Tracheostomy in infants and children after cardiothoracic surgery: Indications, associated risk factors, and timing

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Background: Respiratory insufficiency in children after cardiothoracic surgery delays weaning from the ventilator and prolongs intensive care unit stay. There is little consensus as to the indications for tracheostomy and its safety in this population.

Methods: We reviewed our institutional experience in 37 consecutive infants and children (median age, 8.6 months; weight, 7.2 kg) requiring a tracheostomy after cardiothoracic surgery between January 1998 and December 2001, with follow-up to June 2003.

Results: Twenty-four children underwent tracheostomy after corrective (n = 15) or palliative (n = 9) surgery for congenital heart disease, 8 had undergone thoracic transplantation, and 5 had undergone thoracic surgery. Median duration of pretracheostomy ventilation was 30 days, and median total duration of ventilation was 73 days. Tracheostomy was performed earlier in patients undergoing transplantation (median of 20 days postoperatively), with a duration of ventilation of 34 days. No patient experienced mediastinitis, and a wound infection in 1 child was the only identified complication. Twenty-two children survived to hospital discharge, of whom 15 have since been decannulated; 6 still have a tracheostomy in situ and 1 has been lost to follow-up. A number of preoperative and postoperative factors were identified in this cohort. These were preoperative respiratory insufficiency, a history of neonatal ventilation, the need for cardiac reoperations, diaphragmatic paralysis, tracheobronchomalacia, neurological comorbidity, and associated chromosomal abnormalities.

Conclusion: Tracheostomy can be performed safely and without increased risk of complications in infants and children early after cardiothoracic surgery. The presence of identifiable factors in patients in whom weaning has been unsuccessful should alert clinicians to early consideration of tracheostomy.

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Postoperative respiratory insufficiency and the need for prolonged mechanical ventilation can influence early recovery after pediatric cardiothoracic surgery. Early extubation is safe and feasible in many patients,¹⁻³ but in an important minority this might not be possible. A number of factors have been shown to contribute to delayed weaning from the ventilator. These include the underlying diagnosis, the presence of airway and pulmonary disease, the complexity of the operation, surgical complications, myocardial dysfunction, and residual cardiac lesions.⁴⁻⁶

Prolonged nasotracheal and orotracheal intubation have known complications,⁷⁻¹¹ and tracheostomy represents a valuable alternative if there is a need for prolonged intubation and respiratory support.¹² Tracheostomy provides a stable airway with a reduced risk of pulmonary infection, is usually better tolerated, and therefore can allow more rapid weaning of sedation. Tracheostomy in infants and children has been widely reported in patients with congenital or acquired tracheal

abnormalities¹³ but not in pediatric patients early after cardiothoracic surgery. Early tracheostomy is routinely performed in many intensive care units (ICUs) in ventilated adults after cardiac surgery.^{14,15} However, there is little consensus on the indications and optimal timing of tracheostomy in the pediatric population.

We have reviewed the use of tracheostomy in a single pediatric cardiothoracic unit that undertakes surgical intervention for congenital heart disease, tracheal surgery, thoracic transplantation, and extracorporeal life support. The aim of this review was to identify potential indications and optimal timing and to define risks related to tracheostomy in pediatric cardiac and thoracic surgical patients.

Methods

This is a retrospective review of all infants and children who underwent tracheostomy after cardiac or thoracic surgery at Great Ormond Street Hospital for Children between January 1998 and December 2001. Patients were identified from ICU and cardiothoracic surgical databases. The period of review ended in May 2003.

Patient Characteristics

Patient demographics, diagnoses, any preexisting comorbidities, and the primary (or current) cardiothoracic surgical procedure requiring postoperative ventilation were recorded.

Ventilation

A number of variables were noted. These were mechanical ventilation during the neonatal period, duration of respiratory support (oxygen or ventilator dependency) immediately before the current cardiothoracic surgical procedure, the duration of ventilation before tracheostomy, the duration of ventilation after tracheostomy, and the total interval between tracheostomy and decannulation (or death). The number of attempts at extubation was noted for each patient.

Postoperative Factors (After Primary Operation)

The presence of any of the following postoperative complicating factors was recorded: residual cardiac lesions, the need for any cardiothoracic reoperation (excluding tracheostomy itself), tracheobronchomalacia, diaphragmatic paralysis, chylothorax, persistent lobar collapse, subglottic stenosis, infection, and neurological complications.

Tracheostomy

The indication or indications for tracheostomy, duration of ventilation before tracheostomy, complications of tracheostomy, duration of ventilatory support after tracheostomy, timing of decannulation (failed or successful), and patient outcome (decannulation or death or tracheostomy still in situ) were all recorded.

