

Physiology, Lactation

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Introduction

The normal physiology of lactation is a process that begins to take effect well before the initial latch of the newborn infant. It requires the breast to change in composition, size, and shape during each stage of female development. Development includes puberty, pregnancy, and lactation. These stages are influenced by a cascade of physiologic changes that are crucial to successful breastfeeding. This article will review the development of the mammary gland (mammatogenesis), the process by which the mammary gland develops the ability to secrete milk (lactogenesis), and the process of milk production (lactation).[1][2][3]

Issues of Concern

The process of lactation and breastfeeding can be negatively affected by anything that interrupts the normal development of the female breast, or that interferes with the production of milk. Women who have had breast augmentation may experience issues with lactation and breastfeeding, but this is dependent on the location of the incision. Incisions made in the armpit are more favorably for normal breastfeeding; whereas, the "smile" incision around the areola increases the woman's risk of having breastfeeding issues.

In the post-partum period, some women may experience difficulty with lactation if they have inadequate milk production, poor milk extraction, and insufficient caloric intake to meet demands. Current recommendations for lactating women is to have a minimum excess of 500 calories per day to meet the caloric demands for milk production. Women are also encouraged to empty the breast as often as possible, typically every 2 to 3 hours to maintain milk supply. [4][5][6][7]

Other issues of concern regarding lactation include the infants inability to latch, nipple pain, mastitis, or plugged ducts.

Cellular

It is important to learn the normal anatomy and cellular composition of breast tissue to understand the physiologic process of lactation. The normal breast consists of 2 major structures (ducts and lobules), 2 types of epithelial cells (luminal and myoepithelial), and 2 types of stroma (interlobular and intralobular). Six to 10 major duct orifices open onto the skin surface of the nipple. The uppermost portion is lined with keratinized squamous cells that abruptly change to the double-layered epithelium (luminal and myoepithelial) of the remainder of the duct and lobule system. Large ducts will eventually lead to the terminal duct lobular unit, and these terminal ducts will then branch into grape-like clusters of small acini to form a lobule. There are 3 types of lobules, type 1, 2, and 3 which form at different stages in a woman's development. Lobules increase progressively in number and size, and by the end of pregnancy, the breast is composed almost entirely of lobules separated by small amounts of the stroma. Only with the onset of pregnancy does the breast become completely mature and functional.[8]

Development

During puberty, lobule type 1 is formed. Changes in the level of estrogen and progesterone during each menstrual cycle stimulate lobule 1 to produce new alveolar buds and eventually evolve to more mature structures, known as

type-2 and type-3 lobules. Once puberty is complete, no further changes occur to the female breast until pregnancy.

During pregnancy, stage-II mammogenesis (alveolar development and maturation of the epithelium) occurs largely in response to higher levels of progesterone. The increased volume of breast tissue during pregnancy is a result of the proliferation of secretory tissue. In early pregnancy, lobule type 3 is formed due to the influence of chorionic gonadotropin. These newly formed lobules have larger size and number of epithelial cells composing each acinus. In late pregnancy, the proliferation of new acini are reduced, and the lumen becomes distended with secretory material or colostrum.

During labor and lactation, further growth and differentiation can be seen in the lobule along with milk secretion. The glandular component of the breast has now increased to the point where it is mainly formed of epithelial elements and very little stroma. This will persist throughout lactation.

Finally, the involution of mammary glands occurs with the cessation of lactation and requires a combination of lactogenic hormone deprivation and local autocrine signals that signal apoptotic cell death and tissue remodeling. Full regression does not occur, and pregnancy causes a permanent increase in the size and number of lobules. Following lactation, there is always the potential of the glands to produce milk in response to regular stimulation.

Organ Systems Involved

Normal lactation involves the female breast, anterior lobe of the pituitary, and the posterior lobe of the pituitary. Their roles in lactation are discussed below.

