

Infant's Sigh Breathing Matters—The Role of the Hering-Breuer Deflation Reflex in Bronchial Decongestion

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How to cite this paper: Truflandier, K., Albert, K., Moraine, J.-J. (2024) Infant's Sigh Breathing Matters—The Role of the Hering-Breuer Deflation Reflex in Bronchial Decongestion. *Open Journal of Therapy and Rehabilitation*, 12, 197-212.
<https://doi.org/10.4236/ojtr.2024.123015>

Received: May 14, 2024

Accepted: June 18, 2024

Published: June 21, 2024

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Abstract

Background: The prolonged slow expiratory (PSE) technique can induce sigh breaths related to the Hering-Breuer reflex in children. PSE is a specific chest physiotherapy technique often used in children to help with the clearance of secretions, reduce pulmonary obstruction and decrease ventilatory effort.

Purpose: The main objective of this review was to synthesize and clarify the existing knowledge of the physiological mechanism behind the Hering-Breuer reflex and its utility in the PSE technique. The secondary objective was to provide an overview of PSE which is probably the main mechanical feature for mucus clearance in infants and to identify gaps and any further research required. **Method:** A comprehensive literature search was performed using PubMed/MEDLINE and Ovid EMBASE, from 1968 to January 2024, using search terms relating to “Interaction of Hering-Breuer reflex and chest physiotherapy therapy, sigh breath in infants and prolonged slow expiration technique” to create an overview of the advances and gaps in current knowledge of PSE. **Result:** The data obtained following treatment with PSE maneuvers in infants with histories of recurrent wheezing shows that the presence of sighs could be the main active principle of treatment. **Conclusion:** Changes in volume induced by PSE technique and, effects from crying may stimulate the Hering-Breuer deflation reflex and sighs in turn improving alveolar ventilation as well as lung volume in infants.

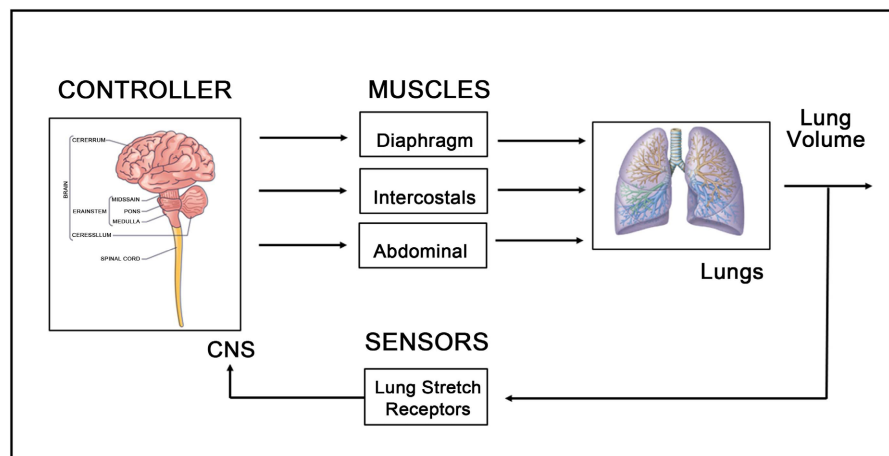
Keywords

Hering-Breuer (HB) Reflex, Sigh Breath, Infants, Prolonged Slow Expiration Technique, Large Volume, Chest Physiotherapy

1. Introduction

Bronchiolitis, most often caused by respiratory syncytial virus (RSV), is a common self-limiting illness in early childhood. It represents the most prevalent lower respiratory tract infection during the first years of life, generally presenting with mild to moderate severity. In 2019, RSV was responsible for an estimated 3.6% of all global deaths among children aged 28 days to 6 months, with 97% of these fatalities occurring in low and middle-income countries [1]. Chest physiotherapy techniques used in children with bronchial congestion showed increases in expiratory volume which can also trigger deep inspiration [2]. This phenomenon is related to the Hering-Breuer reflex which aids in lung volume restoration through sigh breathing, thus maintaining functional residual capacity and ensuring alveolar re-inflation [3] [4].

