Name: Chukwuemeka Chukwunonso

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**Assignment**

I expect more on the physiology of lactation and details on the physiology of pregnancy in a normal woman.

**Answer**

**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 oestrogen, 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, oestrogen, 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, oestrogen and progesterone also increase slightly.

When the infant suckles, sensory nerve fibres 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).

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.

**CHANGES IN THE COMPOSITION OF BREAST MILK**

In the final weeks of pregnancy, the alveoli swell with colostrum, a thick, yellowish substance that is high in protein but contains less fat and glucose than mature breast milk (In the table below). Before childbirth, some women experience leakage of colostrum from the nipples. In contrast, mature breast milk does not leak during pregnancy and is not secreted until several days after childbirth.

Compositions of Human Colostrum, Mature Breast Milk, and Cow’s Milk (g/L)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Human colostrum | Human breast milk | Cow’s milk |
| Total protein | 23 | 11 | 31 |
| Immunoglobulins | 19 | 0.1 | 1 |
| Fat | 30 | 45 | 38 |
| Lactose | 57 | 71 | 47 |
| Calcium | 0.5 | 0.3 | 1.4 |
| Phosphorus | 0.16 | 0.14 | 0.90 |
| Sodium | 0.50 | 0.15 | 0.41 |

**NOTE**: Cow’s milk should never be given to an infant. Its composition is not suitable and its proteins are difficult for the infant to digest.

Colostrum is secreted during the first 48–72 hours postpartum. Only a small volume of colostrum is produced—approximately 3 ounces in a 24-hour period—but it is sufficient for the new-born in the first few days of life. Colostrum is rich with immunoglobulins, which confer gastrointestinal, and also likely systemic, immunity as the new-born adjusts to a nonsterile environment.

After about the third postpartum day, the mother secretes transitional milk that represents an intermediate between mature milk and colostrum. This is followed by mature milk from approximately postpartum day 10 (in the table above). As you can see in the accompanying table, cow’s milk is not a substitute for breast milk. It contains less lactose, less fat, and more protein and minerals. Moreover, the proteins in cow’s milk are difficult for an infant’s immature digestive system to metabolize and absorb.

The first few weeks of breastfeeding may involve leakage, soreness, and periods of milk engorgement as the relationship between milk supply and infant demand becomes established. Once this period is complete, the mother will produce approximately 1.5 litres of milk per day for a single infant, and more if she has twins or triplets. As the infant goes through growth spurts, the milk supply constantly adjusts to accommodate changes in demand. A woman can continue to lactate for years, but once breastfeeding is stopped for approximately 1 week, any remaining milk will be reabsorbed; in most cases, no more will be produced, even if suckling or pumping is resumed.

Mature milk changes from the beginning to the end of a feeding. The early milk, called foremilk, is watery, translucent, and rich in lactose and protein. Its purpose is to quench the infant’s thirst. Hind milk is delivered toward the end of a feeding. It is opaque, creamy, and rich in fat, and serves to satisfy the infant’s appetite.

During the first days of a new-born’s life, it is important for meconium to be cleared from the intestines and for bilirubin to be kept low in the circulation. Recall that bilirubin, a product of erythrocyte breakdown, is processed by the liver and secreted in bile. It enters the gastrointestinal tract and exits the body in the stool. Breast milk has laxative properties that help expel meconium from the intestines and clear bilirubin through the excretion of bile. A high concentration of bilirubin in the blood causes jaundice. Some degree of jaundice is normal in new-borns, but a high level of bilirubin—which is neurotoxic—can cause brain damage. New-borns, who do not yet have a fully functional blood–brain barrier, are highly vulnerable to the bilirubin circulating in the blood. Indeed, hyperbilirubinemia, a high level of circulating bilirubin, is the most common condition requiring medical attention in new-borns. New-borns with hyperbilirubinemia are treated with phototherapy because UV light helps to break down the bilirubin quickly.

