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Excess Weight Loss in First-Born Breastfed Newborns Relates to Maternal Intrapartum Fluid Balance

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KEY WORDS

excess weight loss, infant, breastfeeding, intrapartum fluid balance, neonate

ABBREVIATIONS

CI—confidence interval
EWL—excess weight loss
EBF—exclusively breastfed
IBFAT—Infant Breastfeeding Assessment Tool
RR—relative risk
UCDMC—University of California, Davis, Medical Center

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WHAT'S KNOWN ON THIS SUBJECT: Excess weight loss is relatively common in term breastfed infants, occurring in up to 16% of first-born infants in previous studies. Delayed onset of lactogenesis and suboptimal infant breastfeeding behavior were associated with excess weight loss in multivariate analyses.

WHAT THIS STUDY ADDS: This study describes an independent association between excess weight loss among breastfed infants and maternal intrapartum fluid balance. The prevalence of excess weight loss—19% of exclusively breastfed, demographically diverse, first-born, term infants—was higher than previously reported.

abstract

OBJECTIVES: The objectives were to describe weight loss in a multiethnic population of first-born, predominantly breastfed, term infants and to identify potentially modifiable risk factors for excess weight loss (EWL).

METHODS: Data on prenatal breastfeeding intentions, demographic characteristics, labor and delivery interventions and outcomes, breastfeeding behaviors, formula and pacifier use, onset of lactogenesis, and nipple type and pain were collected prospectively. Logistic regression analyses identified independent predictors of EWL (≥10% of birth weight) by using a preplanned theoretical model.

RESULTS: EWL occurred for 18% of infants who received no or minimal (≤60 mL total since birth) formula ($n = 229$), including 19% of exclusively breastfed infants ($n = 134$) and 16% of infants who received minimal formula ($n = 95$). In bivariate analyses, EWL was associated ($P < .05$) with higher maternal age, education, and income levels, hourly intrapartum fluid balance, postpartum edema, delayed lactogenesis (>72 hours), fewer infant stools, and infant birth weight. In multivariate logistic regression analysis, only 2 variables predicted EWL significantly, namely, intrapartum fluid balance (adjusted relative risk for EWL of 3.18 [95% confidence interval [CI]: 1.35–13.29] and 2.80 [95% CI: 1.17–11.68] with net intrapartum fluid balance of >200 and 100–200 mL/hour, respectively, compared with <100 mL/hour) and delayed lactogenesis (adjusted relative risk: 3.35 [95% CI: 1.74–8.10]).

CONCLUSIONS: EWL was more common in this population than reported previously and was independently related to intrapartum fluid balance. This suggests that intrapartum fluid administration can cause fetal volume expansion and greater fluid loss after birth, although other mechanisms are possible. *Pediatrics* 2011;127:e171–e179

Improving rates of breastfeeding exclusivity and duration are among national Healthy People 2010 goals.[1] Optimal support of exclusive breastfeeding entails conducive maternity practices[2] and careful monitoring of the neonates to ensure adequate intake,[3,4] typically through measurements of weight loss and urine and stool counts and observation and auscultation during feedings. Weight loss of >7% of birth weight suggests possible breastfeeding problems and requires further evaluation and possibly intervention to improve milk production and/or transfer.[3,4] Excess weight loss (EWL), typically defined as loss of ≥10% of birth weight, is common, for example, 7.7% in an Italian study[5] and 12% in a report from California.[6] Associated morbidities such as hyperbilirubinemia[7] and hypernatremic dehydration[5,8] are well-known complications of inadequate intake among newborns, often result in rehospitalization,[8,9] and can cause adverse long-term sequelae or even death.[8,10,11]

Despite potential adverse sequelae, few studies have assessed risk factors for EWL systematically. One multivariate analysis found delayed onset of lactogenesis and suboptimal infant breastfeeding behavior to be significant predictors of EWL.[6] Without delayed lactogenesis and suboptimal infant breastfeeding behavior in the model, risk factors for EWL included longer labor, no oxygen treatment for the infant, and labor pain medication (the latter among multiparous women only). Objectives of this larger study were to describe weight loss in a diverse population of first-born, predominantly breastfed infants and to evaluate potentially modifiable risk factors for EWL.

