Fertilization, Maternal recognition of pregnancy and Implantation

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Some definitions

• Obstetrics  Science of midwifery (obstare "stand opposite to)
• A branch of medicine that deals with care of pregnant women during pregnancy, at child birth and afterwards

• Veterinary Obstetrics:
• A branch of Veterinary Medicine that deals with
• care of animals during pregnancy, at parturition
• and during the postpartum period
• **Embryo:** from fertilization to the differentiation stage (45 days in cattle)
• **Fetus:** from differentiation till parturition
• **Conceptus:** Fetus with its fetal membranes.
• **Nullipara:** An animal which has not become pregnant and not parturated.
• **Primipara:** An animal which has become pregnant and would parturate for the first time
• **Monotocous (Uniparous):** Animals giving birth to single young ones
• **Polytocous:** Animals giving birth to many young ones
• **Embryology:** Science of physiological development of the fetus
• **Teratology:** Embryology + pathology dealing with abnormal fetal development
Carazol: A beta-blocker given to sows to reduce the expulsive time of labor in sows.

Clenbuterol: A beta-adrenergic that quietens the uterus and inhibits labor.

Psuedopregnancy: False pregnancy occurs in the bitch and the goat and in many other species like mare.

Feathering: Tapping of the vagina of a whelping bitch with finger leads to oxytocin release and delivery of a pup.

Single pup syndrome: The presence of a single pup in a bitch leading to problem in initiation of parturition and development of an extra large puppy.

Spalding sign: Overlapping of the fetal skull bones seen on radiography of a bitch with dead fetuses.

Fergusons reflex: The release of huge quantities of oxytocin in cows when the fetal legs touches thee pelvis during parturition.

Theilers disease: Infectious hepatitis in mare developing due to injection of an eCG.
PREGNANCY IN DOMESTIC ANIMALS
• The period of intrauterine development (from fertilization to parturition) in mammals is termed pregnancy or gestation.

• Ovum + sperm → fertilization → Embryo ↓
  Completion of gestation ← Growth in uterus (Pregnancy) → Parturition
FERTILIZATION

- External → Amphibians
- Internal → Mammals
- Fertilization in mammals
  - Gamete transport
  - Changes in gamete structure
  - Cleavage and blastocyst formation
  - Maternal recognition of pregnancy
Gamete transport

- Synchronous transport of male and female gametes to oviduct ampulla should occur

- Semen deposited in vagina (human, cattle, buffalo, sheep, goats, rabbits).
- Semen deposited in the uterus
- (in dogs, horses, pigs).
During sexual intercourse about 300 million sperm enter the vagina.
Oocyte transport

• Except mares the oocyte is picked by the fimbriae and enters the ostium

• Propelled towards the ampulla by ciliated cells
# Fertile life of gametes in domestic animals

<table>
<thead>
<tr>
<th>Species</th>
<th>Fertile life sperm (hrs)</th>
<th>Fertile life ovum (hrs)</th>
<th>Day of entry of embryo in uterus</th>
<th>Blastocyst formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>24-48</td>
<td>20-24</td>
<td>3-3.5</td>
<td>7-8</td>
</tr>
<tr>
<td>Horse</td>
<td>72-120</td>
<td>6-8</td>
<td>4-5</td>
<td>6</td>
</tr>
<tr>
<td>Sheep</td>
<td>30-48</td>
<td>16-24</td>
<td>3</td>
<td>6-7</td>
</tr>
<tr>
<td>Swine</td>
<td>24-72</td>
<td>8-10</td>
<td>2</td>
<td>5-6</td>
</tr>
<tr>
<td>Dog</td>
<td>120-168</td>
<td>48-72</td>
<td>5</td>
<td>7-8</td>
</tr>
<tr>
<td>Buffalo</td>
<td>24-32</td>
<td>6-12</td>
<td>4</td>
<td>5-6</td>
</tr>
</tbody>
</table>
Changes in gamete structure

- Sperm capacitation, sperm oocyte interaction, acrosome reaction, oocyte activation, zona reaction and intermingling of male and female gametes

- Capacitation occurs in female tract
Effect of Capacitation

Epididymal Secretions + Seminal Plasma and/or Epididymal Secretions → Ejaculated

+ Female Tract → Capacitated
Zona Pellucida
Perivitelline Space

Oocyte

Zona Block to Polyspermy

Ca$^{2+}$
Cortical Granules
Sperm acrosomal region binds to sperm receptor on zona

Vitelline Membrane
ZP3
Binding

Initiation of Acrosome Reaction

Continuation of Reaction

Acrosome-Reacted Sperm

Penetration

Sperm penetrates zona

Perivitelline Space

Initiates completion of Meiosis II and release of 2nd polar body

1st Polar Body
Zona Pellucida

Fusion

Cortical Granule Release

Cortical Granule

Zona Reaction

Excluded Sperm

Zona and Vitelline Reactions block polyspermy

Redrawn from Wasserman, P.M. 1988 Scientific American. p78
Hatching

- Bovine
  - 9 - 11 days
- Equine, Ovine
  - 7 - 8 days
- Porcine
  - 6 days
- Buffalo
  - 6.5 days
Conceptus Growth

Occurs in cow, pig and sheep

Cow
- Day 15, 1-2 mm
- Day 18-19, 10-20 cm

- Spherical
  - Mare remains spherical!

