Section: Paediatrics

Original Research Article

ASSOCIATION BETWEEN PREOPERATIVE RISK FACTORS AND OUTCOME OF CARDIAC SURGERY IN CHILDREN PRESENTING WITH CONGENITAL HEART DISEASE IN A TERTIARY CARE HOSPITAL IN SOUTH INDIA

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Received : 16/05/2023
Received in revised form : 28/06/2023
Accepted : 12/07/2023

Keywords:
Acyanotic, RACHS – 1, Prolonged preoperative ventilation, Sepsis, Malnutrition, Postoperative weight gain, Down syndrome.

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DOI: 10.47009/jamp.2023.5.4.203

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (4); 1010-1015

Abstract

Background: Focusing on morbidity and long-term outcome indicators and the influence of preoperative risk factors linked to long-term neurodevelopmental repercussions in children with congenital heart disease (CHD) is crucial for CHD management. This study is aimed to analyse the association between preoperative risk factors in children with CHD and outcome of the heart surgery in a tertiary care hospital in south India. **Materials and Methods:** This prospective observational study was conducted among patients admitted in cardiothoracic and cardiology wards at the Institute of child health and Hospital for Children, Chennai, for one year (August 2020 to October 2021). A total of 105 children diagnosed with CHD, after obtaining informed consent from parents, were noted of birth, and demographic information were evaluated for various preoperative risk factors and RACHS-based surgery. Postoperatively followed-up up to 3 months, analysing postoperative data including hospital stay, postoperative ventilation and sepsis, weight gain, neurodevelopmental red flags and outcome measures in discharge and mortality. **Results:** Acyanotic and cyanotic CHDs were observed around 69.2% and 30.8 % respectively .The most common CHD was VSD . Majority of children (74.3%) presented with risk factors out of which 46 % are below 1 year of age .53.3% of children were under risk adjusted classification for congenital heart surgery (RACHS – 2) category , while 5.7 % in RACHS -4 and 1% in RACHS -5 . 13.7 % of children expired .The mean duration of hospital stay in the study was 10.92+-7.04. Statistically significant difference in weight gain preoperatively and postoperatively was observed in the non risk factor group. **Conclusion:** Preoperative risk factors is statistically significant determinant for post operative outcome in terms of survival and mortality . Majority of deaths (85.7%)was recorded in children aged less than 1 year . Complexity of heart surgery analyzed with RACHS -1 revealed higher mortality with RACHS 4 and 5. Statistically significant post operative weight gain observed in both groups with significant difference in weight gain in the non risk factor group, thus by performing early cardiac surgery, vicious cycle of malnutrition is broken. There has to be increased awareness communicated to general population about early diagnosis of congenital heart disease and early referral for surgery.

INTRODUCTION

Congenital heart abnormalities (CHD) are the most frequent congenital anomalies, with a frequency of 6 to 8 per 1000 live births recorded. CHD refers to a group of congenital abnormalities that disrupt the proper functioning of the heart.[1] The phrase "congenital" refers to a condition from birth. Congenital heart disease (CHD) is a congenital abnormality or heart structure issue, such as a hole in the heart wall. Problems with blood vessels (too many or too few, blood moving too slowly, to the wrong spot or in the wrong direction), heart valve problems.[2] Some cases of CHD are uncomplicated and have no symptoms, but others are life-threatening and require treatment. Heart

abnormalities can be discovered early (before or shortly after birth). However, CHD is sometimes not diagnosed until infancy, adolescence, or adulthood.[3]

Foetal wastage occurs owing to CHDs incompatible with life and some cardiac lesions that remain asymptomatic in early life (e.g., bicuspid aortic valve and patent ductus arteriosus), rendering the real incidence unclear. CHD patterns vary according to the population; Premature and tiny for gestational age infants, for instance, have a higher frequency of congenital impairments than full-term neonates.[4] Paediatric cardiac surgery began roughly two decades later in underdeveloped countries than in industrialised countries, and its expansion remains limited in these countries.[5] The average population's affordability is the primary cause behind this.In India, over 1-2 million, infants with CHDs are waiting for surgery at any given moment, with approximately 80,000 requiring extremely urgent surgery and just 5% or fewer being able to afford it.[6]