METHODS

Study Subjects and Design

This prospective study of 448 pregnant women recruited subjects prenatally from among all eligible women who were receiving prenatal care at the University of California, Davis, Medical Center (UCDMC), a teaching hospital in northern California, between January 2006 and December 2007. Eligibility criteria included expecting a first live-born infant, 32 to 40 weeks of gestation, singleton pregnancy, English or Spanish speaker, and residence within 8 miles of UCDMC. Exclusion criteria were previous referral to the UCDMC because of a high-risk medical condition, known absolute contraindication to breastfeeding, or <19 years of age and unable to obtain parental consent. Institutional review board approval from the University of California, Davis, and written informed consent from each participant were obtained. UCDMC has a breastfeeding policy consistent with the Ten Steps for Successful Breastfeeding.[2] Mothers experiencing lactation difficulties are referred to a nurse lactation consultant, who was available 6 days per week during the study period except for vacations and sick leave. Women also are referred to an early breastfeeding follow-up clinic after discharge, for ongoing lactation assistance.

Data Collection

Subjects were interviewed prenatally regarding demographic features (including self-identified ethnicity, years of education, health insurance status [public versus private, used as a proxy indicator of income], and age), psychosocial measures related to infant feeding, and infant feeding intentions by using a previously validated tool.[12] Within 24 hours after birth, research assistants visited mothers in the hospital to obtain information from the mothers and medical records regarding labor, delivery, and birth interventions and outcomes, infant breastfeeding behaviors, breastfeeding problems, formula and pacifier use, onset of lactogenesis, and nipple type and pain. Data on intrapartum fluid status were extracted from electronic medical records, which were instituted at UCDMC in April 2006; therefore, these data were available only for mothers who delivered after this date (63.8% of the study population). Assistants observed and rated breastfeeding according to the Infant Breastfeeding Assessment Tool (IBFAT),[13] if possible. Mothers were asked to record breastfeeding events, volumes of infant formula supplementation (if any), reasons for supplementation, and urine and stool output. If maternal and medical record reports of formula volumes used during hospitalization were discrepant, then the larger volume was used.

Similar information was collected and infants were weighed on an electronic scale (accurate to the nearest 1 g) on days 3 and 7, at the home, hospital, or clinic. Mothers also were questioned regarding infant problems for which a physician visit or hospitalization occurred.

Definitions

EWL was defined as loss of ≥10% of birth weight at 3 days of age (70–98 hours) and delayed onset of lactogenesis as the mother not feeling "noticeably fuller" breasts by 72 hours after the birth. The maternal perception of noticeably fuller breasts was validated previously as a measure of lactogenesis.[14,15] Suboptimal infant breastfeeding behavior was defined as an IBFAT score of ≤10, consistent with previous studies.[6,16] Intrapartum fluid balance was defined as the total amount of fluid delivered (both intravenously and orally) to the mother in the intrapartum period minus urine output, divided by the number of hours of labor in the hospital.

Statistical Analyses

Bivariate analyses with χ^2 tests were performed to evaluate associations of demographic and clinical data with EWL. Logistic regression analyses were performed to evaluate independent associations with EWL in 2 models, that is, a theoretical model and a traditional empirical model including all variables associated with EWL in bivariate analyses (unadjusted $P < .10$). In the theoretical model, variables included were breastfeeding frequency, suboptimal infant breastfeeding behavior, delayed lactogenesis, gestational age, intrapartum fluid balance, and formula use. Multivariate analyses were performed for the combined group of infants who either were exclusively breastfed (EBF) or received ≤60 mL of formula cumulatively between birth and day 3. The group of infants who received >60 mL of formula was not analyzed further, because only 3% of those infants experienced EWL and weight loss in predominantly breastfed infants was the subject of interest. Sixty milliliters was chosen as the cutoff value because the mean percentage of weight loss for infants fed 1 to 60 mL of formula was not significantly different from that for EBF infants (6.1 ± 3.6% vs 6.4 ± 3.8%; $P = .61$). This cutoff value was consistent with previous work[6] and allowed for inclusion of infants who might have received supplementation once for a medical indication (eg, hypoglycemia). Adjusted relative risks (RRs) were estimated by using the method described by Kleinman and Norton.[17] Maternal characteristics for infants with and without EWL were compared by using the Wilcoxon signed-rank test for means, the χ^2 test for proportions, and the Kaplan-Meier test for onset of lactogenesis. All analyses were performed by using SAS 9.2 (SAS Institute, Cary, NC).

