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of hospitals
& mothers*

2-Phase and Double Pumping: **Increase and maintain milk supply**

“There is a need to provide appropriate scientific evaluation of the effectiveness of the current pumping patterns.” Prof. Peter Hartmann

Human milk – the gold standard



Few interventions rival breastfeeding in promoting the health of a mother and her infant. A wealth of scientific evidence demonstrates why, and systematic reviews of the literature have consistently demonstrated that the provision of breastmilk can permanently modify an individual's biological, neural and social growth and development.¹ The Lancet² demonstrates this with a profound statement: "If a new vaccine became available that could prevent one million or more child deaths a year and that was moreover cheap, safe, administered orally and required no cold chain, it would become an immediate public health imperative." Breastmilk can do all this and more. From this it should be concluded that breastmilk feeding should be seen as standard, normal nutrition for all newborn infants.

Human milk is species-specific and has been adapted throughout evolution to meet the nutritional requirements of the human infant, supporting growth, development and survival.³ Breastmilk facilitates safe adaptation to extra-uterine life by providing more than just nutrition. The unique, ever-changing constituents of human milk also have developmental and immunological benefits. Breastmilk is an extremely complex biological fluid: it is infused with antibodies to provide protection against infection, something which formula milk cannot do. In addition, breastmilk provides growth-regulatory effects in the form of hormones, growth modulators and growth factors that are not present in artificial substitutes. Certain key components in breastmilk have a unique function, such as oligosaccharides: these complex compounds act as decoys for various microbes, preventing the attachment of bacteria to the gut wall. Lactoferrin binds iron and therefore enhances iron absorption and there are even living cells.

Recent research has shown that human milk is a unique source of multipotent stem cells.⁴ These living cells have immense differentiation potential, underlining their importance in neonatal development and offering a promising target for stem cell therapy and breast cancer research. This discovery has highlighted the value of human milk for newborn and older infants even more.

The benefits of breastfeeding go beyond the nutritional, developmental and immunological aspects. Bonding and nurturing benefit both mother and baby. However, there are many instances where an infant is unable to breastfeed directly but can still derive the benefits of breastmilk. The World Health Organisation (WHO) states: "The vast majority of mothers can and should breastfeed, just as the vast majority of infants can and should be breastfed. For those few health situations where infants cannot, or should not, be breastfed, the choice of the best alternative – expressed breastmilk from an infant's own mother, or if not available, breastmilk from a human-milk bank."⁵ In whatever way the baby receives breastmilk, it should be considered the norm, and suitable education, knowledge and a warm chain of support all help to make its provision the gold standard for all infants.

Providing the life giving benefits of breastmilk



Illustration of a Lactocyte

Exclusive breastfeeding is recommended for the first 6 months of life by the World Health Organisation⁵ and the benefits of breastfeeding are well highlighted. There are many reasons a mother may not be able to directly breastfeed (table 1). But this does not mean she cannot provide her baby with the life giving benefits of breastmilk.

Reasons for needing a breastpump	Advantages of using a breastpump
Premature or sick infant is unable to nurse properly	In order to provide breastmilk for a premature baby that is too weak to breastfeed a mother can use a pump to express milk for feedings. A pump will also provide breast stimulation to initiate and maintain a sufficient supply of milk.
Babies with special needs ie. cleft lip/palate, downs syndrome	In certain circumstances, breastfeeding may be difficult, using a breastpump can ensure that the breast is well drained and can complement breastfeeding.
Maintain or increase milk supply	Using a breastpump will support the mother to maintain her milk supply or in the event of low milk supply, the extra stimulation will help to increase the milk output.
Induce lactation for an adopted baby	A breast pump can be used to stimulate a mother's breast to induce milk production to breastfeed an adopted baby. Breastfeeding is a great way for a mother and her adopted child to bond.
Need to return to work	For many new mothers, returning to work shortly after giving birth is a reality, but by pumping and storing milk while at work a mother can continue to provide her baby with breastmilk as long as she would like.
Relieve breast engorgement	When a mother's breasts are overly full and engorged with breastmilk, she can use a breast pump to express enough milk to provide relief from discomfort and to assist the baby to latch on.
Support mothers with Mastitis	When a mother is faced with the problem of mastitis, using a breastpump alongside continued breastfeeding will help with the healing process.
Avoid supplementing with infant formula	Occasionally it may be recommended that a baby needs to have some supplemental feedings. By expressing in addition to breastfeeding a mother can continue to feed her child only breastmilk.
Draw out flat or inverted nipples	Mothers with flat or inverted nipples may have trouble when trying to get the baby to latch on properly. By pumping for a few minutes before breastfeeding, a mother can draw out her nipple so that the baby can nurse more easily.
Provide milk for children of a multiple birth	Breastfeeding twins or multiples, can be very challenging, but with regular stimulation, it is certainly possible. Using a breastpump can help maintain and stimulate milk supply.
Donate extra milk to a milk bank	While some mothers may have difficulties producing a sufficient amount of milk for their babies, other mothers seem to produce an abundance of milk and choose to donate this surplus to infants that may not have access to breastmilk. A breastpump is an important piece of equipment in this situation.
Supplement first foods with breastmilk while weaning baby from the breast	When the baby is ready to wean, a mother can continue to supplement her infant's diet with breastmilk if she expresses and stores her milk.

