Nutrition in children is needed for rapid growth, development, & for maintenance of high metabolic rate, while in adult is needed for maintenance of metabolism.

Infancy especially the 1st 6 mo, is a period of rapid growth & a high nutritional requirement, reaching up to four times that of adult (regarding the body weight).

The early baby nutrition depends on a single food, either breast milk, formula feeding, or mixed.

**BREAST-FEEDING**

**Anatomy of the breast**

It is the largest exocrine gland, specialized for secretion of milk. Each 1 breast consist of 16-18 lobules embedded in fat & connective tissue of chest wall, each lobule is consisted of thousands of secreting units called alveoli , the alveoli are surrounded by profuse blood supply & myoepithelial cells & lined by specific secreting cells (acini cells) that secret the milk to the alveolar lumen. Contractions of the myoepithelial cells push the milk to the lactule, ductile, ducts, & finally to the lactiferous ducts & sinuses that opens in the nipple each lobule with an isolated opening.
**Mechanism of milk production**

Lactogenesis starts in the 5th mo of gestation under the effect of prolactin hormone, but full lactation during pregnancy is prevented by the elevated maternal progesterone level (which decreases after labor) that antagonizes the prolactin action.

Breast milk secretion in the alveoli is directed after birth by neurohormonal mechanism, started by the infant sucking of the breast which results in afferent impulses to the mother's hypothalamus and then to both the anterior and the posterior pituitary, stimulation of the anterior pituitary gland will lead to secretion of prolactin (this called milk production reflex), while stimulation of the post. pit. gland leads to secretion of the oxytocin, which contract the myoepithelial cells to push the formed milk out of the alveolar lumen making it available to the baby (this called milk ejection or let down reflex), when this reflex is functioning well, it can lead to spontaneous milk flow from the opposite breast.

**Factors affecting breast milk production**

- Certain drugs, e.g. chlorpromazine & metaclopramide stimulate the prolactin secretion, while bromocriptin suppress its secretion & reduce milk production.
- Maternal status, e.g. tension, pain, fatigue & emotional distress, leads to failure of let down reflex & decrease of breast milk production.

**Breast Milk Composition**

It is isotonic with plasma & composed of protein, fat & lactose. During the 1st postpartum days, lactation started with colostrum, it is higher than the mature breast milk in sodium, chloride, protein, & cells & is lower in fat, lactose, & potassium. then during the 1st 2-3 wk of lactation, the protein continue to decrease, while the fat & lactose increase, so passing the transitional period to reach the mature milk.

Milk from the mother whose diet is sufficient and properly balanced will supply all the necessary nutrients except, perhaps, fluoride and, after several months, vitamin D. If the water supply is not adequately **fluoridated** (≤0.3 ppm), the breast-fed infant should receive it. If the maternal vitamin D intake is inadequate and the infant's exposure to sunlight is limited (e.g., dark-skinned infants and infants who are chronically protected from sunlight), 10 μg/24 hr of **vitamin D** is recommended. The **iron** content of human milk is somewhat low. However, most normal infants have sufficient iron stores for the first 6 mo of life. Moreover, human milk iron is more biological than cow milk iron, so well absorbed. Nonetheless, by 4-6 mo of age or when the body weight double, the breast-fed infants diet should be supplemented with iron-fortified complementary foods or a ferrous iron preparation. The **vitamin K** content of human milk also is low and may contribute to hemorrhagic disease of the newborn. Parenteral administration of 1 mg of vitamin K at birth is recommended for all infants, and this is especially important for those who will be breast-fed.

**Establishing & Maintaining the Milk Supply**

The most satisfactory stimulus to the secretion of human milk is early (during the 1st few days after birth), regular, and complete emptying of the breasts. Infants should room in with the mother and should not be offered other milks or water supplements. Infants who can't be fed on demand should be brought to the mother for feeding approximately every 3 hr during the day and night. Once lactation is well established,
most mothers are capable of producing more milk than their infant needs.

