CHAPTER 5

# Science of Lactation

## In This Chapter



## Breast Anatomy

### *External Features*

- Skin layers
  - The dermis (inner layer) contains nerve endings, capillaries, hair follicles, lymph channels, and other cells.
  - The epidermis (outer layer) contains epithelial cells that cover and protect deeper skin layers from drying out and from invasion by bacteria.
  - The germinating layer (transitional layer) contains basal cells that continually divide. New cells constantly push older ones up toward the surface of the skin.
  - Keratin (the surface layer) contains tough, protective protein. It is dead skin.
- Nipple
  - There are an average of 5 to 9 nipple duct openings.
    - Smooth muscle fibers function as a closing mechanism for the milk ducts.
    - Sensory nerve endings in the nipple trigger milk release when the baby suckles.

- An inverted nipple appears inverted or inverts when stimulated.
  - It will respond to correction during the last trimester of pregnancy.
  - Nipple stimulation should be avoided when there is increased risk for preterm labor.
  - Inversion is usually not a problem if the areola is pliable enough for the baby to grasp a large portion.
- Areola
  - The areola enlarges and becomes darker during puberty, menstruation, and pregnancy.
  - The baby's mouth needs to enclose a large portion to compress sufficient breast tissue.
- Montgomery glands (Montgomery's tubercles)
  - Sebaceous glands are located around the areola and are pimply in appearance.
  - They secrete an oily substance to lubricate and protect the nipple.
  - They are rudimentary mammary glands and may secrete a small amount of milk.

## *Internal Features*

- Connective tissues support the breast, and subcutaneous fatty tissues give it shape.
  - Fibrous bands (Cooper's ligaments) support the breast.
  - Fibrous tissue holds the breast together and supports the ducts as they fill with milk.
- Nerves trigger milk synthesis and release.
  - Sensory fibers innervate smooth muscle in the nipple and blood vessels from the fourth, fifth, and sixth intercostal nerves.
  - The nipple and areola are composed of autonomic and sensory nerves.
  - The epidermis of the nipple and areola has few nerves.
  - The dermis is highly innervated and responsive to suckling stimulation.
- Blood and lymph systems
  - The bloodstream transports proteins, fats, carbohydrates, and other substances to the cells for milk production.
  - The lymphatic system absorbs excess blood fluids and returns them to the heart.

- Lymph nodes filter and trap bacteria and cast-off cell parts.
- Swelling of a lymph node in the armpit could suggest an infection in the breast, arm, or hand.
- Engorgement decreases the flow of blood and lymph, increasing the risk of local infection.

- Fatty tissue
  - There is very little fat immediately beneath the areola and nipple.
  - Fatty tissue does not contribute to milk synthesis or transport.
  - Larger breasts may have a larger storage capacity, though size is not a predictor of milk production.

- Glandular tissue is the functional part of the breast that produces and transports milk.
  - Milk production takes place in tiny individual glands called alveoli or acini.
    - Alveoli consist of epithelial cells (lactocytes) encased by myoepithelial cells and are clustered together to form lobuli.
    - Capillaries surrounding the alveoli bring nutrient-rich blood to make milk.
    - Release of oxytocin and prolactin signals myoepithelial cells to contract the alveoli to release and produce more milk.
    - The normal lactating breast is lumpy due to enlarged milk-filled alveoli.
    - Alveoli multiply and increase in size during pregnancy and lactation, then decrease in size and number when breastfeeding ends.
  - The Tail of Spence is breast tissue that extends into the axilla.

- Milk-transporting tissue (see **Figure 5-1**)
  - Milk flows through a system of lactiferous ductules, secondary ducts, and nipple pores.
  - Ducts grow lengthwise as alveoli and lobuli develop.
  - Sprouting and growth of ducts and alveolar development intensify during the first 4 to 5 months of pregnancy.
  - Duct and alveolar tissues become more specialized in the second half of pregnancy in preparation for milk-related functions.
  - Ducts widen throughout the breast and in the area beneath the areola during passage of milk.
  - Milk beneath the areola that is not removed flows backward into the breast.
  - Milk ducts, once labeled as "lactiferous sinuses," have been shown to be ducts that transiently fill and drain, not sinuses.

