HYPOGLYCEMIA, HYPERBILIRUBINEMIA, EXCESS WEIGHT LOSS, AND DEHYDRATION: BREASTFEEDING'S NEMESIS QUARTET

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NEMESIS was the goddess of indignation against, and retribution for, evil deeds and undeserved good fortune.

Nemesis directed human affairs in such a way as to maintain equilibrium.
Her name means ‘she who distributes or deals out’.

Happiness and unhappiness were measured out by her, care being taken that happiness was not too frequent or too excessive.

...and he who is blessed with too many or too frequent gifts of fortune, is visited by her with losses and sufferings, in order that he may become humble...

Nemesis was thus a check upon extravagant favours conferred upon man by Tyche or Fortune...

https://www.theoi.com/Daimon/Nemesis.html

Nemesis and Tyche
Athenian red-figure amphora C5th B.C.
Antikensammlung Berlin

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Nemesis then, is not an end to all good things

- Beware complacency
- Anticipate problems
- Intervene just in time and just enough
OBJECTIVES

At the end of the session, the attendee will be able to:

• Apply principles of breastfeeding physiology to medical conditions in newborns

• Determine when supplementation of breastfeeding is medically appropriate
OVERVIEW

• Review breastfeeding physiology in mother and baby
  – Causes for delay in lactogenesis II
• Assess milk transfer
• Excess weight loss, and methods to monitor intake
• Infants at risk for hypoglycemia
• Infants at risk for hyperbilirubinemia
BREAST DEVELOPMENT

Early Pregnancy
- Increased branching
- Acini form and mature progesterone, prolactin and placental lactogen

Mid-Pregnancy
- Acinar cells differentiate and begin secretory function

Postpartum
- Colostrum secretion increases
- Secretion changes to mature milk Prolactin, and oxytocin
  Insulin, corticosteroids, TRH
HORMONAL CONTROL OF LACTATION

PLACENTA DELIVERED

- Progesterone level drops

Hypothalamus

- Prolactin releasing factor rises

Anterior Pituitary

- Prolactin

Breast acini

Milk Secretion

Feedback Inhibitor of Lactation (FIL)

Posterior Pituitary

- Oxytocin

Myoepithelial cells

Milk Excretion

SUCKLING

- Direct Nerve stimulation

- Posterior Pituitary
PROLACTIN
- **To establish** breastfeeding
  - High baseline level (>200ng/dL)
  - Frequent sustained surges – **strength, and duration of suck**
  - **More responsive at night**

- **After 2 months**, baseline is highly variable
  - Surges are still present, and necessary
  - **Night surges may be necessary to maintain milk supply**

- **Drop in nighttime prolactin surges** when night feeds stop allows ovulation to begin

OXYTOCIN
- Letdown reflex
- Necessary at each breastfeed for milk ejection from acini and ductules
- Bonding, reduces bleeding, uterine involution

LACTATION INHIBITION FACTOR
- Secreted by acinar cells into the milk
- Rising concentration within each acinus feeds back to suppress milk secretion by the acinar cells

WHO Breastfeeding Counseling Training Program
https://www.who.int/nutrition/publications/infantfeeding/bf_counselling_participants_manual1.pdf
MILK VOLUMES IN THE FIRST WEEK

- 88 NSVD, 97 C-section
- Test weights with each feed (more reliably performed day #2-6)
- Vaginal delivery babies regained birthweight earlier

Breast milk transfer (mL/kg) over the first six postnatal days to infants born by c-section or vaginal delivery

LACTOGENESIS STAGE II

• Delayed lactogenesis: Milk transfer <10mL/feed at 60h

• Validated maternal feeling of fullness or leaking = onset of Lactogenesis II

• Delayed: has not occurred by 72h

Chapman DJ, Perez-Escamilla R. J Nutr 2000
MILK VOLUME IN THE FIRST WEEK

Extrapolating to volume of milk per feed for a 3.5 kg baby, 8-12 feeds each 24h period.
## INSUFFICIENT MILK SUPPLY

### Poor Milk Removal
- Separation
- Poor position, latch, effort
- Early use of pacifier, bottle
- Scheduled feeds
- Prematurity

### Maternal Stress
- Complicated labor, prolonged labor with lack of sleep
- Cesarean delivery (nationally 24% -37% of all deliveries, CDC)
- Pain
- Maternal medications (decongestants, antihistamines, estrogen, combination OCPs)

