Anatomy and Lactation Physiology

Dairy Cattle Technology

Anatomy of the Mammary Gland url: www.rosholt.k12.wi.us/faculty/ticichon/Mammary%20Udder.ppt

Mammary Gland (Udder)

- Common to all mammals
- Exocrine gland
- Two Functions
  - To nourish the young
  - Produce immunoglobulins for protection
- Relies on many of the same hormones that control reproduction
The surface anatomy (External Features) of the bovine udder.

- The appearance of the udder varies depending on maturity and functional status.
- In dairy cows it is very large and can weigh up to 60 kg.
- The udder is divided into quarters corresponding to the four glands - each bearing a principle teat.

Four separate glands or quarters

- Fore (40%) and rear (60%)
- The division between fore- and rear quarters is less distinct.
- Right and left sides separated by a median intermammary groove
- No interaction between quarters
Teats

- Usually one teat per quarter
  - Supernumeries (~50%)
    - Nonfunctional and functional
    - 92% caudal, 5% between, 3% cranial
    - Removed when 1-2 years of age
- No hair, sweat or sebaceous glands
- 2.5 inches
**Udder Suspensory System**

- Skin
- Superficial fascia
- Coarse aerolar tissue
  - fore udder to abdominal wall
- Lateral suspensory ligaments
  - superficial
  - deep
  - arise from the subpelvic ligament and prepudic tendon
- Median suspensory ligament
  - main suspension
  - elastic

**Suspension of the Udder**
Udder Suspension

Median Suspensory Ligament
Compass Cow

Udder Edema
**Interior of the Udder**

- **Gland cistern**
  - 100-400 ml. milk storage
  - duct systems drains into
  - used to detect end of milking

- **Duct system**
  - drains secretory tissue
  - no secretory function

- **Alveoli**
  - Milk producing units
  - secretory cells, myoepithelial cells and capillaries, duct

- **Lobules**
  - 150-200 alveoli, common duct

- **Lobes**
  - group of lobules
Diagram of Duct System

Alveolus
Vascular System

- Blood:Milk Ratio; 500:1
- 2 Arteries
  - External pudic
  - Perineal
- 3 Veins
  - External pudic
  - Perineal
  - Subcutaneous abdominals
    - Milk wells
    - Venous circle

Blood System to the Udder
Diagram of Arteries and Lymphatics
Fig. 1.18. Routes of venous blood from the udder of the cow to the heart.
**Lymph System**

- **Lacteals**
  - Originate in the peripheral tissues of the teat ends
  - Move fluids to the lymph nodes
- **Ducts**
  - 2-4 main ducts drain the rear udder
  - 1-3 main ducts drain the fore udder
- **Supramammary Lymph Nodes**
  - Located in the rear udder

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**Lymphatic Drainage**

- Subiliac (prefemoral) lymph node
- Ischial lymph node
- Mammary (superficial inguinal) lymph node
- To deep inguinal lymph node
Innervation of the Mammary Gland

Milk Ejection Reflex

- **Neuroendocrine**
- Pressure sensitive receptors on the teats feed back to the supraoptic and paraventricular nuclei
- Stimulation of these neurons causes release of oxytocin
  - Other stimuli can cause letdown
- Oxytocin causes myoepithelial cells to contract
  - Peak oxytocin 2 mins following stimulation
  - Half life of .55 - 3.6 mins
- Timing of stimulation important to milk flow rate and machine-on time
- Machine attachment in 20-45 seconds
- Adrenalin blocks letdown by:
  - Decreasing mammary blood flow
  - Reducing myoepithelial response
  - Reducing oxytocin release
Oxytocin Release

Milking Frequency:

Effects on Milk Production
Effect of Increased Milking Frequency (IMF) on Milk Production

<table>
<thead>
<tr>
<th>Milking Frequency Change</th>
<th>Increased Milk Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X - 2X</td>
<td>13.6 lb.</td>
</tr>
<tr>
<td>2X - 3X</td>
<td>7.7 lb.</td>
</tr>
<tr>
<td>2X - 4X</td>
<td>10.8 lb.</td>
</tr>
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</table>

Effect of Udder Pressure on Milk Secretion
Early Lactation IMF & Changes in milk yield

<table>
<thead>
<tr>
<th>Study</th>
<th>Times Milked</th>
<th>Length of Trt</th>
<th>“Earned Milk” Trt Diff.</th>
<th>“Free Milk” Carryover Effects</th>
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<tbody>
<tr>
<td>Poole, 1982</td>
<td>3X vs. 2X</td>
<td>20 wks</td>
<td>8.8 lb/d</td>
<td>4.8 lb/d</td>
</tr>
<tr>
<td>Bar Peled et al., 1995</td>
<td>6X vs. 3X</td>
<td>6 wks</td>
<td>16.0 lb/d</td>
<td>11.2 lb/d</td>
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<tr>
<td>Sanders et al., 2000</td>
<td>6X vs. 3X</td>
<td>6 wks</td>
<td>9.0 lb/d</td>
<td>5.5 lb/d</td>
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</tbody>
</table>

IMF Results Depend on Timing

- IMF initiated during mid lactation
  - Increases milk production during IMF
  - Milk production declines to pre IMF level after IMF ceases
  - All extra milk is “Earned”

- IMF initiated during early lactation
  - Increases milk production during IMF
  - Milk production does not decline to pre IMF level after IMF ceases
  - A large portion of the extra milk is “Free”
IMF & Mammary Growth

- There is a high correlation between milk yield and the number of secretory cells (Tucker, 1966).
- In goats, IMF correlates with an increase in rate of secretory cell proliferation (Wilde et al., 1987).
- Administration of bST during lactation may increase the rate of mammary cell proliferation (Capuco et al., 2001).
- How does IMF in early lactation affect mammary growth in cattle?

IMF Milking Interval

- IMF cows milked before and after the normal 2X milking.
- ~2 ½ hours between 2 AM and 2 PM milkings.
- 8 ½ hours between AM and PM milkings.
**Effects of IMF**

- **Milk Response**
  - 15 lbs. “Earned” Milk
  - 6 lbs. “Free” Milk
- **Older Cows had a greater carryover effect**
  - 2 lb versus 6 lbs
- **Profitability**
  - 8 cents/cow/day at 3 lb response
  - 32 cents/cow/day at 6 lb response
Effect of Milking Interval

<table>
<thead>
<tr>
<th>Interval</th>
<th>Cows</th>
<th>Days</th>
<th>Milk</th>
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<tbody>
<tr>
<td>12-12</td>
<td>35</td>
<td>305</td>
<td>13.760</td>
</tr>
<tr>
<td>14-10</td>
<td>35</td>
<td>305</td>
<td>13.716</td>
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<tr>
<td>16-8</td>
<td>35</td>
<td>305</td>
<td>13.582</td>
</tr>
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</table>

Schmidt & Trimberger (1963)

Normal Lactation Curve of a Dairy Cow
Figure 10-6 The neurohormonal reflex of milk ejection. Stimulus (A) that a cow associates with milking causes a nerve impulse (B) to travel via the inguinal nerve (1) to the spinal cord (2) and the brain (3). The brain causes the release of oxytocin (D) from the posterior pituitary (C). Oxytocin is released into a branch of the jugular vein (4) and travels to the heart (5) and is then transported to all parts of the body by the arterial blood. The oxytocin reaching the udder leaves the heart by the aorta (6) and enters the udder through the external pudic arteries (7). In the udder, it causes the myoepithelial cells to contract, resulting in milk ejection from the alveoli.