The infant should empty at least 1 breast at each feeding; otherwise, the breast will not be stimulated sufficiently to refill. Both breasts should be used at each feeding during the early weeks to encourage maximal milk production & to achieve satiety of the baby. After the milk supply is established, the breasts may be alternated at successive feedings (one breast may be sufficient).

Appropriate care for sore nipples should be instituted before severe pain from abrasions and cracking develops. Exposing the nipples to air; applying pure lanolin; avoiding soap & alcohol; changing disposable nursing pads frequently; feeding more frequently; manually expressing milk; & nursing in different positions are recommended. If nipple is painful, the milk-ejection reflex may be delayed. This makes the infant vigorously feeding, which further injures the nipple and areolar area.

Retracted and/or inverted nipples are not contraindications to breast-feeding, it usually benefit from daily manual breast-pump suction during the later weeks of pregnancy.

The 1st 2 wk after birth are important for establishing breast-feeding.

**Technique of Breast Feeding**

At feeding time, the infant should be hungry, dry, and neither too cold nor too warm. It should be held in a comfortable, semi-sitting position to prevent vomiting with eructation. The mother, too, should be comfortable. The infant should be supported comfortably with the face held close to the mother's breast by 1 arm and hand while the other hand supports the breast, making the nipple easily accessible to the infant's mouth without obstructing nasal breathing. The infant's lips should engage considerable areola as well as nipple. The nipple is approached to the baby mouth using the **rooting reflex** on smelling of the milk or by stroking the cheeks, while the **sucking reflex** will evacuate the breast by its compression against the hard palate, & **swallowing reflex** will swallow the taken milk.
Some infants will empty a breast in 5 min; others will nurse for 20 min or longer.

At the end of the nursing period, the infant should be held erect over the mother's shoulder or on her lap, with or without gentle rubbing or patting of the back to assist in expelling swallowed air.

**Determining the Adequacy of Breast Feeding**

The milk supply is sufficient if the infant is:

1. satisfied after each nursing.
2. sleeps 2–4 hr between feedings especially in early infancy, unless awaken & crying due to other cause.
3. gains weight adequately (start gaining weight by the end of the 2nd wk).
4. urinate adequately.

- Three possibilities should be excluded before assuming that a mother cannot produce sufficient milk: (1) errors in feeding technique; (2) maternal factors related to diet, rest, or emotional distress; and (3) physical disturbances of the infant that interfere with nursing or with weight gain.

**Advantages of Breast-Feeding vs Formula-Feeding.**

1. Human milk is uniquely adapted to the infant's needs and, hence, is the most appropriate milk for the human infant.
2. Breast milk is always available at the proper temperature & requires no preparation time, in addition to its economic benefits.
3. Breast-feeding is associated with fewer feeding difficulties incident to allergy and/or intolerance to bovine milk.
4. Decreasing incidence of infections, this due to many causes:
   a. It is fresh and free of contaminating bacteria.
   b. Human milk contains bacterial and viral antibodies, including relatively high concentrations of secretory IgA that prevents microorganisms from adhering to the intestinal mucosa.
   c. Macrophages in human milk.
   d. Breast milk contains lactoferrin which has an inhibitory effect on the growth of Escherichia coli in the intestine.
e- The lower pH of the stool of breast-fed infants.

f- Human milk also contains bile salt–stimulated lipase, which kills Giardia lamblia and Entamoeba histolytica.

g- Transfer of tuberculin responsiveness by breast milk suggests passive transfer of T-cell immunity.

5- It reduces the liability of sudden infant death syndrome & later diabetes mellitus.

7- The psychological advantages of breast-feeding for both mother and infant are well recognized.

For mother, it enhances the involution of the uterus through the release of oxytocin & it is a method of contraception & decrease the incidence of breast cancer.

