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Original Article

Frequency and Risk Factors of Early Complete Heart Block Post Cardiac Surgery in Children: A Multicenter Prospective Study

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Abstract:
Background: Complete heart block (CHB) remains a foremost complication post cardiac surgery with subsequent medical, social, and financial burden.
Aim of work: To evaluate the frequency of early permanent CHB in children and to assess the contributing risk factors among children with congenital heart disease (CHD) who underwent surgical correction.
Material and Methods: A prospective descriptive study included 1668 patients post cardiac surgery, who were enrolled from two tertiary centers; Cairo University Children Hospitals and Atfal Misr Insurance Hospital, from February 2019 to February 2020. Medical history, examination, perioperative data as aortic clamp time and cardio bypass times and electrocardiogram were recorded.
Results: from a total of 1668 patients, 50 (3%) developed early permanent CHB. Their mean age at the time of the operation was 59.37 ± 41.91months (median:19 months, range: 5-144 months), 62% were males and 38% females. They underwent total surgical repair for Fallot tetralogy in 25 (50%) patients, ventricular septal defect in 14 (28%), atrial septal defect in 3 (6%) and common atrioventricular canal in 6 (12%). All 50 patients had undergone clamping of the aorta for a mean ± SD of 42.6 ±16.05 min, (median: 42 min, range: 5-105 min) and cardio bypass with a mean ± SD of 65.4±20.34 min, (median:60, range:10-145min). Prolonged aortic clamp (p=0.001) and cardio bypass times (p=0.003) were important risk factors of CHB. Thirty-eight (76%) patients were scheduled for pacemaker implantation, 12 (24%) died from complications of prolonged surgery. Mortality was related to younger age (p=0.027), and prolonged ICU stay (p=0.001).
Conclusion: The frequency of CHB post open cardiac surgery was 3%. Early permanent CHB is related to perioperative parameters such as aortic clamp time and cardio bypass time. Mortality in patients with CHB is linked to younger age, and prolonged ICU stay.

Level of Evidence of Study: IV (*1*)**.**
Keywords: complete heart block; children; post-operative; aortic clamp time.
Abbreviations: AVC: atrioventricular canal; ASD: atrial septal defect; AxcT: aortic clamp time; CAVC: common atrioventricular canal; CHB: complete heart block; CHD: congenital heart disease; CPB: cardio bypass time; ECG: electrocardiography; ICU: intensive care unit; VSD: ventricular septal defect.

Introduction

Complete heart block (CHB) represents a significant post cardiac surgery complication. The global incidence agreed worldwide is 1-4% (*2*). CHB is defined as postoperative heart block with failure to return to preoperative heart rate after 10 days. Morbidity and mortality from CHB are due to inability to supply sufficient cardiac output, ultimately resulting in longer intensive care unit (ICU) stay and prolonged hospital admissions along with its medical and financial burden. The definitive treatment is the insertion of artificial pacemaker (*2*, *3*). This kind of treatment entails huge social, medical, and economic burden. The surgeons must be completely aware of the problem magnitude in order to perform their best efforts to avoid subsequent occurrence of CHB post surgery (*2*). In this study we aimed to evaluate the frequency of early permanent CHB

and assess the contributing risk factors among children with congenital heart disease (CHD) who underwent surgical correction.

Subjects and Methods

This prospective descriptive study included 1668 children who had open cardiac surgery in Cairo University Children Hospitals, and Atfal Misr Children's Hospital Cardiothoracic Centre over a period of one year from February 2019 to February 2020. The study design conformed to the requirements of Revised Helsinki Declaration of Bioethics (2013) (4). The study was approved by Higher Studies Research Committee of Faculty of Medicine.

Participants

All patients diagnosed with early post-operative permanent complete heart block were enrolled in the study during one year from February 2019 to February 2020. The age range of the enrolled children was 1 month to 16 years old. Patients with any type of congenital heart disease (CHD) were enrolled, but not those with congenital or temporary CHB, and chronic arrhythmias.

