

Supporting mothers to effectively activate milk production

Summary

The first few hours and days of an infant's life are a critical window for establishing lactation and providing mothers with the support that they need to initiate breastfeeding.¹ Early, frequent and effective breast stimulation decrease the time to milk 'coming in',^{2,3} produce a higher milk yield in the short- and long-term^{4,5} and extend the breastfeeding duration.^{2,6,7}

The first two weeks have been shown to be a predictor of long-term milk production.⁸ Insufficient stimulation in this critical window can result in a cascade of negative effects: Mothers may experience delayed secretory activation, difficulty 'coming to volume' and impaired long-term milk production.⁹

If the infant is unable to effectively and frequently stimulate the breasts in the critical window after birth, proactive, skilled and appropriate lactation support and intervention are critical.

Electric pumping or hand expression techniques are currently used to replace the absent or ineffective feeds and remove colostrum for the infant. Whilst hand expression is an important tool, it lacks the vacuum required to effectively stimulate the prolactin response¹⁰ and, when used exclusively, it has been shown to yield significantly less daily milk volumes than electric pumping.¹¹ Some studies show that combining breast massage and hand expression with the vacuum of a double electric pump is associated with significantly higher mean daily milk volumes.^{12,13}

Practices surrounding effective initiation of milk production should be grounded in evidence-based recommendations in order to establish an adequate milk supply, facilitate long-term breastfeeding and improve health outcomes for mothers and infants.¹ The appropriate usage of hand expression and electric pumping is imperative for a successful lactation journey.

Background

The first few hours and days of an infant's life are a critical window for establishing lactation and providing mothers with the support they need to initiate breastfeeding.¹ The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) recommend immediate and uninterrupted skin-to-skin contact with initiation of breastfeeding within the first hour of birth¹ and exclusive breastfeeding for six months to provide the nurturing, nutrients and energy needed for physical and neurological growth and development.¹⁴

Frequent and effective stimulation of the breast in the early days is crucial to leverage the hormonal changes during the critical window after birth. UNICEF has published a tool to assess how well the infant is feeding; from this it can be described that an effective feed should, amongst other aspects, be constructed of the following elements: The infant is alert, good positioning and attachment and deep rhythmic sucks are observed for a duration of around 5-40 minutes.¹⁵ Early, frequent and effective breastfeeding provides the optimum suckling vacuum^{16,17} to stimulate the breast and remove colostrum in the early days after birth.

Early initiation decreases time to secretory activation,² produces a higher milk yield in the short and long term⁴ and extends the breastfeeding duration.^{2,6}

Plentiful research papers provide evidence to support the recommendation of early initiation, demonstrating multiple benefits, including, but not limited to: Decreased time to secretory activation;² higher milk yield in the short and long term;⁴ extended breastfeeding duration^{2,6} and a protective advantage for the infant, extending until the age of 6 months and beyond.¹⁸

In a study of 111 primiparous mothers of healthy, term infants, it was found that putting the infant to the breast as soon as possible after birth, followed by 2-hourly feeding until lactation was established, had a significant effect on the duration of breastfeeding when followed-up at 18 months.²

The optimum time to start breast stimulation has been explored more extensively with samples of mothers whose babies are in neonatal intensive care units and are therefore pump dependent, by assessing timing to first milk expression. Policies promoting initiation of expression within six hours of birth have been associated with increased maternal breast milk feeding for very preterm babies.¹⁹

Exploring the first 6 hours further, Parker et al. found in a pilot study that expressing within 1 hour of birth, compared to 1-6 hours, significantly increased expressed milk yield at week three of life (267 mL/d to 613 mL/d) and reduced the time to secretory activation.⁴ When analysing a larger group, Parker found that expressing 1-3 hours after birth, compared to 3-6 hours, increased breastfeeding at discharge from 35%, to 62% respectively and also supported the finding of a reduced time to secretory activation.⁶

'Early' versus 'late' initiation of breast stimulation and its impact on breastfeeding at NICU discharge⁶

