Impact of Breast Pumping on Lactogenesis Stage II After Cesarean Delivery: A Randomized Clinical Trial

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ABSTRACT. Objective. Women at risk for delayed onset of lactation are often advised to pump their breasts before lactogenesis stage II to hasten the timing of this process. The effectiveness of this clinical practice has not been previously evaluated. This study investigates the effects of breast pumping before the onset of lactation on early milk transfer and subsequent breastfeeding duration among women giving birth by cesarean delivery.

Methodology. Sixty women were randomly assigned to either the pumping group (n = 30), which used a double electric breast pump for six 10- to 15-minute sessions from 24 to 72 hours postpartum, or to the control group (n = 30), which held the pump to their breasts without suction for the same amount of time. Milk transfer was assessed by test weighing infants before and after 3 breastfeeding sessions daily. Test weight data were fitted to a second-order polynomial curve, to predict milk transfer over time.

Results. Breast pumping between 24 and 72 hours after cesarean delivery did not improve milk transfer. Participants in the pumping group tended to have lower milk transfer than did controls. Primiparous in the pumping group breastfed for ~5 months less than their counterparts in the control group; however, this difference was not statistically significant.

Conclusions. Breast pumping did not improve milk transfer during the first 72 hours postpartum and may negatively affect breastfeeding duration among primiparous women. Pediatrics 2001;107(6). URL: http://www.pediatrics.org/cgi/content/full/107/6/e94; lactation, lactogenesis, breast milk, breast pumping, milk expression, breastfeeding, cesarean delivery.

ABBREVIATION. PP, postpartum.

Lactogenesis stage II, defined as the initiation of copious secretion of breast milk after delivery, is a complex physiologic phenomenon that may be affected by a number of factors, including maternal hormonal milieu, delivery mode, infant suckling, maternal nutritional status, and psychobiologic stress. The main known trigger for lactogenesis stage II is a precipitous decline in progesterone values in combination with maintained prolactin levels. Clinically, most women experience either breast fullness or engorgement between 40 and 72 hours postpartum (PP). Milk volume has been shown to increase rapidly near 36 hours PP and plateau at ~96 hours PP.

Recently, risk factors for delayed onset of lactation (i.e., maternal perception that milk has come in later than 72 hours PP) have been identified. These risk factors include maternal obesity, unscheduled cesarean delivery, prolonged stage II labor, white ethnicity, and infant birth weight <8.5 lb. Delayed onset of lactation is of public health concern, because women who plan to breastfeed for at least 6 months but experience a delayed onset of lactation have a shorter breastfeeding duration than do their counterparts with an earlier onset of lactation. To promote better breastfeeding outcomes among women at risk for delayed onset of lactation, it is important to evaluate potentially modifiable factors controlling the timing of this process. The impact of early nursing frequency on the timing of the onset of lactation remains inconclusive, with evidence supporting and disputing its importance. Because it is difficult to manipulate the frequency and duration of infant suckling, this study uses an electric breast pump as a research tool to provide additional breast stimulation and to remove milk. In clinical settings, breast pumping is commonly recommended to mimic infant suckling and to help establish the milk supply in PP women whose infants are not nursing well. Even without a clinical reason, breastfeeding women frequently request to use breast pumps in the first few days after delivering a healthy term infant (S. Young, Hartford Hospital, personal communication, 1999). The effectiveness of this practice, however, has not been established. Physiologically, breast pumping has been shown to increase levels of prolactin 4 to 6 weeks PP. In addition, the simultaneous (vs separate) pumping of both breasts has been shown to increase milk production 3 to 6 weeks PP; however, the effects of simultaneous pumping on the onset of lactation are unknown.

The objectives of this study were: 1) to measure the impact of increased breast stimulation via breast pumping on breast milk transfer during the first 72 hours after cesarean delivery, and 2) to investigate potentially dormant effects of breast pumping before the onset of lactation, including effects on milk transfer during the first 2 weeks after delivery and subsequent breastfeeding duration.

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METHODS

Participants
Sixty women who gave birth by cesarean delivery were recruited to participate in this study between June 1997 and November 1998. Recruitment occurred 8 to 24 hours PP on the maternity unit of Hartford Hospital in Hartford, Connecticut, and prenatally through posters in local obstetricians’ offices. Women giving birth by cesarean delivery provided an ideal convenience sample for studying lactogenesis stage II, attributable to their longer length of hospitalization. At the time of this study, Hartford Hospital had filed a Certificate of Intent with the Baby Friendly Hospital Initiative. Thus, this research was conducted in an environment supportive of breastfeeding. Women received breastfeeding assistance in the delivery/recovery room. Rooming-in was encouraged but not mandatory. This study was approved by the institutional review boards at the University of Connecticut and Hartford Hospital.

