Perioperative Factors Affecting Fast Tracking in Paediatrics Cardiac Surgical Patients.

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Background: Preoperative and intraoperative factors that influence the postoperative period including weaning time from mechanical ventilation and extubation: in a paediatric cardiac patients have been widely studied with contradicting reports and variation from centre to centre. *The aim* of this study was to determine factors that influence the duration of weaning in paediatric cardiac surgical patients and their associated complications at our centre.
Methods: This was a prospective study that recruited all eligible paediatric patients from infancy to childhood whom underwent cardiac surgical repair at Care Hospital Hyderabad, India between January and June 2007.Excluded were old age more than 18 years or patient with cardiac lesion undergoing palliative operation other than those involving cardiopulmonary bypass. Patients` demographic data including age, sex, height, weight and consequently body surface area were retrieved from patients` record file. The duration of symptoms was also determined and reported in months. Patients' diagnoses details of the nature of the cardiac lesion as reported from echocardiography and or cardiac catheterization was recorded. Intraoperative parameters including the type of cardiac operation were taken care and recorded accordingly. Patient was followed up postoperatively both in the intensive care unit and in the general ward while closely monitored noting for any complications till the patient was discharged from either of these units. Patients' data were entered into a master sheet data and later into a SPSS.11.5 window program for analyses using χ2-test for categorical data.
Results: There were 103 patients of which 60.2% and 39.8% were male and female respectively. The mean age was 74.45 months: mean duration of symptoms was 54.52 months. Majority of patients had congenital heart disease that accounted for 93.6% of all cases while chronic rheumatic heart disease was found in 6.8% of cases. Tetrallogy of fallot and ventricular septal defect were the commonest among congenital heart disease representing 27.2% and 25.2% respectively. Young age was found to be a factor associated with prolonged mechanical ventilation and extubation. Further, the presence of pulmonary hypertension, lower cardiac grade and ventricular dysfunction were found to be factors significantly associated with prolonged weaning. While, cardiac disease occurring in combination, ischemia time, duration of cardiopulmonary bypass, total operation time, left ventricular ejection fraction, pH at the end of cardiopulmonary bypass and preoperative hemoglobin were factors found not to be associated with prolonged weaning.
Conclusion: Our study has shown that presence of pulmonary hypertension, cardiac grade and ventricular dysfunction were factors associated with prolonged time to weaning. While aortic cross-clamp, total duration of cardiopulmonary bypass, , cardiac disease occurring in combination, total operation time and level of hemoglobin were not associated with prolonged time to weaning.

Introduction

Weaning of a paediatric cardiac surgical patient from ventilator and extubation of endotracheal tube depends on stabilization of haemodynamics and adequate tissue perfusion as a result of increased oxygen delivery to both the myocardial tissue and metabolizing tissue[1]. When there is a delay in achieving adequate haemodynamics particularly in the paediatric population where the myocardium is deemed to be immature this result in prolonged ventilation with its associated complications. Factors and particularly perioperative co-morbid medical conditions associated with cardiac disease and poor handling of particular parameters during intraoperative period and conduct of cardiopulmonary bypass might result in failure to achieve adequate haemodynamics and consequently delayed weaning. The age of the patient is a factor as this is directly related to maturity of the myocardial tissue, the nature of the cardiac disease whether cyanotic or acyanotic and whether associated with pulmonary hypertension might result in a different outcome postoperatively. Despite of various studies advocating weaning strategies from

mechanical ventilation and timing of extubation is still a topic of debate in paediatric critical care. Both preoperative and intra-operative factors are the prerequisite determinant of the postoperative events to the cardiac surgical patient. Low hemoglobin causes impaired oxygen delivery to tissue leading to lactate-acidosis and hence metabolic acidosis this in turn leads to cardiac dysfunction[2]. The mere presence of heart failure that is long standing causes myocardial remodeling and fibrosis this in turn causes receptor and transmitter down regulation[3].The nature of cardiac disease, whether occurring as an isolated lesion or in combination predicts whether early or late extubation is anticipated. Studies have shown that low haematocrit during conduct of cardiopulmonary bypass, deep hypothermia and good LVEF have been associated with early extubation and short duration of ICU stay[4]. Normal systolic functions are associated with ejection fraction of 60-75% mild dysfunction in range of 51-59%, moderate left ventricular dysfunction 35-50% while severe impairment of cardiac contractility when ejection fraction is below 35%. Patients with left ventricular hypertrophy are susceptible to diastolic dysfunction; diastolic dysfunction causes increase in work of the myocardium and increased oxygen demand[5]. While prolonged CPB duration, cardiac disease occurring in combination were found to be associated with prolonged mechanical ventilation and extubation.

