Anatomy and Lactation Physiology

Sources:
- Dairy Cattle Science; Tyelr and Ensminger
- https://nydairyadmin.cce.cornell.edu/uploads/doc_113.pdf
- www.rosholt.k12.wi.us/faculty/ticichon/Mammary%20Udder.ppt

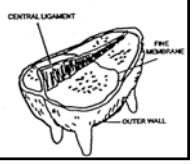
Mammary Gland (Udder)

- 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

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

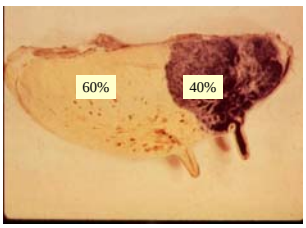
(each bearing a principle teat)



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

Separate Mammary Glands (Quarters)

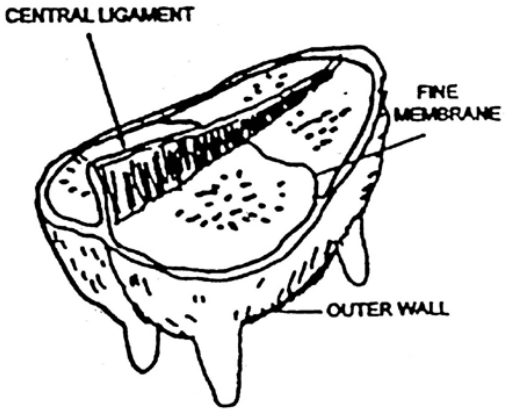


Teats

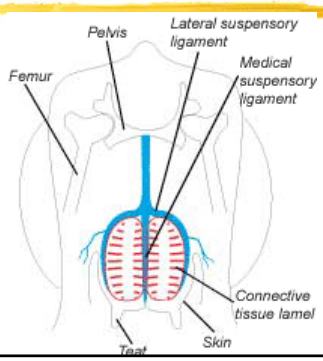
- Usually one teat per quarter
  - Supernumeries (~50%)
    - Nonfunctional and functional
    - 92% caudal, 5% between, 3% cranial
    - Removed when 1-2 years of age
- No hair, sweat or sebacious glands
- 2.5 inches

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

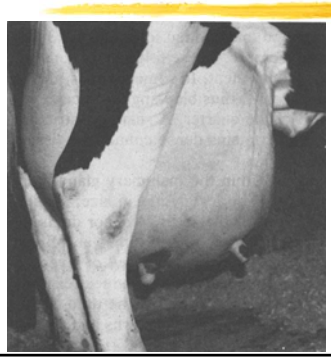


Udder Suspension



Median Suspensory Ligament

Compass Cow



Decreased

- Productivity
- Health
- Longevity

Udder Edema

Related to:

- Pre-partum management
- Nutritional management

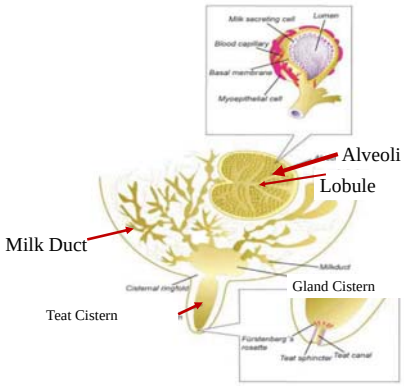
Affects:

- Udder health
- Production

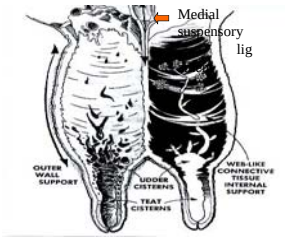
Interior of the Udder

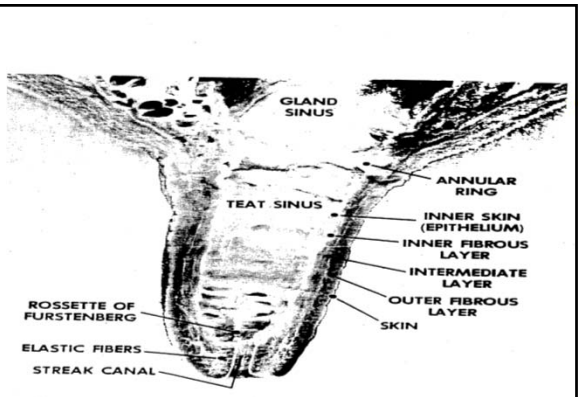
- Gland cistern
  - 100-400 ml. milk storage
  - duct systems drains into
  - used to detect end of milking
- Duct system
  - drains secretory tissue
  - no secretory function
- Alveoli
  - milk producing units
  - secretory cells, myoepithelial cells and capillaries, duct
- Lobules
  - 150-200 alveoli, common duct
- Lobes
  - group of lobules

