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Clinical Profile and Outcomes of Children Admitted to a Brazilian ICU

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Abstract

Background: The aim of this study was to describe the clinical profile of children admitted to a pediatric intensive care unit (PICU) in Southeast Brazil and to analyze predictive factors associated with mortality.

Methods: A retrospective cross-sectional study was conducted over a 24 month (August 2018–2020), including 562 patients aged 1 month to 18 years admitted to the PICU. Patients were categorized into two groups: cardiac and non-cardiac diseases. Mann-Whitney U, Fisher's exact test, and logistic regression were used for group comparisons, with a significance level set at 5%.

Results: The median age of the patients was 31 months (interquartile range 9-108), with 53.9% being male. Surgical interventions predominated (51.2%), primarily for congenital heart diseases (38.8%). Other frequent causes of admission included respiratory disease (19%) and sepsis (14.1%). Children with cardiac diseases had a higher incidence of mechanical ventilation (66.5% vs. 48%, $p<0.001$) and vasoactive drug use (57.3% vs. 24.7%, $p<0.001$). However, they had shorter durations of invasive ventilation (1 vs. 5 days, $p<0.001$) and vasoactive drug use (2 vs. 3 days, $p=0.032$) compared to non-cardiac patients. A total of 38 patients (6.8%) died, with a higher mortality rate observed among those with non-cardiac diseases (9% vs. 3.2%, $p=0.009$).

Conclusion: Non-cardiac patients had higher mortality rates and longer durations of invasive mechanical ventilation and vasoactive drug use. Cardiac disease patients experienced more favorable clinical outcomes in this study population.

Key Words: Heart Defects, Congenital, Intensive Care Units, Pediatric, Cardiac Surgical Procedures.

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1- INTRODUCTION

The concept of intensive care for critically ill patients expanded during the Second World War, in shock units, and with the beginning of technological resources from the 1940s. Today, intensive care provides multidisciplinary assistance and uses technological resources to promote early diagnosis and treatment (1). The establishment of pediatric intensive care units (PICUs) has significantly improved the care of cardiac patients, leading to decreased mortality rates, particularly in developed countries (2) With the implementation and advancement of these units, including better distribution of PICUs, pediatric mortality has decreased over the years, especially in developed countries, from around 10% in the 1980s to 1.4% in 2014 in the United States (3).

Congenital heart diseases (CHD), characterized by structural abnormalities of the heart or great vessels, impair cardiovascular and other organ systems. The global incidence of CHD varies widely due to factors such as population age and diagnostic criteria (4) In Brazil, there is underreporting in the prevalence of congenital heart disease, with an estimated 25.757 new cases per year, based on a global prevalence of 9 cases per 1.000 live births (5).

The effectiveness of a pediatric heart surgery center depends on several factors, including the stage and complexity of the disease, as well as technical, organizational, and structural elements (6) In the United States, the one-year survival rate is 75.2% for complex heart diseases and 97.1% for simple heart diseases (7).

Research on clinical-epidemiological profiles and predictive risk factors for outcomes and mortality in developing countries, like Brazil, is crucial for understanding the challenges faced by patients in these resource-limited settings. Assessments of primary and long-term outcomes, including functional, cognitive, social, and family aspects, remain limited in these countries (3).

Analyzing patient records and their progress can help identify the strengths and weaknesses of a healthcare service regarding critical patient care. Understanding predictive and modifiable risk factors in both cardiac and non-cardiac patients can inform critical care practices and serve as a basis for future studies on the impact of pediatric heart diseases on public health in Brazil.

This study aims to conduct a clinical-epidemiological study and identify predictive factors for outcomes and mortality in a PICU that serves as a reference center for pediatric heart surgery in Espírito Santo state, Brazil.

2- MATERIALS AND METHODS

2-1. Study Design and Population

This retrospective, single-center cross-sectional study reviewed data from patients aged 1 month to 18 years admitted to the pediatric intensive care unit (PICU) of Alzir Bernardino Alves Children's and Maternity Hospital (HIMABA), a reference center for congenital heart surgery in Southeast Brazil. The study covered a 2-year period (August 2018–2020). Inclusion criteria required complete information. All procedures adhered to institutional and national ethical standards and were approved by the Ethics Committee (number 50071421.4.0000.5064) on August 19, 2021.

