Original Article

Transesophageal Probe Placement Increases Endotracheal Tube Cuff Pressure but is not Associated with Postoperative Extubation Failure after Congenital Cardiac Surgery

Abstract

Context: The concomitant use of cuffed endotracheal tubes (ETT) and transesophageal echocardiography (TEE) probes increases ETT cuff pressures (CP), which may contribute to mucosal ischemia and perioperative complications such as failed extubation. **Aims:** To assess changes in ETT CP after TEE insertion in patients of different age groups undergoing congenital heart surgery and examine the relationship between ETT CP and postoperative extubation failure. **Settings and Design:** Single-center quality improvement project. **Subjects and Methods:** ETT CP was measured with a manometer following intubation and again after TEE insertion. Tracheal perfusion pressure was then calculated and postoperative extubation failures were recorded. **Statistical Analysis:** Chi-square testing, Fisher's-exact testing, one-way analysis of variance testing or Kruskal–Wallis testing with Dunn's pairwise, and student's *t*-test or Wilcoxon rank-sum testing were used to analyze the data. **Results:** Median ETT CP increased significantly after TEE insertion in each age group, with infants showing a smaller magnitude of increase (+2 [1-6] cm H_2O, $P < 0.001$) than adults (+12 [8-14] cm H_2O, $P = 0.008$) (intergroup comparison $P = 0.002$). Five patients (9%) failed extubation, all of which were infants. Within the infant subgroup, no significant difference existed between failed vs successful extubation regarding ETT CP during bypass (15 ± 1 vs 16 ± 2 mmHg, $P = 0.206$) or tracheal perfusion pressure pre-bypass (34 ± 9 vs 38 ± 11 mmHg, $P = 0.518$), during bypass (20 ± 9 vs 22 ± 6 mmHg, $P = 0.697$), or post-bypass (42 ± 9 vs 41 ± 9 mmHg, $P = 0.923$). There was a significant difference in cardiopulmonary bypass duration (151 ± 29 vs 85 ± 32 min, $P < 0.001$). **Conclusion:** Factors beyond intraoperative ETT CP likely play a larger role in postoperative extubation failure.

Keywords: *Congenital cardiac anesthesia, endotracheal cuff pressure, extubation failure, transesophageal echocardiography*

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Introduction

Congenital heart disease (CHD) is the most common congenital defect in newborns affecting approximately 8 per 1,000 live births.[1] Nearly 25% will have critical CHD and require cardiac surgery within their first year of life.[2] Cuffed endotracheal tubes (ETT) and transoesophageal echocardiography (TEE) have become standard practices in congenital cardiac surgery.[3,4] Although inflating the ETT cuff has been shown to reduce mucosal blood flow in animal studies,[5,6] many clinical studies have failed to definitively demonstrate increased airway complications between cuffed versus uncuffed ETTs in humans undergoing surgery.[7]

Adult studies have shown that TEE probe placement significantly increases ETT cuff pressure (CP).[8,9] Similar findings have been observed in children during esophagogastroduodenoscopy and TEE probe insertion.[10,11] Given that neonates and infants are often perfused at a lower blood pressure than adults during cardiopulmonary bypass (CPB) for cardiac surgery, increases in CP from the TEE probe could result in significantly diminished tracheal perfusion. However, the effect of this on postoperative airway complications remains unclear. Because children undergoing cardiac surgery have high extubation failure rates in pediatric intensive care units, which then lead to longer lengths of hospitalization,[12] it is imperative to continue to investigate contributing factors in order to continue to improve outcomes. Currently, our cardiac intensive care unit has an approximate 10% extubation failure rate.

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Thus, the primary objective of this quality improvement project was to objectively monitor changes in ETT CP after TEE insertion in patients of different age groups undergoing congenital cardiac surgery with CPB to ensure high CP would be avoided. Second, we followed patients postoperatively to examine if intraoperative tracheal perfusion pressure (assumed to be the mean arterial pressure minus the ETT CP) was associated with postoperative extubation failure and if by checking and resetting the CP, we could reduce the extubation failure rate of our cardiac ICU.

