Prevention of Insufficient Feeding Complications in Healthy, Term Newborns

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The Fed is Best Foundation
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All resources at FedisBest.org are free because safe infant feeding is a human right.

Presentation Outline

- Case of hypernatremic dehydration from early exclusive breastfeeding
- Basics of feeding, fasting and starvation
- How an infant is underfed - caloric and fluid requirements, weight loss
- Brain- and life-threatening feeding complications of newborn/infant
- Safe limits for newborn weight loss/fasting from exclusive breastfeeding
- Preventing complications and Safe Breastfeeding support

Case Presentation: Landon

Landon was born to a G2P0 mother at 39 weeks 2 days born by c-section due to fetal intolerance of labor. Born with Apgar scores 8 and 9 weighing 3360 g.

Developed grunting and given supplemental O2 and IV bolus.

Glucose levels monitored q1hr x 4 - 109, 107, 103, 85.

Landon was shortly transferred to MBU to exclusively breastfeed

Case Presentation: Landon

Mom's risk factors for insufficient or delayed lactogenesis II:

Diet-controlled diabetic, small widely-spaced breasts with minimal growth during pregnancy, PCOS, issues with infertility (SAB1), high BMI, primiparity, cesarean.

Landon was born in a Baby-Friendly hospital and mom was supported to exclusively breastfeed with close monitoring of breastfeeding by RNs, LCs and MD support.

Breastfeeding Log

2/25 22:01	---	Time of birth, birth weight 3360 g
2/26 00:07	40 minutes	1st feeding @ 2.5 hrs, LATCH 6, difficulty maintaining latch
2/26 02:24	18 minutes	Per mom, latch improved
2/26 03:15	15 minutes	
2/26 04:22	12 minutes	
2/26 05:00		Weighed @ 7 hours 1.19% weight loss
2/26 07:50	32 minutes	LC: LATCH 10, presence of colostrum confirmed
2/26 10:00	18 minutes	
2/26 10:30	14 minutes	
2/26 11:00	27 minutes	

Breastfeeding Log

2/26 11:35	15 minutes	RN: LATCH 10
2/26 12:00	35 minutes	LC: LATCH 10, mom expressed concern about baby breastfeeding so long, reassured
2/26 13:38	15 minutes	
2/26 14:45	15 minutes	
2/26 17:00	27 minutes	
2/26 20:45	20 minutes	LATCH 10
2/26 21:10	15 minutes	First 24 hrs: 0 wet diapers 4 stools
2/26 22:15	0 minutes	Repeated attempts to hold nipple in mouth

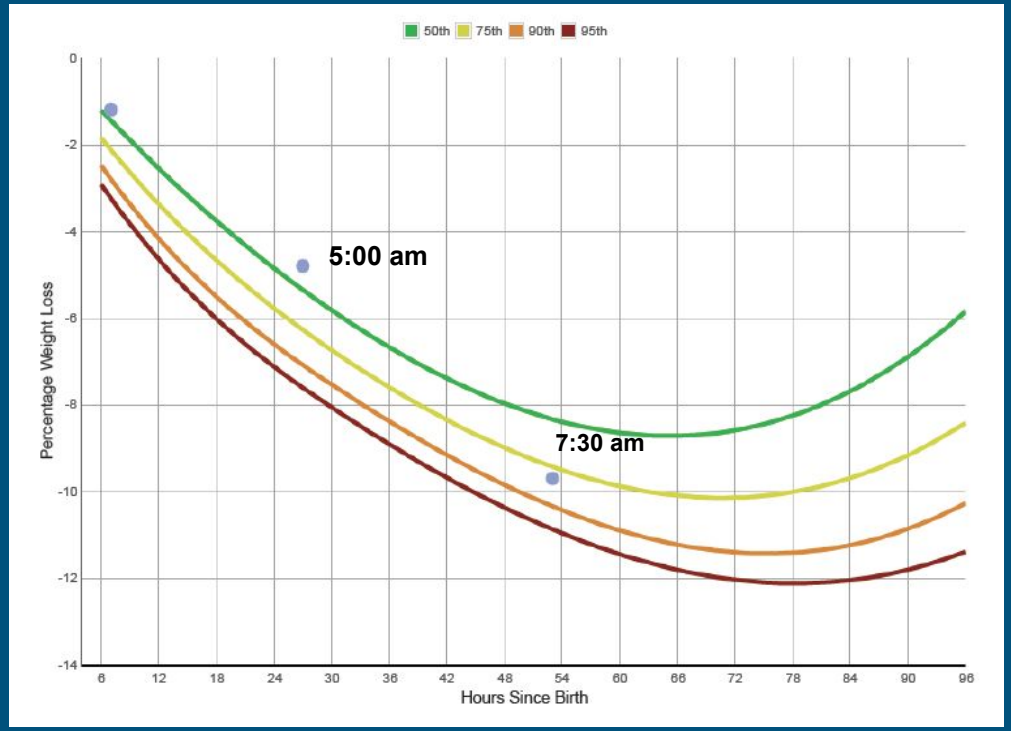
Breastfeeding Log

2/26 23:30	2 minutes	
2/26 23:50	10 minutes	In first 24, baby breastfed 9.3 hours
2/27 01:10	60 minutes	RN: LATCH 7: few audible swallows, 4.76% weight loss @ 27 hours
2/26 02:10	60 minutes	
2/27 03:25	90 minutes	
2/27 05:30	5 minutes	
2/27 07:30	45 minutes	
2/27/10:30	45 minutes	MD: “4.76% wt loss, LATCH 7, 3 wet/6 stools, TcB 0.6”

Breastfeeding Log

2/27 21:15	60 minutes	2nd 24 hours: 13.75 hours of breastfeeding 2nd 24 hrs: 3 wet diapers, 6 dirty diapers, “Clusterfeeding”
2/28 03:00	60 minutes	According to mom, no more logging occurred b/c Landon fed continuously, “Clusterfeeding,” LATCH 10
2/28 04:00	60 minutes	“Clusterfeeding”
2/28 07:30	60 minutes	MD Note: “Clusterfeeding” LATCH 10; 9.72% weight loss @ 53 hours
2/28 13:30	60 minutes “Clusterfeeding”	Discharged with next day follow-up, no onset of lactogenesis II, no supplementation plan for home, baby exclusively breastfeeding near-continuously for 64 hours, both with little to no sleep

Weight Loss Nomogram



Birth Details

Weight	Date	Time
3360 g	Jan 25	22:01

Delivery Type	Feeding Method
Cesarean	Breast Fed

Measurements

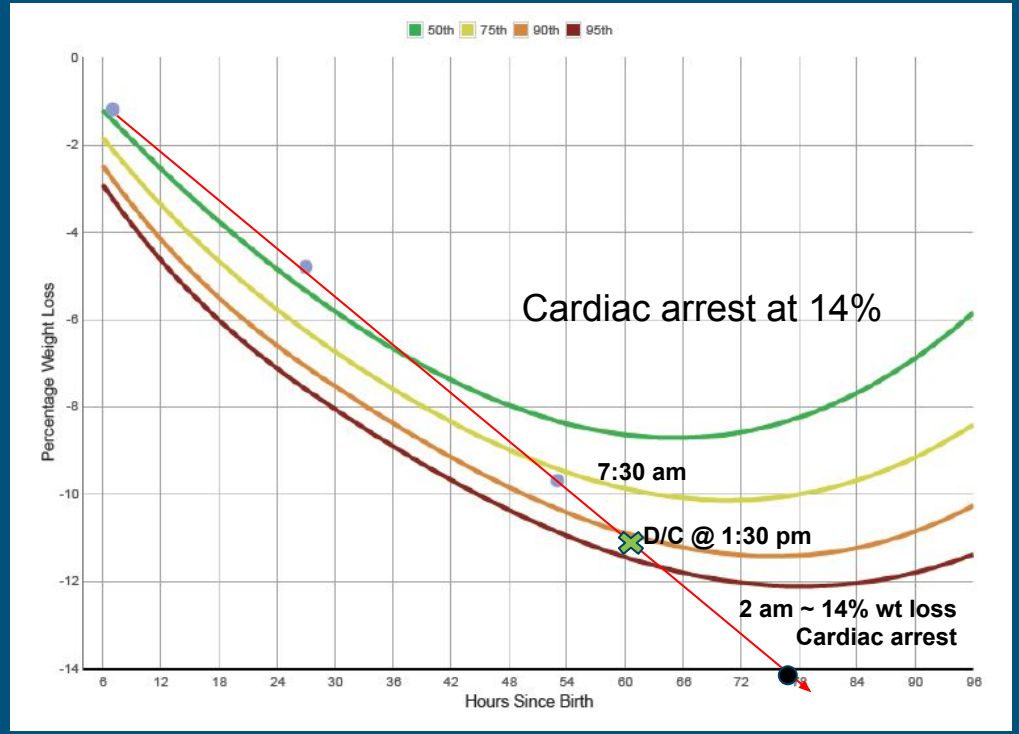
Hour	Weight	Change
Birth	3360 g	—
7	3320 g	-1.2%
27	3200 g	-4.8%
53	3033 g	-9.7%

At Home

Landon continued to “clusterfeed” when they got home.

At 2 am, 12 hours after discharge, Landon “fell asleep” while clusterfeeding.

He was found limp, unresponsive, blue, and EMS was called…



Questions

What was happening to this baby and why did he feed longer and longer until he was continuously on the breast?

If colostrum provides all the nutrients necessary to meet a newborn’s needs, why do EBF newborns develop insufficient feeding complications and why would they breastfeed for hours a day?

