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Physiology, Breast Milk

Rutvi Shah; Ali F. Alhawaj.

Author Information

Authors

Rutvi Shah[1]; Ali F. Alhawaj[2].

Affiliations

[1] Pramukhswami Medical College
[2] Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

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Introduction

Breast milk is one of the major sources of nutrition for a newborn. It provides fats, carbohydrates, proteins, vitamins, and minerals needed exclusively for the first 6 months of life. Furthermore, it provides the neonate with resources to develop immunity to infections and aids in digestion and absorption of other substances.

Issues of Concern

In many societies, formula feeding is becoming more prominent, and breast milk has become the least preferred choice.[1] Further evidence demonstrates how formula and bottle feeding leads to an increased risk of oral disease and alterations in oxygenation, thermoregulation, and gut bacteria of the newborn.[1] Formula feeding is necessary for some situations. However, the most appropriate recommendation to a newborn is exclusive breastfeeding for at least six months before adding complementary feeding.[2][3]

Cellular

Breast milk is composed of fats (3 to 5%), carbohydrates (6.9 to 7.2%), proteins (0.8 to 0.9%), vitamins, minerals, and bioactive substances.[4][5][6] Breast milk yields around 60 to 75 kcal/100 ml. The colostrum (breast milk in the early days) has more proteins, and mature milk contains more carbohydrates.[4]

Fats

The content of fat in breast milk ranges from 3.5 to 4.5%. Triglycerides account for the majority of the lipids. Saturated fatty acids account for nearly half of the fatty acids with palmitic acid being around 23%. Breast milk contains two essential fatty acids: linoleic acid and alpha-linoleic acid. These get converted to arachidonic acid (AA) and eicosapentaenoic acid (EPA). EPA converts to docosahexaenoic acid (DHA).[6] The fatty acid composition varies somewhat upon the diet of the mother.[4]

Carbohydrates

Breast milk mainly contains lactose. There are 30 or more oligosaccharides with the terminal Gal-(beta1,4)-Glc as well. They range from 3 to 14 saccharide units per molecule.[4]

Proteins

Breast milk primarily consists of casein and whey proteins. Whey consists of alpha-lactalbumin, lactoferrin, and immunoglobulin A.[6] Casein is more difficult to digest than is whey. Breast milk initially contains more whey than casein. Eventually, however, both casein and whey become equal. Other proteins include lysozyme, folate-binding protein, bifidus factor, lipase, amylase, alpha1-antitrypsin, antichymotrypsin, and haptocorrin.[6]

Vitamins and Minerals

Breast milk contains most vitamins except vitamin K and D. Hence, and vitamin K is given at birth. Mothers are advised to expose their infants to the sun or supplement them with vitamin D. Breast milk contains sodium, potassium, calcium, magnesium, phosphorus, and chlorine. Iron, copper, and zinc are also present in breast milk but vary in quantity. The infant's iron needs depend upon the mother's intake.[4]

Bioactive Substances

Breast milk contains white blood cells, IgA, IgG, IgM, cytokines, chemokines, growth factors, hormones, and anti-microbial substances.[5]

Development

The mammary tissue consists of alveoli and ducts. The breast milk production is into the alveoli where it gets stored and then pumped through the ducts during lactation.

During pregnancy, the mother undergoes stage II mammogenesis due to high levels of progesterone; this increases secretory tissue in the breast. The high levels of chorionic gonadotropin form type three lobules in the breast alveoli. These lobules consist of epithelial cells and acini of increased size and number. During the latter part of pregnancy, the acini atrophy and give leeway for colostrum storage in the lumen.[7]

In the initial week after pregnancy, the mother secretes colostrum, which is a thick and yellow liquid. From days 7 to 14, the mother secretes transitional milk. This type is a combination of colostrum and mature milk. After two weeks, the mature milk is formed and secreted.[5]

Two hormones are involved in the development of breast milk: prolactin and oxytocin. Prolactin increases during pregnancy to prepare the mammary tissue to start forming the milk. However, due to high levels of progesterone and estrogen, prolactin is inhibited from forming any milk. After placental delivery, progesterone and estrogen levels fall, allowing prolactin to exert its effect and secrete the milk. Oxytocin acts on the cells to expel the stored milk.[7][8]

Organ Systems Involved

The organs and structures involved in breast milk formation are the mammary glands, the anterior pituitary gland, and the posterior pituitary gland. The individual roles of those organs are discussed below.

