Randomized Trial Comparing the Efficacy of a Novel Manual Breast Pump With a Standard Electric Breast Pump in Mothers Who Delivered Preterm Infants

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ABSTRACT. ***Objective.*** **The benefits of human milk for preterm infants are widely recognized, yet technological advances in milk expression have been slow. We compared the efficacy of a standard electric pump (EP; Egnell) used in 94% of United Kingdom neonatal units with a novel manual pump (MP; Avent ISIS) designed to operate more physiologically by simulating the infant's compressive action on the areola during breastfeeding.**

Methods. **We randomized 145 women who delivered infants of <35 weeks' gestation to use the MP or the EP and measured total milk volume expressed while using the randomized pump during the infant's hospital stay, pattern of milk output and creamatocrit of milk expressed during a test period in the second week, and pump characteristics by maternal questionnaire.**

Results. **Mothers who used the EP, who frequently double pumped, showed shorter expression times but produced no more milk than mothers who used the MP. When both pumped sequentially, however, mothers who used the MP showed significantly greater milk flow and total volume over 20 minutes. Creamatocrit was unaffected by pump type. The MP was rated significantly higher than the EP on 5 major characteristics.**

Conclusions. **When compared on equal terms (sequential pumping), mothers who used the MP showed greater milk flow, perhaps reflecting more physiologic pump design. Even with double pumping, mothers who used the EP did not advantage their infants with greater milk production. We believe that this novel, effective MP, preferred by mothers and costing a fraction of the EP price, reflects a significant advance in milk expression for high-risk infants.** ***Pediatrics*** **2001;107:1291-1297;** ***breast pumps, randomized trial, preterm infants.***

ABBREVIATIONS. EP, electric pump; MP, manual pump; SD, standard deviation.

In recent years, significant benefits have been proposed for using breast milk in neonatal intensive care for preterm infants. These include evidence of improved feed tolerance,[1] protection against necrotizing enterocolitis[2] and systemic infection,[3] and promotion of cognitive development.[4] These benefits have been emphasized at a time when breast milk banks largely have been eclipsed after concerns about human immunodeficiency virus transmission.[5] The net effect has been that a high proportion of mothers now wish to provide their own breast milk for their preterm infant. Infants who are born before 34 weeks' gestation usually are too immature to breastfeed; the mother must express her milk, either manually or with the use of a breast pump, possibly for weeks or even months if her infant is extremely preterm or sick. This pumping is exhausting and time consuming for mothers, and, not surprising, the proportion of mothers who eventually establish breastfeeding is low: 21% in a recent study.[6]

Breast pumps have been in existence for decades. All pumps to date, whether hand operated, battery, or electric, operate by simple suction, which is unphysiologic because during normal breastfeeding, the infant compresses the breast beyond the areola and only minimal suction is needed to empty the milk ducts of milk that has been forced forward by the infant's compressing action. It is known that the adequacy of breast emptying influences milk composition as a result of differences between fore- and hindmilk, with higher fat content in the latter.[7] The method used to express milk therefore may influence not only a mother's success in providing breast milk for her infant but also, importantly, the composition of milk produced and, therefore, the nutrient intake of her infant. A limited number of studies in mothers of term infants have shown differences in milk volume and composition according to the method of breast milk expression used.[8-11] However, no studies have been performed in mothers who delivered preterm infants–a group in whom such differences would have more practical importance.

The large electric pumps (EPs), such as the Egnell Ameda (Ameda, Taunton, UK), are regarded as the gold standard and are used in 94% of UK neonatal units (M.S. Fewtrell, unpublished observation). The new ISIS breast pump (Canon Avent, Glemsford, Suffolk, UK) is a hand-operated pump that has been designed to operate in a more physiologic manner, with petals that simulate the infant's compressive action on the areola during breastfeeding rather than simply operate by suction (Fig 1). The more physiologic action is expected to result in a more efficient letdown reflex and improved milk flow. Another major difference between the large EPs and this novel manual pump (MP) is cost (hundreds of pounds [dollars] vs less than £25 [$36], respectively). Even if the MP were shown to be equally (as opposed to more) effective as the large EP, this would have important

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Fig. 1 Cup insert from manual pump, showing petal cushions.

financial and practical implications for neonatal units in which EPs may be in limited supply.