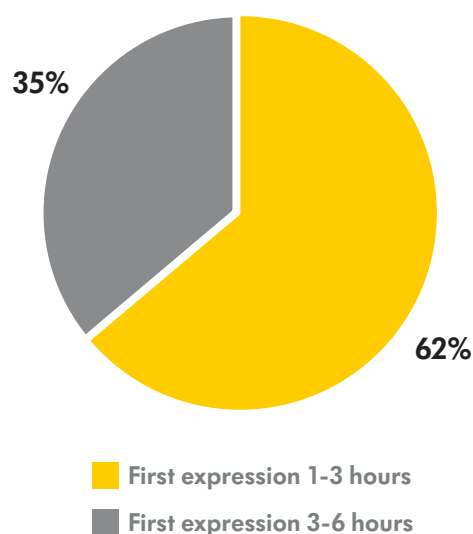


Figure 1 - Percentage of very low birth weight infants breastfeeding at NICU discharge when expression was initiated 'early' (1-3 hours after birth) or 'late' (3-6 hours after birth).

Frequent stimulation has a significant impact on timing of secretory activation^{2,3} and long-term milk production.⁵

In addition to early initiation of breast stimulation, it is known that frequent stimulation also has a significant impact on timing of secretory activation^{2,3} and long-term milk production.⁵

From the research that is available, it is commonly found that more frequent breast stimulation results in higher milk volumes.²⁰ Work by Hoban et al. showed that 86% of mothers who expressed more than 5 times per day achieved the target yield, versus 22% of mothers who expressed less than 5 times per day.⁹ Research in this area has led to a general recommendation of breast stimulation at least 8 times per day.

The work of Salariya et al. on term infants found that 2-hourly breastfeeding, rather than 4-hourly, resulted in earlier secretory activation and a significant reduction in the need for complementary feeding,² which has been associated with secondary lactation failure when used unnecessarily.²¹

Additionally, Morton et al. found that for pump-dependent mothers, expressing ≥ 7 times per day was associated with a higher milk yield at 2 weeks versus < 7 times per day.¹² In another paper of a similar sample by Ru et al., expressing ≥ 6 times per day was associated with higher milk fat, carbohydrate and energy levels on day 7 and greater milk outputs on days 7, 14, and 42.²²

Milk volumes (mL) at day 14 in relation to pumping frequency²²

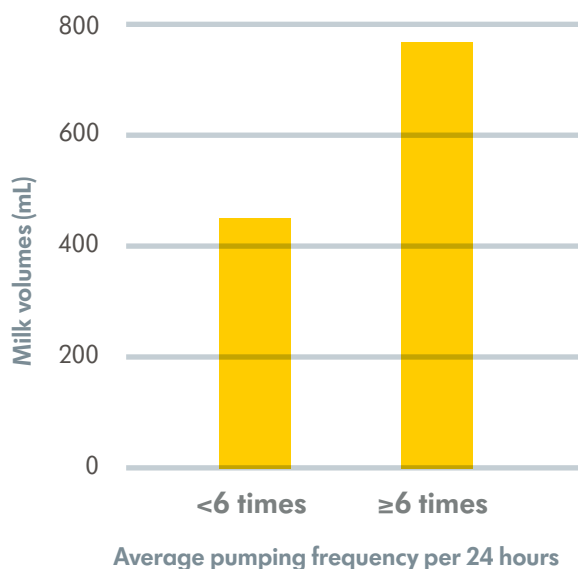


Figure 2 - Daily breast milk volumes at day 14 postpartum produced by mothers who pumped less than 6 times in 24 hours or more than 6 times in 24 hours from a study conducted in pump-dependent mothers of premature infants.