Methods

For each subject full medical history was taken including demographic data such as age, gender, body weight, any medical condition or medications, operative details including cardio bypass time (CPB) (considered prolonged if > 50minutes), cross clamp time (AxcT) (considered prolonged if >40minutes)(*5*), post-operative details including ventilation hours, and drugs as steroids. Regular full medical examination was done including vital signs, and signs of heart failure daily for the initial 10 post-operative days. Each patient was subjected to routine preoperative 12 lead electrocardiogram (ECG) on the first day, 7 and 10 days postoperatively using Nihon Kohden apparatus; model 2150, Japan, and continuous post-operative monitoring during ICU period using monitor GE (model B40, USA). For all patients, temporary epicardial pacing was inserted routinely for less than 24 hours. Post-operative CHB was considered when patients with CHB showed failure of separation with resulting bradycardia and hypotension; ultimately temporary pacing was continued for maximum 10 days. If no regain of normal rhythm occurred within 10 days post-operatively, diagnosis of permanent CHB was confirmed according to the guidelines from the American College of Cardiology/American Heart Association/Heart Rhythm Society (ACC/AHA/HRS) (*6*).

Statistical Analysis

Data were coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when parametric and median, inter-quartile range (IQR) when data found non-parametric. The comparison between groups regarding qualitative data was done by using Chi-square test and/or Fisher exact test when the expected count in any cell found less than 5. The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: p-value > 0.05: nonsignificant (NS), p-value < 0.05: significant (S), p-value < 0.01: highly significant (HS).

Results

From a total of 1668 patients who underwent open cardiac surgery (400 in Cairo University Children Hospital, and 1268 in Atfal Misr Children Hospital), our study included the 50 (3%) patients who developed early complete heart block. (Figure 1). Their underlying congenital heart diseases are presented in Table 1. They were 16 (32%) patients from Cairo University Children Hospital, and 34 (68%) from Atfal Misr Children Hospital (0.177). (Figure 2).

Their mean age ±SD at time of operation was 59.37 months ± 41.91 (median:19 m, range:5-144 months). Of them 31 (62%) were males, and 19 (38%) females. Their mean ± SD weight z score was -1.55 ±1.9 (median -1.44, range: -4.56- 0.82). Twenty (40%) patients received various pre-operative medications (propranolol, diuretics, angiotensin converting enzyme inhibitors, and digoxin).

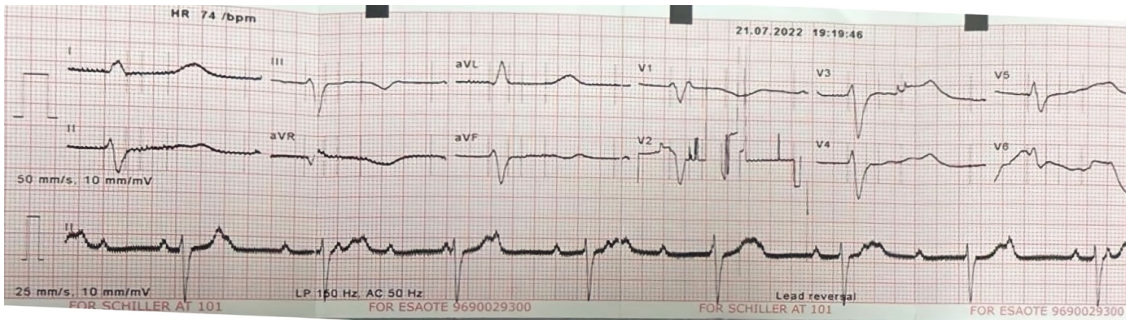

Figure 1. Electrocardiogram of complete heart block in a child post- ASD surgery.

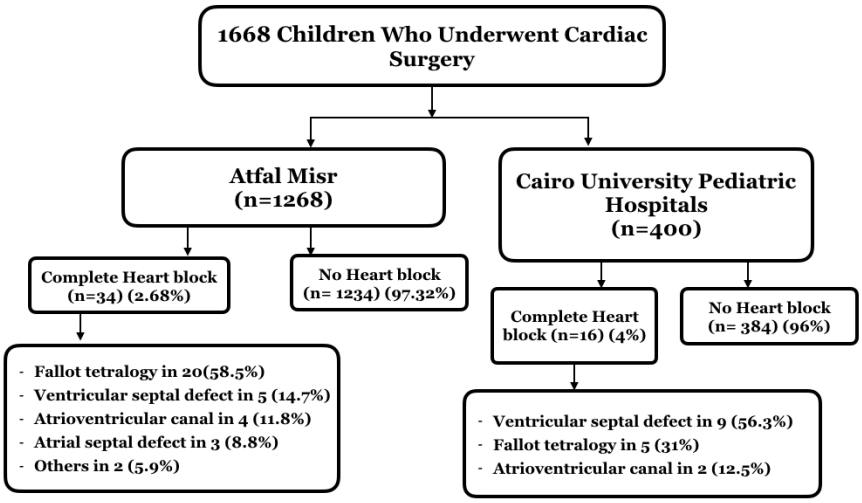

Figure 2. Frequency of complete heart block according to underlying congenital heart disease.