In this study, we tested the hypotheses that the total amount of milk expressed by mothers who used the novel MP would be greater than that produced by mothers who used the standard EP. We also compared the pattern of milk flow and the creamatocrit of milk produced by mothers who used their randomized pump under observation, expressing for 10 minutes from each breast sequentially, and recorded each mother's opinion of her randomized pump with the use of a questionnaire.

METHODS

The study was conducted in the Rosie Hospital (Cambridge, UK) between February 1998 and January 2000. Mothers were eligible if they delivered a preterm infant <35 weeks' gestational age and decided to provide milk for their infant. Women who delivered in another hospital but whose infants were transferred to Cambridge for neonatal intensive care also were eligible. All mothers were recruited within 3 days of delivery; if necessary, they started expressing milk using the standard pump for the hospital or unit where the infant was delivered before entry into the trial.

The study was explained by 1 of 2 research nurses. After giving informed consent, the mother was assigned randomly to use either the EP or the MP for as long as she continued to express milk. Randomization was performed with the use of permuted blocks of randomized length and was stratified by the infant's sex and gestation (<30 weeks and 31-34 weeks) to ensure an equal spread of the most preterm infants whose mothers might be expected to express milk for the longest period. Assignments were held in sealed opaque envelopes prepared by a member of the research team who was not involved in other practical aspects of the study.

After randomization, each mother was given information and help with using her assigned pump by the midwifery staff on the postnatal ward and by the nursing staff on the neonatal unit. The policy at the Rosie Hospital during the study was to recommend expressing at least 6 times per day, initially for 5 minutes each breast, then increasing as tolerated. Mothers who were using the EP also were encouraged to use double pumping (pumping from both breasts simultaneously) once they were familiar with the use of their pump, although the final method chosen was left up to the individual mother. Research nurses were not involved in advising mothers about the frequency and duration of expression.

The main outcome measure was the total volume of milk expressed by the mother during her time in the trial. Subsidiary outcome measures were 1) the volume of milk expressed in a set 20-minute period during the second week postpartum, 2) the time taken to express a designated volume of milk during the second week postpartum, 3) the creamatocrit of milk expressed during this set period, and 4) a maternal questionnaire rating 5 consumer characteristics for the assigned pump.

Mothers were asked to complete a form each time they expressed milk, detailing the method used (hand expression or pump), the time they started and finished, the volume of milk expressed, and, for mothers who were using the EP, whether they double pumped. They also recorded the number of attempted breast feedings. Daily information was then summarized by research staff to give the total for each parameter during the whole study period and also the mean per day of study.

Research nurses collected information on the infant(s) each day, including the volume and type of milk received (breast milk and formula) and clinical progress. These data were recorded until the infant left the hospital, regardless of whether the mother was still expressing milk at that time.

At 7 to 10 days postpartum, mothers were asked to complete a questionnaire about their assigned pump. They were asked to rate the pump on an analog scale of 1 to 7 (1 being most favorable, 7 least favorable) for the following parameters: ease of use, amount of suction, comfort, pleasant to use, and overall opinion of pump.

Mothers left the study when they reached 1 of 5 endpoints: 1) they stopped using the assigned pump (either stopped expressing completely or changed to another pump); 2) they stopped completing the data forms, even if they continued to produce some milk (in the latter case, the research nurses attempted to record each day whether the mother was still using the assigned pump, although no details of volume could be obtained); 3) their infant was discharged or transferred to another hospital; 4) the infant was fully breastfed; 5) the infant died. At the time of discharge from the study, the mode of infant feeding was recorded (all breast milk, >50% breast milk, half breast milk and half formula, >50% formula, all formula, or no enteral feeds).