Subjects and Methods

Context

This was a quality improvement project that occurred at a single institution. This project was approved by the institution's Quality Improvement Review Committee and as a quality improvement project, patient consent was waived. All data were obtained during a single perioperative encounter. All patients regardless of age, who underwent cardiac surgery with CPB and intraoperative TEE were included. Patients with preexisting tracheal or esophageal pathology that precluded the use of TEE could not be included. Our aim was to determine if objective CP measurement would result in reduced postoperative extubation failure. Additional outcome measures included measuring the change in ETT CP after insertion of the TEE probe and to also examine the relationship between tracheal perfusion pressure and postoperative extubation failure. This manuscript adheres to the Standards for QUality Improvement Reporting Excellence (SQUIRE) guidelines for reporting quality improvement projects.

Intervention

After anesthetic induction, patients were intubated with a cuffed ETT (Mallinckrodt Pharmaceuticals, Staines-Upon Thames, United Kingdom). The ETT cuffs were then inflated to a point where there was a cessation of air leak. For those without an audible air leak with the ETT cuff down, ETTs were exchanged for an ETT one half-size smaller. The ETT CP was then measured using a Posey Cufflator™ ETT Inflator and Manometer (JT Posey Company, Arcadia, CA, USA).

Study of the intervention and measures

The initial post-intubation ETT CP was recorded and then reset between 20 and 25 cm H_2O for pressures exceeding that range. Next, the CP was remeasured after TEE probe insertion (resting with the probe tip in the stomach) and the change in pressure recorded. Any pressures exceeding 25 cm H_2O were again reset to be between 20 and 25 cm H_2O (these pressures were considered to be the ETT CP during CPB). For any patient remaining intubated postoperatively, the CP was measured at the end of the operation and reset to be no greater than 20–25 cm H_2O just prior to transport and admission to the intensive care unit.

Demographic variables included age, sex, weight, and body surface area. Preexisting airway abnormalities and the number of intubations attempts were documented. Patients were grouped based on the National Institute of Child Health and Human Development suggestions for pediatric trials: Infants (inclusive of neonates up through 12 months), young children (inclusive of toddlers and early childhood, 1–5 years old), middle childhood (6–11 years old), adolescents (12–18 years old), and adults (>18 years old).[13]

Additional intraoperative covariables recorded include the duration of CPB, use of deep hypothermic circulatory arrest, and extracorporeal membrane oxygenation, mean arterial blood pressure, hemoglobin, arterial oxygen partial pressure, and saturation, and whether the patients were extubated immediately in the operating room prior to intensive care unit admission.

An estimate of tracheal perfusion pressure was calculated by subtracting the ETT CP (after conversion from cm H_2O to mmHg using the formula: 1.36 cm H_2O = 1 mm Hg) from the average mean arterial pressure for three intraoperative time intervals: pre-bypass, during CPB, and post-bypass. Additionally, the arterial oxygen content (CaO_2) was calculated for the same intraoperative time intervals utilizing each patient's average hemoglobin, arterial oxygen partial pressure (PaO_2), and oxygen saturation (SaO_2) using the equation:

$$CaO_2 = (1.36 \times \text{hemoglobin (g/dL)} \times \text{arterial oxygen saturation}) + (PaO_2 \times 0.003)$$

Patients were followed up during their initial postoperative intensive care unit stay. All postoperative extubation failures were recorded. Extubation failure events that occurred after the patient was transferred to the ward following their initial intensive care unit admission were not considered given that these events were far removed from the effects of intraoperative events.

Analysis

All data were recorded as count with percentage, mean with standard deviation, or median with interquartile range for non-normally distributed data. The normality of data was assessed using Shapiro–Wilk testing and histograms. No data were transformed. Chi-square testing was used to examine differences in categorical variables with Fisher's exact testing used when appropriate. Multigroup continuous variable differences were analyzed using one-way analysis of variance testing or Kruskal–Wallis testing with Dunn's pairwise comparisons for non-normally distributed data. Bonferroni adjustment of the *P* value was made for all *post hoc* pairwise comparisons. Student's *t*-test or Wilcoxon rank-sum testing were used for pairwise comparison analysis. Statistical analysis was completed using Stata/SE™ 14.2 (StataCorp, College Station, TX, USA).