Statistics

Data were analyzed with a commercially available statistical software package (SAS version 8.2). Descriptive data are expressed as medians (ranges) or as means (standard deviations) for normally distributed data. Group data were compared by using *t* tests,

analysis of variance, and log-rank tests as appropriate. Categorical data were assessed by using cross-classification tables and their corresponding χ^2 or Fisher exact tests. Kaplan-Meier survival curves were created to compare time-to-event rates.

Results

Patient Characteristics

Over a 48-month period, 37 infants and children (21 boys and 16 girls) underwent tracheostomy. This represents 2.7% of all cardiothoracic ICU admissions during this period. The median age at tracheostomy was 259 days (range, 31–6022 days), and the median weight was 7.2 kg (range, 2.38–63 kg). Ten infants were aged 3 months or less at the time of tracheostomy.

Preexisting Risk Factors

Fifteen (41%) patients were ventilated in the neonatal period. Chromosomal abnormalities were present in 12 (32%) of 37. One child (aged 9 years) with chromosome 22q11 microdeletion and scoliosis who underwent pulmonary artery reconstruction late after tetralogy of Fallot repair had previously also required a tracheostomy for a period of 6 weeks at the time of his original repair. Seven patients had significant neurodevelopmental impairment in combination with chromosomal abnormalities (6 children) or an antecedent neurological insult (1 child). One patient with mixed mitral and aortic valve disease had an additional diagnosis of restrictive lung disease.

Primary Operation

In this review we have used the term “primary” operation or procedure to refer to the cardiothoracic operation necessitating the period of postoperative ventilation leading to tracheostomy. Details of primary cardiothoracic surgical procedures are given in Table 1. The broad surgical categories were as follows: surgical intervention for congenital heart disease (24 children), heart transplantation (6 children), bilateral lung transplantation (1 child), heart-lung transplantation (1 child), and thoracic surgery (5 children). Of the patients with congenital heart disease, 15 had undergone biventricular repair, and 9 had undergone palliative surgical procedures: total cavopulmonary correction (2 children) or staged procedure toward corrective intervention (3 children) or single-ventricle palliation (4 children). The thoracic cases consisted of 4 infants undergoing airway operations after previous surgical relief of extrinsic vascular compression and resection of an extensive mediastinal neuroblastoma in 1 child. All patients underwent midline sternotomy for their primary operation, and 35 of 37 required the use of cardiopulmonary bypass.

Five patients undergoing tracheostomy required a period of extracorporeal life support during the perioperative period: 2 children required extracorporeal life support after corrective cardiac surgery, 1 after heart transplantation, 1

TABLE 1. Primary operation, previous cardiothoracic operations, associated procedures, and preexisting pulmonary problems

Primary operation	No.	Associated procedure/existing pulmonary problem (no. of patients)	Previous C-T operation
Transplantation	8		2
Mitral valve surgery	5	Aortic valve repair and restrictive lung disease (1), ECMO cannulation (1)	2
Pulmonary artery banding	5	Coarctation repair (2), hypoplastic lung (1)	1 (rebanding)
Tracheobronchial surgery	4		4
Pulmonary artery surgery	3	Unifocalization (1), previous tracheostomy (1)	1
Fontan operation	2		2
Interrupted aortic arch repair	2	Aortopulmonary window (1), subaortic membrane (1)	
Ventricular septal defect repair	2	Pulmonary artery debanding (1), aortic valve repair (1)	1
Aortic valvotomy	1		
Mediastinal tumor	1		
Norwood procedure	1		
Fallot, primary repair	1		
Arterial switch operation	1	ECMO cannulation (1)	

The primary operation is the operation requiring the current episode of postoperative intubation and ventilation. Details of additional operations performed during the same procedure, important preexisting intrapulmonary pathologies, and whether any patients had undergone previous cardiothoracic operation are also shown. *C-T*, Cardiothoracic; *ECMO*, extracorporeal membrane oxygenation.

before cardiac transplantation, and 1 both before and after heart transplantation.

Pretracheostomy Ventilation

Respiratory insufficiency was present immediately before the primary operation in 26 (70%) of 37 children, of whom 22 were already intubated and ventilated, and the remainder were not intubated but were oxygen dependent. The median total duration of intubation before tracheostomy (including preoperative ventilation) was 30 days (range, 6-91 days),

and the interval between the primary operation and tracheostomy was 27 days (range, 3-114 days).