Physiologic Studies

During the second week postpartum, a subsample of 45 consenting mothers (24 MP and 21 EP) were studied on 2 consecutive days during a fixed 20-minute period, expressing milk for 10 minutes from each breast sequentially using the assigned pump (all mothers who remained in the study at that point were invited to participate in these studies, but not all were willing to do so). None of the participating mothers had changed from her randomized pump before the test. Thirteen (54%) mothers who were using the MP and 10 (48%) mothers who were using the EP had put their infant to the breast. During this investigation, milk was expressed in the normal manner but collected into preweighed sterile bottles. On the first day, the weight of milk expressed at 1-minute intervals and the time taken to produce a given volume of milk were recorded. On the second day, a sample of milk was taken at 1-minute intervals and the creamatocrit was measured.[12]

Sample Size

The target sample size was 76 women per group, to detect a 0.5 standard deviation (SD) difference in outcome measures between groups with 80% power at the 5% significance level, allowing for 12 (15%) dropouts per group.

Statistics

Data for the 2 randomized groups were compared by Student's *t* test or Mann-Whitney *U* test for nonparametric data. Proportions were compared by x^2 test or Fisher's exact test. For the questionnaire, results were recoded before analysis with scores of 5 to 7 as one category in view of the small numbers receiving each score. Analyses were performed initially on an intention-to-treat basis for as long as the mother provided data (including each woman in her randomized

group even if she had changed to the other pump during the study and continued to collect data), and then including data from women only while they were using their randomized pump. Repeated measures analysis of variance was used to analyze data from the physiologic studies where measurements were made on the same women at 1-minute intervals during a 10-minute period.

RESULTS

A total of 145 mothers were recruited: 74 were randomized to use the MP, and 71 were randomized to use the EP. There were no significant differences between the groups in maternal characteristics (Table 1). Mothers left the study if 1 of 5 criteria were met (Fig 2); the proportions in different categories did not differ between randomized groups. The median (25th, 75th centiles) length of time in the study was similar for mothers who were using the MP and mothers who were using the EP (14 days [7,25] vs 16 [9,30] days). Twelve (16%) mothers who were using the MP and 15 (21%) mothers who were using the EP changed to the other breast pump after randomization. Some of these mothers continued to express breast milk and to record data about milk volumes (see below).

Main Outcome: Breast Milk Expressed During Entire Study Period

There were no significant differences between randomized groups for any parameter except the total and mean time spent expressing milk per day, which was significantly higher in mothers who were using the MP (Table 2). This almost certainly reflects the fact that the majority of the mothers who were using the EP double pumped (expressed both breasts simultaneously; median percentage [25th, 75th centiles] of sessions in which double pumping was used = 98.7% [45 100]). All mothers who were using the MP expressed both breasts at each session. When mothers who were using the EP and double pumped on more than 66% of occasions were excluded, the differences between pump groups in the total and mean time spent expressing were reduced and no longer significantly different (mean time spent expressing per day = 66 vs 59 minutes [P = .1]). Moreover, when mothers who were using the MP were compared with mothers who were using the EP and who double pumped exclusively, the calculated milk output *per breast* per minute for the whole study was higher in the MP group (3.1 ml/breast/min [SD = 2.5] vs 2.4 ml/breast/min [SD = 1.9]; P = .2), and the estimated time spent expressing per session if sequential rather than double pumping had been used was significantly lower in the MP group (20 minutes [SD = 6] vs 25 minutes [SD = 9]; P = .004).

