Composition of Human Milk
The Latest Scientific Findings

The Uniqueness of Human Milk

- Continually changing
- Living
- Tailor-made

Overview

- Incredible human milk
- Anatomy review
- Continually changing, living, and tailor-made
- How the breast makes milk
- A new discovery
Incredible Human Milk

• Until recently, research in the field of lactation was lacking

• Scientific studies demonstrate human milk is best for ALL babies

• Now we have evidence-based guidelines for best practices
Evidence-Based Benefits for Baby

- Less risk of respiratory illnesses, otitis media, diarrhea, UTIs, SIDS
- Promotes mother-baby bonding
- Optimal nutrition
- Promotes brain development


More Benefits

- Protective against some childhood lymphomas and leukemias
- Decreases risk of Type I and II diabetes
- Improves growth, intelligence, and brain maturation
- Development of immune system

(Sa et al. Breastfeeding and maternal/infant health outcomes in developed countries. Scand J Public Health 33:2005.)

Extra Protection for Vulnerable Infants

- Standard of care in NICU (AAP 2005)
- Protects the gut
- Reduces incidence of NEC
- Protection from late-onset sepsis

Extra Protection for Vulnerable Infants

- Breastmilk improves neuro-developmental outcome

Gyral development in the human brain. LATE PRETERM POPULATION


Benefits for Mom Include...

- Natural completion of the reproductive cycle
- Decreased risk of cardiovascular disease, such as hypertension, heart attack or stroke (Schwarz, EB et al. Obstetrics & Gynecology 2009.)
- Decreased risk of developing Type II diabetes (Steube AM, et al. JAMA 2005.)
- Decreased risk of ovarian, endometrial and premenopausal breast cancers (Steube, AM et al. Archives of Internal Medicine 2009.)

The longer a woman breastfeeds throughout her lifetime, the more protection she receives.

Long-Term Protection

- Celiac Disease
- Ulcerative colitis
- Diabetes – Type 1 and Type 2
- Obesity
- Cholesterol metabolism
- Other autoimmune disorders

Benefits for the World

- Decreases infant mortality
- Improves health outcomes
- Decreases healthcare costs
- Child spacing
- No waste of energy
- No packaging – no landfill waste

New Findings in Breast Anatomy

Anatomy of the Lactating Breast

Dr. Donna Geddes (on left)
How is Breastmilk Made?

Alveoli - group of lactocytes

Blood supply
Myoepithelial cells
Lactocyte
Milk duct

Clinical Implications of Breast Anatomy Findings

- Importance of proper latch
- Importance of proper flange size/fit
- Avoid pressure on ducts
- Drain breasts completely to maximize milk supply
- Breastfeeding and pumping may be individualized
- Surgical implications
Breastmilk Composition

• Continually changing
• Living
• Tailor-made

Humans are Mammals
Breastfeeding

Not only best nutritionally, but plays an important role in immune system development and neurological development or "brain wiring"
What is Involved in the Process?

Continually Changing:
...throughout the feeding...
...throughout the day...
...as the baby grows...

There are over 100,000 components in human milk and we currently only know the function of about 1000

Charles Czank, UWA

Highlights of a Few Components
Highlights of a Few Components

- Secretory IgA
- Lactoferrin
- Lysozyme
- Antistaphylococcal and antistreptococcal factors
- Antiparasitic factors
- Anti-inflammatory properties
- Immunoglobulins
- Interferon
- Anti-tumor cells
- Bifidus factor
- Enhanced bioavailability of nutrients such as iron and zinc
- New discovery???

Continually Changing Breastmilk

- Colostrum
- Transitional
- Mature
Colostrum
• Earliest milk produced
• “Liquid Gold”
• Contains antioxidants
• Contains antibodies and anti-inflamatory properties
• Yellow color due to beta-carotene
• Laxative effect increases stooling and decreases hyperbilirubinemia

Transitional Milk

Mature Human Milk
• Higher in volume than colostrum
• Lower in caloric density than colostrum
• 2 weeks-6 months: 750-1000 mL/day
Macronutrients (fats, lactose and proteins)

Constantly Changing

Mitoulas et al. (2002)

Fat (g/L)

Protein (g/L)

Lactose (g/L)

Mitoulas et al. (2002)

Fatty Acids

Mitoulas et al. (2002)

Breastmilk Composition

Living . . .

Alive . . .
Living Microscopic View of Breastmilk

Lymphocyte
Microscopic View of Breastmilk

Living

- Macrophage

Why??