The presence of pulmonary hypertension, poor myocardial preservation during conduct of cardiopulmonary bypass has been associated with post operative low cardiac output states and hence a delay in achieving good haemodynamic states. The presence of low pH at the end of conduct of cardiopulmonary bypass might be a predictor of poor myocardial preservation during conduct of cardiopulmonary bypass. Long lasting operation again might be the cause of postoperative wound infection. Similarly prolonged duration of cross-aortic clamp has been associated with high morbidity and mortality and prolonged mechanical ventilation as well as extubation[6,7].

This study looked into a wide range of non-ventilator factors of both preoperative and intraoperative nature that predicts the extubation status in paediatric patients undergoing cardiac surgery. Age and sex of the patient, type of cardiac disease and its associated lesion, preoperative hemoglobin, and left ventricular ejection fraction. The presence of pulmonary hypertension, total operation time, the duration of aortic cross-clamp (ischemia time) and the total duration of conduct of cardiopulmonary bypass, the presence of ventricular dysfunction, the cardiac grade at the end of cardiac surgical repair, the urine output and pH at the end of conduct of cardiopulmonary bypass. These factors were related to the total time at extubation. Further noted during follow up were presence of renal failure, wound infection, pneumonia or lung infiltrate, the total duration of intensive care stay and the duration of hospital stay after discharge from the intensive care.

Patient and Methods

This was a prospective study that recruited all eligible pediatric patients from infancy to childhood whom underwent cardiac surgical repair at Care Hospital Hyderabad ,India between January and June 2007.Excluded were old age more than 18 years (216 months) and patient with cardiac lesion undergoing palliative operation other than those involving cardiopulmonary bypass. Patients` demographic data including age, sex, height, weight and consequently body surface area were retrieved from patients` record file. The duration of symptoms was also determined and reported in months. The main diagnosis (DX) as reported in the 2-Dimension echocardiography and or as by cardiac catheterization that was later evidenced by the operation itself was entered into the master data sheet. The associated lesion (ADX) deemed not to be part of the main diagnosis was also noted. Preoperative hemoglobin (HB) level was noted and further graded as hemoglobin range (HBR) into low level but permissive (9-11g/dl), normal (11.1-15g/dl) and viscous (>15g/dl). The left ventricle ejection fraction (LVEF) was classified according to functional status as dysfunction when □60%, normal ≥60%. Whether the cardiac lesion was associated with pulmonary hypertension (PAH) or not was noted. The type of operation was noted as intracardiac repair (ICR) for all both cyanotic and acyanotic congenital heart diseases and valve replacement (VL) or repair (VR) for all valvular lesions. The specific type of operation (STOP) was also noted when necessary. The total operation time (TOT) was defined as the time interval from skin incision to its closure. The cardiopulmonary bypass time (CPBT) was defined as the time interval during conduction of

cardiopulmonary bypass and its termination on the patient this was classified into ≤60; 61-100 and >100 minutes for short ,moderate, prolonged time respectively. The time of aortic cross-clamp; the ischemia time (IT) of the aorta was classified into those short lasting (≤45 minutes), and prolonged (>45 minutes). During operation the right and left ventricle recorded as ventricular dysfunction (VD) assessment was done as whether was dilated edematous or normal. The cardiac function and how it attained normal sinus rhythm at the end of surgery known as **cardiac grade** was assessed and weighted as **grade A**; when attainment of sinus rhythm and cardiac function was spontaneous and or a single defibrillation by a direct shock was required, **grade B** when attainment of sinus rhythm and cardiac function needed vigorous manipulation, long time waiting and a single defibrillation was needed or two sequential defibrillation was needed and **grade C** when low voltage sinus rhythm, cardiac function depends on pacing continuous till patient is shifted to the ICU and several other defibrillation by direct shock current was required. Determined and or measured during intraoperative period were *ρH that* was further classified as acidemia ≤7.35,normal to alkamia >7.35.