TABLE 1. Baseline Characteristics of Participants

Characteristic	MP (n = 74)	EP (n = 71)
Maternal age (yrs)*	29.7 (5.6)	28.4 (4.9)
Social class 1 + 2 [n (%)]	25 (34)	21 (30)
"A" levels or higher professional qualification [n (%)]	26 (34)	23 (33)
Living with partner [n (%)]	70 (95)	66 (93)
Number of previous live births (%)		
0	44 (60)	43 (61)
1	20 (27)	23 (32)
2	9 (12)	4 (6)
3	1 (1)	1 (1)
Number of children breastfed (%)		
0	54 (75)	53 (75)
1	13 (18)	16 (23)
2	5 (7)	2 (3)
Used breast pump previously [n (%)]	11 (15)	11 (16)
Mode of delivery [n (%)]		
Vaginal	30 (41)	35 (49)
Elective caesarean	36 (49)	29 (41)
Emergency caesarean	8 (11)	7 (10)
Singleton pregnancy [n (%)]	61 (82)	64 (90)
Twin pregnancy [n (%)]	12 (16)	7 (10)
Triplet pregnancy [n (%)]	1 (1)	–
Infant characteristics (singletons)		
Birthweight (g)*	1357 (540)	1305 (565)
Gestation (wk)*	29.4 (3.0)	29.1 (3.3)
Males [n (%)]	32 (53)	35 (55)

MP indicates manual pump; EP, electric pump.
* Mean (SD).

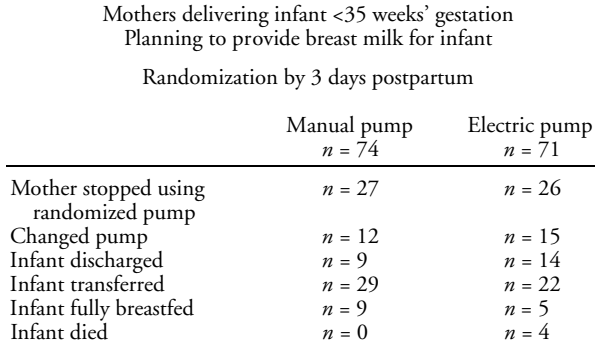


Fig 2. Trial profile.

Thirty-seven mothers (23 MP and 14 EP; P = .12) attempted to breastfeed their infant while participating in the study. The median (25th, 75th centiles) number of attempts to breastfeed was 20 (8,32) with a mean number of attempts per day of 1.1 (0.6,2.1). Compared with mothers who did not attempt to breastfeed, these mothers were significantly older (30.9 years [SD = 4.5] vs 28.6 years [SD = 5.5]; P = .03), and their infants were heavier (birth weight = 1800 g [SD = 504] vs 1171 g (SD = 484); P < .001) and more mature (gestational age = 31.6 [SD = 2.6] vs 28.5 [SD = 2.9] weeks; P = <.001). Mothers who attempted to breastfeed their infant expressed significantly greater volumes of milk during the study (both total volume and volume per day) and spent more total time expressing with a greater total number of sessions (Table 3) than mothers who did not put their infant to the breast. However, results for the comparison of breast milk expression data in MP and EP groups were the same in the groups of mothers who had and had not attempted to breastfeed.

Secondary Outcomes

Physiologic Measurements

Physiologic measurements were made at a mean of 11 days (SD = 2.5) postpartum. The volume of milk

TABLE 2. Breast Milk Expression Data (Results Are Median [25th and 75th Centiles])

	MP	EP	P
As randomized	*n* = 60	*n* = 58	
Total number of expressions	38 (15,69)	34 (15, 74)	.8
Mean expressions/day	3.7 (3.0, 4.1)	3.9 (3.2, 4.4)	.3
Total time spent expressing (min)	745 (289, 132l)	515 (231, 1069)	.06
Mean time/day spent expressing	65 (56, 85)	51 (38, 63)	<.001
Total volume expressed (mL)	1928 (322, 5408)	2062 (728, 5485)	.6
Mean volume/day expressed	199 (57, 323)	218 (126, 341)	.5
As randomized with data for mothers who changed pumps included until they changed			
Total number of expressions	37 (15, 69)	31 (14, 62) .8	
Mean expressions/day	3.7 (3.0, 4.1)	3.9 (3, 2, 4.3) .4	
Total time spent expressing (min)	45 (283, 132l)	406 (216, 857) .02	
Mean time/day spent expressing	66 (56, 85)	50 (38, 63) c.001	
Total volume expressed (mL)	1806 (314, 5408)	1653 (554, 5152) .8	
Mean volume/day expressed	199 (57, 323)	205 (119, 341) .6	

The number of participants per group for the analysis (MP, *n* = 60; EP, *n* = 58) is less than the number randomized as some mothers (14 MP and 13 EP) failed to fill in the daily milk collection sheets.