Microscopic View of Breastmilk

Living

- Lactocytes

Breastmilk Composition

- Tailor-made to biologic specificity of human infants
  - In other words, "species-specific"
Tailor-made Ingredients of Breastmilk

- Proteins
- Fats
- Carbohydrates
- Others

Proteins

- Secretory IgA
- Lactoferrin
- α-lactalbumin
- Caseins
- Lysozyme

Fats

- Provide approximately 50% of the calories, contains essential fatty acids, and delivers fat-soluble vitamins
- Most variable component – changes within a feeding, during the day, between breasts, age of baby, and among women
- AA: Arachidonic acid plays a role in infant growth and is especially important for brain development
- DHA: Docosahexaenoic acid plays a central role in cognitive development – especially vision and nerve supply
Brain Development

Gyral development in the human brain.

LATE PRETERM POPULATION

Carbohydrates

<table>
<thead>
<tr>
<th>Lactose</th>
<th>Oligosaccharides</th>
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<tbody>
<tr>
<td>• The major carbohydrate in human milk.</td>
<td>• Probiotic activities</td>
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<tr>
<td>• Supplies ~40% of infant's energy.</td>
<td>• Anti-infective properties</td>
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<tr>
<td>• Important for brain development.</td>
<td>• Act as decoys</td>
</tr>
<tr>
<td>• Human milk contains one of the highest concentrations of lactose of any mammal.</td>
<td>• ~130 oligosaccharides in human milk.</td>
</tr>
<tr>
<td>• Used by brain for energy.</td>
<td>• Formula may contain one oligosaccharide (plant-based).</td>
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<td>• Helps develop central nervous system.</td>
<td>• May protect against urinary pathogens.</td>
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<td>• Improves infant's absorption of calcium.</td>
<td>• Play role in infant gray matter development.</td>
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Other Components

• Nucleotides
• Carnitine
• Taurine
• Enzymes
• Growth factors
• Hormones
• Vitamins and minerals
• Even more…
How Does This Incredible Process Work?

How is Human Milk Manufactured?
Lactocyte – milk making cell

Pathways for Milk Synthesis and Secretion into Alveolus
Four Major Transcellular Pathways and One Paracellular Pathway
Pathway 1: Exocytosis

Lactocyte – milk making cell

Pathway 2: Lipid Secretion
Pathway 2: Lipid Secretion
Lactocyte – milk making cell

Pathway 3:
Transport Across Cell Membrane

Pathway 3:
Simple Transfer Across Cell Membrane
Lactocyte – milk making cell
Pathway 4: Pinocytosis/Exocytosis of Immunoglobulins

Lactocyte – milk making cell

Pathway 5: Paracellular Pathway
Pathway 5: Paracellular
Lactocyte – milk making cell

Tailor-made
Lactocyte – milk making cell

Tailor-made

<table>
<thead>
<tr>
<th>Alphalactalbumin</th>
<th>Lactoferrin</th>
<th>Lysocysteine</th>
<th>Oligosaccharides</th>
<th>Urea</th>
<th>sigA</th>
<th>EGF</th>
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<tr>
<td>Alphalactalbumin</td>
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<td>AA</td>
<td>EGF</td>
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<td>Alphalactalbumin</td>
<td>Casen</td>
<td>Glucose</td>
<td>Lactose</td>
<td>Sodium</td>
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Immunological
Developmental
Nutritional
Clinical Implications

• Human milk and infant formula are not equal
• All mothers deserve to make an informed decision
• Human milk has life-giving benefits and mothers need support and protection of their breastfeeding

Clinical Implications

• Importance of human milk use in the NICU
• There is a need to participate in research
• Staff need education to learn the value of human milk and how to support the mother and baby
New Discovery

What is New?

Cregan et al. 2007

New Discovery

Stem Cells in Breastmilk

Cregan et al. 2007

New Discovery

What is a Stem Cell?

Multipotent

Breast stem cell

Ductal Lactocyte Myo-epithelial

Add stimuli

Pluripotent

Bone Muscle Nerve

Add stimuli
New Discovery
Putative Stem Cells – Stained Nestin Positive

Commitment to Research and Education

- Funding research to increase the body of knowledge in the field of lactation
- Disseminating the results of both general and applied research to health care professionals throughout the world
- Striving for excellence in meeting our responsibility to promote the health and well-being of mothers and babies by promoting breastfeeding and the use of human milk

Human Milk

- Constantly changing
- Living
- Tailor-made
Acknowledgements

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