



Early extubation after congenital heart surgery

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ABSTRACT

Introduction: Despite recent advances in anesthesia, cardiopulmonary bypass and surgical techniques, children undergoing congenital heart surgery require postoperative mechanical ventilation. Early extubation was defined as ventilation shorter than 12 hours. Aim of this study is to identify factors associated with successful early extubation after pediatric cardiac surgery.

Methods: The study was performed during period from January 2006 to January 2011 at Pediatric Clinic and Heart Center University Clinical Center Sarajevo. One hundred children up to 5 years of age, who have had congenital heart disease, with left-right shunt and obstructive heart disease were included in the study. Patients were divided into two groups: Group I - patients extubated within 12 hours after surgery and Group II - patients extubated 12 or more hours after surgery.

Results: The most frequently encountered preoperative variables were age with odds ratio 4% 95%CI (1-7%), Down's syndrome 8.5 95%CI (1.6-43.15), failure to thrive 4.3 95%CI (1-18). Statistically significant postoperative data included lung disease (reactive airways, pneumonia, atelectasis, pneumothorax) and with odds ratio 35.1 95%CI (4-286) and blood transfusion with odds ratio 4.6 95%CI (2-12). Blood transfusion ($p=0.002$) (Wald=9.2) 95%CI (2-12), during as well as after operation procedure has statistically significant influence on prediction time of extubation. Proven markers were age with cut of 21.5 months (sensitivity 74% and specificity 70%) and extracorporeal circulation (ECC) with cut-off of 45.5 minutes (sensitivity 71% and specificity 65%).

Conclusion: Early extubation is possible in many children undergoing congenital heart surgery. Younger age and prolonged ECC time are markers associated with prolonged mechanical ventilation.

Keywords: Early extubation; congenital heart disease; congenital heart surgery

INTRODUCTION

Despite technological progress in diagnostic cardiology, anesthesia, surgical, extracorporeal techniques

and improvements in the perioperative management strategies, that all contributed to successful outcome of surgical procedures performed on neonates, infants and children with congenital heart disease (CHD), still, almost all children undergoing congenital heart surgery require postoperative mechanical ventilation. Patients with CHD in postoperative period depend on balance of the pathophysiological and compensatory mechanisms that often decreased cardiopulmonary reserves.

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Submitted July 14 2014 / Accepted September 24 2014



Early extubation was defined as mechanical ventilation in period shorter than 24 hours (practically shorter than 24 hours, usually 4-8 hours) (1-4). Determination of the optimal moment for extubation is based on clinically and laboratory factors, that indicates possibility of appropriate blood gas exchange during spontaneously breathing. Early extubation may be a component of the fast-track process as a method for reducing length of hospitalization for surgical patients (5,6). The aim of this study was to investigate prevalence and type of the treated congenital heart disease and to identify preoperative, intraoperative, postoperative factors associated with successful early extubation after operation.

METHODS

Study design

The study was performed in Pediatric Clinic and Heart Center University Clinical Centre Sarajevo from 01.01.2006 to 01.01.2011. The institutional Ethics committee approved the study.

We included 100 children up to 5 years of age who had congenital heart disease with left-right (L-R) shunt and obstructive congenital heart disease. Patients were divided into two groups: Group I - patients extubated within 12 hours after surgery and Group II - patients extubated more than 12 hours after surgery.

Evaluated factors were divided into: preoperative, intraoperative and postoperative. Preoperative data included: age, gender, history of prematurity (<36 weeks gestation), time of mechanical ventilation, lung disease, lesion type, prior cardiac surgery, pulmonary hypertension, Down's syndrome, recent viral infection, anemia (hematocrit <35%), congestive heart failure, failure to thrive (less than fifth percentile for weight) and renal failure. Intraoperative data evaluated duration of extracorporeal circulation, intraoperative arrhythmias, thoracotomy vs. sternotomy, type of the anesthetic, type of the operation (complete vs. palliative) and complexity (simple vs. complex), blood transfusion. Analyzed postoperative data were: infection (positive culture or increased C reactive protein), lung disease (reactive airways, pneumonia, atelectasis

and chronic lung disease), arrhythmias, inotropes longer than 48 hours postoperatively, pH <7.25, pCO₂ <45 mmHg pO₂ 50-100 mmHg, potassium >5.0 mEq/L, ionized calcium <1.0 mmol/L, blood transfusion. Criteria for extubation were: blood gas analyses: pH 7.32-7.47, pCO₂<50 mmHg, pO₂ >60 mmHg, with blood oxygen saturation 95%, adequate oxygenation with fraction of inspired oxygen (FiO₂)≤50%, PEEP (positive end-expiratory pressure) ≤7 cm H₂O, ventilatory frequency ≤8, air leak around endotracheal tube, hemodynamic stability, without signs of myocardial ischemia or significant hypotension, consistent level of consciousness with adequate protective reflexes, body temperature <38.5 C, level of the hemoglobin >80 g/dl.

