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REVIEW PAPER

Application of expiratory flow increased technique in the respiratory therapy of premature neonates: a systematic review

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ABSTRACT

Expiratory flow increased technique (EFIT) in respiratory therapy is a treatment strategy for neonates in neonatology departments. The purpose of this study was to present the current understanding of the application of the EFIT in respiratory therapy for premature neonates. The first part describes an overview of the literature on EFIT. PubMed, Medline, Embase, Scopus, and Google Scholar databases were searched for trial studies on EFIT therapy in infants published from January 2020 to September 2024. The second part presents the EFIT technique for newborns, along with its indications and contraindications. There were 5 papers concerning the respiratory therapy of neonates and related solely to EFIT. Literature shows that EFIT therapy improves the respiratory parameters. The knowledge and experience that has been gained concerning the impact of therapy on the respiratory system of premature neonates encourages the use of the EFIT therapy in neonatology.

KEY WORDS:

neonates, preterm, respiratory physiotherapy, chest physiotherapy, expiration technique.

INTRODUCTION

The expiratory flow increased technique (EFIT) in respiratory therapy forms part of the strategy and care provided by the entire team responsible for the intensive care of the neonate. It is a therapeutic method administered in the treatment of respiratory failure in the pediatric population. The available literature demonstrates a lack of adequate data and studies on respiratory physiotherapy in neonatology. However, limited research has been conducted in this area. Recently, this technique was modified to address the needs of premature neonates. The expiratory flow increased technique was developed by Barthe in 1973 in France, a technique often referred to as *augmentation du flux expiratoire* [1, 2].

This technique is based on the physiological compliance of the neonatal chest. The purpose of this therapy is to mobilize and evacuate bronchial tree secretions, which improves the conditions for gas exchange, recruits alveoli for activity, and improves respiratory mechanics.

All these benefits lead to a shortened duration of mechanical ventilation and eventually to a decreased length of hospitalization. Expiratory flow increased technique may have beneficial effects on respiratory parameters such as respiratory rate (RR), oxygen saturation (SpO_2), and reduced pain [3, 4]. This therapy may reduce the risk of respiratory complications. It is administered to oxygen-dependent neonates, either intubated or on noninvasive respiratory support, such as positive airway pressure in a variety of combinations. The purpose of this paper was to present the current understanding of the application of the EFIT in respiratory therapy for premature neonates with respiratory failure.

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TABLE 1. Inclusion and exclusion criteria

Criteria	Inclusion criteria	Exclusion criteria
Type of studies	Randomized trials, randomized controlled trials, intervention study, crossover study, prospective non-randomized study	Reviews, letters to editors, editorials, survey reports and case reports
Type of participants	Preterm (< 37 weeks gestation) and newborns (< 11 months) who underwent EFIT therapy	Older children
Type of intervention and control	Respiratory therapy EFIT	Studies using other respiratory therapy techniques
Article	Articles available in English, French and Spanish [w tekście jest Portuguese]	

EFIT – expiratory flow increased technique

METHODS

The paper has two parts. The first section presents a literature review. PubMed, Medline, Scopus, Embase, and Google Scholar databases were searched for randomized controlled trials and observational studies on EFIT in infants published in English, French, and Spanish from January 2020 to September 2024. The studies were analyzed in terms of methodology and effects of EFIT on term and preterm infants. The search strategy included key words, combinations, medical subject headings, title abstract, and related papers. Trials based on other methods of chest physiotherapy (CPT) and those involving patients older than neonates were excluded. The results of the initial search of all the databases were screened by two review authors independently for inclusion and further analysis (Table 1). In the event of disagreement, third investigator was expected to make the decision. Information on the type of study, number of participants, participant characteristics, type of intervention, evaluation times, results, and years was collected from each study.

The second section is a detailed description of the EFIT method used, which was adapted to the conditions of a neonatal intensive care unit for pre-term neonates. The description includes photographs illustrating this method.

RESULTS OF LITERATURE REVIEW

After a bibliographic search of different electronic databases, 180 initial studies were identified, and eight articles because they were duplicates. All the titles were read. abstracts, 172 new articles were eliminated to avoid meeting the eligibility criteria. Eleven articles were excluded because they did not meet the intervention criteria (Figure 1).

