**Characteristics and hemodynamic effects of extubation failure in children undergoing
complete repair of tetralogy of fallot**

Running title: Extubation failure and tetralogy of fallot

Authors: Andrew L. Dodgen¹; Amber C. Dodgen¹; Christopher J. Swearingen²; Jeffrey M.
Gossett²; Rahul Dasgupta³; Warwick Butt⁴; Jayant K. Deshpande^{3,6}; Punkaj Gupta^{5,6}

Author Affiliations:

¹Department of Pediatrics; ²Department of Biostatistics, ³Division of Pediatric Anesthesiology,
⁵Division of Pediatric Cardiology, ⁶Division of Critical Care, University of Arkansas for Medical
Sciences, Little Rock, USA; ⁴Department of Pediatric Intensive Care, The Royal Children's
Hospital, Melbourne, Australia

Corresponding Author and Reprints:

Punkaj Gupta, MBBS

Assistant Professor of Pediatrics

University of Arkansas for Medical Sciences, College of Medicine

Sections of Pediatric Cardiology and Critical Care Medicine

Arkansas Children's Hospital

1 Children's Way, Slot 512-3, Little Rock, AR

Telephone: (501) 364-1479

Fax: (501) 364-3667

Email: pgupta2@uams.edu

Abstract:

Objective: Identify prevalence, etiology, and outcomes of extubation failure in children after complete repair of tetralogy of fallot at a single tertiary care, academic children's hospital. A second objective of this study was to determine the cardio-respiratory effects of transition of positive pressure ventilation to spontaneous breathing in children with extubation success and extubation failure.

Patients and Methods: Extubation failure for our study was defined as need for reintubation within 96 hours after extubation. We collected demographics, preoperative, intraoperative, post-operative and peri-extubation data in a retrospective, observational format in patients who underwent complete repair of tetralogy of fallot during the period January 2001 to June 2011. Patients with multiple aortopulmonary collateral arteries or associated complete atrioventricular septal defects were excluded from the study. The cardio-respiratory variables collected prior to extubation and immediately after extubation included heart rate, respiratory rate, mean arterial blood pressure, central venous pressures, near infrared spectroscopy, oxygen saturations and lactate levels. Clinical outcomes evaluated included the success or failure of extubation and hospital length of stay. Descriptive and univariate statistics were utilized to compare groups with extubation failure and extubation success.

Results: Of 164 eligible patients during the study period, extubation failure occurred in 7% (12/164) of the patients. The median age of patients at surgery was 200 days (98 days, 356 days) and median weight of patients was 6.8 kg (5.2 kg, 8.5 kg). 6% (10/164) of the patients were intubated prior to surgery. Median duration of mechanical ventilation was 33 hours (19.5 hours, 73 hours), and the median hospital length of stay was 10 days (7 days, 15 days). Of the 12 patients with extubation failure, two patients had extubation failure in first two hours after extubation, six patients in 2-24 hour period, three patients in 24-48 hour period, and one patient in 48-96 hour period. The patients in groups with 'extubation success' and 'extubation failure' were similar in age, sex and body weight at the time of surgery. All pre-existing conditions were also similar in two groups. There were no differences in intraoperative variables, post-operative complications between the two groups. The duration of hospital stay was higher in children with extubation failure ($p < 0.001$). PaO_2 , tachycardia, mean arterial blood pressure, and inotrope score

improved significantly on conversion from PPV to spontaneous ventilation in patients with
'extubation success'.

Conclusions: This study demonstrates that extubation failure in patients after complete repair for tetralogy of fallot is low and etiology is diverse. Majority of extubation failures in these patients occurs in the first 24 hours. Extubation success in children after repair for tetralogy of fallot is associated with improvement in PaO₂, tachycardia and mean arterial pressure with decrease in inotrope score. Extubation failure is associated with increased hospital length of stay.

Key words: extubation failure; reintubation; mechanical ventilation; tetralogy of fallot; cardiac intensive care unit

Introduction

In recent times, early extubation has become a major component of post-operative care in children following repair of tetralogy of fallot (TOF). This approach is based on the rationale that children undergoing repair of TOF have right ventricular diastolic dysfunction. This limits the forward pulmonary blood flow and increases the time available for pulmonary regurgitation. As diastolic pulmonary arterial flow is sensitive to changes in intrathoracic pressure, removal of positive pressure ventilation (PPV) is associated with improvement in hemodynamics and cardiac output [1-2]. However, the risks of early and untimely extubation are manifold [3-5]. Extubation failure requiring emergent reintubation may cause significant hemodynamic instability, unnecessary airway trauma, increased risk for nosocomial infections, and prolonged duration of mechanical ventilation and ICU length of stay [6-8].

