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Research Article

The Effect of Oxygen Inhalation Therapy on Hemodynamics (Heart Rate and Respiratory Rate) in Toddlers with Pneumonia

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Abstract

Background: Pneumonia causes the lung tissue to become inflamed, the alveoli are filled with pus and fluid causes difficulty in oxygen absorption resulting in difficulty breathing. Inhalation therapy employing high-pressure air will change the drug into an aerosolized format that can be breathed into the respiratory system.
Objectives: The purpose of this study was to determine the effect of inhalation therapy using oxygen on hemodynamics (Heart Rate and Respiratory Rate) in children under five with pneumonia.
Methods: The design of this study was a quasy experiment with the control group and the intervention group, the number of respondents in this study was 32 respondents who were divided into two groups, the sampling used was a simple random sampling method.
Results: The results showed that the mean heart rate value of the intervention group compared to the control group was 124bpm vs 131bpm, in addition to that the mean respiratory rate value of the intervention group and control group was 28bpm vs 32bpm. from the results of the bivariate analysis it was found that there was an influence before and after in oxygent inhalation with p-value 0.000
Conclusion: Oxygen inhalation therapy is very useful in improving patient hemodynamics, although in this study the number of respondents is still limited, which may not represent the entire patient population with the same characteristics.

Keywords: pneumonia, inhalation therapy, hemodynamics

Introduction

Respiratory diseases are one of the common causes of illness and death in children. One of them is pneumonia. Pneumonia is an acute infection of lung tissue that can be caused by bacteria, viruses, fungi, exposure to chemicals, or physical damage to the lungs. Pneumonia is an endemic disease and a significant public health problem in most developing countries, including Indonesia.[1] Pneumonia causes nearly four million deaths in children worldwide every year. In 2019, pneumonia caused the deaths of 740,180 children under five years of age or accounted for 14% of all deaths of children under five years of age.[2] More than 90% of the estimated 1.8 million annual deaths from acute respiratory infections in children under 5 years of age occur in developing countries and are primarily caused by bacterial infections.[3] Half of the under-five deaths due to pneumonia occurred in five countries, including Nigeria (162,000), India (127,000), Pakistan (58,000), the Democratic Republic of Congo (40,000), and Ethiopia (32,000). Pneumonia is also the biggest cause of death for children under five in Indonesia. In 2018, it is estimated that around 19,000 children died from pneumonia. Global estimates show that every hour 71 children in Indonesia contract pneumonia.[4]

Pneumonia causes inflammation of the lung tissue, the alveoli fill with pus and fluid, causing difficulty absorbing oxygen and breathing problems. Children suffering from pneumonia experience a decrease in lung capacity, causing rapid breathing to prevent hypoxia.[5] According to Maulana's research (2018), one of the treatments for pneumonia patients is collaborative nursing care with the medical team which includes nebulizer therapy. Nebulizer therapy aims to thin mucus, reduce bronchospasm and bronchial hyperactivity, and treat infections. Nebulizers produce finer particles, ranging from 2-8 microns, which can settle in the respiratory tract.[6] According to Wahyuni (2015), the advantage of using a nebulizer is its effectiveness in respiratory treatment because of its fast action and small drug dose. Nebulizer therapy is safe to use repeatedly. When a child's oxygen needs increase due to respiratory problems, the heart rate (HR) increases to deliver oxygen to the body's cells. Increased oxygen delivery to the respiratory tract causes the respiratory rate (RR) to become faster. The respiratory rate represents the intensity of air intake or output per minute. The normal respiratory rate for toddlers is 30-60 times per minute.[7]