**Disadvantages of Breast Milk**

1- It is not possible to see how much the baby takes.

2- It needs a discrete place to expose the breast for feeding.

3- Women wishing to return to work will find it is difficult to fit with the breast feeding regimen.

4- Some times, breast feeding may be impossible due to the medical illness of the mother.

**Contraindications of breast feeding**

1- **Inborn errors of metabolism of the baby:** Galactosemia, phenylketonuria, urea-cycle defects, & primary lactase deficiency.

2- **Maternal Infections:** Septicemia, HIV, active TB, typhoid fever, malaria, CMV (in preterm infants), & herpes simplex (when lesions are present on breast).

3- **Maternal Medications:** Sulfonamides (for some preterm infants or infants with hyperbilirubinemia & G6PD deficiency), certain antithyroid drugs, radioactive medicines, chemotherapeutic agents (alkylating agents), & lithium, Cocaine, & narcotics (in general, anti-psychotic drugs should be used with cautions), in addition to substance abuse.

4- **Severe maternal neurosis or psychosis.**
5- Maternal breast cancer.

FORMULA-FEEDING

Indications of Bottle Feeding

In healthy infants, bottle feeding can be used by one of the following 3 methods:

a) **Complementary feeding:**

Where breast feeds are completed by bottle feeds. It is indicated when breast milk is *insufficient* for normal growth (scanty breast milk secretion). In this case, the breast milk should be given first then the feed is completed by the bottle.

b) **Supplementary feeding:**

Where some breast feeds are replaced by bottle feeds. It is indicated in two conditions; *working mother* (where the mother is absent part of the day) & twin *delivery* (where the breast milk is not enough to feed both babies).

c) **Substitutive feeding:**

Where breast feeding is completely replaced by bottle feeding. It is indicated in three conditions; *absent* breast milk secretion, *chronically sick mother* & mothers who are *unwilling* to breast fed their babies. In the last condition, the reason should be explored & the advantages of breast feeding should be explained. When she insists, encourage her on artificial feeding & do not let her to feel guilty.

Technique of Formula Feeding

The setting for formula-feeding should be similar to that for breast-feeding; the baby should be held as though being breast-fed. The nipple holes should be of a size that allows the milk to drip slowly, and the bottle should be held so that milk, not air, channels through the nipple. The bottle of formula is usually warmed to body temperature. This may be tested by dropping milk onto the wrist. Eructation of air swallowed during feeding is important for avoiding regurgitation and abdominal discomfort,
especially during the 1st 6–7 mo of life. All infants occasionally regurgitate or “spit up” a small amount of milk after feeding, a fact that the mother should know. Spitting up seems to occur more often in the formula-fed than in the breast-fed infant.

A feeding may last from 5–25 min, depending on the age and the vigor of the infant. Because the infant’s appetite varies from 1 feeding to another, each bottle should contain more than the average amount taken per feeding, but in no case should the infant be urged to take more than desired. Excess formula should be discarded.

The number of feedings required daily decreases throughout the 1st year of life from 8 or more shortly after birth to only 3 or 4 at 1 yr of age. For the 1st 1–2 mo, feedings are taken throughout the 24 hr period; thereafter, as the quantity of milk consumed at each feeding increases and the infant adjusts his or her demand to the family pattern of daytime activities, the infant usually sleeps for longer periods at night.

**Preparation of Milk**

The dried milk should be properly reconstituted to provide the proper concentration. [Milk with small scoop (4 gm) needs 1 oz (30 ml) of water giving 20 kcal & milk with large scoop (8 gm) needs 2 oz (60 ml) water giving 40 kcal].

**Sterilization of Bottle**

The bottle should be washed after each feeding, and then boiled with water for 10-15 minutes (while the teat for 5 minutes only), after that it can be used or kept in a refrigerator to be used at other time.