Recognition of children who can be successfully extubated after cardiac surgery is a complex decision making process. Mechanical ventilation is discontinued and patients are extubated when the underlying reasons for intubation and mechanical ventilation are resolved. Extubation failure after prolonged mechanical ventilation in children is quite common and is seen in 22-28% of premature babies, 15-20% of critically ill children, and 10% of children after cardiac surgery [6-11]. This study was undertaken to investigate prevalence, etiology and outcomes of extubation failure in children undergoing complete repair of tetralogy of fallot (TOF). A second objective of this study was to determine the cardio-respiratory effects of transition of positive pressure ventilation to spontaneous breathing in children with extubation success and extubation failure.

METHODS

Setting and Patients:

We performed a single center retrospective observational study in a 15-bed pediatric cardiovascular ICU (CVICU) at a tertiary academic children's hospital during the period January 2001 to June 2011. The Institutional Review Board of the University of Arkansas Medical Sciences approved the study and the need for informed consent was waived. The study included all children undergoing complete repair of tetralogy of fallot (TOF) at the Arkansas Children's

1 Hospital. Patients with multiple aortopulmonary collateral arteries or associated complete
2 atrioventricular septal defects were excluded from the study. Patients undergoing initial
3 palliation rather than complete repair were also excluded from the study. Patients operated upon
4 in outside institutions and subsequently transferred to our institution, patients with unplanned
5 extubation, patients with tracheostomy, patients needing continuous positive airway pressure
6 after extubation, and patients with 'Do Not Resuscitate' order were also excluded from the study.
7 We identified the potential subjects by querying the departmental surgical database and the
8 hospital medical records.

9 **Airway Management:**

10 All patients in our cohort were intubated with age appropriate cuffed endotracheal tube
11 (Mallinckrodt Inc., Missouri, USA) and ventilated with a Servo-I[®] ventilator (Maquet Inc., New
12 Jersey, USA). The initial mode of ventilation was pressure-regulated volume control. Once the
13 patient was breathing spontaneously and ready for weaning, the ventilator mode was switched to
14 volume support for at least 30 minutes prior to extubation. Tracheal extubation was performed
15 following a standardized protocol for ventilator weaning in our CVICU: fraction of inspired
16 oxygen in a gas mixture ≤ 0.4 to maintain systemic oxygen saturation ≥ 92 -100 % as measured
17 by pulse oximetry, peak inspiratory pressure of ≤ 20 cm H₂O, and/ or positive end-expiratory
18 pressure of ≤ 6 cm H₂O. All patients included in the study were extubated to humidified high
19 flow nasal cannula (Fischer & Paykel Inc., Auckland, New Zealand) with peak flow pressures
20 varying between 6 and 10 liters per minute. All patients were continuously monitored by a
21 member of the CVICU medical team prior to extubation for respiratory rate, heart rate,
22 transdermal oxygen saturation, the adequacy of chest wall excursion, and use of accessory
23 respiratory muscles. According to the routine clinical practice in our CVICU, patients were
24 completely weaned off the sedation and analgesic infusions prior to extubation if the duration of
25 mechanical ventilation was < 5 days. If the duration of mechanical ventilation was ≥ 5 days, the
26 patient remained on these infusions in the peri-extubation period; however, the dosages were
27 reduced to half or less than half depending on the patient's wakefulness and team's comfort
28 levels.

29 Patients who failed extubation were reintubated if they met one or a combination of the
30 following criteria: (1) presence of clinical signs of respiratory fatigue and severe respiratory

distress, (2) worsening hypercarbia (increase of $\geq 20\%$ from the baseline value) and/ or hypoxemia (decrease of $\geq 20\%$ from the baseline value), (3) inability to clear airway/ oral secretions, (4) hemodynamic decompensation, (5) cardiorespiratory arrest, and (6) Glasgow coma scale of ≤ 8 , or (7) inability to maintain adequate airway patency due to neurological impairment. The decision to extubate or reintubate each patient was made by the CVICU attending and team caring for the patient.