Inclusion criteria specified that women must be: 1) ≥18 years old; 2) planning exclusive breastfeeding for at least 10 days; 3) willing to remain hospitalized for at least 72 hours PP; 4) residents of the greater Hartford area; 5) available for telephone follow-up; 6) free of diabetes mellitus; gestational diabetes mellitus; pregnancy-induced hypertension; human immunodeficiency virus; inverted nipples; or a history of smoking, alcohol, and/or illegal substance abuse within the past 6 months; 7) not using hormonal contraceptives for 2 weeks PP; and 8) high school graduates (or equivalent). Medical records were reviewed to ensure that participants were free of complications interfering with breastfeeding initiation within the first 12 hours PP (ie, hemorrhage and use of medications contraindicated with breastfeeding).

Newborn inclusion criteria were: 1) healthy, singleton delivery; 2) gestational age ≥37 weeks; 3) birth weight >2.5 kg; 4) 5-minute Apgar score ≥7; 5) admission to the normal newborn nursery; and 6) absence of congenital anomalies.

Study Design
After obtaining their informed consent, participants were randomly assigned, on an alternating basis, to either the intervention or control group. After the first 4 participants were enrolled, randomization was stratified by parity and type of cesarean delivery (ie, scheduled vs unscheduled) to ensure that the potentially confounding combinations of parity and delivery type were evenly distributed among study groups.

Research Protocol
The breast pumping intervention, control procedures, and first study measurements were initiated at ~24 hours PP for all participants. At this time, all participants were interviewed to obtain demographic data, intended breastfeeding duration, recalled prepregnancy weight, weight gain during pregnancy, and the time of breastfeeding initiation. Women in both the intervention and control groups were visited 3 times daily (8:42 AM ± 1:02, 1:21 PM ± 1:21, 7:55 PM ± 1:02) by research staff specially trained in lactation management. There were no significant between-group differences in the times of the research visits.

The following occurred at each research visit.

Test Weighing
To assess the impact of the additional breast stimulation, milk transfer was measured. Infants were weighed before and after breastfeeding to determine milk transfer to the infant. This method has been validated and is commonly used in lactogenesis research. Test weighings were obtained in triplicate by research staff using an electronic integrated scale (accuracy = 0.05 g) fitted with an infant seat and a recording printer (Sartorius Inc, Goettingen, Germany). Each printed weight is the average of 20 consecutive measurements. Women were not provided with the results of the test weighing. Insensible water loss was measured over the 15-minute period. Milk production was not measured, because the provision of additional breast stimulation to both groups would have confounded the study design.

Breastfeeding Support
Research staff remained with the mother throughout the entire breastfeeding session to provide support, information, and assistance with proper positioning, latch-on, and breastfeeding technique.

Interview
After the breastfeeding episode, research staff interviewed the participants regarding breastfeeding frequency, infant feeding method, use of breast milk substitutes, and maternal perception of whether the onset of lactation had occurred. All of the frequency and duration of breastfeeding sessions and were advised to breastfeed their infant on demand, at least every 3 to 4 hours.

Breast Pumping Intervention
Participants in the pumping group used an electric breast pump (Lactina Select, Double Pumping Kit, Medela, McHenry, IL) to pump both breasts simultaneously for 10 to 15 minutes 3 times daily after breastfeeding. The initial pump settings were minimum suction (100 mm Hg), and cycling rate 1 (40 cycles/min) for 10 minutes. Over the next 2 to 3 sessions, the cycling rate was increased to 2 (44 cycles/min) and the duration was increased to 15 minutes. Research staff assisted with the use of the pump and confirmed compliance with the intervention by directly observing the pulling action of the pump on the nipple and by maternal sensation report. Expressedcolostrum was fed to the infant via syringe. Immediately after pumping, women used a visual acuity scale to separately rate the levels of overall breast pain and whole body pain that they felt while pumping. Women were advised to use the breast pump only with the assistance of research staff. Breast pumping began at ~24 hours PP and was completed by 72 hours PP. Thus, this group used the electric breast pump for a total of 30 to 45 minutes daily for 2 days. After the sixth visit, the breast pump was removed from the participant’s room.