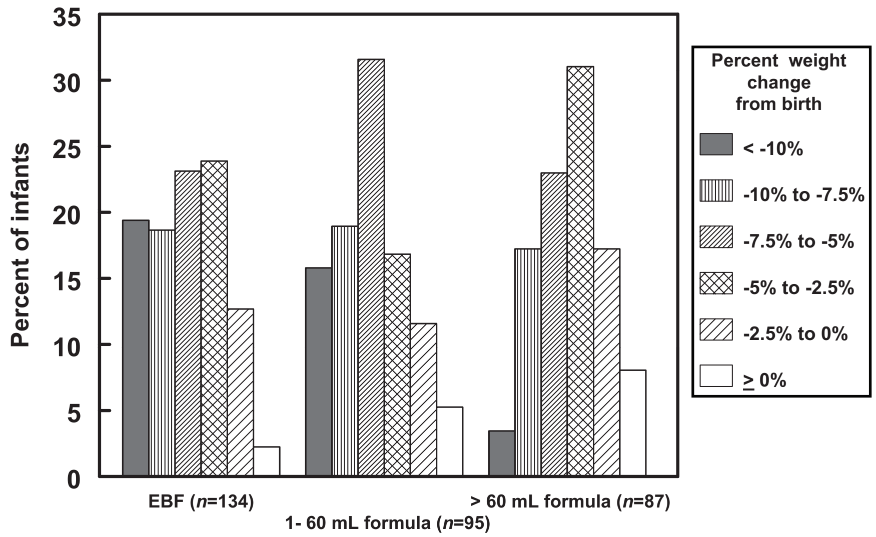

FIGURE 1
Distribution of weight changes from birth to day 3 of life according to formula supplementation category.

RESULTS

Over the 24 months of enrollment, 768 of women screened met initial eligibility criteria and 69% ($n = 532$) agreed to the prenatal interview. Of the 532 women interviewed, 40 (8%) were lost to follow-up monitoring and 44 (8%) subsequently became ineligible (preterm birth, $n = 11$; mother and infant separated beyond 24 hours, $n = 21$; chose not to breastfeed, $n = 12$), which resulted in a sample size of 448 postnatal dyads. Infant weight data were available on day 3 for 418 of these infants (93.3%), but data were outside the 70- to 98-hour window for 102 infants (22.8%), which resulted in available data between 70 and 98 hours of age for 316 infants (70.5% of the postnatal study population); these infants did not have different illness or hospitalization rates during the first week of life, compared with those without valid day 3 weight data. For mothers of these 316 infants, the mean ± SD age was 26.3 ± 5.9 years (range: 16.4–41.5 years); 38% had a high school education or less, 45% had public health insurance, and the self-identified ethnic distribution was 42% non-Hispanic white, 27% Hispanic, 12% non-Hispanic black, 12% Asian, and 7% mixed or other. These mothers were more likely to have had vaginal deliveries, long stage II labor, higher pain ratings, and earlier introduction of breastfeeding and were less likely to have low income, to supplement with formula, to use pacifiers, and to remain hospitalized at 3 days after the birth, compared with mothers whose infants had missing or invalid day 3 weight data.

The mean ± SD infant gestational age and birth weight were 39.6 ± 1.0 weeks and 3368 ± 433 g, respectively. Of the 316 infants in the sample, 134 (42.4%) were EBF throughout the first 3 days, an additional 95 (30.1%) received minimal formula supplementation (a total of ≤60 mL before day 3), and 87 (27.5%) received ≥60 mL of formula.

On day 3, the mean ± SD weight loss for infants who received no or minimal supplementation was 6.3 ± 3.7%, whereas that for all infants was 5.8 ± 3.7% (range: 19.3% loss to 10.0% gain). Figures 1 and 2 depict weight loss distributions for the 3 subgroups (EBF, 1–60 mL of formula, and >60 mL of formula) on days 3 and 7. By day 7, the 106 infants who were EBF since birth were nearly back to their birth weights on average, with mean weight loss of 0.8 ± 4.4%.

EWL occurred for 19% of EBF infants, 16% of infants who received minimal formula (≤60 mL), 3% of infants who received larger amounts of formula,

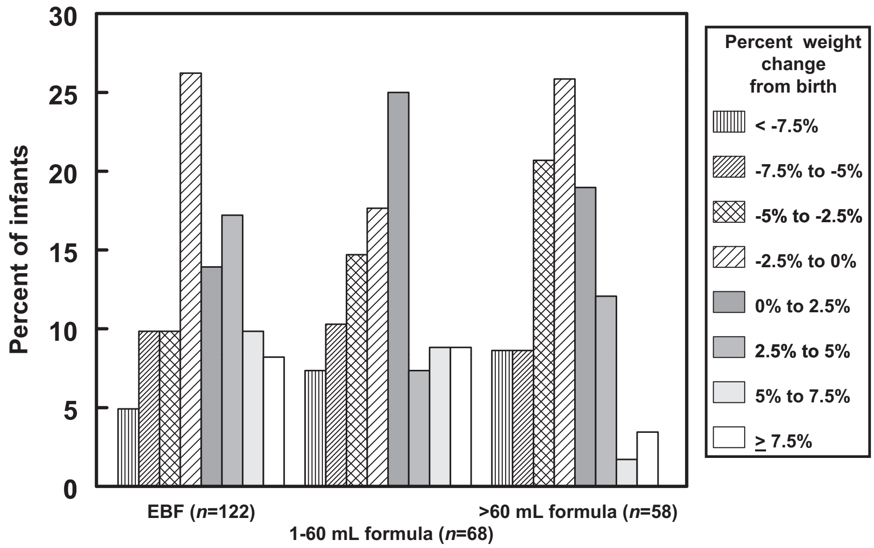

FIGURE 2
Distribution of weight changes from birth to day 7 of life according to formula supplementation category on day 3.