Function

Breast milk is the primary source of nutrients for the newborn. The composition of breast milk serves many functions.

The general makeup of breast milk is water, fat, protein, and lactose. Because of the constant growth of a newborn, the breast milk adapts itself to accommodate the child's needs. When each nursing session begins, the foremilk satisfies the baby's thirst due to the high content of lactose.

The hindmilk is more abundant in fat to provide the nutrition a baby requires. Breast milk can differ depending on maternal health, environmental exposure, and the age of the infant.[6]

The fats in the milk are necessary for growth regulation, inflammatory responses, immune function, vision, cognitive development, and motor systems in newborns.[6]

The lactose in the milk aids in the absorption of minerals and calcium.[6] Furthermore, carbohydrates are also able to produce certain strains of lactobacilli. These strains, in turn, helps to control the intestinal flora in the gut.[4]

Compared to formulas, human breast milk contains higher levels of whey protein, making digestion easier for the newborns. Furthermore, various whey proteins provide different functions necessary for the newborn. For example, immunoglobulin A antibody protects the gut surface and destroys bacteria. Also, both lactoferrin and lysozymes stop pathogenic bacteria.[6]

Vitamins and minerals play a critical role in the development of the newborn. They are necessary for enzymatic functions and constitute the building blocks of many molecular substances. However, vitamin D and K are not present in breast milk and require external supplementation. Iron requirement is also essential to a newborn to prevent anemia. The newborn can have direct iron supplementation, or the mother's diet can be fortified with iron-rich foods and the iron passed on in the breast milk.[8]

Mechanism

Early on in the pregnancy, prolactin secretion increases. Prolactin stimulates epithelial proliferation of breast tissue to start secreting milk. High levels of both progesterone and estrogen in pregnancy lead to prolactin inhibition. After delivery, progesterone and estrogen levels decrease rapidly, allowing mammary epithelial cells to synthesize milk in response to prolactin.[9][10]

The baby suckling the nipple also stimulates prolactin secretion. It reaches its peak levels in the blood about 30 minutes after the feeding. Hence, prolactin is necessary to provide milk for the next feed. Furthermore, prolactin secretion is at its maximum height at night. Thus, breastfeeding at night is considered significant.[9]

Prolactin is beneficial to the mother as well. It causes a feeling of happiness and relaxation. Prolactin secretion also affects the release of gonadotropin-releasing hormone (GnRH). Inhibition of GnRH in its turn decreases the release of follicle-stimulating hormone and luteinizing hormone, which leads to a natural birth control mechanisms in the mother called lactational amenorrhea.[9]

Oxytocin is known as the "let-down" hormone. It acts on the myoepithelial cells around the alveoli, contracting them to help release the milk, allowing ejection of the already-made milk from the breast.[9][10]

Oxytocin secretion occurs when the mother starts seeing, smelling, or even thinking about her child, and also when the baby sucks the nipple, constituting the sucking reflex. This reflex explains why a mother and child should be roomed together as often as possible. If the mother is emotionally unbalanced, this reflex can be affected; hence keeping the mother emotionally stable is essential.[11]

Oxytocin also promotes bonding and affection between the mother and child.[11]

Pathophysiology

One of the main maternal concerns is not having enough breastmilk. Since breast milk is indispensable to a newborn, physicians should be able to discern milk supply difficulties. Signs include low weight gain, dry mucous membranes of the baby, weak cry, infrequent hard stools, and frequent strong smelling urine.[12] Many factors can affect breast milk supply such as poor maternal health (e.g., anemia), abnormalities in the breast tissue, retained fetal products in-utero, urinary tract infections in the mother, and poor feeding habits.[12] Effective feeding habits and optimizing the mother's health status helps to achieve optimum feeding.[12]