The Hering-Breuer reflex, first described by Joseph Breuer and Ewald Hering in 1868, includes the inspiratory-inhibitory and exciting-inspiratory reflexes [5] known respectively as the inflation and deflation reflexes. This reflex is crucial in the nervous regulation (“**Figure 1**”) of respiratory movements, preventing lung over-expansion [6] [7] [8].



The inspiratory muscles are the diaphragm and the intercostals. Abdominal muscles are active in forced expiratory phase only. During the eupneic breathing, the expiration becomes passive by the elastic recoil of ribcage and abdomen. CNS: Central nervous system.

Figure 1. Schema showing the presumed neurological pathways involved in Hering-Breuer Reflex.

Sigh breaths are spontaneous inspiratory efforts that are deeper than normal breaths and are responses to both emotional and physiological stimuli such as hypoxia and hypercapnia [9]. These sighs improve alveolar ventilation and lung volume, especially in infants whose respiratory systems are still maturing [10] [11].

The Prolonged Slow Expiration (PSE) technique, developed for infants, aims to increase expiratory volume and induce sigh breaths. This technique has been utilized since 2001 to address bronchial secretions in children, aiming to en-

hance respiratory secretion clearance, improve oxygen saturation and, reduce lung hyperinflation [10]. However, the exact mechanisms by which PSE influences respiratory outcomes and their interactions with the Hering-Breuer reflex are not fully understood.

This study aims to review advancements in the understanding of PSE and its potential to induce sigh breaths related to the Hering-Breuer Reflex in children. It seeks to clarify the physiological mechanisms behind this interaction and identify gaps in the current knowledge that may warrant further research. Understanding these mechanisms is crucial for improving clinical practice in pediatric respiratory care.

2. Method

2.1. Special Series Articles Category

This study includes a literature review that was not performed systematically. The study was set up to create an overview of the advances and gaps in current knowledge of (PSE) therapy in infants (which induces sighs and consequently interacts by stimulating the HB reflex). There are few studies on the value of the role of the Hering-Breuer deflation reflex induced by prolonged slow expiration or crying in pediatric patients with lung disease. In addition, they differ in population and measurements. Thus, a comparative analysis (and/or statistical analysis) of the results is not possible. As such, it can serve as an impetus this gap highlights the need for further research on the subject. Due to the scope of this study and the new field of research, this study falls into a special series articles type.

2.2. Data Sources

The databases PubMed/MEDLINE and Ovid EMBASE were used to retrieve peer-reviewed journal articles and book chapters while non-listed citations, such as Springe Link, were obtained from standard internet searches. The information gathered spans from 1968 to January 2024 and was retrieved using search terms related to “Interaction of Hering-Breuer reflex and chest physiotherapy therapy, Sigh breath in infants and prolonged slow expiration technique”.

2.3. Study Selection and Eligibility Criteria for Articles

The outcome of the search was everything relevant about the Hering-Breuer reflex and its triggering factors, including any chest physiotherapy involved in bronchial secretions clearance and, the potential benefit of stimulating HB reflex during respiratory physiotherapy treatment to improve airway clearance in children. The study also included the monitoring and inhibition of the Hering-Breuer reflex and its role in human respiratory studies.

The following inclusion criteria were applied: human study, Hering-Breuer reflex, sigh breath, infants, prolonged slow expiration technique, large volume and, chest physiotherapy. The following exclusion criteria were used: chest phy-

siotherapy such as percussion, vibration and acceleration of expiratory volume.