Table 1. Diagnosis of the group with complete heart block.

	Patients of same CHD		Patients with permanent CHB	
	Number	%	Number	%
Fallot tetralogy	25/312	8	25/50	50
VSD	14/350	4	14/50	28
CAVC	6/85	7	6/50	12
ASD	3/150	2	3/50	60
Others	2/771	0.25	2/50	4

ASD: atrial septal defect; CAVC: common atrioventricular canal; CHB: complete heart block; CHD: congenital heart disease; VSD: ventricular septal defect.

Table 2. Peri-operative data of the studied group

	Mean ± SD	Range	median		N	%
AxcT (min)	42.6 ±16.05	5-105	42	>40 min	32	64
CPB (min)	10-145	65.4±20.34	60	>50 min	41	82

AxcT: aortic clamp time; CPB: cardio bypass time (*5*).

Four (8%) patients had pre block arrhythmia in the form of nodal rhythm (NR), 2 (4%) patients had junctional ectopic tachycardia (JET),1 (2%) patient had sick sinus syndrome (SSS). Our patients had undergone right ventricular outflow tract resection in 17 (34%), transannular repair in 8 (16%) for Fallot tetralogy repair, ventricular septal defect (VSD) patch closure in 14 (28%),

atrioventricular canal (AVC) closure by single or modified patch in 6 (12%), atrial septal defect (ASD) patch closure in 3 (6%), subaortic membrane resection in 1 (2%), and pulmonary valve replacement in 1 (2%). The most common CHD complicated with permanent CHB in our patients were Fallot tetralogy (50%) followed by VSD (28%). (Table 1). High percentage of our patients had longer aortic clamp time and cardio bypass time (64%, 82%) respectively. (Table 2). There was statistically significant difference in aortic clamp time and CPB in relation to type of CHD being longer in TOF patients. (Table 3).

Table 3. Association between perioperative data and CHD in the studied group.

		TOF	VSD	AVC	ASD	others	P value
AxcT	Range	20-105	5-95	15-40	15-50	15-45	0.001
	Mean ± SD	56 ±19.26	36±19.62	26.6±11.69	30±18.02	25.72±12.03	
CBP	Range	45-120	10-145	25-60	40-70	40-70	0.003
	Mean ± SD	76.9±20.07	56.28±28.55	42.5±14.4	50.33±16.07	45±15.87	
ICU stay	Range	2-15	5-15	6-12	3-5	4-5	0.87
	Mean ± SD	6.7±3.18	8.4±2.98	8±2.44	4±1	4.5±0,707	
Hospital stay	Range	6-25	6-18	10-27	6-15	7-13	0.264
	Mean ± SD	13.7±4.67	11.8±3.6	15.66±6.2	10.33±4.509	10±4.243	

AVC: atrioventricular canal; ASD: atrial septal defect; AxcT: aortic clamp time; CPB: cardio bypass time; ICU: intensive care unit; TOF: tetralogy of Fallot; VSD: ventricular septal defect.

Once diagnosis of CHB was established, the patients received corticosteroids (methylprednisolone was given in 21 (42%) patients, and dexamethasone in 29 (32%) patients) but with no noticeable improvement (p= 0.341). We followed our patients for 7-14 days post operatively, 38 (76%) patients inserted pacemakers at 10-14 days, while 12 (24%) patients died from the complications of prolonged surgery which resulted in prolonged ICU stay, prolonged mechanical and pharmacological support. We compared demographic and perioperative data between alive and dead patients with CHB in table (4). There was a statistically significant difference between age of the patients and the mortality, being higher in younger patients <12 m, and there was statistically significant difference between ICU stay and the mortality, being higher with longer duration in ICU.

Table 4. Outcome of the studied children with complete heart block.