and 14% of the total study population. The prevalence of EWL was not statistically different between infants who were EBF and infants who received minimal formula (P = .56); these groups were combined for further analyses (n = 229). In bivariate analyses for the combined group, EWL was significantly associated ($P <$ .05) with higher maternal age, education, and income levels, longer labor, greater hourly maternal intrapartum fluid balance, infant birth weight, postpartum maternal edema, delayed lactogenesis, and fewer stools on day 2. Table 1 shows the proportions of infants with EWL according to each of these variables for the combined group and 2 subgroups of infants; characteristics of infants with and without EWL are shown in Table 2.

In logistic regression analyses with the theoretical model, only intrapartum fluid balance (<100 vs 100–200 mL/hour, P = .031; <100 vs >200 mL/hour, P = .012) and delayed lactogenesis (after 72 hours; $P <$ .001) predicted EWL. Adjusted RRs for EWL were 3.18 (95% confidence interval [CI]: 1.35–13.29) when the net fluid balance during labor was >200 versus <100 mL/hour and 2.80 (95% CI: 1.17–11.68) when the net fluid balance was 100 to 200 versus <100 mL/hour (Table 3). The adjusted RR for delayed lactogenesis (>72 hours) was 3.35 (95% CI: 1.74–8.10). Without delayed lactogenesis in the model, the only significant association with EWL was intrapartum fluid balance. There was no interaction between these 2 independent variables (P = .50). Empirical multivariate analysis produced identical results. Furthermore, intrapartum fluid balance and delayed lactogenesis were the only independent predictors of EWL among EBF infants (fluid balance of <100 vs 100–200 mL/hour, P = .022; fluid balance of <100 vs >200 mL/hour, P = .013; delayed lactogenesis, P = .004).

To explore potential causes and mediators of the association between fluid balance and EWL, numbers of feedings and voidings during the first 24 hours were compared across intrapartum fluid categories. Numbers of voidings during the first 4 hours of life were greater for infants whose mothers had greater fluid balance (mean ± SD numbers of voidings of 0.36 ± 0.59, 0.23 ± 0.47, and 0.15 ± 0.35 for >200, 100–200, and <100 mL/hour, respectively; $P <$ .009). Numbers of feedings on day 1 did not differ according to fluid category (data not shown). Bivariate analyses were performed to measure associations of demographic, labor, and birth variables with intrapartum fluid balance. Labor induction, labor duration (>14 vs ≤14 hours), and longer periods without sleep before birth (>18 vs ≤18 hours) were significantly associated with greater hourly intrapartum fluid balance. Birth weight was not associated with fluid category, and there was not a trend for increasing birth weight with greater intrapartum fluid balance (mean ± SD birth weight of 3341 ± 412, 3460 ± 429, and 3356 ± 420 g for <100, 100–200, and >200 mL/hour, respectively; P = .11). Birth weight did not correlate with fluid balance in multivariate analysis with adjustment for other significant predictors of birth weight (gestational age, maternal height, and infant gender; P = .26).

Of mothers who used 1 to 60 mL of supplementation after birth, 88.3% were still using supplementation at the day 3 interview; reasons cited were EWL (26.2%), difficulty latching (13.1%), concerns about milk supply (27.4%), and other (33.3%). Of mothers who used >60 mL of supplementation, all except 1 (1.1%) were still using supplementation when interviewed on day 3; reasons cited were EWL (15.1%), difficulty latching (18.6%), concerns about milk supply (34.9%), and other (31.4%). The strength of intention to breastfeed exclusively, as measured prenatally, was related to the likelihood of supplementation with >60 mL of formula before day 3; 45.1% of mothers with low or moderate intention to breastfeed supplemented with >60 mL during the first 3 days, compared with 25.2% of women with strong or very strong breastfeeding intentions ($P = .002$). Of mothers who cited concerns about milk supply as a reason for using supplementation, 50% had delayed onset of lactogenesis. Finally, there were not greater rates of illness or hospitalization during the first week of life for infants with versus without EWL among infants who were EBF, infants who received formula supplementation, or all groups combined ($P > .50$ each).