TABLE 3. Breast Milk Expression Data for Mothers Who Attempted to Breastfeed Their Infant Compared With Those Who Did Not (Results are Median [25th, 75th centiles])

	Attempted to Breastfeed	No Attempt to Breastfeed	P
n	37 (23 [62%] MP)	81 (37 [46%] MP)	
Total number of expressions	52 (39, 85)	27 (11, 6 7)	<.001
Mean expressions/day	3.9 (3.3, 4.6)	3.7 (3.0, 4.1)	.06
Total time spent expressing (min)	851 (638, 1388)	380 (170, 1033)	.001
Mean time/day spent expressing	62 (52, 80)	58 (40, 79)	.2
Total volume expressed (mL)	4151 (1726, 7715)	1406 (271, 3880)	<.001
Mean volume/day expressed	305 (178, 399)	162 (67, 296)	.002

expressed was higher at each measurement time point for mothers who were using the MP than for mothers who were using the EP (Fig 3A and B), and the total volume of milk expressed during the 20-minute test period was significantly higher for mothers who were using the MP (112 mL [SD = 69] vs 76 mL [SD = 44]; difference = 36 mL [95% confidence interval = 2-71]; *P* = .04). The trend for greater milk production during each 10-minute period in mothers who were using the MP was significant for both breasts. Similarly, mothers who were using the MP took significantly less time to express a given volume of milk than mothers who were using the EP (Figs 4A and 4B). Creamatocrit (which correlates with fat content) values at 1-minute intervals and the mean creamatocrit during a 10-minute period were not significantly different in the 2 pump groups for either breast (mean creamatocrit for first breast = 6.73% [SD = 2.80] vs 6.80% [SD = 2.41]; mean creamatocrit for second breast = 6.82% [SD = 2.61] vs 7.31% [SD = 2.81] for MP and EP, respectively).

Questionnaires

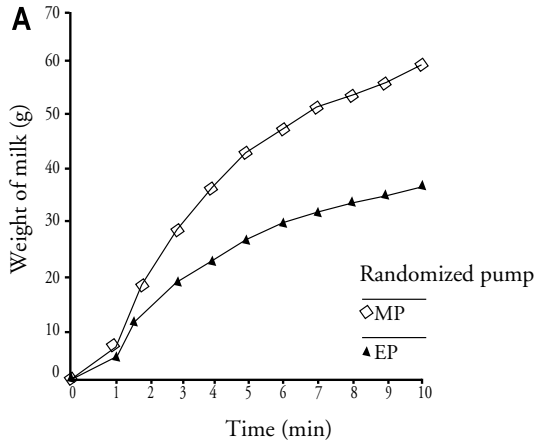
On all parameters, mothers who were using the MP gave significantly better (ie, lower) scores than mothers who were using the EP. The advantage for the MP was greatest for comfort, pleasure, and over-all opinion of pump (Table 4).

Maternal Health Related to Use of Pump

Similar proportions of mothers from each pump group developed sore nipples (7% both groups) or engorgement (4% MP vs 6% EP). Two mothers who were using the EP (2%) developed mastitis. Six (8%) mothers who were using the MP and 6 (9%) mothers who were using the EP were prescribed metoclopramide to increase milk output during the study period; the median (25th, 75th centiles) number of days on which it was prescribed did not differ significantly between groups (1 [1,5] for MP vs 3 [2,6] for EP). The median number of expressions per day for mothers who were receiving metoclopramide was 3.4 (2.7, 4.1) for MP and 4.3 (3.2, 4.6) for EP; this was not significantly different from mothers who did not receive metoclopramide.

Mode of Feeding at Discharge

Of those infants who were receiving milk feedings when discharged or transferred to another unit, 45 of 62 (73%) MP infants and 40 of 53 (76%) EP infants were receiving more than 50% of their intake as breast milk. However, the MP group contained more twins and 1 set of triplets, which would be expected to reduce the proportion of mostly or fully breastfed infants. The proportion of *singleton* infants who were receiving more than 50% breast milk at discharge was 37 of 46 (80%) for the MP group and 32 of 45 (71%) for the EP group (*P* = .3).



