Physiologic Stability of Newborns During Cup- and Bottle-feeding

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Abstract. ***Background.*** **To prevent breastfeeding problems, cup-feeding has been recommended as a method of providing medically necessary supplemental feedings to breastfed infants.**

Objectives. **To compare amounts ingested, administration time, and infant physiologic stability during cup-, bottle-, and breastfeeding.**

Design/Methods. **A total of 98 term, healthy newborns were randomized to either cup-feeding ($n = 51$) or bottle-feeding ($n = 47$). The heart (HR), respiratory (RR), and oxygen (O_2) saturation rates were monitored on these infants and 25 breastfed newborns during 1 feeding. Differences in amounts ingested and administration times were evaluated with *t* tests and physiologic data with repeat measures analysis of variance.**

Results. **There were no significant differences in administration time, amounts ingested or overall HR, RR, and (O_2) saturation rates, between cup and bottle groups. Breastfed infants had longer administration times and lower overall HR, RR, and higher O_2 saturation as compared with cup- and bottle-fed infants.**

Conclusions. **Administration times, amounts ingested, and infant physiologic stability do not differ with cup- and bottle-feeding. Breastfeeding takes longer than cup- or bottle-feeding, but infants experience less physiologic variability. These data support cup-feeding as an alternative to bottle-feeding for supplying supplements to breastfed infants. *Pediatrics* 1999;104:1204–1207; *breastfeeding, bottle-feeding, cup-feeding.***

ABBREVIATIONS. O_2, oxygen saturation (rate); HR, heart rate; RR, respiratory rate; ANOVA, analysis of variance.

Breastfeeding is widely acknowledged as optimal infant nutrition.[1–6] Successful breastfeeding requires an infant learn proper attachment and suckling during the first few days of life.[7,8] Early oral experiences that illicit sucking mechanics different from those of breastfeeding are believed to cause improper latch and subsequent breastfeeding failure—a problem termed "nipple confusion."[8–10] Thus, many experts recommend avoiding artificial suckling experiences including bottle-feeding in breastfed infants.[5,11,12]

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Received for publication Mar 17,1999; accepted Jun 29, 1999.

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To prevent "nipple confusion," cup-feeding has been recommended for providing medically indicated supplements to breastfed infants for problems including hypoglycemia, hyperbilirubinemia, and dehydration.[15–17] A lack of empiric evidence and concerns about potential choking, aspiration and time efficiency, however, have impeded its implementation in most US facilities.[13,15] Although historical evidence of cup-feeding exists,[18] the scientific literature is limited to descriptive studies and anecdotal reports.[13,14,19] Such reports describe similar physiologic stability and weight gain in cup- and bottle-fed premature infants and improved adaptation to full breastfeeding after cup-feeding.[19,13,20]

Studies comparing cardiorespiratory changes during breast and bottle-feedings demonstrate better coordination of sucking, swallowing, and breathing in breastfed preterm infants[21] and fewer episodes of oxygen desaturation below 90% in breastfed term infants.[22] No comparative data, however, are available for cup-fed infants.

We undertook this study as a preliminary step in evaluating the safety of cup-feeding. Our primary objectives were to compare infant physiologic stability, quantities ingested, and administration time for cup- and bottle-feeding. A secondary objective was to compare these findings to data in breastfed infants.

METHODS

Term, healthy, appropriate-for-gestational age, 1- to 3-day-old formula-fed newborns were randomized and fed by either cup ($n = 51$) or bottle ($n = 47$). Oxygen (O_2) saturation and heart rates (HR) were recording using a Nellcor (Nellcor, Hayward, CA) cardiorespiratory monitor. Respiratory rates (RR) were assessed by a registered nurse. Data were recorded every 30 seconds during feedings, including a 2-minute pre- and postfeeding time interval. For comparison purposes, a group of 25 breastfed newborns were also evaluated.

Cup- and bottle-fed infants were brought to a quiet room at the time of a regularly scheduled feeding. Infants were readied for monitoring and allowed to attain a quiet, alert state before data collection began. Cup- and bottle-feedings were administered by a nurse. Breastfed infants were fed in the mother's room with monitoring limited to feeding time on 1 breast. Pre- and postfeeding data were recorded while the infant was cuddled by the nurse or mother (breast).