DISCUSSION

There are 2 particularly noteworthy findings in this study. The first is that the prevalence of EWL among these first-born infants was alarmingly high. Eighteen percent of infants who received ≤60 mL of formula before day 3 lost ≥10% of their birth weight, an amount that is uniformly considered excessive.[6,16,18–20] This prevalence is higher than that reported previously for term infants and nearly double the 9.6% reported by Manganaro et al[5] for first-born infants (who constituted nearly one-half of the 686 newborns studied) in Italy. Furthermore, no infants in the latter study received supplementation during the first 3 days, and the population included infants at >36 weeks of gestation. Similarly, 10% of first-born infants experienced EWL in a recent study from Peru.[21] The highest rates of EWL heretofore reported among first-born term newborns were 16% in a study by Dewey et al[6] in California and 14% in a smaller study in France.[16] The prevalence of EWL among term infants in our study matched that among late preterm infants of 35 to 37 weeks of gestation,[22] a population well known to be at greater risk for breastfeeding difficulties.[23] Our methods were similar to those used previously by Dewey et al,[6] with the exception that lactation consultation was universally provided in the previous protocol, whereas this study relied on provision of routine clinical services and lactation consultation was not universally

TABLE 1 Bivariate Associations With EWL in Study Population on Day 3

Independent Variable	No. With EWL/Total (%)		
	EBF Infants ($N = 134$)	Infants Who Received Minimal Formula ($N = 95$)[a]	EBF and Minimal Formula Groups Combined ($N = 229$)[a,b]
Overall	26/134 (19)	15/95 (16)	41/229 (18)
Maternal variables			
Age		c	c
<30 y	16/91 (18)	8/78 (10)	24/169 (14)
>30 y	10/43 (23)	7/17 (41)	17/60 (28)
Education			d
No college	4/38 (11)	4/42 (10)	8/80 (10)
Some college	22/96 (23)	11/53 (21)	33/149 (22)
Ethnicity		d	
Asian	2/10 (20)	6/16 (38)	8/26 (31)
Black	2/11 (18)	0/13 (0)	2/24 (8)
Hispanic	4/30 (13)	2/27 (7)	6/57 (11)
White	15/74 (20)	5/32 (16)	20/106 (19)
Low income			d
No	18/82 (22)	11/48 (23)	29/130 (22)
Yes	7/51 (14)	4/44 (9)	11/95 (12)
BMI on day 7			
≤30 kg/m^2	16/96 (17)	8/56 (14)	24/152 (16)
>30 kg/m^2	9/36 (25)	6/31 (19)	15/67 (22)
Smoking			
No	25/124 (20)	15/91 (16)	40/215 (19)
Yes	1/8 (13)	0/3 (0)	1/11 (9)
Edema and pitting	d		d
None	7/66 (11)	4/37 (11)	11/103 (11)
Edema, no or 1+ pitting	15/53 (28)	8/44 (18)	23/97 (24)
Edema, 2+ to 4+ pitting	4/13 (31)	3/14 (21)	7/27 (26)
Nipple type on day 0		d	
Both everted	22/109 (20)	14/68 (21)	36/177 (20)
Flat or inverted	4/24 (17)	1/26 (4)	5/50 (10)
Nipple pain on day 0[e]			
<3	15/70 (21)	10/62 (16)	25/132 (19)
3	8/39 (21)	2/11 (18)	10/50 (20)
>3	3/24 (13)	3/22 (14)	6/46 (13)
Delayed onset of lactogenesis[f]	g	d	g
No	5/81 (6)	6/61 (10)	11/142 (8)
Yes	21/53 (40)	9/33 (27)	30/86 (35)
Labor and delivery variables			
Type of delivery			
Vaginal	19/107 (18)	12/62 (19)	31/169 (18)
Assisted vaginal	0/3 (0)	0/5 (0)	0/8 (0)
Cesarean, planned	0/1 (0)	0/3 (0)	0/4 (0)
Cesarean, unplanned	7/23 (30)	3/24 (13)	10/47 (21)
Pain during childbirth[e]			
1–4	0/6 (0)	0/10 (0)	0/16 (0)
5	3/29 (10)	6/20 (30)	9/49 (18)
6	23/99 (23)	9/65 (14)	32/164 (20)
Net intrapartum fluid balance in mother	c		d
≤100 mL/h	1/28 (4)	4/22 (18)	5/50 (10)
100–200 mL/h	10/35 (29)	3/15 (20)	13/50 (26)
>200 mL/h	9/23 (39)	5/23 (22)	14/46 (30)
Blood loss during delivery	d		
<500 mL	16/96 (17)	7/48 (15)	23/144 (16)
>500 mL	8/22 (36)	3/27 (11)	11/49 (22)