2-2. Clinical Characteristics

The study considered several variables, including age in months, sex, region of origin, primary diagnosis associated with PICU admission, presence of genetic syndromes, and comorbidities. Length of stay (LOS) in days was recorded and categorized as short if <3 days or

prolonged if >14 days. The use of mechanical ventilation, vasoactive drugs, and dialysis was also recorded, along with the duration of these interventions in days. Patients were grouped as having either cardiac or non-cardiac disease during hospitalization. The primary clinical outcome was mortality.

2-3. Data Collection and Analysis

Data was collected retrospectively from medical health records and entered into a Microsoft Excel datasheet. Statistical analysis was performed using STATA, version 15 (Stata Corporation, College Station, TX). Descriptive analysis included frequencies and proportions for categorical data and median and interquartile range (IQR) for continuous data. For group comparisons, Fisher's exact test was used for categorical data, and Mann-Whitney U for continuous data. Logistic regression was used as predictive exploratory analysis to assess risk factors associated with mortality. Univariate and multivariable models adjusted for sex and age in months were constructed. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported. Statistical significance was set at $p < 0.05$ for a two-tailed test.

3- RESULTS

The study included 562 patients, excluding 2 due to incomplete data. Patients were followed until death or discharge from the PICU, with transfers directly to pediatric wards upon discharge as no step-down unit was available. All deaths occurred in the PICU, where withdrawal of life support is not routinely practiced.

The median age was 31 months (IQR 9–108), with 303 males (53.9%). The PICU served a diverse population: 375 patients (66.7%) from the Greater Vitória Metropolitan area, 172 (30.6%) from rural regions, and 15 (2.7%) from out of state. Surgical conditions were the leading cause of admission (51.2%), with postoperative cardiac surgery (38.8%), respiratory issues (19%), and sepsis (14.1%) being the most common specific diagnoses. The median LOS in the PICU was 10.3 days (range: 1 to 121 days). Mechanical ventilation was required by 310 patients (55.2%), vasoactive drugs by 210 (37.4%), and renal replacement therapy by 32 (5.7%). Genetic syndromes were identified in 72 patients (12.8%), with Down syndrome being the most common (41.7% of cases).

Table-1: Diagnostic Causes of the 562 Cardiac and Non-Cardiac Patients Admitted to the Pediatric Intensive Care Unit from 2018 to 2020.

Diagnostic Cause	Hospitalizations N (%)
Neurologic	12 (2.1)
Cardiovascular	31 (5.5)
Respiratory	107 (19.0)
Gastrointestinal	11 (2.0)
Renal	22 (3.9)
Sepsis	79 (14.1)
Others	12 (2.1)
Cardiovascular Surgery	218 (38.8)
Thoracic Surgery	3 (0.5)
Gastrointestinal Surgery	53 (9.4)
Renal Surgery	3 (0.5)
Orthopedic Surgery	9 (1.6)
Otorhinolaryngology Surgery	2 (0.4)

3-1. Group Comparison: Cardiac vs. Non-cardiac disease

Table 2 compares clinical characteristics between cardiac and non-cardiac patients. Cardiac patients were younger, but the difference was not statistically significant (25 vs. 36 months, P=0.578). Cardiac patients more frequently required mechanical ventilation (66.5% vs. 48%, P<0.001) and vasoactive drugs (57.3% vs. 24.7%, P<0.001). However, the duration of vasoactive drugs and ventilation was shorter among cardiac patients (2 days vs. 3 days, P=0.032; 1 day vs. 5 days, P<0.001).Mortality was lower among cardiac patients (3.2% vs. 9%, P=0.009). No significant difference was observed in the presence of genetic syndromes. Comorbidities were more prevalent in non-cardiac patients (58.4% vs. 37.6%, P<0.001). Prolonged PICU stays (>14 days) were more common in non-cardiac patients (20.6% vs. 13.3%, P=0.031). No difference was found in short LOS (<3 days) (P=0.655).

