



Nutritional status, age and gender factors associated on pneumonia in congenital heart disease: A hospital-based cross-sectional study in Banda Aceh, Indonesia

Faktor faktor status nutrisi, usia, dan jenis kelamin yang berhubungan dengan pneumonia pada penyakit jantung bawaan: Sebuah studi cross sectional berbasis rumah sakit di Aceh, Indonesia

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Abstract

Pneumonia is a leading cause of morbidity and mortality in children with congenital heart disease (CHD). Risk factors for pneumonia in these children include anemia, hypoxemia, nutritional status, congestive heart failure, and neuromuscular disorders. This study aimed to determine the risk factors for pneumonia in children with CHD at the Dr. Zainoel Abidin Public Hospital, Banda Aceh, Indonesia. This analytical, observational study employed a cross-sectional approach. This study included children aged 1 month to 18 years who were treated at the Dr. Zainoel Abidin Public Hospital from January 2022 to December 2023. Data were collected from medical records of 121 children who met the inclusion and exclusion criteria. Data were analyzed using bivariate analysis with the chi-square test and multivariate analysis with logistic regression. Pneumonia was observed in 66 (54,5%) patients. The majority of children with critical illnesses who developed pneumonia were between 1 month and 5 years of age (60%), female (61,7%), had poor nutritional status (53,2%), and had a birth weight ≥ 2500 g (54,5%). The type of CHD was found to be a significant risk factor for pneumonia ($p = 0,024$), with an odds ratio of 3,16 (95% CI: 1,162–8,617). In conclusion, the CHD type is a risk factor for pneumonia in children with CHD.

Keywords: Pneumonia, Risk Factors, Children, Congenital Heart Disease.

Abstrak

Pneumonia menjadi penyebab morbiditas dan mortalitas tersering pada anak dengan PJB. Terdapat berbagai faktor risiko untuk pneumonia telah diidentifikasi antara lain faktor anemia, hipoksemia, status gizi, gagal jantung kongestif dan *neuromuscular disorders*. Untuk mengetahui faktor risiko pneumonia pada anak dengan PJB di RSUD dr. Zainoel Abidin Banda Aceh. Jenis penelitian ini adalah studi analitik observasional dengan pendekatan *cross sectional* pada anak usia 1 bulan sampai 18 tahun yang dirawat di RSUD dr. Zainoel Abidin sejak Januari 2022 sampai Desember 2023 dengan menggunakan data rekam medis 121 anak yang memenuhi kriteria inklusi dan eksklusi. Analisis data bivariat dengan uji *chi-square*, selanjutnya analisis multivariat dengan regresi logistik. Diperoleh subjek pneumonia sebesar 66 (54,5%) pasien. Sebagian besar anak dengan PJB yang mengalami pneumonia yaitu berusia 1 bulan hingga 5 tahun (60%) berjenis kelamin perempuan (61,7%) mempunyai status gizi buruk (53,2%) dengan berat badan lahir ≥ 2500 gram (54,5%) serta dengan jenis PJB asianotik (80,2%) dan mempunyai defek jantung *single* (70,2%). Hasil analisis multivariat didapatkan adanya hubungan yang signifikan antara jenis PJB dengan kejadian pneumonia pada anak dengan PJB ($p=0,024$) dengan OR 3,16 (IK95%:1,162-8,617). Penelitian ini menyimpulkan bahwa jenis PJB merupakan faktor risiko pneumonia pada anak dengan PJB.

Kata Kunci: pneumonia, faktor risiko, anak, penyakit jantung bawaan

Introduction

Pneumonia is a leading infectious disease that causes deaths in children worldwide. In 2021, pneumonia kills more children than any other infectious disease, claiming the lives of over 700,000 children under five every year, or around 2,000 every day. This included approximately 190,000 newborns. Almost all these deaths were preventable. Globally, there are over 1,400 cases of pneumonia per 100,000 children or one case per 71 children every year, with the highest incidence occurring in South Asia (2,500 cases per 100,000 children) and West and Central Africa (1,620 cases per 100,000 children) (Unicef, 2024). According to Indonesia's 2019 health profile, there are more than 400,000 cases of pneumonia in the country. Without immediate intervention in pneumonia prevention, an estimated 11 million child deaths could occur worldwide by 2030, with pneumonia being the second leading cause of death in children under five in Indonesia (Sulung et al., 2021). Between 2008 and 2009, of the 2035 pediatric cases admitted to Dr. Zainoel Abidin Public Hospital (RSUDZA), 144 (7,1%) were diagnosed with pneumonia, and among those, approximately eight children had congenital heart disease (CHD) (Nurjannah et al., 2016).