### Medications
- Orofacial conditions: Cleft, retrognathia, Down Syndrome, tongue tie
- Maternal Hormonal disorders: PCOS, Metabolic Syndrome, Retained Placenta
- Breast Surgery: Reduction, Augmentation, piercing, other breast surgery
- Primary Glandular failure: Hypogalactia (*no change in breast through pregnancy*)

About 5% of mothers are estimated to have a true inability to make milk

Neville MC, Morton J. Physiology and Endocrine Changes Underlying Human Lactogenesis II. Journal of Nutrition 2001
NEWBORN BEHAVIORAL PHASES IN THE FIRST HOURS

BIRTH CRY
RELAXATION
No activity of limbs, shoulders, or trunk

AWAKENING
Small head thrusts
Limb & shoulder movements

ACTIVE
Movements of limbs
Rooting
Look at breast
Look at mom’s face

CRAWLING
Soliciting sounds

FAMILIARIZATION
Licking the areola

SUCKLING

SLEEPING

BEHAVIORS THAT ARE NOT RESTRICTED TO A PHASE
• Eyes look mainly at breast, mother’s face
• Soliciting sounds
• Hand-to-mouth activity
• Hand-breast-mouth
• Rooting
• Rocking/pushing

BEHAVIORS RELATED TO SUCCESS IN FINDING THE AREOLA (18/28 infants)
1. Increased soliciting sounds
2. Hand-breast-mouth movement
   (100% of infants vs 47% without)
3. Time to first crawling movement

Negative: Exposure to meperidine

A-M Widström et al. Newborn behaviour to locate the breast when skin-to-skin. Acta Paediatrica 2010
IS MY BABY GETTING ENOUGH?

How do I know he is getting enough?

She seems to be always hungry. I don’t think she is getting enough

I don’t feel like I have any milk

I never have enough milk – I always have to use formula

I squeezed my breast and nothing came out

50% OF MOTHERS EXPRESS CONCERNS ABOUT MILK SUPPLY
SOCIAL AND CULTURAL CONTEXTS

• Family and peer experience with breastfeeding is limited
  – Frequent feeds seen as evidence of insufficient milk
  – Previous bad experience: medical cause for delay in lactogenesis, poor/ineffective lactation support

• ‘Los Dos’ - Formula is started right away, may have a long duration of breastfeeding
  – and mothers see themselves as breastfeeding effectively for a long duration

• Early milk is ‘weak’, ‘thin’
  – Colostrum is a thin yellowish fluid
  – Caloric content is lower (56-60 kcal/100mL vs 60-75 kcal/100mL for mature milk)

• Baby may get ‘too attached’ to the breast
  – Early return to work; Inability to pump at work; cultural construct
  – Babies can go on a ‘bottle-strike’
“HOW DO I KNOW HE IS GETTING ENOUGH?”

- Active feeding for 10-20 min, at least on one side
- Swallows every 2-3 sucks
- Hands relax and open, come off the breast naturally when feeding ends

- Sleeps 1-2 hours (except with cluster feeding)
  - *Cluster feeding* – short feeds of 5-10min alternating with 45-60min of shallow sleep, lasting 3-6 hours, followed by deep sleep for the same duration as the cluster

- Feed 8-12 times in a 24h period
  - May be sleepy for several hours on first day

- Day 2-3 onward:
  - Audible swallows follow each suck
  - Smear of milk on mouth
  - Stools transition by day 3-4

- Number of wet and dirty diapers match day of life
EXPECTED WEIGHT LOSS

• Weight loss of 2-3% per day
• Weight loss ceases by day #5
• Upto 10% weight loss
  – 5% of vaginal and 10% of C-section infants will lose >10% of weight by 48h
• Regain birth weight by 10-14 days
• Thereafter, gain an average of 30-45 g/day
  – Measured over 7 days, then averaged
‘NEWT’ – NEWBORN WEIGHT TOOL

Flaherman V et al. Pediatrics 2015
- Trajectory of weight loss
- Quality of breastfeeding
  - Progress of lactogenesis
  - Milk transfer
- Large weight loss in first 24 h
  - Diuresis
  - Faulty birth weight
- Reweigh
  - 10-12 hours later
  - Test weights around feeds
DEHYDRATION

• Sunken fontanelle
• Sunken eyes
• Tacky to dry mucus membranes
• Skin tenting (abdomen)
• Capillary refill >2 seconds (nail bed)
• Sustained tachycardia

• High serum sodium
HYPOGLYCEMIA

Transient low glucose in normal to all mammalian species
• Nadir at 1-2 hours after delivery - as low as 30 mg/dL (Alkalay et al, 2006)
• Feeding does not change glucose in first 24 h
  – In normal newborns, mean plasma glucose level 57–69 mg/dL with no feeding for 24 hours (1950)
• No clear data that low blood sugar without symptoms causes neurological damage