The frequency of congenital heart disease (CHD) in newborns is an important public health concern requiring close monitoring. Although surgical therapy for CHD is fast developing and early mortality has fallen considerably in underdeveloped and developing countries, neonatal CHD management remains problematic.[7] Early mortality of neonates with transposition of the great arteries in both such countries was five times greater than in developed countries. According to a recent comprehensive analysis, the death rate of newborns with severe CHD is twofold higher in countries with lower GDP.[8] CHD is classified into cyanotic congenital heart disease and acyanotic congenital heart disease. Cyanotic congenital heart disease is characterised by cardiac abnormalities that limit the quantity of oxygen given to the rest of the body. This is known as a critical congenital cardiac defect. Babies born with cyanotic congenital heart disease typically have low oxygen levels and require surgery. Acyanotic congenital heart illness is caused by a condition that causes blood to flow improperly through the body.[9]

CHD signs and symptoms vary depending on the kind and severity of the problem. Some abnormalities may have little or no visible indications or symptoms. Others, such as blue-tinted nails or lips, may lead a newborn to exhibit the symptoms. Breathing that is too fast or difficult, Sleepiness and tiredness during feeding. The causes of CHDs in the majority of newborns remain unknown. Some are born with cardiac abnormalities due to mutations in their unique genes or chromosomes. CHDs are likely caused by a mix of heredity and environmental factors, such as the mother's nutrition, health problems, or medication usage during pregnancy.[10] At the time of diagnosis, over one-third of all hospitalisations for congenital heart surgery had an accompanying complication. When compared to hospitalisations without problems, these complications during these admissions are associated with a greater risk of death.[11]The current study sought to determine the relationship between preoperative risk factors in infants with congenital heart disorders and the outcome of cardiac surgery at a tertiary care hospital in south India.

MATERIALS AND METHODS

This is a one-year (August 2020 to October 2021) prospective observational study of patients hospitalised in the cardiothoracic and cardiology wards at the Institute of Child Health and Hospital for Children in Chennai. One hundred five children clinically diagnosed with CHD were enrolled in the study, confirmed by echocardiogram and underwent heart surgery.

Inclusion Criteria

Children aged 0 to 12 years diagnosed with CHD based on echocardiogram (ECG) and having heart surgery, as well as those with dysmorphism and syndromic, were included.

Exclusion Criteria

Preterm newborns and children whose parents did not volunteer to participate were excluded.

After receiving written informed permission, birth information, demographic data, and complaints were recorded. A full physical examination is performed, which includes vitals, anthropometry, head-to-toe examination, and systemic examination, as well as ECG, radiography, and ECHO results. Failure to thrive, pulmonary artery hypertension, recurrent lower respiratory tract infection, cyanotic episodes, preoperative sepsis, preoperative ventilation, and syndromic association are then assessed in the patients. The procedure is classified using the risk-adjusted categorisation for congenital heart surgery (RACHS)-I criteria.12 Postoperative data were gathered following the procedure. POD - 0 saw the collection of blood cultures. Data was gathered on the length of hospital stay, the duration of postoperative ventilation, the requirement for antibiotics to be upgraded, and the outcome measure regarding discharge or mortality. These patients were also followed up at 1 and 3-month intervals. At these intervals, anthropometry, height, weight, developmental red flags, and overall well-being were evaluated.

Following approval from the ethics committee, the trial was launched, and parent/guardian informed consent was obtained. While analysing and presenting the data, strict secrecy was maintained.

Statistical Analysis

Data was input into an Excel spreadsheet. The statistical programme SSPS Version 20 was used to analyse the data. The outcome variables were presented as a percentage with a 95% confidence interval.The Chi-square test was used to assess the correlation of various parameters. The unpaired t-

ISSN (O): 2687-5365; ISSN (P): 2753-6556

test and the Maan Whitney U test were also employed.

RESULTS

Among the study populations, 5.7% were neonates (preterm babies were removed), 45.7% were less than one year old, and 10.5% were children over five. Of105studysamples, 56.3% weremales,and 43.7%werefemales. Severe malnutrition was the most prevalent risk factor identified in the research group, followed by PAH and preoperative sepsis, contributing 19.2%. The majority (74.3%) had risk factors, whereas the remaining 25.7% did not.It was also observed that many patients < 3 years of age were under severe malnutrition, 60% (Table 1).