3. Incidence and Complication of Lung Congestion

In Europe, every year, approximately a quarter of the child population requires emergency hospital care for an acute lung infection. The Respiratory Syncytial Virus (RSV) is present throughout the world and is the most common pathogen and leading cause of frequent respiratory failure in infants and young children. In the United States, each year, 100,000 hospitalizations and 4500 deaths are attributed to infections by RSV [12] [13]. The primary infection of the RSV manifests itself through lower respiratory disease, pneumonia, bronchiolitis, tracheo-bronchitis or disease of the upper respiratory tract. The common clinical symptoms are tachypnea or dyspnea, nasal flaring, intercostal and subcostal retractions, hypoxia, grunting, rhinorrhea, sneezing, cough, headaches, fatigue and fever. As with asthma, the first signs of the disease will appear as inflammation of the bronchial wall, increased bronchial reactivity and production of mucus. The tendency of the bronchi to clog spontaneously leads to difficulty breathing (dyspnea). There is no curative treatment for these respiratory conditions. Infants with mild forms of infection may follow a conservative type of treatment while children with a more severe illness, patients with an underlying disease or immunocompromised patients may require hospitalization.

4. Physiological Mechanisms

4.1. HB Inflation Reflex

The inflation reflex is described as suppressing inspiratory activity and promoting expiration. HB inflation reflex is mediated by mechanical sensory feedback from the lungs that ensures that the depth of the inspiration does not exceed physiological tidal volume [5]. Among newborns and infants, HB reflex is more prominent as compared to adults and may play a significant control in lung volume [14].

Lung inflation is activated by slowly adapting pulmonary stretch receptors in the smooth muscles surrounding large and small airways. When inspiration is inhibited, expiration may occur [15] [16] [17]. Breuer and Hering showed in their work that complete control of the inspiratory movement was dependent on the vagal nerve [5]. The essential role of the HB inflation reflex is the limitation of the amplitude of the augmented breath (sigh).

4.2. The HB Deflation Reflex

The deflation reflex restores lung volume by sigh breathing. It stimulates an inspiratory effort by increasing the respiratory rate and the inspiratory force in infants and newborns [3] [18]. It becomes stronger towards the end of expiration in adults [19] and newborn animals [20]. Before this millennium, researchers believed that this “not classical” reflex seemed to be initiated by the same pulmonary stretch receptors involved in the HB inspiratory-inhibitory reflex and, relayed

via vagal nerve to brain cells in respiratory centers to encourage inspiration.

While different types of airway receptors such as the rapidly adapting receptors (RARs) and the slowly adapting receptors (SARs) are known to be responsible for HB inspiratory-inhibitory reflex, studies on the receptors of the excitatory-inspiratory reflex have never been agreed upon and still need to be conducted [21]. Using a multiple-sensor theory in which sensory units contain different receptors for sensing different forces, Yu *et al.* provide evidence supporting the existence of a distinct group of pulmonary sensors, called deflation-activated receptors (DARs), that would mediate the HB exciting-inspiratory reflex in association with SARs and RARs units. The activation of DARs may directly provoke the HB exciting-inspiratory reflex, sighs, airway secretion and dyspnea [21] [22].

4.3. Evolution of HB Exciting-Inspiratory Reflex from Early Age to Adult

HB reflexes are primarily present and detectable in newborns [8]. The Trippenbach *et al.* study shows that HB deflation reflex has an important power at birth but then decreases with age. It also plays a considerable role in regulating the work of breathing [14]. Even though there is a great change and a reduced need as an individual passes from childhood to adulthood, HB reflex firmly maintains its important functionality, especially thanks to its pulmonary receptors that react to large volumes and pulmonary expansion [8] [23]. As the infant grows, the threshold for the stimulation of HB reflex increases showing a progressive habituation to the development.

5. Sigh Breathing

A sigh is a large inspiratory effort that appears spontaneously at rest and is much deeper than a normal breath in response to emotional and physiological stresses, including hypoxia, hypercapnia, and anxiety disorders [24] [25]. Sighing may express sadness, relief, or exhaustion, but it is crucial for improving alveolar ventilation, lung volume and forced vital capacity [26]. Normal mammalian breathing is punctuated every 5 minutes in humans and every 2 minutes in rodents, with sighs that are essential for maintaining proper lung function and improving gas exchange [27]. Indeed, mechanically ventilated patients in intensive care units are more sensitive to developing respiratory symptoms when the ventilation mode is set at constant tidal volume and breathing frequency. Sometimes, sighs like inspiratory efforts are programmed in the ventilation mode to prevent this phenomenon, leading to improved lung compliance and blood oxygen levels [28] [29].