The first two weeks after birth are a critical window and a predictor of long-term milk production.⁸

It is also considered significant that mothers of preterm infants achieve a certain volume of milk by day 10 after birth; defined as 500 mL per day²³ with a target for a full supply in mothers of term infants of greater than 750 mL per day in established lactation.²⁴ This is because the first two weeks have been shown to be a predictor of long-term milk production.⁸

Early work by Hill et al. showed that milk volume on day 4 was predictive of lactation adequacy at 6 weeks in pump-dependent mothers of preterm infants.²⁵ Later work by Hoban et al. reported in a study of preterm infants, that when mothers meet the 500 mL per day goal by day 14, it makes them more likely to still be breastfeeding at discharge.⁸ Hill et al. had also produced similar findings; milk output on day 6 and 7 in term and preterm infants, are a reliable predictor of volumes at week 6.²⁶ This suggests a critical window, where the mammary gland is susceptible to programming for optimum long-term milk production,^{4,12,27,28} implying that practices focusing on early, frequent and effective breast stimulation to promote an adequate milk supply in the first week postpartum are essential.

Prolactin catalyses the closure of tight junctions of the alveolar epithelial cells in the mammary gland, allowing for copious milk production.^{29,30}

The literature clearly explains the physiological reasons behind this critical window: Secretory activation is a transitional process whereby the delivery of the placenta marks a rapid decline in progesterone, allowing prolactin and other factors to take action.³⁰ Prolactin catalyses the closure of tight junctions of the alveolar epithelial cells in the mammary gland, allowing lactose, an osmotic component, to get caught inside the cell and draw water in, granting copious milk production.^{29,30}

Activating milk-making cells: Stimulating the closure of lactocyte tight junctions²⁹

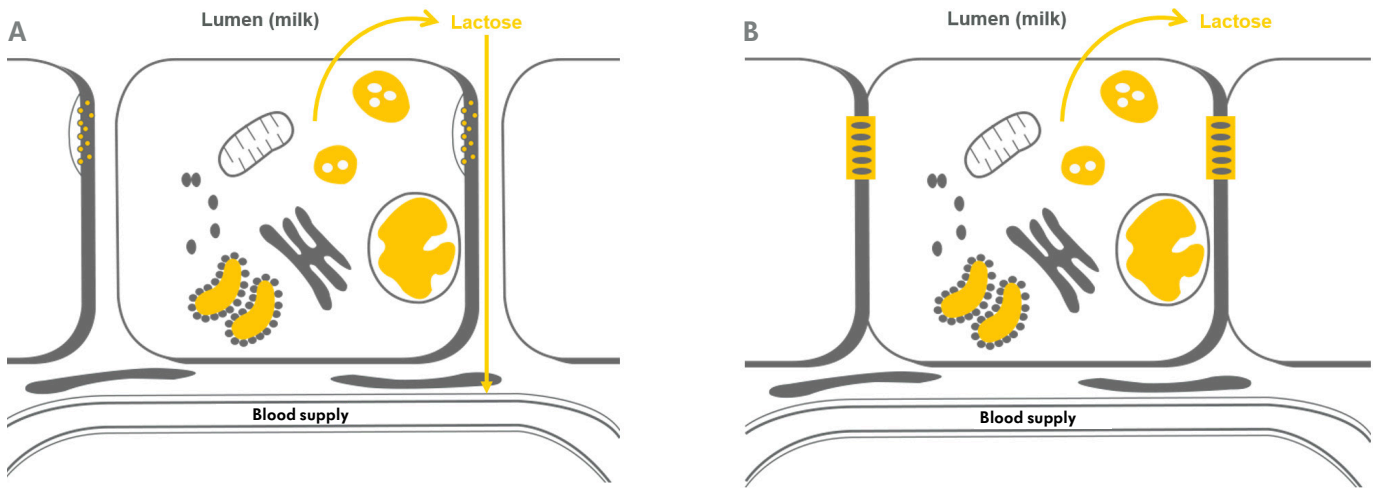


Figure 3 - Illustration of the closure of the tight junctions around the lactocytes. **A:** Open tight junctions. **B:** Closed tight junctions allow for copious milk production.