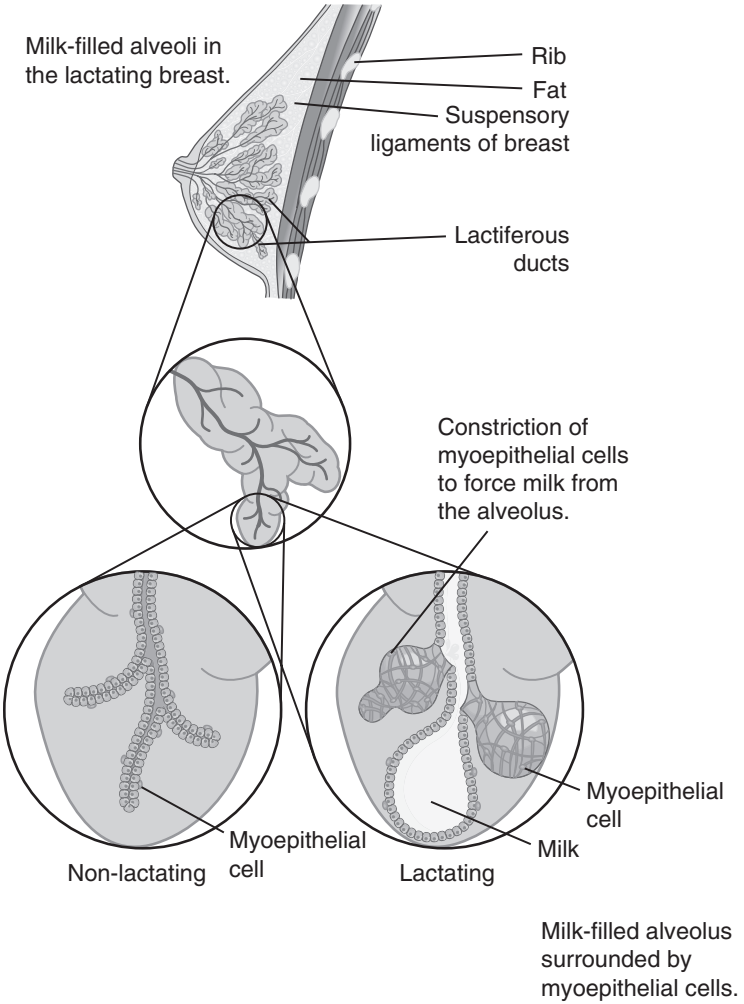


**Figure 5-1** Anatomy of the Breast.

## *Breast Anomalies*

- Differences in physical features
  - A galactocele is a cyst caused by obstruction of one or more mammary ducts. It may resolve spontaneously or it can be compressed, aspirated, or removed surgically.
  - An intraductal papilloma is a small benign growth in a milk duct that produces a bloody discharge.
  - Paget's disease is a cancerous condition that produces scaly, itchy nipples and areolas and sometimes a bloody discharge.
  - Hypoplasia is widely spaced, tubular and thin breasts, a marker for insufficient glandular tissue.
- Signs of possible glandular insufficiency
  - There is no noticeable change in breast size during pregnancy or lactation.
  - Breasts are scant with little tissue or development.
  - One breast is appreciably smaller than the other breast.
  - There is a family history of lactation failure.
  - Milk production is inadequate despite appropriate feeding practices.
  - Ductal atresia (lack of a milk duct opening) prevents milk secretion from that duct.
- Evidence of surgery
  - The presence of functional tissue depends on the type of breast surgery.
    - Breast augmentation may damage nerves but usually does not destroy functional tissue.
    - Breast reduction is more intrusive and often affects lactation.
    - Resection of the nipple severs all ducts and may prevent full milk production.
    - The pedicle technique transposes the nipple, areola, and ducts.
    - Breastfeeding may be possible if the nerve supply to the breast remains intact.
    - Breast, chest, back, or cardiac surgery can affect blood flow and innervation to the nipple.
  - Breastfeeding can be attempted with careful monitoring of the baby's output and weight.
  - Milk production may respond to galactogogues, external oxytocin, or increased nipple stimulation.
  - This situation requires early and frequent follow-up for evaluation of feeding effectiveness and infant growth.

## Breast Physiology

### *Breast Development and Milk Synthesis*

- Puberty and pregnancy are the times of most functional breast tissue development.
  - Increased estrogen during menstruation produces the growth of ducts and connective tissue.
  - In the absence of pregnancy, tissue growth regresses and glandular cells degenerate.
  - Breast development is far more significant during pregnancy than during menstruation.
- Mammogenesis occurs during the first trimester of pregnancy.
  - The duct system multiplies and the skin stretches to accommodate internal enlargement.
  - The nipple and areola increase in circumference.
  - The areola darkens and the Montgomery glands become noticeable.
- Colostrum production begins during the second trimester.
- Stage I lactogenesis occurs during the third trimester.
  - The breast begins to gather the nutrients needed for milk synthesis.
  - Lactose, total proteins, and immunoglobulins increase.
  - Sodium and chloride decrease.
- Stage II lactogenesis occurs at around day 2 to 5 postpartum.
  - Blood flow within the breast increases.
  - Transitional milk production and copious milk secretion begin.
- Stage III lactogenesis (galactopoiesis) occurs at around day 8 to 10 postpartum.
  - Establishment and maintenance of mature milk occurs.
  - Milk production continues until weaning.
- Involution occurs after weaning, and the breast slowly returns to its prepregnant state.

### *Hormonal Control*

- Several hormones are involved in milk production.
  - Estrogen stimulates growth of the uterus, vagina, and other reproductive organs.
  - Progesterone inhibits prolactin's effects during pregnancy.

- Prolactin stimulates alveolar growth and milk synthesis and induces maternal behavior.
- Unlimited, effective suckling during the night maintains high prolactin levels.
- Oxytocin releases in response to suckling and contracts the myoepithelial cells to eject milk.

