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Article

The Outcome of Congenital Cardiac Surgery in Patients with Down Syndrome: Single-Center Experience

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Abstract

Objectives: This study aimed to describe the outcomes of Down syndrome patients who underwent cardiac surgery for congenital heart defects and to develop risk prediction models for in-hospital mortality, recurrent hospital admission, and the need for catheter intervention among a cohort of patients. **Methods**: This single-centre retrospective cohort study included consecutive Down syndrome patients who underwent cardiac surgery for congenital heart defects between January 2018 and December 2021. We reviewed the electronic medical records. Two hundred patients fulfilled the eligibility criteria with complete data reporting. The patients' perioperative data and outcomes were recorded. **Results**: Females constituted 56.5%. Most (78.5%) patients showed accepted recovery. The incidence of all-cause in-hospital mortality was 3.0%. The rates of the need for a second operation, heart failure management, and permanent pacemaker insertion were 3.0%, 2.0%, and 2.5%, respectively. Only 8 (4.0%) patients stayed in the hospital for a long duration after chylothorax or tracheostomy (if intubated more than 2 weeks). The model had an accuracy of 99% and included the intraoperative transesophageal echocardiography (TEE) abnormalities (residual heart lesions) (adjusted odds ratio [AOR]: 26.541, p = 0.033), the duration of mechanical ventilation following the operation (AOR: 1.152, p = 0.009), and the occurrence of postoperative heart block (AOR: 76.447, p = 0.005). **Conclusion**: Surgical treatment of congenital heart defects in Down syndrome patients had good outcomes with accepted recovery (without intra-hospital or during follow-up mortality or morbidity) of 78.5% and a 3% incidence of in-hospital mortality. Though, the occurrence of chylothorax was considerably high, and resulted in a long hospital stay (more than 10 days). Repair of tetralogy of Fallot and coarctation of the aorta were associated with an increased likelihood of catheter intervention following the operation.

Keywords

cardiac surgery; Down syndrome; congenital heart defects; mortality; outcomes

Introduction

Down syndrome (DS) is a very common chromosomal abnormality among live-born infants [1]. Various types of congenital heart disease (CHD) are frequently diagnosed in children with DS, with an incidence of 40–50% [2]. A much higher prevalence of CHD, almost 86.8%, has been found in Saudi Arabia [3]. Cardiac comorbidities have a significant effect on morbidity and mortality outcomes of DS patients [4], and affect their quality of life [5]. Atrioventricular septal defect (AVSD) is the most common form of CHD accounting for approximately 45%, followed by a ventricular septal defect (VSD, 30%), atrial septal defect (ASD, 20%), and tetralogy of Fallot (TOF, 5–10%) [6]. Children with DS usually undergo one or more cardiac surgeries in their lifetime. Timely surgical correction of CHD is important to prevent the development of pulmonary hypertension and Eisenmenger syndrome. Effective surgical management requires detailed preoperative assessment, meticulous procedural care, and proper management of postoperative complications [7]. Improvements in surgical techniques and perioperative management are contributing to a significant increase in life expectancy and the quality of life for children with DS [8].

Limited data exist regarding cardiac surgery outcomes in DS patients in Saudi Arabia. Therefore, this study to describe the outcomes of DS patients who underwent cardiac surgery for congenital heart defects and to develop risk prediction models for in-hospital mortality, recurrent hospital admission, and the need for catheter interventions among a cohort of Saudi patients.

Table 1. Characteristics of the studied Down syndrome patients (N = 200).

