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ORIGINAL ARTICLE

Primary causes of in-Hospital Mortality in Pediatric Cardiac Surgery Population

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ABSTRACT

Objective: To present primary causes of in-hospital mortality in large surgical population who underwent surgical correction for CHDs for the period of a decade at our institute.

Methods: Retrospective analysis of pediatric cardiac surgery database along with decision of morbidity and mortality meeting at Department of Cardiac Surgery at CPE Institute of Cardiology from January 2009 to April 2021.

Results: An overall 3705 patient underwent surgery for CHDs. The in-hospital mortality for CHDs surgery is 2.37% with RV dysfunction, Residual cardiac defect with valve dysfunction (TR/PR), pulmonary hypertensive complication, mediastinal bleeding, cardiac tamponade, respiratory complication, MODs, heart block as major primary cause of in-hospital mortality with frequency of 15.91%, 18.18%, 18.18%,18.18%,9.09%,10.23%, 4.54% and 4.54% respectively.

Conclusion: in our population of 3705 congenital cardiac surgery patients, incidence of overall in-hospital mortality is promising for wide range of CHDs. RV dysfunction, residual RV defects with vale regurgitation, pulmonary hypertension, bleeding complications and respiratory failure are major primary causes of in-hospital mortality.

Keywords: In-hospital Mortality, Atrial septal defect (ASD), Tetralogy of Fallot (TOF), Ventricular septal defect

INTRODUCTION

Operative mortality is one of the most notable outcome of pediatric and adult cardiac surgery. Mortality fallowing pediatric cardiac surgery is multifactorial that includes type & complexity of congenital heart defect, intra-operative factor and post-operative ICU complications.[1] Congenital heart defects (CHD) are mainly divided into cyanotic and acynotic. Atrial septal defect (ASD), Ventircular septal defect (VSD), Patent ductus arteriosus (PDA) etc are most commonly encountered acynotic CHDs while Tetralogy of Fallot (TOF) is most frequently encounter cyanotic CHD in pediatric cardiac surgery practice in Pakistan in addition to many other less frequent CHDs.[2,3,4] Surgery for more complex CHDs like transposition of great vessels (TGA) is offered at certain specialized pediatric cardiac surgery units across the country. Risk adjustment for congenital heart surgery version 1 (RACHS-1) categorizes the congenital heart disease into six group on the basis of CHDs complexity that ultimately is linked to operative outcome.[5] Intra-operatively the cross clamp time and total cardiopulmonary bypass time are major determinant of operative outcome along with myocardial protective strategy. Post-operative complication have significant impact over in-hospital mortality. Bleeding, cardiac rhythm problems, respiratory complication, low cardiac output state (LCOS) and infections etc are major known cause of ICU related complication that impact mortality in pediatric population.[6,7,8,9,10] Hence all above mentioned factor make the entire process of pediatric cardiac surgery as a challenge for the surgical team.

Many of the well developed pediatric cardiac surgery center arrange regular team discussion regarding morbidity and mortality of patient population to improve patient outcome. Our publication is based on the departmental morbidity and mortality meeting (MMM) of congenital cardiac surgery. The objective of this study is to report the primary causes that leads to in-hospital mortality following congenital cardiac surgery at CPE institute of cardiac surgery over the period of more than a decade. At the same time, this will generate a local statistic based on large pediatric cardiac surgery population. This shall help to guide us to maneuver our team approach to target this primary cause of in-hospital mortality and improve surgical outcome related to congenital cardiac surgery.

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MATERIAL AND METHODS

Approval of study was taken from the ethical committee and institutional review board (IRB). The study is conducted at CPE Institute of Cardiology, Multan. The duration of study spans from January 2009 to April 2021. Cardiac surgery services offered at the institute include both adult and pediatric cardiac surgery. Electronic cardiac surgery database (Cascade Lahore) is used for entry of all patient related information. The study population include all patient who underwent surgery for congenital heart defect (CHDs) while patient who underwent cardiac surgery for non-CHD were excluded.Congenital cardiac surgery was performed by team of cardiac surgery with good expertise in the speciality along with expertise perfusionist team. Institute has developed dedicated congenital cardiac surgery operation suite, intensive care team. For reporting purpose, The patient population is divided into different groups named after surgery for primary pathology like ASD repair, VSD repair, PDA ligation, Repair of TOF, Repair of complete AV canal defect, Resection of right ventricular outflow tract obstruction (RVOTO), Coarctation of aorta repair, repair of partial and total anomalous pulmonary vinous connection (PAPVC & TAPVC), Pace-maker implantation, Cavo-pulmonary shunt (CP-shunt), BT-shunt etc.

