

Original article:

Post-Operative Pulmonary Complications Following Surgery for Congenital Heart Disease

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Abstract:

Objective: To identify the incidence and related factors for pulmonary complications and its impact on outcome in patients subjected to surgery for congenital heart disease (CHD).

Methods: The sample comprised 100 patients of both genders, subjected to surgery for CHD, during one years period from 2021 to 2022.

Methodology: This is a retrospective study, executed at G,B, Pant Hospital, india. The study sample consisted of all children as well as few grown up and adult patients of both genders, diagnosed with CHDs, subjected to cardiac surgery, during one year period from 2021 to 2022.

Results: Twenty (20%) patients developed some form of pulmonary complications. Age, weight, length and body surface area are significantly low among them ($p < 0.05$). They also have higher Aristotle score & RACHS score, higher CPB time and aortic cross clamp time ($p < 0.01$). Patients who had pulmonary complications had significantly higher ($p < 0.01$) vasoactive inotrope score, prolonged mechanical ventilation, longer post operative ICU stay and post operative hospital stay. There was no mortality.

Conclusions: Pulmonary complications are common after surgery for CHD which is more common in small children and complex surgeries. It significantly affects outcome including duration of mechanical ventilation and length of stay but no effect in mortality.

Keywords: Congenital heart disease, post operative, pulmonary complications

Introduction:

Although minimal invasive catheter based treatment for congenital heart diseases (CHD) are possible now a days(1), surgery remains as an important modality for treating most congenital cardiac malformations(2). Pulmonary complications with wide variation of incidence, ranging from 6% to 76% are the most common causes of morbidity and mortality in surgeries for CHDs(3). Children and adolescent with CHD who underwent surgical repair are a special group of patients associated with an increased risk of development of post-operative pulmonary complications(4). Popular believe is that general anesthesia, surgical incision, cardiopulmonary bypass (CPB), ischemia time, intensity of surgical manipulation and number of drains may predispose patients to pulmonary function changes, which are highly relevant on the onset of pulmonary complications in cardiac surgery postoperative(3). Most complications such as pneumonitis, bronchospasm, lobar collapse, prolonged

mechanical ventilation and generalized pulmonary dysfunction develop as a result of changes in lung volumes that occur in response to dysfunction of muscles of respiration and other changes in chest wall mechanics . All of these have effect on outcomes in term of duration of mechanical ventilation, length of ICU stay and post operative morbidity. Department of Cardiac Surgery of G. B. Pant Hospital is performing surgery for CHDs on regular basis. But we did not have any previous organized documentation of respiratory event in these patients. Therefore, this initial report aims at identifying the post operative pulmonary events and their effect on outcome.

Methodology:

This is a retrospective study, executed at G,B, Pant Hospital, india. The study sample consisted of all children as well as few grown up and adult patients of both genders, diagnosed with CHDs, subjected to cardiac surgery, during one year period from 2021 to 2022.

Data collection:

. The data collection instrument approached issues related to:

Demographic characters, diagnosis, procedures performed, pulmonary complication, types of pulmonary complications, pulmonary pressure, cardiopulmonary bypass, postoperative mechanical ventilation, ICU stay and post operative hospital stay, procedure risk scores, post operative inotrope score and vasoactive inotrope score.

Operational method of the database:

Every day one data entry operator entered the cases of the day and also the detail data entry of the patients who were shifted out of intensive care unit (ICU). On the same day resident medical officer recheck all the data entry of that day. On the day of discharge pediatric intensivist again check all the data entry of that patient and complete the entry of that particular patient. To make the database having minimal error, periodic analysis of the database is also done.

Case selection:

During the period of time from 2021 to 2022 (12 months) we had total 100 cases.

Statistical analysis:. Continuous data are expressed as Median and Interquartile range (IQR) and categorical data are expressed as Percentage.

Depending on the distribution a Student's t test or Mann–Whitney U test was performed. Categorical variables were compared using the chi squared test and if expected frequencies less than five were found in contingency tables Fisher's exact test was used. All statistical tests were two-tailed. P values of less than 0.05 were considered statistically significant.

Results:

The demographic characteristics of the studied patients (1 cases) showed [Table -1] that median age of the cohort was 60 months with interquartile range (IQR) 27– 132 months. Median weight of 14.6 kg with IQR 9.8 – 28.5 kg and median length 100 cm with IQR 82 – 141 cm. 45 patients (45%) were male and 55 patients (55%) were female. Two (2 %) patients had Down syndrome. Pulmonary arterial hypertension (PAH) was present among 74 (74%) patients with median PASP 41 mmHg.