There were seven papers concerning the respiratory therapy of neonates and relating solely to EFIT, of which five dealt with neonates born prematurely (Table 2).

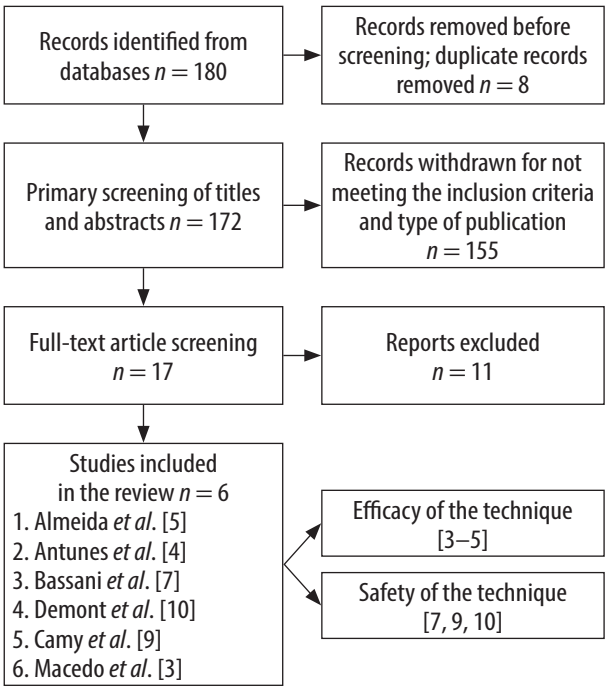

FIGURE 1. PRISMA flow chart

BENEFITS OF EXPIRATORY FLOW INCREASED TECHNIQUE ON THE RESPIRATORY SYSTEM OF NEONATES

Almeida *et al.* [5] analyzed a method based on repeated variations in a prospective observational study. The expiratory flow increased technique was administered to 22 infants with acute obstructive pulmonary insufficiency who underwent invasive ventilation between April 2001 and April 2003. Blood gas levels, oxygen saturation, and RR were recorded. The authors concluded that the therapy was effective in improving oxygenation in neonates and indicated the need for additional research to determine the effectiveness of EFIT. Antunes *et al.* [4] conducted a comparative study of conventional CPT (n = 20) and EFIT (n = 20) in preterm neonates mean 28 weeks' gestational age (GA) and found that both techniques produced significantly increased saturation. Expiratory flow in-

TABLE 2. Characteristics of studies

Study	Country, study time	Type of study	Number of patients	Gestational age	Intervention	Measures	Outcomes
Almeida *et al*. [5]	Brazil, 2001–2003	Observational, prospective	22	1–11 months	EFIT	PaO_2, $PaCO_2$, $SatO_2$, PaO_2/FiO_2, PaO_2/PAO_2 P(A-a) O_2/PaO_2 VD/VT,	Efficacy of technique significant increase in respiratory rate, $SatO_2$ and PaO2/PAO_2 and a significant decrease in P(A-a) O_2/PaO_2
Antunes *et al*. [4]	Brazil, 2004	RCT	40 (20; 20)	< 33 weeks GA	EFIT CCP	$SatO_2$, HR, RR	Efficacy of the technique EFIT and CCP –significant increase in $SatO_2$ after 10 and 30 minutes of chest physical therapy, with no change in RR, only CCP significant increase in HR
Bassani *et al*. [7]	Brazil, 2013–2014	Observational, prospective	40	< 35 weeks GA	EFIT	$SatO_2$, HR, CBF variable (PSV, EDFV, MFV, IR and PI)	Safety of the technique not significantly alter
Demont *et al*. [10]	France, 17 months	Cohort study	362	24–41 weeks	EFIT	PEA IVH and PVL	Safety of the technique 9 PEA (2%; 95% CI: 1–4.0) IVH 59 (16%) PVL 5 (1%)
Camy *et al*. [9]	Brazil, 2007–2008	Crossover study	18 (9; 9)	< 37 weeks GA	EFIT 1 hour after feeding EFIT 2–3 hours after feeding	RI	Safety of the technique EFIT performed 2 and 3 hours after feeding, it is not associated with an increase in acid reflux episodes
Aberaro *et al*. [6]	India, 2024	A case report	1	32 weeks	EFIT for 3 times a day	Silverman Andersen respiratory severity score	Efficacy of the technique improves ventilation and reduces work of breathing
Macedo *et al*. [3]	Brazil, 2015–2017	Prospective randomized and controlled trial	43	< 35 weeks	EFIT CPT	SpO_2. HR, RR	Efficacy of the technique EFIT consistently achieved higher SpO_2 to CPT, EFIT caused an increase in HR post – intervention, EFIT is better tolerated than the CPT – the effect on RR

