Predicting and optimizing 'coming to volume'

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Professor of Pediatrics
April 11, 2024

Disclosures

- I have no real or apparent conflicts of interest related to the content of this presentation.

- The following terms are used throughout this presentation for simplicity: *mother, woman/women, mother's own milk, breastmilk,* and *breastfeeding* for anatomic clarity and brevity in this lecture.
- All concepts discussed here are applicable to transgender, nonbinary and non-birthing people who lactate and/or chest feed.
- The term "*mother's own milk*" is intended to distinguish milk provided by a parent from donor human milk, knowing that not all human milk may come from a parent who identifies as a mother.
- We acknowledge that it is important to utilize a patient's preferred pronouns and other preferred terminology when addressing patients directly regarding their lactation experience.

Outline

- Lactation physiology
- To review coming to volume and its association with later lactation outcomes
- To review lactation practices in the early postpartum period associated with coming to volume
- To identify milk biomarkers that may be associated with coming to volume

Example Case

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- Ms. J is a 23 year old G1P0 with preeclampsia and obesity (BMI 32) who was admitted at 25 5/7 weeks gestation and started on magnesium and labetalol and received 2 doses of betamethasone.
- After 48 hours, due to rising BP she underwent urgent cesarean delivery and gave birth to a 26 0/7 week infant girl, weight 730g who was admitted to the NICU on CPAP.
- Ms. J received 24 hours of magnesium postpartum.
- She pumped for the first time 4 hours after delivery, then again at 12 hours post delivery (DOL 1).
- On infant's DOL 2, she pumped 3 times and produced drops of milk.
- On DOL 8 infant developed sepsis and was intubated.
- On DOL 22 infant was extubated and placed on CPAP
- Infant discharged home at DOL 92 at corrected age 39 1/7 weeks, weight 2900g

Socioecological Model

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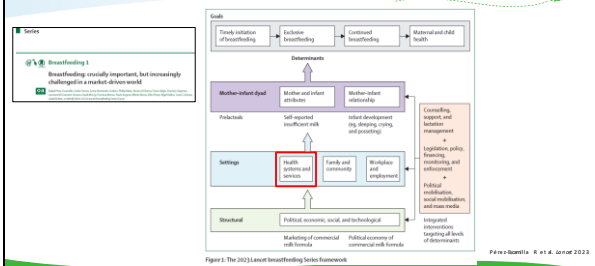

Figure 1: The 2023 Lancet breastfeeding Series framework

Pérez-Escamilla R et al. Lancet 2023

Lactation Physiology

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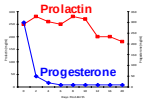
Secretory Differentiation (Lactogenesis I)

- During pregnancy breast undergoes significant changes due to multiple hormones (estrogen, progesterone, prolactin, oxytocin, human growth hormone, glucocorticoids, insulin):
  - Increased blood flow
  - Mammary epithelial cells differentiate into lactocytes
  - Alveolar and ductal proliferation
- Breast development continues to occur until delivery (incomplete in preterm)
- Mid-pregnancy: starts to make colostrum – but secretory activity limited by high progesterone which inhibits prolactin

Secretory Activation (Lactogenesis 2)

- Triggered by post-partum hormonal changes:
  - Progesterone falls
  - Inhibition of Prolactin ends - with insulin → closure of tight junctions (TJ)
  - Infant suckling increases secretion of prolactin and oxytocin



Neville & Morton. J Nutr 2001
Breastfeeding Handbook for Physicians. 2nd Edition. AAP Medina-Pestana et al. Breastfeed Med 2020
Neville et al. J Mammary Gland Biol Neoplasia 2012

Review

Measures of Secretory Activation for Research and Practice: An Integrative Review

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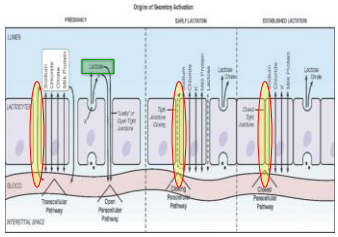
- **Tight junction closure** prevents lactose from exiting the lumen via open paracellular pathways
- Lactose = primary osmotic component draws water into lumen
- Secretory activation or milk "coming in"- typically within 72 hours after term delivery



Medina Poo line t et al. *Breastfeed Med* 2020

Symposium: Human Lactogenesis II: Mechanisms, Determinants and Consequences

Physiology and Endocrine Changes Underlying Human Lactogenesis II[1,2]

Margaret C. Neville[3]* and Jane Morton[4]

[3]Department of Physiology, University of Colorado Health Sciences Center, Denver CO 80262 and [4]Stanford University School of Medicine, Palo Alto Medical Foundation, Palo Alto, CA 94303

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Failed lactogenesis

- **Preglandular:** hormonal causes, such as retained placenta or lack of pituitary prolactin
- **Glandular:** surgical procedures, such as reduction mammoplasty or insufficient mammary tissue
- **Postglandular:** ineffective or infrequent milk removal