- Hormones respond to the frequency and degree of breast drainage.
  - Frequent feeding increases prolactin levels by increasing prolactin receptors.
  - The prolactin inhibitory factor (PIF) prevents prolactin release when the baby is not suckling. Suckling inhibits the PIF to allow prolactin release.
  - Autocrine control through the human whey protein, feedback inhibitor of lactation (FIL), inhibits milk synthesis when milk remains in the breast.

## *Milk Ejection Reflex (Letdown)*

- Suckling stimulates nerve endings and sends a message to the hypothalamus.
  - The message goes to the anterior pituitary, lowers the PIF, and triggers prolactin release.
  - The posterior pituitary gland secretes oxytocin and contracts alveoli and uterus muscles.
  - The contraction forces milk down through the lactiferous duct system to the nipple.
- Letdown moves fat globules down through the ducts (hindmilk) to provide higher-calorie milk.
- Fatigue, anxiety, fear, pain, or weak stimulation from ineffective latch can inhibit letdown.
- Signs of letdown
  - Milk drips from one breast while the baby is nursing on the other breast.
  - There may be a feeling of fullness, tingling, or a burning sensation in the breasts.
  - Thirst or sleepiness may increase.
  - Uterine contractions may be felt in the early days postpartum.
  - The baby begins gulping or gagging from the sudden rush of milk.
  - There is more pronounced swallowing of milk.

## *Hormonal Anomalies*

- Pituitary, thyroid, and adrenal imbalances can affect milk production and release.
- Sheehan's syndrome (hypopituitarism) resulting from severe postpartum hemorrhage and hypotension can cause irreversible damage to milk-producing cells.

**Advice to Clinicians**

**Teach Parents**

- How to preserve the keratin layer and lubrication of skin on the nipple
- The baby needs to take in about a 1-inch diameter of areolar tissue
- The baby needs to grasp the breast well and suckle vigorously to stimulate the deeper nerves
- Breast size corresponds to fatty and glandular tissue and not to milk synthesis or transport
- Breast sagging is a result of pregnancy, not lactation
- Suckling signals more blood to provide the nutrients needed to make milk
- Engorgement decreases the flow of blood and lymph, causes edema, increases the risk of local infection, and leads to poor milk drainage
- Frequent feedings, effective positioning at the breast, and pumping in the absence of effective and frequent suckling will protect milk production

- Polycystic ovarian syndrome (Stein-Leventhal syndrome) is associated with insufficient milk production.
- A prolactinoma is not a reason to not breastfeed.
- Thyroid supplementation for hypothyroidism does not compromise the baby's health.

## Physiology of Milk Transfer

### *Sucking*

- The baby draws the breast into his mouth and maintains negative pressure to keep it there.
- Nonnutritive sucking has low flow with a light suck, almost a flutter.
  - There are short jaw excursions and little or no audible swallowing.
  - It elicits about two sucks per second.
  - It indicates the baby is trying to make milk available.
- Nutritive sucking has high flow with a long, deep suck–swallow–breathe pattern.
  - It elicits about one suck per second.
  - It is affected by central nervous system (CNS) depressants.
  - It indicates effective milk transfer.

## *Effects of Sucking*

- Effects on the baby
  - Sucking is a means of comfort and nourishment.
  - Sucking stimulates saliva, gastrointestinal secretions, hormones, and motility, helping the baby pass gas and stool.
  - Sucking releases the hormone cholecystokinin (CCK) to promote satiety and sleepiness.
  - A baby's need for sucking is usually greatest in the first 3 months.
- Effects on the breastfeeding parent
  - Prolactin release stimulates milk production and a yearning for the infant.
  - Oxytocin release causes cuddly and warm feelings, triggers milk to let down, and contracts the uterus.

## *Sucking Pattern*

- Sucking rhythm corresponds inversely to the amount of milk available.
  - Sucking alternates between nutritive and nonnutritive sucking throughout the feeding.
  - The baby adjusts the sucking rate to cope with letdown.
  - Sucking is rapid at the beginning of a feeding to initiate milk flow.
  - Sucking pace slows when letdown occurs and the baby swallows.
  - Rapid sucking resumes, stimulates further milk flow, and then slows as milk flows.
- Nutritive sucking has a regular rhythm of suck–swallow–breathe.
  - Swallowing cannot occur simultaneously with breathing.
  - The baby pauses between bursts of sucking and regulates breathing.
    - On days 2–3, when there is a small volume of colostrum, the baby sucks with several short, fast bursts per swallow.
    - On days 3–4, when transitional milk increases in volume, the baby establishes a regular rhythm.
    - On days 4–5, as milk flows following letdown, the baby swallows with every suck.
  - Preterm infants have fewer sucks per burst and longer pauses. They can coordinate suck–swallow–breathing as easily when breastfeeding as when bottle feeding.