One of Medela's main goals is to support mothers, and encourage them to breastfeed as long as possible. For this reason Medela has worked closely with research professionals from around the world for over 30 years with exclusive cooperation with the Hartmann Human Lactation Research Group from The University of Western Australia.

Years of extensive research led to the development of a complete range of breastpumps with 2-Phase Expression Technology. In addition Medela has combined this technology with Double Pumping which has been proven to have major advantages for mothers' milk production and in this way Medela can provide the ultimate alternative of 2-Phase double pumping, when breastfeeding is not possible.

2-Phase Expression Technology



The healthy term infant will naturally regulate their physiological sucking behavior to make it as efficient and effective as possible. It is Medela's aim to mimic this behavior to enable mothers to maintain that pattern of sucking whilst pumping with efficiency and comfort.

Classic research in the physiology of lactation demonstrates that the healthy human infant adapts the sucking rate, rhythm and pressure to the milk flow rate.^{6,7,8} Specifically, during nonnutritive sucking (NNS) or when milk flows slowly – before milk ejection, the infant sucks rapidly to stimulate the milk-ejection reflex (approx. 2 sucks per second). Once the milk flow rate increases, the sucking rate slows considerably (approx. 1 suck per second). The sucking performance is now called nutritive (nutritive sucking, NS).^{8,9} Thus, during established lactation, a breastfeeding infant sucks rapidly before milk ejection and more slowly afterwards (Fig. 1)⁹ due to the extra time required for swallowing and breathing once milk begins to flow regularly.⁶

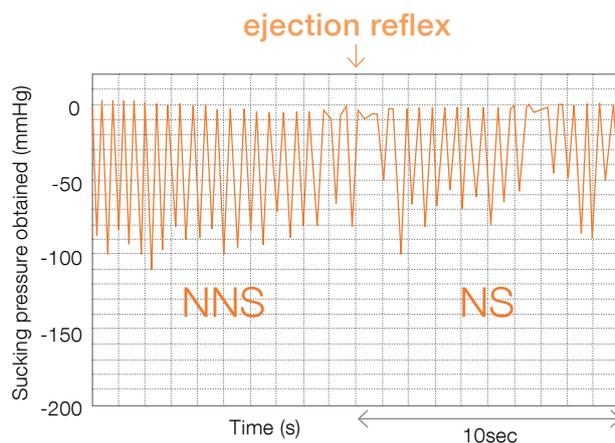


Figure 1 – Sucking trace during a breastfeeding session.

This physiologic biphasic pattern led to the 2-Phase Expression Technology in Medela breastpumps:

- I Stimulation phase (phase 1): Fast and efficient to start milk flow.⁸
- I Expression phase (phase 2): Slower to mimic nutritive sucking with regular milk flow.¹¹

The study performed by Kent and coworkers¹⁰ determined the importance of vacuum for breastmilk expression. The authors proved that the use of mother's maximum comfortable vacuum (mcv) enhances milk flow rate and milk yield. The mcv chosen by mothers was variable (range from -98 mm Hg to -200 mm Hg). Therefore health professionals should advise mothers not to expect to use maximum vacuum but to select the vacuum that is most comfortable for her.^{10,11}

Further important results of this study were:

- I When pumping with a 2-Phase breastpump at maximum comfortable vacuum (mcv) 80% of the expressed milk was removed within the first 7 minutes, which is much less time than when pumping at lower vacuums. This is a consequence of high milk flow rates resulting in a high volume of milk being expressed (76% of the total milk expressed) during the first two milk ejections after the pump was changed from stimulation to expression mode.
- I 65.5% of the total available milk was removed in the 15minute expression period using mother's mcv. This is directly comparable to the amount of available milk removed by the breastfeeding infant (67.3%).