Results

Initially, we found that a small amount of air would leak from the ETT cuff with each manometer measurement, especially in the neonates and infants. This resulted in the need for multiple measurements and multiple adjustments of the ETT CP. However, we quickly observed that by leaving the manometer attached to the ETT pilot balloon, as opposed to removing after each measurement, the air leak was eliminated.

A total of 58 patients were included [Table 1]. Initial post-intubation ETT CPs were significantly different between the five age groups with infant initial pressures being significantly lower than all other age groups [Table 2]. There were also significant differences in the proportion of patients with initial CP ≥30 cm H_2O between the five age groups [Figure 1a]. After insertion of the TEE probe, all age groups experienced a significant increase in ETT CP (within-group change-in-pressure *P* value listed within the table cell), however, the magnitude of the ETT CP increase was significantly smaller for the infants when compared against the increase in the adolescents and adults [Table 2]. Similar to the initial ETT CP assessments, there were significant differences in the proportion of patients within each age group who experienced an increase in pressure to ≥30 cm H_2O after TEE probe insertion [Figure 1b].

Table 1: Patient characteristics for each of the five age groups

	Infants *n*=22	Young children *n*=11	Older children *n*=9	Adolescents *n*=7	Adults *n*=9
Age, years*	29 (7-102)*	3.9 (2.7-4.9)	8.4 (6.9-9.4)	15.1 (13.3-15.4)	24.6 (18.9-33.6)
Male, *n* (%)	13 (59%)	8 (73%)	3 (33%)	7 (100%)	4 (44%)
Weight, kg	3.5 (3.2-4.9)	13.2 (11-18.3)	26.3 (22.8-31.4)	58.6 (47.5-7.5)	69.6 (66.4-76.6)
Body surface area, m^2	0.22 (0.2-0.27)	0.57 (0.51-0.75)	0.97 (0.87-1.08)	1.67 (1.45-1.9)	1.77 (1.7-1.85)
>1 intubation attempt, *n* (%)	0 (0%)	0 (0%)	0 (0%)	1 (14%)	3 (33%)
ETT size, mm	3.5 (3-3.5)	4.5 (4-4.5)	5.5 (5-6)	7 (6.5-7.5)	7.5 (7-7.5)
Pre-existing airway abnormality, *n* (%)	1 (5%)	0 (0%)	0 (0%)	1 (14%)	0 (0%)

Data presented as count with percentage or median with interquartile range. Infants = <1 year old, young children=1-5 years old; older children=6-11 years old; adolescents=12-17 years old; adults = ≥18 years old. *Age presented in days for infant age group

Table 2: Endotracheal tube cuff pressure comparisons among age groups

	Infants *n*=22	Young children *n*=11	Older children *n*=9	Adolescents *n*=7	Adults *n*=9	*P*
Initial CP	12 (10-20)	24 (18-30)	30 (26-30)	43 (29-70)	30 (23-42)	<0.001*
Reset CP	22±2	24±3	25±2	21±2	23±3	0.014**
CP with TEE probe	24 (22-29)	27 (24-31)	30 (28-32)	34 (26-40)	36 (32-38)	0.003†
Change in CP∮	2 (1-6), *P*<0.001	4 (2-7), *P*=0.004	6 (3-8), *P*=0.008	14 (6-18), *P*=0.027	12 (8-14), *P*=0.008	<0.001‡