CPT – chest physiotherapy, EFIT – expiratory flow increased technique, HR – heart rate, RCT – randomized controlled trial, RI – reflux index, RR – respiratory rate, SpO2 – oxygen saturation, VD/VT – dead space volume / tidal volume

TABLE 3. Indications and contraindications for expiratory flow increased technique therapy in the neonates

EFIT indications	EFIT contraindications
Respiratory distress syndrome	Pneumothorax
Bronchitis and pneumonia	Hemodynamic essential ductus arteriosus
Meconium aspiration syndrome	Necrotizing enterocolitis
Chronic lung disease	Distended intestinal loops
Atelectasis	Pulmonary hypertension
Cystic fibrosis	Postoperative states
Respiratory syncytial virus infection	Significant birth defects
Neuromuscular diseases	Circulatory and respiratory instability

EFIT – expiratory flow increased technique

creased technique is less stressful (no change in the heart rate compared to CPT) and can be safely used in premature neonates following extubation.

In a randomized study, Macedo *et al.* [3] compared both techniques and confirmed that both increase saturation and that the EFIT technique is less stressful and painful.

Based on a single case report, Aberaro *et al.* [6] described the beneficial effects of EFIT therapy in improving ventilation, reducing work of breathing, and reducing secretions.

SAFETY OF EXPIRATORY FLOW INCREASED TECHNIQUE THERAPY

Bassani *et al.* [7] assessed the effects of EFIT on the brain hemodynamics in premature neonates. The interventional study included 40 premature neonates with a maturity of less than 34 weeks of gestation who completed the 15th day of life. The cerebral blood flow velocity, arterial resistance, and pulsation indices were also assessed. The assessment was performed before, during, and 5 min after the EFIT session. The results showed that EFIT did not affect cerebral blood flow in clinically stable premature neonates. Demont *et al.* [8] found that the incidence of post-extubation atelectasis in infants treated with EFIT is low and that this technique does not increase the incidence of brain lesions above the percentage normally observed in neonates with respiratory failure.

The effect of therapy on reflux episodes in premature neonates with bronchopulmonary dysplasia (BPD) has been previously evaluated [9]. A crossover study was performed with 18 patients divided into two groups. In the first group, EFIT was administered 2 hours after feeding, whereas in the second group, EFIT was administered 3 hours after feeding. The effect of therapy on esophageal acid was assessed using the reflux index during treatment, and esophageal pH was tested 20 min before treatment. The results of this study showed that therapy performed 2 and 3 hours after feeding had no effect on reflux episodes in premature neonates with BPD.

APPLICATION OF EXPIRATORY FLOW INCREASED TECHNIQUE THERAPY

The objectives of therapy are to prevent the consequences of bronchial obstruction, reduce the consequences of mechanical ventilation, reduce respiratory effort, and mobilize and evacuate bronchial tree secretions. The indications and contraindications for performing EFIT are presented in Table 3.

The expiratory flow increased technique involves the synchronized compression of the neonatal chest and abdomen [10]. Dynamic compression increases exhaled airflow inside the bronchial tree. The therapist can manipulate the speed and amplitude of compression.

The technique is a so-called closed system: patient-ventilator-therapist. It consists of synchronized hand movements performed on the chest by a therapist in the thoracic-abdominal direction. Both hands are placed such that the axes of opposite trajectories form an angle of 90° (Figure 2 A).