The urine output per kilogram body weight per hour (UOP) for the age group was rated as whether was low (L) or normal: this was measured at the end of cardiopulmonary bypass. The time interval to weaning of the ventilator and extubation (TTW) was counted from the time of induction of anaesthesia in the theatre till when the patient was weaned from the ventilator, extubated and connected to the T-piece and this time interval was further rated into a weaning scheduled (WS) into: **early** when it was ≤48hrs, intermediate 48.1-72 hrs and **prolonged** when weaning was >72hrs.The duration of intensive care stay (ICS) and further classified into ≤10 days or more; being early or late. The post intensive care hospital stay (PIHS) was the time of hospital stay after discharge from the intensive care unit this was noted and similarly classified into ≤10 days or more being early or late. Patients were followed both in the ICU and in the ward to see whether they developed surgical wound infections pneumonia or renal failure necessitating dialysis. Patients' data were entered into a master sheet data and later into a SPSS.14 window program for analyses using χ2-test for categorical data.

Results

There were 103 patients of which 62 (60.2%) were males and 41 (39.8%) were females making a male to female ratio 3:2 and no difference in age was noted between male female patients (Table 1). The mean age was 74.45 months and minimum age was 3 months and maximum 216 months (18years).The mean duration of symptoms was 54.52 months, five patients were asymptomatic and were diagnosed on routine screening. The minimum duration of symptoms among those who had presented was 2 months and maximum was 168 months (Table 2). Majority of patients had congenital heart disease that accounted for 93.2% (96 patients) with Tetrallogy of Fallot being the commonest in 27.2% followed by ventricular septal defect 25.2%.chronic rheumatic heart disease was found in 7 cases and accounted for 6.8%: all patients with chronic rheumatic heart disease had mitral regurgitation of varying degree and severity. Other types of congenital heart disease were found at variable number (Table 3).

Table 1. Age-sex Distribution.

Age groups*	***Sex***		***Total (%)***
	Male (%)	**Female (%)**	
Infancy	10 (66.7)	5 (33.3)	15 (14.6)
Toddler	21 (61.8)	13 (38.2)	34 (33.0)
Preschool/young age	19 (52.8)	17 (47.2)	36 (35.0)
School/adolescence	12 (66.7)	6 (33.3)	18 (17.5)
Total	62 (60.2)	41 (39.8)	103 (100)

* Infancy ages 0-12 months, Toddler13-48 months, preschool and young age 49-132 months, school and adolescent age 133-216 months. χ2 =1.438;df 3: p= 0.697.

Table 2. Descriptive statistics

Variable *	*No of Cases*	*Mean ±SD*	*Variance*	*Minimum*	Maximum
Age(months)	103	74.45±58.59	3432.39	3.0	216.0
Body weight(kg)	103	18.81±13.64	186.12	3.7	59.0
BSA (M2)	103	0.75±0.37	0.14	0.3	1.7
DS (months) §1	98	54.52±46.10	2125.16	2.0	168.0
HB (g/dl)	103	13.24±2.35	5.53	9.1	20.3
TOT (min)	103	176.83±51.27	2628.51	95.0	436.0
IT (min) §2	102	42.27±19.90	396.16	3.0	152.0
CPBT (min)	103	61.17±22.16	491.11	18.0	165.0
LVEF (%)	103	64.84±7.44	55.40	47.0	83.0
TTW (hrs)	103	48.48±69.65	4850.74	0.6	456.0
ICU stay(days)	103	4.44±4.78	22.82	1.0	42.0
PIHS(days) §3	102	5.92±4.79	22.91	1.0	30.0

§1 five patients were asymptomatic and were diagnosed on routine screening: §2 one patient underwent BDG on beating heart: §3 one patient died in the ICU

*BSA=Body surface area, DS=Duration of Symptoms, TOT= Total Operation Time, IT= Ischemia Time, CPBT =cardiopulmonary bypass time, LVEF= Left Ventricular Ejection Fraction, TTW= Total Time to Weaning, ICU=Intensive Care, PIHS= Post-ICU Hospital Stay.