- Tubular
  - Embryonic Area
  - Elongating Trophoblast

- Filamentous
Development of Fetal Conceptuses from Day 10 to 12

- 5 mm Spherical
- 10 mm Spherical
- 14 mm Tubular
- 150 mm Filamentous

Inner Cell Mass
Elongated Day 15 Porcine Conceptus
Uterine Location of Elongating Ruminant Blastocyst

Bovine and Ovine

Corpus Luteum
Pig Intrauterine Migration

Day 5
Pig Intrauterine Migration

Day 7
Pig Intrauterine Migration

Day 12

Embryos become fixed

Transuterine migration is rare in cow and ewe!
Trans-uterine Migration in the Mare

Fixation can occur in either horn!

Begins Day 10

Fixation on day 15 - 16

Corpus Luteum
Gastrulation

Formation of Germ Layers

Inner Cell Mass

Endoderm

Blastocoele Cavity

Trophectoderm
Gastrulation

Endoderm

Yolk Sack
Gastrulation
Gastrula

- Ectoderm
- Mesoderm
- Endoderm
- Yolk Sack
- Trophoblast (Chorion)
- Extraembryonic Coelom
Germ Layers

- **Ectoderm**
  - CNS
  - Sense organs
  - Mammary glands
  - Sweat glands
  - Skin
  - Hair
  - hooves

- **Mesoderm**
  - Circulatory
  - Skeletal
  - Muscle
  - Reproductive tracts
  - Kidneys
  - Urinary ducts

- **Endoderm**
  » Digestive
  » Liver
  » Lungs
  » Pancreas
  » Thyroid gland
  » Other glands
Fetal membrane Formation

- Embryonic Ectoderm
- Yolk Sack
- Extraembryonic Coelom
- Trophoderm
- Mesoderm
- Endoderm
- Amniotic Folds
- Chorion
Fetal (Placental) Membranes

- **Yolk Sack**
  - In birds to nourish embryo
  - In mammal atrophies but source of blood cells and primordial germ cells

- **Amnion**
  - Non-vascular, fluid filled
  - Fluid produced by fetus
  - Protective cushion
  - Ruptures at birth (not breaking of water)
Placental Membranes

• Allantois
  – Blood vessels
  – Fuses with chorion
    • Allantochorion or chorioallantois
    • Brings blood vessels to chorion

• Chorion
  – Outermost membrane
  – Attachment to mother
Maternal Recognition of Pregnancy
Luteal Regression

PGF$_{2\alpha}$ (Bovine, Ovine, Porcine)

PGF$_{2\alpha}$ (Equine)

No Uterine Factor (human)
CL Status

- CL Status
  - (+) Uterine PGF$_{2\alpha}$
  - (+) Filamentous Embryo
  - Maintained

- CA
  - CL Regression
    - Luteolytic
    - No CL support
  - CL Maintenance
    - Antiluteolytic
      - Block PGF$_{2\alpha}$ effects
    - Luteotrophic
      - Stimulate progesterone production by CL

Mechanisms
Recognition of Pregnancy in Bovine and Ovine

**Mechanism**
- Antiluteolytic
  - Inhibit oxytocin receptor synthesis
  - Inhibit PGF$_{2\alpha}$ synthesis

**Conceptus Secretions**
- Interferons
  - oIFN-τ
  - bIFN-τ

**Critical Days**
- Bovine - 16 to 17
- Ovine - 12 to 13
Recognition of Pregnancy in the Porcine

Conceptus Secretions
- Estradiol

Critical Days
11 to 12

Mechanism
- Antiluteolytic
  » Redirect PGF$_{2\alpha}$
  » Requires 2 embryos per horn
Recognition of Pregnancy in the Mare

Conceptus Secretion
- ?

Critical Days
- 10 to 14

Mechanism
- antiluteolytic
Recognition of Pregnancy in the Human

Conceptus Secretes
- HCG

Mechanism
- luteotrophic

Critical Days
- 8 to 12
Dog and Cat

- CL does not regress if not pregnant
  - no uterine effect
- Psuedopregnancy
  - CL last similar length as in pregnancy
Implantation
## Time of Implantation

<table>
<thead>
<tr>
<th>Species</th>
<th>Beginning</th>
<th>Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>pig</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td>cow</td>
<td>22</td>
<td>40</td>
</tr>
<tr>
<td>sheep</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>mare</td>
<td>24 - 40</td>
<td>95 - 100</td>
</tr>
<tr>
<td>human</td>
<td>7 - 8</td>
<td>30</td>
</tr>
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The time from ovulation, during which implantation occurs in different species.

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<tr>
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<td>Human</td>
<td>6 to 7</td>
</tr>
</tbody>
</table>
Type of Implantation

- **Centric**
  - Chorion lies opposed to uterine wall
  - Farm animals
- **Eccentric**
  - Chorionic sack in a uterine fold
  - Rodent
- **Interstitial**
  - Embryo digests part of uterine wall
  - human
Patterns of Implantation

- Centric
- Eccentric
- Interstitial
Thank You

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