The therapist's hand movement is initiated at the peak of inspiration, sustained throughout the exhalation phase, and continually modulated in terms of amplitude, direction, and velocity depending on the indications (e.g., in the case of bronchial obstruction or meconium aspiration, the amplitude should have a larger range to activate the functional residual capacity, as only this provides for mobilization and evacuation of secretions from the bronchial tree; in the case of advanced bronchopulmonary dysplasia, the movement performed has a smaller range of amplitude and velocity). Maneuvering the therapist's hands on the chest increases the exhalation and inhalation flow. It is closest to the physiological mechanisms of expectoration of secretions observed in adults in the form of a cough, which does not occur or is not possible in premature neonates, thus leading to the retention of secretions and respiratory infection. Technically, the most important feature of increasing expiratory flow is the speed and amplitude of hand movements, which activate of the functional residual capacity. The hand

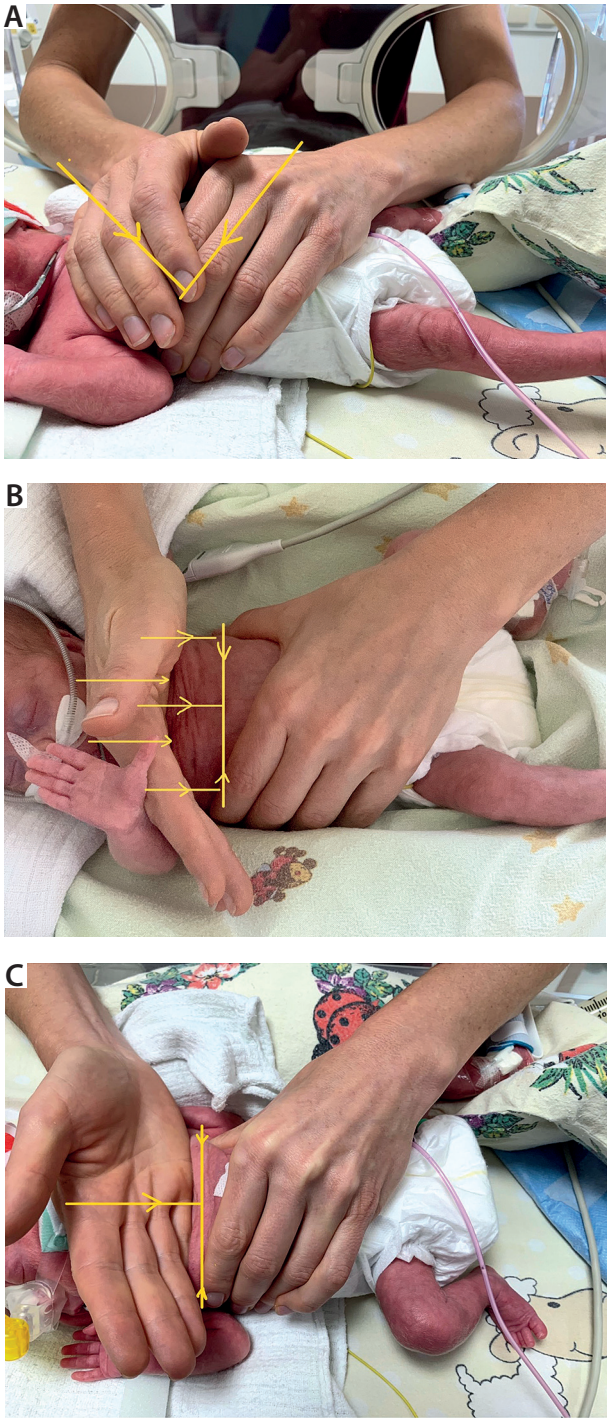

FIGURE 2. A) Expiratory flow increased technique (EFIT) before modification for the premature infants. **B, C**) EFIT technique in the supine position, adapted to the needs of premature infants

movement on the chest was sustained until the airflow reached zero.

The risk of respiratory collapse increases with increasing neonatal immaturity and depends on the quality of bronchial smooth muscle tone. During the therapist's hand movement, the pressure applied to the chest is transferred to the outer walls of the bronchi, which increases the intra-wall pressure. The consequence is a decrease in the size of the bronchi, the more immature the bronchial walls and the quality of the bronchial smooth muscle tone, the greater the risk of bronchial collapse. As expiratory flow deepens, the bronchial closure area increases.