Clinical Significance

Breast milk is vital for the newborn's development. However, due to the increased norm of working mothers, pumping and storage of breast milk has become a widespread practice. The maintenance of this practice is crucial to prevent the spread of pathogens through expressed milk. Preserving the integrity of the breast milk is essential, hence using proper hygiene is advised. Furthermore, short-term storage of the milk can be achieved by the refrigerator to prevent contamination.[13]

Breastfeeding correlates with decreased risk for cardiovascular diseases, atopic diseases, and several infectious diseases. Additionally, breastfeeding has links to a reduction in the risk of behavioral and developmental disorders.[1]

Questions

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References

1. Brahm P, Valdés V. [The benefits of breastfeeding and associated risks of replacement with baby formulas]. Rev Chil Pediatr. 2017 Feb;88(1):7-14. [PubMed: 28288222]
2. Jenness R. The composition of human milk. Semin. Perinatol. 1979 Jul;3(3):225-39. [PubMed: 392766]
3. Ballard O, Morrow AL. Human milk composition: nutrients and bioactive factors. Pediatr. Clin. North Am. 2013 Feb;60(1):49-74. [PMC free article: PMC3586783] [PubMed: 23178060]
4. Martin CR, Ling PR, Blackburn GL. Review of Infant Feeding: Key Features of Breast Milk and Infant Formula. Nutrients. 2016 May 11;8(5) [PMC free article: PMC4882692] [PubMed: 27187450]
5. Pillay J, Davis TJ. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Oct 27, 2018. Physiology, Lactation. [PubMed: 29763156]
6. Kramer MS, Kakuma R. The optimal duration of exclusive breastfeeding: a systematic review. Adv. Exp. Med. Biol. 2004;554:63-77. [PubMed: 15384567]
7. Kramer MS, Kakuma R. Optimal duration of exclusive breastfeeding. Cochrane Database Syst Rev. 2012 Aug 15;(8):CD003517. [PubMed: 22895934]
8. Lee S, Kelleher SL. Biological underpinnings of breastfeeding challenges: the role of genetics, diet, and environment on lactation physiology. Am. J. Physiol. Endocrinol. Metab. 2016 Aug 01;311(2):E405-22. [PMC free article: PMC5005964] [PubMed: 27354238]
9. Neville MC, Anderson SM, McManaman JL, Badger TM, Bunik M, Contractor N, Crume T, Dabelea D, Donovan SM, Forman N, Frank DN, Friedman JE, German JB, Goldman A, Hadsell D, Hambidge M, Hinde K, Horseman ND, Hovey RC, Janoff E, Krebs NF, Lebrilla CB, Lemay DG, MacLean PS, Meier P, Morrow AL, Neu J, Nommsen-Rivers LA, Raiten DJ, Rijnkels M, Seewaldt V, Shur BD, VanHouten J, Williamson P. Lactation and neonatal

nutrition: defining and refining the critical questions. J Mammary Gland Biol Neoplasia. 2012 Jun;17(2):167-88. [PMC free article: PMC3428522] [PubMed: 22752723]

10. Aono T. [Hormonal control of lactation]. Nippon Sanka Fujinka Gakkai Zasshi. 1990 Aug;42(8):867-72. [PubMed: 2230414]
11. Sue Carter C. Oxytocin and Human Evolution. Curr Top Behav Neurosci. 2018;35:291-319. [PubMed: 28812268]
12. Amir LH. Breastfeeding--managing 'supply' difficulties. Aust Fam Physician. 2006 Sep;35(9):686-9. [PubMed: 16969436]
13. Peters MD, McArthur A, Munn Z. Safe management of expressed breast milk: A systematic review. Women Birth. 2016 Dec;29(6):473-481. [PubMed: 27318564]

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