Congenital heart disease (CHD) is the most common disorder in newborns, with a prevalence of 8 per 1000 births. It is one of the leading causes of infant mortality in the first year of life. In Indonesia, five million infants are born annually, with approximately 50,000 infants born with CHD and 12,500 born with critical CHD (BKKBN, 2018). CHD are classified into two types: acyanotic and cyanotic (Yani, 2022). A study by Rahayuningsih et al. (2021) involving 1258 children with CHD from 2015 to 2018 at Hasan Sadikin Public Hospital in Bandung identified ventricular septal defect and malnutrition as risk factors for recurrent pneumonia.

According to Wu et al. (2020), children with CHD experience many complications that affect various organ systems, with the respiratory system being the most vulnerable organ. Pneumonia is the most common cause of morbidity and mortality in children with CHD (Şahan et al. 2018). Based on research conducted at Dr. Sardjito Public Hospital Yogyakarta from January 2009 to November 2012 involving 430 children, the proportion of pneumonia with CHD was 16,74%. This study also found that the mortality rate, pediatric intensive care unit admissions, and length of

hospitalization were higher and more prolonged for children with both pneumonia and CHD than for those without comorbidities (Rodiah AT et al., 2015).

Therefore, it is very important to identify the nutritional status, age, sex, and other risk factors that influence the development of pneumonia in children with CHD as an important step in implementing preventive and treatment measures to reduce the incidence of pneumonia.

Methods

This was an observational analytic study that employed a cross-sectional design to assess the associated risk factors (nutritional status, age, and sex) and pneumonia incidence at Dr. Zainoel Abidin Public Hospital from 2022 to 2023. The study was conducted at the Medical Records Department of Dr. Zainoel Abidin Public Hospital in Banda Aceh, Indonesia.

Data were collected between June and July 2024, the bio-data of each patient was documented, each patient was clinically evaluated thoroughly, and the findings were noted. The inclusion criteria were patients with CHD who were also diagnosed with pneumonia between 1 and 18 years of age. The echocardiography was performed by a cardiologist. Congenital heart disease was also noted. The type and size of the defects were documented. Pneumonia was diagnosed based on a typical history, physical findings, blood investigations, and chest radiographic findings of pneumonia infiltrates in either one or both lung fields. Patients with a diagnosis of comorbidities that could be confounding factors (such as bronchial asthma, cerebral palsy, or recurrent pneumonia) and those with missing or incomplete data were excluded. The sample used in this study was obtained through total sampling. The sample size was calculated using the *formula of thumb*, so that a minimum sample size of 60.

The dependent variable was pneumonia in PJB, and the independent variables were age (e.g., 1 month-<6 years, 6-<12 years, 12-18 years), sex (male, female), birth weight (e.g., ≥ 2500 g, < 2500 g), nutritional status based on WHO Z score (BW/BH, or IMT/U), type of congenital heart disease (e.g., cyanotic, acyanotic), and number of heart defects (e.g., single, multiple). Data were collected from medical records from January 1, 2022, to

December 31, 2023, for all patients with congenital heart disease (CHD) who met the inclusion criteria at Dr. Zainoel Abidin Regional Hospital, Banda Aceh. In this study, data were recorded based on the dependent and independent variables. The collected data were checked for completeness, coded, tabulated, and entered into a computer.

Univariate analysis was performed using descriptive statistics to examine the characteristics of each variable. Categorical data were analyzed using frequency distributions as percentages or proportions, while numerical data were analyzed using the mean and standard deviation if the data were normally distributed and the median and minimum/maximum if the data were not. The results of the analysis are presented in tables, graphs, and narrative forms. In the bivariate analysis, the χ statistical test was performed (chi-square test), and the odds ratio (OR) was obtained for each risk factor for the incidence of pneumonia in children with CHD. The OR value obtained from the bivariate analysis is referred to as the crude OR because it was not adjusted by multivariate analysis. The variables included in the multivariate analysis were bivariate variables with a value ($p < 0,05$). Statistical analyses were performed using SPSS for Windows v. 25.0 program.