Certain biomarkers have been noted in breast milk that indicate closure of tight junctions; an increase in lactose and citrate levels, in combination with decreasing sodium and total protein levels, can provide indication of the process of secretory activation.^{9,31} The opposite is also true and seen in involution of the mammary gland.³² Prolactin is not only instrumental in regulation of the genes that promote the production of lactocytes, it is also known to prevent cell death; both vital for sustained and long-term milk synthesis.³²

Vacuum plays a vital role in milk removal from the breast during an infant feed;¹⁶ prolactin is known to be directly influenced by the infant sucking stimulus.³¹

The role that high levels of maternal prolactin play in the early days after birth for long-term milk supply cannot be underestimated. Research has shown that vacuum plays a vital part in milk removal from the breast during an infant feed;¹⁶ and prolactin is known to be directly influenced by

Breast milk biomarkers and milk volumes over the first 2 weeks post-birth⁹

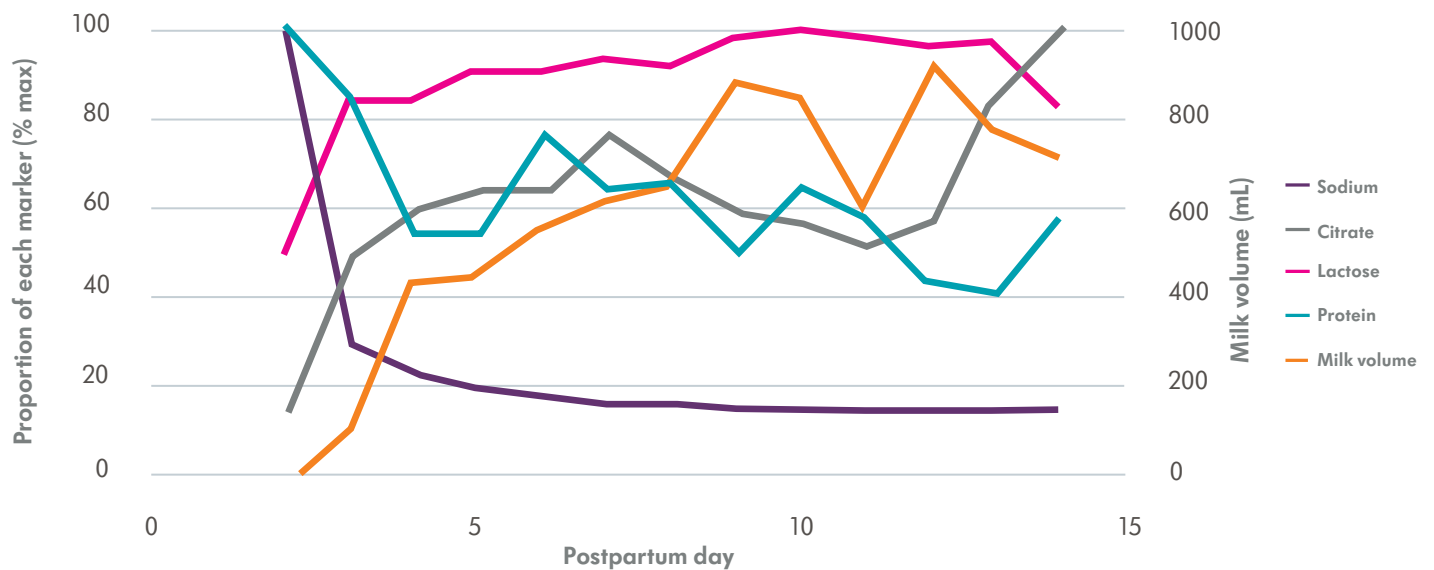


Figure 4 - Representative pattern of biomarkers for a pump-dependent subject who achieved 500 mL/day, on postpartum day 6. Concentrations of sodium and protein decline precipitously while citrate and lactose concentrations, in addition to milk volume, increase rapidly. All four breast milk biomarkers were normal on postpartum day 4. The subject averaged 8 pump sessions per day.

the sucking stimulus,³¹ peaking 45 minutes after the start of a breastfeed.³³ In a study aiming to better understand how milk yield and maternal hormone release are affected by manual and electric pumps compared with natural infant sucking, Zinaman et al. reported that the greatest prolactin response was found with electric pulsatile pumps; these responses compared favourably with those of natural infant sucking.¹⁰ The basal and suckling-stimulated concentrations of prolactin are significantly higher in the first month and slowly decline until six months post-birth;³³ further supporting the concept of the critical window in the early days and weeks after birth.