Diagram of Duct System



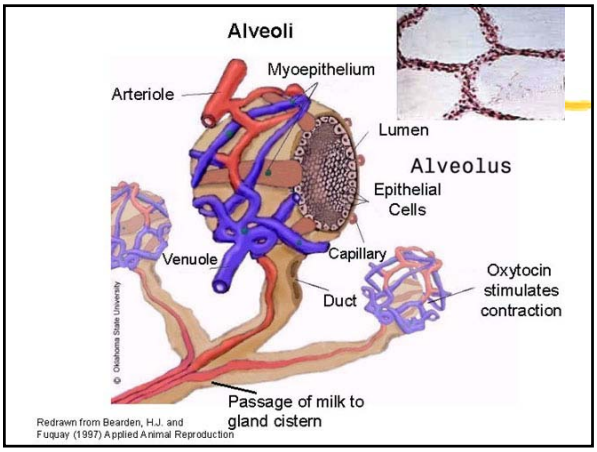
Duct System

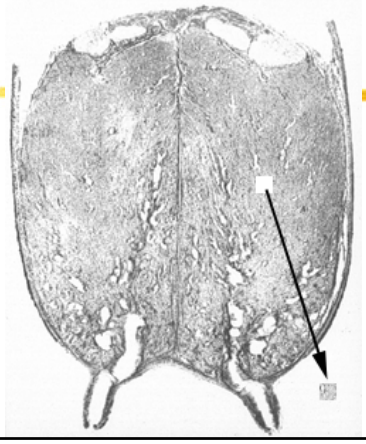




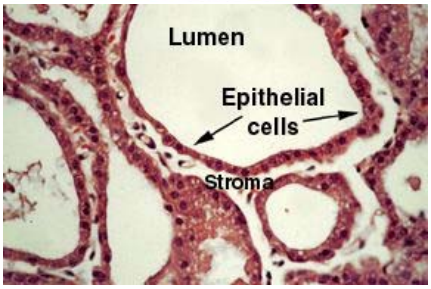
Alveolar structure

- **Alveolar components & function:**
  - ***epithelial cells*** - milk synthesis & secretion
  - ***lumen*** - collect milk components & water
  - ***myoepithelial cells*** - milk ejection
  - ***basement membrane*** - selective transfer
  - ***terminal duct*** - milk transport out of alveoli
  - ***capillary system*** - supply milk precursors and deliver hormones

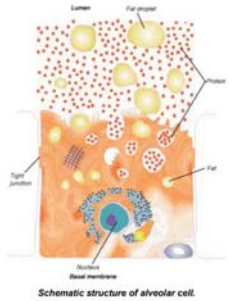




Alveolus



Mammary Epithelial Cell Structure



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

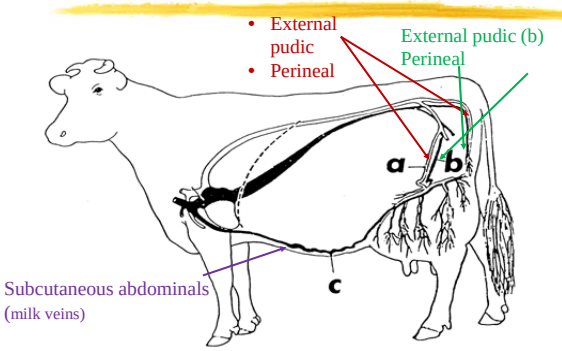
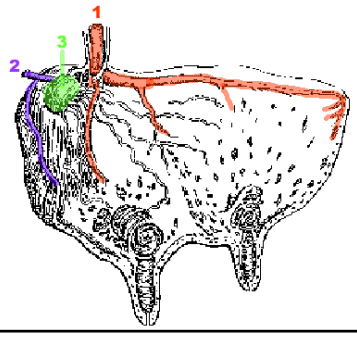
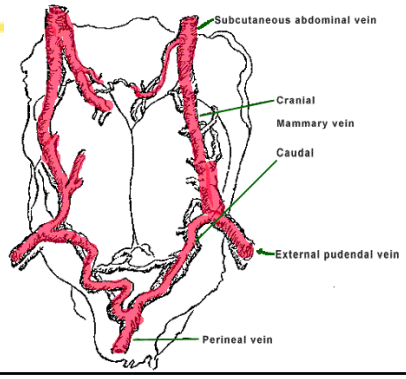


Diagram of Arteries and Lymphatics



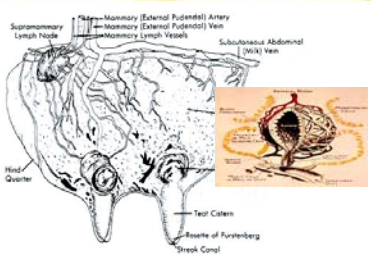
Venous Circle



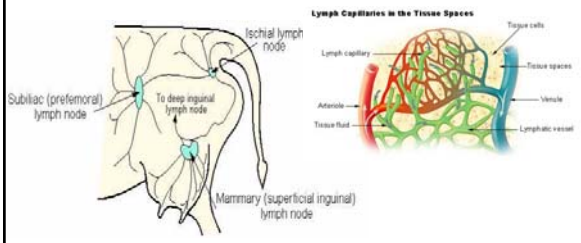
Lymph System

- 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 dusts drain the fore udder
- Supramammary Lymph Nodes
  - Located in the rear udder