Variable	
Male, N %	87 (43.5%)
Female, N %	113 (56.5%)
Age, months, median (IQR)	9.0 (6.0–14.0)
Weight, kg, median (IQR)	6 (4.6–8.0)
RACHS-1 (1), N %	11 (5.5%)
RACHS-1 (2), N %	76 (38.0%)
RACHS-1 (3), N %	99 (49.5%)
RACHS-1 (4), N %	14 (7.0%)
Previous pulmonary artery band	38 (19.0%)
Gradient around the band, mmHg, median (IQR)	70 (53.0–80.0)
The time between PA band and the operation, months, median (IQR)	8.0 (7.0–10.0)
Age at time of pulmonary artery band, months, median (IQR)	4.0 (2.0–6.0)
Number of pre-operative catheterization	35 (17.5%)
CPB time, minutes, median (IQR)	98.5 (67.5–132.0)
Cross-clamp time, minutes, median (IQR)	66.0 (45.0–96.0)
Need for second bypass, N %	24 (12.0%)
Intraoperative TEE abnormalities ^{a}, N %	18 (9.3%)
ICU stay, days, median (IQR)	4.0 (3.0–7.0)
Ventilation, days, median (IQR)	2.0 (1.0–3.0)
Total post-operative hospital stay in days, median (IQR)	8.0 (6.5–12.0)
Follow up, months, median (IQR)	15.0 (11.0–22.0)
Last TTE abnormalities ^{a}, N %	31 (15.5%)

CPB, cardiopulmonary bypass; ICU, intensive care unit; PA, pulmonary artery; TEE, transesophageal echocardiography; TTE, transthoracic echocardiography; RACHS-1, Risk Adjustment for Congenital Heart Surgery-1; IQR, interquartile range; N, number; ^{a}: the main echocardiographic abnormalities included different degrees of valves abnormalities, residual VSD, and poor left ventricle function.

Methods

Eligibility Criteria

All children aged less than 14 years old with DS who underwent cardiac surgery for congenital heart defects during the study period were included. Patients with missing data were excluded.

Follow Up

All patients' follow-up was through routine outpatient clinic visits via complete clinical assessment, Electrocardiography, and transthoracic echocardiography (TTE) depending on the primary clinical status. The pattern of follow-up visits was at 1 and 3 months after surgery and every 6 months thereafter.

Outcomes

We recorded all outcomes including complete recovery, the incidence of all-cause in-hospital mortality, all-cause recurrent hospital admission, need for catheter intervention (device closure or balloon dilatation), need for a second operation, heart failure management, permanent pacemaker (PPM) insertion, and the long hospital stay after chylothorax or need for tracheostomy.

Statistical Analysis

All data were tabulated and analyzed by the statistical package for the social sciences software program, IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as median with interquartile range because they were not normally distributed data. Categorical variables were reported as frequencies and percentages. A univariate analysis using Mann–Whitney U, Chi-Square or Fisher's Exact tests was performed between the above-mentioned collected preoperative, operative, and postoperative data and each of the three main outcomes including all-cause in-hospital mortality, all-cause recurrent hospital admission, and the need for catheter intervention to determine the factors which show significant association with these outcomes. As well, a univariate binary logistic regression analysis for the risk of all-cause in-hospital mortality was performed.

Then a multivariable logistic regression analysis was performed with a stepwise, forward selection procedure. The identified significant ($p < 0.05$) risk factors were used as candidate variables in the development of the multivariable risk prediction models. As well, the risk stratification models were adjusted for the Risk Adjustment for Congenital Heart Surgery-1 (RACHS-1) to adjust for the differences in the patient's mix, and the patient's age and weight. The most performed CHD operations including AVSD, ASD, VSD, TOF, coarctation of the aorta (COA), and pulmonary artery (PA) banding were also considered as potential risk factors and were included as candidate predictors during the development of the multivariable regression analyses. The obtained results are presented as adjusted odds ratios (AOR) and their 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant.

Results

This study included 200 DS patients who underwent cardiac surgery for congenital cardiac defects. Females constituted 56.5% while males were 43.5%. The medians of their age and weight at the operation time were 9.0 (interquartile range (IQR): 6.0–14.0) months and 6 (IQR: 4.6–8.0) kg. There were 11 (5.5%) RACHS-1 risk category 1, 76 (38.0%) risk category 2, 99 (49.5%) risk category 3, and 14 (7.0%) risk category 4. The previous pulmonary artery band was recorded in 38 (19.0%), and 35 (17.5%) underwent pre-operative catheterization. The median cardiopulmonary bypass (CPB) time was 98.5 (IQR: 67.5–132.0) minutes while the cross-clamp time median was 66.0 (IQR: 45.0–96.0) minutes. Eighteen (9.3%) patients showed abnormalities in the intraoperative TEE. The main echocardiographic abnormalities included different degrees of valve abnormalities, residual VSD, and poor left ventricle function. The medians of intensive care unit (ICU) stay and Mechanical Ventilation duration were 4.0 (IQR: 3.0–7.0) and 2.0 (IQR: 1.0–3.0) days, respectively. The total postoperative hospital stay showed a median duration of 8.0 (IQR: 6.5–12.0) days and the median of the follow-up duration was 15.0 (IQR: 11.0–22.0) months (Table 1).