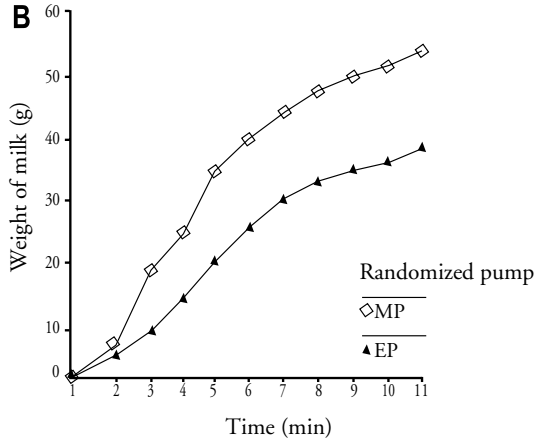
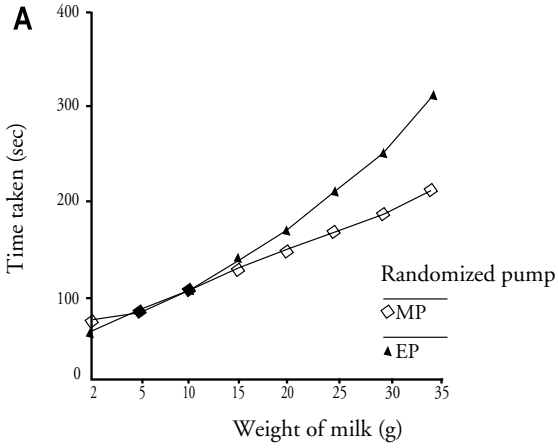


Fig 3. Weight of milk at 1-minute intervals according to pump used: A) first breast, B) second breast (MP, *n* = 24; EP, *n* = 21).



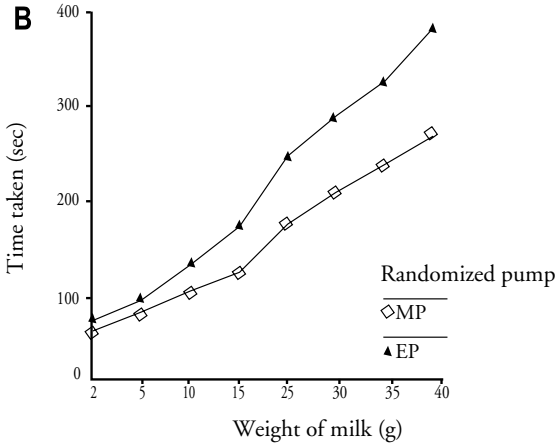


Fig 4. Time taken to express a given weight of milk according to pump used: A) first breast, B) second breast (MP, *n* = 24; EP, *n* = 21).

Clinical Course of Infants

There were no significant differences between pump groups in the proportion of infants who required supplemental oxygen or ventilation or in the duration of support required. Similar numbers of infants from each group developed confirmed necrotizing enterocolitis (4 MP vs 5 EP), and there were no significant differences in the number of courses or total number of days of antibiotics received.

DISCUSSION

The efficacy of the novel, inexpensive, and portable MP and a large standard EP was broadly similar in terms of the volume of breast milk produced by mothers who were using the pumps on a day-to-day basis. Mothers who were using the MP awarded significantly better scores for all consumer characteristics than mothers who were using the EP. These findings have practical, biological, and economic implications. Mothers who were using the MP spent significantly longer expressing milk, almost certainly because most mothers who were using the EP used double pumping. Interestingly, however, we found evidence that the removal of milk from each breast was more efficient with the use of the MP. When mothers who used double pumping more than two thirds of the time were excluded, the time spent expressing was more similar in the 2 pump groups. In addition, the calculated volume of milk per breast per minute was slightly higher, and the theoretical time spent expressing per session, assuming sequential rather than double pumping, was significantly lower for mothers