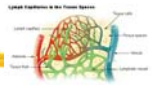
Mammary Vessels



Lymphatic Drainage



Udder Edema



- **Causes:**
  - **increased mammary blood flow; increased hydrostatic pressure ("snowball effect")**
    - **increased capillary permeability**
    - **serum & protein leakage into tissue spaces**
    - **protein leakage causes even greater fluid leakage**
    - **fluid accumulation causes tissue inflammation**
    - **inflammation obstructs lymph vessels; inability to remove fluid fast enough**

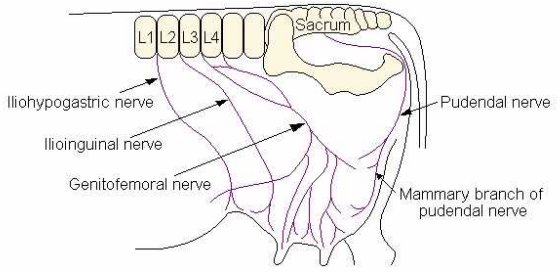
Udder Edema cont'd

- **Signs of udder edema:**
  - **hard, swollen teats and tissue ("caking")**
  - **shortened teats**
  - **redness, pain, behavioral discomfort**

Udder Edema cont'd

- **Consequences:**
  - **milking difficult; teat injury, improper milkout**
  - **weakening of supporting ligament**
  - **critical buildup of intramammary pressure; decline in milk secretion rate**

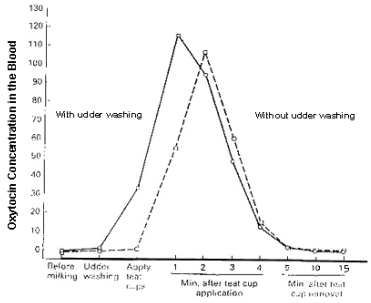
Innervation of the Mammary Gland



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
- Adrenaline blocks letdown by:
  - Decreasing mammary blood flow
  - Reducing myoepithelial response
  - Reducing oxytocin release

Oxytocin Release



Important Terminology

1. **Mammogenesis**
   - **Mammary gland development and growth**
2. **Lactogenesis**
   - **Milk synthesis and secretion**
3. **Galactopoesis**
   - **Enhancement of established lactation**

Steroid Hormones and Mammogenesis

- **Estrogens (E2) (follicle, placenta)**
  - **stimulate mammary duct growth; prolactin release**
  - **Synergizes with progesterone & prolactin to stimulate protein synthesis and duct growth (combined effect is greater than separate)**

Steroid Hormones and Mammogenesis

Progesterone (P4) (corpus luteum, placenta)

- stimulates lobulo-alveolar growth; synergizes with estrogen and prolactin
- P4 + PRL stimulates aa incorporation into protein
- retards milk synthesis
  - retards synthesis of enzymes (α-lactoalbumin) necessary for lactogenesis in the prepartum mammary gland

Lactogenesis

Anterior Pituitary :

Prolactin (PRL)

- Mammary growth
- Initiation and maintenance of lactation
- mammary cell protein synthesis

Lactogenesis

Adrenal Cortex:

Cortisol

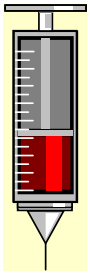
- synergizes with PRL (ant. pit) to enhance protein synthesis in mammary cells
- increase RER, increase mRNA
- increase protein transcription/translation
- increase casein/ α-lactoalbumin/lactose synthesis

⌘ **Cortisol is permissive to action of PRL**

Endocrine Support of Established Lactation

Galactopoesis:

- enhancement of established lactation
  - direct effect on mammary tissue ??
  - indirect effect on metabolism affecting supply of precursors for milk synthesis



Galactopoesis

Exogenous anterior pituitary hormones:

- PRL: no galactopoetic effect in cattle
- ACTH: suppresses milk yield in cattle
- TSH: increases milk yield (short acting); increases T3,T4, PRL & GH

Galactopoesis

Thyroid hormones (galactopoetic)

- thyroxin (injected; short acting)
- thyroprotein (iodinated casein; fed)
  - early lactation > increases yield 10%
  - late lactation > increases yield 15 - 20%

Galactopoesis

- **Thyroprotein**
  - **catabolic action:**
    - **increases BMR; heart rate, respiration rate**
    - **increases blood glucose (gluconeogenic)**
    - **increases mammary uptake of glucose & FA**
  - **generally little economic advantage**
    - **increases weight loss**
    - **milk declines rapidly after removal**

Endocrine Glands Supporting Mammary Function

Posterior pituitary (protein hormones):

Oxytocin

- **synthesized in the hypothalamus → transferred to post. pit.**
- **secreted into blood → acts on myoepithelial cells**
- **contraction of myoepithelial, smooth muscle**