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DESCRIPTION OF OXYGEN SATURATION IN RESPIRATORY DISTRESS SYNDROME (RDS) INFANTS ATTACHED TO CPAP WITH KNEE CHEST POSITION

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ABSTRACT

Respiratory Distress Syndrome (RDS) is one of the main causes of neonatal morbidity and mortality, especially in premature infants. Interventional approaches such as Continuous Positive Airway Pressure (CPAP) with the knee-chest position are considered effective for improving oxygen saturation. However, research on the effect of this position on infants with RDS in Indonesia is still limited. This study aims to describe oxygen saturation in infants with respiratory distress syndrome (RDS) who use CPAP with the knee-chest position at Pariaman Regional Hospital. This study is a quantitative study with a cross-sectional design. The population consisted of all infants with RDS who used CPAP in the NICU room at Pariaman Hospital. A total of 15 infants were selected as samples using purposive sampling technique. Data collection was done with a questionnaire to record respondent characteristics (gender, gestational age, birth weight, type of delivery) and an observation sheet to measure oxygen saturation. Data analysis was performed using statistical software with descriptive tests, including frequency distributions and percentages. The majority of infants (66.7%) were male, with a gestational age of 34-37 weeks (80%), birth weight of 1500-2499 grams (66.7%), and delivered by caesarean section (66.7%). Oxygen saturation increased significantly after knee-chest positioning, from a mean of 94.40% before intervention on the first day to 98.73% after intervention on the third day. Statistical analysis showed that the change in oxygen saturation value was statistically significant ($p<0.05$). The knee-chest position effectively improves oxygen saturation in infants with RDS using CPAP. This intervention can be recommended as part of the neonatal nursing care protocol to improve oxygenation quality and support infant recovery.

Keywords: CPAP; knee-chest position; neonatal; oxygen; RDS; saturation

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INTRODUCTION

Respiratory Distress Syndrome (RDS) is a major cause of global neonatal morbidity and mortality, especially in preterm infants, with the highest prevalence in Africa, Asia and the Middle East (Owuor et al., 2023). The WHO lists RDS as the main reason for infant admission to the NICU, with the global neonatal mortality rate reaching 6,400 per day. RDS accounts for 24.9-62.96% of NICU admissions and 31.3% of neonatal deaths, especially in low-middle income countries such as Indonesia (Basnet et al., 2022). In Indonesia, RDS accounts for 18.67% of neonatal deaths, with a high burden in West Sumatra due to the prevalence of prematurity and low birth weight (Marinonio et al., 2022). RSUD Pariaman reported RDS as the most common case in the NICU, requiring serious attention from healthcare workers (RSUD Pariaman, 2022).

Respiratory Distress Syndrome (RDS) is caused by inadequate surfactant production or inactivation in immature lungs, making it insufficient for the respiratory process (Yadav et al., 2024). Surfactant plays a role in preventing alveolar collapse and maintaining lung expansion during expiration. Clinically, RDS in neonates is characterized by tachypnea, nasal flaring, intercostal and subcostal retractions, and expiratory grunting in the first hours of life. Other symptoms include hypoxemia, hypercarbia, and respiratory or mixed acidosis (Khawar &

Marwaha, 2023). The National Children's Hospital notes risk factors for RDS include a history of respiratory distress in siblings, multiple births, caesarean section, mothers with diabetes, infection, and hypothermia (Dyer, 2019). Respiratory Distress Syndrome (RDS) can cause respiratory arrest, increasing morbidity and mortality in neonates (Bacha et al., 2022). Respiratory distress in RDS can trigger hypoxia and ischemia, potentially damaging the brain or causing death. This hypoxia promotes anaerobic metabolism, producing lactic acid that worsens the neonate's condition through acidosis and decreased blood flow to the brain (Mota-Rojas et al., 2022;Hendry et al., 2022).