Several inhalation systems can be adjusted to suit your needs, one of which is by using a high-pressure oxygen source connected to an inhalation mask (inhalation mask). Inhalation therapy using high-pressure air at 10 liters per minute will convert the drug into an aerosol form that can be inhaled into the respiratory tract.[8] In principle, inhalation therapy using a compressor and oxygen source is the same. Bronchodilator drugs are converted into steam and inhaled to treat respiratory problems.[9] One of the treatments for pneumonia patients is nebulization therapy which usually uses a compressor. The limited availability of compressor machines can delay the provision of nebulization therapy to children. An alternative nebulization method is to use a high-pressure oxygen source of 10 liters per minute connected to an inhalation mask. In principle, inhalation therapy using a compressor and using an oxygen source are the same. Bronchodilator drugs are converted into vapor and inhaled to treat respiratory problems. When a child's oxygen needs increase due to respiratory problems, the heart rate immediately increases to deliver oxygen to the body's cells. Increased oxygen delivery to the respiratory tract also causes the breathing rate to become faster. This study aimed to determine the effect of inhalation therapy using a compressor and oxygen on hemodynamics (heart rate and respiratory rate) in toddlers suffering from pneumonia.

Methods

This research employed a quasi-experimental research design, specifically utilizing an intervention group and a control group.[10] The study aimed to investigate the influence

of inhalation therapy on hemodynamics (HR and RR). In this research, interventions were administered to two groups by comparing the differences between pre-test and post-test values within each group. The intervention group received inhalation therapy using oxygen, while the control group received inhalation therapy with a compressor nebulizer. The research sample consisted of 32 respondents, comprising 16 individuals in the control group and 16 individuals in the intervention group, selected through simple random sampling. The inclusion criteria for the research respondents were: 1. Toddlers with pneumonia, 2. Newly admitted patients, 3. Negative antigen and PCR results. The exclusion criteria for this study were: 1. Children diagnosed with severe pneumonia, 2. Children with other underlying diseases. During the research implementation, the intervention group received oxygen inhalation therapy for 30 minutes, after which their HR and RR were measured again. The control group received standard inhalation therapy with a compressor and was also re-evaluated after 30 minutes for HR and RR. The research instruments used in this study included an observation sheet to record the HR and RR of patients, as well as an analog wristwatch to calculate HR and RR for one minute. Statistical analysis employed in this research included dependent t-tests for pre- and post-treatment comparisons, as well as independent t-tests to assess differences between the two groups. This research obtained ethical clearance from the research ethics committee of Muhammadiyah Jakarta University on May 25, 2022.

Results

Table 1. Distribution of Mean Respondent Characteristics Based on Age in the Control and Intervention Groups at RSUD Pasar Rebo from June to July 2022 (n=32)

Variable	Category	Mean (SD)/ n (%)
Age, Mean (SD)	Age	16 (15,7)
Gender, n (%)	Male	17 (53,1)
	Female	15 (46,9)

Based on table 1, it is found that the largest number of respondents was an average age of 16 years, and the largest gender was male with 17 (53,1%) compared with females with 15 (46,9%).

Table 2. Mean and Mean Difference of Hemodynamic (Heart Rate and Respiratory Rate) of Respondents Before and After Inhalation Therapy in the Control and Intervention Groups at RSUD Pasar Rebo from June to July 2022 (n=32)

Intervention Group (oxygen)	Mean	SD	Min-Max	P-Value
Heart Rate:				
Before (Pre)	126	14,899	100-145	0.000
After (Post)	124	15,000	96-148	
Respiratory Rate:				
Before (Pre)	30	3,508	26-39	0.000
After (Post)	28	2,899	23-35	
Control Group (Compressor)	**Mean**	**SD**	**Min-Max**	**P-Value**
Heart Rate:				
Before (Pre)	135	12,857	111-154	0.000
After (Post)	131	13,033	108-150	
Respiratory Rate:				
Before (Pre)	34	7,182	24-55	0.000
After (Post)	32	7,105	23-53	

Based on Table 2, it is Found That Intervention Group (Oxygen Inhalation Therapy):

Before the intervention, the mean heart rate was 126 bpm, with a range of values between 100 bpm and 145 bpm. After the intervention, the mean heart rate decreased to 124 bpm, with a range of values between 96 bpm and 148 bpm. The statistical analysis showed a significant difference ($p < 0.001$) in heart rate before and after the intervention. Before the intervention, the mean respiratory rate was 30 bpm, with a range of values between 26 bpm and 39 bpm. After the intervention, the mean respiratory rate decreased to 28 bpm, with a range of values between 23 bpm and 35 bpm. The statistical analysis indicated a significant difference ($p < 0.001$) in respiratory rate before and after the intervention.