Because of the differences in the respiratory systems of premature neonates, EFIT therapy must be appropriately adapted to the respiratory system [11]. In the modification of the method developed for premature neonates, abdominal pressure was abandoned and replaced by blocking the dome of the diaphragm, that is, reducing the costo-costophrenic angle. Figures 2 B, C shows a possible arrangement of hand movements, allowing for effective contraction of the diaphragm. The modified method also applies to EFIT therapy in the prone position (Figure 3 A). Release of abdominal pressure prevents increased venous pressure and cerebrovascular consequences.

The movement of the hand on the chest is individual and modulated in terms of strength, velocity and amplitude, this range is always dictated by the needs of the patient depending on the respiratory problem and indications. Therefore, the challenge for physiotherapists is to identify and understand what is required, and adapt their techniques as needed.

A very positive effect was observed on supporting the technique of increasing the expiratory flow with "handling" and positioning in a "crescent." Depending on the requirements of the respiratory system in premature neonates, the position may be modulated differently: supine, prone, or on the side. The most advantageous positions, if there are no contraindications, are the prone position (Figure 3 B) and side position (right or left) (Figure 3 C). These positions support the aeration of the alveoli, which is of great importance in the healing process.

DISCUSSION

The authors performed a systematic review of the literature from PubMed, Medline, Scopus, Embase, Google Scholar, and Cochrane Library databases. The review and interpretation of the current literature on the use of EFIT therapy in preterm and full-term newborns resulted in seven articles. The journals focused on the effect of EFIT on neonatal respiratory parameters and the safety of the therapy. A prospective non-randomized study conducted in 2001–2003 showed a significant positive effect of EFIT on respiratory parameters, such as PaO_2, $PaCO_2$, $SatO_2$, PaO_2/FiO_2, P(A-a) O_2/PaO_2, PaO_2/PAO_2, and dead space volume/tidal volume [10]. Similarly, in a randomized clinical trial, the authors observed a significant increase in SpO_2, additionally comparing the EFIT technique with the CPT technique, and showed, based on changes in the heart rate, that EFIT is a less stressful and painless technique [4]. These observations are consistent with the results of Macedo *et al.* [3] in a prospective randomized study published in 2024. The results of this study demonstrate that the application of CPT and EFIT in premature

infants on mechanical ventilation induces similar acute effects on respiratory parameters and heart rate. However, EFIT resulted in less pain and more favorable responses in peripheral SpO_2 and RR than CPT. These findings suggest that EFIT elicits a lower pain response, making it a potentially less stressful intervention for this population.

A case report of a neonate born at 32 weeks with neonatal respiratory distress syndrome also showed a positive effect of EFIT therapy (administered twice a day), in which there was a reduction in secretions, improvement in the breathing pattern of the baby, oral motor assessment scale, Silverman Andersen respiratory severity score, and arterial blood gas [6]. A crossover study confirmed that EFIT does not worsen reflux episodes [9]. This study indicated that modern EFIT was not associated with acid reflux episodes, even though a gastric tube was used to feed all subjects, which favors the occurrence of reflux episodes. In 2016, Bassani *et al.* [7] assessed the effects of EFIT on cerebral hemodynamics in premature neonates.

Brain neuroprotection strategies can prevent the death of nerve cells, support the proper development of the CNS, reduce the death of neuronal cells, and allow healing of damaged brain through the development of new connections [12]. Following analysis and review of the papers that referred to the EFIT method, modified for the needs of premature neonates, appears to be not only a safe but also an effective respiratory therapy in neonatal departments. Therapeutic hand movements are adapted to the compliance of the neonate's chest, with an emphasis on the individual approach to indications for therapy in premature neonates. Therapeutic hand movements consisting of EFIT combined with elements of NDT Bobath Baby (neurodevelopmental treatment Bobath Baby) applied when positioning the neonate in the incubator appear to have a positive effect on the respiratory system and stimulate the development of the correct motor pattern of the premature neonate. The therapeutic measures described above, combined with EFIT therapy, not only have a positive effect on the respiratory system, but are also safe for the delicate nervous system of premature newborns.