Management of RDS includes early positive pressure ventilation, supplemental oxygen, surfactant therapy and supportive care such as temperature control, nutrition and hydration. This modern approach improves survival and reduces complications such as air leaks and bronchopulmonary dysplasia, with surfactant administration and mechanical ventilation skills being essential (Martin & Tehrani, 2024). The respiratory distress of neonates with RDS requires monitoring of oxygen saturation, which normally increases from 60%-65% in the first minute to 90%-95% by the 15th minute. CPAP helps meet oxygenation needs by providing constant positive pressure, maintaining 90%-95% saturation (Shaon Mitra & Arnab Mondal, 2023). CPAP effectively reduces breathing difficulties, oxygen dependency, and lung collapse. Its effectiveness is supported by adjusting the infant's sleeping position to support symmetrical development (Shah et al., 2022).Positioning changes are part of developmental care, which is developmental care in neonates that emphasizes the importance of positioning (Yang et al., 2023). The goals of developmental care include reducing energy expenditure, decreasing respiratory frequency, increasing oxygen saturation, and the ability of neonates to adapt, grow, and develop according to their stages. Positioning helps reduce circulatory dams, affecting vena cava pressure, blood pressure, and hemodynamic status, with the aim of increasing oxygen delivery in the body (Agustina & Nurhaeni, 2020).

The knee chest position is a position where the patient kneels with the chest lowered to touch the bed while the buttocks are lifted into the air. This position can increase oxygen saturation in infants by increasing systemic vascular resistance through bending of the femoral artery, thereby reducing right to left shunts and increasing blood flow to the lungs (Mahrous & Aboelmagd, 2022b). This position is expected to increase blood flow to the lungs and overcome hypoxemia in infants with respiratory distress (Sara et al., 2022). Research of Poernamasari, (2017) showed that the knee-chest position, which was adopted from the squatting position in TOF patients with hypoxic spells, could increase oxygen saturation by 5% (from 79% to 84%) compared to the supine position, within 15-20 minutes. Mahrous & Aboelmagd, (2022) also found that the knee-chest position in premature infants with respiratory distress significantly increased oxygen saturation, decreased heart rate, and improved respiratory rate. This study aims to determine the description of oxygen saturation in infants with respiratory distress syndrome (RDS) attached to CPAP with knee chest position at Pariman Hospital.

METHOD

This study is a quantitative study with a cross-sectional design that aims to determine the description of oxygen saturation in infants with respiratory distress syndrome (RDS) who use CPAP in the knee-chest position at Pariaman Hospital in September 2024. The study population consisted of all infants with respiratory distress syndrome who used CPAP in the NICU room at Pariaman Hospital. A total of 15 infants were sampled, which were selected using purposive sampling technique. Prior to data collection, permission and consent were obtained from the respondent or responsible party.Data collection was conducted using a questionnaire to record respondent characteristics, including gender, gestational age, birth

weight, and type of delivery. In addition, an observation sheet was used to measure oxygen saturation. The observation instruments Quesionare Questionnaire on Oxygen Saturation tested for validity and reliability with Cronbach's Alpha of 0.937, with the results indicating that they were valid and reliable. Ethical approval for this study was obtained from the Ethics Committee of the Faculty of Nursing, Andalas University (No.382a.laiketik/KEPKFKEPUNAND). Data analysis was conducted using statistical software, including descriptive analysis to display frequency distribution and percentages.