Frequent and effective breast stimulation in the critical window proliferates and maintains lactocytes, shortening the time to secretory activation⁶ and promoting adequate milk volumes for the future.⁵

It is known that secretory activation is not wholly reliant upon breast stimulation, as demonstrated in women who never stimulate the breast from birth; secretory activation will still occur. However, the process can be influenced: Research has shown that the mammary gland is extremely sensitive to the effects of prolactin in the early post-birth period.^{31,34} In the study by Parker et al. of mothers of preterm infants, frequent stimulation of the breast in the first few days resulted in milk 'coming in' earlier.⁶ This further supports that frequent, effective breast stimulation in the first few days and weeks results in the maintenance and proliferation of lactocytes, bringing milk in and ensuring optimum future milk volumes for the infant.

The consequences of ineffective breast stimulation

Insufficient stimulation results in a cascade of negative effects, such as delayed secretory activation^{2,3} and mothers who may not 'come to volume', potentially impairing long-term milk production.⁹

In a study of biomarkers in breast milk, Hoban et al. showed, that the tight junctions between the lactocytes could open up again if there was not

enough adequate breast stimulation, resulting in 'leaky cells', counterproductive to copious milk production.⁹ This suggests that frequent and effective breast stimulation, especially in the first two weeks, preserves the high levels of prolactin responsible for building and maintaining the milk-making cells. If breast stimulation is ineffective or infrequent, the lack of prolactin surges allows for non-proliferation and cell death of existing lactocytes.

If infant feeding is insufficient to stimulate the breasts in the critical window after birth, proactive, skilled lactation support and intervention are crucial.

Proactive, skilled lactation support and intervention, where infant feeding is insufficient to stimulate the breast in those early days and weeks after birth, are crucial for mothers to achieve their long-term milk production goals.

Lactation can be complicated by coexisting maternal pre-pregnancy, pregnancy, or birth risk factors that have been associated with lactation problems in otherwise healthy populations, such as high pre-pregnancy body mass index and caesarean delivery.³⁵⁻³⁸ Infants of these mothers are particularly at risk of being unable to effectively stimulate the breast and distinct attention should be paid to this population. When an infant is unable to effectively stimulate the breast in the first few days after birth, activation of the milk-making cells is jeopardised,⁹ potentially delaying milk 'coming in' and impairing long-term milk production.²

Optimum breast stimulation in the critical window is essential for long-term breastfeeding goals to be achieved.

Ineffective stimulation is known to have a negative impact on the time it takes for milk to 'come in'.^{4,6} The less frequent and effective the breast stimulation, the longer it will take for milk to 'come in' and future milk volumes will be impacted.^{8,5} Considering the WHO targets of exclusive breastfeeding for six months and continued breastfeeding up to two years and beyond,¹ adequate, early breast stimulation in this critical window after birth, should be a priority for these targets to be achieved.

Provision of immediate lactation support is critical when ineffective feeding is identified.

It is therefore time-critical for healthcare professionals to assess for and identify cases of ineffective or infrequent breastfeeds, so that appropriate and early support and intervention can be provided.

Options to address ineffective feeds

When breastfeeding remains ineffective, even after skilled breastfeeding support has been provided, electric pumping or hand expression techniques are currently used to replace the absent or ineffective feeds and remove colostrum for the infant.

Electric pumps



Electric pumps use vacuum²⁸ to effectively trigger the prolactin response¹⁰, activating the milk-making cells^{11,42,43} and removing colostrum.

Hand expression



Hand expression uses tactile compression to facilitate milk ejection and colostrum collection.