Control Procedures
To control for the Hawthorne effect,[20] women in the control group held the breast shields of the electric breast pump on their breasts for 10 to 15 minutes 3 times daily but did not turn on the pump. Research staff remained with the participants for the entire time that the pump was held to their breasts. Immediately after removing the breast shields from their breasts, women in the control group rated breast and body pain experienced while holding on the breast shields, using the same scale as the pumping group. The prescribed timing and duration of the control procedures were identical to those of the pumping intervention; however, there was no suction applied to the breast. To confirm compliance with control procedures, pumping kits used by the control group were modified (by removal of a membrane in the collection bottle) to prevent the pump from drawing suction.

After the first 6 visits, women in the intervention and control groups were treated identically. Breastfeeding support, breastfeeding sessions, and interviews continued 3 times daily in the hospital at least until the onset of lactation had occurred. At ~72 hours PP, maternal weight was assessed using a Healthometer Professional Scale.

If participants were discharged from the hospital before the onset of lactation, test weights were obtained by the participant at home, as has been previously described. On the date of discharge, research staff delivered an electronic balance (Sartorius, Goettingen, Germany) to the participant’s home and instructed the participant/family members on the proper procedures for test weighing. All participants received verbal and written instructions on the use of the scale and were required to demonstrate their ability to correctly use the balance before collecting data. Participants were requested to weigh their newborns before and after 3 feeding sessions per day until advised to stop by research staff. Participants continued to complete breastfeeding logs. Researchers were available by pager and remained in telephone contact with the participants to ensure compliance with the test-weighing protocol and to continue the survey protocol.

Follow-Up Data Collection
Using the designation of the first 24 hours PP as day 1, all participants were visited in their homes at 7 to 10 days PP. All participants were asked whether they were willing to weigh their infant before and after each breastfeeding session at home for a
24-hour period. If they agreed (n = 22), a Sartorius electronic balance (BP34) was set up in the home. Participants received verbal and written instructions on the use of the scale and demonstrated their ability to correctly obtain data. All participants were asked to complete a breastfeeding log during the 24-hour test-weighing period. Participants were requested to obtain weights in triplicate before and after all breastfeeding sessions. If, however, a feeding was missed, participants were advised to note the time of any missed feedings on the breastfeeding log. Researchers were available by pager and remained in telephone contact with participants during the 24-hour test-weighing period.

Researchers contacted participants by telephone to obtain data on duration of exclusive breastfeeding, duration of any breastfeeding, infant-feeding practices, and perceptions about the impact of their group assignment on their breastfeeding success. Participants were initially contacted at 6 months PP and recontacted approximately every 4 months. At the time of data analyses, the average infant was 1.99 ± 0.42 years old.

Incentives
In addition to the breastfeeding education and support provided by the research staff, all participants received a check for $25 and their choice of one of the following Medela products: nursing pillow, nursing stool, or insulated cooler/carrier bag.

Data Analyses
Corrections to Test-Weighing Data
Milk transfer to the infant per feeding was calculated as the mean postfeeding weight minus the mean prefeeding weight. These values were corrected for insensible water loss, which was individually measured. For 12 infants with missing data for insensible water loss, the mean (1.29 g/kg/hour) was used. As previously found,3 negative milk transfer values were detected before the onset of lactation in some cases. These negative values may be attributed to the electronic scale measurement error, which as small as it is, could have been greater than the negligible milk transfer volumes before the onset of lactation. In some instances, this could have also been the result of insensible water loss exceeding breast milk intake. This artifact applied equally to both groups, thus not biasing any of the milk transfer group comparisons.

Milk Transfer Curves
Milk transfer was plotted over time to generate individual milk transfer curves for each mother–infant pair. Because infants may not consistently empty the breast, an “unsusaly small feeding” was defined as a feeding in which the milk transfer was <50% of each of the 2 previous feedings. A total of 4 data points (1 from each of 4 different women) were identified as “unsusaly small feedings” and dropped from analyses. After evaluating several curve fitting equations, the second-order polynomial was determined to best fit the data and individual milk transfer curves were generated. The coefficients of each individual predictive curve were then used to predict milk transfer for 24, 30, 36, 48, and 72 hours PP. These values were averaged at each time interval to generate predictive curves by group.