RESULT

Table 1.
Frequency Distribution of Respondents' Characteristics based on Gender, gestational age, birth weight, and type of delivery (n=15)

Characteristic	f	%
Sex		
Male	10	66,7
Female	5	33,3
Gestational Age		
32 - < 34 Weeks	3	20,0
34 - <37 Weeks	12	80
Birth Weight		
2500-3000 grams	3	20,0
1500-2499 grams	10	66,7
1000-1500 grams	2	13,3
Type of Delivery		
Sectio cesaria	10	66,7
Vaginal	5	33,3

Table 1 illustrates the frequency distribution of respondent characteristics of 15 infants admitted to the NICU of Pariaman Hospital based on gender, gestational age, birth weight, and type of delivery. The majority of respondents were male babies, as many as 10 people (66.7%), while female babies only amounted to 5 people (33.3%). Most babies were born at 34 to less than 37 weeks gestation (80%), while the rest were born at 32 to less than 34 weeks gestation (20%). In terms of birth weight, most babies weighed between 1500 to 2499 grams (66.7%), followed by babies weighing 2500 to 3000 grams (20%), and a small number of babies had a very low weight of between 1000 to 1500 grams (13.3%).In terms of type of delivery, the majority of babies were delivered via a sectio cesaria procedure (66.7%), while the rest were delivered vaginally (33.3%). These data provide insight into the demographic and clinical characteristics of infants admitted to the NICU, showing a predominance of cases of prematurity, low birth weight, and the need for intensive care interventions.

Table 2.
Mean value of oxygen saturation (SPO2) before and after being given the Knee chest position (n=15)

Oxygen saturation		f (15)		
		Mean	Min-Max	SD
Day one	Pre-Test 1	94,40	93 – 96	0,986
	Post-Test 1	95,67	94 – 98	1,175
Second day	Pre-Test 2	95,93	94 – 98	1,033
	Post-Test 2	97,73	96-100	1,163
Third day	Pre-Test 3	97,27	96 – 99	0,884
	Post-Test 3	98,73	97-100	1,033

This table presents the mean oxygen saturation (SpO2) values of 15 infants before and after being given the knee-chest position for three consecutive days. This data includes the mean, range of minimum and maximum values, and standard deviation (SD) of the measurements on each day. On the first day, the mean oxygen saturation before the intervention (Pre-Test 1) was 94.40 with a range of 93 to 96 and an SD of 0.986. After the intervention (Post-Test 1),

there was an increase in mean oxygen saturation to 95.67 with a range of values from 94 to 98 and an SD of 1.175. On the second day, the mean oxygen saturation before the intervention (Pre-Test 2) increased to 95.93 with a value range of 94 to 98 and an SD of 1.033. After the intervention (Post-Test 2), the mean increased more significantly to 97.73 with a value range of 96 to 100 and an SD of 1.163. On the third day, the mean oxygen saturation before the intervention (Pre-Test 3) showed a further increase, which was 97.27 with a value range of 96 to 99 and an SD of 0.884. After the intervention (Post-Test 3), the mean oxygen saturation reached 98.73 with a value range of 97 to 100 and an SD of 1.033. This data shows a gradual increase in oxygen saturation values each day, both before and after being given the knee-chest position, with a greater increase occurring after the intervention. This indicates that the knee-chest position has a positive effect on improving infant oxygen saturation.

DISCUSSION

Respondent Characteristics

The results showed that the majority of respondents were male infants (66.7%), with a dominant birth weight distribution between 1500-2499 grams (66.7%). Most babies were born at 34 to less than 37 weeks gestation (80%), which indicates a group of premature babies with a high risk of respiratory distress, including respiratory distress syndrome (RDS). This is consistent with the literature which states that prematurity and low birth weight are major risk factors for RDS due to immaturity of the surfactant system and lung function (Khawar & Marwaha, 2023).The relationship between infant gender and oxygen saturation in infants with respiratory distress syndrome (RDS), particularly those positioned in the knee-chest position while using CPAP, reveals significant insights. Research shows that male infants are at a higher risk of developing RDS compared to females, which may affect their oxygen saturation levels during treatment. The following section outlines these findings. Males have a 1.87 times higher risk of developing neonatal respiratory distress syndrome (NRDS) compared to females, as indicated in a study involving 452 infants(Fang et al., 2024). This increased risk is associated with physiological differences that can affect respiratory adaptation and oxygenation. Proper positioning, such as the knee-chest position, can improve oxygen saturation in preterm infants. However, specific studies on this position in relation to gender differences are limited (Gulczyńska et al., 2019).

