

PROLONGED SLOW EXPIRATION (PSE) AND PRONE POSITION INTERVENTION IN CHILDREN : A LITERATURE REVIEW

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ABSTRACT

Nursing interventions to reduce the impact of respiratory problems in children aged < 24 months in inpatient rooms are not only a science but also an art. This study aimed to determine the effectiveness of Prolonged Slow Expiration (PSE) and prone position in improving respiratory function in hospitalized children aged < 24 months with respiratory distress in inpatient rooms. This literature review examined thirteen peer-reviewed journals based on inclusion criteria. The results of the review showed that PSE and prone position can reduce the respiratory frequency, maintain the neuromechanical diaphragm, and increase tidal volume. PSE was more effective at lowering the bronchiolitis scale score, preventing the child from experiencing moderate to severe respiratory distress, and decreasing relative sputum production. The prone position is more effective in increasing SaO₂ even when using mechanical ventilation (MV), can increase maximal inspiratory pressure (MIP) and tissue oxygenation index (TOI), provides sleeping comfort, improves cardiorespiratory function, reduces moderate to severe respiratory distress, and can perform intubation. It can be concluded that PSE is a safe and easy therapy to administer to mild respiratory distress patients but has not a significant effect on children < 24 months with moderate to severe respiratory distress in inpatient rooms.

Keywords: Children < 24 months; Prolonged Slow Expiratory (PSE); prone position; respiratory distress



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INTRODUCTION

Currently, children are susceptible to various diseases. UNICEF (2019) stated that respiratory problems are the main cause of death in children in poor and developing countries. Nayani et al. (2018) supported the nation and reported that respiratory problems were the global death in children aged under 5 years. In Indonesia, respiratory distress was the second health problem in 4.4% or 1,017,290 children (Kemenkes RI, 2019). Generally, child respiratory problems are caused by immaturity of the lungs of premature babies and respiratory infections that originate from various pathogens that attack the trachea, bronchi, bronchioles, and alveoli followed by severity ranging from mild to severe (Orloff et al., 2019) (Rahmawati et al., 2020).

It is important for nurses to provide independent interventions for children to reduce respiratory distress (Baudin et al., 2019). Interventions given to neonates, infants, and toddlers aim to prevent disturbances in airway clearance, ineffective breathing patterns, and increased oxygenation (Puji, 2018). The interventions are provided with a therapeutic technique through prolonged slow expiration (PSE) (Nogueira et al., 2019) and the prone position (Cheifetz, 2017).

PSE and prone position are non-pharmacological therapies that can be given to children which are not only a science but also an art in independent nursing practice (Liu et al., 2018). PSE is nonpharmacological-advanced chest physiotherapy that can stimulate children's diaphragm to clear the lungs from secretions and increase oxygenation

(Mishra et al., 2020). The prone position is a nonpharmacological action that can improve the lung mechanism to increase oxygenation (Orloff et al., 2019). Both PSE therapy and prone position provide benefits in maintaining lung expansion and increasing oxygenation in children (Schaan et al., 2020).

This literature review aims to distinguish both interventions and determine the best time when nurses can provide both therapies to children. We have not found published literature discussing the benefits and effectiveness of PSE therapy and the prone position in hospitalized children aged < 24 months with respiratory distress in inpatient wards. Therefore, it is considered necessary to synthesize

published evidence of the effectiveness of PSE therapy and prone position and explain the indications of both therapies in dealing with children's respiratory distress aged < 24 months in inpatient wards (Liu et al., 2018).

METHOD

Study design

This is a literature review of the effectiveness of Prolonged Slow Expiratory (PSE) therapy and prone position in children aged < 24 months with respiratory distress in inpatient wards. The development of the research question follows the PICO guideline as presented in Table 1 below.

Table 1. PICO

Research Title	Prolonged Slow Expiration (PSE) and Prone Position Intervention in Children
PICO questions	<ol style="list-style-type: none"> 1. Children Under 24 Months with Respiratory Distress in Inpatient Rooms, What Is the Effect of Prolonged Slow Expiration (PSE) Compared to The Prone Position on Respiratory Tract Function? 2. Are there any changes in respiratory function when given Prolonged Slow Expiration (PSE) compared with the prone position in Children Under 24 Months with Respiratory Distress in Inpatient Rooms?