Control Group (Compressor Inhalation Therapy):

Before the intervention, the mean heart rate was 135 bpm, with a range of values between 111 bpm and 154 bpm. After the intervention, the mean heart rate decreased to 131 bpm, with a range of values between 108 bpm and 150. The statistical analysis showed a significant difference ($p < 0.001$) in heart rate before and after the intervention. Before the intervention, the mean respiratory rate was 34 bpm, with a range of values between 24 bpm and 55 bpm. After the intervention, the mean respiratory rate decreased to 32 bpm, with a range of values between 23 bpm and 53 bpm. The statistical analysis indicated a significant difference ($p < 0.001$) in respiratory rate before and after the intervention. Overall, the results of this study demonstrate that inhalation therapy, whether with oxygen or a compressor, has a significant impact on patients' heart rate and respiratory rate. Oxygen intervention tends to be more effective in reducing both heart rate and respiratory rate compared to compressor inhalation therapy.

Table 3. Difference in Mean Hemodynamic (Heart Rate and Respiratory Rate) Before and After Inhalation Therapy Using Oxygen in RSUD Pasar Rebo from June to July 2022 (n=32)

Group	Heart Rate			
	n	Mean	SD	P-Value
Control	16	135,04	12,85	0,419
Intervention	16	131,29	13,03	
Group	**Respiratory Rate**			
	N	Mean	SD	P-Value
Control	16	34,20	7,18	0,393
Intervention	16	32,01	7,10	

Based on table 3, the results of the independent t-test it is known that the average heart rate in the group of Toddlers with pneumonia receiving inhalation therapy using a compressor is higher than in the group of Toddlers with pneumonia receiving inhalation therapy using oxygen, with an average difference of 3.75 bpm. The statistical t-test yielded a p-value of 0.419, so it can be concluded that there is no difference in the average heart rate of Toddlers with pneumonia between the control group and the intervention group. Meanwhile, the other results shown in Table 3 reveal that the average respiratory rate in the group of Toddlers with pneumonia receiving inhalation therapy using a compressor is higher than in the group of Toddlers with pneumonia receiving inhalation therapy using oxygen, with an average difference of 2.19 bpm. The statistical t-test yielded a p-value of 0.393, so it can be concluded that there is no difference in the average respiratory rate of Toddlers with pneumonia between the control group and the intervention group.

Discussion

The results of the analysis conducted in both groups to determine the hemodynamic

status of heart rate before and after inhalation therapy showed that the difference in the average heart rate in the intervention group (oxygen) decreased by 2.1 beats per minute. Meanwhile, the difference in the average heart rate in the control group (compressor) decreased by 3.75 beats per minute. Therefore, there is a difference in the average hemodynamic value of heart rate in respondents before and after inhalation therapy using a compressor. Oxygen therapy (O2) is a medical form of treatment by administering oxygen (O2) to prevent or correct tissue hypoxia and maintain adequate tissue oxygenation by increasing the intake of oxygen (O2) into the respiratory system, increasing the capacity to carry oxygen. (O2) into the circulation and increases the release or extraction of oxygen (O2) into tissues, Apart from that, if a lot of oxygen enters the cells, it will indirectly affect heart contractions to be more normal and tachycardia will not occur.[11] According to The Royal College of Nursing (2017), children aged 2-7 years have a normal heart rate ranging from 80-150 beats per minute. Heart rate is a palpable wave in the artery when blood is pumped out of the heart. This wave can be felt wherever an artery passes. Blood pushed toward the aorta during systole not only moves forward in the blood vessels but also generates a pressure wave that travels along the arteries. The pressure wave stretches the artery walls along its path, and this stretching can be felt as a pulse. The palpable pulse is not the blood pumped by the heart into the aorta, but rather a pressure wave transferred from the aorta that travels faster than the blood itself.[12]