## *Suckling*

- The baby suckles milk from the breast with tongue compression.
  - The baby's tongue draws the nipple and areola into his mouth.
  - A cone-shaped extension of the breast conforms to the shape of the baby's mouth.
  - The areola and nipple press upward progressively against the upper gum, hard palate, and soft palate.
  - The gums alternately compress and release as milk flows.
- Consequences of ineffective suckling
  - There is a risk of engorgement, plugged ducts, mastitis, and compromised milk production.
  - There is a risk of increased infant hunger, fussiness, or colic-like symptoms; low urine and stool output; jaundice; and inadequate weight gain or weight loss.
- Causes of disorganized suckling
  - Illness or prematurity
  - Drugs given to the infant or received through the milk
  - Delay in the first breastfeeding at birth
  - Neuromotor dysfunction
  - Variations in oral anatomy
  - Nipple preference due to artificial nipple use
  - Vigorous oral suctioning at birth
  - Birth trauma such as forceps, vacuum, or bruising

## *Milk Transfer*

- Milk transfer requires a functioning letdown, appropriate suckling, and an effective latch.
- The transfer process
  - The baby draws the end of the nipple back almost to the soft palate.
  - The front tip of the tongue wells up and the lower jaw rises.
  - The jaws compress the breast and pinch off milk in the lactiferous ducts.
  - The tongue pushes against the hard palate and compresses the lactiferous ducts.
  - When the baby's jaw opens, more milk is released from the breast.
  - Milk reaches the back of the baby's mouth and stimulates the baby to swallow.
  - The back of the tongue depresses to create negative pressure and maintain latch.

- Differences between milk transfer in breastfeeding and bottle feeding
  - The baby combines sucking and suckling in breastfeeding.
    - The baby's lips, gums, tongue, cheeks, and hard and soft palate mold the breast to the size and shape of the baby's mouth.
    - The baby actively suckles to receive milk.
  - The baby sucks in bottle feeding.
    - The baby draws in the nipple and must alter the shape of the mouth to accommodate the shape of the artificial nipple.
    - The baby must generate suction pressure so milk flows freely from the bottle.
    - To control flow, the baby may thrust his tongue against the nipple. This motion may transfer to breastfeeding and create problems.

## Human Milk

### *Properties of Human Milk*

- Colostrum is the first milk.
  - Residual materials in the breast mix with newly formed milk.
  - Colostrum is richer than mature milk in sodium, potassium, chloride, protein, fat-soluble vitamins, and minerals.
  - Colostrum contains less fat and lactose than mature milk.
  - Colostrum has high concentrations of IgA, IgG, and IgM (higher than mature milk).
  - Colostrum engulfs and digests disease organisms and aids in rapid gut closure.
- Fat content varies among individuals and from feeding to feeding.
  - Fat is inversely proportional to the time between feedings and the degree of breast fullness.
  - Fat may be up to 4 to 5 times higher at the end of a feeding.
  - Fat decreases in the later months of lactation.
  - Long-chain polyunsaturated fatty acids promote optimal neural and visual development.
- Composition and volume are variable.
  - Transition from colostrum to mature milk is driven by gene expression.
  - The ratio of whey (clear fluid) to casein (curd) in milk is 90:10 in colostrum, 60:40 in early milk, and 50:50 in late lactation.
  - Milk is high in immunoglobulins and protein during the first several weeks.
  - Volume is dependent on regular removal of milk.

- Human milk can provide 75% of nutrient needs from about 8 months through 12 months of age.
- Daily output during the second year is typically about 8 ounces.

- Carbohydrates
  - The enzyme amylase is important for carbohydrate digestion.
  - Lactose is the most constant of all the constituents in human milk.
    - It enhances calcium absorption and prevents rickets.
    - It supplies energy to the brain and is essential to central nervous system development.
    - It protects the intestine from the growth of harmful organisms.
- Digestive properties that protect the infant
  - The curd (casein) is soft, small, less compact and easier to digest than artificial baby milk.
  - Oligosaccharides prevent pathogens from binding to receptor sites in the gut.
  - IgA protects the GI tract and is the most important of the antiviral defense factors.
  - Bifidus factor works with the pH of the stool to discourage the growth of *E. coli*.
  - Lactoferrin inhibits the growth of *E. coli*; its effects decrease if saturated with exogenous iron.
  - Lysozyme breaks down bacteria in the bowel and protects against Enterobacteriaceae and gram-positive bacteria.
  - Alpha-lactalbumin inhibits bacteria and yeast growth.
  - Xantine oxidase combined with nitrites inhibits *E. coli* and *Salmonella enteritidis*.
  - Nucleotides promote optimal function and growth of the GI and immune systems.
- Growth factors
  - Lactase converts lactose into simple sugars that the infant can absorb and protects babies born with immature or defective enzyme systems.
  - A deficiency in lactase can result in lactose intolerance.
  - Suckling triggers CCK and causes sleepiness in breastfeeding parents and babies.
  - Thyroid hormones prevent hypothyroidism, mask diagnosis, and protect the baby until weaning.
  - Cytokines are thought to stimulate gut maturation.
  - Lipase helps digest fat and make it available to the baby as energy.
  - Epidermal growth factor promotes growth and healing of gut mucosa.
  - Leptin, ghrelin, and other peptide hormones, including resistin, obestatin, and adiponectin, play a key role in appetite.
  - Adiponectin signals proteins secreted by fat tissue.
  - Resistin aids in metabolic growth.