Definitions are arbitrary
• American Academy of Pediatrics guidelines: upto 48 hours
  – < 40mg/dL in the first 4 hours of life
  – < 45 mg/dL from 4 hours to 48 hours
  – < 47mg/dL is being used increasingly
  – > 50 mg/dL by 48-72h of life (Alkalay et al, 2006)

Immediate action:
• < 25 mg/dL
• < 45mg/dL WITH clinical signs
INFANT AT-RISK FOR HYPOGLYCEMIA

• Imbalance between supply of fuel (glucose or alternative fuel) and use of fuel

• Regulatory mechanisms are not working
  – Gluconeogenesis, glycogenolysis, ketogenesis
  – Ketones could be used for neurological function
‘AT-RISK’ FOR HYPOGLYCEMIA

Imbalance between supply of fuel and its use

- Infants of diabetic mothers
- Exposure to high sugar levels
- High insulin levels in baby lowers blood glucose
- May take 12h for pancreas to adjust
- Monitor for at least 12 hours of life

Lack of appropriate substrate for counter-regulation

- Premature Infants
- Low glycogen stores
- Fuel depends solely on adequate volume of feeds
- Monitor for at least 24 hours of life

- Large for gestation (LGA)
- Low brown fat deposits

- Small for gestation (SGA)

OTHER CONDITIONS

• Sustained low Apgar
• Very high hematocrit
• Maternal medications
  – Beta-agonists: terbutaline
  – Beta-blockers
<table>
<thead>
<tr>
<th>Table 4. Clinical Manifestations of Possible Hypoglycemia</th>
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<tbody>
<tr>
<td>Irritability, tremors, jitteriness</td>
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<tr>
<td>Exaggerated Moro reflex</td>
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<tr>
<td>High-pitched cry</td>
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<tr>
<td>Seizures or myoclonic jerks</td>
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<tr>
<td>Lethargy, listlessness, limpness, hypotonia</td>
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<tr>
<td>Coma</td>
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<tr>
<td>Cyanosis</td>
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<tr>
<td>Apnea or irregular breathing</td>
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<tr>
<td>Tachypnea</td>
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<tr>
<td>Hypothermia; temperature instability</td>
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<tr>
<td>Vasomotor instability</td>
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<td>Poor suck or refusal to feed</td>
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- Jitteriness
- Tachypnea
**MANAGEMENT**

- Feed in the first hour
- Facilitate skin-to-skin
- Check glucose AFTER first feed
- Recheck before feeds, every 3 h
- Feed frequently, 10-12 times/24h

1. Mom’s breast
2. Mom’s milk
3. Formula – 1-5mL/kg

- Intravenous glucose
  - Below 25 mg/dL
  - Symptomatic
  - Sustained or repeated low glucose < 35 mg/dL

- Consider nasogastric feeds if preterm, sleepy or tired
- Avoid NG feeds if ill and refusing feeds
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3. Formula – 1-5mL/kg

Stabilizes glucose

Do not delay a feed in order to measure the glucose

- Prioritize feed at breast
- Do not feed formula ‘just in case’
HYPOGLYCEMIA MANAGEMENT – NEW DIRECTIONS

• Dextrose gel (40% dextrose gel 200 mg/kg): Sugar Babies Study
  – ~ 250 babies in each group
    • Reduced NICU admission for hypoglycemia (14% vs 21%, OR 0.54)
    • Reduced formula use at 2 weeks (4% vs 13%, OR 0.34)
    • Time to normalize glucose level and the total duration of low glucose was not changed

• Antenatal colostrum expression: Diabetes and Antenatal Milk Expressing [DAME]
  – Low risk women w/ diabetes, hand expression starting at 36 weeks (~300 each group) for no more than 10 min, 2 times a day
    • No increase in preterm infants
    • No increase in maternal hypoglycemia
  – For women having a First baby
    • More likely to exclusive breastfeed in first 24 hours (69% vs 60%, RR 1.21)
    • More likely to exclusively breastfeed during hospital stay (upto 7d) (57% vs 49%, OR 1.21)
  – For women with previous babies – no difference

Harris DL et al, Lancet 2013; Foster DA et al, Lancet 2017
HAND EXPRESSION

- Hold well behind the areola
- Compress fingers towards each other (not towards nipple)

“I squeezed my breast and nothing came out”

http://med.stanford.edu/newborns/professional-education/breastfeeding/hand-expressing-milk.html
RESULTS WITH EXPRESSION: HAND EXPRESSION & PUMPING