Study definitions and data collection:

For study purposes, failed extubation was defined as the need for reintubation within 96 hours of an extubation attempt. For each patient, the following variables were collected: age, gender, weight, prematurity, associated diagnoses (chronic lung disease, dysrhythmia, pulmonary hypertension, chromosomal abnormality, underlying neuromuscular disease), airway diagnoses (tracheobronchomalacia, tracheal stenosis), and status of intubation prior to surgery. The operating room variables collected included: cardiopulmonary bypass time, cross clamp time, inotrope score [12], lactate, and mechanical support in the form of extracorporeal membrane oxygenation at the time of leaving the operating room. We collected data on peak right ventricular outflow tract (RVOT) data by echocardiogram prior to surgery ('pre-op') and after surgery ('post-op'). The data collected on variables immediately prior to extubation included administration of intravenous glucocorticoids within 24 hours of extubation, need for dialysis, presence of chylothorax and/ or pleural effusion, diaphragm paralysis, sepsis, necrotizing enterocolitis, and ventricular ejection fraction. The laboratory indices collected prior to extubation included arterial blood gas, white blood cell count, hematocrit, blood urea nitrogen, serum creatinine, and lactate. We also collected data on days of mechanical ventilation and days of inotropic support prior to extubation, hours on volume support mode and time of mechanical ventilation after cardiac surgery.

The cardio-respiratory variables collected prior to extubation and immediately after extubation included heart rate, respiratory rate, mean arterial blood pressure, central venous pressures, and oxygen saturations. Cerebral tissue oxygenation was assessed using near infrared spectroscopy (NIRS) using oxygen sensors on the forehead. Data for all these variables was

collected for six hours prior to extubation and six hours after the extubation and hourly mean was represented as either 'pre-extubation' or 'post-extubation' value. 'Lung disease' as the cause of extubation failure included presence of atelectasis or consolidation, with or without presence of chylous or pleural effusion. As a routine practice in our unit, patients receiving positive pressure ventilation receive chest radiograph every morning. For study purposes, the official radiologist interpretation was used to differentiate consolidation from atelectasis on chest radiographs. Any patient with suspicion of diaphragmatic paresis or paralysis on routine chest radiograph received chest ultrasound to evaluate for diaphragmatic mobility. 'Cardiac dysfunction' as the cause of extubation failure included echocardiographic evidence of right and/or left ventricular dysfunction with or without valvular regurgitation. This was determined by an echocardiographer blinded to the two groups. Clinical outcome evaluated for all patients included the success or failure of extubation, and hospital length of stay.

Statistical Analysis

Continuous variables are presented as the median (Q1, Q3), where Q1 is the 25th percentile, and Q3 is the 75th percentile, whereas categorical variables are presented as numbers and percentages. P-values were calculated using Pearson's chi-square test or Fisher's exact test of independence for categorical variables and Wilcoxon rank-sum test for continuous or ordinal variables. Comparisons of hemodynamic variables for pre-extubation and post-extubation values were performed within the extubation failure and extubation success groups using the Wilcoxon matched pairs signed-rank test. A Bonferroni correction was applied to correct for the two-subgroup comparisons per variable. Analyses were performed using STATA/ MP, Version 11.1 software (Stata® Corp LP, College Station, Texas), and Harrell's RMS package in R (Available from biostat.mc.vanderbilt.edu/rms).

RESULTS:

During the study period, 164 patients qualified for inclusion in the study. The median age of patients at surgery was 200 days (98 days, 356 days) and median weight of patients was 6.8 kg (5.2 kg, 8.5 kg). 6% (10/164) of the patients were intubated prior to surgery. **Extubation failure**

1 requiring reintubation occurred in 7% (12/164) of all subjects. No patients in our study received
2 non-invasive ventilation after extubation. Median duration of mechanical ventilation was 33
3 hours (19.5 hours, 73 hours), and the median hospital length of stay was 10 days (7 days, 15
4 days). 99 patients in our study had TOF with pulmonary stenosis (TOF/PS), 34 had TOF with
5 pulmonary atresia (TOF/PA), and 31 had TOF with non-confluent pulmonary arteries. Neonatal
6 repair was performed in 12 patients with 10 patients (6.5%) in the extubation success group and
7 2 patients (16%) in the extubation failure group ($p=0.196$).