Pretracheostomy Ventilatory Weaning

Ventilation could not be weaned sufficiently to allow a trial of extubation in 15 patients. In 10 cases extubation had failed on a single occasion, in 9 cases on 2 occasions, and in 3 cases on 3 or more occasions.

Cause of Prolonged Mechanical Ventilation: Postoperative Factors

A number of postoperative factors influenced the ability of the patients to be weaned from mechanical ventilation. For most patients, the reasons for failure to wean were multifactorial (Table 2).

Persistent underlying cardiac insufficiency was present in 25 children. In 11 children a residual cardiac surgical lesion requiring reoperation was identified, and persisting myocardial dysfunction affected 18 children in total. Four patients had myocardial dysfunction and a residual lesion. Tracheobronchomalacia, confirmed on bronchography, was the next most common factor and was present in 18 (49%) of the patients. Diaphragmatic paralysis after cardiac surgery leading to failure to wean from endotracheal intubation affected 13 (35%) infants. Paralysis was unilateral in 7 infants and bilateral in 6 infants. Neurological comorbidity was present in 17 children: 10 had experienced new insults, and 7 had preexisting major neurodevelopmental abnormalities. Three infants had unilateral vocal cord palsy. Persistent chylothorax requiring prolonged intercostal drainage affected 5 children.

TABLE 2. Reasons for prolonged ventilation

Postoperative factor	No. (%)
1 Cardiac	25 (68)
2 Tracheobronchomalacia	18 (49)
3 Unilateral/bilateral DP	13 (35)
4 New CNS event	10 (27)
5 Chylothorax	3 (8)
6 Vocal cord palsy	3 (8)
7 Subglottic stenosis	1 (3)
Cardiac + TBM	4 (10)
Cardiac + DP	6 (16)
Cardiac + CNS event	3 (8)
3 or more of (1-4)	9 (24)

Postoperative factors influencing the ability of patients to be weaned successfully from ventilation are shown. The 4 most common risk factors were cardiac insufficiency, tracheobronchomalacia, diaphragmatic paralysis, and new central nervous system events (1-4). Many patients were affected by more than one of these factors. *DP*, Diaphragmatic paralysis; *CNS*, central nervous system; *TBM*, tracheobronchomalacia.

TABLE 3. Surgical reinterventions in patients with myocardial dysfunction, a residual cardiac surgical lesion, or both

Cardiac problem	No. of patients	Surgical reinterventions (no. of procedures)				
		ECLS	Diaphragm	Cardiac reoperation	Other*	None
Cardiac dysfunction	14	3	3	1	6	5
Residual cardiac lesion	7		3	9		
Dysfunction + lesion	4	1	2	4		1

Surgical reinterventions (excluding tracheostomy) in 25 patients whose recoveries were complicated by myocardial dysfunction, a residual cardiac surgical lesion, or both are shown. ECLS, Extracorporeal life support. *Drainage of pericardial effusion (1), removal of atrial thrombus (1 patient, 2 occasions), pleurectomy-pleurodesis (2), ligation of thoracic duct (1; same patient, separate procedures).

Reoperation

Of the cohort of 37 children, 21 (57%) required cardiopulmonary reoperation (excluding the tracheostomy). Eleven required one or more intracardiac reoperations (not including extracorporeal membrane oxygenation) for residual lesions. Seven children required unilateral diaphragmatic plication (before tracheostomy), 2 underwent additional tracheal operations (for tracheal or bronchial stenosis), and 2 required lobectomy for pulmonary hemorrhage ($n = 1$) and pulmonary venous infarction ($n = 1$). One child with Noonan syndrome and hypertrophic cardiomyopathy who underwent cardiac transplantation in early infancy required 3 thoracic surgical procedures for treatment of persistent chylothoraces (Table 3). Nine children underwent 2 or more cardiac reoperations, thoracic reoperations, or both.

Patients Undergoing Transplantation

Tracheostomy was carried out earlier in the patients undergoing transplantation (median of 19 days [range, 11-51 days] after transplantation). Two children died after cardiac transplantation while still undergoing tracheostomy ventilation, and the remainder were decannulated before hospital discharge. In transplantation survivors the median duration of tracheostomy ventilation was 20 days (range, 5-47 days), and total duration of ventilation was 35 days (range, 20-74 days). The duration of tracheostomy ventilation and the total duration of ventilation were lower for transplant recipients than for patients not undergoing transplantation ($P = .04$, Mann Whitney U test).