**Physiology of Pregnancy**

Pregnancy is the time from fertilization of an egg, also known as conception, to birth. Getting pregnant and growing a human from scratch is a very complicated biological process that takes a lot of resources. As a result, pregnancy can have a wide range of effects on the mother, both physically and emotionally. Each egg that is released during a menstrual cycle travels to your uterus. However, unlike unfertilized eggs that proceed unaltered and then disintegrate when they get there, a fertilized egg develops into a tiny human embryo on the way. On reaching the uterus, the embryo implants itself in the uterine wall, develops into a foetus, and steadily grows, until about nine months later it is ready to emerge into the outside world as a new-born baby.

**Signs and symptoms**

If you are fertile, sexually active, and become pregnant, the first thing you are likely to notice is a late or missing menstrual period. Fertilization of an egg triggers changes in the production of various hormones almost immediately, and hormone changes evolve and persist throughout your pregnancy to help you grow a healthy baby. Unfortunately, these changes may also cause unpleasant side effects. As a result, in addition to a missed period, many women experience tender, swollen breasts, fatigue, nausea and vomiting, or morning sickness during the first few weeks of becoming pregnant.

**Diagnosis**

If you are experiencing some or all of the early signs and symptoms of pregnancy, or if you suspect you might be pregnant, you may want to take a home pregnancy test. These tests are designed to detect the presence of human chorionic gonadotropin in a sample of your urine. This hormone becomes detectable in urine once the embryo has implanted in the uterus, typically about 8 or 9 days after fertilization.

Whether your home pregnancy test is positive or not, a visit to your healthcare provider can confirm if you are pregnant. Much like the home pregnancy test, this is usually done by testing a urine sample or blood sample for human chorionic gonadotropin (HCG). Your healthcare provider may also perform a physical exam of your uterus and cervix, looking for other physical signs that you are pregnant. For example, there may be signs that your uterus has enlarged, that your cervix is larger and softer, or that your cervix is blueish in colour. Less commonly, and usually only if you are experiencing vaginal bleeding or abdominal pain, your healthcare provider may recommend a transvaginal ultrasound to confirm whether you are pregnant. The earliest observable pregnancy-related change that can be seen with ultrasound is the development of a gestational sac. Later, ultrasound images are commonly used to monitor fetal development over the course of pregnancy.

Once you know for sure that you are pregnant, you can calculate an approximate delivery date for when your baby will be born; usually accurate to within a couple of weeks. As the exact day your egg was fertilized is difficult to pinpoint, the beginning of your pregnancy is usually taken to be the first day of your last normal menstrual period.

**Physiological changes that occur during pregnancy**

**Hormonal**: The menstrual cycle refers to the normal changes in your ovaries and uterus that make an egg accessible for fertilization and prepare your uterus for pregnancy. It typically occurs once every 28 days. If you are ovulating normally, an egg, or ovum emerges from one or other of your ovaries, leaving behind a structure called the corpus luteum. This structure produces large amounts of progesterone and oestrogen, hormones that help prepare your uterus for implantation of a fertilized egg. If the egg is not fertilized, the corpus luteum degenerates, causing progesterone and oestrogen levels to drop, and menstruation to begin. If the ovum is fertilized, on the other hand, the corpus luteum remains intact and continues to maintain the hormone levels you need to keep your uterus baby-friendly. Eventually, the placenta develops the ability to secrete the necessary hormones itself, and the corpus luteum typically disappears after 3 to 4 months.

In addition to progesterone and oestrogen, human chorionic gonadotropin also spikes in early pregnancy. The levels of this hormone double every two days in the first 10 weeks of pregnancy. Its primary role is to prevent any further menstruation, and to prepare the placenta - the organ that connects the foetus to the uterus. The placenta allows the foetus to be supplied with nutrients and oxygen, as well as providing a route for the removal of toxic waste products.

Although many signs and symptoms of pregnancy are related to hormonal changes, there are also many that occur due to the growing foetus invading the spaces that were previously occupied by your other organs.