Research topics		P (POPULATION)	I (INTERVENTION)	C (COMPARATION)	O (OUTCOME)
Key Term		“Children Under 24 Months with Respiratory distress in Inpatient Rooms”	AN “Prolonged Slow Expiration”	AN “Prone Position”	AN “Respiratory Function”
Alternative Term	OR	Pediatric with Respiratory Distress in Hospital	OR -	OR Semi prone	OR Respiratory Rate
Alternative Term	OR	Pediatric Acute Respiratory Syndrome in Pediatric Intensive Care Unit	OR -	OR Quarter prone position	OR Oxygen saturation
Alternative Term	OR	Children with RDS in Neonates Intensive Care Unit	OR -	-	OR Hard to breath

Search Strategy

Alternative term for population (P) used “Children Under 24 Months with Respiratory Distress in Inpatient Rooms” OR “Pediatric with Respiratory Distress in Hospital” OR “Pediatric Acute Respiratory Syndrome in PICU” OR “Children with RDS in Neonate Intensive Care Unit” OR “Children with Pneumonia in Hospital” OR “Pneumonia in Child” OR “Child with Bronchiolitis in Patient Room” OR “Pediatric with Respiratory Distress in PICU” OR “RDS in Children” OR “Pediatric Acute Lung Injury in PICU” OR “Pediatric with acute respiratory infection in Patient Room; Researchers did not use alternative terms for intervention (I); Alternative terms for comparison (C), researchers used “Semi Prone Position” OR “Quarter Prone Position”; Alternative terms for the outcome (O), researchers used

“Respiratory Rate” OR “Oxygen saturation” OR “Hard to breathe” OR “Oxygenation” OR “Cough with phlegm” OR “Wheezing”.

Selection Criteria

The inclusion criteria of this study included 2012-2020-journal collection, quantitative and qualitative researches, using only original research, the full text of children with respiratory distress in children, children who have additional breath sounds, children aged 0 to 24 months, children in the intensive care unit and inpatient rooms, and children receiving PSE therapy and prone position. The exclusion criteria included conference papers, symposia, discussion papers, and children with respiratory arrest. Researchers have described the filters in Flowchart 1. A total of 13

studies were included in the review, including 5 studies that reviewed PSE and 8 studies that reviewed the prone position.