TABLE 4. Results of Breast Pump Questionnaires

Parameter	Score					*P* (x^2)
	1	2	3	4	5	
Ease of use						
MP	43	41	9	7	0	.03
EP	33	27	25	10	6	
Amount of suction						
MP	26	47	14	10	4	.05
EP	29	24	25	16	10	
Comfort						
MP	29	43	9	17	1	.003
EP	12	25	29	25	7	
Pleasant to use						
MP	24	35	17	21	3	.01
EP	6	20	27	37	10	
Overall opinion						
MP	26	47	19	5	3	.003
EP	12	22	41	18	6	

Numbers are the percentages of mothers in each pump group awarding each score. For each parameter, 1 is the most favorable and 7 is the least favorable score. MP, *n* = 58; EP, *n* = 49.

who were using the MP than for mothers who were using the EP and who exclusively double pumped. Most important, when the pumps were compared under the same conditions in the physiologic study–with mothers expressing their breasts sequentially–the volume of milk produced was greater at each time point in mothers who were using the MP, and these mothers also produced a greater total volume of milk during the 20-minute test period. Mothers who were using the MP also took less time to express a given volume of milk, suggesting their let-down reflex may have operated more quickly, although the creamatocrit of the milk produced did not differ significantly between pump groups. These findings suggest that the principles used to design the MP are reflected by measurable changes in the physiology of milk expression.

One previous study[13] examined the relative efficacy of single versus double pumping with the use of an EP in 32 mothers of preterm infants during a 4- to 6-week period and found that although there was no difference between the 2 groups in the number of pumping sessions per week, the weekly milk production, or prolactin levels, mothers who double pumped spent significantly less time expressing (7.6 [SD = 3.0] vs 11.1 [SD = 3.1] hours per week). The equivalent figure for mothers who were double pumping in our study was 6 hours per week, whereas that for mothers who were single pumping using the MP was still only 7.6 hours–considerably less than that for mothers who single-pumped in the earlier study. Currently, we are studying the feasibility of double pumping with the use of the MP in mothers of preterm infants, after a successful pilot in 4 term mothers. Theoretically, this should reduce the duration of expression with the use of the MP below that of the EP. This hypothesis will be tested formally if feasibility is established.

The relative efficacy of different modes of breast milk expression has received relatively little attention, particularly in mothers of preterm infants, although it may influence the volume and composition of milk obtained. Garza et al[8] compared single-breast expression with the use of the Egnell pump with hand expression in 11 mothers who had delivered term infants and found that significantly greater volumes of milk were obtained with the Egnell pump, with a 25% higher fat content. Green et al[9] compared hand expression with 3 pumps (the Egnell electric; the Loyd B [Lopuco Ltd, Woodbine, MO], a trigger-handled hand pump; and the Evenflo Evenflo Products Co, Ravenna, OH] a bulb-operated hand pump) in 6 term mothers. Mothers produced significantly more milk with the Egnell pump than any other method, although the creamatocrit of the milk did not vary. Boutte et al[10] compared the Egnell EP with the Medela hand pump (a cylinder-operated pump) in 10 term mothers and found that mothers obtained milk with a significantly higher energy content using the EP. In addition, the variance of fat and energy content was greater in milk that was produced with the hand pump. Finally, Zinaman et al[11] compared the hormonal response to breastfeeding, hand expression, and expression with the use of 3 types of breast pump (White River Electric [White River Technologies, Santa Ana, CA], Gentle Expression Manual, and Medela Manualelectric [Medela, Chicago, IL]) in 23 term mothers on consecutive days. The EP most closely reproduced the prolactin response seen during a normal breastfeeding, and mothers produced the highest volumes of milk with the EP compared with any other method of expression. These studies collectively suggested that the EPs are more efficient at removing breast milk and may favorably influence the composition of the expressed milk. It is relevant to note that there may have been some improvements in the various MPs since these studies were conducted (all >8 years ago). Nevertheless, our study is the first in which an MP has been shown to be superior to an EP when compared on equal terms.