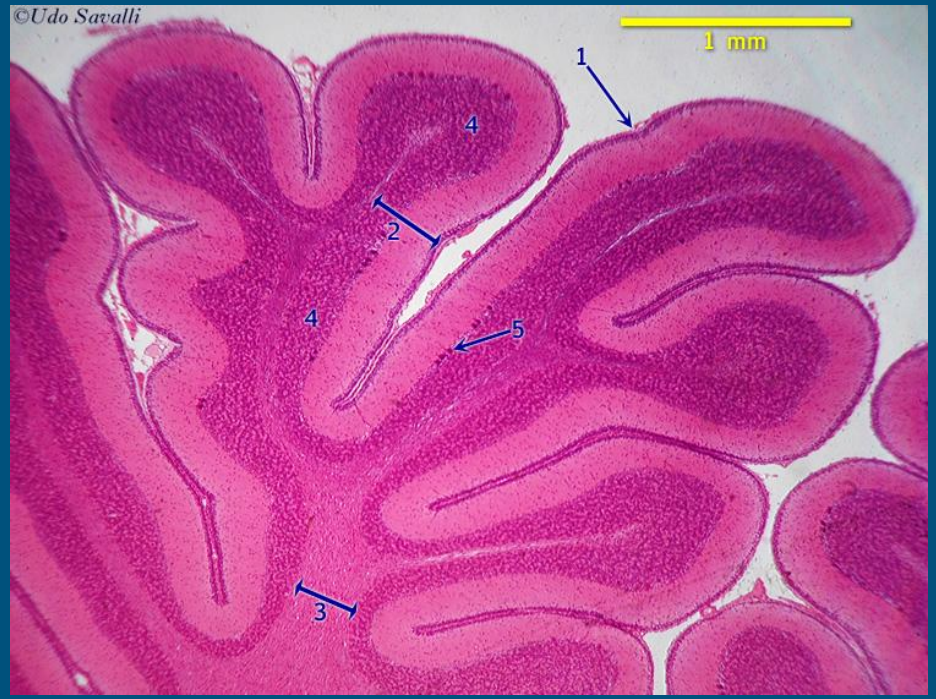
Why are most exclusively breastfed newborns crying? Why do they lose weight?

When does a newborn go from hungry to starving and what are the consequences?

The Basics: Living Cells

Healthy babies are born with all their cells arranged in a way to optimize bodily function and brain development

Every living cell needs calories every second to maintain the basic architecture and function of vital organs.



The Basics: Living Cells

Newborns are born with variable amounts of reserve:

Some are born depleted - SGA, premature, complicated delivery, maternal prolonged fasting

Some are born with high requirement - large, maternal diabetes

The birth weight does not signify a full tank

Fasting and Starvation

If a child does not receive the calories needed to feed their living cells,

Glycogen, protein and fat are depleted → “fasting” or catabolic

Glucose becomes depleted → ketones is the primary fuel of fasting, present in exclusively colostrum-fed newborns[1]

If the caloric reserve is depleted, then living cells die and substrates released are used for fuel → “autophagy” → weight loss

Fasting and Dehydration

Babies receiving minimal fluid → "antidiuresis" or ↓ UOP (0-2 wet diapers a day)

However, since lack of urine output results in lethal electrolyte abnormalities, we produce urine even with minimal to no fluid intake[2]

Fluid deprivation → dehydration → hypotension

Hypotensive dehydration leads to lethargy from poor brain perfusion

→ brain injury → cardiac arrest → death

Brain Injury Occurs within Minutes

Loss of fuel delivery to brain cells from hypotension and hypoglycemia causes widespread brain cell death

- 10 minutes ischemia / loss of circulation from hypotension[3]
- Within 20 - 30 minutes of hypoglycemia[4]

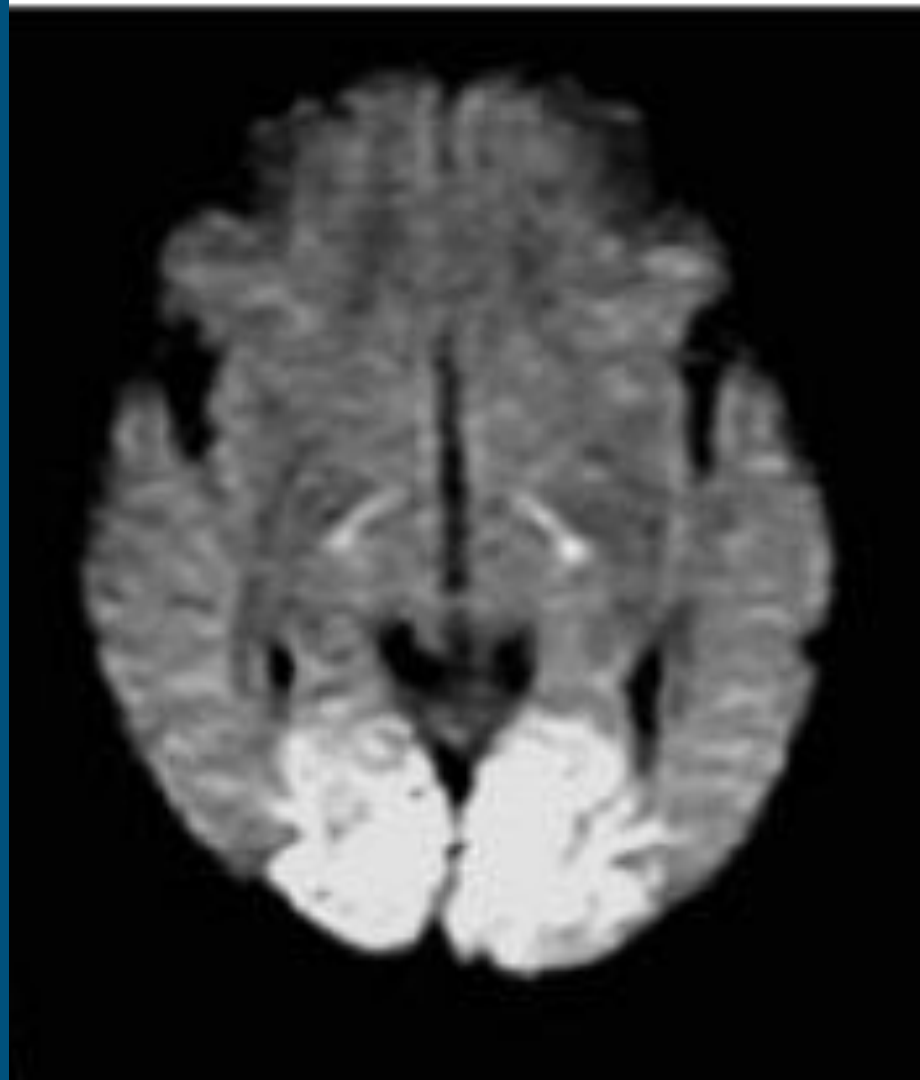
Brain cell death from 10 minutes of loss of fuel delivery

Hypoglycemia

Hypoglycemia - critical state of “running on empty” where necrotic cell death begins to occur

The longer the hypoglycemia, the more brain cells die[5]

Brain injury has severe, permanent negative consequences → lifelong disability



Hyperbilirubinemia

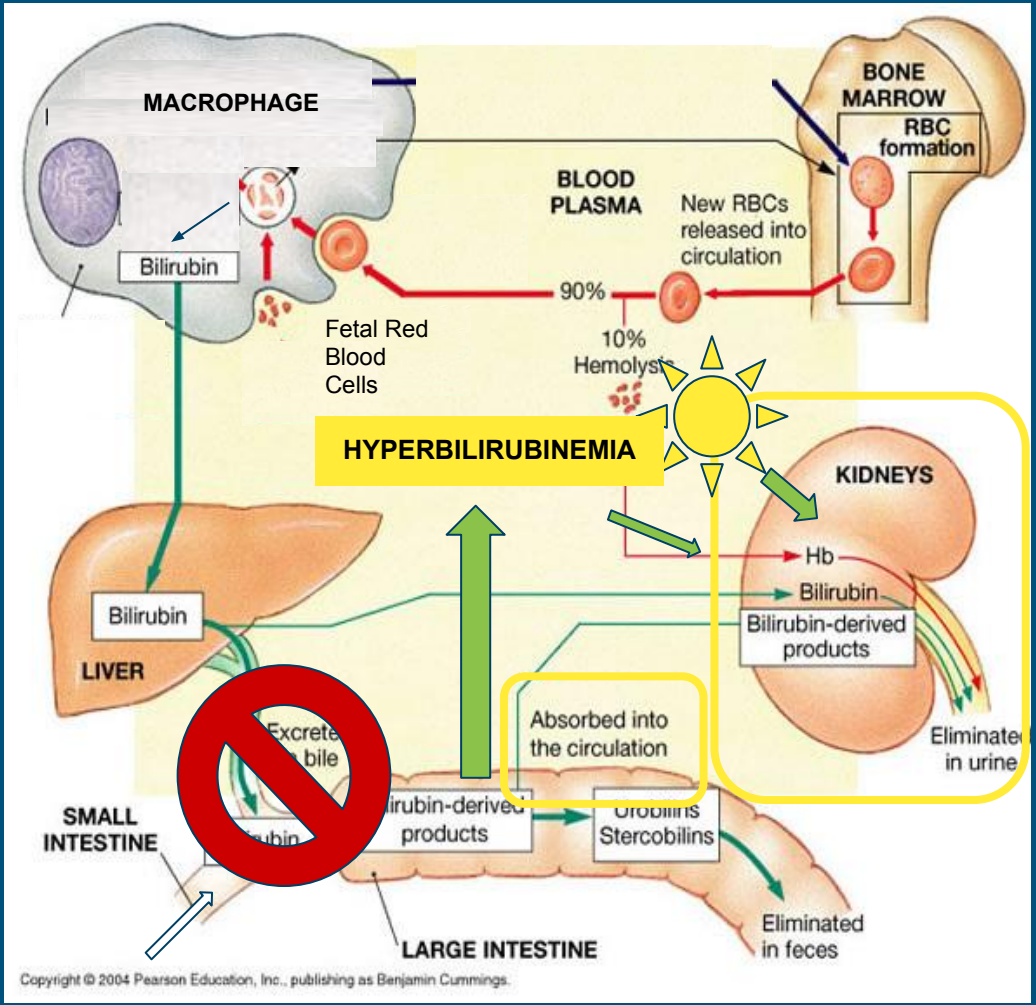
Insufficient milk → “breastfeeding jaundice” or starvation jaundice[6]

Bilirubin excreted through bile to digest milk = primary means of bilirubin removal

Low milk volume → bilirubin accumulation

15% of bilirubin removed via the kidneys, increases w/ phototherapy[7-9]

Excess bilirubin → brain injury, disability



The primary goal of feeding is to prevent critical starvation that leads to massive body and brain cell death and disability

How many calories do newborns need to prevent starvation and brain injury?