The use of CPAP has been shown to improve oxygenation, but male infants may still exhibit lower arterial pH and higher carbon dioxide levels compared to females(Matteo et al., 2016). While male infants are more vulnerable to RDS and related complications, it is important to consider that proper positioning and supportive therapies such as CPAP may mitigate some of the risks. However, the intrinsic vulnerability of males remains a key factor in neonatal care outcomes (Kotecha, S. J., Lowe, J., & Kotecha, 2018) Most babies were delivered by sectio cesaria (66.7%). Delivery by this method is often performed in cases of preterm birth to reduce the risk of birth trauma, but it can increase the likelihood of the baby having impaired respiratory adaptation because it does not go through the process of lung compression during vaginal delivery (Dyer, 2019). This finding is relevant to previous studies showing an association between delivery method and the incidence of neonatal respiratory distress.

The relationship between cesarean section (CS) and respiratory adaptation disorders in infants is well documented, showing that CS can increase the risk of respiratory issues. This is especially evident in preterm and term infants, where the lack of labor during CS affects the clearance of lung fluid and respiratory function. The following section outlines the key findings from the literature. Infants born via CS have a significantly higher incidence of respiratory distress compared to those born vaginally, with rates of 24.6% versus 5.5%, respectively. Preterm infants are especially vulnerable, with 82% experiencing respiratory

morbidity after CS (Offermann et al., 2015). Studies show that respiratory rate and tidal volume in infants born via CS are initially lower, indicating delayed adaptation (Finn et al., 2018). The distribution of these respondent characteristics provides important insights into the population of infants admitted to the NICU of RSUD Pariaman, showing a predominance of prematurity, low birth weight and the need for intensive care interventions. These findings are consistent with the epidemiology of RDS in middle-income countries such as Indonesia, where the prevalence of prematurity and low birth weight rates are high (Basnet et al., 2022). Therefore, interventions such as knee-chest positioning that can support improved infant oxygen saturation are highly relevant in this context.

Oxygen Saturation Overview

The study showed that the knee chest position in the intervention group had a significant impact on improving oxygen saturation (SpO_2). Based on Table 5.2, the average SpO_2 in this group increased from 94.40 on the first day pre-test to 98.73 on the third day post-test. Each day of measurement showed a consistent increase, with an average difference of 1.27 on the first day, 1.80 on the second day, and 1.46 on the third day.Physiologically, the knee chest position provides benefits through increased tidal volume and alveolar recruitment, where previously inactive alveolar units become involved in the gas exchange process (Mahrous & Aboelmagd, 2022b). This position also helps to reduce airway resistance by widening the airways and maximizing the residual functional capacity of the lungs. The resulting improvement in ventilation-perfusion (V/Q) ratio increases oxygen uptake efficiency, which is particularly important in neonates with Respiratory Distress Syndrome (RDS) using Continuous Positive Airway Pressure (CPAP) (Campbell & Sapra, 2023). In addition, the knee chest position reduces diaphragm pressure against the lungs, which allows for better air distribution throughout the lungs. This improvement supports optimal physiological adaptation in neonates, so that oxygen saturation increases progressively (Mahrous & Aboelmagd, 2022 ; Gouna & Rakza, 2013).