TABLE 1 Continued

Independent Variable	No. With EWL/Total (%)		
	EBF Infants (*N* = 134)	Infants Who Received Minimal Formula (*N* = 95)[a]	EBF and Minimal Formula Groups Combined (*N* = 229)[a,b]
Labor pain management			
No medication	1/11 (9)	2/11 (18)	3/22 (14)
Epidural (vaginal)	15/88 (17)	9/49 (18)	24/137 (18)
Intravenous (vaginal)	1/4 (25)	0/2 (0)	1/6 (17)
Epidural and intravenous (vaginal)	2/6 (33)	1/5 (20)	3/11 (27)
Cesarean section	7/24 (29)	3/28 (11)	10/52 (19)
Stage II labor duration			
≤1 h	6/45 (13)	536 (14)	11/81 (14)
>1 h	14/63 (22)	7/36 (19)	21/99 (21)
Length of labor			
<6 h	1/22 (5)	1/13 (8)	2/35 (6)
6–14 h	13/63 (21)	8/48 (17)	21/111 (19)
>14 h	12/48 (25)	6/34 (18)	18/82 (22)
Labor induction/augmentation[h]			
None	10/52 (19)	6/40 (15)	16/92 (17)
Induction	6/28 (21)	2/20 (10)	8/48 (17)
Augmentation	9/49 (18)	6/31 (19)	15/80 (19)
Induction and augmentation	1/4 (25)	1/4 (25)	2/8 (25)
Infant variables			
Apgar score at 1 min			
≤7	5/34 (15)	1/17 (6)	6/51 (12)
>7	20/98 (20)	14/76 (18)	34/174 (20)
Apgar score at 5 min			
≤7	1/2 (50)	0/4 (0)	1/6 (17)
>7	25/130 (19)	15/89 (17)	40/219 (18)
Gestational age			
37–39.9 wk	12/69 (17)	12/64 (19)	24/133 (18)
40–42.3 wk	13/63 (21)	3/30 (10)	16/93 (17)
Gender			
Female	14/67 (21)	9/42 (21)	23/109 (21)
Male	12/67 (18)	6/53 (11)	18/120 (15)
Birth weight	d		d
≤3340 g[i]	7/61 (11)	7/54 (13)	14/115 (12)
>3340 g	19/73 (26)	8/41 (20)	27/114 (24)
Resuscitation			
None	19/92 (21)	13/63 (21)	32/155 (21)
Blow-by oxygen therapy	5/32 (16)	2/25 (8)	7/57 (12)
Positive pressure ventilations	1/3 (33)	0/5 (0)	1/8 (13)
Chest compressions and/or endotracheal intubation	1/2 (50)	0/0	1/2 (50)
Skin-to-skin contact at introduction[j]			
Yes	9/46 (20)	6/33 (18)	15/79 (19)
No	17/88 (19)	9/61 (15)	26/149 (17)
Suboptimal infant breastfeeding behavior on day 0[k]			
No	6/32 (19)	0/12 (0)	6/44 (14)
Yes	9/50 (18)	6/40 (15)	15/90 (17)
Suboptimal infant breastfeeding behavior on day 3[k]			
No	15/72 (21)	6/43 (14)	21/115 (18)
Yes	3/22 (14)	5/24 (21)	8/46 (17)
Pacifier use on days 0–2			
No	17/81 (21)	7/43 (16)	24/124 (19)
Yes	9/49 (18)	7/50 (14)	16/99 (16)

available. The rate of EWL might have been even higher for these infants if they had all been EBF; nearly one-fourth of the 95 mothers who provided minimal formula supplementation did so because of concerns regarding inadequate intake. It is worth noting, however, that only one-half of mothers who provided supplementation because of concerns about milk supply actually had delayed lactogenesis. This is consistent with multiple previous reports that perceived insufficient milk supply is common[24,25] and may be influenced by factors unrelated to actual milk supply, such as parenting self-efficacy and family support.[24,26] The high prevalence of EWL noted here confirms that the recommended evaluation of breastfeeding newborns by a knowledgeable health care professional within 1 to 3 days after hospital discharge[3,27] is critical.