Why do exclusively breastfed newborns lose weight?

Caloric Needs of Newborns to Ensure Cell Survival

Newborn requirement

Daily caloric req't of newborn = 100-120 Cal/kg/day[10]

Provided by 6 oz/kg/day (20 Cal/oz; 66 Cal/dL)

For an average 3 kg baby (6.5 lbs), daily caloric requirement is 300 Cal per day at birth

Daily fluid requirement of newborn = 100 mL/kg/day

Minimum fluid requirement is 300 mL per day

Large, small, premature and medically ill babies may have higher caloric requirement

Average mother's colostrum

According to a 2014 study of human milk[11]

Caloric content of colostrum = 54 Cal/100 mL

Mature breast milk = 66-77 Cal/100 mL

Colostrum, in fact, has fewer calories than mature milk

Colostrum is present in small volume and in some women, it is not present at all

Caloric content colostrum vs. mature milk[11]

Table 3 Meta-analysis results of preterm and term breast milk energy content over time from measured and calculated estimates

Comparison: Bomb calorimetry energy measurement (kcal/dL)♦

	Preterm			Term			Preterm & term compared	
Time frame:	**mean**	**SD**	**n**	**Mean**	**SD**	**n**	**% difference**	**p-value**
d 1-3	49	7	12	54	8	19	−10	0.34
d 4-7	71	9	52	66	9	37	7	0.02
week 2	71	12	53	66	9	34	7	0.04
week 3-4	77	8	27	66	8	97	16	< 0.00001*
week 5-6	70	5	14	63	7	40	11	< 0.00001*
week 7-9	76	8	11	63	7	77	21	< 0.00001*
week 10-12	-	-	-	63	8	83	-	-

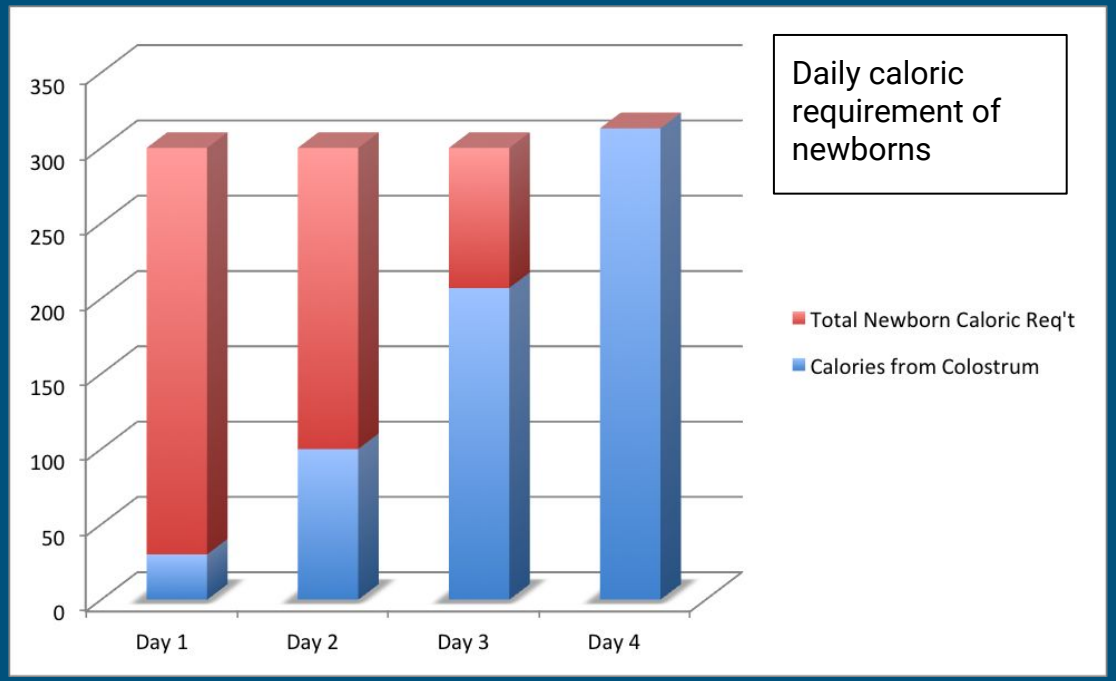
Energy meta-analysis was limited to 24 hour collections

Caloric Needs of Newborns to Ensure Cell Survival

Day of life	Average daily colostrum production[12]	Calories provided by colostrum	Daily 3 kg newborn caloric req't
Day 1	56 mL/day	30 Cal	300 Cal
Day 2	185 mL/day	100 Cal	300 Cal
Day 3	383 mL/day	207 Cal	300 Cal
Day 4	580 mL/day	313 Cal	300 Cal

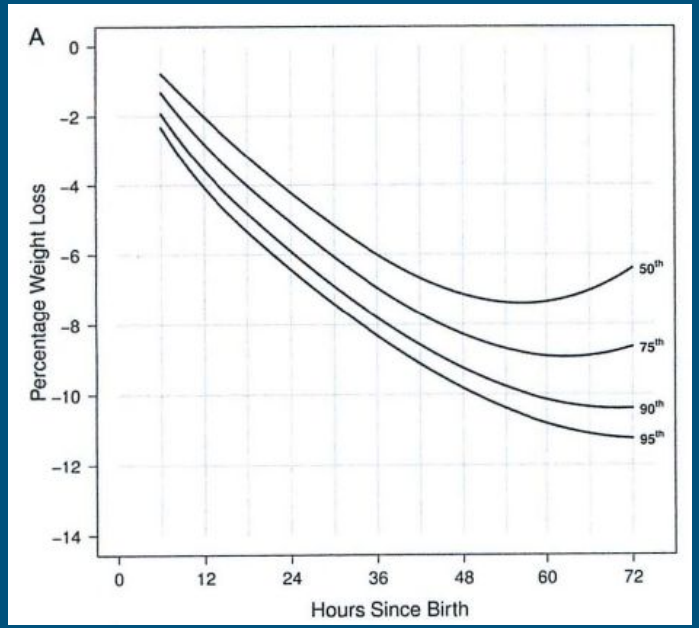
Also the expected volumes of colostrum/supplemental feedings per BFHI/ABM guidelines[13]

When colostrum/milk meets the newborn caloric need

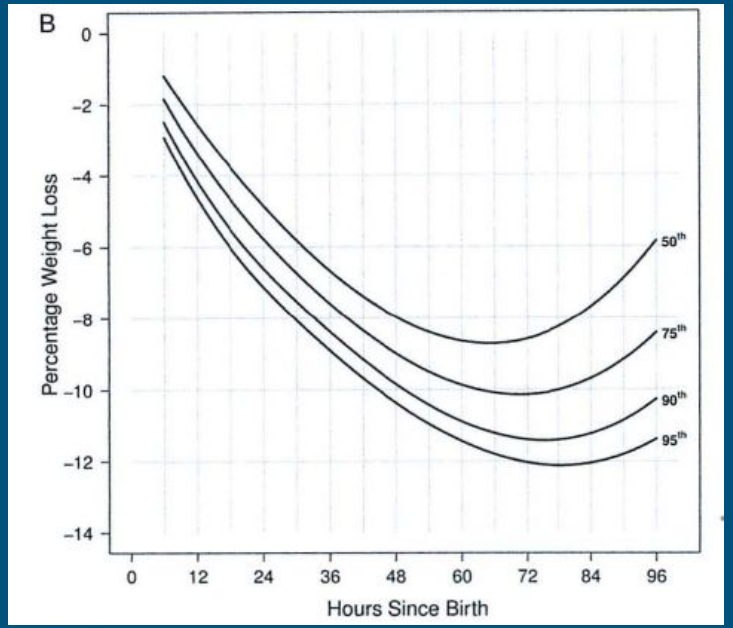


Only on the fourth day does an “average” mother produce sufficient milk to meet the full caloric need of a 3 kg newborn.

How does the newborn respond to this?



Weight loss of vaginally-delivered EBF babies[14]



Weight loss of cesarean-delivered EBF babies[14]

PEDIATRICS , Volume 135, number 1, January 2015 ARTICLE D

So why does an EBF newborn lose weight?

Exclusive breastfed newborns are losing weight because the caloric and fluid content of colostrum does not meet their full metabolic demand.

So why does an EBF newborn lose weight?

Exclusively breastfed

newborns are fasting.

How often do EBF newborns have to fast longer?

Study of 280 healthy mothers delivering healthy, term babies, BFHI protocol[15]

- 22% of mothers had delayed lactogenesis II (>72 hrs of life)
- Babies of moms with DLII were 7-fold more likely to lose > 10%
- Associated with primiparity* w/ >3.6 kg babies (34% w/ DLII), prolonged labor, BMI >27, flat/inverted nipples, use of labor medication in multips

Study of 431 EBF primip mothers - 44% had delayed onset of lactogenesis II[16]

15. Pediatrics. 2003 Sep;112(3 Pt 1):607-19. 16. Am J Clin Nutr. 2010 Sep;92(3):574-84. doi: 10.3945/ajcn.2010.29192. Epub 2010 Jun 23.