**Weaning from breast feeding & complementary foods**

**Complementary foods** should be introduced in a stepwise fashion to both breast-fed and formula-fed infants, beginning about the time the infant is able to sit, usually between 4-6 mo of age. Avoid starting with foods with high allergenic potential (cow’s
milk, eggs, fish, nuts, soybeans), Cereals, a good source of iron, are usually introduced 1st, followed by vegetables and fruits, then meats, and finally, eggs. Only 1 new food should be introduced at a time and additional new foods should be spaced by at least 3–4 days to allow detection of any adverse reaction to each newly introduced food.

**Weaning** can be initiated when mutually desired by the mother and infant by substituting formula or bovine milk by bottle or cup for part and, then, for all of a breast-feeding. Occasionally, an infant takes a cup as readily as a bottle. If so, the intermediate transfer from breast to bottle before transferring from bottle to cup can be avoided. These changes should be made gradually and should be a pleasant experience, not a conflict, for both the mother and the infant.

**Dietetic Errors**

Several dietetic errors may occur in breast fed infant & if uncorrected early they will lead to nutritional disorders as the following:

<table>
<thead>
<tr>
<th>Error</th>
<th>Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanty breast milk with no supplementation</td>
<td>Undernutrition</td>
</tr>
<tr>
<td>Scanty breast milk with wrong supplementation (supp. with CHO)</td>
<td>Kwashiorkor</td>
</tr>
<tr>
<td>Prolonged breast feeding without vitamin D supp.</td>
<td>Rickets</td>
</tr>
<tr>
<td>Prolonged breast feeding without additional foods or iron supp.</td>
<td>Anemia</td>
</tr>
</tbody>
</table>
Comparison of Mature Breast Milk, Cow Milk, & Standard Formula- Milk (cow milk-based) after good preparation

**Water:** relatively the same.

**Calories:** may vary slightly, but in average is 20 kcal/oz in all.

**Protein:** in breast milk is about 1.3 % (1.3 gm/dl), in cow milk is 3.3 %, in formula milk is about 1.8 %. Its type: in breast milk casein: whey protein is 25:75, while its reversed in both cow & formula milk.

**CHO:** in breast milk contains 6.7 % lactose, cow milk 4.5 %, formula milk is about 7.5 %.

**Fat:** is about the same in all 3.5 %.

**Iron:** it is lower in breast milk than the other but it has more biological value by better absorption.

**Calcium:** is more in both cow & formula milk than breast milk, but incidence of hypocalcaemia is more with the formers because high content of phosphorus.

**Sodium, chloride, & potassium:** are more in cow & formula milk.
MALNUTRITION

World wide, it is one of the leading causes of morbidity & mortality in childhood. It may be primary (due to inadequate dietary intake) or secondary (due to inadequate absorption, increased metabolism, or an abnormal loss). Primary malnutrition is more common in developing countries, while secondary type is more in developed countries. Milder degrees over a prolonged period result in failure to thrive with growth retardation, whereas severe deficiencies cause protein-energy malnutrition (marasmus & kwashiorkor).

Types of malnutrition

- Macronutrient malnutrition: involve def. of CHO, protein, or fat, also called Protein Energy Malnutrition (PEM).
- Micronutrient malnutrition: involve def. of vitamins or minerals.

Assessment of Nutritional State

Clinical assessment of nutritional status should be an essential step in examination of every infant or child. Precise evaluation is difficult, severe disturbances are readily apparent, but mild one may be overlooked, even after careful evaluation.

It is done by the following steps:

- Careful dietary history: With good nutritional history, an alert physician can detect nutritional disorders very early at the stage of dietetic errors.

- Physical examination: for Anthropometric measures & these include:

  . Wt/ Ht (wasting): indicate acute malnutrition.

  . Ht/ age (stunting) : indicate chronic malnutrition.

  . Wt/age : indicate combined acute & chronic malnutrition.
OFC: affected only in severe cases especially during the 1st 2 years of life.

Skin fold thickness: for subcutaneous fat.