Table-2: Clinical Outcomes of Cardiac and Non-Cardiac Patients Admitted to the Pediatric Intensive Care Unit from 2018 to 2020.

Category	Cardiac (N=218) N (%)	Non-Cardiac (N=344) N (%)	P-value
Age (months) p50	25 (10-85)	36 (8-119.5)	0.578
Gender			
Male	117 (53.7)	186 (54.1)	0.931
Region			<0.001
Metropolitan region	119 (54.6)	256 (74.4)	
Rural region	88 (40.4)	84 (24.4)	
Another state	11 (5.0)	4 (1.2)	
Diagnosis			<0.001
Surgical	206 (94.5)	94 (27.3)	
Genetic syndrome	33 (15.1)	39 (11.3)	0.197
Presence of comorbidities	82 (37.6)	201 (58.4)	<0.001
Mortality	7 (3.2)	31 (9.0)	0.009
Length of stay	7 (4-9)	7 (4-13)	0.398
PICU stays < 3 days	41 (18.8)	70 (20.3)	0.655
PICU stays > 14 days	29 (13.3)	71 (20.6)	0.031
Mechanical ventilation			<0.001
Yes	145 (66.5)	165 (48.0)	
No	73 (33.5)	179 (52.0)	
Mechanical ventilation days p50	1 (1-2)	5 (2-8)	<0.001
Vasoactive drugs			<0.001
Yes	125 (57.3)	85 (24.7)	
No	93 (42.7)	259 (75.3)	
Vasoactive drugs days p50	2 (2-3)	3 (2-5)	0.032
Dialysis	1.000		
Yes	12 (5.5)	20 (5.8)	
No	206 (94.5)	324 (94.2)	
Dialysis days p50	8.5 (4-13)	11 (4-26.5)	0.274

Notes: PICU: Pediatric Intensive Care Unit. P-value is considered significant if less than 0.05.

3-2. Risk factors for mortality

Table 3 presents univariate logistic regression results identifying cardiac disease as a protective factor, while prolonged invasive ventilation, vasoactive drug use, and dialysis increased mortality risk. In the multivariable model after adjusting for age and sex, cardiac disease remained a protective factor (OR 0.13, 95% CI 0.05–0.32, P<0.001) as a shown in Table 4).

4- DISCUSSION

In this retrospective cross-sectional study of pediatric patients admitted to a public PICU in Espírito Santo, Brazil, we demonstrated a mortality rate of 6.8% over 2 years. Most patients originated from the metropolitan area of Espírito Santo and 56.1% were male. More than 50% of the patients required vasoactive drugs, and two-thirds needed invasive mechanical ventilation. Non-cardiac disease patients experienced longer hospitalizations with increased durations of invasive ventilation, vasoactive drug use, and a higher mortality rate compared to cardiac disease patients.

4-1. Mortality Rate

The mortality rate in the study was 6.8%, with a higher prevalence among non-cardiac clinical patients. This is similar to an Iranian study that identified a mortality rate of 6.6% in PICUs, with 50% of the deceased patients having associated congenital malformations (8). Despite advancements in the Brazilian public healthcare system, there remains a challenge for patients to access PICUs and pediatric cardiology care units, contributing to the high prevalence of comorbidities in the patients (50.3%) and an increased demand for technological resources, resulting in longer PICU stays.

Table-3: Univariate Logistic Regression Assessing the Risk Factors Associated with Mortality.

Risk Factor	OR	95% CI	P-value
Age in months	0.99	0.99-1.00	0.247
Sex	0.60	0.30-1.16	0.134
Genetic syndrome	1.91	0.84-4.36	0.121
Presence of comorbidity	1.56	0.79-3.05	0.197
Cardiac disease	0.33	0.14-0.77	0.011
Days of invasive ventilation	1.02	1.00-1.06	0.036
Use of vasoactive drugs	12.94	4.96-33.72	<0.001
Dialysis	5.55	2.30-13.40	<0.001

Note: OR: Odds Ratio; **CI:** Confidence Interval. P-value is considered significant if less than 0.05.