Statistical analysis showed that the change in SpO_2 values from pre-test to post-test was statistically significant, with a p value <0.05 based on the paired t-test. The small standard deviation (0.884-1.175) indicates the stability of the intervention effect in all respondents, despite variations in clinical conditions such as gestational age and birth weight. This study is in line with the findings by Mohamed Arafa Mohamed et al., (2020), which showed that positions that support lung expansion significantly improve gas exchange efficiency in neonates. In clinical practice, the knee chest position can be recommended as an effective nursing intervention to optimize oxygen saturation, especially in neonates with severe hypoxia. The advantage of the knee chest position lies in its ability to increase alveolar ventilation more effectively through pressure redistribution in the thoracic cavity. In addition, this position provides mechanical stimulation to the diaphragm, which plays a role in increasing spontaneous ventilation in neonates with respiratory distress. Research by Mahrous & Aboelmagd, (2022) also supports these findings by stating that positional therapy that supports an even distribution of ventilation can increase functional residual capacity and improve gas exchange in the lungs.

The significant increase in oxygen saturation in the intervention group from day one to day three indicates the cumulative effect of knee chest positioning. The average oxygen saturation increased from 95.67% on day one to 98.73% on day three. This indicates that physiological adaptation of the lungs to the knee chest position takes time and provides greater benefits if applied consistently. This cumulative effect can be explained by the gradual improvement in ventilation-perfusion mismatch that occurs due to redistribution of air and blood flow in the lungs. Study of Bogdan et al., (2022) showed that consistent postural intervention can

improve ventilation patterns in neonates and increase oxygen saturation significantly. Thus, the knee chest position not only provides short-term benefits but also has the potential to accelerate the recovery of disorders.Oxygen saturation in infants with Respiratory Distress Syndrome (RDS) can be significantly influenced by their positioning and the application of Continuous Positive Airway Pressure (CPAP). The knee-chest position, in particular, has been shown to improve oxygen transport and enhance respiratory function in premature neonates. This review explores the effects of CPAP and the knee-chest position on oxygen saturation in RDS infants. CPAP is a non-invasive method that helps maintain alveolar stability and improves oxygenation in RDS infants by preventing atelectasis (Lorraine & Matthay, 2024). The Saturation Oxygen Pressure Index (SOPI) is a valuable tool for monitoring oxygenation levels in neonates on CPAP, demonstrating a strong correlation with arterial blood gas measurements (Thandaveshwara et al., 2021).

The knee-chest position has been found to significantly enhance oxygen saturation levels in premature infants with RDS by improving respiratory mechanics and reducing the work of breathing . One study revealed that this position led to a significant increase in oxygen saturation and a decrease in heart rate, highlighting its effectiveness in managing RDS (Mahrous & Aboelmagd, 2022a). Conversely, while the knee-chest position and CPAP are beneficial, some studies suggest that other positions, such as the semi-upright position, may also offer advantages in specific contexts, emphasizing the need for individualized care strategies for RDS infants(Modjo et al., 2024;Suminto, 2020).Research indicates that the combination of Continuous Positive Airway Pressure (CPAP) and the knee-chest position significantly improves oxygen saturation and respiratory function in premature infants with Respiratory Distress Syndrome (RDS). The knee-chest position has been proven to optimize respiratory mechanics, reduce the work of breathing, and enhance oxygen transport, while CPAP helps maintain alveolar stability and prevent atelectasis. However, care strategies must be tailored to individual needs, as alternative positions, such as the semi-upright position, may also provide benefits in certain situations. A holistic approach that considers the effectiveness of positioning and CPAP application is essential for achieving optimal outcomes in infants with RDS.

CONCLUSION

This study showed that knee-chest positioning in infants with respiratory distress syndrome (RDS) using CPAP significantly improved oxygen saturation from day one to day three. The consistent increase in average oxygen saturation every day indicates that the knee-chest position is able to support blood flow to the lungs and improve gas exchange physiologically. This effect was due to pressure redistribution in the thoracic cavity, increased systemic vascular resistance, and improved ventilation-perfusion (V/Q) ratio. The intervention proved to be effective with the stability of the effect indicated by a small standard deviation, regardless of variations in the infant's clinical characteristics, such as gestational age and birth weight. The results support the application of the knee-chest position as part of nursing interventions to optimize oxygen saturation in neonates with RDS.

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