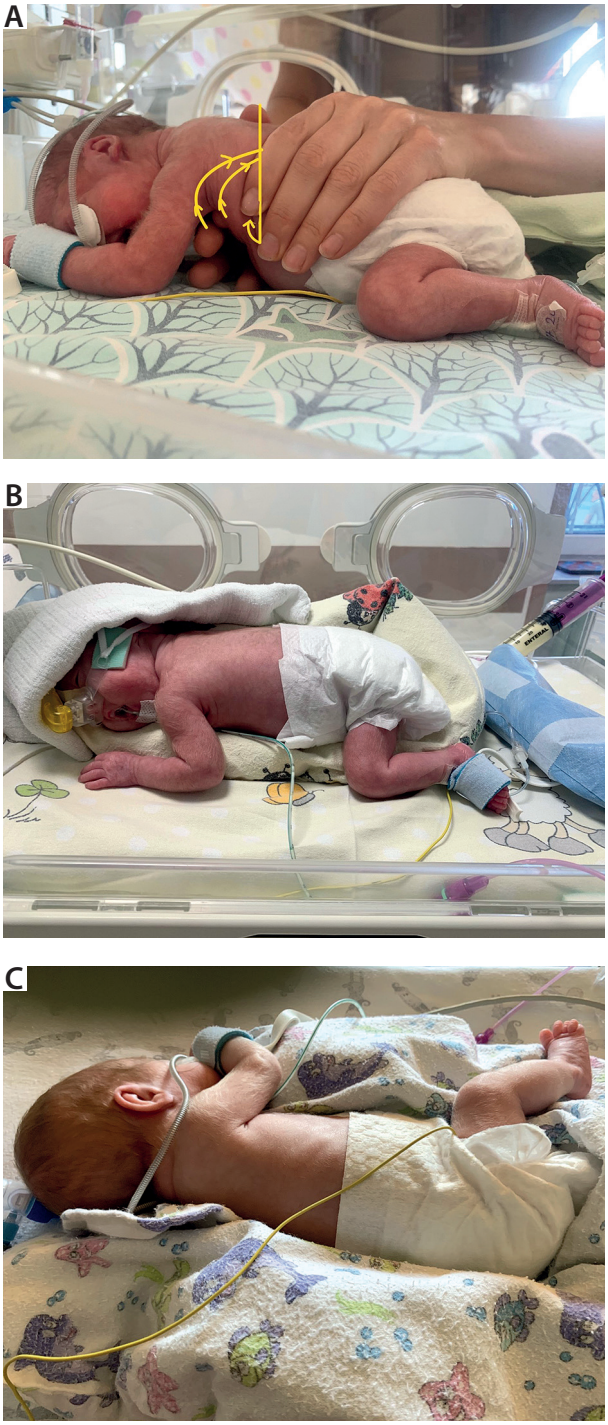

FIGURE 3. **A**) Expiratory flow increased technique in the prone position adapted to the needs of premature infants. **B**) Crescent's positioning – prone position. **C**) Crescent's positioning – side position

CONCLUSIONS

Many respiratory therapy techniques are not recommended for use in neonatology due to the instability of the circulatory and respiratory systems and the risk of bronchial collapse in premature infants. A review of the available literature suggests that the most effective and safest method of respiratory therapy in neonatology is to increase expiratory flow, modified to the needs of premature infants.

Many years of experience in the use of EFIT at the Department of Neonatology at the Medical University of Warsaw, related observations and our own clinical trials to date indicate a positive effect of this method on the respiratory parameters of premature infants and the patient's recovery process. To date we have not observed any negative effects or complications during the EFIT therapy. In combination with handling and positioning of the newborn in an incubator, EFIT therapy modified to the needs of premature infants is an effective and safe form of treatment strategy in the neonatal intensive care unit.

DISCLOSURES

1. Institutional review board statement: This study was approved by the Ethics Committee of the Medical University of Warsaw (approval decision no. KB/171/2021, dated: 08.11.2021).
2. Assistance with the article: We thank Editage for language and editorial assistance in preparing this manuscript.
3. Financial support and sponsorship: None.
4. Conflicts of interest: None.
5. Patient consent: Written informed consent was obtained from the patient's legal guardian for publication of this case report and any accompanying images.

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