Insufficient Exclusive Breastfeeding

The most common complications of early exclusive breastfeeding are caused by fasting:

Hypoglycemia

Excessive Weight loss

Dehydration/Hypernatremia

Hyperbilirubinemia

→ Starvation

Brain Injury

Vital Organ Injury

→ Death

Causes of Readmissions, N = 5308 (17.9/1000 WBN Discharges) (Utah)

Cause	N (%)
Feeding problems*	2170 (40.9)
Jaundice*	1873 (35.3)
Respiratory distress	1753 (33)
Rule out sepsis	1193 (22.5)
Infection	1124 (21.2)

Early Readmission of Newborns in a Large Healthcare System. Pediatrics May 2013, Volume 131(5)

*The leading causes of newborn hospitalizations in the U.S. are complications from insufficient feeding due to early exclusive breastfeeding.[17]

Poor Exclusive Breastfeeding Readmissions

- Among healthy term EBF newborns, 10% of vaginally-delivered and 25% of cesarean-delivered newborns developed excessive weight loss of > 10%[14]
- Exclusive breastfeeding at discharge increases the risk of readmission
  - 2- to 11-fold increased risk for readmission among healthy, term EBF infants for jaundice and dehydration [20,21]
  - 2.3-fold increased risk for hypoglycemia readmission (U.K. NHS data)[22]
  - 98% severe hypernatremic dehydration is in underfed EBF newborns[23]

Phototherapy Admissions

- Worldwide, 12-35% of exclusively breastfed newborns develop hyperbilirubinemia [24-32]
- 5.7% of newborns in a hospital system with high EBF rates (>90-97%) required phototherapy[56]
- Estimated 190,000 phototherapy admissions in the U.S. annually (83% BF initiation rate), majority in dehydrated breastfed newborns
- Cost of U.S. phototherapy admissions = $2.7 billion a year
- Lifetime care of brain-injured newborns costs millions per child

Why do complications occur to exclusively breastfed newborns if colostrum is “enough” and 10% weight loss is “normal”?

Why do we think that 10% weight loss is normal?

Derived from a 1984 study of 7 vaginally-delivered, healthy term EBF newborns[33]

2 babies lost 10%, one baby failed to thrive, gained minimal weight at 4 wks

No laboratory markers for starvation (glucose, Na, bilirubin levels) were reported.

No long-term data on brain development to compare them to babies who did not lose weight

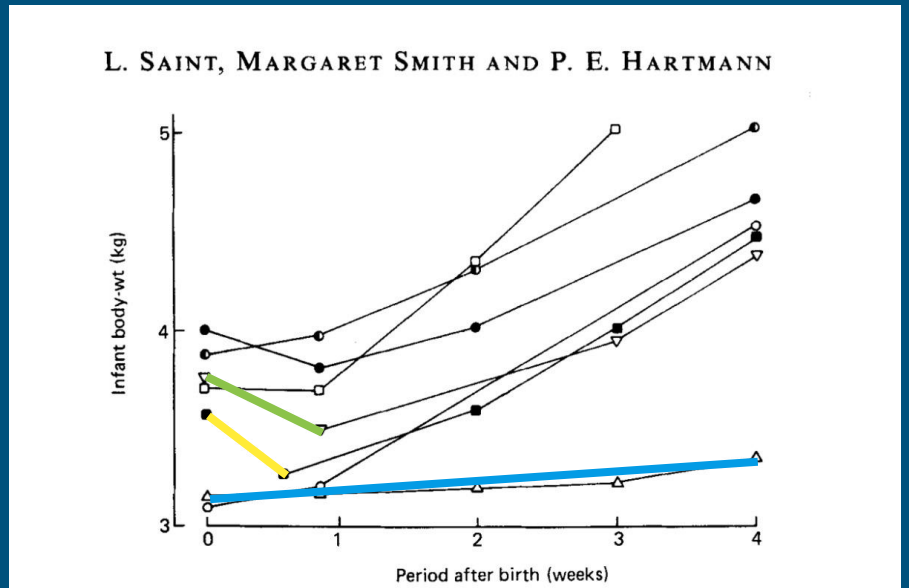


Fig. 4. The body-weight (kg) of the infants of seven mothers (A_1(○), A_2(●), A_4(■), A_6(□), A_8(◐), A_{11}(△), A_{12}(▽)) from birth of infant to 4 weeks post-partum.

How can this be if we survived through EBF?

No historical evidence that we primarily fed babies through *exclusive* breastfeeding from a single mother from birth prior to the WHO BFHI.

Before the WHO BFHI, newborns were near-universally *supplemented* in the first days of life with prelacteal feeding (milk of wet nurses, animal milk or sugar water)

High Breastfeeding Rates Despite Supplementation

Country (Survey date)	*Prelacteal Feeding*	*Median BF Duration*	*BF @ 1 year / 2 year*
Vietnam (1997)	Nearly 100% [34]	16.7 months	80.2% / 23.3%
India (1992-1993)	87.9%.,[35] 99%[36]	24.4 months	87.5% / 67.5%
Gambia (2000, earliest)	98% [37]	No data	96.8% / 53.9%
Nigeria (1990)	Nearly 100% [38]	19.5 months	86.4% / 42.9%
S. Africa (1998)	57% mix-fed;47.1% PLF[39]	16 months	66.6% / 30.4%
Bangladesh (1993-94)	90%[40]	>36 months	95.5% / 86.5%
Pakistan (1990-91)	Nearly 100% [41]	19.9 months	78.2% / 51.7%

From the WHO Global Data Bank on Infant and Young Child Feeding

Why was prelacteal feeding common?

- Most common answer from breastfeeding mothers is "not enough milk"
- 2002 Study of 1100 healthcare workers in Kaduna, Nigeria[42]
  - Doctors gave prelacteal feeds to prevent dehydration, hypoglycemia and jaundice
- Take home point: the purpose of prelacteal feeding was for the safety of the newborn, to alleviate hunger and prevent starvation

But the newborn stomach is so small…

Where do these volumes come from?

The commonly taught newborn stomach sizes were obtained from the colostrum production of 12 breastfeeding mothers… divided by 10 feeds[37]

NOT the actual size of the newborn stomach

*Am J Clin Nutr 1988;48: 1375

Days postpartum	Corrected milk yield*	Number of subjects
n (range)	*mL/d*	
1	56 ± 65 (−11–155)†	7
2	185 ± 103 (12–379)	10
3	393 ± 158 (226–745)	11
4	580 ± 250 (306–1010)	11
5	563 ± 145 (354–929)	12
6	558 ± 156 (360–888)	10
7	610 ± 187 (421–1008)	8

What is the actual size of the newborn stomach?

ACTA PÆDIATRICA
NURTURING THE CHILD

Acta Pædiatrica ISSN 0803-5253

VIEWPOINT ARTICLE

Neonatal stomach volume and physiology suggest feeding at 1-h intervals

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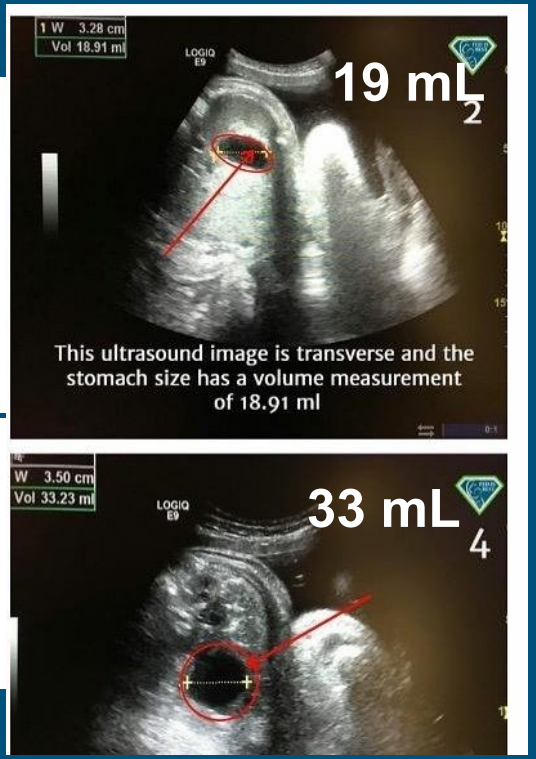
ABSTRACT

There is insufficient evidence on optimal neonatal feeding intervals, with a wide range of practices. The stomach capacity could determine feeding frequency. A literature search was conducted for studies reporting volumes or dimensions of stomach capacity before or after birth. Six articles were found, suggesting a stomach capacity of 20 mL at birth.



44. Acta Paediatrica, May 2013 102:773-777

How often and how soon do healthy, term exclusively breastfed newborns develop hypoglycemia given their fasting state?

Hypoglycemia in healthy, term EBF babies

- Study of 100 healthy, term strict BFHI-protocol EBF newborns → incidence of hypoglycemia < 40 mg/dL[45]
- All had good sucking reflex and latch
- POC glucose at 1, 6, 24 and 48 hours
- 10% of all newborns developed hypoglycemia, all events at 1 and 6 hours
- 23% of the first-born newborns developed hypoglycemia

J Clin Diagn Res. 2015 Sep;9(9):SC07-10.

What does transient hypoglycemia do?

