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A Study On The Influence Of Different Factors On Surgical Outcomes In Congenital Heart Conditions

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ABSTRACT

Background: Congenital heart disease (CHD) is present in 0.5-0.8% of live births and significantly affects neonatal and infant morbidity and mortality worldwide [1]. In low- to middle-income countries, various factors such as widespread malnutrition in children, financial constraints faced by families, limited awareness of the signs and symptoms of heart disease, and a tendency for cases to be diagnosed later can adversely affect the outcomes of congenital heart disease surgeries [2].

Objectives: 1. The primary objective is to identify and analyze perioperative factors that influence the outcome of surgery in children with congenital heart disease.

2. To determine the prevalence of complications, morbidity, and mortality in a developing nation's pediatric cardiology intensive care unit.

3. To evaluate the role of perioperative factors in determining surgical success.

Material & Methods:

Study Design: Hospital-based Cross-sectional study.

Study area: The study was conducted in the Department of Paediatrics.

Study Period: 1 year.

Study population: children undergoing CHD Surgery.

Sample size: The study consisted of a total of 340 subjects.

Sampling Technique: Simple Random technique.

Results: Post-operative sepsis, arrhythmia, pleural effusion requiring drainage, peritoneal dialysis, and low cardiac output syndrome (LCOS) were all strongly associated with prolonged ICU stay of more than 5 days. Additionally, longer duration of mechanical ventilation increased oxygen demand, ICD removal, and inotrope requirements were among the best set of variables linked to extended postoperative ICU stay.

Conclusion: Our study highlights significant advancements in managing congenital heart diseases (CHDs) in children, particularly acyanotic CHDs like VSD, emphasizing the need for targeted strategies. The low mortality rate and manageable complications reflect the success of our multidisciplinary approach, with younger age, complex CHD, and severe pulmonary hypertension identified as key predictors of stay prolonged ICU.

Keywords: *Congenital heart disease, multidisciplinary approach, Risk Adjustment in Congenital Heart Surgery-1*

1. INTRODUCTION

Congenital heart disease (CHD) is present in 0.5-0.8% of live births and significantly affects neonatal and infant morbidity and mortality worldwide [1]. In low- to middle-income countries, various factors such as widespread malnutrition in children, financial constraints faced by families, limited awareness of the signs and symptoms of heart disease, and a tendency for cases to be diagnosed later can adversely affect the outcomes of congenital heart disease surgeries [2]. In addition to these challenges, healthcare facilities in these nations are constrained by a lack of human and material resources for performing corrective heart surgeries in newborns and young infants, insufficient pediatric cardiac anaesthesia facilities, a deficiency of surgical expertise, the unavailability of pediatric cardiac surgery anesthesiologists, inadequately trained staff, inadequate infrastructure in pediatric cardiology ICUs (PCICUs), and ineffective referral systems [2]. The experience of surgeons presents a concern for both the families of children with congenital heart disease and their medical practitioners [3]. Although there is a common assumption connecting physician seniority with patient outcomes, the relationship between surgeon experience and the outcomes of congenital heart disease surgeries is still unknown [3]. Recent progress in management strategies within pediatric intensive care units (PCICUs) has improved survival rates for children with congenital heart diseases, especially those facing more severe conditions [4].

To accurately assess the differences in complication and mortality rates across pediatric cardiac surgery centres, methods that consider the complications related to various procedures that have been widely used include the Risk Adjustment in Congenital Heart Surgery-1 (RACHS-1) and the Aristotle Complexity Score (ACS) [5].

The most common side effect following heart surgery is low cardiac output syndrome, also known as LCOS [6]. Prolonged mechanical ventilation is often linked to longer ICU stays, and both conditions are associated with increased mortality rates [7]. The length of post-operative hospital stay is independently influenced by the presence of intra-operative complications, issues with post-operative feeding, the length of chest drain placement, and the duration of mechanical ventilation [8].

Nearly one-third of admissions for congenital heart surgery present with a complication at the time of diagnosis [9]. Reduced total body fat and both acute and chronic malnutrition have been connected to poorer clinical outcomes and measures of myocardial performance in children undergoing congenital heart disease (CHD) surgery [10]. These findings indicate that healthcare professionals and surgeons should carefully assess a child's nutritional status when planning non-emergency surgeries for CHD and when discussing potential surgical risks with parents [11,12]. In developed nations, the mortality rate for surgeries related to CHD varies from 1 to 10% [13,14]. CHD combined with complications carries a higher risk of mortality, even after adjusting for other known risk factors for death [15,16,17].