Data presented as mean with standard deviation or median with interquartile range. Infants = <1 year old, young children=1-5 years old; older children=6-11 years old; adolescents=12-17 years old; adults = ≥18 years old. CP: Cuff pressure; TEE: Transesophageal echocardiography. *Infant cuff pressures significantly lower than young children (*P*=0.018), older children (*P*=0.001), adolescents (*P*<0.001), and adults (*P*=0.001). **Infant reset cuff pressures significantly lower than older children (*P*=0.028). †Infant TEE pressures significantly lower than older children (*P*=0.048), adolescents (*P*=0.02) and adults (*P*=0.002). ‡Infant change in cuff pressures significantly lower than adolescent (*P*=0.007) and adults (*P*=0.002). ∮*P*-values for the intragroup change in cuff pressure derived via Wilcoxon signed-rank test

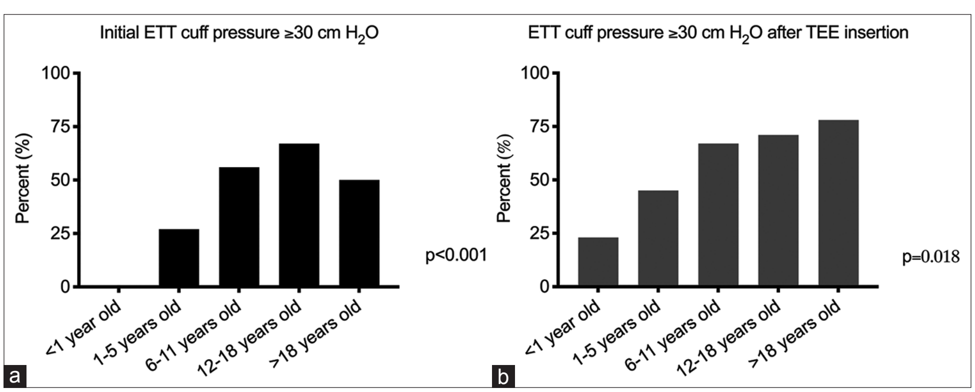

Figure 1: Proportion of patients with endotracheal tube (ETT) cuff pressures ≥30 cm H_2O. (a) Immediately after intubation. Cuff pressures were then adjusted to be between 20–25 cm H_2O prior to transesophageal (TEE) probe insertion. (b) After insertion of the TEE probe

Five of the 58 patients studied (9%) failed extubation postoperatively, which was not substantially different than our historic observation of 10% extubation failures. All five of the extubation failure patients were infants. Considering there were 22 infants included (thus 5/22, or 25% of infants experienced extubation failure), we elected to only examine the infant subgroup regarding factors associated with extubation failure [characteristics presented in Supplemental Table 1]. Only CPB duration was significantly different between the failed versus successful extubation infants, with those failing extubation having nearly twice as long of a bypass duration [Table 3]. Three of the five (60%) extubation failure infants had an ETT *in situ* at the time of their operation as compared to only 2/17 (12%) of the infants without extubation failure (P = 0.055) [Table 3]. All other infants were successfully intubated on the first attempt. Tracheal perfusion pressure and CaO_2 did not differ between the two groups in any of the three intraoperative time intervals [Table 3]. Given the sample size of our infant age group, we were 80% powered to detect a 15 mmHg difference in tracheal perfusion pressure for each of the three intraoperative time intervals (pre-, during, and post-CPB) at an alpha error = 0.05 (logistic regression models for extubation failure for the entire sample with all variables in Table 3 adjusted for age presented in Supplemental Table 2]. Characteristics of each of the extubation failure infants are presented in Table 4.

Discussion

Summary

We observed a statistically significant increase in ETT CP after TEE probe insertion among all age groups, which is consistent with prior studies. Overall, 9% failed extubation, which was similar to our historic outcomes. Infants experienced the smallest magnitude increase in CP with less than 25% experiencing increases to ≥30 cm H_2O, which is possibly explained by the high compliance of the newborn's trachea.[14]