**Immune tolerance**: Your growing foetus is a foreign object, something that your immune system is normally programmed to attack and reject. In order to prevent this from happening, as soon as the embryo becomes implanted in the uterine wall, a key pathway that usually triggers the launch of an immune attack is turned off, making this part of your immune system dormant, and preventing immune cells from targeting the foetus or placenta. In addition to making it possible for you to grow your baby, there can be secondary benefits of pregnancy-related changes in immune function. In particular, women suffering from diseases caused by immune disorders, such as rheumatoid arthritis, multiple sclerosis, and psoriasis, may find relief from disease symptoms during pregnancy due to increased levels of anti-inflammatory steroids that occur naturally.

**Cardiovascular**: During pregnancy, your cardiac output - the amount of blood your heart pumps around your body per minute - increases to meet the needs of the developing foetus, and to provide the volume of blood necessary to fill the uteroplacental circulation.

This is achieved by increasing the stroke volume, which is the amount of blood pumped out of your heart with each heartbeat. Your cardiac output peaks around week 24 of your pregnancy, when it is 30%-40% higher than normal. As the foetus grows, your uterus begins to crowd your aorta, the major artery that carries oxygenated blood to your tissues and organs and vena cava, the major vein that carries deoxygenated blood back to your heart. Sometimes, certain positions, such as lying on your back, puts excess pressure on these vessels, which can lead to a drop in blood pressure causing dizziness, fainting, and in some cases, even damage to the foetus. In addition, exercise or activities that change heart rate tend to put a greater demand on your cardiovascular system when you are pregnant than they normally would, and the large changes in cardiac output associated with pregnancy may add additional strain for women with pre-existing heart conditions, such as valvular heart disease, or coronary heart disease. One other relatively common cardiovascular complication of pregnancy is varicose veins, which are enlarged, swollen veins that typically develop in the legs. During pregnancy, your growing uterus puts pressure on your veins making it harder for the blood to flow back to your heart. This causes the blood to pool in the veins making them swell.

**Hematologic**: As cardiac output increases, blood volume increases to match. This is due to a 50% increase in the volume of your plasma (the clear, yellowish fluid of your blood), and a 20% increase in the number of red and white blood cells. Overall, this has the effect of diluting the blood, often resulting in “physiological anaemia of pregnancy” (a relative deficiency of red blood cells). Iron requirements increase during pregnancy as the foetus and placenta grow, and as the red blood cell numbers rise. Iron is essential for red blood cell production, and supplements are often needed as the amount of iron absorbed from the diet and recruited from iron stores is often not enough. Several hormones are thought to play a role in changing blood composition to support pregnancy including the renin-angiotensin-aldosterone hormonal system, atrial natriuretic peptide, oestrogen, and progesterone, although exactly how they do this is not clear. Whatever the mechanism, the increased blood volume is very important as it ensures that the extra blood needed to supply the growing uterus and placenta is available, and can help protect the mother against normal blood loss that occurs while giving birth.

**Renal**: Your kidneys are responsible for filtering waste products from your blood, and regulating blood pressure and electrolytes; for example, sodium (Na+), potassium (K+) and calcium (Ca2+). During pregnancy, changes in kidney function approximately follow changes in cardiac function - both organs work considerably harder. By around the 20th week, and sometimes as early as the 8th to 10th week of pregnancy, your kidneys are filtering 30% to 50% more blood than before you were pregnant. The effects of this are greater reabsorption of sodium, and increased elimination of sugars (glycosuria), amino acids (aminoaciduria), and creatinine in your urine (creatinine clearance tests are often used by doctors as a measure of how well your kidneys are working). After about the 12th week of pregnancy, progesterone, a smooth muscle relaxant, causes the tubes that transport urine from the kidneys to the bladder, called the ureters, to dilate. As your uterus expands, it may compress the dilated ureters, obstructing the flow of urine to your bladder, and increasing the chances that you get a urinary tract, or kidney infection while you are pregnant. Laying down on your side can help relieve the pressure on your major blood vessels letting your kidneys work more effectively. However, this can make for a lot of urine production and toilet breaks during the night when you are trying to sleep.