Table 2 demonstrates the primary diagnosis of the studied DS patients. Complete AVSD was highly frequent (40%), followed by transitional AVSD (10.5%). Inlet and outlet VSD constituted 13% and 5.5%, respectively. Eight (4%) patients had isolated TOF and one patient had combined TOF–AVSD. Coarctation of the aorta was detected in 6 (3%) patients.

Table 3 shows a total surgical procedure of 237. The surgical repair of complete AVSD (n = 61 patients) and transitional AVSD (n = 18), in addition to VSD surgical closure (n = 50) and ASD Closure (n = 18), were the main surgical procedures. Other surgeries included patent ductus arteriosus (PDA) ligation (n = 10), COA repair (n = 7), and TOF repair (n = 6). Also in Table 3 we found 4 patients died from 61 patients (6%) and 1 D-TGA patient was the only D-TGA in our study. All our mortality 5/200 (2.5%). Not all complete AVSD patients (80) underwent full repair from the start. Some (19) underwent pulmonary artery banding as stage for full repair.

Table 2. The primary diagnosis of the studied Down syndrome patients (N = 200).

The primary diagnosis	N = 200	%
ALCAPA	2	1
ASD II	8	4
AVSD-complete unbalanced	3	1.5
Complete-AVSD	80	40
COA	6	3
D-TGA	2	1
Heart block	1	0.5
Inlet VSD	26	13
Outlet VSD	11	5.5
PA/MR	1	0.5
PAVSD	4	2
PDA	3	1.5
PM VSD	18	9
PM VSD COA	1	0.5
SAM	2	1
TAPVD	2	1
Transitional-AVSD	21	10.5
TOF	8	4
TOF-AVSD	1	0.5

ASD, atrial septal defect; AVSD, atrioventricular septal defect; COA, coarctation of the aorta; VSD, ventricular septal defect; TOF, tetralogy of Fallot; D-TGA, D type of transposition of great arteries; ALCAPA, Anomalous left coronary artery from the pulmonary artery; PA/MR, Pulmonary atresia with Mitral regurgitation; PAVSD, Partial atrioventricular septal defect; PM VSD, Perimembranous ventricular septal defect; PDA, patent ductus arteriosus; SAM, sub aortic membrane; TAPVD, Total anomalous pulmonary venous drainage.

Fig. 1 illustrates the early postoperative complications. The pleural collection was the most frequent (5.5%), followed by pulmonary hypertension crisis (3.5%), sepsis (3%), and heart block (3%).

Table 4 summarizes the outcomes of the studied patients. 157 (78.5%) patients showed complete recovery (without intra-hospital or during follow up mortality or morbidity). The incidence of all-cause in-hospital mortality was 3.0%. During the follow-up of the surviving patients, the incidence of all-cause recurrent hospital admission and the need for catheter intervention (device closure or balloon dilatation) was 3.5% each. The rates of the need for a second operation, heart failure management, and PPM insertion were 3.0%, 2.0%, and 2.5%, respectively. There were 8 (4.0%) patients who stayed in the hospital for a long duration after chylothorax or tracheostomy.

The univariate binary logistic regression analysis for the risk of all-cause in-hospital mortality showed some significant risk factors including the weight of the child (OR: 7.752, $p = 0.049$), Cardio-pulmonary bypass (CBP) time

Table 3. Types of surgical procedures.