Patient related morbidity and mortality was discussed in MMM once every month. All part of team that include operating surgeon, surgery scrub staff, cardiac perfusionist,

pediatric anesthetist and intensive care members etc. discuss the pediatric cardiac surgery cases who face major morbidity or mortality. During the meeting different patient related risk factor, disease complexity, intra-operative events, details of cardiopulmonary bypass, course of shifting from operation room to ICU, patient stay in ICU, Lab reports etc are discuss in fine details. The meeting ends with decisions that decide the primary cause of morbidity and mortality.

Primary cause of in-hospital mortality is defined as the first clinical complication that eventually result in clinical demise of patient after congenital hearts surgery. Multiple organ dysfunction syndrome (MODs) and cardiopulmonary failure are not considered as primary cause of death unless no other primary cause is identified.In this study, we reported age (years), gender (male or female), weight (kg), height (cm), Body surface area (m2), type of surgery performed as mentioned above, Cardiopulmonary Bypass time (CPB-mins), Ventilation time ((hrs), ICU stay (hrs), inotropes use (hrs), in-hospital mortality and primary cause of mortality. All those informations are retrieved from cardiac surgery electronic database (Cascade Lahore) that generate Microsoft Excel 2007 file and hospital paper record. Numeric variables are reported as mean and standard deviation of mean while categorical variables are reported as frequencies.

RESULTS

Analysis of data had shown that 3705 case of pediatric cardiac surgery were operated at CPE Institute of cardiology Multan from January 2009 to March 2021. Mean & standard deviation and frequency for age, gender, weight, height, BSA, CPB time, Cx time, ventilation time, ICU stay, Inotropic support etc are mentioned in table no 1. These statistics revealed that reasonable proportion of congenital heart surgery is performed in grown up kids and young adults. As per protocol of pediatric cardiac surgery and anesthesia, patient age above 3 years or with weight around 10 kg were entertained for surgical correction of CHDs. Table no.2 showed the overall outcome of pediatric cardiac surgery. Distribution of number of case for ASD repair, VSD repair, TOF repair, PDA lighten, Complete AV-canal defect repair, RVOT resection, Repair of coarctation of Aorta, TAPVC/PAPVC repair, pacemaker implantation, CP-shunt, BT shunt. Table no.2 showed that the overall mortality for all type of pediatric cardiac surgery is 2.37% (n=88) in 3705 number of congenital heart surgery cases. RV dysfunction, residual cardiac defect with valve regurgitation, pulmonary hypertensive crisis, mediastinal bleeding and cardiac tamponade are prominent primary causes that lead to in-hospital mortality in addition to respiratory complications and MODS as shown in table 2.

When we looked in individual CHD analysis, we found that operative mortality in ASD is 0.91% with pulmonary hypertensive crisis and RV dysfunction as major primary causes of mortality in addition to mediastinal bleeding, cardiac tamponade and respiratory dysfunction. For VSD and TOF repair, the in-hospital mortality is 2.63% and 3.91% respectively with RV dysfunction, residual defect, mediastinal bleeding and cardiac tamponade are important primary cause of mortality. However pulmonary hypertensive crisis and post-operative complete heart block are also important primary reasons for in-hospital mortality in VSD repair. 0.72% is operative mortality of PDA lighten surgery and the major primary reason for death is pulmonary hypertensive crisis and intra-operative bleeding in PDA lighten surgery. Surgery for complete AV canal defect carries highest mortality of 7.14% and the major primary reason for death are RV dysfunction, residual valve defect and pulmonary hypertensive crisis as shown In table no.2.