- Other properties
  - High levels of antibodies protect the lining of the infant's intestine from absorption and enhance infant antibody response.
  - Protein is relatively constant regardless of diet.
  - All vitamins are sufficient, with sun exposure for additional vitamin D.
  - In the absence of anemia during pregnancy, sufficient iron stores are laid down to sustain the infant for about the first 6 months.
  - Mucins protect against bacterial infections.
- Properties of milk with preterm birth
  - The milk is higher in sodium, chloride, nitrogen, and immunoprotective factors.
  - Human milk fortifiers (HMF)—protein, calcium, potassium phosphate, carbohydrates, vitamins and trace minerals—are used to supplement infants with very low birth weights.
  - Lactoengineering offers an alternative to cow's milk–based HMF by concentrating human milk components to provide 100% fortification from human milk.
  - Manufacturers now provide these human milk–based fortifiers commercially by isolating hindmilk to increase calories, carbohydrates, and proteins for preterm infants.

## *Health Benefits of Human Milk*

- The child has fewer dental caries and better dental health.
- Benefits are dose-dependent in increasing IQ.
- The child receives lifelong protection against upper and lower respiratory infections, otitis media, diarrheal disease, urinary tract infections, sepsis, rotavirus, meningitis, leukemia, lymphoma, Hodgkin's disease, and neuroblastoma.
- There is a lower risk of necrotizing enterocolitis (NEC), asthma, breast cancer, chronic and autoimmune diseases, hypertension, high cholesterol, and heart disease.
- Bacteria are destroyed in the GI tract before they affect the infant.
- Antibodies are produced to fight against organisms that pass into the breast from the suckling infant.
- Antigens to a cold, fever, or more serious illness protect the breastfed baby.

## *Storage and Use of Expressed Milk*

- Collection and storage guidelines (see **Figure 5-2**):
  - Glass or hard plastic are preferred for storage; soft plastic reduces antibodies in milk.
  - Store in amounts the baby will consume, leaving room for expansion.

**Storage Recommendations**

| Temperature | Healthy baby | Baby in the NICU |
|---|---|---|
| Room temperature | Up to 6 hours | Up to 1 hour |
| Insulated cooler with gel paks | Up to 24 hours | Up to 24 hours |
| Refrigerator | Up to 8 days | Up to 8 days |
| Refrigerator freezer | Up to 6 months | Up to 3 months |
| Deep freezer | Up to 12 months | Up to 6 months |

**Figure 5-2** Storage Recommendations. Human Milk Banking Association of North America, 2011.

- Label and use the oldest milk first.
- Chill newly pumped milk before adding it to refrigerated or frozen milk.
- Freeze milk if it will not be used within 3 to 8 days.
- Frozen milk with a bad odor may be due to lipase levels; warm the milk to scalding and immediately freeze to prevent this.

- Defrosting and warming milk
  - Thawed milk may remain refrigerated for up to 24 hours before use.
  - Place frozen milk in a refrigerator overnight for a slow thaw.
  - Thaw frozen milk rapidly in a pan of warm water or under a stream of warm tap water.
  - Do not use a microwave oven to warm milk.
  - Milk that has been warmed must be used immediately and only for that feeding.
  - Do not refreeze milk.

- Guidelines for the neonatal intensive care unit (NICU)
  - Express milk just before feeding it to the baby.
  - If the baby will not receive the milk within 1 hour, refrigerate it immediately.
  - Place the milk from each pumping session in a separate container to minimize handling.
  - Talk with the NICU staff regarding how much to store for feedings to avoid waste.

## *Safety of Human Milk*

- Medications
  - Most medications are compatible with breastfeeding.
  - In general, a relative infant dose of less than 10% is considered safe.

- Use drug information from well-documented sources.
- Become acquainted with drug groups and their risks and benefits.
- Questions to ask about a particular medication
  - Will it pass into the milk and be absorbed in the baby's GI tract?
  - Can the baby safely be exposed to the substance as it appears in the milk?
  - How soon after birth will it be taken?
  - What is the baby's gestational age?
  - How resistant is it to detoxification?
- How to minimize the effects of a medication
  - Take medication timed to minimize its peak in blood plasma.
  - Avoid nursing when it is at its peak level in the milk.
  - Avoid drugs with a long half-life.
  - Select the least risky drug.

- Social toxicants
  - Newborn and preterm babies are susceptible to caffeine because it takes time to eliminate.
  - Generally, an occasional drink socially is not a problem.
  - Breastfeeding is safe after the effects of alcohol have worn off.
  - Smoking should be reduced or eliminated, as toxins transfer to the infant and may increase irritability and the risk of SIDS. If smoking continues, it should occur outside and after breastfeeding.

### Advice to Clinicians

#### Teach Parents

- Consider alternatives that do not involve medication or substitute a safer medication.
- Weigh benefits of a medication against possible risk to the baby.
- Weigh the risk of a medication to the baby against the risk of artificial baby milk.
- Avoid nicotine and tobacco or time breastfeeding to minimize exposure in the milk.
- Avoid excessive alcohol consumption.
- Avoid all drugs of abuse.
- Avoid occupations, hobbies, and clothes that involve possible exposure to chemicals.
- Avoid eating shark, swordfish, king mackerel, and tilefish.
- Limit consumption of canned albacore tuna and other fish.
- Avoid eating organ meats.
- Wash or peel fresh fruits and vegetables.