Table 1: Demographics of patients involved in the study

Parameter		Frequency	Percentage
Age	0-28 days (Newborn)	6	5.7%
	One month - 1 year	48	45.7%
	1-5 years	40	38.1%
	>5 years	11	10.5%
Gender	Male	67	56.3%
	Female	38	43.7%
Weight for age	Normal(-1to+1)	15	14.3%
	Mildunderweight(-1to-2)	12	11.4%
	Moderatemalnutrition(-2to-3)	15	14.3%
	Severemalnutrition(below-3)	63	60%
Risk factor presence	Yes	73	74.3%
	No	27	25.7%
Risk factors	Weight for age (Severe malnutrition)	63	80.8%
	PAH	27	34.6%
	Cyanotic spells	6	7.7%
	Syndrome	4	5.1%
	Preoperative SEPSIS	15	19.2%
	(2 vents) Preop Ventilation yes	3	3.8%
Diagnosis age	0-28 days	30	28.6%
	Onemonth-1year	63	60%
	1-5 years	12	12.5%

Upon analysis of age at diagnosis, 28.6% were in the neonatal period, 60% were in the infantile period, and the rest, 12.5%, were above one year of age.Parameters such as patient age, risk factors, and discharge and death werecorrelated. It was found that there existed a significant association between patient age and risk factors ($p<0.001$). This was evident by the observation of risk factors in 95.8% of patients.

An associative significance between age and outcome measure was also noted in the study population, as most deaths occurred in neonates and the infantile age groups. 85.7% of mortality is in the above group, whereas no mortality is in children above five.There is no correlation between gender, risk factors and also gender and outcome measures in the study.Hence gender is not a risk factor in determining outcomes. There was a statistically significant difference in preoperative weight between the risk and non-risk groups ($p<0.001$) (Table 2).

Table 2: Association of preoperative age, gender and weightwith risk factors and outcomes

Parameters	Age				Total	P value
	0-28 days (Newborn)	1 month - 1 year	1-5 years	>5 years		
Risk factors						
Yes	5(6.4%)	46(59%)	23(29.5%)	4(5.1%)	78	0.001*
No	1 (3.7%)	2 (7.4%)	17 (63%)	7 (25.9%)	27	
Total	6(5.7%)	48(45.7%)	40(38.1%)	11(10.5%)		
Outcomes						
Discharge	3(3.3%)	39(42.9%)	38(41.8%)	11(12.1%)	91	0.006*
Death	3(21.4%)	9(64.3%)	2(14.3%)	0	14	
Total	6(5.7%)	48 (45.7%)	40(38.1%)	11(10.5%)		
Gender						
Risk factors	Male		Female			
Yes	47(60.3%)		31(39.7%)		78	0.198
No	20(74.1%)		7(25.9%)		27	
Total	67(63.8%)		38(36.2%)			
Outcomes						
Discharge	59(64.8%)		32(35.2%)		91	0.577
Death	8(57.1%)		6(42.9%)		14	
Total	67(63.8%)		38(36.2%)			
Weight						
Risk factors	Yes		No			

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	5.88±3.19	13.67±5.76	105	<0.001
Total	78	27		

The study used the RACHS -1 (risk adjustment in congenital heart surgery) -1 classification tool. Of these, 23.8% were categorised under RACHS -1, 53.3% were under RACHS -2, and the least, about 1%, came under RACHS-5.The complexity of heart surgery, analysed using RACHS-1 classification, has a significant correlation with outcome in terms of mortality (p<0.001) (Table 3).

Table 3: RACHSwith discharge and death (N=105)

RACHS	Discharge	Death
1	25 (100%)	0 (0%)
2	49 (87.5%)	7 (12.5%)
3	14 (82.4%)	3 (17.6%)
4	3 (50%)	3 (50%)
5	0 (0%)	1 (100%)
Total	91	14
Chi-square–17.63		
Pvalue-0.001(Significant)		

The majority were acyanotic heart disease, out of which 34.3% were VSD,25% of children were grouped under cyanotic heart disease, out of which TAPVC (total anomalous pulmonary venous connection) contributed to 10.5%, followed byTOF (including TOF with pulmonary atresia) owing to 9.6%.A preoperative risk factor significantly correlates withoutcome in terms of mortality (p=0.018). Out of 14 deaths, all occurred in the risk factor group (Figure 1).

69.2% of children came under acyanotic congenital heart disease,and 25%came under cyanotic congenital heart disease, of which 5.8% presented withcyanotic spells, included as a preoperative risk factor. Only 2.9% of them were observed with recurrent LRI. 26.7% of children presented with pulmonary artery hypertension, which isincluded as a risk factor, and 59% with CCF. 3.8% of children belong to the syndromic group, most of whom were observed with Down syndrome. Preoperative sepsis and ventilation were observed among 14.3% and 3.8% of the study population.