**Respiratory**: Breathing exercises are often practised by expectant mothers to use during labour and birth, but this isn’t the only way changes in respiration are helpful. As with your other organs, the growing uterus begins to invade the space normally reserved for your lungs, which restricts their expansion during normal breathing. Once again, progesterone, the multi-talented pregnancy hormone gets to work, triggering your lungs to increase the amount of air inhaled with each breath - the tidal volume - as well as the number of breaths per minute - the respiratory rate. This increases the oxygen supply required to meet the metabolic needs of the foetus, placenta and other organs.

**Metabolic**: Changes in metabolism during pregnancy alter the distribution of body fat, as well as how you digest and process food. While accumulating fats and nutrients is necessary for the healthy growth of your baby, metabolic changes can also affect the way in which medications are processed. As such, it is important to know how your pregnant body may respond to any drugs or homeopathic remedies you may be taking, and whether or not this could have an effect on your growing baby.

**Body weight**: Supporting the growth of a developing foetus takes a lot of energy, so it’s not surprising that more calories are required during pregnancy. In fact, after the first three months (trimester) your appetite generally increases so that you are consuming about 300 extra calories a day. Although in the first trimester you can expect to gain just a few pounds, it’s normal to gain about a pound per week for the rest of your pregnancy. In addition to weighing more, you can expect your breasts to grow around 1 to 2 cup sizes in preparation for breastfeeding.

**Gastrointestinal**: As your uterus grows, it puts pressure on your digestive organs including your colon, gallbladder, liver, and stomach. This can impair their function, and lead to constipation, gallstones, reduced bile transport, as well as a general slowing of the digestive process that is related to lower levels of the hormone gastrin. Gastrin stimulates the secretion of stomach acid, which in turn leads to the production of pepsin, an enzyme that digests proteins in your food - less gastrin leads to slower digestion. In addition to this, elevated progesterone levels during pregnancy slacken the cardiac sphincter, the “door” between your oesophagus and stomach, making it open more easily. It is very common to experience heartburn due to acid reflux into your oesophagus during the third trimester, as the cardiac sphincter cannot withstand the pressure that builds up in your stomach as your uterus grows. It’s also worth noting that taking analgesics during pregnancy may not be for the best, as they can slow down gastric emptying even more, creating an even higher pressure that the cardiac sphincter must withstand.

**Musculoskeletal**: Numerous anatomical and physiological changes occur during pregnancy that strain the muscles and skeleton, particularly the pelvis, and which may lead to lower-back pain, leg cramps, and hip pain. One of the hormones responsible for musculoskeletal changes during pregnancy is relaxin, which softens your ligaments and cartilage tissues to help your body accommodate your growing baby. In addition to relaxin’s relaxing effects, the arrangement of the abdominal muscles themselves is particularly well adapted for childbearing. Unlike in men, where they form a “six pack”, women’s abdominal muscles are positioned to allow them to stretch around a baby-bump.

**Integumentary**: The integumentary system consists of your skin, hair and nails, as well as underlying connective tissue that attaches your skin to your body and various glands including sweat and oil producing glands, and your mammary glands. As your pregnancy proceeds, your skin stretches to accommodate your growing uterus and breast tissue. Sometimes the stretching can tear the underlying connective tissue causing red or purple marks to appear on your abdomen, commonly known as stretch marks. In addition, increased oestrogen levels during pregnancy increases the production of melanin, the pigment that gives human skin and hair its colour. This often causes the ring of colour around your nipples (areolae) to darken, and may create a line of pigment that typically runs from your navel to your pubic bone. It’s also possible you may develop patchy discoloration of your face and darkening of any moles and freckles. Other integumentary changes that may occur during pregnancy include accelerated nail growth and excessive hair growth in unusual places, while increased blood supply to your skin often leads to increased perspiration. Finally, while it’s commonly said that pregnancy makes your skin clear and radiant, it’s also possible for it to become oily and acne prone.