An earlier study from Mitoulas in 2002¹¹ demonstrated that the mean volume and fat content of a breastfeed were similar to the volume and fat content of milk expressed using a 2-Phase breastpump. It was also shown that the Symphony, hospital grade double pump was able to remove 99.4% of the available milk in 5 minutes – which demonstrates the efficiency of 2-Phase expression.

The benefits for mothers using a breastpump with Medela 2-Phase Expression Technology compared to other expressing patterns are:

- I Shorter and more effective pumping sessions.¹⁰
- I Quicker time to milk ejection and more milk expressed.^{8,11}
- I Broad vacuum range allows individual regulation of vacuum levels for optimal comfort and maximum efficiency.¹⁰
- I Help initiate and maintain lactation by imitating the sucking behaviour observed in healthy-term infants.⁸



Double Pumping – increase milk supply



The benefits of Double Pumping (simultaneous breast expression), are well known, but continuous scientific research has confirmed this and has also uncovered other benefits for pumping mothers.

Increased Number of Milk Ejections (MEs)

The neurohormonal milk ejection reflex is crucial for milk removal and maintenance of lactation. Milk ejections (ME) are described as short discrete uncoordinated increases in intraductal pressure (measured by ductal cannulation)¹², and milk duct diameter (measured by ultrasound)¹³ with a range of 1–17 observed during breastfeeds. Moreover, MEs can be identified as transient peaks in milk flow rate (MFR) measured using a weigh balance. According to Prime et al¹² larger expression volumes and a larger percentage of available milk removed were associated with a shorter time until the onset of milk flow and a higher number of MEs. Concurrently, a shorter time until onset of milk flow correlates with both stronger stimulation and expression vacuums as well as with a larger total expression volume.

In this recent study four ME patterns were identified, differentiated by both, number and shape of MEs during simultaneous breast expression. MEs with a clearly defined beginning and end were defined as discrete, whereas MEs without clear definition were defined as non-discrete. Pattern 1 was discrete few (less than 5 MEs), pattern 2 was discrete many (5 or more MEs), pattern 3 was non-discrete (five or more MEs) and pattern 4 was pulsatile (multiple clearly defined MEs occurring with rhythmic repetition).

Milk Ejection and Higher Milk Volume

In 2009 Prime et al¹⁵ performed a study to investigate ME in both breasts during simultaneous breast expression. This was the first time that both breasts could be measured together and the results confirmed that ME occurs simultaneously in the left and right breast during double pumping.

Further investigation in 2011¹⁶ studied breastfeeding mothers who regularly used a breastpump. They expressed their milk with an electric breastpump for 15 minutes on two different occasions, using either simultaneous (SIM) or sequential (SEQ) expression. Simultaneous expression yielded more MEs (4.4±1.7 vs. 3.4±1.4; Table 1), greater milk volumes at all measuring time points (2, 5, 10 and 15 minutes; Fig.2) and removed a greater percentage of available milk (74.8 ± 23.6% vs. 65.7±26.2%; Table 1).

Another finding from this study was that SIM expression also yielded milk with higher energy content. This confirms what had already been discussed by Jones et al in 2001¹⁷.

	SIM	SEQ	P
No ME	4.4 ± 1.7	3.4 ± 1.4	<0.001
Total Volume (mL)	82.3 ± 50.6	69.5 ± 53.2	<0.001
PAM (%)	74.8 ± 23.6	65.7 ± 26.2	<0.022

Table 1 – Expression type and milk output characteristics

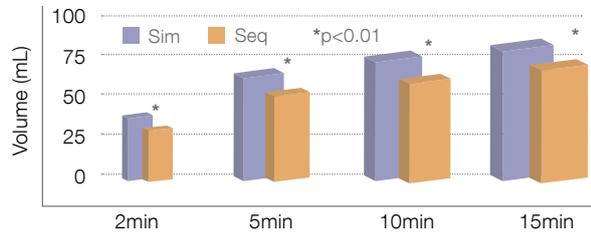


Figure 2 – Volume at 2, 5, 10 and 15 minutes.