	Vacuum	Tactile compression	Colostrum collection	Effective activation of milk-making cells	Reduced risk of delayed secretory activation
	✓	✓	✓	✓	✓
	✓	✗	✓*	✓	✓
	✗	✓	✓	✗	✗

*Tiny volumes of colostrum are sometimes difficult to recover, which can lead to wastage

Whilst hand expression is an important tool, it lacks the vacuum required to effectively stimulate the prolactin response.¹⁰

Hand expression is an important skill that mothers should be taught to support their lactation journey. It can be useful to soften the breast to assist latching, alleviate engorgement, manage blocked ducts and relieve the symptoms of mastitis.³⁹ Besides postnatal usage, hand expression during the antenatal period is considered safe after 36 weeks gestation for mothers without complications and may be recommended for mothers with diabetes to gather colostrum for use in the early days, with the aim to prevent neonatal hypoglycaemia and reduce the need for infant formula use.⁴⁰

Antenatal hand expression has also been reported to improve mothers' confidence in breastfeeding before birth.⁴¹

In the context of replacing infrequent or ineffective infant feeds in the critical window after birth, hand expression alone is insufficient.

Hand expression alone does not provide vacuum or mimic the suckling stimulation of the infant to effectively trigger the maternal prolactin response.¹⁰ It is known that insufficient stimulation can cause the tight junctions around the lactocytes to 'open up' once again, which is counterproductive to copious milk production.⁹

Best practice is to support mothers to initiate and maintain breastfeeding and manage common difficulties so that they can provide their infant with the benefits of an exclusive human milk diet.¹ If the infant is unable to effectively stimulate the breast, supporting the mother to manage this appropriately by mimicking the healthy, term infant as closely as possible is crucial.

Evidence

Vacuum provided by an electric pump has been shown to effectively trigger the prolactin response¹⁰ required to fully activate the milk-making cells.^{11,42,43}

Electric pumping is associated with a significant advantage in milk production. Women who were unable to breastfeed and exclusively used hand expression for the first 7 days who then switched to electric expression, did not catch up with the volumes of those who initiated with an electric pump.¹¹

A randomised controlled trial of 26 mothers of preterm, very low birth weight infants who were unable to breastfeed, showed that double electric pumping yielded a higher volume of milk up to day 7 of life, with a difference in milk output seen from as early as day one. Electric pumping was also associated with a significant advantage in milk production of an average of 119 mL per day, during the first 28 days postpartum compared with hand expression alone, controlling for covariates.

In addition to this, the women who initiated lactation by exclusively using hand expression for the first 7 days, who then switched to electric expression, were never seen to catch up with the mothers who initiated with an electric pump.¹¹

Exclusive hand versus exclusive electric expression¹¹

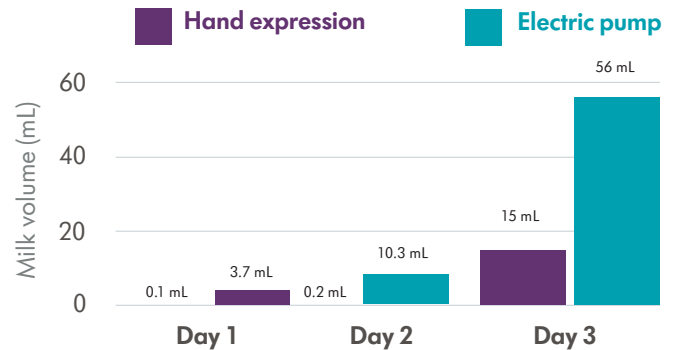


Figure 5 - Daily milk volumes (mL/day) for mothers of preterm, very low birth weight infants in the exclusively electric pumping group and the exclusively hand expressing groups.

