

Primary Oocyte
- Dog
- Fox

Sperm Penetration
- Dog
- Fox

Secondary Oocyte

Ovulation (most species)

Zygote (pronucleate egg)

Sperm Penetration

- Dog
- Fox

4N → 2N → 2N

(4N) (2N) (2N)