Predicted milk transfer curves provided a useful estimate of actual milk transfer values. The overall correlation coefficient (r) for the actual versus predicted curves was 0.84 (range: 0.3–1.0). For 98% of cases had an r value >0.90. The average predicted value for milk transfer at 60 hours PP was 94% of the corresponding value derived by averaging raw data. Because of the strength of the association between the predictive milk transfer curves and the raw data, we chose to evaluate predicted milk transfer/feeding, rather than extrapolating daily milk transfer rates from our data. Previous research has documented that daily milk transfer rates cannot be accurately obtained from estimates based on individual test weights obtained during the first 72 hours PP.23

Sample Size Estimation
The sample size of 30 participants per group provides sufficient power to detect a clinically relevant difference of 12 hours in the time of the onset of lactation between groups, assuming α = 0.05 (2-sided), β = 0.20,24 and a standard deviation of 16.3 hours as previously reported.25

Statistical Analyses
SPSS for Windows, Version 5.0 (SPSS, Chicago, IL) was used to conduct all statistical analyses. Of the 60 participants recruited, 1 was dropped because of insufficient pumping, and 2 women were dropped because of ineffective suckling by the infant. Thus, final statistical analyses included 57 participants with 28 in the pumping group and 29 in the control group. Between-group baseline characteristics were compared using Student’s t test and χ² analyses. Average predicted milk transfer values at 24, 30, 36, 48, and 72 hours were compared between groups using Student’s t test. Analysis of covariance was used to adjust for baseline group differences detected among primiparous and among multiparous. Cox survival regression analyses were used to test for group differences in the duration of exclusive or any breastfeeding, after controlling for potential confounders at baseline. The duration of breastfeeding among women who were still breastfeeding when the last contact was made was identified as right censored in the Cox regression model. Main effects were interpreted using P ≤ .05 (2-tailed), and interactions using P < .10 (2-tailed), as the level of statistical significance.

RESULTS
Participants were primarily married, white, ~31 years old with some college education (Table 1). Epidural anesthesia was used in 40.4% of cases, and spinal anesthesia was used for the remaining 59.6%. During the first 72 hours PP, infants spent ~18 hours per day rooming-in. There were no baseline differences between the pumping and control groups. However, when study groups were analyzed by parity, significant baseline differences emerged in maternal education level and age among primiparous and in maternal age among multiparous (Table 1). Overall, participants had baseline demographic, delivery-related, and infant characteristics similar to the 111 women who declined to participate in the study. The only significant difference between participants and nonparticipants was that participants intended to breastfeed longer than did those who declined (7.3 ± 4.0 vs 5.8 ± 3.2 months; P < .05).

There were no significant differences in breastfeeding frequency, the amount of time spent breastfeeding, or the amount of time in contact with the breast pump between study groups. On average, participants in the pumping group had 2 hours of additional breast stimulation (time spent breastfeeding + 2 × [time spent using the double pump]) between 24 and 72 hours PP compared with those in the control group (647.2 ± 108.1 vs 527.6 ± 120.3 minutes; P < .0001). The median volume of colostrum expressed per breast pumping session ranged from 0.1 mL (at the first session) to 1.0 mL (at the sixth session). These volumes were not added to the amount of milk transferred/feeding for the pumping group, to maintain consistency with the control procedures.

Breast pumping beginning at 24 hours PP did not improve milk transfer (Fig 1). In fact, milk transfer values for the pumping group are slightly lower than for those of controls. This was observed for both primiparous and multiparous women (Table 2). This trend persisted, even after controlling for baseline group differences in maternal age and education level among primiparous, and age among multiparous.
Breast Pumping and Lactogenesis II

There were no significant differences in milk transfer conclusions, all separate analyses of primiparae and multiparae are presented as unadjusted data.

Participants in the pumping group reported significantly higher breast pain scores during the first 4 pumping sessions (Table 3). There were no significant differences in overall body pain scores between groups.