8
9 The risk factors and timing of extubation failure is shown in **Table 1**. Of the 12 patients
10 with extubation failure, two patients had extubation failure in first two hours after extubation, six
11 patients in 2-24 hour period, three patients in 24-48 hour period, and one patient in 48-96 hour
12 period. Nine patients with failed extubation were extubated in the second attempt with median
13 duration of mechanical ventilation of 2.5 days (1 day, 7 days). One patient with extubation
14 failure required diaphragmatic plication prior to successful extubation and two patients needed
15 tracheostomy after two failed extubation attempts.

16
17 **Table 2** demonstrates baseline characteristics and outcomes for patients in our study. The
18 patients in both groups were similar in age, sex and body weight at the time of surgery. All pre-
19 existing conditions were also similar in two groups. The duration of inotropes and duration of
20 mechanical ventilation was similar in two groups prior to extubation. The duration of hospital
21 stay was higher in children with extubation failure ($p<0.001$). **Table 3** demonstrates
22 intraoperative, peri-extubation variables and post-extubation complications for the study patients.
23 There were no differences in intraoperative variables, post-operative complications between the
24 two groups. The mean cardiopulmonary bypass time for patients in our cohort was 131 ± 37
25 minutes with mean cross-clamp time of 73 ± 25 minutes. 5 patients arrived in CVICU from
26 operating room with open chest and 11 patients required inhaled nitric oxide in the post-
27 operative period. 9 patients had chylothorax prior to extubation while 3 patients had evidence of
28 diaphragmatic paralysis prior to extubation. 22 patients required use of temporary pacemaker
29 prior to extubation. 94 patients had atelectasis on chest radiograph prior to extubation, 19
30 patients had pulmonary edema and 25 patients had pleural effusion on chest radiograph prior to
31 extubation.

Table 4 demonstrates changes in cardiopulmonary parameters and tissue oxygenation using near infrared spectroscopy (NIRS) following conversion of positive pressure ventilation (PPV) to spontaneous breathing. We compared these variables among extubation failure and extubation success groups both prior to and after extubation. Among the patients with extubation failure, there was an increase in PaCO₂ (partial pressure of carbon dioxide in arterial blood) with decline in NIRS (near-infrared spectroscopy) after extubation. However, these patients did not need have significant decline in oxygen saturations or partial pressure of oxygen in arterial blood (PaO₂) after extubation failure. In the group with extubation success, the PaO₂ improved significantly on conversion from PPV to spontaneous ventilation. In this group there was a significant improvement in heart rate, mean arterial blood pressure and inotrope score after removal of positive pressure ventilation. Inotrope score decreased in this group after extubation. We also compared the changes in cardio-pulmonary variables in the peri-extubation period between extubation failure and extubation success groups. **Figures 1, 2, 3 and 4** demonstrate changes in central venous pressures, NIRS, PaCO₂ and PaO₂ in extubation failure group and extubation success group prior to and after extubation.

DISCUSSION:

This study investigates prevalence, etiology and outcomes of extubation failure in children undergoing complete repair of tetralogy of fallot. The incidence of extubation failure was low (7%) and etiology diverse. Extubation failure in this study was associated with increased hospital length of stay. Majority of extubation failures in this select patient population occurred in the first 24 hours. There was a significant change in cardio-respiratory parameters in these patients after conversion from positive pressure ventilation to spontaneous breathing. There was a significant improvement in partial pressure of oxygen in arterial blood (PaO₂), heart rate, mean arterial pressure, and inotrope score in children with extubation success after conversion from positive pressure ventilation to spontaneous breathing.

The results from this study are in contrast to two other studies done by our group in homogenous patient population after cardiac surgery [13,14]. Extubation failure in patients undergoing Norwood operation was high (22%) and was much slower with 43% (6/14) of

extubation failure occurring in 24-96 hours period of extubation [13]. In patients with shunt dependent pulmonary blood flow and univentricular physiology, incidence of extubation failure was high (27%) [14]. However, majority (80%) of the patients failed extubation in the first 24 hours (12/15) after extubation. In existing literature, successful early extubation after surgical repair of tetralogy of fallot has been demonstrated in two studies. In their study of 11 patients, Shekerdemian et al demonstrated successful extubation within 12 hours of surgery for tetralogy of fallot (with a median duration of mechanical ventilation of 2.5 hours) [15]. In another study, Karthekeyan et al demonstrated successful extubation in 56 patients (73%) within 4 hours and the remaining 20 patients (26%) after 4 hours [16]. It is unclear from both these studies if early extubation was associated with higher rates of reintubation and higher rates of complications. Although the median duration of mechanical ventilation was longer (~ 33 hours) in our study was longer (~ 33 hours) as compared to these studies, the rate of reintubation was very low (7%).