Flowchart 1. Journal Search Strategy

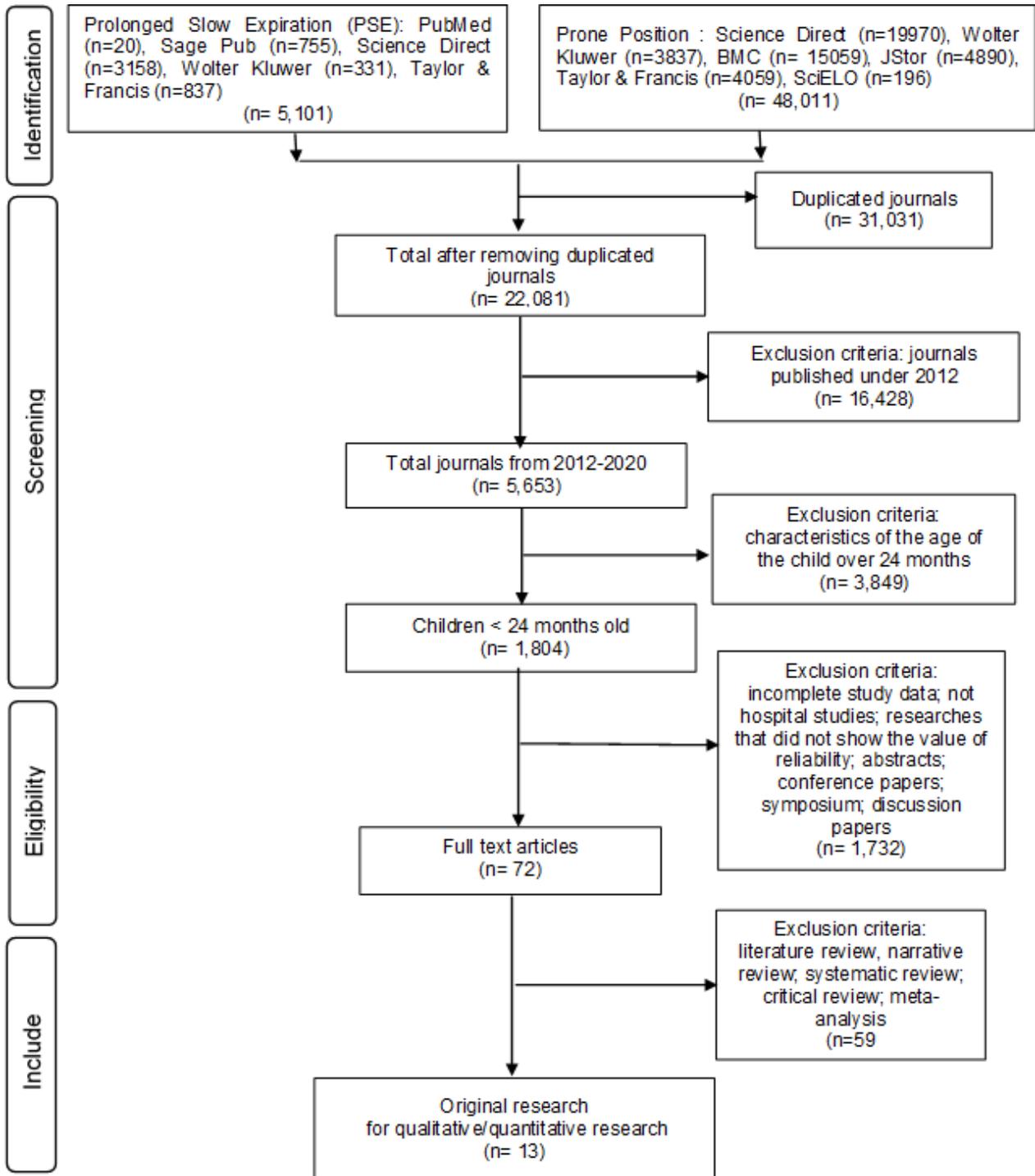
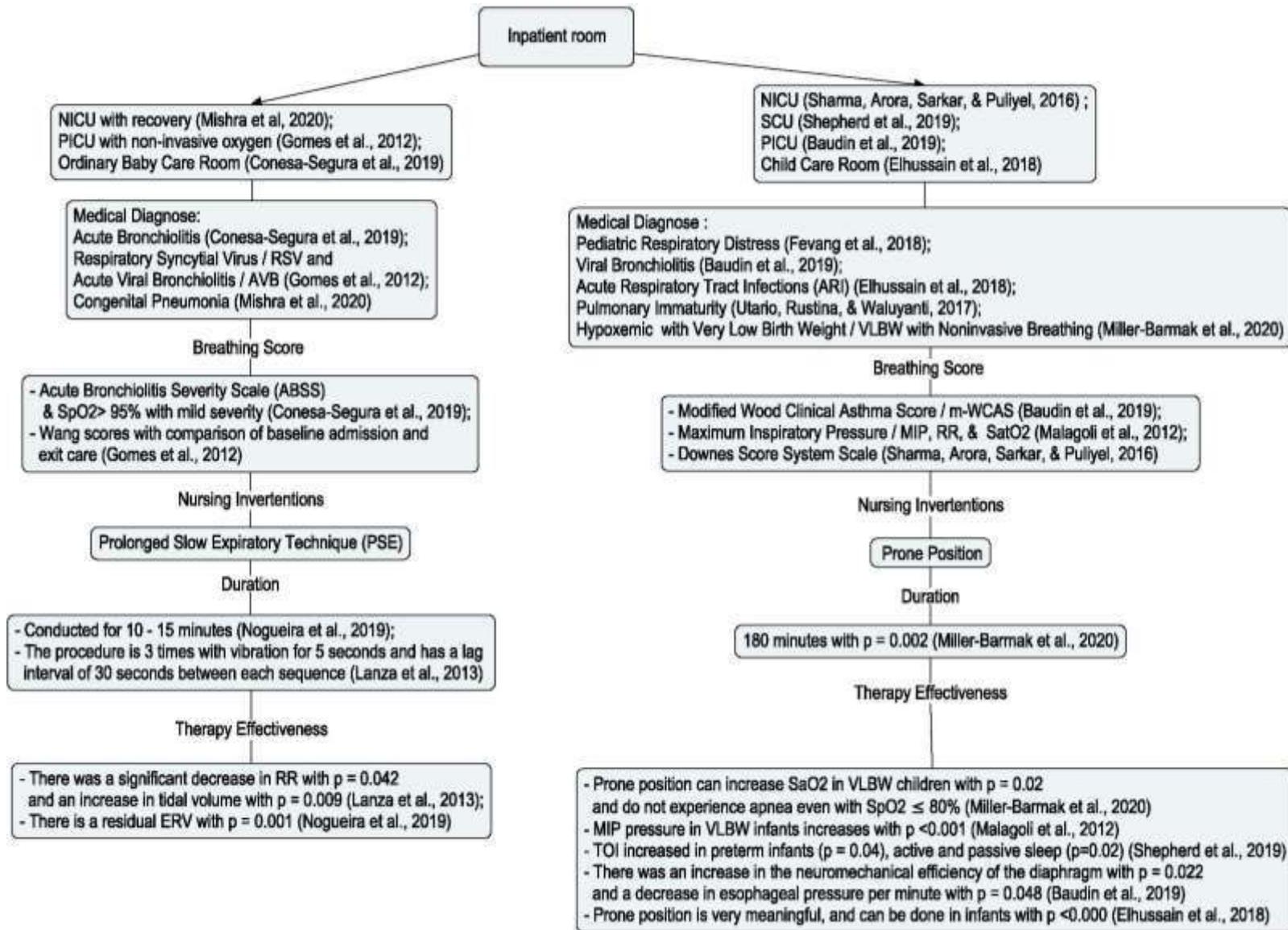