- **Quantity** increases with relaxation, music, warmth, massage, increased frequency
- **Protein** higher with hand expression and large electric pump compared to manual pump
- **Fat** content higher with breast massage during pumping

- Hand expression may lead to longer duration of breastfeeding

HYPOGLYCEMIA – KEY POINTS

• Skin-to-skin
• Feed within the first hour
• Prioritize human milk feeds
  – Work hard to bring in milk

• Non-human milk feeds
  – Should be medically necessary
  – Use ‘In addition to’, not ‘instead of’ mom’s milk
  – Set limits to volume
  – Set a clear end point
HYPERBILIRUBINEMIA

• Jaundice: bilirubin >5 mg/dL
• Almost all babies get jaundice
• ~ 10% will attain levels that need treatment
PHYSIOLOGY OF JAUNDICE

- Red cell death
- Hemoglobin breakdown
- Bilirubin:
  - Free
  - Albumin bound
- Conjugation
- Uptake into liver cells
- Glucuronyl Transferase
- Excretion from liver cells
- Excretion
- Enterohepatic recirculation
PHYSIOLOGY OF JAUNDICE GONE AWRY

- Red cell death
- Hemoglobin breakdown
- Bilirubin Free & albumin-bound
- Conjugation
- Uptake into liver cells
- Excretion from liver cells
- Conjugation
- Excretion

- Rh or ABO
- High cell count
- Red cell defects

Glucuronidases in meconium uncouple the bilirubin, which gets reabsorbed

- Glucuronyl Transferase

- Poor intake leads to less stool output
- Low levels at birth
- Slower rise in preterm infants, infants of diabetic mothers
- Enzyme function defects

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- Low levels at birth
- Slower rise in preterm infants, infants of diabetic mothers
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GREATER RISK FOR NEUROTOXICITY

• Faster production or Slower conjugation
  – Red cell breakdown
  – Prematurity
  – Liver enzyme defects

• Blood brain barrier more vulnerable
  – Prematurity
  – Acidosis
    • Sustained low Apgars
    • Sepsis

Early Rapid rise
NEUROTOXICITY

Bilirubin Induced Neurologic Dysfunction

• Level at which brain damage occurs
  – >35 mg/dL: all infants affected
  – >25 mg/dL: 1 in 5 affected
  – Undetermined biologic susceptibility

• Symptom progression
  – Lethargy, low tone, poor feeding
  – Variable tone, irritable cry
  – Increased central tone: arched neck, back
  – 10% may have seizures
  – death

• Long term consequences
  – Hearing loss
  – Kernicterus: stiffness, movement disorders (slow writhing, fast jerky), seizures, cognition is preserved in comparison

Johnson L, Seminars in Perinatology 2011
MANAGEMENT GOALS

• Prevent damage

• Not cause undue alarm

• Necessary intervention
MANAGEMENT

• Monitor
  – Risk for higher levels
  – Risk for neurotoxicity
  – Assess clinically, lab test or both, before discharge

• Prevent
  – Optimize breastfeeding

• Treat
  – Based on nomograms
  – Treatment at levels lower than threshold is NOT recommended
    • Exception: Within 2 mg/dL of threshold, consider biliblanket for home use
  – Routine supplementation is NOT recommended
  – Routine intravenous fluids are NOT recommended

• Educate
  – Feeding: frequent, on cue, focus on milk transfer
  – Output: # to match day of life
  – Symptoms: lethargy, poor feeding (suck less strong, shorter duration)
INDICATION FOR SUPPLEMENTATION IN JAUNDICE

- Very high levels – approaching exchange transfusion threshold
- No response or increase despite adequate phototherapy
  - Unclothed
  - Intensity of phototherapy (30-60 µW/cm²)
- Poor Milk intake
  - Poor feeding
    - Effect of high bilirubin level
    - Effect of phototherapy
  - Delayed lactogenesis
  - Low stool output
  - Signs of dehydration
LATE PRETERM INFANT

• Maternal conditions that led to prematurity may interfere with breast milk production
• Separation
• Neurological immaturity, and deceptively mature appearance
  – Oro-motor incoordination
  – Decreased stamina
  – Suboptimal milk transfer despite appearance of good feeding
FEEDING THE LATE PRETERM INFANT

- Early skin-to-skin
- Teach mom hand expression colostrum early [https://med.stanford.edu/newborns/professional-education/breastfeeding/hand-expressing-milk.html](https://med.stanford.edu/newborns/professional-education/breastfeeding/hand-expressing-milk.html)
- Cue-based feeding (responsive feeding) of 8-12 feeds in a 24h period
  - but awaken at least every 4 hrs