Surgical procedure	No of death	RACHS score	N = 237[a]
AVSD-complete repair	4	2	61
Transitional AVSD repair	0	1	18
Pulmonary artery de-band, AVSD repair	0	3	10
Partial AVSD repair	0	1	1
VSD surgical closure	0	1	50
Pulmonary artery de-band and VSD closure	0	2	8
ASD closure	0	1	18
Pulmonary artery banding	0	1	13
PDA ligation	0	1	10
COA repair	0	1	7
Glenn Shunt	0	2	5
TOF repair	0	2	6
ALCAPA repair	0	3	2
SAM resection	0	1	2
Arterial switch procedure	1	3	1
BT shunt	0	4	1
Kawashima	0	1	2
PDA device removal	0	2	1
PPM insertion	0	2	1
TOF-AVSD repair	0	4	1

[a]: Patient may have more than one procedure. Abbreviations: RACHS, Risk adjustment for congenital heart surgery; BT, Blalock –Taussig;

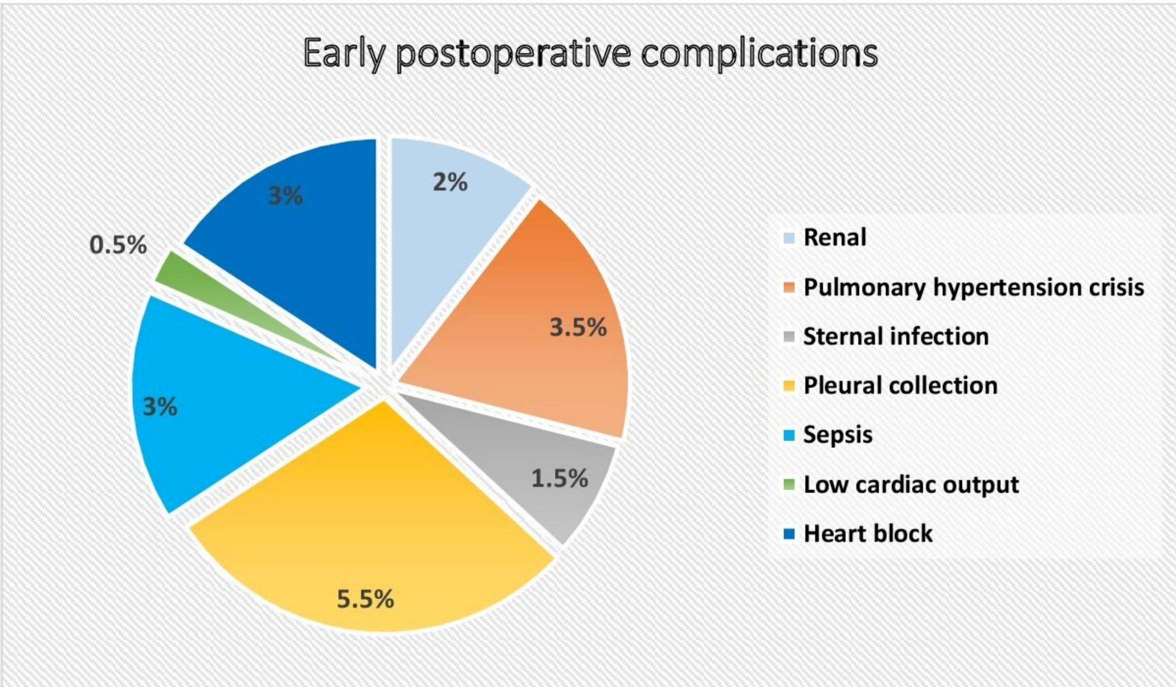

Fig. 1. Frequency of early postoperative complications following cardiac surgery of Down syndrome patients.

(OR: 1.016, $p = 0.032$), intraoperative TEE abnormalities (OR: 17.40, $p = 0.003$), duration of ICU stay (OR: 1.095, $p = 0.010$), duration of Mechanical Ventilation (OR: 1.201, $p = 0.011$), postoperative renal complications (OR: 193.0, $p < 0.001$), postoperative pulmonary hypertension crisis (OR: 47.50, $p < 0.001$), sepsis (OR: 23.750, $p = 0.002$), pleural

Table 4. Outcomes of the studied Down syndrome patients (N = 200).

Outcome	N = 200	%
Long hospital stay after Chylothorax or need for tracheostomy	8	4.0%
Recurrent hospital admission	7	3.5%
Need for catheter intervention (device closure or balloon dilatation)	7	3.5%
Need for second operation	6	3.0%
In-hospital mortality	6	3.0%
Need for PPM insertion after heart block	5	2.5%
Need for heart failure management	4	2.0%

PPM, permanent pacemaker.

collection (OR: 23.250, $p < 0.001$), and postoperative heart block (OR: 63.667, $p < 0.001$) (Table 5).

