

# Nutrition of the Newborns



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# Intestine

- Organ of the digestion and resorption
- Largest organ of the immunity in the body
- Largest endocrine organ in the body
- Volume of its neural tissue is similar to the volume of the spinal cord

# Length and area of the intestine

- Human fetal intestine grows from 5<sup>th</sup> to 40<sup>th</sup> week of gestation 1000-folds in length
- The lengths doubles in the last 15 weeks of gestation
- The average length of intestine of the mature child is in time of birth 250 cm, absorption area of 1 cm<sup>2</sup> of intestine is due to villi and microvilli 600 cm<sup>2</sup>

# Enteral intake

Fetus swallows 450-500 ml amniotic fluid daily

Early enteral intake (until 5<sup>th</sup> day of life):

- trofic effect,
- hormonal stimulation,
- better motoric activity,
- better feeding tolerance, will reach full enteral nutrition earlier,
- improved liver function.

# Natural nutrition of newborns

- nutrition exclusively with breastmilk
- full 6 months from birth
- early attachment to breast (in first two hours after birth)
- beneficial for both mother and child

# Breastmilk – optimal nutrition

- WHO - Global strategy on infant and young child feeding
  - Goal is to increase the ratio of exclusively breastfed children until 6th month of age to 50%
- **ESPGHAN - 2014: DONOR HUMAN MILK for preterm infants Donor human milk for preterm infants: current evidence and research directions**
- **AAP 2012 Policy statement**
  - All premature infants should be given mother/donor breastmilk
  - Infants with birthweight <1500 g should be given breastmilk fortified with proteins, minerals and vitamins to ensure optimal intake of nutrients
  - If mother's breastmilk is not available or it's use is contraindicated the pasteurised donor milk adequately fortified should be used
- In accordance with the Slovak legislation and with the recommendations of AAP 2012, ESPGHAN and WHO our clinic (NDIM) supports natural nutrition with breastmilk in NICU. It is thanks to the operation of the Human Milkbank in our hospital.

# Breastmilk

- hormonally active
- anti-infectious properties
- quality of nutrients
- growth factors
- enzymes
- fatty acids, cholesterol

# Variability of breastmilk

- Composition and nutrient ratio is not constant and it depends on:
  - the length of lactation
    - colostrum...transitional...mature milk
  - individual regime of the mother
    - nutrition...the amount of sleep...way of expression
  - the gestational age of the baby
    - breastmilk differs in mother who gave birth prematurely from the mother of mature baby



# Composition of the breastmilk

Day	1	2	3	5	14	28
volume (ml/d)	50	190	400	700	1100	1250
Lactose (g/100ml)	4,1 ± 1	4,5 ± 0,7	5 ± 0,75	5,1 ± 0,5	5,4 ± 0,8	4,0 ± 1,1
Fat	2,1 ± 0,9	2,5 ± 0,7	3,0 ± 0,8	3,1 ± 0,4	3,6 ± 0,9	4,0 ± 1,1
Proteins	2,9 ± 0,9	2,5 ± 0,6	2,0 ± 0,2	1,8 ± 0,2	1,6 ± 0,4	1,5 ± 0,27

# Breastmilk and Breastfeeding Promotion

- Natural nutrition in first 6 months of age – exclusive breastfeeding
- WHO/UNICEF 2003 – Global strategy for infant and young child feeding
- 2012 American Academy of Pediatrics supports WHO recommendation and WHO/UNICEF programme „10 steps to successful breastfeeding“
- Governmental programs e. g. National Programme of Health Support
- Health institutions

# Breastmilk and Prevention of Diseases

- Instant effect on gastrointestinal tract function
  - improves motility, digestion and absorption of nutrients in GIT
  - promotes immunity and self-defense, prevents acute illnesses (otitis media, urinary tract infections, respiratory infections, NEC and other GIT infections)
- Long-term effect on immunity
  - reduces the frequency of acute illnesses even after weaning from breastfeeding
  - the length of breastfeeding relates to decrease in incidence of obesity, childhood cancer (lymphomas and leukemia), coronary disease in adulthood, some allergies, DM I, Crohn disease