Interpretation

Of the five infant extubation failures, none appeared to be correlated with ETT CP, tracheal perfusion pressure, or CaO_2. A focused chart review of each of the five postoperative courses revealed that each extubation failure was complicated by a pulmonary and/or cardiac pathologies such as pleural effusion, pneumonia, mucus plugging, hemidiaphragm paralysis, and pericardial effusion as per intensive care unit documentation [Table 4]. Also, a higher proportion of infants with extubation failure had been intubated preoperatively, which may suggest further evaluation of the cumulative duration of intubation and/or requirement for mechanical ventilation preoperatively for infants at risk for postoperative extubation failure are warranted. Additionally, these infants with longer CPB times may have had relatively more complex lesions and

Table 3: Characteristics of infants with postoperative extubation failure compared to infants with successful extubation

	Extubation failure *n*=5	Successful extubation *n*=17	*P*
Age, days	9 (7-25)	42 (9-102)	0.504
Male, *n*	3 (60)	10 (59)	>0.999
Weight, kg	3.2 (3.1-3.3)	3.6 (3.2-5.1)	0.158
BSA, m^2	0.2 (0.2-0.22)	0.23 (0.21-0.28)	0.254
Preexisting ETT, *n*	3 (60)	2 (12)	0.055
CPB, min	151±29	85±32	<0.001
DHCA, *n*	3 (60)	4 (24)	0.274
ECMO, *n*	0 (0)	2 (12)	>0.999
Immediately extubated, *n*	0 (0)	5 (31)	0.278
Otolaryngology consult, *n*	4 (80)	1 (6)	0.003
Tracheostomy, *n*	1 (20)	0 (0)	0.227
CPB ETT CP, cm H_2O	20±1	22±3	0.206
MAP pre-bypass, mmHg	49±8	54±10	0.337
MAP bypass, mmHg	35±9	38±5	0.409
MAP post-bypass, mmHg	57±8	58±9	0.864
TPP pre-bypass, mmHg	34±9	38±11	0.518
TPP bypass, mmHg	20±9	22±6	0.697
TPP post-bypass, mmHg	42±9	41±9	0.923
CaO_2 pre-bypass, mL O_2/dL	17.3±1.4	14±3.3	0.054
CaO_2 bypass, mL O_2/dL	16.6±1.1	15.6±1.8	0.252
CaO_2 post-bypass, mL O_2/dL	14.8±3.5	16±1.9	0.309

Data presented as count with percentage, mean with standard deviation, or median with interquartile range. BSA: Body surface area; CPB: Cardiopulmonary bypass; DHCA: Deep hypothermic circulatory arrest; ECMO: Extracorporeal membrane oxygenation; CPB: Cardiopulmonary bypass; ETT: Endotracheal tube; CP: Cuff pressure; MAP: Mean arterial blood pressure; TPP: Estimated tracheal perfusion pressure; CaO_2: Arterial oxygen content

Table 4: Characteristics of infants who failed extubation postoperatively

Infant	Age at surgery	Gender	Underlying congenital heart defect	Surgery	Cause for extubation failure
1	5 months	Female	Severe RVOT obstruction, MPA hypoplasia, branch PA stenosis	Main right and left PA augmentation and RVOT obstruction repair	Loculated right pleural effusion, complicated by rhinovirus and enterococcus pneumonia
2	9 days	Male	Aortic atresia, subaortic stenosis, aortic arch hypoplasia with coarctation, and posterior malaligned VSD	Yasui procedure (with RV to PA homograft conduit), VSD enlargement, primary closure of ASD, aortic arch augmentation	Complete heart block and mucus plugging in the right upper lobe
3	3 weeks	Male	DiGeorge syndrome, truncus arteriosus, and tetralogy of Fallot with pulmonary atresia and MAPCAs	Central unifocalization of MAPCAs and placement of an RV to PA conduit	Left hemidiaphragm paralysis
4	7 days	Female	Hypoplastic left heart syndrome	Norwood, Sano shunt, atrial septectomy, and patent ductus arteriosus ligation	Large pericardial effusion
5	7 days	Male	Double inlet left ventricle, double outlet right ventricle, hypoplastic right ventricle, VSD, interrupted aortic arch	Norwood, BT shunt, repair interrupted arch, atrial septectomy	Mediastinal hemorrhage