Similar results were seen in a randomised controlled trial conducted by Slusher et al. of 65 mothers across two African special care nurseries, who were unable to breastfeed their premature or sick infants. Mothers were randomly assigned to one of three groups: Hand expression, pedal pump or electric pump and were taught to completely empty their breasts using their assigned method of expression every 2-3 hours. Milk volumes were measured and recorded at the end of each session by a nursery nurse for a duration of 6-10 days. Results showed that mothers using the electric pump achieved significantly greater mean daily milk volumes than those using hand expression.⁴³

Not only do electric pumps provide the required vacuum to effectively activate the milk-making cells,^{11,42,43} simultaneous expression compared with pumping each breast in turn, has been shown to reduce the time spent expressing⁴⁴ and to yield higher maternal milk volumes.¹³ In addition to the benefits of double electric pumping, Medela's Initiation Technology is a novel pump suction pattern that when used by pump-dependent mothers for the first days of the infant's life, is more effective at achieving secretory activation and earlier adequate milk supply than a standard suction pattern.^{28,46} Breast pumps with Initiation Technology have been shown to increase volumes of milk by 200 mL per day from day 6 of life onwards.²⁸

In comparison, hand expression alone has been shown to yield significantly less daily milk volumes than exclusive electric pumping from birth to day 7 of life.¹¹ It is often believed that hand expression should be used rather than pumping in the first 48 hours after birth. However, there is no recommendation on exclusive hand expression in the first days after birth. In fact, UNICEF states in their implementation guidance, that any method of expression may be taught, depending on the mother's context.¹

Hand expression has been promoted due to a few studies that appear to show an increased milk yield with hand expression compared to pumping. However, there are key limitations to these studies.

Ohyama et al. conducted a sequential cross-over study with 11 mothers expressing within 6 hours of birth, subsequently alternating between hand expression and electric pumping every 3 hours for the first 48 hours after birth. The study reports that hand expression produced twice as much milk as pumping.⁴⁷ However, in addition to the small sample size, the major limitation of this study is that hand expression was performed directly by experienced midwives. As this is not always the case in practice, the question arises as to whether the results could be replicated when mothers perform hand expression themselves; an approach that is generally more widely advocated. It is also worth noting that significantly more pain was reported in the hand expression group and at the end of the study, all mothers chose to continue using the pump.

A study by Flaherman et al. aimed to compare the effect of pumping versus hand expression on breastfeeding outcomes for term newborn infants feeding ineffectively at 12-36 hours of birth. Mothers were randomised to an expression group and instructed to express for 15 minutes. It was self-reported that mothers in the hand expression group were more likely to be breastfeeding at 2 months.⁴⁸ The researchers attributed this finding to two factors: Increased comfort was described when hand expressing and breastfeeding in front of others compared to using a pump and it was concluded that increased confidence meant mothers were more likely to breastfeed for longer.

Secondly, the median volumes of milk expressed in both groups were minimal; researchers claimed that the hand expression group may perceive the small amount of colostrum expressed as 'normal' whereas the pumping group may see this as 'insufficient' when using the large collecting system. However, there was no reported difference in milk output between the two expression methods and although more mothers in the hand expression group were found to be breastfeeding at 2 months, none of them were using hand expression at that time, they were all using a breast pump when expressing their milk.

The randomised controlled trials provide unclouded data showing less milk comparing hand expression only, to pumping only.

It is significant to note that in both trials by Ohyama and Flaherman, mothers received vacuum stimulation in addition to hand expression, either by the infant or by breast pump; neither of the studies looked at the effect of hand expression alone in the absence of vacuum. In contrast to this, the clean design of the randomised controlled trials conducted by Lussier et al. and Slusher et al. provides clear data that compares hand expression only, to pumping only, highlighting the detrimental impact that the absence of effective vacuum can have on a mother's milk production when building a supply.^{10,11,26,43}

Solution

An effective infant breastfeed provides the optimal suckling vacuum¹⁶ to stimulate the breast and remove colostrum. Skilled breastfeeding assessment will be required to evaluate the effectiveness of infant feeding. Each mother-infant dyad should be examined on an individual basis, using clinical judgement in order to ensure that the mother establishes an appropriate milk supply during the critical window, where the mammary gland is sensitive to the effects of prolactin. During this critical window, one needs to be mindful of issues that can arise from over- or under-stimulation.