Twenty-two participants completed a 24-hour test weighing of their infant between days 7 and 10 PP. There were no significant differences in milk transfer calculated as g/day or g/kg/day by study group (Table 4). Follow-up data on the duration of exclusive and any breastfeeding were obtained on 56 of the 57 participants. No participants were exclusively breastfeeding at the time of initial follow-up (ie, 6 months after the last participant delivered). There were no differences in the duration of exclusive breastfeeding by group (Table 4), even after adjusting for baseline differences in age, education, and type of cesarean delivery. At the time of data analyses, ~30% of all participants were still breastfeeding. The median breastfeeding duration by group was not significantly different. The effect of pumping on breastfeeding duration tended to be modified by parity. Among primiparous women, those who pumped tended to breastfeed for less time than did controls (4.2 vs 9.7 months, respectively; P = .18). This tendency toward shorter breastfeeding duration among primiparous women in the pumping group was not explained by baseline differences among primiparae (ie, maternal age, education level, or type of cesarean delivery), because controlling for these variables yielded similar results. This relationship was not observed for multiparous women.

**DISCUSSION**

The milk transfer curves presented here are unique because they reflect breast milk transfer between 24 and 72 hours after cesarean delivery. Similar to the milk transfer curves generated by Neville et al.,3 our curves gradually increase during the first 48 hours PP, and 72 hours after cesarean delivery. Similar to the milk transfer curves presented here.

BF indicates breastfeeding.

* P < .05 between pumping and control group.

**TABLE 1.** Participant Characteristics by Parity and Study Group (n = 57)

<table>
<thead>
<tr>
<th></th>
<th>All Participants</th>
<th>Primiparae</th>
<th>Multiparae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pumping (n = 28)</td>
<td>Control (n = 29)</td>
<td>Pumping (n = 10)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>31.44 ± 5.28</td>
<td>30.93 ± 3.34</td>
<td>27.60 ± 5.15</td>
</tr>
<tr>
<td>Education (y)</td>
<td>14.98 ± 1.87</td>
<td>15.41 ± 2.23</td>
<td>14.70 ± 1.49</td>
</tr>
<tr>
<td>Percent married</td>
<td>92.90</td>
<td>86.20</td>
<td>90.00</td>
</tr>
<tr>
<td>Ethnicity (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>78.60</td>
<td>72.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Black</td>
<td>10.70</td>
<td>13.80</td>
<td>0.00</td>
</tr>
<tr>
<td>Hispanic</td>
<td>3.60</td>
<td>6.90</td>
<td>0.00</td>
</tr>
<tr>
<td>Asian</td>
<td>3.60</td>
<td>3.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Other</td>
<td>3.60</td>
<td>3.40</td>
<td>0.00</td>
</tr>
<tr>
<td>BMI (prepregnancy weight in kg/m²)</td>
<td>25.91 ± 5.42</td>
<td>24.85 ± 4.86</td>
<td>23.61 ± 2.38</td>
</tr>
<tr>
<td>Percent scheduled delivery</td>
<td>53.60</td>
<td>55.20</td>
<td>20.00</td>
</tr>
<tr>
<td>BF initiation (h PP)</td>
<td>2.90 ± 2.62</td>
<td>3.08 ± 3.17</td>
<td>2.83 ± 2.92</td>
</tr>
<tr>
<td>Intended BF duration (mo)</td>
<td>7.61 ± 3.38</td>
<td>7.09 ± 4.61</td>
<td>6.40 ± 2.14</td>
</tr>
<tr>
<td>Infant birth weight (kg)</td>
<td>3.52 ± 0.47</td>
<td>3.61 ± 0.37</td>
<td>3.65 ± 0.45</td>
</tr>
<tr>
<td>Infant sex (% male)</td>
<td>60.70</td>
<td>55.20</td>
<td>80.00</td>
</tr>
<tr>
<td>Gestational age (wk)</td>
<td>39.31 ± 0.90</td>
<td>39.47 ± 1.05</td>
<td>39.70 ± 0.63</td>
</tr>
<tr>
<td>5-min Apgar score</td>
<td>9.00 ± 0.27</td>
<td>9.00 ± 0.27</td>
<td>9.00 ± 0.00</td>
</tr>
</tbody>
</table>

Fig 1. Milk transfer curves (pumping vs control). Group curves are based on the average of the individual quadratic coefficients for each participant within the group.
TABLE 2. Unadjusted Predicted Milk Transfer Values (Grams/Feeding)*