RVOT: Right ventricular outflow tract; MPA: Main pulmonary artery; PA: Pulmonary artery; VSD: Ventricular septal defect; RV: Right ventricle; ASD: Atrial septal defect; MAPCA: Major aortopulmonary collateral arteries; BT: Blalock-Taussig

therefore may have been more technically challenging to repair from a surgical perspective. These longer bypass times may have resulted in prolonged exposure to the systemic inflammation associated with CPB,[15] perhaps affecting airway/respiratory physiology. The optimal tracheal perfusion pressure during CPB is unknown. While it has been suggested that tracheal capillary perfusion may be occluded at CPs of 25–30 cm H_2O in adults,[16,17] similar studies in neonates and infants are lacking and therefore we cannot be sure what the "safe" ETT CP is in these age groups. Until these threshold pressures are determined, CP measurements may be a poor surrogate for the evaluation of the anatomic and physiologic causes that lead to extubation failure in infants undergoing congenital cardiac surgery with CPB.

Our observations contradict a recent study by Shinkawa *et al.* who did not find a relationship between CPB time and extubation failure following pediatric cardiac surgery.[18] Additionally, evidence from Kamata *et al.* showed that the increases in CP following TEE insertion are transient with the CP returning to values similar to those at baseline when the tip of the TEE probe was advanced into the stomach at the completion of the TEE examination.[11] However, our observations somewhat differed in that the elevated CP we measured were observed while the probe tip was in the stomach. Our data suggest that the presence of the probe within the esophagus, regardless of the tip location, may still cause an increased CP. Thus, it remains inconclusive whether the CP changes recorded with TEE insertion/removal are temporary and/or insignificant, which may help to explain the lack of correlation we observed between tracheal perfusion and extubation failures. Given that many of the studies regarding postoperative extubation failure are from an overall pediatric intensive care unit population with recognition of post-cardiac surgery as a risk factor, more studies aimed at investigating extubation failure specifically in the CHD population are warranted. This population is particularly fragile to the effects of hypercarbia and hypoxia and often undergo extreme operative conditions making them highly vulnerable and highlighting the need for focused studies.

Overall, failed extubation and tracheostomy occur at a rate of 6–13% and 0.2%, respectively, after CHD surgery,[12] and therefore all efforts for optimizing conditions conducive to successful extubation should be implemented at every stage of each patient's perioperative course. Additional studies are warranted to examine intraoperative nonsurgical factors that may contribute to postoperative extubation failure so that management strategies can be optimized to improve postoperative extubation success.

Limitations

Our project was limited by a presumption that ETT CP remained constant throughout each operation. Kako *et al.* revealed a drop in ETT CP during hypothermia with a return to baseline pressure with rewarming such that it is likely that when blood pressure is lower during CPB, the ETT CP is lower and therefore tracheal perfusion likely remains fairly constant.[19] Thus, we acknowledge that our tracheal perfusion pressures are not a definitive value, but rather an estimation to be used in an attempt to identify trends. Additionally, while the low variation in our ETT CP data allowed us to have sufficient power to detect significant increases in ETT CP with TEE insertion, we were underpowered to detect clinically relevant differences in tracheal perfusion pressure before, during, and after CPB between those infants with postoperative extubation failures versus those without. Given we were powered to detect an effect size of 15 mmHg, we would have needed to observe mean arterial blood pressures 11, 13, and 16 mmHg, respectively, lower in the extubation failure group during the pre-bypass, bypass, and post-bypass phases to yield statistically significant differences. We do note that a higher proportion in the extubation failure group had undergone deep hypothermic arrest but again we were underpowered to detect whether this and its contribution to low tracheal perfusion was significantly associated with postoperative extubation failure.