It has been proposed that cardiac output in patients after TOF repair can be augmented by conversion of positive pressure ventilation to either negative pressure ventilation or spontaneous breathing [1,2,17]. The diastolic pulmonary arterial flow is sensitive to changes in intrathoracic pressure. This is due to restrictive right ventricular physiology affecting cardiac output. In a landmark study, Shekerdemian et al demonstrated increase in pulmonary blood flow after application of negative pressure ventilation in children after repair for TOF [1]. They further demonstrated delayed but greater response of negative pressure ventilation in children with restrictive physiology than non-restrictive physiology (84% versus 50%) [1]. In another study, Bronicki et al demonstrated improvement in arterial blood pressure and cerebral oxygenation following conversion from positive pressure ventilation to spontaneous negative pressure respiration [2]. Due to limited data availability, our study is lacking data on right ventricular (RV) diastolic dysfunction. However, our study includes data on CVP that can be used as a surrogate marker of RV diastolic dysfunction. There was no difference in CVP between the two groups both prior to and after extubation. Our study also lacked data on open patent foramen ovale (PFO) after surgery for TOF.

In our study, there was an increase in mean arterial blood pressure with a decrease in inotrope score in children with extubation success on conversion of PPV to spontaneous

breathing. This trend was lacking in children with extubation failure. Similarly, children with extubation success had an improvement in tachycardia after removal of PPV that was lacking in the group with extubation failure. There was an increase in PaO₂ in the group with extubation success after removal of PPV. This trend of improvement in PaO₂ was missing in children with extubation failure. Cerebral NIRS in our study did not change after removal of PPV in children with extubation success. This may be due to the fact that brain was in oxygen supply independent state during PPV in these patients. This is in sharp contrast to significant improvement in cerebral NIRS after removal of PPV in children with extubation failure. This may be due to the fact that in this group of patients there was cerebral vasodilation due to CO₂ retention leading to increased NIRS. Our results for cerebral NIRS in the group with extubation success are in contrast to the results proposed by Bronicki et al that demonstrated improvement in cerebral NIRS after removal of PPV in these children. The central venous pressures in our study remained unchanged after removal of positive pressure ventilation. This finding was similar to findings from Bronicki and colleagues where right atrial pressures did not change after extubation [17].

Optimal timing of extubation in children after cardiac surgery is based on clinical evaluation of patient's ability to sustain spontaneous breathing without eliciting significant sympathetic response. Successful weaning from positive pressure ventilation depends on the presence of adequate cardiovascular function, satisfactory ventilatory reserves, and favorable pulmonary mechanics including functioning diaphragms. Removal of positive pressure ventilation may dramatically worsen ongoing low cardiac output state and precipitate sudden cardiac arrest [18]. Furthermore, extubation related stress response causes massive catecholamine surge that can initiate life-threatening arrhythmias, or precipitate a pulmonary hypertensive crisis, thereby leading to sudden cardiovascular collapse [19].

Our study has several limitations. This single center study generated results may be unique to our institution and not be generalizable to all centers. The retrospective nature of the study renders it susceptible to study design flaws and bias. We did not consider the role of weaning difficulties from mechanical ventilator in the group with failed extubation. The numbers of patients with extubation failure was small, which limits our capability to precisely identify the

predictors for extubation failure. To study the effect of extubation on hemodynamics we had to rely on indirect markers of cardiac output such as mean arterial pressure, heart rate, oxygen saturation, near infra-red spectroscopy and lactate levels. It may therefore be prudent in future studies to have a direct measurement of cardiac output in these patients. **Our study also lacked data on factors of fluid overload at the time of reintubation. These factors include body weight and serum bicarbonate and the difference from their respective baseline values that may also contribute to increased incidence of extubation failure.** The predictors for extubation success should be rigorously evaluated in future, prospective, multi-center trials.

In conclusion, this study demonstrates that extubation failure in patients after complete repair for tetralogy of fallot is low and etiology is diverse. Majority of extubation failures in this select patient population occurs in the first 24 hours. Extubation success in children after repair for TOF is associated with improvement in PaO₂, tachycardia and mean arterial pressure with decrease in inotrope score. Extubation failure in these patients is associated with increased hospital length of stay.

