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QUESTION 1: physiology of lactation

Lactation is the process by which milk is synthesized and secreted from the mammary glands of the postpartum female breast in response to an infant sucking at the nipple. Breast milk provides ideal nutrition and passive immunity for the infant, encourages mild uterine contractions to return the uterus to its pre-pregnancy size (i.e., involution), and induces a substantial metabolic increase in the mother, consuming the fat reserves stored during pregnancy.

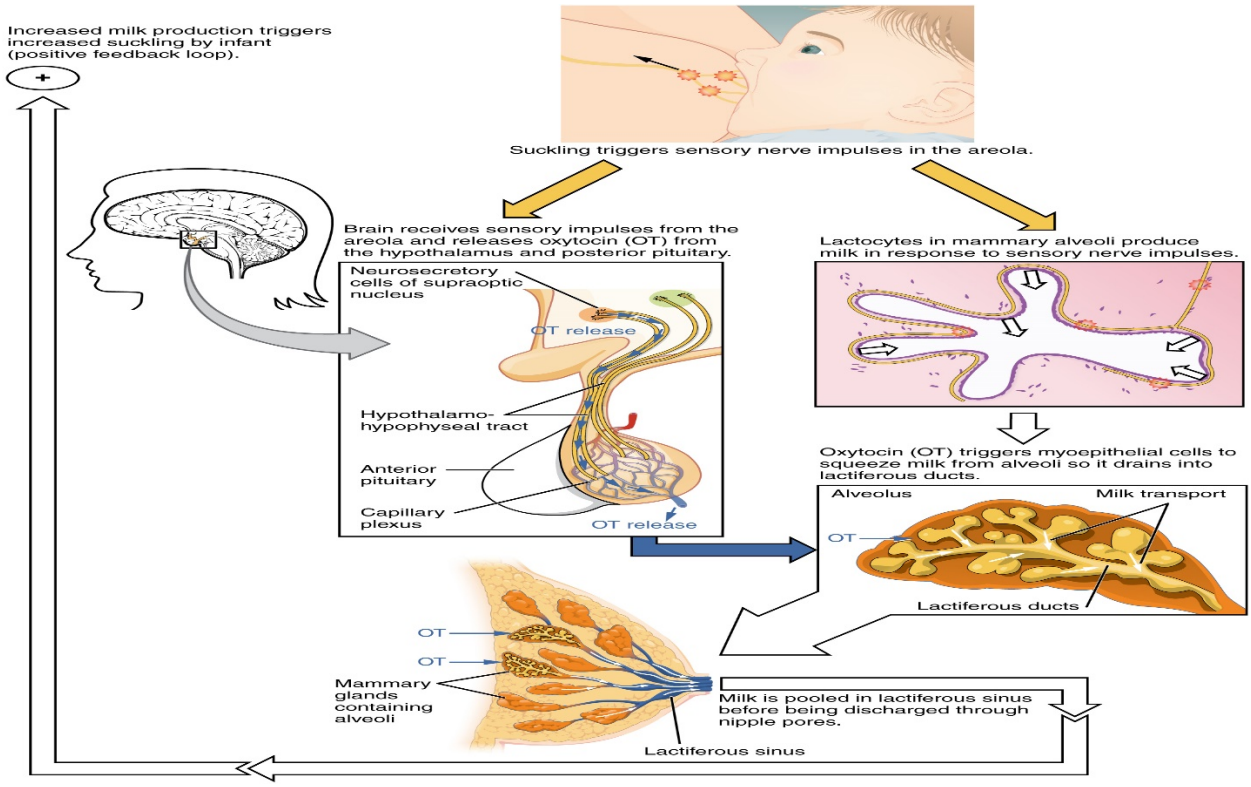
STRUCTURE OF THE LACTATING BREAST

Mammary glands are modified sweat glands. The non-pregnant and non-lactating female breast is composed primarily of adipose and collagenous tissue, with mammary glands making up a very minor proportion of breast volume. The mammary gland is composed of milk-transporting lactiferous ducts, which expand and branch extensively during pregnancy in response to estrogen, growth hormone, cortisol, and prolactin. Moreover, in response to progesterone, clusters of breast alveoli bud from the ducts and expand outward toward the chest wall. Breast alveoli are balloon-like structures lined with milk-secreting cuboidal cells, or lactocytes that are surrounded by a net of contractile myoepithelial cells. Milk is secreted from the lactocytes, fills the alveoli, and is squeezed into the ducts. Clusters of alveoli that drain to a common duct are called lobules; the lactating female has 12–20 lobules organized radially around the nipple. Milk drains from lactiferous ducts into lactiferous sinuses that meet at 4 to 18 perforations in the nipple, called nipple pores. The small bumps of the areola (the darkened skin around the nipple) are called Montgomery glands. They secrete oil to cleanse the nipple opening and prevent chapping and cracking of the nipple during breastfeeding.

THE PROCESS OF LACTATION

The pituitary hormone prolactin is instrumental in the establishment and maintenance of breast milk supply. It also is important for the mobilization of maternal micronutrients for breast milk.

Near the fifth week of pregnancy, the level of circulating prolactin begins to increase, eventually rising to approximately 10–20 times the pre-pregnancy concentration. We noted earlier that, during pregnancy, prolactin and other hormones prepare the breasts anatomically for the secretion of milk. The level of prolactin plateaus in late pregnancy, at a level high enough to initiate milk production. However, estrogen, progesterone, and other placental hormones inhibit prolactin-mediated milk synthesis during pregnancy. It