The results of this study regarding the average heart rate align with a study conducted by Illahi (2019), where the average heart rate ranged above 100 beats per minute before inhalation therapy or nebulization, specifically at 105 beats per minute. This could occur due to an increased heart rate frequency or tachycardia as a result of patients with respiratory diseases such as pneumonia.[13] According to Marhana & Amin (2010), tachycardia in patients with respiratory disorders can be influenced by various conditions, one of which is hypoxia.[14] Therefore, to prevent the effects of tissue hypoxia, the pulmonary blood vessels constrict in response to low oxygen levels, reducing blood flow to poorly ventilated areas. Hence, it is essential to assist patients with pneumonia, who experience tachycardia due to hypoxia, by providing nebulization therapy. Based on these results, the researcher believes that the range of heart rate values in children with pneumonia can indeed fluctuate, depending on the influencing factors. However, the implementation of nebulization therapy can help stabilize heart rate values, as respiratory pathways improve, and adequate oxygen content is maintained, reducing the risk of hypoxia.

The analysis conducted in both groups to determine the hemodynamic status of the respiratory rate before and after inhalation therapy showed that the difference in the average respiratory rate in the intervention group (oxygen) decreased by 1.85 breaths per minute. Meanwhile, the difference in the average respiratory rate in the control group (compressor) decreased by 2.19 breaths per minute. Respiratory rate in toddlers has specific categories, as outlined by The Royal College of Nursing (2017), stating that children aged 2-5 years have a normal respiratory rate ranging from 20-30 breaths per minute. However, the research results showed that the average respiratory rate in the control group was above 30 breaths per minute.[15] According to Farizka (2015), respiratory rate is the intensity of air inhalation and exhalation in humans performed every minute.[16]

These results align with a study conducted by Illahi (2019), where after inhalation therapy was administered to pediatric patients with pneumonia, there was a reduction in the respiratory rate.[13] Similarly, a study by Santosa & Endiyono (2018) found that the average respiratory rate of 60 respondents, both in the group before receiving a compressor and receiving oxygen, was approximately 31 breaths per minute and 30 breaths per minute.[17] Likewise, the average respiratory rate after receiving compressor therapy or oxygen therapy decreased to below 30 breaths per minute, reaching about 22 breaths per minute and 23 breaths per minute. This decrease is attributed to the effects of nebulization

therapy applied to the respondents. Nebulization creates aerosols that can deliver medication to target organs such as the respiratory tract with minimal side effects and high safety and effectiveness levels. As stated by Wahyuni (2014), the formed aerosol is inhaled by the patient through a mouthpiece or mask and enters the lungs into thin secretions. Therefore, to assess its effectiveness, the study compared respiratory rates (RR) before and after therapy.[7]

The average respiratory rate of patients with pneumonia before inhalation therapy or nebulization would typically show high values above 30 breaths per minute. This is because there is an increase in the volume and viscosity of lung secretions, and ineffective coughing can lead to decreased clearance of lung secretions. A decreased clearance of lung secretions predisposes to airway obstruction and ventilation disorders.[18] Therefore, nebulization therapy plays a crucial role in reducing the average respiratory rate from high values to a normal range. From this research, the researcher believes that the implementation of nebulization therapy is necessary to reduce the average respiratory rate in pediatric patients with pneumonia. This is done to help stabilize the respiratory rate so that children with pneumonia do not experience respiratory distress such as tachypnea, which can impact their safety and well-being.

Conclusion

Based on the results of the research conducted, it was found that there was an effect of inhalation therapy using either oxygen or a compressor on heart rate and respiratory rate in both groups. Therefore, inhalation therapy using oxygen is considered no more effective than inhalation therapy using a compressor. However, the results of this study can be an alternative intervention, especially for pediatric patients with pneumonia. However, this study still has several limitations, including the small number of samples and the equipment used for inhalation may be different in each hospital.

Conflict of Interest Declaration

This research is free from conflicts of personal or group interests.

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