		Outcome						P value
		Alive		Death		total		
		N	%	N	%	N	%	
Age at Operation	<12months	3	7.9	8	66.7	11	22	0.027
	>12 months	35	92.1	4	33.3	39	78	
Weight (z score)	<-1.44	12	31.5	7	58.3	19	38	0.096
	> - 1.44	26	68.5	5	41.7	31	62	
Gender	Male	21	55.3	10	83.3	31	62	0.081
	Female	17	44.7	2	16.7	19	38	
Diagnosis	Fallot	17	44.7	8	66.7	25	50	0.635
	VSD	12	31.5	2	16.7	14	28	
	AVC	5	13.2	1	8.3	6	12	
	ASD	2	5.3	1	8.3	3	6	
	others	2	5.3	0		2	4	
AxcT (min)	<40	15	39.5	3	25	18	36	0.362
	>40	23	60.5	9	75	32	64	
CBP (min)	<50	7	18.42	2	16.7	9	18	0.890
	>50	31	81.6	10	83.3	41	82	
ICU stay	<3days	0		5	41.7	5	10	<0.001
	>3days	38	100	7	58.3	45	90	
Ventilation hours	<6 h	9	9	0		9	18	0.063
	>6h	29	76.3	12	100	41	82	

AxcT: aortic clamp time; CPB: cardio bypass time; ICU: intensive care unit

Discussion

Permanent complete heart block remains an important health hazard post cardiac surgery, despite recent advances in surgical techniques. Recent studies report a ratio of 0.9-3% (*7–9*)**.** Complete heart block (CHB) usually develops after surgeries near to the atrioventricular (AV) node and distal conduction system e.g., surgeries for VSD, Fallot tetralogy. The condition is usually associated with huge economic burden either to the family or the global medical system due to high cost of the pacemakers and lifelong follow up due to continued need for programming, change of batteries, and complications including infection (*2*, *7*, *10*).

The frequency of CHB among our studied cohort of 1668 patients was 3% which is comparable worldwide. It was associated with 24% fatality. Hence, CHB should be screened for, and promptly managed to avoid undue deaths. Among our studied cohort with CHB Fallot tetralogy patients were the most common followed by VSD patients. The development of CHB after these surgeries might be due to injury to the atrioventricular node and bundle of Hiss due to anatomical proximity. On studying additional risk factors, we found that prolonged aortic clamp time and prolonged CBP time are the most important risk factors among our patients. Cardio bypass and aortic clamp are essential procedures to allow for bloodless field of surgery, yet the resulting ischemia and myocardial insult are associated with various morbidities and mortalities including CHB. Every effort should be done to decrease the time of ischemia which will effectively decrease incidence of CHB post cardiac surgery. Other studies reported similar frequencies of CHB among their patients (3.5%, 4.7%) and confirmed the same perioperative risk factors (*11*, *12*).

We studied the risk factors of mortality among our patients, we found that prolonged ICU stay and younger age of the patients were the most important risk factors of mortality (p=0.001, p=0.027 respectively) which was congruent with the results of other studies (*5*, *13*). Prolonged ICU stays mostly caused by low cardiac output syndrome in the early postoperative period results in multiple metabolic, neuroendocrinal, inflammatory hazards impairing the integrity of conduction system of the heart, especially with young patients (*14*)**.** The study was limited by an inability to judge if mortality was increased in our patients due to CHB or not.

Insertion of a pacemaker is lifesaving but presents another challenge; it poses a technical and financial burden. Complications range from lead dislodgement to pacing failure. Hence, the importance of early diagnosis, feasibly of procurement of pacemaker devices and the need for a multidisciplinary skilled team to manage children post-cardiac surgery for CHD is essential.

Conclusion and recommendations

The frequency of early post-operative permanent CHB is 3%. CHB is more common in post-surgical repair of Fallot tetralogy and VSD and is chiefly related to longer aortic clamp time, and longer CBP. Mortality in patients with CHB is related to younger age and longer ICU stay.

Author Contributions:

LAI: Interpretation of data, manuscript preparation and drafting of the article, review of literature. MMS design of the study, interpretation, analysis of data, and review the literature. AHG: collection of cases, analysis, interpretation of data. AEE: concept, and design of the study, analysis of data, and final approval of the version to be published. All authors had full access to the data (including statistical results and tables), approved the final manuscript as submitted, and agreed to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors declare no conflict of interest in connection with the reported study. Authors declare veracity of information.

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