Table-4: Multivariable Logistic Regression Model Assessing the Risk Factors Associated with Mortality after adjusting for sex and age in months.

Variable	OR	95% CI	P-value
Age in months	0.99	0.99-1.00	0.493
Sex	0.60	0.27-1.31	0.205
Cardiac disease	0.13	0.05-0.32	<0.001
Days of invasive ventilation	1.02	1.00-1.05	0.021
Use of vasoactive drugs	11.41	3.68-35.40	<0.001
Dialysis	2.86	1.02-8.02	0.045

Note: OR: Odds Ratio; **CI:** Confidence Interval. P-value is considered significant if less than 0.05.

The illness profile and mortality rate in the pediatric population of developed countries differ from those in developing countries due to greater availability and accessibility to technological resources and trained professionals.

4-2. Clinical characteristics

The majority of admissions were among 1 to 4-year-olds (32.5%) and males. Similar age and sex distributions were observed in other Brazilian studies on the epidemiological profile of two PICUs in the Southeast and Northeast regions, with a predominance of males (56.1%) (9) and patients under 12 months of age (41.6%) (10). An Ethiopian study found a median age of 48 months and a predominance of males (59.7%) among PICU patients (11). In our study, we found a similar sex distribution but a slightly older population. It is crucial to individually investigate the epidemiological and clinical profiles of PICUs worldwide to tailor care to specific patient populations.

4-3. Group Comparison: Cardiac vs. Non-cardiac disease

Patients with cardiac disease had a lower mortality rate (3.2% vs. 9%) compared to non-cardiac clinical patients. However, they more frequently required invasive mechanical ventilation and vasoactive amines, albeit for a shorter duration. The lower mortality rate in cardiac patients may be linked to the shorter duration of advanced resource use. A Greek PICU, which does not serve as a reference center for post-operative cardiac surgery, reported that 67.3% of admitted patients required mechanical ventilation (12). In our study, prolonged length of stay (greater than 14 days) was more common among non-cardiac clinical patients, likely due to the higher prevalence of comorbidities in this group (58.4%), which necessitated more intensive use of invasive technological resources such as mechanical ventilation and vasoactive drugs. In a prospective cohort study by Liu et al., which included 382 children in a PICU requiring ventilatory support, 33.2% required invasive mechanical ventilation. This subgroup primarily consisted of children under 12 months old, who had a higher prevalence of comorbidities compared to those receiving non-invasive ventilatory support (13). Similarly, an Indian study found that patients with comorbidities and more severe clinical conditions experienced higher mortality rates and longer hospital stays (14).

Da Silva et al. (2019) reported that patients requiring permanent medical devices for chronic diseases and those with cognitive disabilities experienced prolonged hospital stays, longer durations of invasive mechanical ventilation, and higher mortality rates (15). Studies focusing on illness profiles and the need for intensive care revealed that surgical diagnoses were more frequent among patients without chronic diseases, as the presence of comorbidities increases the likelihood of disease progression and PICU readmission (16).

4-4. Risk factors for mortality

CHD is one of the top five causes of infant mortality, with an 18.7% increase in prevalence and a 34.5% decrease in mortality observed in 2017 compared to the 1990s (17). According to the Ministry of Health (2021) (5). CHDs represent the second most prevalent congenital anomaly in Brazil. HIMABA, as a CHD reference center, reported that surgical cases account for 51.2% of admissions, with congenital cardiac surgeries in 38.8% of cases. However, the mortality rate for surgical patients with CHD at HIMABA was lower than that observed in non-cardiac clinical patients. This can be attributed to early surgical interventions that facilitated the suspension of vasoactive amines and early extubation in the post-surgical period. Additionally, the exclusion of neonates, who were admitted to the NICU rather

than the PICU, contributed to the lower mortality rate among cardiac patients. Ferhatoglu et al. noted a correlation between mortality and prematurity, with a higher incidence of infection in younger and low-weight patients (18). An Iranian study found a 12.4% mortality rate in post-cardiac surgery patients, with cyanotic heart diseases and neonates showing the highest rates of cardiovascular and neurological complications, as well as mortality (19).