Statistical analysis

Nominal and ordinal variables were analyzed with χ^2 test and in case of lack of the expected frequency Fisher test has been used. For continuous variables first symmetric of the distribution was analyzed with Kolmogorov-Smirnov test, then arithmetic mean and standard deviation (for symmetric distribution) and for comparison these variables parametric test (Student t-test). In case of asymmetric distribution, median and interquartile ranges were used and for comparison of these variables nonparametric tests (Mann-Whitney U test, Kruskal-Wallis test). The Pearson correlation method measures the strength of the linear relationship between normally distributed variables. When the variables are not normally distributed or the relation between the variables is not linear the Spearman rank correlation method was used. ROC curve determined if some specific variable could be good marker we used. For statistical analysis SPSS for Windows (version 13.0, SPSS Inc, Chicago, Illinois, USA) and Microsoft Excel (version 11. Microsoft Corporation, Redmond, WA, USA) were used. A two-tailed p<0.05 was considered statistically significant.

RESULTS

From total of 100 patients (Figure 1), 54 patients were extubated within 12 hours and 46 patients were extubated more than 12 hours after surgery, without significant difference between these two groups ($\chi^2 = 0.640$; df=1; p=0.424).

Extubation time and gender affiliation (Table 1) were independent ($p=0.07$) and doesn't depend of history of prematurity ($p=0.117$). Median age of the patient extubated within 12 hours after surgery was 36 months $Med=36$ (18-48) and >12 hours 14 months $Med=14$ (6-24).

Down syndrome ($p<0.0005$) 95% CI (1.6-43.15), younger age ($U=608.0$ $p<0.0005$) 95%CI (1-7), failure to thrive 95%CI (1-18), congestive heart failure, pulmonary hypertension ($p<0.0005$) have statistically significant influence on prediction of extubation time. Anemia ($p=0.09$) and viral infection ($p=0.54$) independently did not show statistically significant influence on prediction of extubation time. Median values of laboratory parameters did not deviate in both groups.

Presence of the lung diseases in preoperative ($p=0.048$) and postoperative period $Wald=11.04$ 95% CI (4-286) is significant parameter for prolonged mechanical ventilation.

TABLE 1. Extubation and demographic data

	Extubation (h)		Total
	≤12.00	12.01+	
Gender			
Female			
Count	32	18	50
% within gender	64.0	36.0	100.0
Male			
Count	22	28	50
% within gender	44.0	56.0	100.0
Total			
Count	54	46	100
% within gender	54.0	46.0	100.0

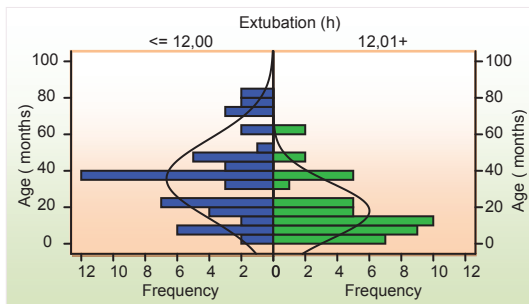


FIGURE 1. Histogram frequency age of the patients and time of the extubation.

Younger age (Figure 2) and prolonged duration of the extracorporeal circulation (Figure 3) ($Wald$ 11.7 $p=0.001$) CI (1-3%) are proven markers for distinction patients according to time of the extubation. Cut off for duration of the extracorporeal circulation is 45.5 minutes, with sensitivity 71% and specificity 65%. Cut off for age is 21.5 months, with sensitivity 74% and specificity 70%.

Blood transfusion ($p=0.002$) ($Wald=9.2$) 95%CI (2-12), during as well as after operation procedure

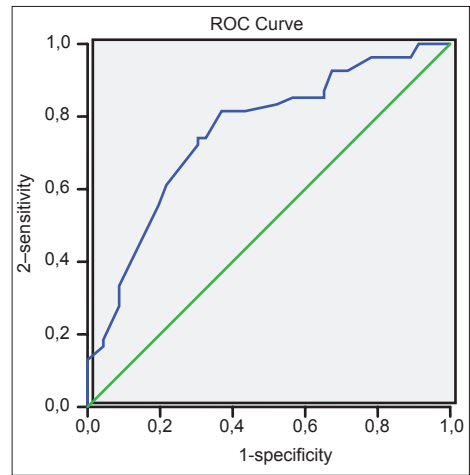


FIGURE 2. Age as marker for prediction successful early extubation, with a cutoff 21.5 months (sensitivity 74% and specificity 70%).