Neville and Morton. *J Nutrition* 2001

Milk Synthesis and Removal in Mothers of Preterm infants

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- Secretory differentiation is incomplete at the time of preterm birth
- Disrupted secretory differentiation with inflammatory processes (obesity, pre-eclampsia, diabetes and other metabolic health problems)
- Mothers viewed as "too sick to pump" → not encouraged or assisted with pumping
- Breast pump dependency = the pump completely replaces the infant for MOM removal and the regulation of lactation processes
- Maternal pumping behaviors unlinked from infant feeding
- Insufficient MOM volume are often traced to the first 14 days postpartum

Medina Poo line t et al. *Breastfeed Med* 2020

Secretory differentiation in NICU mothers and maternal conditions

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Delayed Lactogenesis

- Premature delivery
- Cesarean delivery
- Maternal blood loss
- Overweight/Obesity
- Diabetes mellitus
- Maternal hypertension
- Prolonged bedrest
- Duration and stress of labor

Other Barriers

- Mother-infant separation
- Stress associated with NICU
- Lack of skin to skin (STS)
- Breast pump dependence
- Cost or lack of equipment
- Lack of lactation training/ availability
- Maternal health issues
- Limited maternity leave
- Transportation issues
- Competing responsibilities
- Lack of knowledge
- Lack of family support

Nommsen-Rivers et al. *Am J Clin Nutr* 2010
Hurst. *J Midwifery and Women's Health* 2007
Marshall et al. *J Clin Endocri & Metab* 2010
Hernandez et al., *PLoS ONE* 2012
Parker and Patel. *Sem Perinatol* 2017

Example Case

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NICU Lactation Strategies

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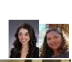
- Parent education – prenatally and postnatally
- Staff education
- Access to NICU-specific and culturally adapted lactation expertise
- **Early milk expression**
- **Frequent pumping +/- hand expression**
- **Monitoring milk volumes during the first 14 days postpartum to achieve at least 500ml/day (coming to volume or CTV)**
- Skin-to-skin (STS)
- Successful transition to direct breastfeeding



Mago-Shah et al *J Perinatol* 2023; Hoban R et al. *Semin Perinatol* 2021; Parker and Patel. *Sem Perinatol* 2017; Hoban R et al. *Breastfeed Med* 2018; Gharib et al 2018; Meier et al. *J Perinatol* 2016; Meier et al *Clin Perinatol* 2016; Bixby C et al *Breastfeed Med* 2016; Dereddy et al *J Human Lact* 2015; Colaizy et al, 2008; Lee HC et al *Pediatrics* 2012; Parker et al *J Hum Lact* 2016; Sisk et al. *Pediatrics* 2006; Philipp et al *J Perinat* 2000; [illegible] [illegible]

Outline

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- Lactation physiology
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STATE-OF-THE-ART

Which breast pump for which mother: an evidence-based approach to individualizing breast pump technology

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- **Coming to volume**: MOM volume of 500 to 600 mL/day in first 14 days
- CTV occurs during transition from endocrine to autocrine control
- Suckling-induced prolactin surge
- Feedback Inhibitor of Lactation (FIL)
  - Milk protein that downregulates sensitivity to prolactin and disrupts movement of milk constituents from endoplasmic reticulum to Golgi
  - FIL functions locally at each breast = MOM not removed from the same breast over time reduces MOM synthesis in that breast
  - Need to pump both breasts

Wilde et al. *Proc Nutr Soc* 1995
Meier et al. *J Perinatol* 2016

CTV and Later Milk Volume

Pediatric RESEARCH

www.nature.com/pr

CLINICAL RESEARCH ARTICLE

Mediators of racial and ethnic disparity in mother's own milk feeding in very low birth weight infants

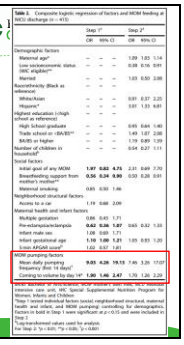
Aloka L. Patel[1], Michael E. Schoeny[2], Rebecca Hoban[3], Tricia J. Johnson[4], Harold Bigger[5], Janet L. Engstrom[2], Erin Fleurant[6], Brittany Riley[6] and Paula P. Meier[7]

BREASTFEEDING MEDICINE
Volume 13, Number 2, 2018
© Mary Ann Liebert, Inc.
DOI: 10.1089/bfm.2017.0169

Clinical Research

Milk Volume at 2 Weeks Predicts Mother's Own Milk Feeding at Neonatal Intensive Care Unit Discharge for Very Low Birthweight Infants

Rebecca Hoban[1,2] Harold Bigger[3] Michael Schoeny[3] Janet Engstrom[3] Paula Meier[1,2] and Aloka L. Patel[1,2]



- 415 mother-VLBW infant dyads born 2008-12

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Pumping Influence on Breast Programming

RUSH UNIVERSITY Children's Hospital

Proceedings of the Nutrition Society (1995), **54**, 401–406 401

Breast-feeding: matching supply with demand in human lactation

BY C. J. WILDE[1], A. PRENTICE[2] AND M. PEAKER[1]
[1]*Hannah Research Institute, Ayr KA6 5HL*
[2]*MRC Dunn Nutrition Unit, Cambridge CB4 1XJ*

Milk Volume on Day 4 and Income Predictive of Lactation Adequacy at 6 Weeks of Mothers of Nonnursing Preterm Infants

Pamela D. Hill, PhD, RN, CBE, FAAN; Jean C. Aldag, PhD

Original research

OPEN ACCESS

Short-term rate of milk synthesis and expression interval of preterm mothers

Ching Tat Lai ,[1] Alethea Rea,[1] Leon R Mitoulas,[2] Jacqueline C Kent,[1] Karen Simmer,[3] Peter Edwin Hartmann,[1] Donna Geddes[1]

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Objective: To determine the impact of the pumping regimes of women with preterm infants on:
(1) daily milk production
(2) short-term rate of milk synthesis during early lactation

Subjects:
Mothers of preterm infants (n=25) recorded start time, finish time and expression volumes from every breast expression on days 10, 15–20 postpartum.