The second particularly noteworthy finding is that the prevalence of EWL was significantly related to maternal intrapartum fluid balance, independent of delayed lactogenesis; the adjusted RR for EWL more than tripled when positive maternal fluid balance exceeded 200 mL/hour, compared with <100 mL/hour. This is very similar in magnitude to the RR for EWL with delayed lactogenesis. To our knowledge, this is the first documentation of this association. We postulate that weight loss associated with positive maternal fluid balance represents loss of excess fluid in the newborn, but caution must be exercised because this weight loss might represent loss of "true" weight through inadequate nutrition. The association between the number of voidings in the first 4 hours and intrapartum fluid balance supports our hypothesis, as does a recent report that newborns with weight loss of ≥7% at 2 days had more voidings on the first day of life than did those who lost <7%.[28] Alternatively, increased hy-

TABLE 1 Continued

Independent Variable	No. With EWL/Total (%)		
	EBF Infants ($N = 134$)	Infants Who Received Minimal Formula ($N = 95$)[a]	EBF and Minimal Formula Groups Combined ($N = 229$)[a,b]
Introduction of breastfeeding			
≤1 h	12/58 (21)	9/43 (21)	21/101 (21)
≤2 h	14/68 (21)	5/33 (15)	19/101 (19)
2.01–4 h	0/8 (0)	1/9 (11)	1/17 (6)
>4 h	0/0	0/10 (0)	0/10 (0)
Nursing frequency on day 0			
<8 times in 24 h	2/13 (15)	2/18 (11)	4/31 (13)
8 or 9 times in 24 h	11/48 (23)	7/37 (19)	18/85 (21)
10–12 times in 24 h	10/50 (20)	3/31 (10)	13/81 (16)
13–18 times in 24 h	3/23 (13)	3/8 (38)	6/31 (19)
Formula use (total before day 3 weight check)			
None	26/134 (19)	0/0	26/134 (19)
0–60 mL	0/0	15/95 (16)	15/95 (16)
No. of voidings in previous 24 h			
≤3	11/42 (26)	3/23 (13)	14/65 (22)
≥4	15/87 (17)	11/67 (16)	26/154 (17)
No. of stools in previous 24 h	d		d
≤3	13/42 (31)	9/44 (20)	21/86 (26)
≥4	13/88 (15)	5/48 (10)	18/136 (13)

[a] Minimal formula indicates cumulative total of 1 to 60 mL before the day 3 weight check.
[b] Group used in multivariate analysis.
[c] $P < .01$.
[d] $P < .05$.
[e] On a 6-point faces pain scale.
[f] Delayed onset of lactogenesis was defined as the mother not feeling noticeably fuller breasts by 72 hours after the birth.
[g] $P < .0001$.
[h] Oxytocin was used for both induction and augmentation.
[i] Median for the entire study sample.
[j] Mother reported skin-to-skin contact when the infant was first held.
[k] Suboptimal infant breastfeeding behavior indicates IBFAT scores of ≤10.

TABLE 2 Characteristics of Breastfed Infants With and Without EWL

Variable	Infants Without EWL ($N = 188$)	Infants With EWL ($N = 41$)	P
Net hourly intrapartum fluid balance, mean ± SD, mL/h	153 ± 128	219 ± 131	.0042[a]
Net intrapartum fluid total, mean ± SD, mL	2442 ± 1368	2964 ± 1681	.29[a]
Length of labor, mean ± SD, h	21.2 ± 17.8	17.5 ± 9.7	.32[a]
Onset of lactogenesis, mean ± SD, h	67.1 ± 21.7	84.2 ± 25.1	.0002[b]
Blood loss of >500 mL, *n* (%)	38 (24)	11 (32)	.30[c]
Birth weight, mean ± SD, kg	3.34 ± 0.38	3.53 ± 0.43	.0040[c]
Formula supplementation, *n* (%)			.48[c]
None (EBF)	108 (57)	26 (63)	
1–60 mL of formula	80 (43)	15 (37)	
Postpartum maternal edema, *n* (%)	94 (51)	30 (73)	.0084[c]

The table includes data for infants who were EBF and those who received ≤60 mL total before day 3.
[a] Wilcoxon signed-rank test.
[b] Kaplan-Meier test.
[c] χ^2 test.

dration might suppress infant thirst and result in less interest in breastfeeding. Feeding frequency in the first 24 hours did not differ according to fluid category in our study, however, which suggests that this potential mechanism is less likely. There might be other causal mechanisms or a noncausal association. For example, greater fluid balance might reflect obstetrical interventions not otherwise captured in our variables, which might result in infants feeding less effectively. The dose-dependent manner in which the RR for EWL increased with fluid balance gives some credence to a causal mechanism.

Typically, loss of ≥10% of birth weight in the first few days suggests dehydration and the need to consider supplementation.[18] Loss of excess fluid in a newborn presumably would not carry the same risk for hyperbilirubinemia and hypernatremic dehydration as does true weight loss and might not require intervention. Further research to evaluate the clinical significance of weight loss associated with vigorous intrapartum hydration is needed, to individualize clinical management for these infants. It also is important to ascertain whether less-aggressive intrapartum fluid management, when appropriate, would decrease the prevalence of EWL among newborns.