This research assesses the results of open heart surgery conducted on pediatric patients with congenital heart disease, focusing on early mortality rates, complications, morbidity, and the duration of postoperative ICU admissions. Additionally, this study investigates the factors that influence the outcomes of congenital heart disease surgeries by utilizing established methods and previous research findings.

2. OBJECTIVES

1. The primary objective is to identify and analyze perioperative factors that influence the outcome of surgery in children with congenital heart disease.

2. To determine the prevalence of complications, morbidity, and mortality in a developing nation's pediatric cardiology intensive care unit.

3. To evaluate the role of perioperative factors in determining surgical success.

3. MATERIAL & METHODS

Study Design: Hospital-based Cross-sectional study.

Study area: The study was conducted in the Department of Paediatrics.

Study Period: 1 year.

Study population: children undergoing CHD Surgery.

Sample size: The study consisted of a total of 340 subjects.

Assuming a 95% Confidence Interval, with a prevalence of 12.4% and precision of 3.5%, the required sample size for the study was calculated to be 340.

Sampling Technique: Simple Random technique.

Inclusion Criteria:

✧ Children 0 - 18 years of age, with congenital heart disease from IPD (NICU, pediatric war and Paediatric ICU) who are undergoing cardiac surgery at AIMSR hospital from 2022 to 2024.

Exclusion Criteria:

✧ Children with congenital heart disease who are undergoing device closure or catheter-based intervention.

✧ Children who are undergoing reoperation for congenital heart disease.

✧ Children with non-operable congenital heart disease.

✧ Children with acquired heart disease.

✧ Children with congenital heart disease associated with syndromes.

Ethical consideration: Institutional Ethical committee permission was taken before the commencement of the study.

Study tools and Data collection procedure:

After noting demographic data, birth information, and presenting complaints, Physical examination for anthropometry; vitals and systemic findings, ECG, Chest X-ray, laboratory data and ECHO findings were studied and children were evaluated for the presence of the following sets of factors:

Preoperative factors:

1. Undernutrition: weight for age <-2SD or weight of the child less than 3rd percentile for the age.

2. Socio-demographic: Age at diagnosis.

3. Prematurity

4. Other medical conditions: Seizure disorder, Lung disease(bronchial asthma), recurrent lower respiratory tract infections, renal disease (pelvic ureteric junction obstruction), Liver disease (deranged liver function tests)

5. Complications of Congenital heart disease:

◆ Pulmonary artery hypertension- Mean pulmonary artery pressure of more than 30 mmHg at rest and systolic pulmonary artery pressure of more than 45 mmHg at rest

◆ Pulmonary artery structural anomaly- identified by computed tomographic pulmonary angiography (CTPA) or ECHO.

◆ Complex/ critical Congenital Heart Disease- A set of cardiac abnormalities that induce significant, life-threatening symptoms and necessitate intervention during the first days or years of life which includes Hypoplastic left heart syndrome (HLHS),

Pulmonary Atresia with an intact septum, Tetralogy of Fallot, Total Anomalous Pulmonary Venous Return(obstructive), Transposition of the great arteries(TGA), tricuspid atresia (TA) and Truncus Arteriosus.

◆ Preoperative CHF.

Intra-operative factors: RACHS-I surgical Category, intraoperative analgesia(spinal analgesia with ketamine and fentanyl)

Post-operative factors: include major complications after surgery and others.

1. Arrhythmia- heart block, supraventricular tachycardia.

2. Post-operative sepsis.

3. Low cardiac output syndrome: a clinical syndrome caused by a transient decrease in systemic perfusion secondary to myocardial dysfunction

4. Requirement for re-intubation.

5. Pleural effusion/ pericardial effusion requiring drainage.

6. Acute kidney injury requiring peritoneal dialysis.

7. Period of mechanical ventilation.

8. Period of oxygen requirement.

9. Period of inotrope requirement.

The PCICU care was given by a group of trained ICU nurses, pediatric cardiologists, anesthesiologists, cardiovascular specialists, and at times pediatric subspecialists. The cardiovascular specialists were in charge of the patient's care, which included communications with different administrations. The postoperative course of each patient from entering the PCICU until being discharged from it was carefully monitored and the following data was analyzed: age, gender, type of cardiac malformation, type of cardiac surgery, complexity score of the surgical procedure, history of non-cardiac conditions, if applicable, intubation time, types of complication, postoperative ICU-stay time, types of complication, and mortality.