Results:
Expressing more often than five times per day did not result in a significant increase in daily milk production

Lai et al. *Arch Dis ChildFetalNeonatal Ed*2020

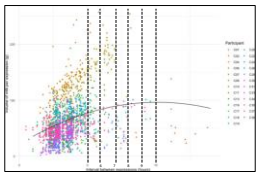
Original research

OPEN ACCESS

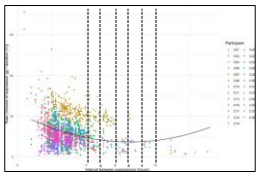
Short-term rate of milk synthesis and expression interval of preterm mothers

Ching Tat Lai, Alethea Rea, Leon R Mitoulas, Jacqueline C Kent, Karen Simmer, Peter Edwin Hartmann, Donna Geddes

RUSH UNIVERSITY Children's Hospital



Milk volume per expression per breastincreasedfor intervals between expressions of between2 and 6 hours then reached a plateau whenthe intervalbetween expression was 7 hours or longer



The short-term rate of milk synthesis decreased as the interval between expressions increased until about 7.5 hours at which point it began to increase

Lai et al. *Arch Dis ChildFetalNeonatal Ed*2020

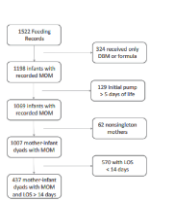
Journal of Perinatology

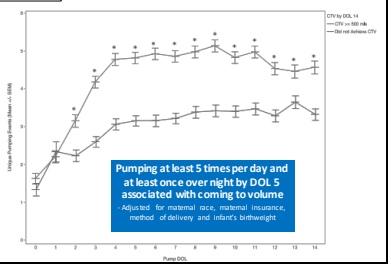
ARTICLE

Early pumping frequency and coming to volume for mother's own milk feeding in hospitalized infants

Jessica D. Mago-Shah, Kamlesh Athawale, Kimberley Fisher, Elizabeth Hayward, David Tanaka, and C. Michael Cotten

RUSH UNIVERSITY Children's Hospital





Mago-Shah et al. *J Perinatol* 2023

Pumping in the First 5 Days

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Clarisa Medina-Poeliniz_PhD

	Cumulative MOM volume in first 7 days postpartum			
Predictor	b	SE	95% CI	p
Model 1 Cumulative hours pumped first 5days postpartum	**1278.0**	590.5	66.4, 2489.7	0.039*

- Mothers of preterm infants
- Each additional hour pumping in the first 5 days → additional 1278 mL cumulative MOM volume in first 7 days

Unpublished data courtesy of Drs. Medina-Poeliniz and Meier

Actual Pumping Frequency

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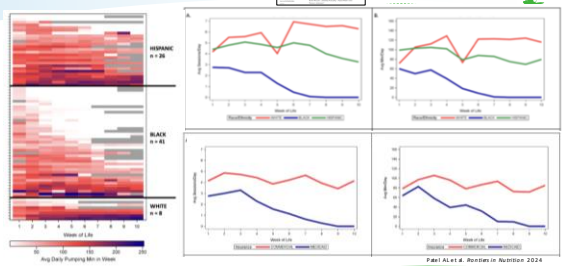

Patel AL et al. Frontiers in Nutrition 2024

Example Case – Ms. J Scenario 1

- Does not CTV
- Is not discharged on any MOM feedings

	Number of pumping sessions	MOM volume (mL)	Infant's ordered feeding volume
DOL 1	2	0	**8**
DOL 2	3	2	**8**
DOL 3	4	4	**8**
DOL 4	5	**15**	**8**
DOL 5	3	**40**	30
DOL 6	4	**100**	52
DOL 7 / wk 1	3	45	**72**
DOL 8	3	60	**88**
DOL 9	5	**110**	104
DOL 10	5	**160**	112
DOL 11	6	**250**	120
DOL 12	5	**220**	120
DOL 13	4	**180**	120
DOL 14 / wk 2	6	**280**	128
DOL 21 / wk 3	4	**210**	136
DOL 28 / wk 4	4	**150**	144
DOL 56 / wk 8	2	80	**208**
DOL 70 / wk 10	1	20	**400**
DOL 92 / Discharge	0	0	**493**