<table>
<thead>
<tr>
<th>Time Postpartum (hrs)</th>
<th>Pumping Group (n)</th>
<th>Control Group (n)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 Hours PP</td>
<td>(P = 0.25)</td>
<td>(P = 0.05)</td>
<td>0.19</td>
</tr>
<tr>
<td>30 Hours PP</td>
<td>(P = 0.06)</td>
<td>(P = 0.03)</td>
<td>0.19</td>
</tr>
<tr>
<td>36 Hours PP</td>
<td>(P = 0.01)</td>
<td>(P = 0.02)</td>
<td>0.19</td>
</tr>
<tr>
<td>48 Hours PP</td>
<td>(P = 0.03)</td>
<td>(P = 0.02)</td>
<td>0.19</td>
</tr>
<tr>
<td>60 Hours PP</td>
<td>(P = 0.00)</td>
<td>(P = 0.04)</td>
<td>0.19</td>
</tr>
<tr>
<td>72 Hours PP</td>
<td>(P = 0.05)</td>
<td>(P = 0.02)</td>
<td>0.19</td>
</tr>
</tbody>
</table>

*The quadratic equation coefficients of each individual predictive curve were used to predict milk transfer for 24, 30, 36, 48, 60, and 72 hours PP. Coefficients were averaged at each time interval to generate predictive curves by group. The overall correlation coefficient (r) for the actual versus predicted curves was 0.84 (range: 0.3–1.0).

†The P values refer to comparisons of pumping versus control among all participants, primiparae, and multiparae, respectively.

TABLE 3. Breast and Body Pain Scores by Group*

<table>
<thead>
<tr>
<th>Session</th>
<th>Pain Score</th>
<th>Pumping Group (n)</th>
<th>Control Group (n)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Breast pain</td>
<td>15.1 ± 10.3 (27)</td>
<td>9.4 ± 9.0 (28)</td>
<td>.034</td>
</tr>
<tr>
<td></td>
<td>Body pain</td>
<td>27.5 ± 19.8 (28)</td>
<td>21.8 ± 23.5 (28)</td>
<td>.333</td>
</tr>
<tr>
<td>2</td>
<td>Breast pain</td>
<td>15.4 ± 10.2 (27)</td>
<td>9.6 ± 7.1 (29)</td>
<td>.016</td>
</tr>
<tr>
<td></td>
<td>Body pain</td>
<td>23.3 ± 17.3 (28)</td>
<td>22.1 ± 23.5 (29)</td>
<td>.830</td>
</tr>
<tr>
<td>3</td>
<td>Breast pain</td>
<td>18.4 ± 16.4 (27)</td>
<td>8.3 ± 4.6 (28)</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>Body pain</td>
<td>26.8 ± 24.6 (28)</td>
<td>17.8 ± 19.0 (28)</td>
<td>.133</td>
</tr>
<tr>
<td>4</td>
<td>Breast pain</td>
<td>18.2 ± 12.9 (27)</td>
<td>10.2 ± 7.4 (29)</td>
<td>.007</td>
</tr>
<tr>
<td></td>
<td>Body pain</td>
<td>26.2 ± 21.6 (28)</td>
<td>18.8 ± 19.1 (29)</td>
<td>.179</td>
</tr>
<tr>
<td>5</td>
<td>Breast pain</td>
<td>14.6 ± 12.2 (27)</td>
<td>11.5 ± 11.9 (28)</td>
<td>.349</td>
</tr>
<tr>
<td></td>
<td>Body pain</td>
<td>21.8 ± 20.5 (28)</td>
<td>16.1 ± 17.2 (28)</td>
<td>.272</td>
</tr>
<tr>
<td>6</td>
<td>Breast pain</td>
<td>22.9 ± 27.3 (21)</td>
<td>14.0 ± 15. 7 (25)</td>
<td>.196</td>
</tr>
<tr>
<td></td>
<td>Body pain</td>
<td>21.7 ± 21.7 (22)</td>
<td>15.6 ± 16.1 (25)</td>
<td>.274</td>
</tr>
</tbody>
</table>

*Pain scores obtained using a visual acuity scale18 and reflect pain felt while pumping.
†Values for n vary because of missing data.

milk volumes, showing no evidence of delayed lactogenesis stage II. Published reports of the effect of increased breastfeeding intensity on milk transfer offer conflicting results. In a randomized clinical trial, Woolridge et al10 found no difference in early milk transfer, despite the additional stimulation provided by a 22-hour difference in the timing of breastfeeding initiation between groups. However, Sozmen6 observed significantly larger milk transfer values among Turkish women who intensively breastfed during the first 24 hours after cesarean delivery.