Mid arm circumference: for muscle mass.

BMI (body mass index): for overweight & obesity.

- **Regional examination**: full body examination from above downward for signs of macro- & micro-nutrient malnutrition.

- **Biochemical tests**: albumin, hemoglobin, electrolyte, vitamins, & amino acids.

- **Radiological examination**: for signs of vitamin C & D deficiencies.

**Average Measures for Both Boys & Girls**

Mean of weight/age: (from 2 mo - 12 mo) = age (mo) + 9/2

(above 1 yr) = age (yr) × 2 + 8

Mean of height/age = age (yr) × 6 + 77

**Classifications of Malnutrition**

**Wellcome classification**

Concentrate on Weight for age & presence of edema, here malnutrition divided into:

1- underweight: weight is 60-80% of standard wt/age with no edema.

2- Kwashiorkor: weight is 60-80% of standard wt/age with edema.

3- Marasmus: weight is less than 60% of the standard wt/age with no edema.

4- Marasmic-kwashiorkor: weight is less than 60% of the standard wt/age with edema.

**WHO classification**
Concentrate on Ht for age, Wt for age, & edema, in addition to Wt for Ht.

- Every 5% decrease from the standard Ht/age = 1 z score (1SD).
- Every 15% decrease from the standard Wt/age = 1 z score (1SD).
- Every 10% decrease from the standard Wt/Ht = 1 z score (1SD).

SD= standard deviation.

- normally, the child should be 1 SD or less from the mean for his age.
- if he is more than 1 SD below the mean ........he has mild malnutrition.
- if 2SD or more below the mean ......moderate malnutrition.
- if 3 SD or more below the mean ..........severe malnutrition.
- In general, if the child has malnutrition with edema............severe malnutrition.

PROTEIN-ENERGY MALNUTRITION (PEM)

It includes both Marasmus & kwashiorkor & a third disorder, marasmic kwashiorkor, which has features of both disorders.

NON- EDEMATOUS PEM (MARASMUS)

Most common form of PEM

Mainly due to caloric depletion.

More common in young infant.
Less common in breast feeding infants.

*Causes:*

occur due to insufficient diet, also severe impairment of any body system may lead to marasmus.

*Clinical manifestations*

- It is characterized by failure to gain weight followed by weight loss until emaciation results, making the weight below 60 % with no edema

- At first, the infant may be fretful with increased appetite but later the appetite diminishes

- The subcutaneous fat disappears making the skin loses its turgor and becomes wrinkled and loose especially over the thigh, buttock, & shoulders, loss of fat from the sucking pads of the cheeks often occurs late in the course of the disease; thus, the infant's face may retain a relatively normal appearance compared with the rest of the body, but this, too, eventually becomes affected.

- Infants are often constipated, but may have starvation diarrhea, with frequent, small, greenish mucoid stools.

- The abdomen is flat, but may be distended, with the intestinal pattern readily visible.

- There is muscle atrophy and resultant hypotonia.
- The basal metabolic rate tends to be reduced, as the condition progresses, the temperature usually becomes subnormal and the pulse slows.

Marasmus is divided into 3 clinical grades:

Grade 1: loss of subcutaneous fat over the abdominal wall.
Grade 2: loss of subcutaneous fat over the buttocks & thighs.
Grade 3: loss of subcutaneous fat over the face (senile face).
EDEMATOUS PEM (KWASHIORKOR)

Mainly due to protein deficiency.

Less common than Marasmus.

May become evident from early infancy to about 5yr old, usually after weaning from breast feeding, so called kwashiorkor (means deposed child).

Causes

It due to insufficient intake of protein of good biological value, this may be accompanied by abnormal absorption, synthesis, or loss of protein.