Outcome was measured in terms of major complications and length of period of postoperative ICU stay. The usual period of postoperative ICU stay was taken as less than or equal to 5 days. Early postoperative mortality was defined as any death that occurred within 30 days after surgery in or out of the hospital, or after 30 days during the same hospitalization following the operation.

Risk Adjustment Method in Congenital Heart Surgery-1

The present study utilized the Risk Adjustment in Congenital Heart Surgery-1 (RACHS-1) category to adjust for the varied risks associated with different types of surgeries. Patients undergoing CHD surgery were assigned to one of the six risk groups, ranging from 1 (the lowest risk) to 6 (the highest risk).

Statistical Analysis:

Categorical information was presented as frequencies and percentages and evaluated using the chi-square test. Quantitative variables were expressed as mean with standard deviation (SD) and analyzed using Student's t-tests. Logistic regression analysis was employed to identify factors associated with prolonged ICU stay. Odds ratios were obtained to quantify the strength of the association between each predictor and the likelihood of prolonged ICU stay. The statistical analysis was performed using SPSS version 24, with a significance level set at $p < 0.05$.

4. OBSERVATIONS & RESULTS

Table 1: Age distribution

Age	**No.**	**Percentage**
0-1 years	65	19.1
1-5 years	139	40.9
6-18 years	136	40
Total	**340**	**100**

More than half of the study population was below the age of 6.

Out of the 340 sample size, 51.2 % of the children were males, and 48.8% were females.

Table 2: Distribution according to type of CHD in the child

CHD type		**Frequency**	**Percentage**
Acyanotic	ASD	82	24.1
	VSD	149	43.8
	PDA	26	7.6
	AVSD	4	1.1
	CORTRIATRIUM	3	0.8
	COA	1	0.3

	AS	1	0.3
Cyanotic	TOF	48	14.1
	D-TGA	7	5.2
	DORV	5	1.5
	TAPVC	4	0.2
	TA	4	0.2
	DILV	3	0.8
	PA	2	0.6
	COMMON ATRIUM	1	0.3
TOTAL		**340**	**100**

Among the 340 cases, 78.2 % had ACHD and 21.8 % had CCHD.

Table 3: Distribution according to RACHS-1 type of CHD surgery in the child

RACHS-1 CATEGORY	FREQUENCY	PERCENTAGE
1	96	28.2
2	202	59.4
3	36	10.6
4	6	1.8
5	-	-
6	-	-
TOTAL	**340**	**100**

28.2% of subjects were classified in RACHS-1 Category 1, 59.4% in RACHS-1 Category 2, 10.5% in RACHS-1 Category 3, 1.8 % in RACHS-1 Category 4, and none were classified in RACHS-1 categories 5 and 6.

In this study, 298 patients (87.6%) received regular postoperative ICU care and had a routine postoperative ICU stay with no/ minor complications (≤5 days), while 42 (12.3%) experienced significant complications. During the postoperative ICU course, the following major complications occurred: low cardiac output syndrome (5.6%), postoperative sepsis (5.3%), arrhythmia (5%), pleural effusion requiring drainage (4.1%), cardio-respiratory failure requiring re- intubation (3.5%), the need for temporary peritoneal dialysis (2.6%), and pericardial effusion requiring drainage (1.2 %).

Table 4: Mortality based on diagnosis, n =number

Diagnosis	**n**
VSD	3
PDA	2

TGA	2
PA	1
Total	**7**

In this study, 333 patients (98%) survived, while 7 (2%) died.

A younger age at the time of congenital heart surgery was associated with a longer ICU stay(> 5 days).