Table 2. Summary of studies

No	Title (Author)	Design	Samples	Aim	Results
1	Effect of Prolonged Slow Expiratory Technique as an Adjunct to Pulmonary Rehabilitation in Resolving Pulmonary Congestion in Neonates with Congenital Pneumonia (Mishra et al., 2020)	Case Report	Two cases with congenital pneumonia: a 6-day old baby girl and a 4-day old baby boy were diagnosed with congenital pneumonia.	To determine the effectiveness of PSE therapy for cleansing pulmonary secretions and improving other respiratory functions	PSE therapy can stimulate diaphragm and lung movement; minimize the occurrence of pulmonary congestion; effective only in children with mild acute respiratory distress in the NICU.
2	Oxygenation Instability Assessed by Oxygen Saturation Histograms During Supine Vs Prone Position in Very Low Birthweight Infants Receiving Noninvasive Respiratory Support (Miller-Barmak et al., 2020)	Prospective, Crossover, Observational Study	23 babies were born with Very Low Birth Weight (VLBW) with noninvasive breathing.	To determine the effectiveness of the prone position compared with the supine process against SpO2 in very low birth weight babies using invasive breathing devices	The prone position did not make the patient apnea and not decrease oxygen saturation.
3	Prolonged Slow Expiration Technique Improves Recovery from Acute Bronchiolitis in Infants: FIBARRIX Randomized Controlled Trial (Conesa-Segura et al., 2019)	Randomized Controlled Trial	80 infants with acute bronchiolitis	To see the effectiveness of PSE therapy in acute bronchiolitis children with bronchiolitis severity scale instruments and O2 saturation from initial admission to hospital discharge	PSE therapy reduced the severity of acute bronchiolitis; was more effective when combined with inhalation therapy; there was no increase in oxygen saturation.
4	Is Prolonged Slow Expiration a Reproducible Airway Clearance Technique? (Nogueira et al., 2019)	Cross-Sectional Study	16 children aged 59 weeks, SpO2 > 93%, no wheezing sound, heart rate 110-140 beats per minute (bpm), had an expiratory reserve volume (ERV)	To assess reliability and agreement between physiotherapists during the application of PSE in infants with wheezing	PSE therapy can reduce mucus production and prevent children from more severe respiratory problems.
5	Physiological Effect of Prone Position in Children with Severe Bronchiolitis: A Randomized Cross-Over Study (BRONCHIO-DV) (Baudin et al., 2019)	Randomized Cross-Over Study	14 newborns aged 25-58 days, diagnosed with viral bronchiolitis, hospitalized in NICU/PICU, needed for respiratory support by nCPAP	To see inspiratory effort, respiratory metabolism, diaphragm movement when given the prone position versus the supine position in children with severe bronchiolitis who use noninvasive ventilation	The prone position was effective in reducing inspiratory efforts and respiratory metabolism; did not occur in the esophagus; and maintained the neuromechanical efficiency of the diaphragm.
6	Effects of Prone Sleeping on Cerebral Oxygenation in Preterm Infants. (Shepherd et al., 2019)	Quasy Experiment	56 very premature and premature babies	To determine the effect of semi-prone on the fulfillment of lung oxygenation of children's brains while sleeping in the NICU	Prone position had an effect in increasing cerebral tissue oxygenation index (TOI), arterial SaO2, and the child felt comfortable and did not fuss while sleeping.
7	Semiprone Position is Superior to Supine Position for Paediatric Endotracheal Intubation During Massive Regurgitation, A Randomized Crossover Simulation Trial	Randomized Crossover Simulation Trial	18 children with high-risk respiratory distress attached to endotracheal tube who were treated in the	To determine the speed of inserting the ETT during the management of respiratory distress in a patient in the semi-	Management of respiratory distress during intubation in the semi-prone position was more effective than the supine position; researchers experienced the ease of clearing the airway.