Table 3. Distribution of cardiac disease.

Diagnosis *	Number of cases (%)
ASD	21 (20.4)
VSD	26 (25.2)
TOF	28 (27.2)
DORV	3 (2.9)
TAPVC	6 (5.8)
PAPVC	2 (1.9)
AVSD	3 (2.9)
MR	7 (6.8)
Pulmonary atresia	1 (1.0)
Sub aortic membrane	1 (1.0)
ALCAPA	1 (1.0)
CO-ATRIUM	1 (1.0)
DILV	2 (1.9)
Tricuspid atresia	1 (1.0)
Total	103 (100)

*ASD=Atria Septal Defect: VSD=Ventricular Septal Defect: TOF= Tetrallogy of Fallot: DORV=Double Outlet Right Ventricle: TAPVC=Total Anomalous of Venous Connection: PAPVC= Partial Anomalous of Venous Connection: AVSD=Atrioventricular Septal Defect: MR=Mitral Regurgitation: ALCAPA= Anomalous of Left Coronary Artery Arising from Pulmonary Artery: CO-ATRIUM= Common Atrium: DILV=Double Inlet Left Ventricle.

Table 4. Age groups as compared to weaning period.

Age groups (months)*	*Total time to weaning (hours)*			*Total (%)*
	Short (%)	**Intermediate (%)**	**Prolonged (%)**	
Infancy	7(46.7)(9.1)	1(6.7)(14.3)	7(46.7)(36.8)	15(14.6)
Toddler	22(64.7)(28.6)	4(11.8)(51.1)	8(23.5)(42.1)	34(33.0)
Preschool/young	30(83.3)(39.0)	2(5.6)(28.6)	4(11.1)(21.1)	36(35.0)
School/adolescence	18(100)(23.4)	0(0)	0(0)	18(17.5)
Total	77(74.8)	7(6.8)	19(18.4)	103(100)

FISHERS EXACT TEST=16.472,DF=6; P=0.004

Table 5. Per Operative Factors as Compared to Weaning Period.

*Factors**		*Total (%)*	*Weaning schedule*			*P*
			Short (%)	**Intermediate (%)**	**Prolonged (%)**	*value*
PAH	Yes	33(32.0)	18(54.5)	4(12.1)	11(33.3)	0.005
	No	70(68.0)	59(84.3)	3(4.3)	8(11.4)	
WDXC	Yes	29(28.2)	18(62.1)	2(6.9)	9(31.0)	0.209
	No	74(71.8)	59(76.6)	5(6.8)	10(13.5)	
VD	Yes	24(23.3)	12(50.0)	2(8.3)	10(41.7)	0.003
	No	79(76.70	65(82.3)	5(6.3)	9(11.4)	
Cardiac	A	58(56.3)	50(86.2)	3(5.2)	5(8.6)	0.008
grade	B	32(31.1)	21(65.6)	3(9.4)	8(25.0)	
	C	13(12.6)	6(46.2)	1(7.7)	6(46.2)	
End ρH	Nm	84(81.6)	62(73.8)	7(8.3)	15(17.9)	0.552
	Ac	19(18.4)	15(78.9)	0(0.0)	4(21.1)	
ITS	S	67(65.0)	50(74.6)	6(9.0)	11(16.4)	0.510
	P	36(35.0)	27(75.0)	1(2.8)	8(22.2)	
CPBTS	S	61(59.2)	48(78.7)	4(6.6)	9(14.8)	0.700
	I	35(34.0)	24(68.6)	3(8.6)	8(22.9)	
	P	7(6.8)	5(71.4)	0(0.0)	2(28.6)	
TOT	S	65(63.1)	50(76.9)	5(7.7)	10(15.4)	0.545
	P	38(36.9)	27(71.1)	2(5.3)	9(23.7)	
LVEF	Nm	63(61.2)	45(71.4)	6(9.5)	12(19.0)	0.432
	Lw	40(38.8)	32(80.0)	1(2.5)	7(17.5)	