A study conducted across 31 CHD reference centers in 17 developing countries observed significant variability in mortality rates, ranging from 1.7% to 25%, with an overall in-hospital mortality rate of 5% (20). A prospective cohort study aiming to determine the epidemiology of mortality in five North American hospitals reported a mortality rate of 2.39% (ranging from 1.85% to 3.38%). The study noted that a country's overall development level influences observed mortality rates, and even countries with similar economic development levels show different mortality rates (21).

CHD remains a significant cause of morbidity and mortality in pediatrics, often necessitating multiple surgical interventions and increasing susceptibility to nosocomial infections due to frequent hospitalizations. Despite these challenges, the survival rate for surgically treated pediatric cardiac patients was high at 96.8%, with a shorter average length of stay of 9.2 days, even though the use of invasive mechanical ventilation (66.5%) and vasoactive drugs (57.3%) was more frequent compared to the overall study sample. Another Brazilian study on post-cardiac surgery patients found that approximately 73.3% of patients were hospitalized for less than 7 days, with a mortality rate of 11.1%, particularly among those under 1 year of age and with cyanotic heart disease (22). Bastos et al. assessed the clinical and epidemiological profile of a cardiology PICU in northeast Brazil and found that one-third of patients had prolonged stays (over 30 days), with 87.6% of all cardiac surgery patients requiring invasive mechanical ventilation. The heterogeneity of CHD patients contributes to the varied clinical and epidemiological profiles observed in different reference centers in Brazil and worldwide (23).

4-5. Clinical implications

The lower mortality rate and shorter hospital stays among cardiac patients suggest that early surgical interventions and specialized cardiac care protocols are effective. This underscores the need to expand specialized cardiac care by creating reference centers in regions where improved timing of cardiac interventions could potentially enhance outcomes for pediatric patients. Additionally, the higher mortality and prolonged use of invasive resources among non-cardiac patients highlight the need to develop standardized care pathways for managing non-cardiac conditions in our center and to optimize the use of invasive therapies, which could improve survival rates.

Understanding the clinical-epidemiological profile of patients treated in PICUs can help inform resource allocation, staffing, and planning within these units. This, in turn, can guide public health policies to ensure adequate support for both cardiac and non-cardiac patient populations and to develop strategies that address risk factors to improve mortality in these settings (24).

5- LIMITATIONS

There are some limitations to consider in our study. The primary constraint was that it reflected only patients diagnosed and referred to HIMABA. Given its single-center, observational, retrospective design, this limits the generalizability of the data due

to potential selection bias. Although HIMABA serves as a regional center for specialized healthcare, the sample does not accurately reflect the prevalence of CHD cases in the state and should be viewed as an approximation. The exclusion of neonates from the study population may have led to an underestimation of the mortality rate among patients with CHD. Additionally, race was not recorded in the electronic health records and was therefore not included in the analysis, leaving the potential impact of race on clinical outcomes unclear. Lastly, there is a risk of information bias, as data were collected from electronic health records. However, trained personnel conducted the data collection with care to minimize this risk.

6- CONCLUSION

This retrospective cross-sectional study of pediatric patients admitted to a public PICU in Espírito Santo, Brazil, demonstrated a mortality rate of 6.8% over a two years of investigation. Patients with non-cardiac diseases experienced longer hospitalizations, increased durations of invasive ventilation and vasoactive drug use, and a higher mortality rate compared to those with cardiac diseases.

Favorable clinical outcomes were more common among patients with cardiac diseases, potentially due to early surgical interventions, shorter durations of invasive mechanical ventilation and vasoactive drug use, and the exclusion of neonates, who were admitted to the NICU instead of the PICU.

These findings highlight the importance of specialized care for pediatric cardiac patients and emphasize the ongoing need for research to improve outcomes for children with non-cardiac diseases in intensive care settings.

7- CONFILCT OF INTEREST

No declared

8- REFERENCES

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