1395 **asymptomatic** newborns universally-screened by 3 hours of life[46]

- Effects of hypoglycemia on ability to pass 4th-grade (10 y.o.) standardized tests in literacy and math
- Tested 3 different cut-offs for hypoglycemia: < 35, < 40, < 45 mg/dL

Hypoglycemia < 45 resulted in 38% reduction in passing literacy test

For newborns with hypoglycemia < 35 and < 40, there were 57% and 49% reductions in their ability to pass the test in literacy and math, respectively

Study published October 2015, JAMA Pediatr. 2015; 169(10): 913-921

Hypoglycemia & Developmental Disabilities

- Nov, 2018 Swedish population study >101,060 healthy, non-hyperinsulinemic newborns → effects of hypoglycemia (inc. transitional hypoglycemia < 40 mg/dl) on risk of developmental delay between age 2-6[47]

Table 3 Numbers, rates and risks of adverse neurodevelopmental outcomes

	Total number	Hypoglycemia N = 1500		No hypoglycemia N = 99,560		Logistic regression Reference group = No hypoglycemia			
		Number	Rate/ 1000	Number	Rate/ 1000	Crude		Adjusted[a]	
						OR	95% CI	OR	95% CI
Any neurological or neurodevelopmental outcome	3371	77	51	3294	33	1.58	1.25–1.99	1.48	1.17–1.88
Any developmental delay	675	29	19	646	6.5	3.02	2.07–4.40	2.53	1.71–3.73
Motor developmental delay	393	12	8.0	381	3.8	2.10	1.18–3.74	1.91	1.06–3.44
Cognitive developmental delay	314	17	11	297	3.0	3.83	2.34–6.26	2.85	1.70–4.76

Early vs. Late Hypoglycemia[47]

Table 4 Risks of adverse neurodevelopmental outcome by early and late neonatal moderate hypoglycemia

	Early hypoglycemia < 6 h N = 383				Late hypoglycemia > 6 h N = 1013			
	Crude		Adjusted[a]		Crude		Adjusted[a]	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Any neurological or neurodevelopmental outcome	2.22	1.50–3.28	1.94	1.30–2.89	1.33	0.98–1.80	1.29	0.95–1.76
Any developmental delay	4.10	2.18–7.72	3.01	1.57–5.79	2.61	1.61–4.24	2.33	1.42–3.82
Motor developmental delay	2.75	1.02–7.40	2.34	0.86–6.41	2.08	1.03–4.19	1.93	0.95–3.92
Cognitive developmental delay	5.30	2.35–11.98	3.17	1.35–7.43	2.99	1.54–5.82	2.54	1.29–5.01

Congenital malformations, inborn errors of metabolism, and maternal diabetes are excluded

[a]Adjusted for mode of delivery, birth weight for gestational age, gestational age, sex, Apgar score and birth year

Table 5 Risks of adverse neurological outcome by birth weight groups

	Small for gestational age n = 5 675				Appropriate for gestational age n = 84 722				Large for gestational age n = 10 688			
	Number	Rate/ 1000 live born	OR	95% CI	Number	Rate/ 1000 live born	OR	95% CI	Number	Rate/ 1000 live born	OR	95% CI
Any neurological or neurodevelopmental outcome	225	39.6			2815	33.2			331	31.0		
No hypoglycemia	203		1.00	Reference	2769		1.00	Reference	322		1.00	Reference
Hypoglycemia	22		2.10	1.33–3.32	46		1.52	1.13–2.05	9		0.95	0.50–1.79
Any developmental delay	58	10.2			549	6.48			68	6.36		
No hypoglycemia	52		1.00	Reference	529		1.00	Reference	65		1.00	Reference
Hypoglycemia	6		2.18	0.93–5.11	20		3.45	2.20–5.41	3		1.92	0.70–5.29
Motor developmental delay	33	5.81			317	3.74			43	4.02		
No hypoglycemia	30		1.00	Reference	309		1.00	Reference	42		1.00	Reference
Hypoglycemia	3		1.87	0.57–6.17	8		2.34	1.16–4.73	1		1.47	0.35–6.07
Cognitive developmental delay	29	5.11			256	3.02			29	2.71		
No hypoglycemia	26		1.00	Reference	244		1.00	Reference	27		1.00	Reference
Hypoglycemia	3		2.16	0.65–7.15	12		4.46	2.49–8.00	2		2.34	0.55–9.87

Congenital malformations, inborn errors of metabolism, and maternal diabetes are excluded

Peripartum Neonatal Hypoglycemia

- Hypoglycemia found in newborns shortly after birth is common but not benign
- Brain cells *do not know* what time the umbilical cord is cut
- Asymptomatic *and* transitional hypoglycemia can cause injury, reduce long-term academic achievement and increase risk of developmental disability
- “Low-risk” EBF newborns are at risk for hypoglycemic brain injury because they are not receiving their full caloric requirement

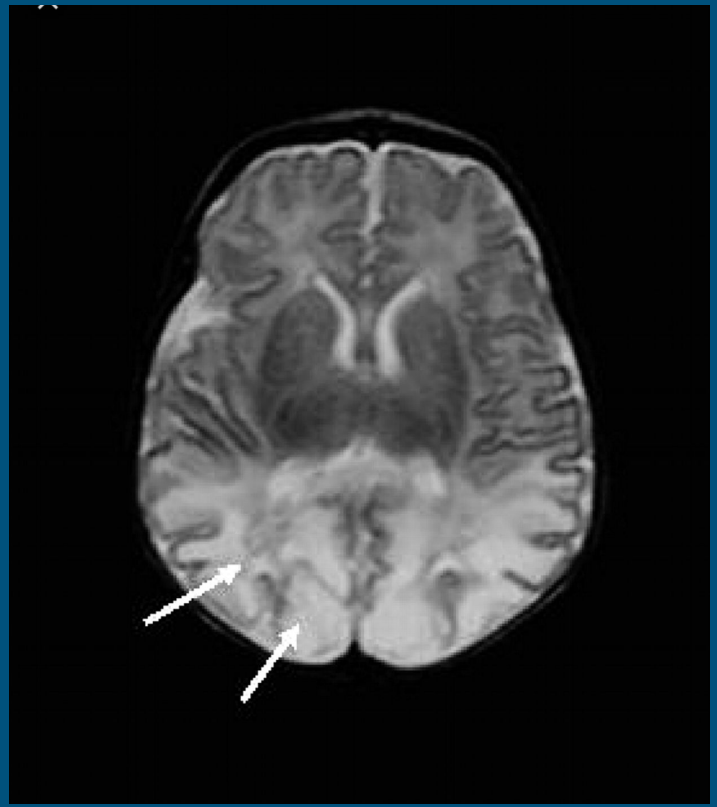
Effects of Prolonged Hypoglycemia

Newborn lethargy occurs when the brain is no longer supplied with enough calories or circulation to keep the brain awake.

By the time they are lethargic, they may have devastating levels of brain injury visible on MRI

Hypoglycemia from Poor Breastfeeding

- 11 healthy, term, AGA EBF babies, with symptomatic hypoglycemia, days 2-5[48]
  - Lost 0-16% of birth weight
  - 9 out of 11 lost < 10%
  - Lethargic, poorly feeding, seizing, hypothermic, apneic
  - 5 out of 6 MRIs - extensive brain injury to several lobes



Hypoglycemia from Poor Breastfeeding[48]

No.	Mode of Delivery	% Wt Loss	Age (DOL)	Presenting Symptoms	Glucose (mg/dL)	Seizure	MRI Results
1	Vaginal	10.5	4	Lethargy, poor feeding, seizure in trauma bay of ED	20	Yes	Extensive areas of restricted diffusion involving the bilateral parietal and occipital lobes
2	Vaginal	7.3	4	Lethargy, poor feeding, seizures	20	Yes	Extensive severe injury to the posterior one-third of the supratentorial brain
5	Vaginal	4.2	3	Poor feeding. shallow breathing, tremors	13	Yes	Restricted diffusion in parietal and bilateral occipital lobes
6	Vaginal	16	3	Lethargy, hypotonia, apnea	<20	Yes	Diffuse brain injury involving frontal, parietal, and occipital
7	Vaginal	0	3	Cyanotic episode at home, lethargy, poor feeding	<20	Yes	Restricted diffusion involving both posterior parietal, temporal, and occipital lobes
9	Cesarean	7.1	2	Apnea, hypotonia	8	No	Normal

The 10% rule is not safe or evidence-based.

Hypoglycemia from Poor Breastfeeding

- Babies went on to have variable long-term neurological disabilities
  - Epilepsy
  - Diffuse body weakness (hypotonia)
  - Visual impairment
  - Severe feeding difficulties requiring speech therapy

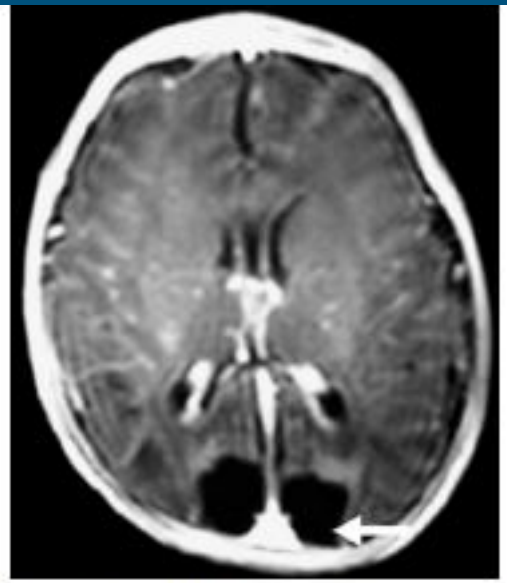


Fig. 1 T1 weighted axial MR image of brain at level of occipital horns showing abnormal hypointense areas in bilateral occipital lobes and parieto-occipital region

Glucose 20 mg/dL in breastfed newborn at 9% wt loss, MRI at 1 month[49]

Hypoglycemic Brain Injury ≤ 47

Study of 35 term infants with isolated symptomatic hypoglycemia < 47 mg/dL with brain MRI[50]

Sx: Poor feeding, hypothermia, jitteriness, limpness, irritability, lethargy, seizures, cyanosis and apnea

33 out of 35 (94%) infants had brain injury visible on MRI

Affected every area of the brain, every possible distribution from small to large areas of injury

Burns, C.M., et al. Pediatrics *122*, 65–74.