No	Title (Author)	Design	Samples	Aim	Results
	(Fevang et al., 2018)		NICU/PICU rooms	prone position, compared with the supine position	
8	Comparison of Respiratory Status Between Semi- Fowler and Elevated Prone Position Among Under 5 Years Old Children with Acute Respiratory Tract Infection in Ibrahim Malik Hospital Sudan	Prospective Based Study	401 children aged < 5 years with grouped acute respiratory tract infections (ARI)	To assess the respiratory rate (RR) between the prone versus semi-fowler positions	The prone position had a greater effect on neonates and infants than toddlers with severe respiratory distress in reducing the respiratory frequency.
	(Elhussain et al., 2018)				
9	The Quarter Prone Position Increases Oxygen Saturation in Premature Infants Using Continuous Positive Airway Pressure	Randomized Controlled Trial with Crossover Design	15 premature babies treated in the NICU room with pulmonary immaturity	To measure the benefits of the quarter prone position on the oxygenation status of preterm infants using CPAP in NICU	The quarter prone position was effective for improving oxygenation status even when using CPAP.
	(Utario et al., 2017)				
10	A Randomized Clinical Trial to Assess the Effectiveness of Prone Position on Cardiorespiratory Outcomes Among Infants with Respiratory Distress	Randomized Clinical Trial	60 babies in childcare units (NICU, PICU, and post-ICU)	To assess and compare the effect of the prone and supine positions on cardiorespiratory outcomes among infants with respiratory distress and to investigate complications of prone position administration	The prone position was effective for improving cardiorespiratory function and reducing moderate levels of respiratory distress.
	(Sharma et al., 2016)				
11	Impact of The Prolonged Slow Expiratory Maneuver on Respiratory Mechanics in Wheezing Infants	Cross-Sectional Study	18 babies aged 4-24 months	To determine the effect of three maneuvers (maneuver A PSE, maneuver B PSE, and maneuver C PSE) on breathing	This breathing therapy technique was able to induce significant changes in VT (Tidal Volume) and RR (Respiratory Rate) in infants with repeated wheezing, even without exacerbations.
	(Lanza et al., 2013)				
12	Chest Physical Therapy Is Effective in Reducing the Clinical Score in Bronchiolitis: Randomized Controlled Trial	Randomized Controlled Trial	30 babies aged 28 days to 24 months, infants with respiratory syncytial virus (RSV), and infants with acute viral bronchiolitis (AVB)	To evaluate the effectiveness of chest physical therapy (nCPT chest physical therapy with new techniques, PSE and CRR) in reducing the clinical score in infants with acute viral bronchiolitis (AVB)	There was a decrease in the respiratory rate for 24 hours and the children were able to breathe normally again after 72 hours of receiving PSE therapy. There was an increase in oxygen saturation after 72 hours of treatment. Wang's clinical score showed the effectiveness of nCPT therapy in children with bronchiolitis.
	(Gomes et al., 2012)				
13	Influence of Prone Position on Oxigenation, Respiratory Rate and Muscle Strength in Preterm Infants Being Weaned from Mechanical Ventilation	Cross-Sectional Study	45 babies with gestation age ranged from 26 to 34 weeks, body weight was > 1500 grams, evaluated for respiratory distress	To see the effect of the prone position on the breathing force, oxygenation, and breathing rate between the prone position and the supine position	The prone position for the neonate in the NICU can increase the SpO2 but cannot decrease respiratory rate.
	(Malagoli et al., 2012)				