The significance of the small milk transfer volumes among the pumping primiparae are not known. Although the primiparous mothers who pumped initially had lower milk transfer values, this trend was not reflected in milk transfer at day 7 or in the duration of exclusive breastfeeding. However, the duration of any breastfeeding tended to be lower among primiparous mothers who pumped. This finding cannot be attributed to baseline differences in the education level, age, and rate of nonelective cesarean deliveries among the pumping primiparae, because controlling for these covariates did not affect the milk transfer or breastfeeding duration conclusions. Although the difference in the duration of any breastfeeding does not reach statistical significance, a 5-month difference in breastfeeding duration is clinically relevant. Our observation that low milk transfer tended to be followed by a shorter breastfeeding duration is consistent with previous research indicating that breastfeeding duration is modified by maternal perception of the onset of lactation.5 In our highly educated population, it is possible that delayed perception of the onset of lactation caused an underlying lack of confidence in breastfeeding ability, resulting in a less satisfying breastfeeding experience and an early termination of breastfeeding after completion of a reasonable period of exclusive breastfeeding for the benefit of the infant.

Because of the limited number of primiparous women in our study, we lack the statistical power to state that breast pumping before the onset of lactation had a negative impact on primiparae. We would have needed 16 primiparous women per group to have sufficient power to detect the observed 10-gram difference in milk transfer per feeding or a 5-month difference in the duration of any breastfeeding. The number of participants completing test weights at days 7 to 10 PP was very limited and may have been biased toward those experiencing greater breastfeeding success. The results of our study were unexpected. During established lactation, breast pumping has been shown to match the hormonal response to breastfeeding13,14 and to promote milk synthesis.27 Previous research has identified practices that limit breast stimulation—ie, exclusive bottle feeding,4 infrequent nursing,6 and lack of rooming-in7,8—as risk factors for delayed perception of the onset of lactation. Given these indicators that the timing of the onset of lactation may be modified by breast stimulation, breast pumping seemed a reasonable clinical practice.

We have considered several hypotheses to explain our findings. First, breast pumping could have decreased breastfeeding frequency or time spent breastfeeding; however, this did not occur. It is also possible that the amount of breast milk refed to the pumping group may have decreased later milk intake by the infant. This seems unlikely, given the small volumes that were refed and our efforts to avoid test weighing at consecutive feedings. Alterna-
Importantly, breast pumping may increase stress hormone levels. Although all participants tolerated the intervention well, the pumping group did report higher levels of breast pain. This is concerning, because delivery-related stress negatively impacts on the timing of lactogenesis II.4,28 Breast pumping may have been psychologically stressful, because participants may have felt discouraged by the small volume of milk expressed after breastfeeding. However, during follow-up phone calls, women in the pumping group seemed satisfied with their group assignment. Sixty percent of them believed that breast pumping during the first 72 hours PP had been helpful. Only 8% reported that breastfeeding would have been easier if they had been in the control group.

Although the hormonal response to breast pumping 3 to 6 weeks PP has been documented13,14 it is not known how closely the hormonal response to breast pumping resembles that of a breastfeeding infant during the first 72 hours PP. The breast pump may not be the appropriate tool to simulate infant suckling during the first 72 hours PP. Physically, the continuous, rhythmic action of the pump may not effectively mimic the immature suckling patterns and peristaltic tongue motions29 of a newborn between 24 and 72 hours PP. Compromised lactogenesis II has been reported recently among women who were expressing milk via breast pump because of a premature delivery, compared with women breastfeeding after a term delivery.30 The mechanism for this difference in the control of lactogenesis was not determined.

By delaying the initiation of breast pumping until 24 hours PP, it is possible that we missed a critical window for breast stimulation. The importance of breastfeeding frequency during the first 24 hours remains controversial.6-10 Our findings should not be interpreted to minimize the role of infant suckling on the timing of the onset of lactation. Logistic regression analyses from this study indicate that breastfeeding frequency during the first 24 hours PP interacts with maternal obesity status to determine milk transfer at 60 hours PP.31 Furthermore, women who exclusively formula feed their newborns perceive the onset of lactation significantly later than those who breastfeed.4 Thus, as suggested by the study by Sozmen,6 breast stimulation by a nursing infant may affect the timing of the onset of lactation after cesarean delivery.