The dynamics of milk removal were studied during simultaneous breast expression using a continuous weigh balance (Showmilk, Medela AG) to determine the changes in milk flow rate, which detected multiple milk ejections coinciding with increases in milk flow rate. A larger total expression volume was also associated with a higher maximum milk flow rate. Milk flow was more active in the first 7 minutes than the last 7 minutes and at the eighth minute (midpoint), $54 \pm 25\%$ of the available milk and $86 \pm 9\%$ of the total expression volume were removed (Fig.3)¹⁸ These findings were similar to those from Kent et al¹⁰

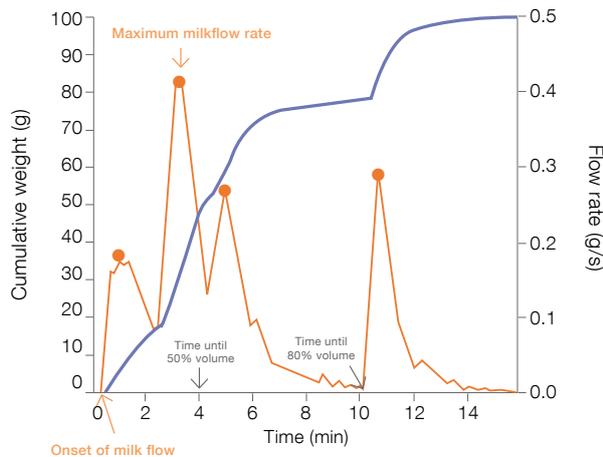


Figure 3 – Typical Showmilk data output indicating cumulative milk weight (g) on the left y-axis and milk flow rate (g/second) on the right y-axis. Milk ejections are indicated (●), and measured variables are labeled.

Higher Levels of Prolactin

Prolactin is the hormone responsible for milk production and Zinaman and coworkers¹⁹ in the early 1990's studied the prolactin responses to infant sucking, hand expression and different types of breast pumps. Each method resulted in a different prolactin response. When both breasts were pumped simultaneously with the electric pump, higher prolactin levels were produced. Only prolactin responses to electric pumps compared favorably with the breastfeeding infant.

Increased Milk Output

Auerbach²⁰ performed a study, also in the early 1990's, comparing sequential and simultaneous breast pumping using four different pumping regimes (5-minute sequential, 5-minute simultaneous, unlimited sequential and unlimited simultaneous) in mothers of full term babies. The greatest amount of milk was collected when simultaneous pumping was allowed to continue until milk was no longer entering the collection chamber. Another important outcome was that women's emotional reactions to pumping regimens may influence the milk volume obtained. By a margin of 3:1, mothers preferred the double pump system, even those that achieved more milk with sequential pumping. Auerbach's findings were confirmed by Jones et al¹⁷, who performed a randomized controlled trial to compare methods of milk expression in mothers of preterm infants. The results were unequivocal and show that simultaneous pumping is more effective, faster and that the energy concentration in milk was considerably higher (Creatocrit analysis). This is particularly important for mothers of preterm infants.

Another pilot study performed by Hill et al²¹ demonstrated that milk yield may be maintained or increased with frequent simultaneous pumping. The simultaneous pumping regime was favoured by mothers as it took less time.

The benefits from Double Pumping ie. simultaneous breast expression compared to single or sequential pumping can be summarized as:

- | Up to 18% more milk compared to single pumping in a pumping session when sequentially pumping on both breasts¹⁶.
- | 80% of the milk volume can be removed in the first 6 minutes¹⁶.
- | Provides milk with higher energy content^{16,17}, which is especially important for preterm babies.
- | High energy content indicates increased breast drainage, thereby assisting in the maintenance of lactation.
- | Increased levels of prolactin – leading to increased milk output¹⁹.
- | Twice as fast as single pumping to get the same amount of breastmilk^{15,19,20}.



Implementing results into best practice



With over 50 years experience in breastfeeding support, Medela is able to offer you, the professional, the opportunity to use innovative and evidence based research to support the mothers and babies in your care. For whatever reason, mothers may need to use a breastpump and with Medela, all can benefit from the most up to date, research based technologies which will help them overcome challenges until they can breastfeed directly.

Our wide product range enables mothers to experience up to date 2-Phase Expression Technology combined with Double Pumping in hospital and at home. Symphony, our leading professional breastpump is ideal for frequent or pump dependent mothers. The personal use pumps Freestyle and Swing Maxi provide the same benefits for mothers at home or on the go.