Clinical manifestations

- May initially present as vague manifestations that include lethargy, apathy, or irritability with loss of appetite. When advanced, there is failure to gain weight, then weight loss, edema (usually develops early and may mask the failure to gain weight, it is often present in internal organs before it is recognized in the face and limbs), muscle wasting, hypotonia, flabby subcutaneous tissues.

- Abdominal distention & Liver enlargement may occur early or late in the course of disease due to fatty infiltration.

- Dermatitis is common, it usually occur in irritated areas, not in areas exposed to sunlight (in contrast to pellagra). Dyspigmentation (darkening) may occur after desquamation in these areas, or it may be generalized.

- The hair is sparse and thin, easily extractable, and in dark-haired children, it may become red or gray, in chronic cases become coarse in texture. Flag sign may be present.

- Starvation diarrhea.
Complications of kwashiorkor

- increased susceptibility to infections: measles (may be fatal), T. B., parasitic infections, HIV.
- In severe cases, mental & physical retardation.
- Eventually, if untreated, stupor, coma, and death.

TREATMENT OF MALNUTRITION

We have 3 graduated phases for treatment of malnutrition:

1st phase: Stabilization phase: (24-48 hr)

The child with malnutrition is liable for life threatening sequelae that must be considered immediately, those include:

- **Hypoglycemia:** prevent hypoglycemia by feeding every 2 hr day & night, if it is developed & the patient is conscious, so treated by giving 50 ml of 10 % GW orally, if the child is unconscious, by giving 1 ml/kg of 10 % GW intravenously, & repeated till blood sugar rise & the patient become conscious, then start oral feeding.

- **Hypothermia (temp. less than 35.5 °C):** treated by warming the child by putting him against the mother chest, skin by skin, & cover them with blanket, or use hot water bottle or warm incubator.
- **Infection**: give broad spectrum Ab even without signs of infection.

- **Anemia**: if severe give packed RBCs.

- **Dehydration & electrolytes disturbances**: Because of the difficulty of estimating hydration, oral rehydration therapy is preferred. Malnourished child has low body potassium & high sodium, so, if mildly or moderately dehydrated, give ReSoMal solution (half Na & double K content), if oral ReSoMal solution is not available, give WHO ORS diluted in 1.5 liter, if severely dehydrated give I. V. fluid with frequent estimation of dehydration, particularly during the first 24 hr of therapy.

2nd phase: **Nutritional rehabilitation**: (1 wk-10 days)

- continued antibiotic therapy with appropriate changes.

- Introduction of a diet providing maintenance requirements of energy and protein - F75 (~75 cal/100 ml) along with adequate electrolytes, trace minerals, and vitamins. If the infant is unable to take the feedings from a cup or bottle, administration of feedings by nasogastric tube rather than by the parenteral route is preferred.

  Feedings are initiated with higher frequency and smaller volumes; over time, the frequency is reduced from 12 to 8 to 6 feedings/24 hr. The initial caloric intake is estimated at 80–100 kcal/kg/day. If diarrhea starts or fails to resolve and lactose intolerance is suspected, a non-lactose-containing formula should be substituted. If milk protein intolerance is suspected, a soy protein hydrolysate formula can be used.

  Monitoring is needed for electrolytes imbalances, poor cardiac function, edema, or feeding intolerance, if any of these developed, further increase is stopped until stabilization.

3rd phase: **continued feeding**:

  e end of the second phase, any edema that was present has y been mobilized, infections are under control, the child is ining more interested in his or her surroundings, and his or her
Appetite is returning. He or she should be switched gradually to a recovery diet providing up to 150 kcal/kg/24 hr, F100 can be used. This phase is often carried out at home.

Iron therapy usually is not started until this final phase of treatment to prevent binding of iron to already limited stores of transferrin, which, in turn, may interfere with the protein's host defense mechanisms. There also is concern that free iron during the early phase of treatment may exacerbate oxidant damage, precipitating clinical kwashiorkor or marasmic kwashiorkor in a child with clinical marasmus.

Follow up: to prevent recurrence.