Example Case – Ms. J Scenario 2

- Does CTV
- Is discharged on MOM feedings

	Number of pumping sessions	MOM volume (mL)	Infant's ordered feeding volume
DOL 1	2	0	**8**
DOL 2	3	2	**8**
DOL 3	5	4	**8**
DOL 4	6	**30**	8
DOL 5	6	**70**	30
DOL 6	6	**180**	52
DOL 7 / wk 1	6	**300**	72
DOL 8	5	**420**	88
DOL 9	5	**520**	104
DOL 10	6	**700**	112
DOL 11	4	**580**	120
DOL 12	5	**660**	120
DOL 13	5	**600**	120
DOL 14 / wk 2	6	**800**	128
DOL 21 / wk 3	6	**960**	136
DOL 28 / wk 4	5	**900**	144
DOL 56 / wk 8	5	**800**	208
DOL 70 / wk 10	5	**800**	400
DOL 92 / Discharge	5	**920**	493

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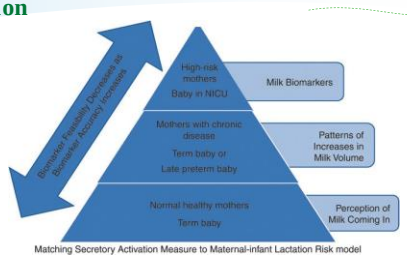
Potential Markers of Secretory Activation



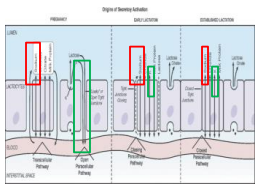
Matching Secretory Activation Measure to Maternal-infant Lactation Risk model

Medina Poeliniz et al. Breastfeed Med 2020

Review

Measures of Secretory Activation for Research and Practice: An Integrative Review

- Four transcellular pathways involved in milk synthesis and secretion of milk components across the cellular membrane
- A single paracellular pathway bypasses the epithelial cell → direct communication between maternal blood and milk
- The paracellular pathway is open at birth → gradually closes during secretory activation → continued milk secretion
- The paracellular pathway reopens during inflammation (mastitis) and involution (weaning)
- Over the first days postpartum:
  - ↑ **lactose, citrate, and potassium (K) levels in MOM**
  - ↓ **total protein and sodium (Na) levels in MOM**



Medina Poeliniz et al. Breastfeed Med 2020

CLINICAL AND LABORATORY OBSERVATIONS www.jpeds.com • THE JOURNAL OF PEDIATRICS

The Relation between Breast Milk Sodium to Potassium Ratio and Maternal Report of a Milk Supply Concern

Masahiko Murase, MD, PhD[1], Erin A. Wagner, MS[1], Caroline J. Chantry, MD[1], Kathryn G. Dewey, PhD[2], and Laurie A. Nommsen-Rivers, PhD[1]

RUSH UNIVERSITY Children's Hospital

Subjects: 196 first-time mothers of term, healthy, singleton infants and exclusively breastfeeding at day 7

Primary objective:

Determine if elevated Na:K at day 7 is significantly more prevalent in mothers reporting a milk supply concern

Table II. Logistic regression model predicting the odds of elevated breast milk Na:K according to presence of a milk supply concern among mothers exclusively breastfeeding on day 7*

Milk supply concern at day 7†		Number (%) with elevated breast milk Na:K	Elevated breast milk Na:K, OR [95% CI]	
Category	Number		Model 1‡	Model 2§
No	160	33 (21)	1.0 (reference)	1.0 (reference)
Yes	36	15 (42)	2.7 [1.3-5.9]	3.4 [1.5-7.9]

*Defined as maternal report of exclusive breastfeeding during the 24 hours before the day 7 interview.
†Defined as breast milk Na:K > 75th percentile (>0.80) on day 7 for the analytic subset.
‡$P = .01$.
§$P = .003$, adjusted for ethnic group.

Murase et al. *J Pediatrics* 2017

CLINICAL AND LABORATORY OBSERVATIONS www.jpeds.com • THE JOURNAL OF PEDIATRICS

The Relation between Breast Milk Sodium to Potassium Ratio and Maternal Report of a Milk Supply Concern

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RUSH UNIVERSITY Children's Hospital

Secondary objective:

Determine whether elevated Na:K at day 7 is predictive of stopping breastfeeding before day 60

Table III. Logistic regression model predicting stopped breastfeeding by day 60 according to day 7 breast milk Na:K status among mothers exclusively breastfeeding at day 7*

Breast milk Na:K at day 7		No. (%) stopped breastfeeding	Stopped breastfeeding by day 60, Odds Ratio [95% confidence interval]			
Category†	No.		Model 1‡	Model 2§	Model 3¶	Model 4**
Not elevated	146	10 (7)	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Elevated	46	8 (17)	2.9 [1.1-7.8]	3.0 [1.1-8.6]	3.1 [1.1-8.9]	3.3 [1.1-9.7]

*Defined as maternal report of exclusive breastfeeding during the 24 hours before the day 7 interview.
†Elevated breast milk Na:K defined as > 75th percentile (>0.80) for the analytic subset.
‡$P = .04$, unadjusted odds ratio.
§$P = .04$, adjusted for maternal age.
¶$P = .04$, adjusted for maternal age and health insurance status.
**$P = .03$, adjusted for Infant Feeding Intentions category, maternal age, and health insurance status.