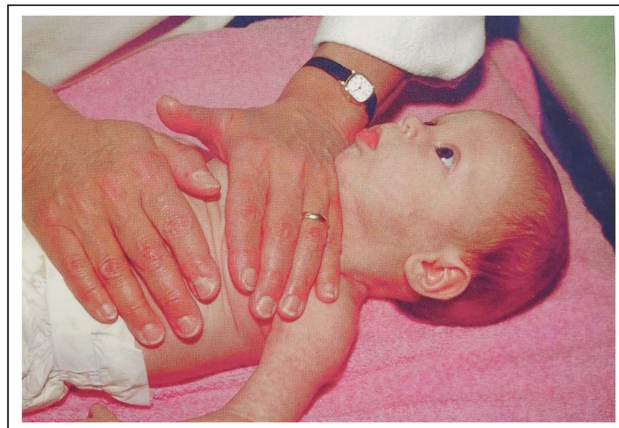
Disordered or excessive sighs can affect the breathing pattern and lead to a pathological condition called sighing dyspnea, also known as hyperventilation syndrome. This syndrome was first identified in patients complaining of shortness of breath with excessive sighing [30]. Although further studies are required to elucidate the underlying mechanisms and the impact on the infant's respira-

tory system, sighs can be triggered by spontaneous expiratory efforts such as cries or specific chest physiotherapy techniques. Some authors looked at pulmonary function, including pulmonary volumes and capacities, and at the response of this technique to those physiologic changes [31].

6. Physiotherapy Treatment: PSE Technique

Chest physiotherapy is used to treat respiratory pathologies and its efficacy in removing bronchial secretions and breathlessness and improving oxygenation in adults and pediatric patients. PSE is part of the standard therapy in patients with cystic fibrosis, cerebral palsy or spinal muscular atrophy [32] [33]. Most of these techniques are employed in the treatment of infants with pulmonary diseases to reduce pulmonary obstruction and clear secretions [34] [35]. Currently, the treatment of acute bronchiolitis in infants through chest physiotherapy has not provided clear results. However, evidence has shown that PSE, designed to help dislodge and remove the accumulated mucus in the lungs of the infants, is a non-invasive and passive technique derived from adult cardiorespiratory techniques [32].

Generally, standard PSE procedures are performed by a physiotherapist specifically trained in this therapy. The physiotherapist positions the hypothenar region of one hand on the thorax, precisely below the suprasternal notch, and the hypothenar region of the other hand on the abdomen, under the umbilicus. The physiotherapist then visually identifies the inspiratory and expiratory phases by observing the thorax movement and applying compression with both hands at the end of the expiratory phase. The hand on the thorax moves in the cranial-caudal direction (“**Picture 1**”).



The patient is positioned in supine position on a semi-hard surface. The physiotherapist applies joint manual abdominal and thoracic pressure at the end of the expiratory time. The pressure is slow and opposes two or three inspiratory attempts by the patient. Reproduced with authorization from G. Postiaux. *Kinésithérapie respiratoire de l'enfant: Les techniques de soins Guidées par l'auscultation pulmonaire*. Ed De-Boeck University, chp6-6 145pp.

Picture 1. Method of PSE procedures.

As seen earlier, the prolonged slow expiration technique (PSE) induces sigh breaths, which appear closely linked to a protective reflex of the airways [2]. The reduction of lung volume is also physiologically well-known to be associated with the Hering-Breuer (HB) exciting-inspiratory reflex [26] [36].

7. PSE & HB Reflex Interactions

Having defined the physiological mechanisms of the Hering-Breuer reflex and PSE therapy, it is now a question of seeing whether the interaction and stimulation of this HB reflex occur during the PSE treatment to enhance airway clearance in infants. This section looks at the significance of the triggering factors of the Hering-Breuer reflex.