Diagram 1. Stages of PSE therapy implementation and prone position in children aged <24 months with respiratory distress



RESULT

The incidence of respiratory distress in children aged less than 24 months is still high in poor and developing countries. Kemenkes RI (2019) reported that one of the causes of the high mortality rate in children is due to respiratory disorders in children, therefore it is noteworthy to implement independent nursing interventions to improve lung function in children (Mishra & Samuel, 2018). After selecting journals based on the inclusion and exclusion criteria, it was retrieved 13 articles published in 2012-2020 were included in this review. Table 2 shows the data extraction of the articles.

Research studies on the provision of Prolonged Slow Expiratory (PSE) therapy and prone position can be given to children aged < 24 months with respiratory problems. PSE therapy is usually given to infants aged 0 to less than 24 months of age who experience improvement in oxygen saturation and generally it is for children who undergo care in the neonatal intensive care unit (NICU) and high care unit (HCU) (Mishra & Samuel, 2018). Nurses need to remember that giving this therapy aims to clear the patient's airway due to an excess secretion (Mishra & Samuel, 2018) and they must pay attention to the anatomy, physiology, and psychology of children (Bellanti & Settupane, 2018). Giving PSE can not only be given to children who have mild respiratory distress but also to the patient's hemodynamic within normal limits (Mishra et al., 2020). PSE can be combined with another chest physiotherapy to reduce the amount of sputum (Conesa-Segura et al., 2019), can increase tidal volume, and reduce the respiratory rate so that it does not obstruct the patient's airway (Lanza et al., 2013).

Giving the prone position to children aged < 24 months with respiratory distress due to lung immaturity in premature babies, early acute lung injury, and infections caused by bacteria and viruses such as pneumonia, bronchiolitis, and COVID-19, actually provides benefits because it can increase oxygen saturation even after using a mechanical ventilator. However, this position should be stopped when PaO2/FiO2 ≥ 150; OI < 12; OSI < 10 in children suffering from COVID-19 (Kneyber et al., 2020). The prone position can also reduce the respiratory rate in children (Elhussain et al., 2018), Tissue Oxygenation Index (TIO), make better quality of sleep (Shepherd et al., 2019), prevent diuresis, and maintain fluid balance in children (Dall' Agnese et al., 2019), as well as increase the neuromechanical efficiency of the diaphragm, decrease esophageal pressure (Baudin et al., 2019), and decrease maximal inspiratory pressure (MIP) so as not to obstruct the patient's breathing (Malagoli et al., 2012) (Table 2).

Before implementation, nurses also need to know the medical diagnosis, respiratory measurement scale, duration, and effectiveness of each therapy for the patient's body (Diagram 1).

DISCUSSION

Acute respiratory disorders of children in intensive inpatient rooms every year amounted to 14.46%. The nurse's inability to think critically can lead to worsening child conditions (Yin et al., 2016). Of the 13 studies that have been reviewed, it was proven the effectiveness of PSE therapy and prone position to improve the respiratory status of hospitalized children aged < 24 months in inpatient rooms. In this study, researchers have also attempted to develop steps to make it easier for nurses to provide PSE and prone position therapy based on literature searches and can be seen in Table 3.

Table 3. Procedure for PSE and prone position

Action	Definition and Work Steps	Indications and Contraindications
<i>Prolonged Slow Expiratory (PSE)</i>	<p>The newest chest physiotherapy technique used in clinical practice in hypersecretory children to remove secretions and reduce hyperventilation (Nogueira et al., 2019).</p> <p>PSE work steps (Mishra et al., 2020):</p> <ol style="list-style-type: none"> Provide information and education to parents prior to action and prepare equipment before action is taken. Wash hands before action. The patient is positioned in a supine position in a comfortable condition and the vital signs are normal, the body is relaxed, and the patient's behavior is calm. During the procedure, place one hand over the chest cavity and the other hand over the abdominal cavity, just above the umbilicus. In the final expiration phase, the therapist exerts a compressive force from the hypothenar (palm) and at the same time presses from the upper hand (the hand above the chest cavity), and gives pressure from the lower hand (the hand above the abdominal cavity). This compression is maintained for 4–5 seconds followed by slow release. One set of three compressions is given three times with a pause of 30 seconds between each compression. 	<p>Indications:</p> <ol style="list-style-type: none"> Reducing the secretion of sputum in the child's body Can be given to children with "repeated wheezing" <p>Contraindications:</p> <ol style="list-style-type: none"> Cannot be given to children with airway obstruction Cannot be given to infants with gastroesophageal reflux disease, babies who have undergone thoracic and/or abdominal surgery and have been diagnosed with heart disease or neuropathy