Murase et al. *J Pediatrics* 2017

THE JOURNAL OF PEDIATRICS • www.jpeds.com ORIGINAL ARTICLES

Associations of Secretory Activation Breast Milk Biomarkers with Breastfeeding Outcome Measures

Anita L. Esquerra-Zwiers, PhD, RN[1], Carly Meeker, BSN, RN[1], Lauren Cyrus, BSN, RN[1], Anastasia Perecki, BSN, RN[1], Emilia Dyrszka Goro, PhD, RN[1], Chong Tai Lai, PhD[2], and Donna Geddes, PhD[2]

Objective: To explore associations between day 10 postpartum (D10) secretory activation biomarkers and breastfeeding outcome measures

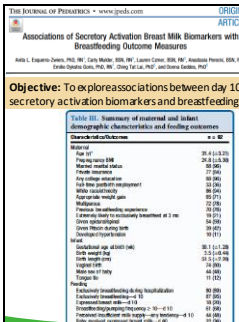
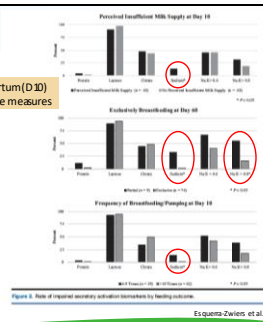


Table III. Summary of maternal and infant demographic characteristics and feeding outcomes



Esquerra-Zwiers et al. *J Pediatrics* 2023

Review

Milk Biomarkers of Secretory Activation in Breast Pump-Dependent Mothers of Preterm Infants: An Integrative Review

RUSH UNIVERSITY Children's Hospital

Are milk biomarkers affected by problems associated with preterm delivery

- preterm birth = interrupted secretory differentiation
- lactation risk factors
- Inflammation
- maternal stress
- maternal health complications
- breast pump dependency

BOX 1. MOTHER'S OWN MILK BIOMARKER REFERENCE RANGES

Biomarker	Reference range during SA with direction of change	Direction of change
Lactose (g/L)	3 Days postpartum >43.4 6 Days postpartum >53.6	Increases Abrupt increase day 1 postpartum Peaks >day 5 postpartum Increases as Na decreases
Citrate (g/L)	3 Days postpartum >0.24 6 Days postpartum >0.92	Increases immediately before copious milk secretion Increases in proportion to milk volume
Sodium (mM)	Trajectory: 60 on day 1, decreasing to <20 or <16[a]	Decreases Rapidly decreases first 3 days postpartum Precedes increase in milk volume
Potassium (mM)	45.3	Increases Paracellular pathway is open, diluting concentrations
Na/K	1.1–7.8 Categorized: <0.6 = Normal ≥0.6 and ≤1 elevated >1 = very high	Decreases Used as a standardization for Na concentration May or may not be additive to Na alone
Total protein, g/L	3 Days postpartum <34.1 6 Days postpartum <24.3 Plateaus day 4 postpartum	Decreases
Fat, g/L	41.1 ± 7.8	Increases but exhibits high variability

Adapted from Medina Poelinizi et al.[31]
[a]Values of <20 or <16 are study specific, and represent small sample sizes and differing days postpartum.

Parker et al. *Breastfeed Medicine* 2018

Clinical Research

Human Milk Biomarkers of Secretory Activation in Breast Pump-Dependent Mothers of Premature Infants

RUSH UNIVERSITY Children's Hospital

- 16 mothers of preterm infants
- Milk samples collected every 12hr for first 14 days

TABLE 3. PUMPING FREQUENCY, MOTHER'S OWN MILK VOLUME, AND COMING TO VOLUME

Characteristic: mean±SD (range) or n (%) unless otherwise specified	Pumped MOM volume ≥500 mL/day: achieved CTV n=8 (50%)	Pumped MOM volume <500 mL/day: did not achieve CTV n=8 (50%)	p
First day with four normal biomarkers (median)	4 (IQR 4–4.5)	9 (IQR 6-11.25)[a]	0.19
Cumulative pumped MOM volume (mL): days 1–5	982.8 (IQR 725.7–1188.3)	166.9 (IQR 71.4-219.3)	0.008
Median daily pumped MOM volume (mL): days 1–14	424.5 (IQR 362.3-497.6)	89.1 (IQR 38.7–156.4)	<0.001
Postpartum day when CTV	6.4±1.8 (4–10)	—	—
Cumulative pumping sessions before CTV	28.8±12.9 (11–52)	—	—
Cumulative pumping sessions: days 1–5	26.3±4.6 (19–32)	13.8±12.4 (0–37)[b]	0.03
Median daily pumping sessions: days 1–14	6.5 (IQR 4-9)	4 (IQR 3–5)	<0.001
Mothers with mean pumping frequency ≥5 times/day (n=7, 43.8%)	6 (85.7)	1 (14.3)	0.01[c]
Mothers with mean pumping frequency <5 times/day (n=9, 56.3%)	2 (22.2)	7 (77.8)	