7.1. Role of the Triggering Factors: Deep Expiration Induced by Chest Compression

Marsh *et al.* studied the effect of a chest compression jacket (compressions 28 - 38 cm H₂O) in newborns [37]. Their results showed that in 85% of cases, an inspiratory effort appeared very quickly after the beginning of chest compression (166 ± 26 ms). The inspiratory effort measured at the level of the esophagus was 2.5 times higher than during spontaneous breathing: the lower the volume is, the higher the inspiratory effort is. Marsh *et al.* suggest that the HB deflation reflex is responsible for the inspiratory effort after lung deflation. The rapid onset of inspiration at low volume highlights a protective role in maintaining infants' functional residual capacity (FRC) [37]. It has been reported in the study of Hannam *et al.* [3] that reduced lung volume by chest compression induced deep inspiration in healthy infants (the mean age at testing was 36 h). These inspiratory efforts were identified as the activation of the HB deflation reflex. Using an inflatable jacket (pressure max of 30 - 40 cm H₂O) to stimulate HB reflex and rapidly reducing pulmonary volume in infants has led to inspiratory efforts with chest compression [2]. The results showed that gradual changes in the strength of the inspiratory response to lung deflation were well associated with greater reductions in lung volume below the FRC, larger rises in esophageal pressure and faster rates of lung deflation. The authors also postulated that the HB deflation reflex may play an important role in protecting the FRC of the newborn.

7.2. Crying-Induced Deflation Reflex and Vibrations: A Vital Aspect in PSE Efficacy

Cries, often associated with displeasing emotions or communication needs in neonates, contribute significantly to the respiratory dynamics observed during the expiratory phase. The distinctive sound mechanism produced during infant crying, with a fundamental frequency of 400 - 600 cycles per second [38], is intricately linked to mechanical vibrations with large amplitudes that traverse intrathoracic structures [39]. The vibrations induced by the constricted air passage during crying, known as the Venturi tube effect, result in a drop in air pressure, aligning with the Bernoulli principle [39]. This unique respiratory phenomenon,

marked by rapid opening and closing of vocal cords at frequencies of 250 to 450 Hz, generates a fundamental frequency (f_0) heard as the pitch of the cry. Additionally, the lower vocal track contributes characteristics such as loudness and rhythm to expiratory cry sounds and inspiration, including inhalation and breath holding. These respiratory efforts, encompassing breath holding, crying, or struggling, induce significant variations in the chest wall diameter, reflecting a dynamic interplay between increased transmural pressure and airway resistance [39]. The tight adduction of vocal folds during the expiratory phase of crying acts as a brake, slowing the expiration phase and promoting increased end-expiratory lung volume [40]. This intricate mechanism enhances alveolar gas exchange, offering valuable insights into the physiological constraints of the pulmonary system during crying [41]. The measured intra-abdominal pressure during intense crying underscores the physiological necessity of laryngeal constriction to maintain pulmonary stability [42]. Studies evaluating laryngeal constriction phenomena in infants during various vocalizations highlight their occurrence during both cry and non-cry vocalizations, emphasizing their developmental significance [43].

These physiological responses, observed during crying, can serve as useful aids to the therapist and particularly in the PSE procedure. The modulation of intra-abdominal pressure, laryngeal constriction, and variations in the chest wall diameter all play integral roles in the intricate dance of respiratory dynamics. The intricate interplay between natural respiratory patterns and the techniques employed in PSE, ultimately contribute to the broader goal of effective mucus clearance in infant respiratory care.