Action	Definition and Work Steps	Indications and Contraindications
<i>Prone Position</i>	<p>This is a simple action by reversing the patient's body position to increase oxygenation throughout the patient's body, especially in patients with respiratory disorders and hypoxemia (Jagadeeswari & Soniya, 2020).</p> <p>The work steps of prone position (Guérin et al., 2013):</p> <ol style="list-style-type: none"> Provide information and education to parents before taking action and prepare equipment before action. Assess the patient's condition from oxygen saturation, respiration rate, lung roentgen in the patients, and make sure the length of the ventilator circuit according to patient needs. Check the fit of the endotracheal tube and NGT/OGT tube and protect the patient's knees, forehead, chest, and iliac crest to prevent pressure sores. Keep nurses clean by washing hands before taking action. Work with 3 to 4 nurses to change the patient to a prone position to maintain the patient's head, endotracheal tube, and ventilator. Be sure to take priority direction of the patient's central vein when turning the patient over. The patient is transferred to the sagittal plane and remains in this position for a while. The goal is to make it easier to attach the heart electrodes to its back and attach a base to prevent the risk of pressure sores. 	<p>Indications:</p> <ol style="list-style-type: none"> Can be given to patients who have moderate to severe ARDS Can be given to children using MV (mechanical ventilation) <p>Contraindications:</p> <ol style="list-style-type: none"> Cannot be done in children with post-thoracic surgery, tracheostomy, patients receiving renal and abdominal therapy Patients with a history of congenital heart disease and Intraventricular Hemorrhage (IVH)

The review of PSE therapy noted that there was an increase in tidal volume in children during treatment at the NICU and HCU. Sound "wheezing" was reduced in both lungs and the lungs did not experience an exacerbation. PSE therapy was able to stimulate the release of sputum in children over 12 months of age and can reduce the respiratory rate in children with congenital pneumonia when it was given routinely within 24 hours of treatment. In addition, newborns who have respiratory problems can also be given PSE therapy as long as they use non-invasive oxygen devices - such as nasal canula oxygen with an APGAR value > 7 for 5 minutes and 10 minutes of birth, and have stable child vital signs. The children were calm and oxygen saturation > 96% or within normal limits. PSE therapy can be combined with other chest physiotherapies such as clapping and postural drainage to remove thick and reduce pain in the chest cavity when it is expelled. PSE therapy can also be done with other methods of nCPT (PSE, retrograde rhino-pharyngeal cleaning chest physiotherapy technique) and it was proven of no side effects in children. A measurement to see the effectiveness of PSE therapy can be done before and after the use of the Wang Score or CS by comparing the results before and after therapy. The prone position also provides benefits to children aged < 24 months who experience respiratory problems, i.e., reducing child pneumonia from moderate to severe pneumonia and increasing SpO2 from ≤ 80% to > 94% of children with very low birth weight (VLBW) in premature babies, as well as preventing apnea and reducing the frequency of breathing when the children experiencing hyperpnea (Elhussain et al., 2018).

The limitation of this study is only generally reviewing the effects of PSE therapy and prone position on respiratory function in hospitalized children aged under 24 months with respiratory distress in inpatient rooms. Further reviews are expected to evaluate which therapies give the best result when hospitalized children aged < 24 months experience respiratory distress in inpatient rooms.

CONCLUSION AND RECOMMENDATION

PSE therapy and prone position are effective in reducing the respiratory frequency and improving lung function to speed up the healing process in children aged < 24 months with respiratory distress, and therefore this is a recommended nursing intervention in pediatric wards. It is worth noting that both therapies are also safe and have no side effects. However, PSE therapy can only be applied to children with normal vital signs and showing mild respiratory distress symptoms, while the prone position can be applied to a more varied condition. In addition, the provision of PSE therapy will be more effective when combined with other types of chest physiotherapies while the prone position does not require a combination of other actions. In practice, PSE is an active intervention that is only given for a certain period of time, while the prone position can be done for a longer time.

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