The multivariable forward stepwise logistic regression analysis revealed a risk stratification model for the risk of in-hospital mortality. The model had an accuracy of 99% and included the intraoperative TEE abnormalities (residual lesions or ventricular dysfunction) (AOR: 26.541, $p = 0.033$), the duration of Mechanical Ventilation following the operation (AOR: 1.152, $p = 0.009$), and the occurrence of postoperative heart block (AOR: 76.447, $p = 0.005$) (Table 6).

The model for risk stratification of recurrent hospital admission showed an accuracy of 96.5% and the CPB time was the only variable that contributed significantly to the model (AOR: 1.016, $p = 0.022$). Alternatively, the cardiac surgery types including TOF (AOR: 51.153, $p = 0.004$) and COA (AOR: 57.927, $p = 0.001$) were the significant predictors that contributed to the risk stratification model for the need for catheter intervention (Table 7).

Discussion

The evaluation of the surgical outcomes and the development of risk prediction models specifically related to preoperative data combined with intra- and postoperative factors would support the identification of patients with unfavorable prognoses. This will help the cardiac surgeons to select the patients who would benefit considerably from the surgical intervention, and to implement behavioral and therapeutic modifications to improve the surgical outcomes [9,10].

This single-center study aimed to describe the outcomes of cardiac surgery in DS children with congenital heart defects and to identify the risk factors for in-hospital mortality, recurrent hospital admission, and the need for catheter intervention among a cohort of Saudi patients. In this study, the most common types of surgeries were the repair of complete and transitional AVSD, isolated VSD surgical closure, ASD Closure, PDA ligation, and repair of COA and TOF. This coincides with Dhillon *et al.* [11] reported that AVSD, VSD, and TOF repairs were the most common interventions among DS children in Texas Children's Hospital. Moreover, previous studies of DS patients in Brazil, Sweden, Ireland, and German also reported that AVSD in both complete and partial forms followed by VSD were the most frequent CHDs that needed cardiac surgery [12–14]. Evaluation of the early postoperative complications should be considered by clinicians because they impact survival and quality improvement [15]. In the present study, the incidence of pleural collection and sepsis was 5.5% and 3%, respectively and they showed a significant association with the risk of in-hospital mortality in the univariate analysis. Infection is one of the annoying complications in the postoperative period of cardiac surgery, and there is a close association between the occurrence of infection and increased mortality and length of hospital stay [16].

Previous studies reported various rates of sepsis. Barker *et al.* [17] showed a sepsis rate of 2.6% in series with 30,078 cases. Ma *et al.* [18] reported that sepsis accounted for 11% of deaths in the postoperative period of congenital heart surgery. Patients with DS are more susceptible both to viral and bacterial infections due to the disordered immune system including reduced T and B lymphocyte counts, reduced size of the thymus, suboptimal response to immunizations, and reduction of immunoglobulin A, with decreased chemotaxis. Non-immunological factors such as airway abnormalities also aggravate the susceptibility to infection [19,20].

Regarding arrhythmia development after surgery for CHD in patients with the studied DS patients, 2.5% developed acomplete heart block that required PPM insertion. It has been shown that the incidence of atrioventricular block after cardiac surgery that requires pacemaker placement is higher in DS patients independent of their age or weight at surgery [21]. Pulmonary hypertension crisis was recorded in 3.5% of the studied patients early after the s, and it significantly contributed to in-hospital mortality in the univariate analysis (OR: 47.50, $p < 0.001$) and we observed that happened in the patients with we delayed final surgery or the age more than 8 months. DS is a known risk factor for severe postoperative pulmonary hypertension [22], and previous studies have shown that Pulmonary hypertension is one of the main risk factors for mortality in DS children [23,24]. This study revealed accepted recovery (without intra-hospital or during follow-up mortality or morbidity) in 78.5% of patients. This favorable outcome coincides with

Table 5. Univariate binary logistic regression analysis for the risk of all-cause in hospital mortality following cardiac surgery of Down syndrome patients.