TABLE 3 Lesions Detected in 35 Infants With Neonatal Hypoglycemia

Lesion Site	No. With Isolated Hypoglycemia (%)
WM abnormalities	33 (94)
Mild	5 (14)
Moderate	13 (37)
Severe	15 (43)
Nature of severe WM lesions	
Focal hemorrhage	2 (13)
Unilateral focal MCA infarction	3 (20)
Widespread infarction	10 (67)
Global	2 (13)
Symmetrical posterior parasagittal	6 (39)
Asymmetrical posterior parasagittal	2 (13)
Location of all WM lesions	
Global	13 (39)
Posterior more than anterior	4 (12)
Anterior more than posterior	2 (6)
Posterior only	6 (18)
Anterior only	0 (0)
Unilateral	2 (6)
Periventricular	12 (36)
Posterior	4 (12)
Basal ganglia or thalami lesion	14 (40)
Normal (score 0)	21 (60)
Mild (score 0)	10 (29)
Moderate/severe (score 1)	4 (11)
PLIC	
Abnormal/absent myelination	4 (11)
Normal myelination	31 (89)
Cerebellum	2 (6)
Abnormal SI	1 (3)
Hemorrhage	1 (3)
Cortex	18 (51)
Highlighting[a]	12 (34)
Loss of markings[a]	9 (26)
Brainstem	2 (6)
Abnormal SI	1 (3)
Hemorrhage	1 (3)
Extracerebral hemorrhage	5 (14)
Intraventricular hemorrhage	3 (9)
Subarachnoid hemorrhage	0 (0)

[a] Not mutually exclusive.

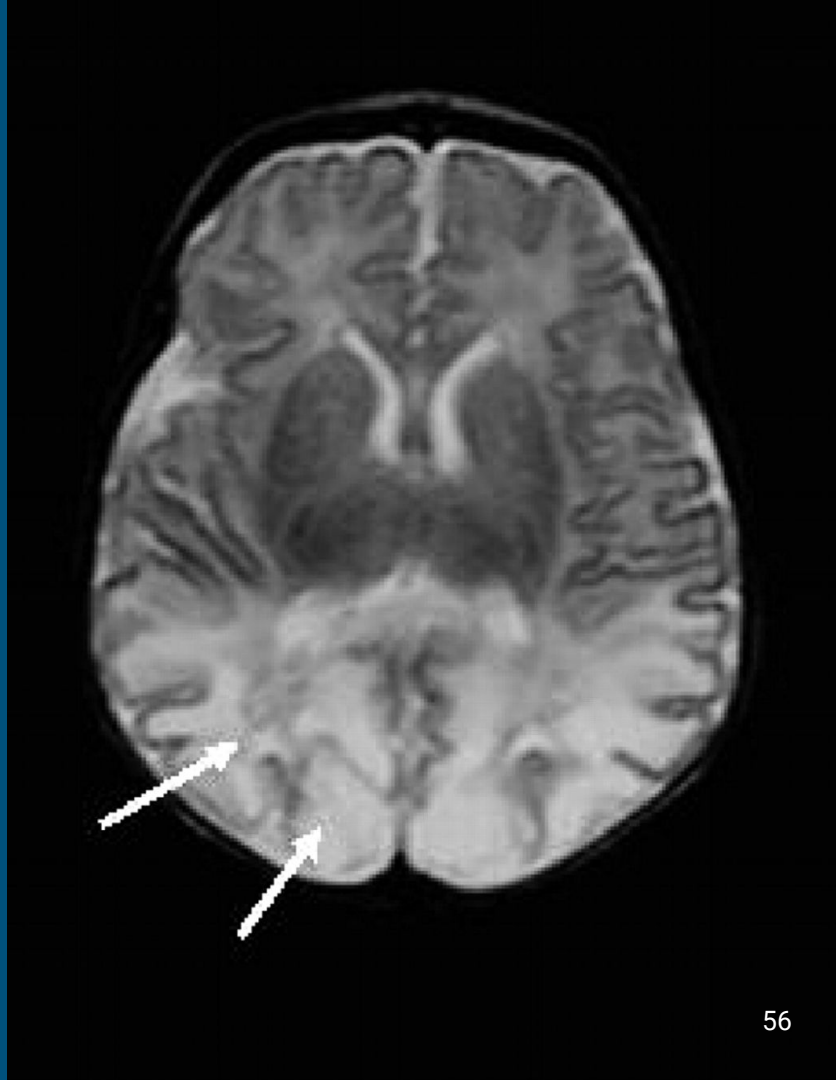
Neurological Outcomes of Hypoglycemia

Variable patterns of neurodevelopmental disabilities[50]

- Cerebral palsy
- Mild to moderate motor deficits
- Mild to moderate cognitive deficits
- Speech and language deficits
- Febrile seizures and epilepsy
- Visual deficits: squint, visual field defects, cortical visual impairment, immature visual attention and tracking, visuospatial difficulties

Hypoglycemic Brain Injury

- Hypoglycemia causes injury easily and rapidly, esp. symptomatic ≤ 47 → 94% chance of brain injury on MRI
- It can reduce a child's cognitive potential irreversibly
- Just ONE episode of starvation can disable a child for life
- The best way to protect the newborn brain is by preventing hypoglycemia



Safe Limits to Prevent Risk of Brain Injury

Lowest glucose level - 47 mg/dL[50,51]

Pediatric Endocrine Society recommends keeping glucose > 50 mg/dL if <48h old then >60 mg/dL[45]

Brain mounts the "neuroendocrine response" at < 55-65 mg/dL[52]

< 47 mg/dL increased risk of brain injury on MRI, lower cognitive scores at 12 months[53] and lower academic proficiency at 10 years of age[46]

< 40 mg/dL increases risk of developmental and cognitive disabilities by 2-3 fold[47]

Safe Limits to Prevent Risk of Brain Injury

Highest bilirubin level - > 15 mg/dL

Higher risk for disabilities associated with neonatal hyperbilirubinemia (ADHD, cognitive declines, BIND, seizures, cerebral palsy, kernicterus)[54-59]

Markers of brain injury found in blood by 17 mg/dL,[60] accelerates at 19[61]

45% of babies with bilirubin > 19.9 mg/dL have long-term neurobehavioral problems (ADHD, low academic performance, alcoholism) (30 year f/u)[62]

Safe Limits to Prevent Risk of Brain Injury

Highest Sodium Level = 145 mEq/L

Study of 116 cases of breastfeeding-related hypernatremia > 150 mEq/dL [63]

More than 50% of babies exhibited abnormal development by 12 months

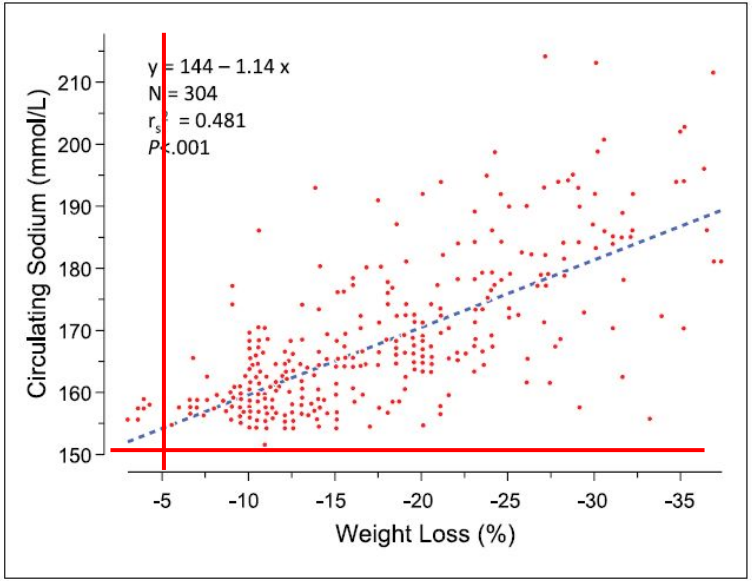
When does hypernatremia occur? - 95% of hypernatremic cases occur at

7% weight loss[64]

Hypernatremia

- Hypernatremia is considered rare
  - Percent weight loss data suggest hypernatremia is not rare
  - Hypernatremia is “rare” because it is not routinely screened for
- Hypernatremia causes brain injury, renal failure, DIC, intravascular thrombosis, epilepsy, disability and increased risk of death[66]

Figure 2. Relationship between Percentage Weight Loss and Sodium Concentration in 304 Late Preterm or Term Newborn Infants Affected with Breastfeeding-Associated Hypernatremia.



The figure and the regression analysis were built based on data found in references 5-118 concurrently reporting circulating sodium level and percentage weight loss.

65. J Hum Lact. 2016 Feb;32(1):67-74

Prevalence of Hypernatremia in BF Babies

- Prospective study of healthy, term newborns universally screened for hypernatremia,[67] a defining condition of insufficient milk intake
- 63% EBF, 17.6% Mix-Fed, 19.4% EFF
- 31% overall developed hypernatremia
- 36% of EBF and mix-fed babies (e.g. medical indication) had hypernatremia ≥ 145 mEq/dL
- 6% of EFF babies had hypernatremia
- Hypernatremia occurred with as little as 4.9% weight loss

Safe Limits to Prevent Brain Injury

Weight loss percent > 7% weight loss

(also recommended by AAP, 2012)[68]

- Newborns who lose > 5-7% weight loss are at higher risk for hypernatremia[64,65] and hyperbilirubinemia > 15 mg/dL[69]
- **No neurological data using developmental tests on safety of 10% wt loss**
- One study of >12% weight loss with developmental testing at 5 y.o.[70]
  - "Dehydrated" newborns had reduced fine motor score, higher rates of parental concern for language delay, higher rates of parental reports of "shyness," "allergies," and "disability"

Case Conclusion

Landon was pulseless and cyanotic and received CPR en route to the ER.