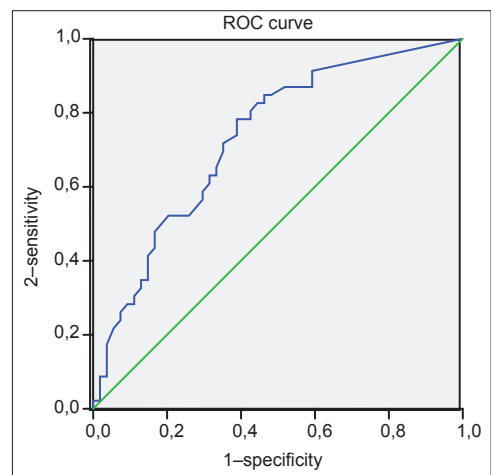


FIGURE 3. Extracorporeal circulation (ECC) time as marker for prediction successful early extubation, with cut off 45.5 minutes (sensitivity 71% and specificity 65%).

has statistically significant influence on prediction of extubation time.

In group of patients extubated in first 12 hours the most common CHD were: patent ductus arteriosus 16/54 (29.6%), ventricular septal defect (VSD) 14/54 (26%), atrial septal defect (ASD secundum) 10/54 (18.5%) (Table 2). In group of patients extubated 12 hours after operation the most common CHD were VSD 17/46 (37%), atrioventricular septal defect (AVSD) 9/46 (19.5%) and ASD secundum with VSD 7/46 (15.2%) (Table 3).

TABLE 2. Time of the extubation and type of the congenital heart disease

	Congenital heart disease		Total
	Obstructive	Non-obstructive	
Extubation (h)			
<=12.00			
Count	9	45	54
% Extubation (h)	16.7	83.3	100.0
12.01+			
Count	5	41	46
% Extubation (h)	10.9	89.1	100.0
Total			
Count	14	86	100
% Extubation (h)	14.0	86.0	100.0

Obstructive congenital heart disease: Aortic stenosis, coarctation of aorta, pulmonary stenosis. Non-obstructive congenital heart disease: patent ductus arteriosus, atrial septal defect, ventricular septal defect, atrioventricular septal defect

Time of the extubation and type of the congenital heart disease are independent parameters ($p=0.405$). There was no reintubation in the early extubation cases.

DISCUSSION

Despite significant advances in perioperative technology debate continues regarding appropriate weaning strategies. There are large institutional differences with respect to pediatric cardiac patient management. While certain centers adopted a fast-tracking concept and attempted extubation in the operating room or within a few hours following surgery, others still routinely continue mechanical ventilation and deep sedation postoperatively for a day or two in the intensive care unit. There is some evidence, mostly from retrospective analyses, that fast-tracking can be beneficial; however, prospective randomized studies are required to determine if fast-tracking improves outcome in children undergoing surgery for CHD (1). Several studies report on factors that prevented early extubation in children following surgery for CHD (1).

Our research pointed that patients age ≥ 6 months with absence of the Down syndrome, pulmonary hypertension, congestive heart failure, lung disease, failure to thrive with short time of the extracorporeal circulation, without blood transfusion in perioperative period, were predictive of successful early extubation.

TABLE 3. The frequency of certain types of CHD compared to the group of respondents

	Type of congenital heart anomalies														
	ASD sec	VSD	PDA	AVSD	AS	PS	CoA	ASD sec+	ASD sec+ VSD	VSD+ PS	ASD primum	ASD sec+ MR	ASAD primum+	CoA+ VSD	Total
Extubation (h)															
<=12.00															
N	10	14	16	1	1	1	6	1	1	0	2	0	0	1	54
Extubation (%)	18.5	25.9	29.6	1.9	1.9	1.9	11.1	1.9	1.9	0.0	3.7	0.0	0.0	1.9	100.0
12.01+															
N	2	17	2	9	0	2	3	7	0	1	1	1	1	0	46
Extubation (%)	4.3	37.0	4.3	19.6	0.0	4.3	6.5	15.2	0.0	2.2	2.2	2.2	2.2	0.0	100.0
Total															
N	12	31	18	10	1	3	9	8	1	1	3	1	1	1	100
Extubation (%)	12.0	31.0	18.0	10.0	1.0	3.0	9.0	8.0	1.0	1.0	3.0	1.0	1.0	1.0	100.0

