Physiology of Lactation

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Learning Objectives

Physiology of Lactation
- Define the stages of breast development during pregnancy and lactation
- Describe the roles of hormones in the processes of mammary development during pregnancy and lactation
- Describe the roles of prolactin and oxytocin in lactation and milk ejection.
- Describe mechanisms and the reflex pathways for the control of prolactin and oxytocin secretion
- Discuss the roles of autocrine factor in maintenance of lactation

Breast Milk
- Identify the compositions of breast milk
- Compare and contrast merocrine and apocrine secretory mechanisms
Suggested readings


- [http://biomarkersandmilk.blogspot.com/2013_02_01_archive.html](http://biomarkersandmilk.blogspot.com/2013_02_01_archive.html)
Development of mammary glands

- Embryonic morphogenesis
- Pubertal growth
- Pregnancy-induced growth
- Terminal differentiation during lactation
The physiological basis of lactation

Four phases:

- Mammogenesis – further growth of the breast
- Lactogenesis – the initiation of milk synthesis and secretion from breast alveoli
  - Lactogenesis stage I
  - Lactogenesis stage II
- Galactokinesis – ejection of milk
- Galactopoiesis – maintenance of lactation

adapted from Riordan and Auerbach, 1998
Hormones involve in the processes of mammary development during pregnancy and lactation.
Mammogenesis

Change during pregnancy

- Proliferation of the distal elements of the ductal tree, creating multiple alveoli
- Breast enlarge to twice their normal weight
- Increase in mammary blood flow
- The areola of the nipples pigmentation and diameter increases
- The Montgomery’s glands enlarge
- By the 16th week (2nd trimester) the breasts begin to produce colostrum
Lactogenesis

Stage I (16-22 wks of gestation)

- Characterized by the differentiation of resting mammary cells into lactocytes, with the potential to secrete the unique fats, carbohydrates, and proteins characteristic of milk.

- High levels of progesterone have a **negative (inhibitory)** effect on lactogenesis. It may hold lactogenesis in check until just prior to parturition.
Lactogenesis

Stage 2 (30-40 hrs. after birth to day 8): the onset of copious milk secretion

- The presence of PRL levels stimulates the onset of copious milk production and secretion.
- The breasts will begin to produce milk independent of infant suckling.
- Breasts are full with milk. Endocrine control switches to autocrine (supply/demand) control.
Galactokinesis

- Discharge of milk from the mammary glands depends not only on the suction exerted by the baby during suckling but also on the contractile mechanism which expresses the milk from the alveoli into the ducts.

- Under a combination of endocrine and autocrine (local) control.
During sucking, a neuroendocrine reflex is set up:

- Mechanoreceptors in nipple and areola
- Ascending sensory (4, 5, and 6) afferent neural arc
- PVN & SON of hypothalamus
- Oxytocin from posterior pituitary
- Contraction of myoepithelial cells (milk ejection or milk letdown reflex)

Milk is forced down into the ampulla of lactiferous ducts, wherefrom it can be sucked by the baby.
Galactopoiesis

- The production and maintenance of mature milk from day 9 postpartum until Mom and baby decide to wean.
- Controlled by the autocrine system, but hormones do still play a role.
- Prolactin is the most important galactopoietic hormone
- Continuous sucking is essential for removal of milk from glands, also release Prolactin
- The more milk that is removed from the breasts, the more milk will be produced. Milk production relies on the supply and demand principal.

Involution (average 40 days after last breastfeeding):
Milk secretion decreases from the buildup of inhibiting peptides.
FULL BREAST = SLOWER MILK PRODUCTION
Milk synthesis stops when the breast is full

1. FULL BREAST
2. ALVEOLI SECRETING LIPID DROPLETS
3. PROLACTIN CANNOT FIT STRETCHED RECEPTOR

EMPTY BREAST = FASTER MILK PRODUCTION
Milk synthesis begins when the breast is empty

4. EMPTY BREAST
5. ALVEOLI OF DUCTS
6. PROLACTIN ATTACHES TO RECEPTOR
The roles of autocrine factor in maintenance of lactation

Galactopoietic hormone receptor:
- Basolateral membrane
- Stimulate synthesis and secretion of milk

Local autocrine factors:
- Luminal surface of alveoli
- Inhibit milk secretion
Lactation period

Conception

Progestosterone

Birth

PRL

16-22 weeks

30-40 hrs After birth

3 month

Mamogenesis

LI Endocrine (hormonal) control

LII Galactopoiesis Autocrine (local) control

LI

LI

Progestosterone
Neuroendocrine reflex control of PRL and oxytocin secretion during lactation
The Breast Milk

The compositions change during lactation

- Colostrum
- Transitional milk
- Mature
  - Foremilk
  - Hind-milk
Colostrum

- The first 2-4 days postpartum
- Yellowish milk due to its high b-carotene content
- High concentration of proteins (lactoferrin)
- Low levels of lactose and fats
- The volume is approximately 100 cc in a 24-hour period.
**Colostrum**

<table>
<thead>
<tr>
<th>Property</th>
<th>Importance</th>
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</thead>
<tbody>
<tr>
<td>Antibody-rich</td>
<td>Protects against infection and allergy</td>
</tr>
<tr>
<td>Many white blood cells</td>
<td>Protects against infection</td>
</tr>
<tr>
<td>Purgative</td>
<td>Clears meconium; helps prevent jaundice</td>
</tr>
<tr>
<td>Growth factors</td>
<td>Helps intestine mature; prevents allergy, intolerance</td>
</tr>
<tr>
<td>Vitamin A-rich</td>
<td>Reduces severity of some infection (such as measles and diarrhea); prevents vitamin A-related eye diseases</td>
</tr>
</tbody>
</table>
Transitional milk

- Is secreted between about 4 to 10 days postpartum.
- It is intermediate in composition in between colostrum and mature milk. The volume increases during this time.
Mature milk

- After days 10 postpartum
- Foremilk:
  - milk secreted at the start of breastfeeding
  - watery, rich in protein, sugar, vitamins and minerals.
  - necessary to satisfy baby's thirst.
- Hind-milk:
  - comes later towards end of feed.
  - Provides the highest fat and more calories
  - important for baby to feel satisfied and to gain adequate weight.
The secretory mechanisms of milk components

I - merocrine: Lactose, proteins
II- apocrine: fat
III- apical transport: ions
IV- transcytosis: Ig, hormones
V- paracellular: materials

MFG = milk fat globule; TJ= tight junction; GJ= gap junction;
D= desmosome; SV=secretory vesicle; ME= myoepithelium
References

- [http://www.breastfeedingbasics.org/cgibin/deliver.cgi/content/Anatomy/index.html](http://www.breastfeedingbasics.org/cgibin/deliver.cgi/content/Anatomy/index.html)
- [http://mammary.nih.gov/reviews/lactation/Hartmann001/index.html](http://mammary.nih.gov/reviews/lactation/Hartmann001/index.html)
Reading Assignment “Menopause”

- What is menopause?

- Executive summary of the Stages of Reproductive Aging Workshop + 10: addressing the unfinished agenda of staging reproductive aging. Sioba´n D. Harlow, PhD,1 Margery Gass, MD, NCMP,2 et al for the STRAW + 10 Collaborative Group. Menopause, April 2012 Vol. 19, No. 4

The journal of the North American Menopause Society