Hoban et al. *Breastfeed Medicine* 2018

Cregan	Australia	N 22 of 31-35 week N 16 of healthy term	Cross-sectional MOM sample day 5	Term mothers more likely to have all 4 MOM biomarkers normal than preterm mothers Preterm: greater pumped volume if all MOM biomarkers normal
Henderson	Australia	N 50 of 28-34 week	Prospective cohort Daily MOM volume and samples days 1-10	Mothers >=28 weeks had increases in MOM volume earlier than mothers <28 week Pumped milk volume was associated with lactose and citrate Mothers who pumped >=6 versus <6 times/day had higher lactose concentration
Hoban	USA	N 16 of <33 week	Pilot prospective cohort Daily MOM volume days 1-14 Every 12 hr MOM samples days 1-14	On postpartum day 3, mothers with all 4 MOM biomarkers normal had greater pumped MOM volume compared with those with 2 normal MOM biomarkers
Hoban	USA	N 39 of <33 week	Prospective cohort Daily MOM volume days 1-14 Every 12 hr MOM samples days 1-14	33% mothers achieved CTV Only Na on postpartum day 5 and Na:K on days 3 and 5 predicted CTV
Medina Poelinizi	USA	N 39 of <33 week - 17 BMI <27 - 22 BMI >=27	Secondary analysis of Hoban Days 1-7 vs 8-14	During days 1–7, mothers with a BMI <27 had a greater rate of decrease in Na and increase in MOM volume but similar Na:K ratios compared to mothers with BMI >=27. No differences in days 8-14
Parker	USA	N 69 of <=32 weeks	First 7 days postpartum. Indicators of SA: - Maternal perception - Volume attainment - MOM biomarkers	Compared with normal values in healthy breastfeeding mothers, secretory activation was delayed.

Parker et al. *Breastfeed Medicine* 2018

Indicators of Secretory Activation in Mothers of Preterm Very Low Birth Weight Infants

Leslie A. Parker, PhD[1], Sandra Sullivan, MD[1], Nicole Cacho, DO[1], Clara Engelmann, MHA[1], Charlene Krueger, PhD[1], and Martina Mueller, PhD[1]

RUSH UNIVERSITY Children's Hospital

Subjects:
69 mothers of VLBW infants (<=32 weeks of GA) during the first 7 days postpartum.

Objective: Compare timing of secretory activation compared using three separate indicators:
1. Maternal perceptions of milk coming in
2. Removing >=20mL of MOM per pump session for two consecutive sessions
3. Normal MOM biomarkers Na and lactose (collected when #2 was met)

Compared with normal values in healthy breastfeeding mothers, secretory activation was delayed.
1. Maternal perception of milk coming in at mean 130.6 – 170.3 hours (5±7 days)
2. Achievement of >=20 mL of pumped MOM volume/session at mean 123.4 – 91.9 hours (5±3 days)
3. Only 42% of mothers had normal Na and lactose at #2 time point
4. Mothers with normal biomarkers had significantly more pumping sessions during Days 3-5 (4.5-4.8 times/day vs. 3.0 times/day)

Parker et al. *J Hum Lact* 202

ORIGINAL ARTICLES www.jpeds.com • The Journal of Pediatrics

Mother's Own Milk Biomarkers Predict Coming to Volume in Pump-Dependent Mothers of Preterm Infants

Rebecca Hoban, MD, MPH[1,2], Clarisa Medina Pestrini, MSN, PNDc[1], Emily Somerset, MSc[1], Ching Tat Lai, PhD[1], Judy Jones, RN, IBCLC[1], Alaka L. Patel, MD[1], Donna Geddes, PhD[3], and Paula P. Meier, PhD[1,2]

RUSH UNIVERSITY Children's Hospital

- **Objective:** To determine associations between serial secretory activation MOM biomarker concentrations from breast pump-dependent mothers of preterm infants to and coming to volume (CTV)

- Viable singleton infant born at gestational age<33 weeks
- Initiated lactation but MOM had not "come in" yet
- No hormonal contraception or galactagogues for the first 14 days postpartum
- Access to hospital-grade double electric breast pumps in the NICU and at home
- Collected paired MOM volume and samples every 12hr for first 14days

- **39 mothers** (mean GA 28.8 weeks; 67% overweight/obese; 59% nonwhite)
- **33% achieved CTV between postpartum days 6 and 14**
- **Associated with CTV between days 6-14**
  - **day 5 Na:K** (1 unit decrease in Na:K: OR, 18.7; 95% CI, 1.13-311.41; p= .049)
  - **maternal pre-pregnancy BMI** (1 unit increase in BMI: OR, 0.88; 95% CI, 0.78-0.99; p= .04)

Hoban et al. *J Pediatrics* 202

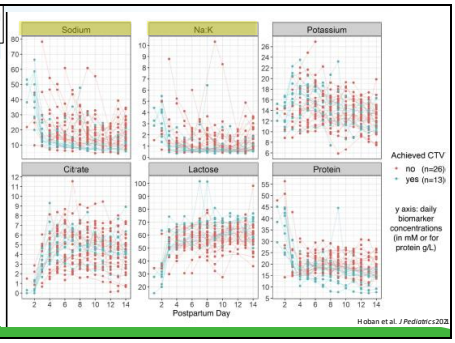
ORIGINAL ARTICLES

Mother's Own Milk Biomarkers Predict Coming to Volume in Pump-Dependent Mothers of Preterm Infants