Parameters	Odds ratio	95% CI	p-value
Age ≤6 months	4.929	0.878–27.677	0.070
Weight	0.579	0.336–0.998	0.049*
Male sex	1.310	0.258–6.652	0.745
History of pulmonary artery banding	2.194	0.387–12.447	0.375
RACHS-1 (2)	21,539,682.3	0.00–0.00	0.999
RACHS-1 (3)	85,929,583.7	0.00–0.00	0.999
RACHS-1 (4)	1.00	0.00–0.00	0.999
ASD closure	95,027,931.7	0.00–0.00	0.999
VSD closure	0.389	0.044–3.413	0.395
AVSD repair	2.460	0.440–13.478	0.305
TOF repair	0.00	0.00–0.00	0.999
COA repair	0.00	0.00–0.00	0.999
Pulmonary artery banding	3.33	0.328–28.071	0.328
CPB time	1.016	1.001–1.031	0.032*
Cross clamp time	1.016	0.999–1.034	0.067
Intraoperative TEE abnormalities	17.400	2.694–112.368	0.003*
Second bypass run	3.909	0.676–22.595	0.128
ICU stay, days	1.095	1.022–1.174	0.010*
Ventilation duration, days	1.201	1.042–1.384	0.011*
Postoperative renal complications	193.0	15.309–2433.1	<0.001*
Postoperative PH crisis	47.50	7.234–311.884	<0.001*
Postoperative sepsis	23.750	3.328–169.474	0.002*
Postoperative pleural collection	23.250	4.041–133.768	<0.001*
Postoperative low COP	0.00	0.00–0.00	1.00
Postoperative heart block	63.667	8.992–454.296	<0.001*

ASD, atrial septal defect; VSD, ventricular septal defect; AVSD, atrioventricular septal defect; TOF, Trilogy of Fallot; COA, coarctation of the aorta; CPB, cardio-pulmonary bypass; ICU, intensive care unit; TEE, transesophageal echocardiography; PH, pulmonary hypertension; COP, cardiac output; RACHS-1, Risk Adjustment for Congenital Heart Surgery-1; CI, confidence interval; * Significant at $p < 0.05$.

the reported improved outcomes of DS patients undergoing congenital heart surgery which has been attributed to improved surgical techniques, perioperative management, and younger age at operation [21]. As well, Alkattan *et al.* [25] concluded that DS patients might be a relatively low-risk procedure if patients are prepared well, and their pulmonary vascular resistance is low.

The incidence of in-hospital mortality in this study was 3.0%. After adjustment for the severity of the procedure by RACHS-1 risk score, the age, and weight of the patient, it was found that patients who showed abnormalities in the intraoperative TEE (residual lesions or poor ventricular function) had 26.641 times increase likelihood of death. Other risk factors that significantly contributed to mortality included the duration of Mechanical ventilation post-operative (AOR: 1.152), and the occurrence of post-operative heart block (AOR: 76.447). We have 5 mortality (4 patients with complete AVSD and one D-TGA) in these 4 patients they have moderate to severe left AV valve regurgitation with 2 of them have single papillary muscles that affect the result post-operative with residual regurgitation and long bypass time. In our centre we use RACHS score for categorization of our patient pre-operative, as we know RACHS score depend on the primary cardiac anatomy not related to associated syndromes or systemic review.

A previous study at Madinah Cardiac Center, Saudi Arabia analyzed 89 DS children from August 2013 to March 2018 and reported acceptable outcomes of CHD surgeries, with an overall mortality rate of 2.32% [26]. Another study in Kuwait retrospectively analyzed the outcomes of 167 DS patients who underwent 204 cardiac surgeries and revealed a lower mortality rate of 2 in-hospital deaths [27]. Though, there was a high incidence of post-operative pacemaker insertion (10 patients) [27]. Though it is well known that the RACHS-1 risk score has a great ability to discriminate against mortality, our study revealed that RACHS-1 did not significantly contribute to in-hospital mortality. This finding is supported by Cavalcante *et al.* [28] who reported a fair power of discrimination for RACHS-1 score in predicting mortality (AUC = 0.754, 95% CI: 0.727 to 0.78), and they suggested that the associated clinical factors, structural and technological barriers should

Table 6. A multivariable forward stepwise logistic regression model for the risk of all-cause in hospital mortality following cardiac surgery of Down syndrome patients.