This study was approved by the Ethics Committee of Dr. Zainoel Abidin Banda Aceh Regional Hospital (letter number 108/ETIK-RSUDZA/2024). Some of the limitations of this research are this study is retrospective in nature and may not represent all subjects with congenital heart disease accompanied by pneumonia in childrenhis research is very dependent on patient data recorded in medical records, not all medical records have complete important data needed to conduct the research.

Result and Discussion

The results showed that among the 121 children with CHD, 54,5% also had pneumonia. A summary of the participants' characteristics is presented in Table 1.

Table 1. The summary of the subjects with CHD

Characteristics	n = 121	
	n	%
Pneumonia		
Yes	66	54,5
No	55	45,5

Age		
0-5 years	100	82,6
6-11 years	10	8,3
12-18 years	11	4,1
Gender		
Male	61	50,4
Famale	60	49,6
Nutritional status		
Obesity	0	0
Over-nutrition	0	0
Good Nutrition	39	32,2
Undernutrition	35	28,9
Poor Nutrition	47	38,8
Birth Weight		
≥2500 gram	88	72,7
<2500 gram	33	27,3
Type of CHD		
Acyanotic	97	80,2
Cyanotic	24	19,8
Number of heart defects		
Single	85	70,2
Multiple	36	29,8

Table 2 shows that most children with CHD who developed pneumonia aged 1 month to 5 years (60%) were female (61,7%), had poor nutritional status (53,2%), and had a birth weight ≥ 2500 g (54,5%). Bivariate analysis was conducted to examine the relationship between the basic characteristics and incidence of pneumonia in CHD, as presented in Table 2. The chi-square test revealed a significant association between age and pneumonia incidence in children with CHD ($p=0,031$). The odds ratio (OR) calculation showed a value of 1,8 (95% confidence interval [CI], 1,054–3,090), suggesting that age increases the risk of pneumonia in children with CHD by 1,8 times. The clinical characteristics of the study, including the type of CHD and the number of heart defects, are presented in Table 3. Among pediatric patients with CHD, those with acyanotic CHD (60,8%) had a higher incidence of pneumonia than those with cyanotic CHD (29,9%). Most cases of pneumonia were observed in patients with a single heart defect (54,1%).

Table 3 shows that the type of CHD has a significant relationship between the type of CHD and the incidence of pneumonia in children with CHD ($p=0,007$). The risk calculation resulted in an odds ratio (OR) of 3,77 (95% CI, 1,429–9,947), indicating that CHD type is associated

with a 3,77 times greater risk of developing pneumonia in children with CHD.

Table 2. Risk factors for pneumonia in CHD based on baseline characteristics

Basic Characteristics	CHD (N=121)		OR	P	CI 95%
	Pneumonia (n= 66) n (%)	Not Pneumonia (n = 55) n (%)			
Age			1,80	0,031	1,05-3,09
1 month-5 years	60(60)	40 (40)			
6-11 years	3 (30)	7 (70)			
12-18 years	3 (27,3)	8 (72,7)			
Gender			1,77	0,120	0,86-3,66
Male	29 (47,5)	32 (52,5)			
Female	37 (61,7)	23 (38,3)			
Nutritional status			1,06	0,767	0,69-1,63
Normal	22 (56,4)	17 (43,6)			
Wasted	19 (54,3)	16 (45,7)			
Severely wasted	25 (53,2)	22 (46,8)			
Birth weight (gram)			1,00	1,000	0,45-2,23
≥ 2500	48 (54,5)	40 (45,5)			
< 2500	18 (54,5)	15 (45,5)			
Type of CHD			3,77	0,007	1,43-9,95
Cyanotic	7 (29,2)	17 (70,8)			
Acyanotic	59 (60,8)	38 (39,2)			
Number of heart defects			0,99	0,885	0,43-2,07
Single	46 (54,1)	39 (45,9)			
Multiple	20 (55,6)	16 (44,4)			

Multivariate analysis using logistic regression was performed to determine the risk factors for pneumonia in children with CHD, and the results are presented in Table 4. The multivariate analysis results presented in Table 4 indicate that CHD type is the most significant risk

factor for the incidence of pneumonia in children with CHD. Age and sex were not significantly associated with pneumonia incidence in children with CHD. CHD type had the highest odds ratio (OR) of 3,16, followed by sex with an OR of 1,79 and age with an OR of 1,69.