- Environmental contaminants
  - Silicone breast implants have not been proven dangerous in breastfeeding.
  - Toxins are primarily deposited in fat and are excreted in the milk.
  - Flame-retardant chemicals affect learning, memory, behavior, thyroid hormones, and other bodily functions.
  - PCBs affect mental development.
  - DDE reduces protection against atopic disorders such as asthma, eczema, and hay fever.
  - Environmental contaminants are present in all artificial milks. The contaminant risk is higher with artificial milk than with human milk.

## Artificial Baby Milk (ABM)

### *Inferior to Human Milk*

- Each brand is only slightly different, yet all are intended to meet universal needs of infants.
- They are deficient in many constituents essential for optimum infant growth and health.
- Some have excessive or deficient amounts of micronutrients or macronutrients.
- Some completely lack essential elements.
- Some have lower levels of nervonic acid (NA)
- Some have excessive vitamin D, which is toxic in high doses.
- Some completely lack or are deficient in essential elements, such as chloride.
- Addition of synthetic long-chain polyunsaturated acids such as docosapentaenoic (DPA) acid, DHA, and arachidonic acid fails to replicate human milk.

### *Potential for Contamination and Errors*

- Contamination with aluminum, arsenic, or bacteria
- Deliberate dilution with melamine, flour, or other fraudulent components
- Inadequate thiamin (causing brain damage) and iron
- Potential botulism contamination
- Contamination with insect parts, metal particles, or plastic
- Mixed with contaminated water
- Mixing errors by parents or caregivers
- Bacteria growth when left at room temperature for too long

### *Increased Health Risk to Babies*

- Infants are at increased risk of late neonatal hypocalcemia and dehydration.
- Rates of allergy can increase after a single feeding in the first days of life.

**Legitimate Need for a Baby to Receive ABM**

- Conditions in the breastfeeding parent
  - Sheehan's syndrome
  - Long-term drug therapy
  - Severe congestive heart failure
  - Insufficient milk production
  - Tuberculosis (until after treatment)
  - HIV
  - Active herpes lesion on the breast
  - Eclampsia
  - Cytotoxic, radioactive, or some antithyroid drugs
- Conditions in the baby
  - Galactosemia
  - Hypoglycemia or dehydration, if unimproved by increased breastfeeding or by expressed or donor milk
  - Jaundice, if sufficient expressed or donor milk is unavailable
  - Prematurity if no human milk is available—use of human milk fortifier with VLBW (very low birth weight) babies is not replacing human milk
  - PKU (breastfeeding is still possible with phenylalanine-free formula supplementation and monitoring of PKU levels)

- Cow's milk protein is the most common food allergen in infants.
- Cow's milk allergy can occur as early as 1 week after introduction of ABM.
- Infants have a higher incidence of atopic dermatitis and eczema.
- Soy formula can change menstrual patterns and cause neurological deficits and renal problems.

## Maternal Nutrition

### *Basic Nutrients*

- Carbohydrates are the main source of energy for all body functions and activity.
  - Simple carbohydrates include sugar, jams, honey, chocolate, and other sweets.
  - Complex carbohydrates include starches such as cereals, rice, breads, crackers, pasta, vegetables, and fruits.

- Proteins are the major source of building material for internal organs, muscles, blood, skin, hair, and nails.
  - Proteins consist of 22 building blocks (amino acids). The diet must supply 8 essential amino acids.
  - Complete protein foods (most meats and dairy products) contain all the essential amino acids.
  - Incomplete protein foods (most vegetables or plants such as beans and grains) are lacking or extremely low in an essential amino acid.
- Fats are the most concentrated source of energy in the diet.
  - Fats are carriers for fat-soluble vitamins A, D, E, and K.
  - Prolonged digestion creates a longer-lasting sensation of fullness.
  - Fatty acids give fats their different flavors, textures, and melting points.
  - Saturated fatty acids are derived from animal sources such as meat, milk products, and eggs.
  - Unsaturated fatty acids are derived from vegetable, nut, and seed sources.
  - A healthy diet should contain a greater amount of unsaturated fats than saturated fats.
  - A diet low in fat is usually not appropriate during pregnancy and lactation.
- Vitamins convert fat and carbohydrates into energy and help to form bone and tissues.
  - The diet must provide necessary vitamins.
  - Excess amounts of some vitamins, such as vitamin A, can be harmful.
  - High doses of vitamin $B_6$ (600 mg/day) were associated in older studies with milk supply reduction. These have not been replicated in recent years.
  - Water-soluble vitamins (Bs and C) need to be replenished daily; maternal intake can affect the amount for most of these vitamins in her milk.
  - Folic acid contributes to cell growth and reproduction and can be obtained from leafy green vegetables and whole grains.
  - Fat-soluble vitamins (A, D, E, and K) are stored in the body's fatty tissues.
    - Vitamin A contributes to skeletal growth and maintains mucous membranes and keen sight.
    - Human milk has sufficient vitamin D if maternal vitamin D levels are optimal.
      - The human body is intended to make vitamin D through sunlight exposure.
      - Vitamin D deficiency is sunlight deficiency due to restricted infant exposure.