**CONCLUSION**

Breast pumping before the onset of lactation had no beneficial effects after cesarean delivery of a healthy, term infant. Rather, this common clinical practice tended to have the negative short-term effect of decreasing breast milk transfer for both primiparous and multiparous women during the first 72 hours PP. In view of the lack of a short-term benefit of pumping and the tendency toward shorter breastfeeding duration among the primiparous women who pumped, we strongly suggest that women delivering healthy, term infants via cesarean at our institution should avoid breast pumping before the onset of lactation. Because we studied well-educated participants after cesarean delivery in an environment that was supportive of breastfeeding, our findings may have limited external validity. We do not know the impact of breast pumping after vaginal delivery, within the first 24 hours PP or in an environment that is not as supportive of breastfeeding.

Additional research is needed to better understand the hormonal impact of breast pumping on breast milk transfer in the first 72 hours PP. Such research would prove useful in developing sound clinical recommendations for the optimal time to initiate breast pumping for women who must pump their breasts to provide breast milk for a sick or premature infant. The role of infant suckling on the timing of the onset of lactation remains unresolved. Future clinical trials should examine whether the frequency of infant

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**TABLE 4. Impact of Breast Pumping on Milk Transfer 7 to 10 Days PP and Breastfeeding Duration**

<table>
<thead>
<tr>
<th>Breast milk transfer d 7–10 PP (g/d)</th>
<th>Pumping (n)</th>
<th>Control (n)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All participants</td>
<td>556.6 ± 193.8 (11)</td>
<td>535.5 ± 156.1 (11)</td>
<td>.78</td>
</tr>
<tr>
<td>Primiparous</td>
<td>598.6 ± 126.0 (5)</td>
<td>560.8 ± 163.3 (8)</td>
<td>.75</td>
</tr>
<tr>
<td>Multiparous</td>
<td>530.0 ± 246.1 (6)</td>
<td>468.0 ± 138.5 (3)</td>
<td>.70</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Breast milk transfer d 7–10 PP (mL/kg/d)</th>
<th>Pumping (n)</th>
<th>Control (n)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>148.4 ± 42.3 (11)</td>
<td>146.6 ± 36.4 (11)</td>
<td>.92</td>
</tr>
<tr>
<td>Primiparous</td>
<td>154.6 ± 26.2 (5)</td>
<td>146.8 ± 41.8 (8)</td>
<td>.72</td>
</tr>
<tr>
<td>Multiparous</td>
<td>143.1 ± 54.4 (6)</td>
<td>145.9 ± 22.2 (3)</td>
<td>.94</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Median duration of exclusive breastfeeding* (mo)</th>
<th>Pumping (n)</th>
<th>Control (n)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All participants</td>
<td>3.2 ± 1.8 (28)</td>
<td>2.8 ± 1.7 (28)</td>
<td>.44</td>
</tr>
<tr>
<td>Primiparous</td>
<td>3.3 ± 1.7 (10)</td>
<td>3.2 ± 1.7 (14)</td>
<td>.88</td>
</tr>
<tr>
<td>Multiparous</td>
<td>3.1 ± 1.9 (18)</td>
<td>2.4 ± 1.6 (14)</td>
<td>.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Median duration of any breastfeeding†‡ (mo)</th>
<th>Pumping (n)</th>
<th>Control (n)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All participants</td>
<td>5.9 (28)</td>
<td>6.7 (28)</td>
<td>.76</td>
</tr>
<tr>
<td>Primiparous</td>
<td>4.2 (10)</td>
<td>9.7 (14)</td>
<td>.38</td>
</tr>
<tr>
<td>Multiparous</td>
<td>7.6 (18)</td>
<td>4.9 (14)</td>
<td>.38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent still breastfeeding‡</th>
<th>Pumping (n)</th>
<th>Control (n)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All participants</td>
<td>28.6 (8)</td>
<td>32.1 (9)</td>
<td>.77</td>
</tr>
<tr>
<td>Primiparous</td>
<td>10.0 (1)</td>
<td>35.7 (5)</td>
<td>.15</td>
</tr>
<tr>
<td>Multiparous</td>
<td>38.9 (7)</td>
<td>28.6 (4)</td>
<td>.54</td>
</tr>
</tbody>
</table>

* Exclusive breastfeeding defined as the provision of breast milk as the infant’s only food source.
† Any breastfeeding defined as the provision of any breast milk to the infant.
‡ At the time of data analysis, the average child age was 1.09 ± 0.42 years.
suckling before the onset of lactation can modify early milk transfer and ultimately impact on breastfeeding duration.

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