Table 4. Analysis of risk factors for pneumonia in CHD

Variable	B	Wald	OR	P	IK 95%
Type of CHD	1,152	5,080	3,16	0,024	1,162-8,617
Gender	0,584	2,253	1,79	0,133	0,836-3,844
Age	0,527	3,408	1,69	0,065	0,968-2,965

This study employed an analytical observational design and a cross-sectional approach. This study collected 121 medical records of pediatric patients with CHD, with and without pneumonia, treated at Dr. Zainoel Abidin Public Hospital, Banda Aceh, from January 2022 to December 2023. The 121 participants were divided into two groups: 66 children with CHD and pneumonia and 55 children with CHD but without pneumonia.

The majority of subjects in this study were aged between 1 month and 5 years, a finding consistent with the research by Shah et al. (2022), who reported that among 765 subjects diagnosed with pneumonia with CHD in Pakistan

from July 2019 to July 2020, the highest proportion belonged to the 1–2 year age group with 209 (27,32%) subjects, followed by the 3–4 year age group with 172 (22,48%) subjects and the 5–6 year age group with 149 (19,47%) subjects. In this study, female subjects were more likely to experience pneumonia, accounting for 61,7% of the cases. This result differs from the findings of Mahapatra et al. (2017), who reported fewer female patients (105, 45,5%) with pneumonia than male patients (126, 54,5%). This variation is due to differences in parental behavior toward boys' health compared to girls in different countries (Mahapatra et al., 2017).

Sulthoni et al. (2023) documented 96 children with CHD and pneumonia at Dr. Soetomo Surabaya General Hospital from January 2016 to December 202, with malnutrition being a significant factor in approximately 70% of the subjects. This aligns with the results of the present study, in which approximately half of the subjects had poor nutritional status. Children with malnutrition are 11 times more likely to develop pneumonia than those with good nutritional status, as malnutrition weakens the immune system and increases susceptibility to pneumonia (Kiconco et al., 2021). Children with CHD and a birth weight ≥ 2500 g experienced more pneumonia (54,5%). These findings are consistent with research by Kiconco et al. (2021) on 336 children aged 2-59 months in Uganda from April to August 2019 and found that more than 70% of the children with CHD and a birth weight of ≥ 2500 g developed pneumonia.

Yasmine et al. (2022), conducted retrospective medical records at Dr. Soetomo Public Hospital, Surabaya, Indonesia, and analyzed 135 subjects, 121 in the acyanotic CHD group and 11 in the cyanotic CHD group. The acyanotic CHD group was dominated by ASD, whereas TOF dominated cyanotic CHD. Similar results were observed in the present study, where acyanotic CHD was the most common type of CHD associated with pneumonia (80,2%). This finding underscores the importance of CHD as a predisposing factor of pneumonia in children.

This study revealed a relationship between age and pneumonia in children with CHD. This finding is consistent with that of Gabriela et al. (2015), who reported that of 3,897 subjects with pneumonia, 149 were diagnosed with CHD, with the majority (80%) being under one year of age. Children with CHD are more susceptible to recurrent respiratory infections owing to anatomical abnormalities that cause hemodynamic disorders in the pulmonary circulation, thereby increasing their risk of respiratory infections (Jat et al., 2021). Pneumonia is common in children with CHD and associated with congestive heart failure. A weak immune system in children under the age of one year allows the progression of upper respiratory tract infections to the lungs, leading to pneumonia (Uwemedimo et al., 2018).

This study found no significant association between sex and the incidence of pneumonia in children with CHD. Research by Patra et al. (2023), reported slightly more male than female

subjects (51,5% and 48,4%, respectively), with a female-to-male ratio of 1.06:1. Hospital-based studies from India have also reported a male predominance in CHD, ranging from 52,4% to 66,7% (Karthiga et al., 2017).