- Vitamin K is essential for blood clotting; babies usually receive vitamin K by injection after birth.

- Minerals contribute to overall mental and physical well-being.
  - The diet must supply essential minerals.
    - Minerals help maintain physiological processes, strengthen skeletal structures, and preserve the vigor of the heart, the brain, and the muscle and nervous systems.
    - Minerals are important in hormone production.
    - Minerals help maintain water balance essential to mental and physical processes.
  - Calcium
    - Calcium gives bones their rigidity and teeth their hardness.
    - Calcium has a role in blood clotting and controlling action of the heart, muscles, and nerves.
    - Pregnancy and lactation require high amounts of calcium (see **Table 5-1** for sources of calcium).
  - Iron
    - Pregnancy requires sufficient iron. Iron supplements are not needed when pregnancy begins with good iron stores and a varied diet is consumed.
    - Heme iron comes from meat, poultry, and fish and is easily absorbed.
    - Nonheme iron comes from vegetables, iron-enriched cereals, and whole grains.
    - Excess calcium can reduce iron absorption.
  - Salt
    - Pregnancy requires more salt for the body to function well.
    - Salt usually causes the body to retain fluid in the bloodstream.
  - Water
    - Water is the most abundant and important nutrient in the body.
    - Additional water intake is needed during pregnancy and lactation.
    - Thirst should dictate water consumption.
    - Excessive water consumption has been shown in one study to reduce milk production.

**Table 5-1** Food Sources of Calcium

| Food | Calcium (mgs per serving) |
|---|---|
| Yogurt, plain (8 oz) | 415 |
| Cheddar cheese (2 oz) | 408 |
| Sardines, drained (3 oz) | 372 |
| American cheese (2 oz) | 348 |
| Yogurt, fruit-flavored (8 oz) | 345 |
| Milk, whole, low-fat, or skim (8 oz) | 300 |
| Watercress (1 cup chopped) | 189 |
| Chocolate pudding, instant (1/2 cup) | 187 |
| Collards (1/2 cup cooked) | 179 |
| Buttermilk pancakes (3–4 inches) | 174 |
| Pink salmon, canned (3 oz) | 167 |
| Tofu (4 oz) | 145 |
| Turnip greens (1/2 cup cooked) | 134 |
| Kale (1/2 cup cooked) | 103 |
| Shrimp, canned (3 oz) | 99 |
| Ice cream (1/2 cup) | 88 |
| Okra (1/2 cup cooked) | 74 |
| Rutabaga, mashed (1/2 cup cooked) | 71 |
| Broccoli (1/2 cup cooked) | 68 |
| Soybeans (1/2 cup cooked) | 66 |
| Cottage cheese (1/2 cup) | 63 |
| Bread, white or whole-wheat (2 slices) | 48 |

## *Nutrition Education*

- Teach parents about practical food choices rather than nutrients.
- Families are most receptive to nutrition education during pregnancy and lactation.
  - Sugary foods cause erratic blood sugar, fatigue, dizziness, nervousness, and headache.
  - Complex carbohydrates take longer to digest and prevent food cravings.
  - Fats create a longer feeling of fullness.
  - Food additives and processing alter nutritional quality favorably and unfavorably.
  - Vegetarian diets that include milk and eggs supply necessary nutrients.

- Nutrition in pregnancy
  - Body stores and the foods consumed provide energy and nutrients for the baby.
  - Pregnancy requires increased calcium, iron, and water intake.
  - Folic acid helps prevent anemia in pregnancy.
  - A newborn's vitamin K levels are low, and infants typically receive a vitamin K injection at birth.
  - Low levels of vitamin D in pregnancy result in low levels in the baby.
- Nutrition in lactation
  - A normal healthy diet will meet nutritional needs during lactation.
  - Protein is needed for hormone formation and milk production during lactation.
  - Lactation requires increased calcium, iron, and water intake.
  - Consuming excessive fluid has been associated with reduced milk production.
  - Lactation uses energy from body stores and from the diet.
  - When the parent is well nourished and healthy, it is safe to lose up to 1 pound per week.
  - Occasional alcohol timed around breastfeeding has not proven harmful to breastfed infants.
  - Wait 2 to 3 hours after each drink or until effects of the alcohol are no longer felt.
  - Infants sensitive to caffeine may experience fussiness or excessive wakefulness.
  - Most foods are acceptable unless they cause allergic reactions in one of the parents or are consumed in excessive amounts.

## Advice to Clinicians

### Teach Parents

- Strive for diet improvement of three well-balanced meals a day with snacks as needed.
- Eat small frequent meals, avoid fatty foods, and drink adequate fluids.
- Use USDA guidelines for meal planning.
- Balance complete protein and incomplete protein foods.
- Consume more unsaturated fats than saturated fats.
- Respond to thirst for necessary additional fluids.
- Protein and complex carbohydrates at breakfast will avoid later fatigue.
- Read food labels for nutritional information.
- A healthy diet helps overcome a fussy baby, recurring breast problems, infections or nipple soreness, depression, and lack of energy.