Figure Legends:

Figure 1. Comparative effects of extubation success and extubation failure on central venous pressures in study patients.

Figure 2. Comparative effects of extubation success and extubation failure on near infrared spectroscopy (NIRS) in study patients.

Figure 3. Comparative effects of extubation success and extubation failure on PaCO₂ (partial pressure of carbon dioxide in arterial blood) in study patients.

Figure 4. Comparative effects of extubation success and extubation failure on PaO₂ (partial pressure of oxygen in arterial blood) in study patients.

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Table 1. Risk factors and timing of extubation failure in the study patients

<i>Etiology</i>	<i>Frequency</i>	<i>Timing of extubation failure</i>
Lung disease	5 (42%)	8 h, 18 h, 22 h, 28 h, 42 h
Cardiac dysfunction	3 (25%)	1 h, 4 h, 6 h
Airway edema	2 (17%)	2 h, 8 h
Diaphragmatic paralysis	1 (8%)	32 h
Vocal cord paralysis	1 (8%)	70 h

Table 2. Baseline characteristics' and outcomes of patients undergoing repair for tetralogy of fallot

	Extubation success (N= 152)	Extubation failure (N= 12)	P-value
Age at admit (days)	199.0 (100.0, 352.8)	168.5 (31.5, 300.8)	0.49
Age at surgery (days)	200.0 (102.0, 356.5)	177.0 (60.5, 321.2)	0.57
Male	60% (91)	67% (8)	0.64
Caucasian race	68% (103)	75% (9)	0.60
Premature ($\leq$ 34 weeks)	7% (11)	0% (0)	0.32
Weight (kg)	6.8 (5.4, 8.5)	6.4 (3.4, 8.3)	0.39
Genetic syndrome	20% (30)	42% (5)	0.08
Seizures	3% (4)	8% (1)	0.27
Tracheobronchomalacia	2% (3)	0% (0)	0.62
Reactive Airway disease	1% (2)	8% (1)	0.08
Intubated prior to surgery	5% (8)	17% (2)	0.11
Duration of inotropes (days)	2.0 (1.0, 3.0)	2.5 (1.0, 4.5)	0.26
Duration of mechanical ventilation (hours)	32.0 (19.0, 73.3)	45.8 (25.0, 77.2)	0.37
Duration of hospital stay (days)	9.0 (7.0, 14.0)	26.0 (19.5, 49.5)	<0.001

Continuous variables are summarized by the triplet of quartiles 50th (25th and 75th). Categorical variables are summarized as percent (N). p-values are based on Wilcoxon-Kruskal-Wallis test for continuous and ordinal data, and Pearson or Fisher's exact test for categorical variables.

Table 3. Intraoperative and peri-extubation variables for the study patients

	Extubation success (N= 152)	Extubation failure (N= 12)	P-value
Cardiopulmonary bypass time (min)	128.0 (105.0, 150.2)	138.0 (112.2, 179.5)	0.27
Cross-clamp time	71.5 (52.0, 89.2)	75.5 (61.0, 93.2)	0.43
Inotrope score leaving OR	5.0 (5.0, 10.5)	11.0 (5.0, 13.1)	0.12
Lactate leaving OR	1.6 (1.3, 2.2)	2.2 (1.7, 2.7)	0.12
Use of nitric oxide	6% (9)	17% (2)	0.15
Delayed sternal closure	3% (5)	0% (0)	0.52
Use of ECMO	1% (1)	0% (0)	0.77
Use of prophylactic amiodarone	28% (42)	42% (5)	0.30
Pre-op ECHO, Peak RVOT	84.0 (67.8, 97.2)	71.0 (61.2, 81.8)	0.25
Post-op ECHO, Peak RVOT	15.0 (0.0, 25.0)	18.0 (6.5, 25.0)	0.61
<i>Pre-extubation variables</i>			
White cell count ($10^3/\text{mm}^3$)	10.7 (8.4, 14.3)	11.9 (9.6, 13.2)	0.69
Hematocrit (%)	39.1 (36.1, 43.2)	37.1 (33.9, 41.0)	0.10
Blood Urea Nitrogen (mg/dl)	17.0 (12.0, 23.0)	19.0 (12.3, 30.0)	0.45
Creatinine (mg/dl)	0.4 (0.3, 0.4)	0.5 (0.3, 0.7)	0.11
Atelectasis on CXR	59% (86)	67% (8)	0.58
Pulmonary edema on CXR	12% (18)	8% (1)	0.68
Pleural effusion on CXR	15% (22)	25% (3)	0.35
Use of glucocorticoids	75% (114)	64% (7)	0.40
Use of temporary pacemaker	13% (20)	17% (2)	0.73
Hours on volume support	7.5 (3.0, 19.2)	8.5 (3.5, 23.2)	0.69
Renal failure	3% (4)	8% (1)	0.26
Use of dialysis	2% (3)	0% (0)	0.62
Evidence of Chylothorax	5% (7)	17% (2)	0.07