***PAH= pulmonary hypertension, WDXC whether diagnosis occurring in combination. VD= ventricular dysfunction. PH at end of cardiopulmonary bypass-Nm=normal; ≥7.35, A= Acidemia; <7.35.ITS=ischemia time schedule; S=short P=prolonged. CPBTS=cardiopulmonary bypass time schedules: S=short, I=intermediate, P=prolonged. LVEF=left ventricular ejection fraction: Nm=normal, Lw=low**

Majority of patients who showed prolonged weaning period postoperative were infancy 36.8% and toddler 42.1% as compared to other age groups whom otherwise showed early weaning this difference was significant $p<0.05$. (Table 4).

Per-operative factors found to have difference in the weaning period were presence of pulmonary hypertension, ventricular dysfunction and cardiac grade; such difference was statistically significant at $p=0.05$.while no statistical significance was noted with cardiac disease occurring in combination, low pH at the end of cardiopulmonary bypass, duration of aortic cross-clamp, cardiopulmonary bypass time and left ventricular ejection fraction When a cutoff point of total operation time was made between procedures that are short; lasting ≤3 hours and prolonged lasting; >3hours no difference in weaning period was noted (Table 5). Further more, it was noted that the level of preoperative hemoglobin whether low (9.1-11g/dl) ,normal (12-15g/dl) or viscous >15 g/dl was not associated with any difference when compared to weaning time. It was also found that during cardiopulmonary bypass; all patient had 2-10 folds urine output of their normal production as per age groups per hour.

Discussion

This study has shown that prolonged mechanical ventilation and extubation was statistically significant in patients who were found to have pulmonary hypertension ($p<0.05$). In which about 33% of patients with pulmonary hypertension had prolonged mechanical ventilation beyond 72 hours; 12.1% with pulmonary hypertension had intermediate weaning while 54.5% of patients were weaned to or less than 48 hours. The presence of pulmonary hypertension in patients with heart disease undergoing cardiac operation has been found to be a major factor and a cause of prolonged mechanical ventilation and intensive care stay in many other series[6,7,8,9]. While Vida et al[10] recently found 65-90% successful early extubation in patient with ventricular septal defect and pulmonary hypertension. Further this study has shown that the presence of ventricular dysfunction was a factor associated with prolonged mechanical ventilation and delay in weaning and extubation.41.7% of patients with ventricular dysfunction were found to be weaned beyond

72 hours and this difference was statistically significant (p=0.05). The presence of ventricular dysfunction or cardiac failure seen prior to cardiac operation has been found to be the cause of prolonged mechanical ventilation and intensive care stay in other studies[6,11].

Patients who scored a lower cardiac grade (grade C) at the end of cardiac operation were found to have prolonged time of weaning; 46.2% with grade C as compared to 25% and 8.6% of cardiac grades B and A respectively, this difference was statistically significant ($p<0.05$). The presence of a cardiac lesion occurring in combination was found in 28.2% of all cases. Patients in this category were found not to be associated with prolonged mechanical ventilation and there was no statistical difference. Ranucci et al[4] while studying determinants of early discharge from intensive care unit after cardiac surgery: found significant prolonged mechanical ventilation among patients who had cardiac lesions occurring in combination. This study further had shown that the presence of prolonged duration of aortic cross-clamp (ischaemia time) and cardiopulmonary bypass during operation was not associated with prolonged mechanical ventilation. This finding was similar to what Garcia-Montes et al[11] found; while determining factors associated with prolonged mechanical ventilation in paediatric patients. However other series have demonstrated significance difference[6,8,12]. The presence of low preoperative hemoglobin or hyperviscous blood was not associated with prolonged mechanical ventilation. Hyperviscosity has been found to increase pulmonary vascular resistance hence pulmonary hypertension and consequently prolonged time to weaning[5]. Finally the total operation time was not found to have significant difference with regard to weaning period.

Conclusion

Our study has shown that presence of pulmonary hypertension, ventricular dysfunction and cardiac grade were factors associated with prolonged time to weaning. While aortic cross-clamp, total duration of cardiopulmonary bypass, cardiac disease occurring in combination, total operation time and level of hemoglobin were not associated with prolonged time to weaning.

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