Table 5: Frequency Distribution of Complex congenital heart disease with period of post-operative ICU stay

Complex CHD	**Stay≤ 5days**	**Stay>5days**	**Total**
Yes	11	16	27
%	40.7%	59.3%	100%
No	275	38	313
%	87.8%	12.2%	100%
Total	**286**	**54**	**340**

Table 6: Association of perioperative factors with postoperative ICU stay

Sl. no	**Variable**	**Category**	**(n)**	**ICU stay up to 5 days(%)**	**ICU stay ≥ 6 days(%)**	**Chi-square**	**p-value**
1.	Age	Infants Preschool children School age and adolescent	65 139 136	58.5 89.1 91.2	41.5 10.9 8.8	39.6	0.000
2.	Prematurity	no yes	301 39	86.7 64.1	13.3 35.9	13.1	0.000
3.	Weight for age ≤-2sd	no yes	147 193	93.2 77.1	6.8 22.9	16.1	0.000
4.	Preoperative CHF	no yes	326 14	85.2 57.1	14.8 42.9	7.9	0.005

5.	RACHS-1 score	1 2 3 4	96 202 36 6	97.9 84.6 52.8 33.3	2.1 15.4 47.2 66.7	51.6	0.000
6.	Complex CHD	no yes	313 27	87.8 40.7	12.2 59.3	41.1	0.000
7.	Severe PAH	no yes	318 22	85.8 59.1	14.2 40.9	10.9	0.000

The odds of a longer post-operative ICU stay increased directly with the RACHS-1 score and decreased inversely with weight. Other preoperative factors that correlated directly with the period of ICU stay were age, prematurity, preoperative CHF, severe PAH and the presence of complex CHD.

Table 7: Association of postoperative complications with postoperative ICU stay

Sl. no	Variable	Category	(n)	ICU stay up to 5 days	ICU stay ≥ 6 days	Chi-square	p-value
1.	LCOS	no yes	321 19	87.2 31.6	12.8 68.4	41.4	0.000
2.	Arrhythmia	no yes	323 17	86.6 35.3	13.4 64.7	31.7	0.000
3.	Pleural effusion	no yes	326 14	86.5 28.6	13.5 71.4	7.9	0.005
4.	Post-op sepsis	no yes	322 18	86.9 33.3	13.1 66.7	36.5	0.000
5.	Peritoneal dialysis	no yes	331 9	85.5 33.3	14.5 66.7	17.7	0.000

Table 8: Order of best set of variables related to postoperative ICU stay

Sl. no	Variable	Category	Odds ratio	95% CI L	95% CI U	p-value
1.	ICD removal	1-3 days ≥ 4 days	1 51.9	10.4	258.1	0.000
2.	Mechanical ventilation	0 days 1 day ≥ 2 days	1 4.2 35.6	1.5 3.3	12.1 386.3	0.007 0.003

3.	Oxygen requirement during post-operative ICU stay	Upto 3days ≥4 days	1 11.8	3.2 43.2	0.000
4.	Inotrope requirements	1-2 days ≥3 days	1 4.9	1.5 15.7	0.007

Post-operative sepsis, arrhythmia, pleural effusion requiring drainage, peritoneal dialysis, and low cardiac output syndrome (LCOS) were all strongly associated with prolonged ICU stay of more than 5 days. Additionally, longer duration of mechanical ventilation increased oxygen demand, ICD removal, and inotrope requirements were among the best set of variables linked to extended postoperative ICU stay.

5. DISCUSSION

Among our study of 340 subjects ranging from newborns to 18 years old, the majority of the children had acyanotic congenital heart diseases (78.2%), significantly more than those with cyanotic congenital heart diseases (21.8%). The most common acyanotic heart disease was ventricular septal defect (VSD), observed in 149 children (43.8%), while tetralogy of Fallot (TOF) was the most frequent cyanotic heart disease, seen in 48 patients (14%). This finding aligns with previous Indian studies. In a study conducted by Mohd Ashraf in Kashmir, among 221 patients with congenital heart diseases, VSD was the most frequent lesion, seen in 69 (31.2%), and TOF was the most common cyanotic heart disease, seen in 17 (7.8%) patients [16]. In our study of 340 patients, 298 patients (87.6%) received regular postoperative ICU care and had routine postoperative ICU stays with no or minor complications (≤5 days). In contrast, 42 patients (12.3%) experienced significant complications, and the mortality rate was 2%, notably lower than the 2.5% to 11.4% range reported in other studies [17,18].