As expected, EWL also was related to delayed onset of lactogenesis in this study, which occurred for 42% of mothers.[29] This also represents a higher prevalence than heretofore described and might account for the greater prevalence of EWL in this study, compared with the previous study.[6] The maternal, labor, and delivery variables associated with delayed lactogenesis in this study are reported elsewhere[30] and are beyond the scope of this discussion. The rates of intrapartum analgesia and anesthesia also were higher in our population than in all previous studies describing weight loss among breastfed newborn infants in which these data were available.[6,16,21] Pain management for multiparous women has been associated with EWL, likely mediated by suboptimal infant breastfeeding behavior.[6] We could not evaluate an association between pain management and EWL be-

TABLE 3 Unadjusted and Adjusted Odds Ratios and RRs for EWL

	Odds Ratio (95% CI)		RR (95% CI)	
	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Intrapartum fluid balance[b]				
100–200 mL/h net	2.92 (0.94–9.04)	3.76 (1.14–12.32)	2.45 (0.93–6.44)	2.80 (1.17–11.68)
>200 mL/h net	4.06 (1.33–12.44)	4.58 (1.42–14.74)	3.11 (1.22–7.95)	3.18 (1.35–13.29)
Delayed onset of lactogenesis (>72 vs ≤72 h)	4.46 (1.88–10.61)	5.03 (2.05–12.37)	3.23 (1.60–6.52)[c]	3.35 (1.74–8.10)

The table includes data for infants who received ≤60 mL of formula in the first 3 days (combined group of EBF infants and infants who received 1–60 mL total; $n = 229$). Odds ratios for the EBF group were not significantly different from those for the combined group.

[a] Adjusted only for the other variable in the final model.

[b] Relative to <100 mL/hour net.

[c] Unadjusted RR for only women with available data on intrapartum fluids ($n = 144$); the RR for all women was 4.40 (95% CI: 2.32–8.35).

cause medicated deliveries were nearly universal in our population.

This study has several limitations. The prevalence of EWL is almost certainly an underestimate, given that the weights used were only those collected between 70 and 98 hours of age. The prevalence of EWL also might have been higher if all infants had been EBF. Nearly one-half (47.9%) of infants who received supplementation were given formula either because of "excess" weight loss (possibly defined by clinicians and/or mothers at <10% of birth weight) or concerns about milk supply. The findings also are limited by our having timely day 3 weight data for only 70% of the study population. We expect that this did not have a major impact on the prevalence of EWL, however, because mothers of infants with missing day 3 weight data did not differ with respect to variables associated with EWL except that they were more likely to have low incomes (56% of those with missing data, compared with 45% of those with valid weight data; $P = .038$). Also limiting our ability to demonstrate an association might have been the reliability of the instrument used to measure infant breastfeeding behavior. A single, random, IBFAT score may not capture infant breastfeeding behavior adequately; for example, despite statistical correlations between IBFAT scores and milk intake for premature infants, scores could not identify clinically adequate versus inadequate intake.[31] Furthermore, although individuals' IBFAT test-retest agreement is high, interrater correlations are moderate at best.[32] Against the argument that the IBFAT is unreliable is the fact that 2 previous studies reported a relationship between IBFAT scores and EWL in newborns.[6,16] Unfortunately, no other assessment tool has been demonstrated to be superior. Finally, as noted previously, we were limited in our ability to detect associations between EWL and labor pain management, because only 9% of mothers received no intrapartum analgesia or anesthesia.

Strengths of this study include its relatively large sample size, prospective design, diverse patient population, and collection of data for a large number of labor, delivery, birth, and breastfeeding variables for use in multivariate analysis. Data collection was standardized and entailed multiple in-person visits, including one within 24 hours after the 72-hour postpartum cutoff time used to define delayed lactogenesis, which maximized accurate maternal recall.

The high prevalence of EWL among newborns in our study undoubtedly led to greater rates of supplementation with breast milk substitutes, which typically are recommended to minimize morbidity when delayed lactogenesis and EWL are concomitant.[18] Because in-hospital formula supplementation independently predicts shorter duration of subsequent exclusive breastfeeding,[33] efforts should be redoubled to delineate causes of EWL and to design and to test preventive strategies. Successful preventive strategies would decrease not only acute morbidities associated with EWL in newborns but also morbidities associated with breastfeeding not exclusively or for recommended durations.[34,35]

CONCLUSIONS

EWL in this multiethnic population of newborns born in a teaching hospital in northern California was more common than reported previously and was independently associated with both maternal intrapartum fluid balance and delayed onset of lactogenesis. We hypothesize that increased EWL associated with maternal fluid balance represents loss of excess fluid in the newborn, but further research to determine the underlying mechanisms is needed before conclusions can be drawn. Because EWL may carry a greater risk of subsequent morbidities, increased attention to preventive strategies is indicated.

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