The combination of the 2-Phase Expression Technology and Double Pumping allows mothers to profit from following benefits:

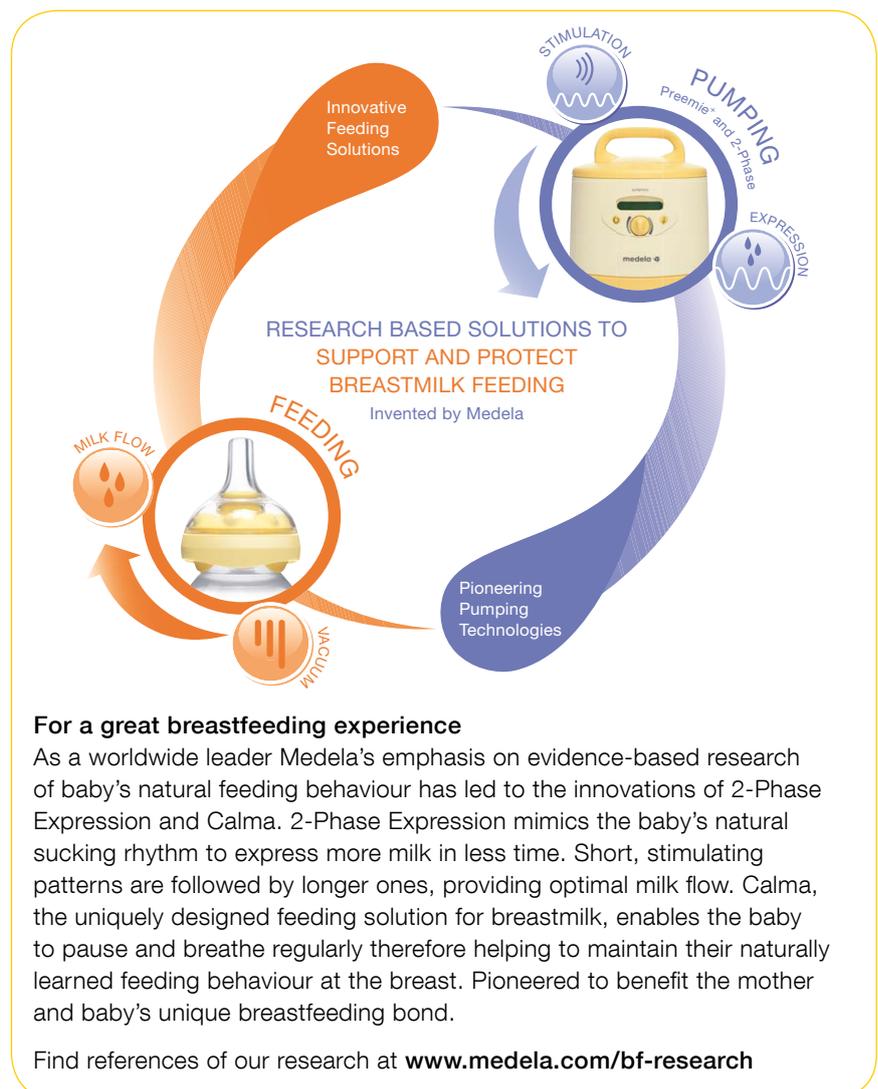
- I Time saving – more milk in less time
- I Maintenance of milk supply when not able to directly breastfeed
- I Milk with higher energy content – especially beneficial for preterm infants
- I Comfort and efficiency



Feeding expressed breastmilk



Following the success of 2-Phase Expression Technology, which is proven to provide more milk in less time and with comfort and efficiency, Medela embarked on a new challenge, to develop a breastmilk feeding solution that was compatible with breastfeeding. Working with researchers both from the Hartmann Human Lactation Research Group from The University of Australia²², and Professor Katsumi Mizuno from Showa University, Tokyo²³, the revolutionary breastmilk feeding solution Calma was produced. A baby in an established breastfeeding situation creates an individual sucking rhythm, thereby efficiently removing just the right amount of milk at a pace which suits the baby best. This rhythm enables maintenance of a good heart rate and oxygen saturation levels due to the ability to suck, swallow and breathe whilst feeding. When feeding from Calma, the evidence shows that this individual rhythm is also established and babies were able to continue with their individual sucking pattern. Milk removal and length of feed were also maintained. The ability to maintain a regular suck-swallow-breathe pattern continued, thus ensuring stability and relaxed calm feeding even when not at the breast and can support a return to the breast when mother and baby are together.



For a great breastfeeding experience

As a worldwide leader Medela's emphasis on evidence-based research of baby's natural feeding behaviour has led to the innovations of 2-Phase Expression and Calma. 2-Phase Expression mimics the baby's natural sucking rhythm to express more milk in less time. Short, stimulating patterns are followed by longer ones, providing optimal milk flow. Calma, the uniquely designed feeding solution for breastmilk, enables the baby to pause and breathe regularly therefore helping to maintain their naturally learned feeding behaviour at the breast. Pioneered to benefit the mother and baby's unique breastfeeding bond.

Find references of our research at www.medela.com/bf-research

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