Diaphragm paralysis	1% (2)	8% (1)	0.08
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Continuous variables are summarized by the triplet of quartiles 50th (25th and 75th). Categorical variables are summarized as percent (N).
p-values are based on Wilcoxon-Kruskal-Wallis test for continuous and ordinal data, and Pearson or Fisher's exact test for categorical variables.

Abbreviations: OR: Operating room; CPB: Cardiopulmonary bypass time; RVOT: right ventricle outflow tract; ECMO: Extracorporeal membrane oxygenation; CXR: Chest X-ray

Table 4. Cardiopulmonary variables on conversion of positive pressure ventilation to spontaneous breathing

	Extubation success (N=152)			Extubation failure (N=12)			Success –vs- failure
	Pre-extubation	Post-extubation	Adjusted p-value	Pre-extubation	Post-extubation	Adjusted p-value	p- value
PaO ₂	111.2 (82.1, 140.1)	136.1 (92.4, 178.2)	<0.0001	106.9 (69.9, 128.3)	95.3 (74.6, 145.3)	0.79	0.88
PaCO ₂	41.8 (38.4, 45.3)	41.3 (38.3, 45.9)	0.99	43.3 (40.7, 48.5)	53.1 (48.7, 55.1)	0.011	0.006
O ₂ saturations	98.7 (97.3, 99.5)	99.0 (97.6, 100.0)	0.06	97.6 (96.4, 99.3)	98.3 (96.3, 99.0)	0.67	0.08
Heart rate (/min)	139.5 (128.5, 151.4)	138.0 (124.3, 148.8)	0.03	145.3 (133.7, 152.9)	147.8 (143.2, 154.2)	0.2	0.31
Mean arterial pressure (mm Hg)	67.2 (62.0, 72.5)	69.4 (65.0, 77.2)	<0.0001	72.7 (65.8, 79.1)	75.6 (65.3, 78.7)	0.99	0.07
Central venous pressure (mm Hg)	11.4 (9.7, 13.2)	11.2 (9.3, 13.2)	0.11	12.3 (10.6, 13.5)	13.3 (10.5, 15.1)	0.24	0.25
Cerebral NIRS	67.3 (58.9, 72.4)	68.2 (61.7, 74.9)	0.47	64.8 (60.9, 68.5)	70.5 (68.6, 76.5)	0.0001	0.01
Inotrope score	7.5 (4.7, 11.3)	7.5 (3.8, 10.4)	<0.0001	8.5 (6.2, 11.3)	9.8 (4.9, 10.6)	0.88	0.38
Lactate (mmol/L)	1.3 (1.0, 1.5)	1.2 (1.0, 1.6)	0.99	1.2 (1.1, 2.2)	1.4 (1.3, 2.2)	0.15	0.005

Continuous variables are summarized by the triplet of quartiles 50th (25th and 75th). Categorical variables are summarized as percent (N). p-values are based on Wilcoxon-Kruskal-Wallis test for continuous and ordinal data, and Pearson or Fisher's exact test for categorical variables.

***Inotrope score:** dosages of dopamine + dobutamine (in µg/kg/min) + [dosages of epinephrine + norepinephrine + isoproterenol (in µg/kg/min)] x 100 + dosages of milrinone (in µg/kg/min) x 15

Abbreviations: PaO_2 : Partial pressure of oxygen in arterial blood; PaCO_2 : Partial pressure of carbon dioxide in arterial blood; FiO_2 : fraction of inspired oxygen in a gas mixture; NIRS: Near infrared spectroscopy

Figure 1.

Figure 2.

Figure 3.

Figure 4.