ASD-atrial septal defect, VSD-ventricular septal defect, PDA-patent ductus arteriosus, AVSD-atrioventricular septal defect, AS-aortic stenosis, PS-pulmonary stenosis, CoA-coarctation of aorta, MR-mitral regurgitation;

Early extubation in operating theatre is not routine, especially for neonate and infant period. In our study there were no detected extubation in operating theatre. Barash and colleague (7) have published experience with early extubation in 197 patient's age less than 3 years: 61% patients have been successfully extubated in theatre. Schuller and colleagues reported on 209 consecutive children undergoing complex open-heart surgery with 88% of those older than 12 months extubated in the operating room (8). Heard et al. (9) published their experience on early extubation following surgery for CHD in 220 patients, of which 147 (67%) were extubated in the operating room, or within six hours in the ICU.

A high-opioid anesthetic technique required prolonged mechanical ventilation following surgery. By the introduction of improved and new anesthetic agents such as modern inhalational anesthetics, short acting opioids, hypnotics and sedatives with favorable pharmacodynamics and kinetic profiles "early extubation" approach has been achieved. Still, advantage of the extubation in operating room opposite from intensive care unit (ICU) is questionable. Typically younger child, who underwent a complex surgery, requires a long time of the extracorporeal circulation, requires prolonged mechanical ventilation.

Heinle et al. (10) published their results about successful early extubation in 45% neonates and infants, with necessary for reintubation in 11% patients.

In our study 46% patients extubated 12 hours after operation had median age 14 months with interquartile range 6-24 months. For each month of the age risk for prolonged ventilation is decreased for 4%. Significant pulmonary hypertension was considered important risk factor of prolonged mechanical ventilation (11-14), that was confirmed by this study.

Down syndrome is documented as factor which increases the risk for unsuccessful early extubation eight times [95% CI (1.6-43.15)]. Since airway obstruction is more likely in Down's patients, it seems reasonable to carefully consider a fast-tracking technique in this patient population, particularly in younger patients after long time on CPB (cardiopulmonary bypass).

Study of the Neirotti et al (15) showed, as well as our research, that failure to thrive is one of the risk factor of prolonged ventilation [95%CI (1-18)].

Congestive heart failure in preoperative period that emphasize Davis (16), in study 2004 confirmed our research, in contrast to prematurity. Time of extubation and gender are independent factors and there is no published study that verify this relationship. In our study none of the patients did not have recent viral infection or anemia in preoperative period.

Duration of the extracorporeal circulation has statistically significant influence in prediction of extubation time, implied that prolongation ECC time increased risk for prolonged extubation for 2% and it is also marker (Figure 3) for prediction successful early extubation with cut off 45.5 minutes (sensitivity 71% and specificity 65%). Longer CPB time is also repeatedly reported to be associated with prolonged mechanical ventilation following CHD surgery (17).

It was demonstrated that early extubation in children undergoing surgery for CHD has no negative affect on postoperative control of the pain and it does not results with increased requirement for analgesics and it help for early mobilization of the patient (18,19).

From all evaluated postoperative factors, significant influence had lung diseases, with odds ratio 35 times and blood transfusion (Odds 4 time), which also emphasize Szekely (20).

Early extubation could result with mild respiratory acidosis, but contrary to results of the Kloth and Baum study (18), arterial blood gases analyses were in referral values during postoperative period.

Mean value differences of the laboratory parameters in repeated measurements have not been statistically significant, in our study that could be explained as adequate postoperative treatment in intensive care unit.

Generally, every patient is possible candidate for early extubation. Individual approach is recommended, considering all aspects, hemodynamic consequences of the congenital heart disease as well as extra cardiac characteristics of each patient. Early extubation is not associated with increased reintubation or mortality. Implementation of a comprehensive early

extubation strategy for all children with congenital heart disease is associated with low morbidity rates and short length of stay. Although there are many benefits resulting from early extubation, it is important to ensure that the practice is both successful and safe (21,22). The majority of children undergoing congenital heart surgery can be extubated in the operating room, but there is question of its benefit and drawback in comparison with extubation couple hours after operation.

This study included CHD with L-R shunt and obstructive anomalies, but it is necessary to expand research to complex CHD, in order to identify additional factors associated with early extubation concept.

CONCLUSIONS

Patients with uncomplicated CHD, with short ECC time are appropriate candidates for early extubation, after assessment of preoperative, intraoperative and postoperative parameters.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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