Function

The decision to breastfeed or to provide breast milk via expression is a decision that every mother must make. Clinicians must inform our patients about all the benefits that breast milk can provide to their newborn. Breast milk provides ideal nutrition for infants with vitamins, proteins, and fats that are more easily digested than formula. Breast milk contains antibodies from the mother that help babies fight off viruses and bacteria. Other anti-infective factors it provides include immunoglobulin (IgA in particular), white blood cells, whey protein (lysozyme and lactoferrin), and oligosaccharides. It also lowers the baby's risk of asthma, allergies, ear infections, respiratory illnesses, bouts of diarrhea, and the risk of diabetes and obesity.

Pathophysiology

Lactogenesis is the process of developing the ability to secrete milk and involves the maturation of alveolar cells. It takes place in 2 stages: secretory initiation and secretory activation.

- Stage I lactogenesis (secretory initiation) takes place during the second half of pregnancy. The placenta supplies high levels of progesterone which inhibit further differentiation. In this stage, small amounts of milk can be secreted by week 16 gestation. By late pregnancy, some women can express colostrum.
- Stage II lactogenesis (secretory activation) starts with copious milk production after delivery. With the removal of the placenta at delivery, the rapid drop in progesterone, as well as the presence of elevated levels of prolactin, cortisol, and insulin, are what stimulate this stage. Usually, at days 2 or 3 postpartum, most women experience swelling of the breast along with copious milk production. In primiparous women, the secretory activation stage is slightly delayed, and early milk volume is lower. Lower milk volume is also observed in women who had cesarean births compared with those who delivered vaginally. Late onset of milk production has also been seen in women who have had retained placental fragments, diabetes, and stressful vaginal deliveries. With retained placental fragments, lactogenesis stage II could be inhibited by the continued secretion of progesterone and would continue to be inhibited until removal of the remaining placental fragments.

Lactation is maintained by regular removal of milk and stimulation of the nipple, which triggers prolactin release from the anterior pituitary gland and oxytocin from the posterior pituitary gland. For the ongoing synthesis and secretion of milk, the mammary gland must receive hormonal signals; and although prolactin and oxytocin act independently on different cellular receptors, their combined action is essential for successful lactation.

Prolactin is a polypeptide hormone synthesized by lactotrophic cells in the anterior pituitary and is structurally similar to growth hormone and placental lactogen. Prolactin is both positively and negatively regulated, but its main control comes from hypothalamic inhibitory factors such as dopamine which act on the D2 subclass of dopamine receptors present in lactotrophs. Prolactin stimulates mammary gland ductal growth and epithelial cell proliferation and induces milk protein synthesis. Emptying of the breast by the infant's suckling is thought to be the most important factor. Prolactin concentration increases rapidly with suckling of the nipple which stimulates nerve endings located there.

Oxytocin is involved in the milk ejection or letdown reflex. The tactile stimulation of the nipple-areolar complex by suckling leads to afferent signals to the hypothalamus that trigger release of oxytocin. This results in contraction of the myoepithelial cells, forcing milk into the ducts from the alveolar lumens and out through the nipple. Oxytocin also has a psychological effect, which includes inducing a state of calm, and reducing stress. It may also enhance feelings of affection between mother and child, an important factor in bonding.

Once lactation is established and maintained, production is regulated by the interaction of both physical and biochemical factors. If milk is not removed, elevated intramammary pressure and accumulation of a feedback inhibitor of lactation reduce milk production and initiate mammary involution. If breast milk is removed, the inhibitor is also removed, and secretion will resume. The role of the feedback inhibitor of lactation is to regulate the amount of milk produced which is determined by how much the baby takes, and therefore by how much the baby needs.

Clinical Significance

The normal development of the female breast is the foundation for mammogenesis, lactogenesis, and lactation. Clinicians who possess an understanding of the physiology of lactation will have the tools necessary to educate their patients to maximize chances of successful breastfeeding.[9][10][8][11]

Review Questions

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