is not until the placenta is expelled that this inhibition is lifted and milk production commences. After childbirth, the baseline prolactin level drops sharply, but it is restored for a 1-hour spike during each feeding to stimulate the production of milk for the next feeding. With each prolactin spike, estrogen and progesterone also increase slightly. When the infant suckles, sensory nerve fibers in the areola trigger a neuroendocrine reflex that results in milk secretion from lactocytes into the alveoli. The posterior pituitary releases oxytocin, which stimulates myoepithelial cells to squeeze milk from the alveoli so it can drain into the lactiferous ducts, collect in the lactiferous sinuses, and discharge through the nipple pores. It takes less than 1 minute from the time when an infant begins suckling (the latent period) until milk is secreted (the let-down).



This diagram shows the process of letdown reflex, the process in which the brain receives sensory impulses to release the hormones necessary for producing and discharging milk to the suckling newborn.

Let-Down Reflex, A positive feedback loop ensures continued milk production as long as the infant continues to breastfeed. The prolactin-mediated synthesis of milk changes with time. Frequent milk removal by breastfeeding (or pumping) will maintain high circulating prolactin levels for several months. However, even with continued breastfeeding, baseline prolactin will decrease over time to its pre-pregnancy level. In addition to prolactin and oxytocin, growth hormone, cortisol, parathyroid hormone, and insulin contribute to lactation, in part by facilitating the transport of maternal amino acids, fatty acids, glucose, and calcium to breast milk.

The Different Stages of Lactation

Lactation is a complex process. It starts long before the mother starts to physically suckle her young one and it continues long after. However the term 'Lactation' does not

refer to a single function or action but it encompasses a wide of variety events, actions and combinations. There are different stages which are:

- Mammogenesis refers to the growth and the proliferation of ducts and the glandular system of the breasts, all under the influence of the increased levels of estrogen and progesterone. This visibly manifests in the form of increased mammary (breast) growth, size and weight. This starts at puberty, and the breast goes through Mammogenesis during each menstrual cycle till about the age of 30. Post conception there is an increase in Mammogenesis.
- Lactogenesis refers to the transition from pregnancy to lactation. It is divided into the following 2 stages:

i. Lactogenesis I starts from about 16-20 weeks (mid pregnancy) and lasts till about day 2-4 postpartum. Basically it refers to the developing capacity of the mammary glands to secrete milk, from mid pregnancy to late pregnancy. This stage is entirely under the endocrine control which means it is completely under the influence of hormones. At this stage there is a differentiation of the alveolar cells into secretory cells. Prolactin induces the colostrum/milk production. This milk supply is governed by the secretions of hormones and not on the 'supply and demand'. Concept

ii. Lactogenesis II refers to the onset of copious milk secretion after birth. It generally starts anywhere between days 2 to 8 postpartum. Initially the milk volume increases rapidly and then suddenly levels off. This is triggered by a sudden drop in the levels of estrogen and progesterone after the expulsion of the placenta. This results in a change of the composition of breast milk.

- Galactopoesis refers to the stage when the milk supply is on maintenance mode. Most women reach this stage by day 10 postpartum. Now the milk production shifts primarily to the autocrine control. This means that only when milk is removed from the breast will more be produced. However there is also some endocrine and metabolic role play, but it is secondary to the autocrine influence.
- Involution stage occurs when the breast is no longer being emptied or when the

infant has been weaned off from the breast. The breast has stopped receiving any stimulation to produce milk, which results in the glandular tissue of the breast to involute and hence lactation ceases. This process generally takes place about 40 days post the last breastfeeding.

Question 2: Physiology of pregnancy in a normal woman

Physiological changes in pregnancy are the adaptations during pregnancy that a woman's body undergoes to accommodate the growing embryo or fetus. These physiologic changes are entirely normal, and include behavioral (brain), cardiovascular (heart and blood vessel), hematologic (blood), metabolic, renal (kidney), posture, and respiratory (breathing) changes. Increases in blood sugar, breathing, and cardiac output are all expected changes that allow a pregnant woman's body to facilitate the proper growth and development of the embryo or fetus during the pregnancy. The pregnant woman and the placenta also produce many other hormones that have a broad range of effects during the pregnancy. Pregnant women experience numerous adjustments in their endocrine system that help support the developing fetus. The fetal-placental unit secretes steroid hormones and proteins that alter the function of various maternal endocrine glands. Sometimes, the changes in certain hormone levels and their effects on their target organs can lead to gestational diabetes and gestational hypertension. A woman will produce more oestrogen during one pregnancy than throughout her entire life when not pregnant. During pregnancy, oestrogen promotes maternal blood flow within the uterus and the placenta. A pregnant woman’s progesterone levels are also very high. Among other effects, high levels of progesterone cause some internal structures to increase in size, including the uterus, enabling it to accommodate a full-term baby. It has other effects on the blood vessels and joints. After conception, the uterus provides a nutritive and protective environment in which the fetus will grow and develop. It increases from the size of a small pear in its non-pregnant state to accommodate a full-term baby at 40 weeks of gestation. The tissues from which the uterus is made continue to grow for the first 20 weeks, and it increases in weight from about 50 to 1,000 gm (grams). After this time, it doesn’t get any heavier, but it stretches to accommodate the growing baby, placenta and amniotic fluid. By the time the

pregnancy has reached full term, the uterus will have increased to about five times its normal size. At 12 weeks' gestation (near the end of the first trimester, i.e. three-month period), the fundus (upper margin of the body of the uterus) may be palpated (felt) through the abdomen above the pubic bone (symphysis pubis). The size of the uterus usually reaches its peak at about 36 weeks' gestation. The uterus may drop slightly as the fetal head settles into the pelvis, preparing for delivery. Notice the position at 40 weeks of gestation, which is shown as a dotted line in Figure 7.1. This dropping is referred to as 'lightening'. It is more noticeable in a prim gravida (pregnant for the first time) than in a multigravida (a woman who has been pregnant previously, regardless of outcome). The cervix remains 2.5 cm long throughout pregnancy. In late pregnancy, softening of the cervix occurs in response to increasing painless contractions of its muscular walls. The vagina also becomes more elastic towards the end of pregnancy. These changes enable it to dilate during the second stage of labor, as the baby passes down the birth canal.