In our study, the presence of complex congenital heart disease and severe pulmonary arterial hypertension in the preoperative period was significantly associated with postoperative complications. Preoperative factors in the present study associated with prolonged ICU stays included younger age at surgery, prematurity, undernutrition, preoperative congestive heart failure, high-risk RACHS categories, complex congenital heart disease, and severe pulmonary arterial hypertension. Similarly, Ahmad Saeed Azhar and Aljefri's study at King Abdulaziz University Hospital, Jeddah, from January 2013-December 2016 found that prolonged ICU stays were linked to complex CHD types, high-risk RACHS categories, and low weight at surgery [8]. During the postoperative ICU course, major complications in this study included low cardiac output syndrome (LCOS) (5.6%), postoperative sepsis (5.3%), arrhythmia (5%), pleural effusion requiring drainage (4.1%), cardiorespiratory failure requiring re- intubation (3.5%), the need for temporary peritoneal dialysis (2.7%), and pericardial effusion requiring drainage (1.2%). LCOS was the most common major complication.

A retrospective analysis by Xinwei Du et al. at Shanghai Children’s Medical Center on January 1, 2014, and December 31, 2017, reported an LCOS incidence of 9.98% and higher rates of mortality (7.18% vs. 1.08%, $p < 0.001$), ICU stays >3 days (89.24% vs. 33.35%, $p < 0.01$), and mechanical ventilation duration >48 hours (93.21% vs. 44.5%, $p < 0.001$) in LCOS children compared to those without LCOS [6]. Younger age has been linked to prolonged mechanical ventilation following CHD surgery [7].

A study by A D J Ten Harkel et al. at Leiden University Medical Center retrospectively analysed 184 consecutive patients with a median age of 9 months, finding that extubation failure due to cardiorespiratory failure was a poor prognostic sign, with a significant association with reoperations and increased inotropic support [17].

In our study, postoperative factors such as longer periods of mechanical ventilation, oxygen demand, ICD removal, and inotrope requirements were associated with prolonged postoperative ICU stays. Major complications such as postoperative sepsis, arrhythmia, pleural effusion requiring drainage, peritoneal dialysis, and LCOS were strongly linked to ICU stays longer than 5 days. The RACHS-1 method was used in the present study to predict postoperative outcomes, particularly focusing on ICU stay length. Higher RACHS-1 risk categories were significantly associated with longer hospital stays. Despite variability within groups, RACHS-1 effectively classified patients into distinct groups regarding total and postoperative hospital stay durations [19].

Additionally, in the present study, intraoperative spinal analgesia with opioids, delivered as a bolus, was found to reduce postoperative pain and analgesic requirements in patients undergoing heart surgery. Prolonged postoperative ventilation after pediatric cardiac surgery is marred not only by the associated complications but also by the harmful effects of continued sedation and anaesthesia in the ICU [20]. In a randomized open-label trial, using epidural analgesia with ketamine and low-dose fentanyl for anaesthetic induction, compared to high-dose fentanyl, reduced postoperative extubation time and ICU stays in pediatric patients undergoing.

Corrective/palliative surgery with CPB and epidural analgesia for congenital cardiac defects [20]. Significant progress has been made in the surgical management of infants with congenital heart defects over the past 25 years [18].

A retrospective study by A F Rossi in New York in 1997 showed an 83% hospital survival rate for infants weighing 2 kg or less who underwent cardiac surgery, with no difference in mortality based on age, weight, or surgical procedure type. Premature infants had poorer hospital survival, with a median postoperative length of stay of 39 days and a median mechanical ventilation duration of 6 days for survivors [18]. The round-the-clock availability of experienced pediatric cardiac surgeons, pediatric cardiac surgery anesthesiologists, and trained personnel in our pediatric cardiology intensive care unit (PCICU), focused on continuously improving surgical and postoperative care quality for congenital heart disease, likely contributed significantly to the favourable outcomes and low mortality following congenital heart disease surgery at our institution compared to other centres in the country.

6. CONCLUSION

Our study highlights significant advancements in managing congenital heart diseases (CHDs) in children, particularly acyanotic CHDs like VSD, emphasizing the need for targeted strategies. The low mortality rate and manageable complications reflect the success of our multidisciplinary approach, with younger age, complex CHD, and severe pulmonary hypertension identified as key predictors of prolonged ICU stay. The RACHS-1 method proved valuable for risk stratification, while advanced anaesthetic techniques improved recovery times. The expertise of our PCICU team was crucial to these outcomes. Moving forward, these insights will guide further improvements in CHD management, enhancing the quality of life for affected children. Pediatricians should focus on preoperative optimization, including nutrition and comorbidity management, to support better surgical outcomes.

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