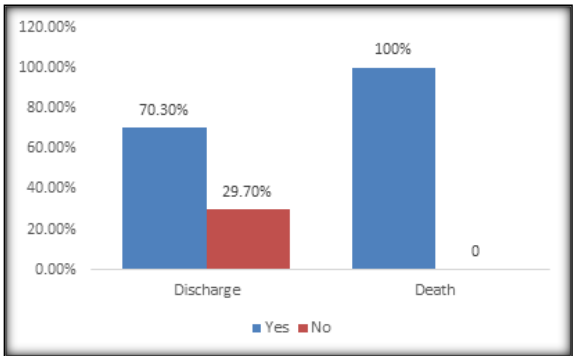
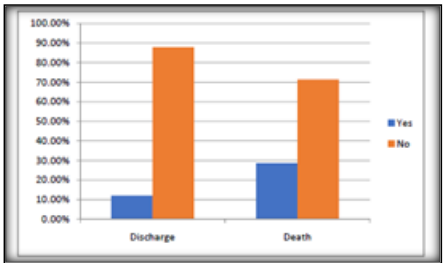


Figure 1: Bar diagram showing analysis between risk factors and outcome

Preoperative sepsis has no significant correlation with outcome in termsof mortality, and preoperative ventilation significantly correlates with outcome in terms ofmortality (Figure 3).7.6% of children presented with developmental red flags, and the postoperative blood culture positivity rate was around 9.5%.



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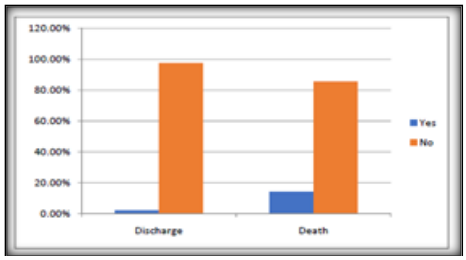

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86.7% of children were ventilated postoperatively for < 7 days, whereas 13.3% needed prolonged ventilatory support. No statistical significance existsbetweenprolongedpostoperativeventilationand weightgain(p>0.05). 82.9% were in the open-heart surgery group, and 17.1% belonged to the closed-heart surgery group.14.1% of the children presented with residual shunt abnormality andre-surgery was done in 2.9% of children. 86.7% were discharged postoperatively, and the mortality rate was 13.3%. The study population's mean length of hospital stay is around 10 to 11 days.

Table 4: Comparison of mean postoperative weight parameters with riskfactors

Parameter	Risk factors		P value
	Yes	No	

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One month	6.68±2.96	14.56±5.89	<0.001
Total	64	27	
Three months	6.88±4.34	16.28±6.22	<0.001
Weight gain difference	1.90	2.60	0.008
Total	68	26	

There was a significant difference between risk factor groups in patients with mean operative weight at months 1 and 3 and weight gain at the end of 3 months (Table 4).

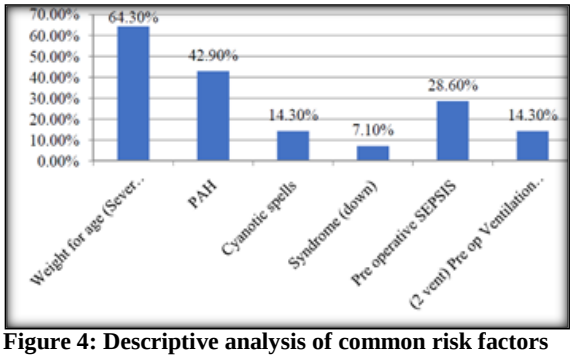

Figure 4: Descriptive analysis of common risk factors among mortality

Out of 14 deaths, all of which occurred in the risk factor group, severe malnutrition is the most common risk factor contributing to mortality (Figure 4).

DISCUSSION

CHD missed during a prenatal examination will be discovered postnatally, either during CHD screening or when symptoms occur. The outcome advantage of CHD screening is inferred from studies that reveal that children with undiagnosed CHD die but is not proven.[13] With lower early mortality from CHD, the emphasis has shifted to morbidity and long-term outcome metrics. Certain early unfavourable characteristics, such as greater duration of stay in hospital, preoperative asphyxia, and perioperative convulsions, have been shown to have long-term neurodevelopmental consequences. Assessing variables that may impact preoperative status and operational morbidity is thus necessary to better understand and enhance long-term outcomes.[14]

In the current study, conducted at a tertiary care hospital in south India, children with acyanotic congenital heart disease were about 69.2%. In contrast, cyanotic CHDs were around 30.8%, with 5.8% of the cyanotic CHDs presenting with cyanotic episodes. Gender was not an influencing factor for CHD-related mortality. This finding was comparable to earlier Indian research performed by Bakshi et al., who showed that the larger percentage of the study population related to risk factors is in the newborn group, which was also consistent with our findings.[15]