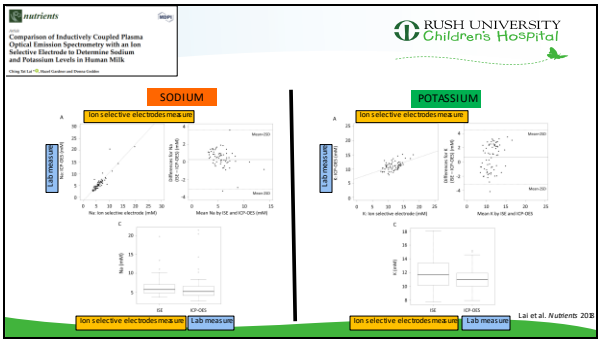
CTV was associated with expected directional changes in all biomarkers

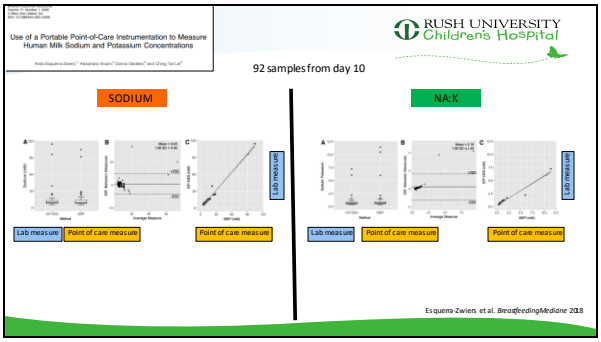
Considerable within and between-mother variability

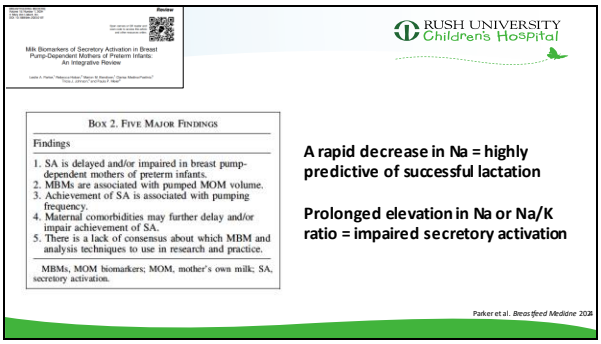
Na and Na:K ratio were most consistent with respect to predicted directionality and CTV achievement



Hoban et al. *J Pediatrics* 202


nutrients
Comparison of Inductively Coupled Plasma Optical Emission Spectrometry with an Ion Selective Electrode to Determine Sodium and Potassium Levels in Human Milk
RUSH UNIVERSITY Children's Hospital
SODIUM
POTASSIUM
Ion selective electrodes measure
Lab measure
Ion selective electrodes measure
Lab measure
Lai et al. Nutrients 2018


Use of a Portable Point-of-Care Instrumentation to Measure Human Milk Sodium and Potassium Concentrations
RUSH UNIVERSITY Children's Hospital
92 samples from day 10
SODIUM
NA:K
Lab measure
Point of care measure
Lab measure
Point of care measure
Lab measure
Point of care measure
Lab measure
Point of care measure
Esquena-Zwiers et al. BreastfeedingMedicine 2018


Review
Milk Biomarkers of Secretory Activation in Breast Pump-Dependent Mothers of Preterm Infants: An Integrative Review
RUSH UNIVERSITY Children's Hospital
BOX 2. FIVE MAJOR FINDINGS
Findings
1. SA is delayed and/or impaired in breast pump-dependent mothers of preterm infants.
2. MBMs are associated with pumped MOM volume.
3. Achievement of SA is associated with pumping frequency.
4. Maternal comorbidities may further delay and/or impair achievement of SA.
5. There is a lack of consensus about which MBM and analysis techniques to use in research and practice.
MBMs, MOM biomarkers; MOM, mother's own milk; SA, secretory activation.
A rapid decrease in Na = highly predictive of successful lactation
Prolonged elevation in Na or Na/K ratio = impaired secretory activation
Parker et al. Breastfeed Medicine 2020

Upcoming Studies using Milk BioMarkers

RUSH UNIVERSITY Children's Hospital

Rebecca Hoban, MD, MPH

Early Pumping Behaviors Predict Pumped Milk Volume, Achievement of Secretory Activation and Coming to Volume in Breast Pump-Dependent Mothers of Preterm Infants

Rebecca Hoban, MD, MPH (University of Washington, Seattle Children's Hospital)
Clarisa Medina-Poeliniz, PhD, MSN, APRN, CPNP (Rush University Medical Center)
Marisa Signorile, MMATH (University Health Network, Toronto)
Judy Janes, BSN, IBCLC (Rush University Medical Center)
Chun-Po Steve Fan, PhD, P.Stat. (University Health Network, Toronto)
Paula P. Meier, PhD, RN (Rush University Medical Center)

Unpublished data courtesy of Drs. Hobanand Meier

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Objective: To measure three pumping behaviors each day during postpartum days 1 to 14

- number of pumping sessions
- minutes spent pumping
- longest interval between pumping sessions

and to determine their relationships to

- achievement of secretory activation (MOM biomarkers: sodium [Na] and sodium-to-potassium ratios Na:K)
- coming to volume (CTV)
- daily and cumulative pumped MOM volume