Table 1: Baseline characteristics, operative information and clinical outcome patients who underwent surgery for CHDs

Clinical information	**ASD repair (n=1203)**	**VSD Repair (n=835)**	**TOF repair (n=998)**	**PDA Ligation (n=413)**	**Complete AV-Canal Defect (n=70)**	**RVOTO resection (n=63)**	**Repair of Aortic coarctation (n=38)**	**TAPVC/PAPVC repair (n=29)**	**Pacemaker Implantation (n=22)**	**CP-shunt (n=19)**	**BT-shunt (n=15)**
Age (years)	24.67 + 14.35	13.88 + 7.51	15.87 +7.21	14.34 + 7.47	9.08 + 4.62	8.62 +3.90	20.19 + 11.13	8.69 + 3.77	9.18 + 4.22	8.90 + 4.87	9.53 + 4.12
Male Female	39.24% 60.76%	57.60% 42.40%	61.42% 38.58%	57.87% 42.13%	31.43% 68.57%	37.51% 63.49%	63.16% 36.84%	31.03 68.97%	45.45% 55.55%	63.16% 37.84%	66.67% 33.33%
Weight (kg)	34.47 + 17.87	25.49 + 18.31	26.80 + 16.43	19.21 +18.36	10.52 + 10.54	17.95 + 7.57	35.25 +20.35	18.80 + 5.93	19.72 + 9.04	17.90 + 7.54	22 + 13.18
height (cm)	140.63 + 29.54	117.55 + 33.61	123.53 + 31.21	103.27 + 12.33	10.28 + 26.85	110.43 +24.41	126.58 + 40.1	113.37 + 25.76	114.41 + 27.52	110.15 + 25.72	111.2 + 34.43
BSA (m2)	1.20 + 0.40	0.88 + 0.36	0.98 + 0.37	0.70 + 0.40	0.76 + 0.30	0.73 + 0.24	1.09 + 0.49	0.77 + 0.20	0.78 + 0.25	0.73 + 0.23	0.81 + 0.36
CPB time (mins)	60.44 + 21.94	76.69 + 35.14	74.36 + 19.22	NA	76.7 + 12.30	76.71 + 12.22	NA	73.48 + 11.33	N/A	N/A	N/A
Ventilation time (hrs)	5.88 + 11.09	6.94 +9.87	9.95 + 35.73	2.04 + 1.2	8.01 + 6.59	6.22 + 1.82	6.96 + 4.92	6.03 + 1.57	1.54 + 0.60	7.52 + 6.14	10+ 11.31
ICU stay (hrs)	32.80 + 24.16	37.32 + 26.78	49.51 + 55.42	27.17 + 19.8	36.63 + 15.04	42.46 + 14.80	35.51 + 32.71	39.31 + 12.13	10.95 + 3.09	42.94 + 11.08	24.8 + 11.13
Inotropes use (hrs)	5.92 + 12.06	9.22 + 18.86	26.28 + 36.57	0.64 + 2.07	9.2 + 4.1	10.06 + 4.25	5.8 + 10.86	12.37 + 3.77	0.72 + 1.15	10.21 + 3.93	8.93 + 4.25

Table 2: in-hospital mortality and primary cause of in-hospital mortality after CHDs

Clinical information	ASD repair (n=1203)	VSD Repair(n=835)	TOF repair (n=998)	PDA Ligation (n=413)	Complete AV-Canal Defect (n=70)	RVOTO resection (n=63)	Repair of Aortic coarctation (n=38)	TAPVC/ PAPVC repair (n=29)	Pacemaker Implantation (n=22)	CP-shunt (n=19)	BT-shunt (n=15)	Overall mortality (n=3705)
In-hospital Mortality	0.91% (n=11)	2.63% (n=22)	3.91% (n=39)	0.72% (n=4)	7.14% (n=5)	1.58% (n=1)	5.2% (n=2)	3.45% (n=1)	0%	10.52% (n=2)	6.67% (n=1)	2.37% (n=88)
RV dysfunction	18.18% (n=2)	9.09% (n=2)	23.08 % (n=9)	0%	20% (n=1)	0%	0%	0%	0%	0%	0%	15.91% (n=14)
Residual defect with TR/PR	0%	22.72% (n=5)	25.64 % (n=10)	0%	20% (n=1)	0%	0%	0%	0%	0%	0%	18.18% (n=16)
Pulmonary Hypertensive crisis	54.54% (n=6)	13.63% (n=3)	0%	75% (n=4)	60% (n=3)	0%	0%	0%	0%	0%	0%	18.18% (n=16)
Bleeding	9.09% (n=1)	13.63% (n=3)	20.51 % (n=8)	25% (n=1)	0%	0%	100% (n=2)	0%	0%	50% (n=1)	100% (n=1)	18.18% (n=16)
Cardiac Tamponafe	9.09% (n=1)	9.09% (n=2)	12.82 % (n=5)	0%	0%	0%	0%	0%	0%	0%	0%	9.09% (n=8)
Respiratory distress syndrom	9.09% (n=1)	13.63% (n=3)	12.82 % (n=5)	0%	0%	0%	0%	0%	0%	0%	0%	10.23% (n=9)
MODS	0%	0%	5.13% (n=2)	0%	0%	0%	0%	100% (n=1)	0%	50% (n-1)	0%	4.54% (n=4)
Sepsis	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Stroke/coma	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Heart Block	0%	18.18% (n=4)	0%	0%	0%	0%	0%	0%	0%	0%	0%	4.54% (n=4)
VF/cardiac rhythm	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