Parameters	Beta coefficient	*p*-value	AOR	95% CI of AOR		Accuracy	*p*-value
				Lower	Upper		
Intraoperative TEE abnormalities	3.279	0.033*	26.541	1.311	537.156	99%	<0.001*
Ventilation duration, days	0.142	0.009*	1.152	1.035	1.282		
Postoperative heart block	4.337	0.005*	76.447	3.780	1546.119		
Constant	–6.510	<0.001*					

TEE, transesophageal echocardiography; AOR, adjusted odds ratio; CI, confidence interval; * Significant at $p < 0.05$.

Table 7. Multivariable forward stepwise logistic regression models for the risk of recurrent hospital admission and the need for catheter intervention following cardiac surgery of Down syndrome patients.

Parameters	Beta coefficient	*p*-value	AOR	95% CI of AOR		Accuracy	*p*-value
				Lower	Upper		
Recurrent hospital admission							
CPB time	0.016	0.022*	1.016	1.002	1.030	96.5%	0.020*
Constant	–5.309	<0.001*					
The need for catheter intervention							
TOF	3.935	0.004*	51.153	3.446	759.249	97%	<0.001*
COA	4.059	0.001*	57.927	4.729	709.570		
Constant	–21.203	0.999					

CPB, cardiopulmonary bypass; TOF, tetralogy of Fallot; COA, coarctation of the aorta; AOR, adjusted odds ratio; CI, confidence interval; * Significant at $p < 0.05$.

also be considered when assessing DS patients' surgical outcomes. Furthermore, it has been reported that RACHS-1 risk score has a low individual predictive power and disability of classification of all cardiac procedures [29]. The incidence of recurrent hospital admission for any reason was 3.5% and it was associated with a prolonged CPB time (AOR: 1.016, p = 0.022). A recent study has suggested that prolonged bypass time possibly has a crucial role in the development of acute kidney injury after cardiac surgery [30]. Moreover, the need for catheter intervention (device closure or balloon dilatation) after cardiac surgery in the present study was 3.5%, and the at-risk operations were TOF and COA repair with an increased likelihood of 51.153 and 57.927 times. In the current study, 6 (3%) patients needed a second operation. The need for a second operation is common after AVSD repair because of abnormalities of either the left-sided atrioventricular valve or the left ventricular outflow tract as stated by [31]. Furthermore, there were 8 (4.0%) patients who stayed in the hospital for a long duration (more than 10 days) due to chylothorax or tracheostomy (if ventilated more than 2 weeks). Previous studies have shown that DS patients had a longer hospital stay after cardiac surgery than non-down patients which might be attributed to higher infection rate, pulmonary complications, or renal failure in the postoperative period [21,23,32].

At the end we should respect the culture of our research (variety in socioeconomic status and education), but Down patient take all them rights and supports.

Limitations

The retrospective study design carries potential procedure and detection bias, and the results might have been affected by unrecorded confounding variables. Another limitation is that the data were obtained from a single center, which might limit the generalizability of the results. Our research is a brief of the medical service our center give to the type of patients.

Conclusion

Surgical treatment of congenital heart defects in DS patients had accepting outcomes (without intra-hospital or during follow up mortality or morbidity) of 78.5% and a 3% incidence of in-hospital mortality. Though, the occurrence of chylothorax was considerably high, and resulted in a long hospital stay. Repair of TOF (residual VSD or pulmonary branches stenosis) and COA (residual coarctation) was associated with an increased likelihood of catheter intervention following the primary operation.

Availability of Data and Materials

The datasets used and/or analyzed during the current. Study are available from the corresponding author on reasonable request.

Author Contributions

ARA, AAAln, SSS, LSB, MBAM and MFM designed and gave the main idea of research study, MAM, AAAlk, MLS, MSH, EWA and AMS performed the research and collected the data. AMS, MA and ARA analyzed the data. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was approved by the Research Ethics Committee of the General Directorate of Health Affairs in Madinah National Registration Number (IRB-ID 23-009), confidentiality of the participants' data was ensured by keeping the data sheets anonymous after assigning a code number specific to each patient, which is known only by the investigators.

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Conflict of Interest

The authors declare no conflict of interest.

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