Unpublished data courtesy of Drs. Hobanand Meier

RUSH UNIVERSITY Children's Hospital

- Non-randomized observational study of breast pump-dependent mothers of preterm infants
- October 2019-October 2020
- Rush University Medical Center
- Inclusion criteria: singleton infant born at <34 weeks without major severe medical complications or anomalies, plan to provide MOM, no hormonal contraception or galactagogues
- Daily data (electronic pumping data with SMART pump, milk weights) and milk specimens for first 14 days postpartum
- Researchers measuring outcomes were blinded to pumping behaviors
- **Outcome:** achievement of secretory activation (defined as Na ≤16 mMol and/or Na:K ratio <0.8)

Unpublished data courtesy of Drs. Hobanand Meier

Early Pumping Behaviors Predict Pumped Milk Volume, Achievement of Secretory Activation and Coming to Volume in Breast Pump-Dependent Mothers of Preterm Infants

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- 29 mothers with usable data
- Achievement of SA in 27 (93%) mothers, at median of 5.8 days [4.30, 8.23] postpartum
- None of the mothers achieved SA prior to postpartum day 4

Table 1 Maternal- infant characteristics (N=29)

Characteristic	Mean ± SD Or n%
Maternal age years	29 ± 6
Race	
Black	15 (52%)
White	10 (34%)
More than one race	4 (14%)
Ethnicity	
Hispanic	10 (34%)
Non-Hispanic	19 (66%)
Prepregnancy Body Mass Index kg/m²	31.6 ± 8.0
Normal weight (<24.9)	9 (31%)
Overweight (25.0-29.9)	4 (13.8%)
Obese (>30.0)	16 (55.2%)
Birth mode	
Cesarean section	17 (59%)
NSVD (vaginal)	12 (41%)
Infant birth weight (grams)	1,474 ± 501
Infant gestational age (weeks)	30.6 ± 2.4
Infant sex	
Male	13 (45%)
Female	16 (55%)
Apgar score @1 min (0-10)	6 ± 2
Apgar score @5 min (0-10)	8 ± 1
Mother received steroids	28 (97%)
Pre-eclampsia	12 (41%)
Infection	9 (31%)
PCOS	5 (17%)
Gestational diabetes	6 (21%)
Psychiatric diagnosis	6 (21%)
Mother on bedrest	17 (59%)
Length of bedrest (days)	2 ± 3
Number of maternal morbidities	3 ± 1
Hemorrhage (excessive blood loss)	7 (24%)
Blood loss (> 500 mL)	19 (66%)
Previous breastfeeding experience	12 (41%)

Unpublished data courtesy of Drs. Hobanand Meier

Early Pumping Behaviors Predict Pumped Milk Volume, Achievement of Secretory Activation and Coming to Volume in Breast Pump-Dependent Mothers of Preterm Infants

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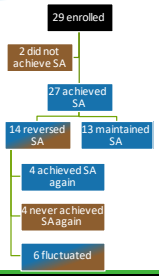

- Each additional daily pumping session increased the odds of achieving SA within the next 2 days by 48% (p = .01)
- Total daily minutes spent pumping was not was associated with achievement of SA
- The longest inter-pump interval was not associated with achievement of SA

Unpublished data courtesy of Drs. Hobanand Meier

Early Pumping Behaviors Predict Pumped Milk Volume, Achievement of Secretory Activation and Coming to Volume in Breast Pump-Dependent Mothers of Preterm Infants

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Two pumping behavior clusters emerged

	High intensity (n 17)	Low intensity (n 12)
Number of pumping sessions per day	5±2	2±2
Minutes spent pumping per day	105±53	46±31
Longest interval (hr) between pumping sessions	5.5±1.7	7.5±3.2

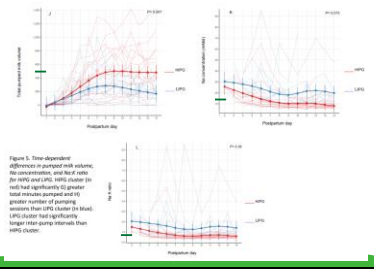

Figure 5. Time-dependent differences in pumped milk volume, fat concentration, and fat:cf ratio for HIPG and LIPG. HIPG cluster (in red) had significantly (p) greater total minutes pumped and (q) greater number of pumping sessions than LIPG cluster (in blue). LIPG cluster had significantly longer inter-pump intervals than HIPG cluster.

Unpublished data courtesy of Drs. Hobanand Meier

Early Pumping Behaviors Predict Pumped Milk Volume, Achievement of Secretory Activation and Coming to Volume in Breast Pump-Dependent Mothers of Preterm Infants

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- Changes in pumping behaviors were confined to the first 5-6 postpartum days with little change in pumped MOM volume, Na and Na:K ratio and after postpartum day 8
- This study underscores the importance of early pumping behaviors for mothers of preterm NICU infants: a critical interval for achievement of SA and CTV may be within the first 6-8 days
- For clinicians, quality improvement initiatives should target the very early postpartum period with respect to the use of lactation experts, rapid access to high-quality breast pumps, and daily monitoring of achievement of SA and CTV

Unpublished data courtesy of Drs. Hobanand Meier

Upcoming Studies using Milk BioMarkers

RUSH UNIVERSITY Children's Hospital

- **NOT YET RECRUITING**
- **Comparison of Breast Pump Suction Patterns**
- **ClinicalTrials.gov ID** NCT06061913
- **Sponsor** University of Florida
- **Information provided by** University of Florida
- **Last Update Posted** 2024-02-14

Thank you

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