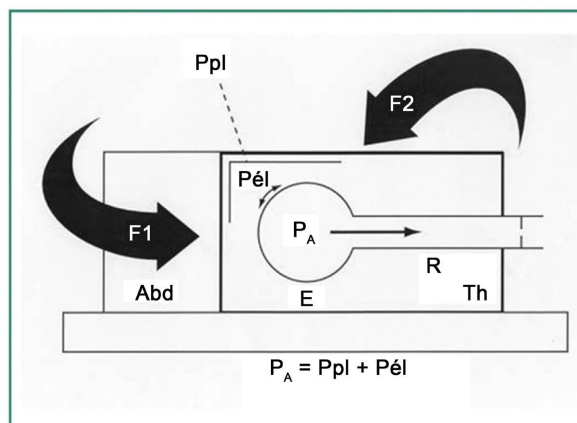
7.3. Pulmonary Decongestion in Infants: Usability and Efficiency

7.3.1. PSE Efficiency

In their controlled trial of 80 hospitalized children with acute bronchiolitis, Conesa-Segura *et al.* showed that PSE significantly decreased the bronchiolitis severity score annotated by medical team 10 minutes after the first intervention and significantly reduced the length of hospitalization of the group of children who received PSE [31]. Indeed, three-quarters of the hospitalized children (1 - 24 months old) with acute bronchiolitis who received PSE recovered in three days compared to six days in the group that did not receive it. Even though bronchiolitis is an acute pathology that usually resolves in 7 - 10 days, the authors conclude that chest physiotherapy, such as the PSE intervention, accelerates the recovery of infants and reduces their stay in intensive care units. Their results indicated that the technique appears to be well tolerated without discernible adverse effects.

Reference to a validated mechanical model for the PSE intervention helps to avoid certain technical errors, the most common of which is exerting elective manual pressure on the anterior or lateral chest wall to aid coughing or to accompany slow expiratory maneuvers. The mechanical representation of the ventilatory system as a deformable chamber with two compartments, thoracic-flexible

and abdominal-liquid (incompressible), helps to identify this technical error (Figure 2) [44].



Manual pressures (F1, F2) may be applied simultaneously to both compartments to avoid intra-pulmonary gas transfer. Manual maneuvers are an application of the alveolar pressure equation: PA: alveolar pressure, Ppl: pleural pressure, Pél: elastic recoil pressure. Reproduced with authorization from G. Postiaux. (2014) Chest physical therapy of the distal lung. Mechanical basis of a new paradigm. *Revue des Maladies Respiratoires* 31, pp 558.

Figure 2. Representation of the ventilatory system as a deformable chamber with two compartments: thoracic (Th), flexible, and abdominal (Abd), liquid.

7.3.2. Cries and PSE

In the context of investigating respiratory dynamics and its potential implications for the efficacy of prolonged slow expiration (PSE), attention turns to an examination of additional factors, notably highlighted in the study by Javorka *et al.* [45] [46]. They observed in 22 premature newborns that the respiratory rate decreases during crying, changing the inspiration/expiration ratio from 1:1.46 to 1:5.1 ($p \leq 0.001$) with an increase of 255% of ventilation in comparison to quiet ventilation. The dynamic compliance decreased by 52%, and the total pulmonary resistance increased by 70% during the crying phase [45]. Moreover, the same authors have demonstrated in another study, where 16 newborns with respiratory distress syndrome (RDS) were enrolled, that active elimination of irritants from the airways (such as sneezing, expiratory reaction and crying) is reduced [46]. They recorded esophageal pressure using an electro-manometer and investigated the reactions to mechanical stimulation of the upper airways by means of a nylon fiber. Compared to 16 newborns without any cardiorespiratory disturbances (healthy newborns), the results showed interesting reactions reflecting mechanical stimulation of the airways. Compared to the healthy newborn group, the stimulation of the nasal mucosa significantly decreased in newborns in the RDS group, producing expulsive reactions in only 45% of cases. The results also showed that the stimulation of the oropharyngeal and laryngeal regions in newborns with RDS significantly leads to expulsive reactions. In other words, newborns with RDS, compared to healthy infants, demonstrate weaker expiratory reaction, sneezing and crying (known as expulsive response), and on the other

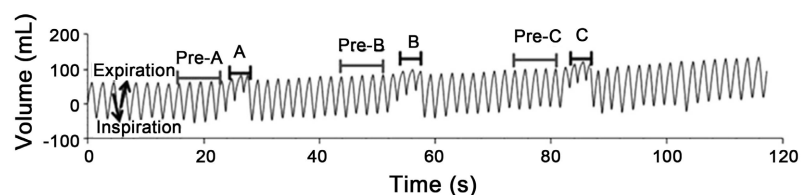
hand, the inspiratory component of sneezing and coughing was stronger in newborns with RDS.