RVOTO resection and pacemaker implantation carries negligible in-hospital mortality. Repair of TAPVC/PAPVC had 3.45% mortality and MODS is the reason of in-hospital mortality. Repair of Coarctation of aorta, CP-shunt and BT shunt had operated mortality of 5.2%, 10.52% and 6.67% respectively. Intra-operative and post-operative bleeding and MODs are major primary cause that lead to death. All above mentioned informations are summarized in table 2.

DISCUSSION

Surgical repair for CHDs is challenging particularly in our part of the world because of certain loco-regional factors. The one is high incidence of CHDs and late diagnosis of disease due to non-availability of expertise because of less well-established healthcare system[11]. Majority of complex CHDs patient present very late. Sequela of late presentation is advancement in disease pathophysiology when operative risk for surgical treatment is substantially high or pathology become inoperable (Eisenmenger syndrome)[12]. Over the period of last decade, services of congenital cardiac surgery had grown substantially across the country. Our surgical results are based on large population who underwent congenital heart surgery for various simple and complex CHDs. Our operative results are promising and matches the international statistics despite our surgical populations was complex due to late presentation and poor socioeconomic/educational background.

CHDs with left to right shunt without restriction to pulmonary flow like ASD, VSD, complete AV-canal defect and PDA showed element of pulmonary hypertension as pathophysiology of disease. The severity of pulmonary hypertension depends on amount and duration of shunted blood along with response pulmonary arterial tree[13].Qp & Qs ratio help to identify patient who are operable or none-operable along with non-invasive echocardiographic findings[14]. However there is reasonable number of patient groups who have borderline pulmonary hypertension (operable but high pulmonary hypertension). Cardio-pulmonary bypass and entire surgical process yield number of chemical substances in the body that make manipulation of pulmonary hypertensive response challenging[15]. At the same time it lead to RV dysfunction as well[16]. So in above mentioned CHDs of our population, pulmonary hypertension and and RV dysfunction with or without valve regurgitation are major primary cause that lead to in-hospital mor-

tality. In CHDs like TOF, raise hematocrit and platelet dysfunction make hemostatic process challenging during course of surgery and early ICU stay[17]. At the same time complexity of disease and presence of RV dysfunction and valve regurgitation like TR or PR after surgery make overall patient management a big challenge. Thus RV dysfunction along with TR or PR, residual VSD with overdid risk of bleeding complication (mediastinal bleed and cardiac tamponade) are significant cause of in-hospital mortality. Resection of RVOTO carries low mortality as it lack of pulmonary vasculature reactivity. Repair of coarctation of aorta, CP-shunt and BT-shunt are usually closed heart procedure or procedure where CPB is not used. These are technically challenging due to surgical exposure and disease presentation itself. Meticulous stitching and creation of good geometric anastomosis is pivotal to success in these procedure. Bleeding from these anastomotic site and failure of surgically created shunt are major concerns and primary cause of death[18]. Procedure like epicardial implantation of Pacemaker carries very low mortality and rewarding unless some iatrogenic injury happen.

Surgery for CHDs carries good overall outcome if a good expertise facility is available. RV dysfunction, residual shunt with valve dysfunction, pulmonary hypertensive pathology, bleeding/cardiac tamponade etc are major primary cause of in-hospital mortality. Focused approach for proper disease work-up particularly related pulmonary vasculature and RV function, meticulous surgical technique, Intensive care team work/ response and provision of good pharmacological support can yield even more impressive outcome for congenital hearts surgery.

CONCLUSION

In our population of 3705 pediatric cardiac surgery patient, incidence of overall in-hospital mortality is promising for wide range of CHDs. RV dysfunction, residual RV defects with vale regurgitation, pulmonary hypertension, bleeding complications and respiratory failure are major primary causes of in-hospital mortality.

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