## Tutorial for Students and Interns

### *Key Clinical Management Strategies*

From *Clinical Guidelines for the Establishment of Exclusive Breastfeeding* (ILCA, 2014):

- Identify any contraindications to breastfeeding.
- Confirm that parents understand milk production and the importance of milk removal.

### *Key Clinical Competencies*

Data from *Clinical Competencies for the Practice of IBCLCs* (IBLCE, 2012):

- Perform a breast evaluation related to lactation.
- Instruct parents about how milk is produced and maintained, including discussion of growth and appetite spurts.
- Inform parents about assessment of adequate milk intake by the baby.
- Explain to parents about normal infant sucking patterns.
- Instruct parents about the importance of exclusive breastmilk feeds and possible consequences of mixed feedings with cow's milk or soy.
- Educate parents about drugs (such as nicotine, alcohol, caffeine, and illicit drugs) and folk remedies (such as herbal teas).
- Assist parents with medications compatible with breastfeeding.
- Help parents with lactose overload.
- Assist parents with safe formula preparation and feeding techniques.

### *From Theory to Practice*

#### *Breast Anatomy*

1. How would you respond to a concern about inverted nipples expressed during pregnancy and whether the baby may not be able to breastfeed? What anticipatory guidance can you provide regarding feedings?
2. What is the purpose of Montgomery glands?
3. Explain the correlation between suckling, nipple innervation, and skin layers.
4. How is the lymph system involved in engorgement?
5. Describe how the alveoli are involved in milk production and release.
6. How can you use your understanding of glandular development in the breast to explain why an adolescent is capable of full lactation?
7. How does a galactocele differ from an intraductal papilloma?
8. What signs would you look for in determining risk for insufficient milk production?
9. Which type(s) of breast surgery offer the greatest chance of successful lactation?

## *Breast Physiology*

10. When does each stage of lactogenesis occur?
11. How is the breast fullness that accompanies stage II lactogenesis different from engorgement?
12. Explain the difference between the roles prolactin and oxytocin play in lactation.
13. How do breastfeeding patterns affect prolactin level?
14. What does "feedback inhibitor of lactation" mean, and how is it associated with breastfeeding patterns?
15. How does the prolactin inhibitor factor work?
16. What is the role of milk ejection relative to foremilk and hindmilk?
17. How would you respond to a concern that milk is not letting down? What would be your first statement?
18. Which of the hormonal anomalies increase the risk for insufficient milk production?

## *Milk Transfer*

19. What are the differences between nutritive and nonnutritive sucking?
20. Describe the typical sucking pattern from beginning to end of a feed.
21. How would you describe the process of milk transfer to an adolescent parent?
22. What do parents need to understand about the relationship between the baby's suckling behavior and milk transfer?
23. What are the consequences of failing to drain the breast regularly, to both the breastfeeding parent and the baby?
24. How will you approach ineffective suckling with parents?
25. What breastfeeding practices will ensure that a baby receives adequate milk transfer?
26. A baby frequently sucks on his fist after feedings, causing the parents to worry that he is not receiving sufficient amounts of milk at feedings. What would you investigate? What would be your first statement?

## *Infant Nutrition*

27. What is the importance of colostrum to a newborn?
28. What explains the difference in appearance between colostrum and mature milk?
29. Which protective properties in human milk are related to the infant's digestion?
30. Why is the mineral content of human milk more favorable to an infant than that of cow's milk?

31. What are the recommendations regarding vitamin D supplementation for a breastfeeding infant?
32. What are the differences between preterm milk and milk when the baby is born at term?
33. Expressed milk was placed in the refrigerator 5 days ago. You are asked if it can now be frozen and for how long. How do you respond? How would your response differ if the baby is in the NICU?
34. You are asked if there are any medications that are not safe while breastfeeding. How would you respond?
35. What are the current guidelines for alcohol consumption while breastfeeding?
36. Why is there so much conflicting information about impurities in human milk?
37. What role would supplemental feedings play in the effect a drug has on a breastfed infant?
38. How susceptible are infants to cow's milk protein allergy?
39. Under what circumstances would it be appropriate for a hypoglycemic infant to receive artificial formula?

## *Maternal Nutrition*

40. What are the effects of malnutrition during pregnancy and lactation?
41. What are the special nutritional needs during lactation? How would you help develop a nutrition plan to meet lactation needs?
42. How would you respond to a question about losing weight while lactating? What practical suggestions can you offer?
43. What information can you use to motivate diet improvement?
44. How would you approach a chronic smoker who plans to continue to smoke during lactation?
45. What precautions would you share with a vegetarian? What do you need to learn in order to provide appropriate suggestions?
46. How can optimal nutrition be achieved on a restricted income?
47. How can consumption of caffeine affect a breastfed infant?

## Resources

USDA meal planning guidelines: https://healthymeals.nal.usda.gov/menu-planning-0