# Benefits of Breastfeeding for Mother

- Instant
  - acceleration of recovery after birth - oxytocin – involution of uterus
  - reduction of maternal stress reaction - neuroendocrine peptides, oxytocin a prolaktin
  - easier weight reduction
  - prolongation of postpartal anovulation
- Long-term
  - lowers the risk of breast and ovarian cancer
  - osteoporosis – some studies present increase of bone density in breastfeeding women up to 5-10 %
  - cardiovascular diseases – studies show that cumulative lactation decreases the risk of vascular and cardiac diseases
  - Diabetes mellitus – lowers the risk DM II

# Breastmilk, breastfeeding and prevention of allergic diseases

## Theories of immunologic effect of breastmilk

- in mice – inhalation allergens digested together with breastmilk stimulate regulatory T cells and induce **allergen specific tolerance**, key to it is transforming growth factor (TGF)-beta
- probiotics together with protection against infectious microorganisms lead to **subclinical infection stimulating immunologic response** without excessive inflammatory and tissue reaction
- dynamic changes of breastmilk during lactation actively influence immunity

# Epidemiologic studies

- Breastfeeding and atopic dermatitis (eczema)
  - majority of studies do not confirm protection against development of eczema, breastfeeding longer than 6 months occasionally appears as protective factor (PROBIT 2001)
- Breastfeeding and asthma, allergic rhinitis
  - exclusive breastfeeding for 3-4 months decreases the risk of wheezing until approximately 6 years of age, the most significantly in first 2 years of life by decreasing the number of respiratory infections, it does not protect directly against asthma
- Breastfeeding and food allergy
  - exclusive breastfeeding for 3-4 months may decrease the risk of allergy against the cow milk protein up to 18 months

# Bioactive compounds of the breastmilk I

- Hormones (cortisol, somatomedin-C, insulin-like growth factors, insulin, and thyroid hormone)
  - influence the intestinal growth and mucosa function
- Growth factors (eg. EGF and nerve growth factor)
  - GIT maturation (DNA and proteosynthesis, cellular proliferation) and protection against invasive diseases, GIT innervation
- Gastrointestinal mediators (neurotensin, motilin)
  - influence motility
- Free aminoacids (taurin, glutamin)
  - trophic functions, stimulation of enterocytes growth

# Bioactive compounds of the breastmilk II

- Antiinflammatory agents (IL-10, cytokines, PUFA)
  - protection against NEC, GIT inflammation
  - enzymes (PAF acetylhydrolase)
  - degrades PAF, a potent mediator of bowel damage in NEC
- Immunoglobulins (IgA, IgG)
  - protection against foreign antigens and microorganisms
- White cells – 90% are neutrophils and macrophages
- Prebiotics



# Prebiotics in breastmilk

- oligosaccharides in breastmilk (OBM) are a group of complex sugars vastly present in breastmilk
- over 160 OBM were identified so far
- amount and composition of OBM varies between women
- every structurally different OBM has unique function
- OBMs are not digested and act as metabolic substrate for microbes, forming infant's gut microbiome
- OBMs act as false receptors, they block bond of viral, bacterial and protozoan pathogens to the surface of epithelial cells

# Weight categories of newborns

Require different nutritional management according to intrauterine growth:

- **Extremely low birth weight** < 1000g
- **Very low birth weight** < 1500g
- **Low birth weight** < 2500g
  
- Newborns > 2500g usually do not require special nutritional approach

# Specific nutritional requirements

- **Low birth weight (< 2500g)**
  - prematurity /hypotrophy
- **Gastrointestinal involvement**
  - congenital malformations
  - short bowel syndrome
  - secretory and absorption function disorders
- **Inherited metabolic diseases**

# Nutritional goals

- growth after discontinuation of nutrients intake from mother via placenta
- appropriate growth rate and increase in lean not fat mass

Early and regular feeding ensures to newborn:

- adequate supply of glucose to brain
- early supply of proteins and fats to prevent catabolism
- prevention of failure to thrive and diseases like BPD and NEC
- optimisation of neurodevelopment

# Reasons for withholding enteral intake in first days of life

- low Apgar score
- umbilical catheters
- apnea and bradycardia
- mechanical ventilation, CPAP
- vasoactive medication
- PDA and/or indomethacin
- availability of parenteral nutrition