Furthermore, no relationship was found between nutritional status and the incidence of pneumonia in children with CHD in this study. This finding differs from that of Wilar et al. (2016), who reported a significant relationship between nutritional status and incidence of acute respiratory infections. This study used calculations based on the World Health Organization (WHO) growth curve. This discrepancy could be attributed to the different methods used to calculate the nutritional status. While this study utilized the WHO growth curve, other studies may have employed different methods, such as those by the Centers for Disease Control and Prevention (CDC) or the Ministry of Health.

Statistical analysis showed no association between birth weight and the incidence of pneumonia in patients with CHD. Similarly, Kasundriya et al. (2020) reported no significant difference in birth weight or history of prematurity between children with CHD, with and without pneumonia ($p>0,05$). This result contradicts that of Sulthoni et al. (2023), which showed that birth weight was significantly associated with the incidence of left-to-right acyanotic shunted CHD with pneumonia ($p<0,001$). The American Academy of Pediatrics (AAP) includes children with critical CHD, bronchopulmonary dysplasia, and prematurity in the high-risk group for respiratory syncytial virus (RSV) infection (Checchia et al., 2017).

This study also found no relationship between CHD type and pneumonia in children with CHD. This finding is consistent with that of Jat et al. (2021), who used retrospective medical record data at the Hindu Rao Hospital, New Delhi, India. Among the 160 subjects with CHD, 12,5% had pneumonia, with 95% of the cases occurring in the acyanotic group and 5% in the cyanotic group. The most common CHDs was VSD (60%), followed by PDA (20%), ASD (10%), and TGA (5%). The severity of pneumonia in patients with CHD may be due to a combination of factors. CHD causes lung injury due to hypoperfusion or hyperperfusion, changes in surfactant composition, and differences in lower airway resistance. The presence of heart defects and pneumonia may lead to pulmonary hypertensive crisis and/or heart failure (Ahuja et al., 2021).

This study did not identify an association between the number of heart defects and the incidence of pneumonia in CHD patients. However, Vernet et al. (2024) reported that mild defects in the ventricular septum or atrial septum were not the main cause of pulmonary arterial hypertension. Nonetheless, pulmonary arterial hypertension is relatively common in CHD, negatively affecting the quality of life and survival (Sulthoni et al., 2023). These findings differ from those of Sulthoni et al. (2023), who showed that heart defect size significantly influences the incidence of pneumonia in CHD with a left-to-right shunt and is a significant risk factor for mortality.

Multivariate analysis revealed that CHD was the most influential risk factor of pneumonia in children with CHD. In cyanotic CHD, the increased volume and pressure load result in greater blood flow to the heart, reducing pulmonary flexibility and increasing respiratory rate. Increased intravascular pressure in the pulmonary capillaries causes pulmonary edema, leading to pneumonia-like symptoms in children (Esmail et al., 2024). In cyanotic right-to-left shunt CHD, the higher the pressure load, the greater is the contraction ability of the left ventricle. However, if the defect remains uncorrected, the pressure load increases, eventually exceeding the LV contraction capacity. This compensatory failure causes blood to be pumped back into the atrium, resulting in pulmonary congestion (Pejaver et al. 2016). The subsequent increase in the blood volume in the lungs reduces pulmonary flexibility and increases breathing. Increased intravascular pressure in the pulmonary capillaries leads to pulmonary edema, exacerbating airway mucosal damage caused by hypoxemia, which further increases the frequency of respiratory infections in cyanotic CHD (Rampengan, 2014).

This retrospective study was conducted in only one hospital, which may not represent all subjects with CHD accompanied by pneumonia in children, and it is highly dependent on patient data recorded in medical records; not all medical records contained the essential data required for the research.

Conclusion

The CHD type was identified as the most significant risk factor influencing the incidence of pneumonia in these children. The contribution of CHD to pneumonia should be evaluated to develop prevention and treatment strategies to reduce the incidence of pneumonia. Further studies are needed to explore additional risk factors, such as vitamin D levels and anemia, which were not examined in this study.

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