The cries of the infant are one of the best complements of the physiotherapist's PSE procedures to facilitate pulmonary decongestion. The effect of the cries would be directly related to those of prolonged expiration itself by favoring pulmonary deflation. In other words, cries would be able to reduce lung volume, and its restoration would be induced by sighs or the activation of a pulmonary protective reflex. Using electrical impedance tomography, Tingay *et al.* recorded videos of every breath (until 6 minutes from birth) in 17 infants in their prospective observational study [47]. They classified the breaths by video data, measures of lung aeration, tidal flow conditions, and intrathoracic volume distribution calculated for each inflation. The results showed that infants have two distinct breathing patterns: crying in primary breathing that recruits FRC and tidal breathing. They also showed that cries are associated with the expiratory braking flow and lead to maintaining gains from the PSE procedures and redistributing gas to poorly aerated regions. The infants in this study significantly improved their oxygen saturation (52% at 60 seconds to 78% by 360 seconds). Increased alveolar pressure, facilitated by infant cries, also plays a crucial role in lung liquid clearance [48].

7.3.3. Triggering of HB Deflation Reflex during Chest Compression

In eighteen sedated infants (mean age 32.2 weeks) with a history of recurrent wheezing, Lanza *et al.* measured peak expiratory flow, tidal volume and frequency of sighs during and immediately after PSE [2]. They observed that PSE maneuvers induced no significant change in peak expiratory flow but induced deep breaths (sighs as a tidal volume increased more than 100%) and significantly decreased tidal volume. They also reported that the reduction in lung volume is associated with the protective HB deflation reflex of the airway.

PSE is one of the chest therapy techniques defined by slow manual pressure at the end of the infant's spontaneous expiration, leading to the expiratory residual volume. Three subsequent inspirations were restricted, and the compression movements were continued into the expiratory phase, per the standard PSE technique "Figure 3".



Pre-A, Pre-B, and Pre-C are the normal breaths before the PSE sequences (A, B and C). Reproduced with authorization from Lanza FC, Wandalsen G, Dela Bianca AC, *et al.* Prolonged Slow Expiration Technique in Infants: Effects on Tidal Volume, Peak Expiratory Flow, and Expiratory Reserve Volume. *Respir Care* 2011; 56 (12) 1930-1935.

Figure 3. Example of a volume-time curve during normal breathing and prolonged slow expiration.

Some studies also showed that PSE acts more distally and positively impacts several parameters in children with viral bronchiolitis by improving oxygen saturation and secretion clearance and reducing the heart rate and pulmonary hyperinflation [10]. Intrathoracic pressure increases slowly by means of thoraco-abdominal compression to prevent bronchial collapse and disruption of the flow that occurs during force expiration. In infants with respiratory diseases such as viral bronchiolitis or under mechanical ventilation, a few studies have observed that PSE could deflate the lung to expiratory reserve volume, induce sigh breathing and may not increase expiratory airflow. However, the results still lack evidence [11]. The presence of sigh breaths after applying PSE technique in infants with respiratory syncytial virus (RSV) suggests that they are probably the main mechanical feature for mucus clearance. Unlike adults, it is practically impossible to obtain slow active inspiratory maneuvers in infants. The sighs that appear between the safe expiratory maneuvers that constitute PSE may well be the main asset of the treatment, as suggested by some authors [49].

Even though several studies have stated that classical respiratory techniques such as vibrations and percussions do not provide clear clinical benefits for acute bronchiolitis in pediatrics [50] [51]. Roqué I Figuls *et al.*, have recorded a clinical trial in which the PSE combined with salbutamol provided temporary relief and a decreased need for oxygen in infants with moderate bronchiolitis [44].