# Consequences of total parenteral nutrition and withholding of enteral nutrition (first changes in 48 hours)



# Prevention - minimal enteral feeding

- improves feeding tolerance and growth
- decreases the need of phototherapy
- less cholestasis
- milder osteopenia
- releases gastrointestinal trophic hormones
- improves gut motility
- without increase of complications (eg. NEC)

# Enteral feeding of extremely preterm newborns

*The ability to tolerate enteral intake depends on the actual degree of the gastrointestinal development:*

- length and surface of the intestine
- swallowing, function of the gastroesophageal sphincter, stomach emptying and intestinal motility
- digestion, absorption and assimilation



# Mechanical obstacles

- discoordination of sucking and swallowing leads to the necessity of tube feeding
- tonus of esophageal sphincter is in prematures lower (4mm Hg) in comparison with mature babies (18mm Hg)
- delayed stomach emptying and intestinal motility disorders
- passage is delayed in premature babies (2-5 days vs. 12-24hours in children < 1250g up to 10 days)

# Digestion and absorption - proteins

- High demand 3,5-4g/kg/day
  - matches 330ml/kg/day of breastmilk
  - gastric pH 5,5-7 first 24-48hrs of life
  - low basal and pentagastrin stimulated HCl production
  - proteases – enterokinase: in 26<sup>th</sup>-30<sup>th</sup> gw 6% activity and in mature babies 29% activity

# Digestion and absorption - lipids

- mature and premature newborns have relative pancreatic insufficiency comparing to adults
- decrease synthesis and reabsorption of bile acids
- lipase in breastmilk of mothers of premature babies is higher than of mature babies, promotes fat digestion
- SCT a MCT do not require bile acids for digestion

# Digestion and absorption - carbohydrates

- in 26<sup>th</sup>-34<sup>th</sup> gw is lactase activity 30% of mature babies, sacharase and maltase 70%
- early feeding increases lactase activity (on day 10 to 100%)
- feeding with breastmilk increases lactase activity more than formula

# Intestinal microbiome

- complete set of microbes (bacterias, fungi, viruses) naturally occurring in human gut
- influences the immune system and inflammatory response in GIT in a positive or negative way
- microbiome is influenced by exogenous factors:
  - antibiotic therapy
  - microbiologic ecology of the environment
  - nutrition
  - prebiotics, probiotics, „postbiotics“

# Micronutrients

- Ca, P: osteopenia of prematurity
- Zn: growth retardation, immunodeficiency, dermatitis, CNS development
- Fe: hemoproteins – CNS development, increased oxidative stress – IVH, ROP, BPD, NEC
- Se, Cu, I – cofactors – neurodevelopment

# Nutritional sources

## *Natural nutrition:*

- breastmilk
- donor breastmilk

## *Complementary nutrition:*

- fortificators

## *Formulas:*

- for premature
- standard
- soya based
- elementary
- aminoacids

# Natural nutrition

- lower incidence of NEC
- higher IQ
- lower incidence of sepsis
- better feeding tolerance
- better bone mineralization
- blood pressure – lower risk of hypertension
- lower risk of overweight, insulin resistance



## Selected properties and effects of breastmilk

- lactoferrin – binds iron (that way decreases its availability for *E. coli* and other organisms)
- lysozyme – lysis of bacterial cell walls
- sIgA – protective factor
- oligosaccharides – *Lactobacillus bifidus*
- Epidermal growth factor – intestinal development