The demographic characteristics of the studied patients [Table -1]

Variable	Median	n
Age(months)	60(27-132)	
Weight (kg)	14.6 (9.8-28.5)	
Length(cm)	100(82-141)	
Sex		
Male	45(45)	
Female	55(55)	
Down Syndrome		2(2)
PAH		74(74)
PASP	41(35-52)	

Concerning the clinical diagnosis [Table – 2],

Diagnosis	N(%)
Acyanotic heart disease	60
PDA	03
ASD	36
ASD,PAPVC	02
VSD	10
ASD,VSD	01
VSD,PS	06
AVSD	02
DORV,TGA	02
TAPVC	01
TOF	28
TOF,ASD	01
DORV,TOF Variety	05
Tricuspid Atresia	02
PA,VSD	01

60 % were acyanotic CHDs, mostly shunt lesions. 40%b has cyanotic CHDs . Among acyanotic heart disease patients most common being ASD 36 (36%) and VSD 10 (10%%) followed by PDA 3 (3 %), . Cyanotic heart diseases with decreased pulmonary flow patients are mostly TOF and TOF variants.

Among the procedures performed [Table 3]

Procedures	N(%)
ASD Closure	36
PDA Ligation	3
ASD closure, PAPVC rerouting	2
VSD Closure	10
ASD Closure, VSD Closure	1
ICR for TOF	28
RVOT Procedure	15
Glenn procedure	5

Most common being ASD closure 36 (36%) followed by ICR for TOF 28(28%), VSD Closure 10 (10%) and few other procedures.

Cardiopulmonary bypass (CPB) was required in 97 (97%) surgeries with median CPB time of 82 min with IQR **66 – 116 min and median cross clamp time was 52 min with IQR 35.5 – 76 min [Table – IV]**

Variable	Median
CPB Status	
CPB	97
Off CPB	3
CPB time(min)	82(66-116)
Cross Clamp Time(min)	52(35.5-76)

Table – 5 showed – variables -

Variable	Median	N(%)
Fast track extubation		70
Duration of MV (hours)	10.8(5-24)	
Prolonged MV		10
Noninvasive ventilation		2
Reintubation		4
Pneumothorax		2
Pneumothorax requiring ICD		2
Pleural effusion		5
Pleural effusion requiring ICD		2
Subcutaneous Emphysema		2

Detail of pulmonary issues and complications. More than half of the patients, 70(70%) were fast tract extubated.

Median duration of mechanical ventilation of the whole study population was 10.8 hours with IQR 5 – 24 hours. Ten (10%) patients required prolonged mechanical ventilation after surgery and another 2 (2%) required non invasive ventilation after extubation. Four (4%) patients experienced reintubation. Pneumothorax developed in 2(2%) patients and among them both(2%) were severe enough to require intercostal chest tube drainage (ICD). Five (5%) patients developed pleural effusion and 3 improved with fluid restriction and diuretic therapy and finally 2(2%) required ICD insertion. Two (2%) patients developed subcutaneous emphysema and improved gradually without any active intervention

Table- VI – Pulmonary complications

	Pulmonary Complications		P value
	Yes	No	
Age(months)	42(20-100)	60(30-155)	<0.05
Weight(kg)	14.7+ _{10.1}	22.6+ _{17.3}	<0.01
Length(cm)	98.7+ _{29.4}	111.7+ _{32.3}	<0.05
BSA (mean+ _{SD})	0.62+ _{0.3}	0.82+ _{0.42}	<0.01
Sex			Not significant
Male	16(11.3)	48(34)	
Female	12(8.5)	65(46.1)	
PASP(mean+ _{SD})	45.9+ _{16.7}	54.6+ _{18.1}	Not significant

Table 7- Pulmonary complications (Analysis)

	Pulmonary Complication		P value
	Yes(n=12)	No(n=88)	
Aristotle Score,mean(SD)	6.7+ ₂	5+ ₂	<0.01
RACHS Score			<0.01
RACHS 1	2	50	
RACHS 2	7	20	
RACHS 3	3	18	
CPB Status			Not significant
CPB	11	86	
Off CPB	01	02	
CPB time(min) mean(SD)	119.9+ _{50.8}	85.9+ _{35.6}	<0.01
Cross Clamp Time(min) mean(SD)	79.1+ _{33.5}	53.8+ _{27.7}	<0.01

Inotrope Score, median	4.5(0-5.6)	0(0-5)	Not significant
Vasoactive Inotrope Score, median	8.3(5-21.4)	5(0-5.9)	<0.01
Duration of MV(hours), median	35.3(18.7-132.2)	7.2(3.8-15.4)	<0.01
Postop ICU stay(days) mean	6.9+ ₋ 5.6	1.9+ ₋ 1.3	<0.01

Discussion:

Many of the patients have preexisting lung issues related with CHD(6). In addition, CHD is often associated with an impaired pulmonary hemodynamic condition that has a great effect on the mechanical properties of the lung(7,8) . Among the 100 patients of the study population 12 (12%) patients had some form of pulmonary complications which is within wide range of incidence (6 – 76%) reported in literature(3,4,9). Most common complication encountered was prolonged mechanical ventilation (10%) followed by pleural effusion (5%), requirement of non invasive ventilation (NIV) (2%), pneumothorax (2%), re-intubation (4%) and subcutaneous emphysema (2%) [Table-V]. There is wide range of incidence of pleural effusion in reported literature. Bocsi et al. showed among 75 children upto 18 years of age undergoing open heart surgery for CHD 29 (38.6%) developed significant pleural effusion(10). O’Callaghan showed subpleural effusion in 11% of 83 paediatric patients after cardiac surgery and all of them improved after conservative management and diuretic therapy(11). Although in our series there was no patient with univentricular repair, Airan et al. showed significant pleural effusion in 27% of 348 patients with univentricular repair . (13, 14) Children undergoing congenital heart surgery are at risk for prolonged mechanical ventilation¹³ which range from 11 – 28%(14-16). The incidence is little lower in our study (5%) which may be due to less number of neonate and infant in our study.

Non invasive ventilation (NIV) to prevent extubation failure after extubation was required in 2% of patient. The incidence of failed extubation after paediatric cardiac surgery is higher, approaching one-fifth in some groups at high risk compared to the general population treated in the pediatric intensive care unit. Non-invasive ventilation may be used to transition in selected patients from tracheal extubation to ventilation via a natural airway(17). In a randomized controlled trial Nava et al demonstrated that NIV had a lower rate of re-intubation in comparison to standard medical therapy in patients at risk for post extubation respiratory failure(18). A Meta analysis of NIV use in selected subgroups of recently extubated patients suggests that the judicious NIV use may reduce ICU and hospital length of stay, pneumonia, re intubation rates and improve hospital survival(19). Two percent patients in our study developed pneumothorax. Bhat et al. showed 1.8% patients developing ventilator associated pneumothorax among 540 neonate(20). In mechanically ventilated patients pneumothorax is not uncommon. Moreover underlying lung diseases and low compliance of lung are associated with ventilator- related pneumothorax with pneumothoraces occurring most commonly during the early phase of mechanical ventilation(20,21).

Patients having pulmonary complications were significantly younger in age and smaller in weight and length (p value <0.05) but there was no difference in complications in gender distributions and the finding is similar to Bandla et al(9). Younger age is associated with prolonged mechanical ventilation after cardiac surgery in children(15). Pulmonary complications are also related with complexity of the surgery which has been evident by higher Aristotle scores among the patients with pulmonary complications (p value <0.01) as well as

higher the RACHS-1 score (p value <0.01). Predictability of post operative mortality and morbidity with higher RACHS-1 and Aristotle score is shown in different Publications(17), although different authors concluded that the Aristotle score is still under development and the reported morbidity scores need to be tested on larger series and in different institutions(18).

There was no difference found in pulmonary complications in relation to whether cardiopulmonary bypass (CPB) required or not, but among the CPB cases incidence of pulmonary complications are significantly higher (P value <0.01) among longer CPB time and longer cross clamp time. Lung injury is a recognized complication of CPB(18,19). In cardiopulmonary bypass, lung injury follows the propagation of an inflammatory response involving cytokines, complement, neutrophils, monocytes, activated endothelial cells and platelets.

Neutrophils sequester in the lung in response to chemo-tactic agents and release injurious free radicals and specific enzymes resulting in widespread pulmonary injury(20). CPB and aortic clamping led to significant decreases in functional residual capacity (FRC), which later improve slightly but remain significantly lower than the baseline value(29). However Stayer et al. did not find any effect of duration of CPB on respiratory mechanics, but longer aortic cross-clamp time was associated with decreased respiratory compliance(7). In our series, inotrope scores are similar in the both groups and vasoactive inotrope scores (VIS) are higher (p value <0.01) among patients with pulmonary complications.

Vasoactive-inotropic score is an independent predictor of clinical outcome in infants after cardiac surgery and high vasoactive-inotropic score was found associated with prolonged intensive care stay and duration of mechanical ventilation. On the other hand, role of the inotrope score is yet to be established as a predictor of outcome (21). Post operative pulmonary complication is one of the most important post operative morbidity which significantly affects outcomes. In our study, patients who suffered any form of pulmonary complications had longer duration of mechanical ventilation (p <0.01), longer post operative ICU stay (p <0.01) and longer post operative hospital stay (p <0.01). Studies also showed that pulmonary complications are a frequent cause for delayed recovery following cardiac surgery and including prolonged duration of mechanical ventilation specially in young children and prolonged ICU stay(9,22).

Conclusion:

Pulmonary complications are common after surgery for CHD. In young children undergoing surgical repair is clearly associated with pulmonary involvement. Complex surgeries, longer CPB & cross clamp time and higher vasoactive inotrope score are also associated with increased incidence of pulmonary complications which significantly affect outcomes including prolonged duration of mechanical ventilation, prolonged post operative ICU stay and post operative hospital stay.

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