Cup-feedings were administered using a small plastic medicine cup. Fifteen milliliter aliquots of formula were fed to infants held in a semi-upright position with head and upper back support. Infants were stimulated to root by stroking the lower lip with the edge of the cup. Small amounts of formula were fed to the infant until the infant appeared satiated.[23]

Analysis

Data were analyzed using SPSS (SPSS, Chicago, IL) Statistical Analysis Software (Version 7.5). The number of data points obtained for physiologic outcomes necessarily varied with the time required to administer a feeding. For purposes of analysis, mean values were calculated for prefeeding and postfeeding stages and each tercile of time during the feeding (1st, 2nd, 3rd terciles; $n = 5$ feeding stages). Physiologic outcomes for cup and bottle groups were evaluated using repeat measures analysis of variance (ANOVA). Because of significant differences at baseline between the bottle-fed, cup-fed, and breastfed groups, ANOVA analyses were conducted with the prefeeding value entered as a co-variate.

Repeat measures ANOVA accounts for the possibility of spurious positive findings when multiple analysis are conducted because of a repeatedly measured outcome. Differences between groups at specific time points (eg, feeding stages), are properly analyzed only if the P value for the overall ANOVA is significant (Table 2). In this study, group differences during specific feeding stages were conducted using Tukey's B test when the overall ANOVA was significant at the $P \leq .05$ level (see Table 3).

RESULTS

The breastfed, cup-fed, and bottle-fed groups did not differ with regard to infant gestational age, Apgar score, sex, birth weight, or mode of delivery. Use of analgesia, however, was higher among women who breastfed ($P \leq .05$; Table 1).

Cup- (5.3 ± 2.1 minutes) and bottle-feedings (5.9 ± 1.9 minutes) were shorter than breastfeedings (9.6 ± 3.5 minutes; $P < .05$). Administration time for cup- as compared with bottle-feedings and amounts ingested during cup- (1.04 ± 0.48 oz.) and bottle-feedings (1.26 ± 0.58 oz.) did not significantly differ.

There were no significant differences in overall HR, RR or O_2 saturation for the cup-fed and bottle-fed groups (Table 2). Compared with breastfed infants, cup- and bottle-fed infants had significantly increased overall HR ($P < .001$), RR ($P = .03$), and decreased O_2 saturation ($P = .05$; Table 2). Group differences during specific feeding stages are displayed in Table 3. No significant differences occurred between the breastfed ($n = 0$), cup-fed ($n = 3$), and bottle-fed ($n = 7$) groups for the number of infants whose O_2 saturation decreased to ≤85% during the feeding.

DISCUSSION

This is the first randomized trial to provide comparative data about physiologic stability, quantities ingested, and administration time during bottle- and cup-feeding. These data demonstrate that O_2 saturation, HR, and RR do not significantly vary in infants fed by cup or bottle. Furthermore, in experienced hands, neither the quantity of formula or the time to administer a feeding varies significantly.

Additionally, these results confirm studies showing less physiologic variability in infants during breastfeeding as compared with bottle-feeding,[21] and provide the first evidence of improved stability during breastfeeding as compared with cup-feeding.

These data are limited by the nonrandomized nature of the breastfed group. It is possible that had breastfed infants been randomized to cup and bottle, infant responses to feeding would differ. Findings in the breastfed, cup-fed, and bottle-fed groups also could be unrelated to the feeding method, but rather attributable to the study design wherein breastfed infants were fed by their mother, in her room, while cup-fed and bottle-fed infants were moved and fed by a nurse. Our findings of reduced baseline HRs in breastfed as compared with formula-fed study groups, however, could alternatively denote a physiologic response to breast milk, as HRs are known to be lower in breastfed infants.[24]

Ideally, this study should be conducted in breastfed infants who require supplements, with feedings administered by the mother. Given the novelty of cup-feeding, and our primary purpose of comparing cup-feeding to bottle-feeding, a study design allowing direct comparison of cup-feeding and bottle-feeding with the aforementioned limitations was elected.

Currently, there is limited evidence that exposure to artificial nipples during bottle-feeding interferes with breastfeeding.[9,10,13] The process of suckling, however, is complex and the mechanics of breastfeeding and bottle-feeding are known to be different.[13,25,26] Comparative studies of the mechanics of cup-feeding are unavailable. Research into the cause of "nipple confusion" including the mechanics of cup-feeding are needed.