Intubated in the ER.

VS: Rectal Temp 93.1 F, Pulseless Electrical Activity 130,

Got 7 rounds of epinephrine with no return of circulation. After 45 minutes of CPR, no spontaneous cardiac activity on U/S.

CPR was stopped with parental consent while continuing ventilation and IVF.

Case Conclusion

After 20 minutes of IV saline after CPR termination, he regained his pulse.

Transferred to the nearest Level II NICU for head cooling.

Diagnosed: hypernatremic dehydration from poor feeding and cardiac arrest from hypovolemic shock. Sodium (Na) =155.

Given dextrose infusion, TPN, head cooling protocol

Case Conclusion

MRI showed injury to the basal ganglia
EEG showed diffuse slowing and seizures c/w widespread brain injury
Landon was taken off life support at 19 days of life.

Cause of death according to autopsy:

1. hypernatremic dehydration →
2. cardiac arrest →
3. hypoxic-ischemic encephalopathy

Few hours after birth

2nd day, hungry, constantly crying and nursing

Landon intubated after resuscitation

Jill holding Landon as he took his last breaths

Prevention of Feeding Complications

Goals:

- No child experiences feeding complications
- No child is disabled by feeding complications

Counseling Before Birth

1. Mother can learn about breastfeeding technique (Stanford Medicine)[71,72]
2. Mothers can download and fill out a free Feeding Plan - Fedisbest.org[64]
3. Assess the mother's risk factors for insufficient/delayed milk production
4. Review feeding plan with the in-hospital pediatrician and staff *before* birth
5. Provide informed consent on early EBF risks of jaundice, dehydration, hypoglycemia, brain injury associated with insufficient feeding[74]
6. Provide informed consent of the risk of decreased milk supply if supplementing without adequate time breastfeeding/pumping[74]

Risk Factors for Feeding Complications

- **Primparity - 34-44% have delayed lactogenesis II[15,16]**
- Cesarean section
- Complicated, prolonged labor
- Maternal BMI > 27
- Flat, inverted nipples
- Large babies > 3600 g
- Maternal Age ≥ 25 years old
- Higher maternal education and income
- Higher IVF - > 200 mL/hr
- History of low supply/failed breastfeeding
- Maternal problems - PCOS, thyroid, diabetes, HTN, smoking, infertility
- Breast surgery, hypoplasia, tubular
- Jaundice observed in the first 24 hours
- ABO incompatibility, other known hemolytic disease, positive Coombs Ab
- Gestation age 35-38k
- Previous sibling received phototherapy
- Cephalohematoma or brushing
- Exclusive breastfeeding if poor with excessive weight loss
- East Asian race
- TSB/TcB high or high intermediate risk
- Male genser
- Vacuum delivery

Making Sure a Newborn is Fed

- Before every breastfeeding session, mothers can manually express breasts to check for milk (Stanford Hand Expression of Breast Milk)[71]
- Breastfeed within the 1st hour (ideally) with CONFIRMED MILK TRANSFER
  - Assist with correct latch, positioning and hearing of swallows, LATCH[75]
- Breastfeed for 15-20 minutes per breast every 2-3 hours while hand expressing; feed on-demand (as baby will tolerate)
  - Longer unsatisfied feedings and excessive crying cause greater caloric expenditure, accelerate weight loss

Making Sure a Newborn is Fed

- **If little or no colostrum is present**, a mother may *choose* to supplement with donor milk or formula 15 mL at time, burp and repeat per hunger cues, to prevent starvation-related complications
  - They may take 15-30 mL+ of milk per feed (newborn stomach is 20 mL)
  - Offer mother's expressed breast milk, milk bank donor milk (as available) or formula *per mother's preference*
  - Finger and syringe feeding, SNS feeding, bottle feeding per mother preference
  - **Allowing newborns to receive what they need to correct dehydration protects their brain and vital organs from injury**
  - Supplement only AFTER breastfeeding. Offer education on pumping for any missed feedings

Glucose Monitoring for EBF Babies

- Healthy, term, AGA, EBF newborns are high risk for hypoglycemia due to low caloric intake from exclusive colostrum feeding[9]
  - Monitor glucose per hospital protocol (starting at birth and by 1-hr) and as needed for inconsolable crying[52] → hypoglycemic babies treated per protocol along with *ad-lib* supplementation
- The brain's neuroendocrine response occurs at blood glucose of 55-65 mg/dL to protect its own survival.[52]

The brain's preference should be honored

Hypoglycemic Threshold

- Keeping glucose > 47 mg/dL is the only prospectively validated glucose level that prevent developmental delay[51]
- If blood glucose < 50 mg/dL, the baby is likely depleted of calories
  - PES guidelines: correct glucoses <50 up to 48 hrs old, correct glucoses <60 thereafter[52]
  - Recommend ad lib, unrestricted supplementation with donor milk or formula after breastfeeding sessions until breastfeeding provides the full caloric requirement
  - Restore caloric reserve to stabilize glucose because recurrent hypoglycemia can worsen brain injury

Signs of Hypoglycemia

Supplement if < 50-60 mg/dL for prevention.[52]

- Hypoglycemia < 45 w/o symptoms is also detrimental
- Low body temperature
- Excessive crying even after nursing, prolonged (>45 min) / unsatisfied nursing
- Lethargy, blank staring and poor feeding
- Shakiness or jitteriness
- Seizures - stiffening, jerking, eyes rolling back
- Bradycardia, decreased breathing, blue skin are late signs

Diaper counts do not reflect milk intake[76]

- Wet/dirty diaper counts do not predict adequate milk intake in the first 4 days
- Diapers mostly come from the fluid and meconium they are born with
- Dehydrated babies can produce up to 6 wet diapers on day 4

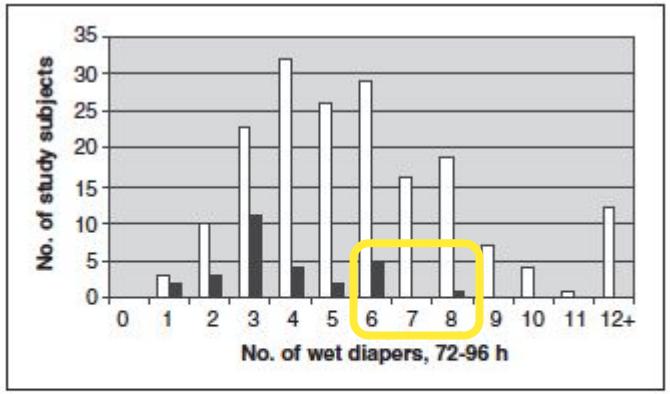


Figure 4. Frequency distribution for wet diaper output on day 4 (72-96 hours) by neonatal weight loss category (white bars = neonatal weight loss < 10% at 72 to 96 hours postpartum, black bars = neonatal weight loss ≥ 10%).

*Newborn Wet and Soiled Diaper Counts and Timing of Onset of Lactation as Indicators of Breastfeeding Inadequacy J Hum Lact 24(1), 2008

Diaper counts do not reflect milk intake[76]

- Dehydrated babies can produce up to 6 dirty diapers on day 4

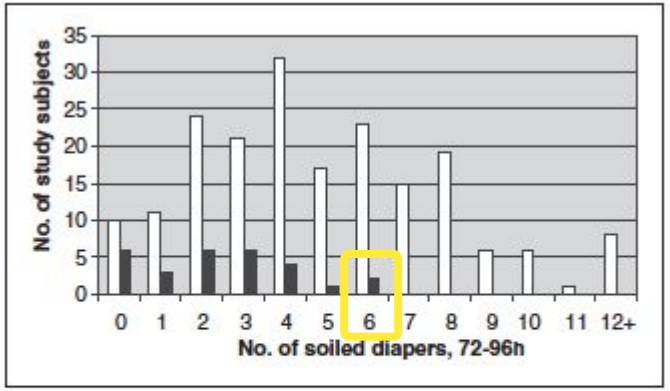


Figure 3. Frequency distribution for soiled diaper output on day 4 (72-96 hours) by neonatal weight loss category (white bars = neonatal weight loss < 10% at 72 to 96 hours post-partum, black bars = neonatal weight loss ≥ 10%).

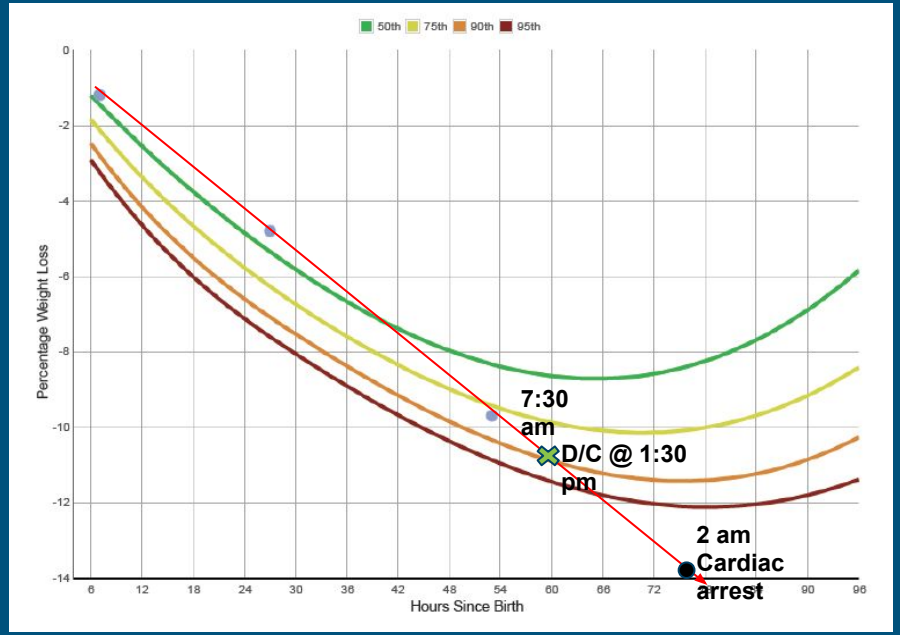
*Newbon Wet and Soiled Diaper Counts and Timing of Onset of Lactation as Indicators of Breastfeeding Inadequacy J Hum Lact24(), 2008