8. Discussion

This study explored the physiological mechanisms of the HB reflex and its utility in the prolonged slow expiration (PSE) technique for infants. Our findings suggest that PSE maneuvers, which induce sigh breaths, can significantly help in bronchial decongestion and improve pulmonary ventilation by activating the Hering-Breuer deflation reflex.

Previous research has established the role of sigh breaths in maintaining functional residual capacity and preventing atelectasis through periodic deep inspirations. Our study builds on this understanding by demonstrating that the PSE technique can effectively provoke these sighs, leading to better mucus clearance and improved respiratory function in infants with recurrent wheezing.

The primary outcome of our investigation indicates that PSE-induced sighs are the main active principle in enhancing alveolar ventilation. This supports earlier observations that changes in lung volume due to PSE and the resulting sighs can stimulate the Hering-Breuer reflex, thereby aiding in the re-inflation of collapsed alveoli and improving overall lung volume.

However, international recommendations do not recommend chest physiotherapy for the management of bronchiolitis [52]. These recommendations are based on Cochrane review analyzing three clinical trials evaluating chest physiotherapy in infants with bronchiolitis, last updated in 2023 [53]. They found low-certainty evidence that the passive slow expiration technique may result in a mild to moderate improvement in bronchiolitis severity in infants treated in

hospital. However, further trials are needed to determine their effects in infants with moderate bronchiolitis, potentially reducing hospitalization admission duration and improving patient outcomes. Due to the lack of studies regarding different pathologies, caution is recommended, particularly in the case of esophageal atresia, cardiac malformations and central neurological damage, or any abdominal syndrome that is not identified or constitutes a contraindication from the outset: abdominal tumors and in general in cases of developmental disorders. Bronchospasm is not a contraindication if the technique is preceded by bronchodilator aerosol therapy. Given the compressibility of the trachea and proximal bronchi in infants, learning PSE in young chest physiotherapists requires careful guidance to avoid any untimely pressure. Due to the high abdominal pressure exerted at the end of the expiratory phase, PSE technique may accentuate an existing gastro-esophagus reflux. The physiotherapist must be aware of the possible respiratory repercussions of gastroesophageal reflux disease.

In summary, the PSE technique leverages the Hering-Breuer deflation reflex to induce sighs that enhance mucus clearance and improve respiratory function in infants. This study underscores the need for further research to optimize PSE application and validate its efficacy in clinical settings, particularly for acute bronchiolitis and asthma management.

9. Conclusion

HB deflation reflex-induced sigh breathing is probably a key factor between alternating inspiratory breath and expiratory movements during pulmonary ventilation. Large inspiratory efforts roughly double the size of normal breaths can be achieved because of forced expirations provoked by the PSE technique. Changes in volume induced by the PSE technique and effects from crying may stimulate the HB deflation reflex and sighs, thus improving alveolar ventilation as well as lung volume in infants. Although studies have shown that PSE may improve mucus clearance, further research needs to be done to understand if this mucus clearance may also be improved by larger variations in tidal volume. This therapy could become a promising adjunct treatment for acute bronchiolitis by accelerating the recovery in hospitalized children and may reduce the length of hospital admission.

10. Points for Clinical Practice

- Sigh breath related to the Hering-Breuer reflex is crucial for pulmonary function.
- Sigh-like inspiratory effort, also viewed as augmented breath, can be induced by adapted chest physiotherapy in infants called the prolonged slow expiration technique (PSE).
- Expiratory “flow” during crying leads to redistribution of ventilation of the lung.

- The benefit of provoking sighs may induce the mobilization of secretions.
- PSE therapy could significantly improve the management of bronchiolitis exacerbation in ambulatory care, allow for easier breathing and ensure adequate oxygenation.
- PSE may be a promising adjunct treatment for acute bronchiolitis and later for asthma by accelerating the recovery in hospitalized children and perhaps reducing the length of hospital admission.

Author Contributions

All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

Conflicts of Interest

No potential competing interest was reported by the authors.

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