- If feeding lasts for longer than 40min, evaluate milk transfer
- For ineffective milk transfer, suboptimal supply, and/or weight loss of >7%
  - Breast compression while infant suckles to increase milk transfer
  - Nipple shield to assist latch
  - Supplementation of 5-10 mL per feeding on day 1, 10-30 mL per feeding thereafter
- Triple feeding regimens (breastfeed, supplement, express) as feasible
- Iron and vitamin D supplementation
SUMMARY

• Anticipate
• Reassess breastfeeding frequently
• Anticipatory guidance

• If supplementation is necessary
  – Justify necessity
  – Set parameters for use, including cessation
  – Use methods other than bottle if working on latch
RESOURCES

• Academy of Breastfeeding Medicine protocols
  https://www.bfmed.org/protocols

• American Academy of Pediatrics
  – Hyperbilirubinemia guidelines:
    https://pediatrics.aappublications.org/content/114/1/297
  – Hypoglycemia guidelines:
    https://pediatrics.aappublications.org/content/127/3/575.short and
    https://pedsinreview.aappublications.org/content/38/4/147

• National Perinatal Association guidelines for care of late preterm infants
  – https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3697041/

• Breastfeeding videos
  – https://globalhealthmedia.org/videos/breastfeeding/
QUESTIONS?
MILK TRANSFER

• Anatomy: baby mouth, mom’s breast
• Latch
• Position
• Oromotor coordination
  – Rooting reflex
  – Suck reflex
  – Suck-swallow coordination
'SLEEPY’ INFANT

• Normal between 4-6h and 12-18h of life
• Exhausted infant
  – Waiting to feed until baby cries
  – Delaying feeds to achieve a schedule
• Underlying condition that is sedating, or has lead to poor milk transfer
  – Maternal medications (multiple sedating medications)
  – Prematurity
  – Hypoglycemia
  – Jaundice
  – Excess weight loss

Teach feeding cues

- Assess neonatal reflexes
- Assess oromotor coordination
- Observe a feeding
PREREQUISITES FOR GOOD LATCH

Rooting reflex
When something touches lips, baby opens mouth puts tongue down and forward

Sucking reflex
When something touches palate, baby sucks

Swallowing reflex
When mouth fills with milk, baby swallows

WHO Breastfeeding Counseling Training Program
https://www.who.int/nutrition/publications/infantfeeding/bf_counselling_participants_manual1.pdf
UNABLE TO LATCH

• Oro-motor function
  – Small chin, retrognathia
  – Poor root or suck reflex
  – ankyloglossia

• Preterm or very SGA infant
  – small mouth
  – Poor effort/energy

• Nipple anatomy
  – Flat or inverted nipples
ASSESS INFANT’S ORAL FUNCTION

• Palpate for hard and soft palate defects
• Assess strength and coordination of suck

• Ankyloglossia
  – ~4% of infants
  – 25% of infants with ankyloglossia have breastfeeding difficulties (baseline 3%)

  – Hazelbacker tool: Appearance and Function
    – Appearance – when lifted, elasticity, length, attachment site to tongue and inferior alveolar ridge (10)
    – Function – lateralization, lift, extension, spread of anterior tongue, cupping, peristalsis, snapback (14)

Amir LH, 2006
NIPPLE ANATOMY

• Inverted and flat nipples -The “pinch” test
  – compress areola about an inch behind the nipple
  – Flat nipple: stays in the same plane as the areola
  – Inverted: the nipple retracts, or becomes concave
  – Note: true flat or inverted nipples will not become erect with stimulation or cold exposure

• Hoffman exercises vs. breast shells vs. no action
  – No difference in breastfeeding at 6 weeks (~45% breastfeeding in each group)
    Midwifery, 1994 Dec;10(4):200-14
COMPONENTS OF A BREASTFEEDING EXAM

MOTHER

- **Mother’s position and comfort:** relaxed, spine straight, shoulders down
- **Hold on the baby:**
  - neck supported slightly extended, body to body, butt support
  - Infant’s hands on either side of breast
- **Mother holds breast** in C or U, far back from areola with space for infant’s chin

INFANT

- **Roots** with mouth wide open, tongue down, cupped, extended to lips
- **Assymmetric latch** - nipple pointed to palate, more areola in towards lower jaw
- **Suckling** pattern of several quick sucks, then settles to slower deep sucks
- Undulating movement of submental region, ear moves with swallow