In our study, the age of diagnosis of CHD was reported to be 28.6% in the newborn period, 60% in the infantile age group, and the remaining 12.5% were above one year of age. The death rate in our research of 105 children who had heart surgery was 13.7%, although prior Indian investigations documented a mortality rate of roughly 7.5%.[16] Western literature, on the other hand, documented a lower death rate of roughly 4.6%, according to research done by Welke et al.[17] The higher mortality rate in the Indian population is because of lack of awarenessregarding early diagnosis and referral, poor nutritional status, socioeconomic andfinancial constraints,the lesser availability of dedicated paediatric cardiology centres inIndia.[18]

According to our findings, the complexity of heart surgery, as defined by RACHS - 1 criterion, is a significant predictor of death. Maximum mortality was observed in children with RACHS - 4 (60%) and RACHS - 5 (100%), while the lowest mortality was observed in children with RACHS - 1 (10%) and RACHS - 2 (12.5%), which is consistent with previous studies by Jenkins et al. using Paediatric Cardiac Care Consortium data, where mortality rates were 0.4% in category 1, 3.8% in 2, 8.5% in 3, 19.4% in 4, and 47.7% in 6. All of the deaths in the trial were in the risk factor group (p=0.016), demonstrating that the existence of a preoperative risk factor had a substantial impact on the outcome in terms of discharge and mortality.[17]

Severe malnutrition was shown to be the most common preoperative complication, followed by greater rates of pulmonary artery hypertension and preoperative infection. This was following the observations of Murniet al.[18] They also said that perioperative infections could have serious repercussions for children with congenital heart disease (CHD), manifesting as acute or chronic infection, followed by poor development and progressive cardiac failure. The effects include postponing or increasing the risk of surgery and increased postoperative morbidity and death.

There were also significant cyanotic episodes, preoperative ventilation, and syndromic children. Prolonged perioperative ventilation was more prevalent when there was an accompanying condition or medical issue, cardiovascular impairment, or end-organ failure on admission.[6] Preoperative ventilation was found to have a statistically significant connection with mortality results.The mean duration of hospital stay in our study population was around 10.92 that wasfollowing that reported by Bakshi et al.[15]

In our study population, the most common acyanotic CHD was VSD, which accounted for around 34.3%, and the most common cyanotic CHD was TAPVC, which accounted for around 10.5%, with tricuspid atresia accounting for the least, around 1.9, which is

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consistent with previous studies, where VSD accounted for around 35%.16The research measured Weight gain 1 month and 3 months after surgery. The risk factor and non-risk factor groups gained weight postoperatively. However, the difference between preoperative and 3-month postoperative weight increases in the non-risk factor group was statistically significant.

The unpaired t-test was used to conduct statistical analysis between the risk factor group and the non-risk factor group. Vaidyanathan et al. showed good catch-up growth following early heart surgery in earlier trials.[19] The current investigation found developmental red flags in 7.6% of the population; however, no sophisticated development evaluation using standard scales was performed. Thus, the presence of preoperative risk factors and the complexity of heart surgery classified as RACHS - 1 significantly influenced the result regarding postoperative mortality.

CONCLUSION

In the current investigation, preoperative risk variables were shown to be a statistically significant predictor of postoperative outcome in terms of survival and death in children undergoing cardiac surgery for congenital heart disease. There is statistically significant postoperative weight gain in both the risk factor and non-risk factor groups, with a statistical difference in weight gain between the preoperative and postoperative periods observed in the non-risk factor group; thus, early cardiac surgery breaks the vicious cycle of malnutrition.

Thus, even in developing countries with limited infrastructure and resources, attention to preoperative risk factors such as severe malnutrition and preoperative sepsis, combined with strict adherence to infection control practises postoperatively, can significantly reduce mortality. There needs to be greater public awareness of congenital heart illness and early detection of congenital heart disease. As avoidable causes of mortality in children decline, the present extent of the problem with congenital heart disease is enormous. Congenital heart disease and cardiac surgery are becoming increasingly important.

Limitations

Due to case availability and timing constraints, the study only included 105 individuals as samples. Because of scheduling restrictions, the follow-up was only done for three months; long-term follow-up could not be done. Only development redflags were examined; no developmental evaluation using standardised measures was performed.Clinically, syndromic children were diagnosed, and karyotyping was performed, but additional genetic testing for identifying other syndromes could not be performed due to a lack of availability.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556