Making Sure a Newborn is Fed: Weight Checks

- Obtain weight checks every 12 hours (fastest weight loss 7-8% in 24 hrs)[14]
  - 7% at any time associated with excessive jaundice[8] and hypernatremic dehydration,[52]
  - > 7% requires evaluation (exam for newborn distress, lethargy, electrolytes, glucose, bilirubin) → recommend ad-lib supplemented breastfeeding if approaching the phototherapy threshold, newborn distress, labs approaching abnormal values that require admission
- Baby should not lose greater than 7% (2012 AAP Guidelines)[77]
  - Consider bilirubin, sodium and glucose screen at or above 7%
  - Consider sodium check above 5% especially if newborn is distressed

Using the Newborn Weight Loss Tool[78]

- Can justify earlier supplementation
- Does *not* tell you whether a child is safe from brain-threatening complications
  - Excluded hospitalized newborns
  - Data set was not matched with glucose, bilirubin or sodium levels or neurological outcomes
  - Use to predict next day after discharge weight if lactogenesis II does not occur



Bilirubin Monitoring Recommendations

- Daily transcutaneous / serum bilirubin check until lactogenesis II and the onset of newborn weight gain (particularly in newborns with hemolytic jaundice) and treat per AAP guidelines[83]
  - Both in-hospital and at follow-up (until the feeding plan provides full requirement of 6 oz/kg/day and bilirubin levels are declining in response)
- Bilirubin elimination is dependent on milk volume.
  - Telling parents to expose jaundiced babies to sunlight without ensuring delivery of the full milk requirement of 6 oz/kg/day is insufficient and *unsafe* treatment of jaundice
  - If parents describe newborn is in distress, it is safer to recommend ad-lib supplementation until baby is medically evaluated to prevent irreversible brain injury

Making Sure a Newborn is Fed: Distress

- Newborn distress or a mother worried about newborn distress should signal immediate medical evaluation, laboratory evaluation (sodium, glucose, bilirubin) and likely supplementation
- If the baby is premature, SGA, LGA, IDM or medically fragile, baby will need closer monitoring and likely earlier ad-lib supplementation.
- Chem-7, serum bilirubin, weight check *close to the time of discharge*
    - Do not discharge newborns who are close to abnormal ranges

Reasons for Supplementation

- Hypoglycemia < 50 mg/dL
- Dehydration / Excessive weight loss > 7% (AAP Guidelines) or > 75%ile weight loss on NEWT (ABM)
- High sodium (sodium > 145 mEq/L)
- Hyperbilirubinemia or abnormal bilirubin approaching 15 mg/dL or high-risk levels on the bilirubin nomogram
- Lethargy
- Poor latch and feeding despite correction
- Intolerable pain during feedings despite correction
- Mother - baby separation
- Maternal medications that are unsafe to her baby
- Metabolic abnormalities / complications
- Insufficient milk production
- Mother's preference
- Baby's persistent crying or hunger signs

Supplemented breastfeeding is a valid and safe feeding choice as no benefit of exclusive breastfeeding justifies the risk of starvation-related brain injury.

Supplemented breastfeeding before lactogenesis II was the norm before the BFHI to prevent starvation/complications.

Pediatrics-trained physicians and NPs are the *only* health professionals qualified to fully evaluate a newborn with labs in order to determine if it is safe to *withhold* supplementation.

No mother can be barred from supplementing her baby if she wishes to do so at any time.

Protecting one's child from hunger and injury is a human right.

EBF newborns being sent home before lactogenesis II are FASTING.

Discharge Instructions for EBF Moms

- Instructions on the signs and symptoms of newborn starvation and that is means breastfeeding is not providing enough
- Provide the calculated 7% weight loss threshold.
- Instructions on how to supplement while protecting the supply in the event her milk does not come in or breastfeeding difficulties arise to prevent newborn brain injury
- Need next day after discharge follow-up with universal bilirubin, electrolyte and glucose check and discussion of percent weight loss limits

Majority of Kernicterus is in Breastfed Babies

98% of kernicterus [bilirubin-induced brain injury] occur in breastfed babies, particularly those that lose > 10%

— ABM Jaundice Guidelines, 2017

H Hypoglycemia (low blood sugar) jittery hands, low body temperature, inconsolable and high-pitched crying, turning blue and seizures

U Unsatisfied nursing, lasting longer than 30 minutes and occurring more frequently than every 2 hours, crying despite prolonged breastfeeding

N Not waking for feeding every 3 hours, difficult to arouse and very sleepy, not maintaining latch, limpness, lethargy

G Growth or weight loss exceeding 7% at any time, which increases risk of high sodium levels (hypernatremia) and excessive jaundice

R Reduced wet and dirty diaper counts (no wet diapers in 6 hours), Red brick dust on diapers, dry lips and mouth, crying without tears

Y Yellowing of the skin or eyes, especially below the face, known as hyperbilirubinemia or excessive jaundice

"Perfect latch": Exclusively breastfed, at five days 20% down with hypernatremia and jaundice.

Excessive Weight Loss and Failure to Thrive

EBF mothers should have a home baby scale

- Before lactogenesis II, weigh baby every 12 hours to prevent weight loss > 7% until baby gaining weight
- Can weigh once weekly to monitor for failure to thrive
  - Gain 5-7 oz per week

How to Supplement and Promote Breastfeeding

1. Supplement only after breastfeeding 15-20 minutes each breast every 2-3 hours or more frequently based on baby hunger cues
2. Manually express breasts to assist milk transfer during breastfeeding
3. Supplement 15 mL (half ounce) at a time until newborn hunger, distress, lethargy and/or medical indications resolve (commonly 15-60 mL)
   a. Finger-feeding
   b. Periodontal syringe feeding at the breast
   c. Supplemental Nursing System to supplement at the breast
4. Burp baby after every 15 mL to prevent regurgitation and gas
5. Pump breasts for 20-30 minutes for any missed feedings

Supplementation Does Not Discourage Breastfeeding

RCT of 40 EBF healthy, term infants 24-48 hours ≥ 5% weight loss (10 mL ELF vs. EBF)[79]

At 1 week, 47% supplemented newborns were EBF vs. 10% in unsupplemented group (p = 0.01)

At 3 months, 79% supplemented newborns were EBF vs. 42% of unsupplemented newborns (p=0.02)

Supplementation NEARLY DOUBLED EBF at 3 months

Pediatrics. 2013 Jun;131(6):1059-65.

RCT of 104 healthy, term infants 24-48 hours ≥ 5% weight loss (10 mL ELF vs. EBF)[80]

No differences in rates of exclusive and any breastfeeding (p-values for EBF, ABF)

- Discharge (p = 0.2, p>0.99)
- 3 months (p=0.12, 0.10)
- 6 months (p=0.45, 0.34)

PLoS One. 2016 Feb 26;11(2):e0150053.

Supplementation Does Not Discourage Breastfeeding

Randomized trial of 164 EBF newborns given 10 mL of formula after every breastfeeding(ELF) vs. EBF[81]
Inclusion: 24-72 hrs, > 75%ile weight loss, mothers before lactogenesis II

	ELF	EBF	p-values
Still Breastfeeding at 1 week	95.8%	93.5%	p>0.5 (no difference)
Still Breastfeeding at 1 month	86.5%	89.7%	p>0.5 (no difference)
Breastfeeding w/o formula at 1 month	54.6%	65.8%	P =.18 (no difference)
Admission	0	4	p =.06 (no difference, small sample)
Gut microbiome	No differences in microbiome between ELF and EBF		

J Pediatr. 2018 Mar 13. pii: S0022-3476(17)31770-5

Summary of Safe Breastfeeding Guidelines

1. Prenatal education - assess risk factors, teach effective latch, positioning and manual expression, signs of insufficient feeding
2. Prevent brain injury - supplement BEFORE they develop brain-threatening complications if BM is insufficient (6 oz/kg/day)
    a. Glucose < 47-50 mg/dL
    b. Sodium > 145 mEq/dL
    c. Bilirubin > 15-19 mg/dL, supplement 2-3 points before phototherapy threshold
    d. Weight loss > 7%, >75%ile esp. if after discharge or no laboratory evaluation is available
3. Protect the supply - teach how to supplement only after nursing, pump
4. Safe Sleep - let mom sleep by allowing access to the nursery, prevent SUPC

Summary

- A newborn who is persistently crying/nursing or lethargic is HUNGRY and is in danger of serious complications if not fed adequately
- EBF newborns need closer glucose, bilirubin, electrolyte, weight monitoring
- Newborns can be supplemented to prevent complications and hospitalizations without compromising long-term breastfeeding success
- No benefit of exclusive breastfeeding justifies the risk of starvation-related brain injury
- Starvation-related brain injury is a mistake that can never be reversed

"Unfortunately, the lack of concern about jaundice among health care providers has led to a major [gap] in childbirth education curricula and has added to the burden of jaundice with unmeasured occurrence of [Bilirubin-Induced Neurological Disorder]. The teaching and discussion of jaundice, impact of early discharge, [and] breastfeeding has been minimal or nonexistent. A sound foundation for a safe, family- based global initiative of education, prevention and early treatment is urgently needed to relieve the burden attributed to unsafe management of newborn jaundice."

—– Dr. Vinod Bhutani, Lead Author of AAP Neonatal Jaundice Guidelines