Overstimulating the breast in the critical window is arguably as problematic as under-stimulation,

albeit for differing reasons. An oversupply can be difficult to downregulate and may lead to engorgement or mastitis.⁴⁹ On the other hand, when there is insufficient breast stimulation, research has shown that the mother may be at risk of delayed secretory activation^{2,3} and inadequate future milk volumes,⁹ which puts the mother at risk of a shortened duration of breastfeeding or cessation altogether.^{38,50} When stimulation from the infant is ineffective, appropriate intervention should be used to effectively activate the milk-making cells,^{10,42} ensuring timely secretory activation and optimum milk volumes for long-term production.¹¹

When an infant feed is ineffective, a combination of hand expression and double electric pumping:



Increases daily milk volumes both in the short and long term^{11,12,43}

Shortens time to milk 'coming in'^{12,3}

Infants primarily use vacuum to remove milk,¹⁶ this natural sucking behaviour inspires the specific vacuum patterns of a breast pump.²⁸ In contrast, hand expression lacks vacuum and uses only compression to remove milk.

Whilst the infant tongue applies a compressive action to the nipple, it has been shown that the vacuum created by the infant is the fundamental component in milk removal.^{16,51} In hand expression, only the compression is associated with milk removal. It is known that the vacuum provided by electric pumps is effective at triggering the prolactin response¹⁰ and effectively activating the milk-making cells.^{11,42,43} This highlights the limitation of using hand expression only during the critical period after birth, where breast programming is possible and insufficient stimulation can have a detrimental impact on long-term milk production.^{10,11,26,43}

Combining breast massage and hand expression with the vacuum of a double electric pump is associated with significantly higher mean daily milk volumes.^{12,13}

In addition to the evidence around double electric pumping providing better outcomes for milk production,^{13,44} studies have also found that combining breast massage and hand expression with the vacuum of a double electric pump is associated with significantly higher mean daily milk volumes after milk 'comes in'.^{12,13} Morton et al. found that frequent double electric pumping combined with hand expression in the early days after birth, produced significantly higher mean daily volumes of expressed breast milk when taught in conjunction with hands-on pumping techniques.¹²

Benefits of combined expression methods

	Vacuum	Tactile compression	Colostrum collection	Effective activation of milk-making cells	Reduced risk of delayed secretory activation
	✓	✓	✓	✓	✓

When an infant feed is ineffective, a combination of hand expression and double electric pumping:

- ✓ Provides a solution to collect colostrum
- ✓ Provides the vacuum required to activate the milk-making cells^{9,10,11,42,43}
- ✓ Ensures optimum milk supply in the future^{11,42}

Acknowledging the appropriate usage of hand expression and electric pumping is imperative for a successful lactation journey.

Practices surrounding effective initiation of milk production should be grounded in evidence in order to establish an optimum milk supply, facilitate long-term breastfeeding and improve health outcomes for mothers and infants.¹ Recognising the differences in outcomes and the appropriate usage of hand expression and electric pumping is imperative to enable mothers to have a successful lactation journey. Current available evidence suggests that when assessing the mother-infant dyad and identifying infants who are unable to effectively stimulate the breast, appropriate intervention is needed.

When breastfeeding remains ineffective, even after skilled breastfeeding support has been provided, double electric pumping is superior to hand expression alone in activating milk-making cells and building and maintaining an adequate milk production.^{11,43}

Consequently, hand expression should not be routinely used in practice as a stand-alone solution to ineffective or infrequent breastfeeds during the early critical window of opportunity to activate milk production.

Instead, whilst performing a breastfeeding assessment, the need and extent of any intervention should be carefully examined, with the mother-infant's particular context in mind and all elements of effective breastfeeding measured. If it is considered that the mother or infant would benefit from some expression of colostrum, hand expression can be combined with the use of a double electric breast pump in order to deliver the essential drops of colostrum to the baby, whilst also ensuring to effectively activate the milk-making cells, bring milk in on time and safeguard adequate long-term milk production.^{4-6,11-13,42,43}

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