Conclusion

In conclusion, our objective monitoring of the ETT CP and adjustments to keep the ETT CP within the proposed safe range did not substantially reduce our observed postoperative extubation failure rate. TEE probe placement significantly increased the ETT CP in all age groups, although the magnitude of increase was smaller in infants compared to adolescents and adults. It is unclear what effect, if any, this has on the airway and perioperative extubation complications. It appears that time on CPB affects the likelihood of postoperative extubation failure in infants but further studies on the specific mechanism and role of tracheal ischemia are warranted.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Supplemental Table 1: Characteristics of the 22 patients in the infant subgroup

ID[#]	Sex	Age, days	Weight, kg	BSA, m^2	CHD	Operation	Circ Arrest	POD extubated	Extubation Failure
1017	Male	4	2.82	0.18	d-TGA, PS, VSD	BTS, PA augmentation	No	3	No
1060	Female	4	2.84	0.19	Truncus arteriosus	Repair truncus arteriosus	No	4	No
1062	Female	5	4.2	0.23	HLHS	Norwood	Yes	7	No
1049	Female	7	2.8	0.18	HLHS	Norwood	Yes	6	Yes
1063	Male	7	3.1	0.2	DILV, IAA	Norwood, repair IAA	Yes	6	Yes
1030	Male	7	3.5	0.22	HLHS	Norwood	Yes	6	No
1019	Male	9	3.27	0.2	Aortic atresia, VSD, arch hypoplasia	Yasui procedure	Yes	6	Yes
1051	Male	9	3.33	0.21	HLHS	Norwood	Yes	6	No
1024	Male	9	3.4	0.21	d-TGA	ASO	No	6	No
1040	Male	12	3.2	0.19	Valvar and supravalvar AS	Aortic valvotomy, patch aortoplasty	No	3	No
1042	Male	25	3.2	0.22	TOF, PA, MAPCAs	Unifocalization, RV-PA conduit	No	5	Yes
1027	Female	32	2.79	0.19	ASD, VSD	ASD and VSD closure	No	1	No
1045	Male	42	3.21	0.21	VSD	VSD closure	No	1	No
1021	Male	49	5.12	0.28	TOF	VSD closure, transannular patch	No	2	No
1029	Male	74	5.96	0.3	Hypoplastic aortic arch	Aortic arch augmentation	Yes	1	No
1043	Female	93	4.3	0.25	d-TGA, HRV, arch hypoplasia	Glenn	No	0	No
1031	Female	102	3.64	0.23	VSD	VSD closure	No	0	No
1005	Female	112	4.45	0.26	complete AVSD	repair AVSD	No	0	No
1044	Male	113	6.71	0.33	TOF	VSD closure, transannular patch	No	1	No
1061	Female	171	4.94	0.27	TOF, PA, MAPCAs	unifocalization, BTS	No	4	Yes
1047	Male	239	8.28	0.38	Supravalvar AS	Patch aortoplasty	No	0	No
1013	Female	304	7.94	0.38	ASD	ASD closure	No	0	No

Supplemental Table 2: Logistic regression models for extubation failure for the entire cohort (*n*=58) adjusting for age

	Coefficient	Standard error	*P*
Age, days	-	-	-
Male	−0.187	1.075	0.862
Weight, kg	−0.875	0.731	0.232
BSA, m^2	−18.966	14.598	0.194
Pre-existing ETT	2.275	1.228	0.064
CPB, min	0.071	0.035	0.044
DHCA	1.394	1.13	0.217
ECMO	-	-	-
Immediately extubated	-	-	-
Otolaryngology consult	4.121	1.528	0.007
Tracheostomy	-	-	-
CPB ETT CP, mmHg	−0.822	0.495	0.097
MAP pre-bypass, mmHg	−0.047	0.071	0.508
MAP bypass, mmHg	−0.063	0.093	0.503
MAP post-bypass, mmHg	0.026	0.078	0.744
TPP pre-bypass, mmHg	−0.015	0.062	0.805
TPP bypass, mmHg	−0.01	0.081	0.897
TPP post-bypass, mmHg	0.058	0.079	0.466
CaO_2 pre-bypass, mL O_2/dL	0.337	0.212	0.112
CaO_2 bypass, mL O_2/dL	0.354	0.352	0.314
CaO_2 post-bypass, mL O_2/dL	−0.262	0.228	0.25