Although the utility of cup-feeding in preventing "nipple confusion" remains unproven, findings from this study provide evidence of infant physiologic stability during cup-feeding and demonstrate that cup-feeding is both effective and time-effi-

TABLE 1. Group Comparisons

Characteristic	Bottle ($n = 47$) Mean (95% CI)	Cup ($n = 51$) Mean (95% CI)	Breast ($n = 25$) Mean (95% CI)
Gestational age (wk)	39.9 (39.6, 40.2)	39.7 (39.4, 40.0)	39.8 (39.4, 40.2)
Apgar (5 minutes)	8.9 (8.8, 9.0)	8.9 (8.8, 9.0)	9.0 (8.9, 9.2)
Birth weight (g)	3434.5 (3281.2, 3587.8)	3439.0 (3292.7, 3585.3)	3497.2 (3354.8, 3639.6)
	n (%)	n (%)	n (%)
Sex			
Male	25 (53.2%)	26 (51.0%)	12 (48.0%)
Female	22 (46.8%)	25 (49.0%)	13 (52.0%)
Vaginal delivery	29 (61.7%)	33 (64.7%)	20 (80.0%)
Anesthesia/analgesia for labor or delivery	38 (80.9%)*	44 (86.3%)*	25 (100.0%)

* $P < .05$ referent to the breastfed group.

TABLE 2. Differences in Overall Physiologic Outcomes in Breastfed, Bottle-fed, and Cup-fed Infants

Value

Outcome	(I) Treatment Group	(J) Treatment Group	Mean Difference (I–J)	95% CI for Difference		*P* Value
HR (beats/min)	Bottle	Cup	3.55	−.85	7.95	.11*
	Breast	Bottle	−11.81	−15.95	−7.67	.000†
	Breast	Cup	−6.50	−10.62	−2.38	.002†
RR (breaths/min)	Bottle	Cup	.34	−1.71	2.40	.74*
	Breast	Bottle	−2.35	−4.44	−.26	.028†
	Breast	Cup	−2.72	−4.78	−.66	.010†
O_2 saturation (percent)	Bottle	Cup	.15	−.91	1.22	.78*
	Breast	Bottle	1.71	.30	3.11	.018†
	Breast	Cup	1.43	.05	2.82	.043†

* Analysis conducted with repeat measures ANOVA.
† Because of significant differences in baseline measures (prefeeding values) between breastfed versus cup- and bottle-fed infants, analyses were conducted with repeat measures ANOVA with prefeeding values entered as a covariate.

TABLE 3. Physiologic Outcomes of Breastfed as Compared With Bottle- and Cup-fed Infants for Individual Feeding Stages

Feeding Stage/Outcome	First Tercile of Feeding Mean (SD)	Second Tercile of Feeding Mean (SD)	Third Tercile of Feeding Mean (SD)	Recovery Mean (SD)
HR (beats/min)				
Breast	123.1 (14.4)	118.8 (12.7)	119.9 (12.2)	117.2 (13.2)
Bottle	136.6 (11.2)**	139.0 (12.0)***	140.7 (10.8)***	133.6 (14.1)***
Cup	132.6 (14.7)	133.4 (12.6)***	132.8 (12.1)**	129.5 (12.1)*
RR (breaths/min)				
Breast	52.5 (5.9)	50.3 (6.3)	49.2 (7.3)	49.0 (5.8)
Bottle	51.9 (5.5)	54.1 (5.5)**	53.1 (6.1)*	51.7 (6.0)
Cup	53.5 (6.4)	53.0 (6.5)*	52.6 (6.6)*	51.8 (6.8)*
O_2 saturation (percent)				
Breast	97.4 (1.8)	97.8 (1.7)	97.1 (1.6)	98.8 (5.2)
Bottle	94.6 (3.3)**	95.4 (4.1)**	95.5 (5.3)	96.2 (1.9)
Cup	94.8 (3.7)**	95.6 (2.9)*	95.7 (2.9)	95.1 (8.0)*

* $P \leq .05$; ** $P \leq .01$; *** $P \leq .001$; referent to breastfed study group.

cient. We believe these findings will be useful to pediatricians in their efforts to limit artificial nipple exposure in breastfed infants. Findings from this study support cup-feeding as a time-efficient and effective alternative to bottle-feeding for term, healthy breastfed infants who require supplementation.

ACKNOWLEDGMENTS

This study was supported by the Maternal and Child Health Bureau (Grant #MCJ-360752-01-0).

We thank Suzanne Kolb, RN, IBCLC, and Susan Costanza, RN, IBCLC, for their assistance with the implementation of this study.

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Pediatrics 1999;104;1204