The proportion of infants who were discharged from the Cambridge Neonatal Unit receiving >50% breast milk was very similar for singleton infants in both pump groups. It is a feature of modern neonatal intensive care in the United Kingdom that preterm infants are transferred back to their referring unit as soon as their condition stabilizes. This makes studies such as ours more difficult as many mothers are transferred some distance away, thus precluding any regular ongoing contact. In addition, with improvements in neonatal community nursing services, many preterm infants are now discharged from the hospital while they are still receiving feeds predominantly via a nasogastric tube. We are currently collecting information on the proportion of mothers who eventually breastfed their infants and the duration of breastfeeding to determine whether these parameters are influenced by the method used to express milk during the early postpartum period.

Although mothers were advised to express milk a minimum of 6 times per day, a notable feature of our study was the low frequency of pumping sessions, even among the fairly motivated mothers who completed the milk collection forms. It became apparent during the course of the study that many mothers who had not intended to breastfeed had their infant delivered at term were persuaded to attempt to provide at least some milk for their sick infant. This was reflected in the large number of women who expressed milk only for a short period or who failed to complete the daily milk collection forms and may also explain the low overall mean number of pumping sessions per day. Nevertheless, some mothers were prescribed metoclopramide to improve their milk output when they were in fact expressing on average fewer than 5 times per day; simply increasing the frequency of expression would have been likely to increase milk output without the need for pharmacologic intervention. This emphasizes the need for continuing practical support of mothers who are attempting to

provide breast milk for their sick infant, particularly if they wish to establish breastfeeding eventually.

We found that mothers who attempted to breastfeed their infant during the study expressed significantly greater volumes of milk than those who did not, although the performance of the MP and the EP within the groups of mothers who did and did not attempt to breastfeed was similar. The greater milk production in mothers who attempted to breastfeed may be attributable to a number of factors. First, mothers who put their infant to the breast may have been a select population who were planning to breastfeed before delivery and therefore were more motivated both to feed their infant and to express milk. Second, the process of putting the infant to the breast, regardless of whether the infant actually suckled or simply nuzzled, may have had a beneficial effect on lactation by increasing maternal prolactin concentrations and therefore improving milk yield when expression was next attempted. Third, infants whose mothers attempted to breastfeed were, not surprising, more mature and had higher birth weights; they therefore were likely to be less unwell, perhaps inducing less maternal stress, which would inhibit lactation. We cannot distinguish among these factors with the information available.

Mothers showed a clear preference for the MP over the EP, rating it significantly higher overall and on each of the individual characteristics, including "ease of use," "amount of suction," "comfort," and "pleasant to use." The last was of particular biological interest. Our repeated casual observation has been that although mothers most commonly find breastfeeding to be a pleasant experience, this often is not so for mechanical milk expression. However, we are not aware of previous detailed data on this subject. Our study showed that the MP was rated as significantly more pleasant to use than the EP; twice as many mothers who were using the MP selected the top 2 scores for this parameter than mothers who were using the EP (59% vs 26%) and 4 times as many selected the top score (24% vs 6%). Whether this observation has a physiologic basis, for example, reflecting changes in oxytocin release during milk expression, requires additional study.

CONCLUSION

We showed that the efficacy of an inexpensive MP was similar to that of the more expensive, standard EP used in the majority of UK neonatal units. When compared on equal terms (sequential pumping), mothers who were using the MP showed greater milk flow and produced more milk in a fixed time period, perhaps reflecting more physiologic pump design. We believe that this novel, effective MP, preferred by mothers and costing a fraction of the EP price, reflects a significant advance in milk expression for high-risk infants.

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NEONATAL DECISIONS IN EUROPEAN COUNTRIES

Physicians regularly employed in neonatal intensive care units in 10 European countries with beliefs valuing quality of life were more likely to report having set limits to intensive neonatal interventions in cases of poor neurological prognosis than physicians with beliefs valuing sanctity of life at any cost. Of several factors associated with physicians' attitudes and practices, including religious background and professional experience, country was the most important.

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