# Breastmilk

Risk of  
cardiovascular  
disease

- Hypercholesterolemia
- Obesity
- Diabetes type II
- Hypertension

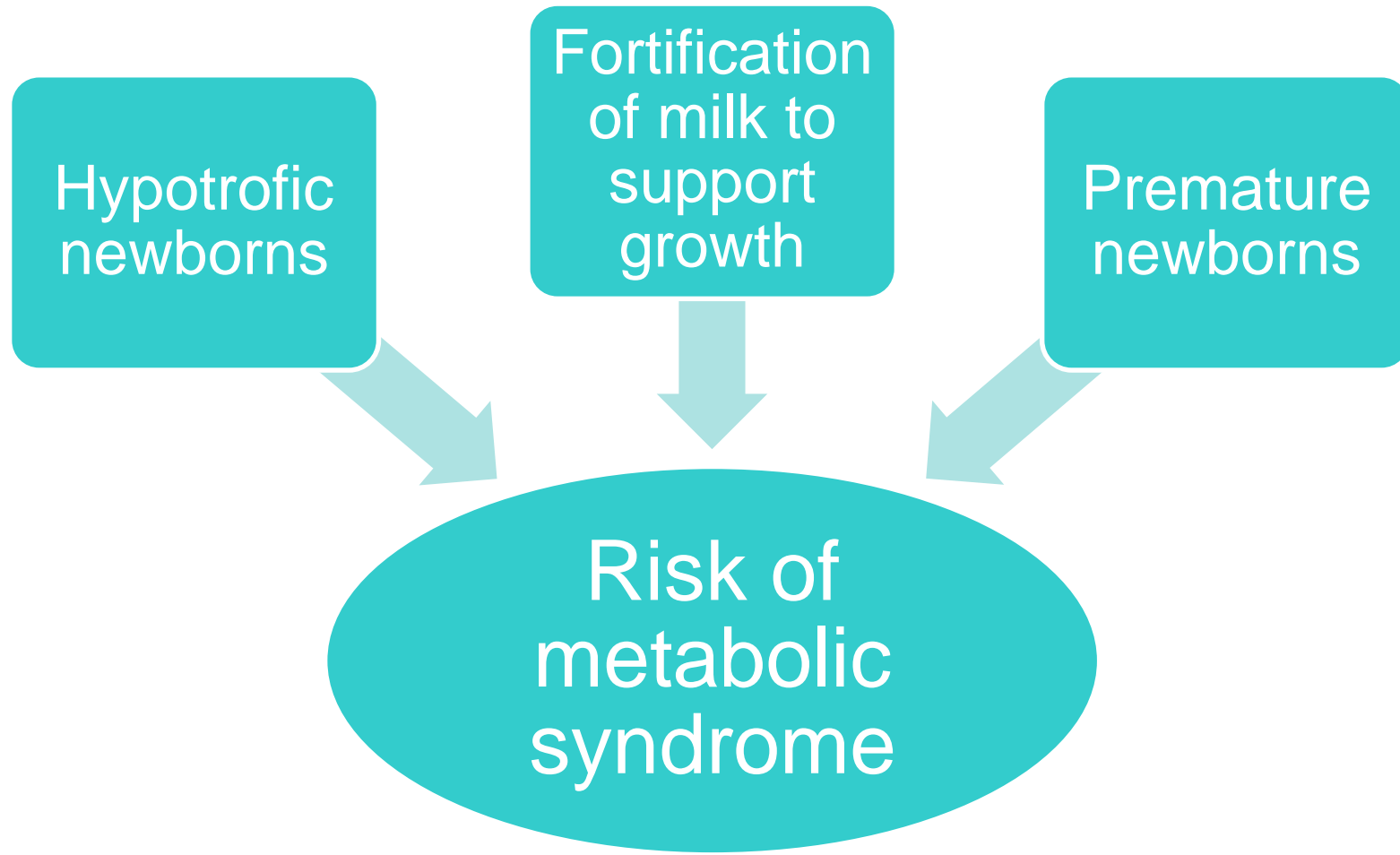
# Lipid system of the breastmilk

- main energy compound (50%)
- high ratio of essential FA
- triglycerides ratio improves the fat absorption
- contains lipase
- cholesterol – brain development
- LC PUFA (DHA a ARA)
  - present in breastmilk, not in cow milk
  - neurodevelopment and retinal development

# Nutritional programming

- stimulus or insult if acting in critical point of development can result in permanent or long-lasting effect on structure or function of the organism:
  - obesity, insulin resistance, diabetes mellitus, cardiovascular diseases, impaired neurodevelopment, decreased visual acuity

# The effect of postnatal growth acceleration



# Risks of growth acceleration in early infant age

insulin resistance

endothelial dysfunction – risk of early atherosclerosis

obesity, dyslipidemia

hypertension

→ **Cardiovascular disease in adulthood**

# Conclusion for praxis

- **Early nutritional support**
  - reduces growth restriction and decreases the need of increased nutritional intake after discharge
- **Premature babies with the weight appropriate to corrected age**
  - should be breastfed after discharge
  - if on formula, should be given normal infant formula
- **Premature babies with the weight low to corrected age**
  - are in risk of long-term growth restriction
  - if on breastmilk, need fortification to increase the nutrient intake
  - if on formula, recommended post-discharge formula