Complications of Tracheostomy

One infant with congenital heart disease and bronchomalacia had a local infection at the tracheostomy site, and the tracheostomy was exchanged for a period of nasotracheal ventilation. After the infection had cleared, the tracheostomy was revised without any further complications. There were no other complications, including airway complications directly related to the tracheostomy, in this cohort.

Overall Outcome

At the time of completion of the period of review, 21 children were known still to be alive. Late follow-up data

were not available for 1 patient, an infant from overseas who had undergone palliative surgery for congenital heart disease and had a diagnosis of bronchomalacia. He returned to his country of origin, still ventilated with a tracheostomy.

Decannulation had been attempted in 16 children, and was successful in 15. The median duration of mechanical ventilation after tracheostomy until death or decannulation was 27 days (range, 2-1159 days), and the median total duration of ventilator support (before and after tracheostomy) was 73 days (range, 20-1209 days). The median duration of tracheostomy to decannulation in survivors was 49 days (range, 11-1189 days), and in nonsurvivors it was 59 days (range, 10-220 days).

Prolonged Tracheostomy Ventilation

Preoperative ventilation (before the primary procedure, Figure 1) was associated with a longer period of postoperative pretracheostomy ventilation (43.8 ± 21.2 days vs 24.8 ± 17.45 days for oxygen-dependent but nonintubated children and 20.11 ± 6.43 days for those self-ventilating in air, $P = .0041$). Preoperative respiratory insufficiency ($P = .003$) and tracheobronchomalacia ($P = .026$) were both associated with a longer period of tracheostomy ventilation.

At the end of the follow-up period, 6 children still had a tracheostomy in situ, all of whom had an additional diagnosis of tracheobronchomalacia. In 5 of these children, 1 or more of the following factors were also present: phrenic nerve injury (2 children), neurodevelopmental delay (3 children), and associated chromosomal abnormalities (2 children). A trial of decannulation had failed in 1 child on 2 attempts, and another child underwent tracheal reconstruction but was still tracheostomy dependent at the time of completion of this review. The median duration of tracheostomy in this subgroup was 1497 days (range, 792-1735 days).

Deaths

Fifteen (40.5%) children died during the primary hospital admission. Seven died during the initial ICU admission while still ventilated through the tracheostomy, and 8 died after ICU discharge (6 before and 2 after decannulation). The causes of death were multifactorial (Table 4). In 9

Figure 1. This box plot shows the relation between preoperative respiratory insufficiency and length of pretracheostomy ventilation. Preoperative mechanical ventilation (before the primary procedure) was significantly associated ($P = .0041$) with a longer period of postoperative pretracheostomy ventilation (43.8 ± 21.2 days) when compared with oxygen-dependent but nonintubated children (24.8 ± 17.5 days) and those self-ventilating in air (20.1 ± 6.4 days).

children sepsis, multiorgan dysfunction, or both were ultimately responsible but on a background of persistent myocardial dysfunction (5 patients) and major chromosomal abnormalities (3 patients). Seven of the 11 children who underwent redo cardiac surgery subsequently died, and all children who required both diaphragm plication and 1 or more redo cardiothoracic operations also died. Survival time or time to event was calculated from date of tracheostomy to date of decannulation or death or end of study date. The overall survival was 60.5% at the end of the follow-up period. Kaplan-Meier survival curves were constructed to determine whether there was a statistical difference in survival rates for the following variables: presence of neonatal ventilation, preoperative respiratory insufficiency, tracheobronchomalacia, cardiothoracic reoperation, and transplantation versus no transplantation for the duration of the study. The log-rank test was used to assess the significance, and the survival with time was lower in those requiring cardiothoracic reoperation (Figure 2), but this did not reach statistical significance ($P = .16$) and neither did the rest of the above-mentioned variables.

Discussion

We have shown that tracheostomy can be safely carried out without major complications in small infants and children requiring prolonged ventilatory or airway support after major cardiothoracic surgery through a midline sternotomy. This is the first extensive review of tracheostomy in a cohort of infants and children after cardiothoracic surgery.

Complex cardiothoracic surgery is now possible in the pediatric population, largely because of advances in prenatal diagnosis, neonatal resuscitation, intraoperative techniques, and perioperative intensive care. However, a small proportion of patients require prolonged respiratory support after surgical intervention. As in adults, prolonged nasotracheal or orotracheal intubation in children can compromise patient comfort, feeding, and mobility. Furthermore, the need for continued sedation and the risks of accidental extubation, vocal cord dysfunction, subglottic stenosis, sinusitis, and upper and lower respiratory tract infection can all present important morbidity to this high-risk group. Tracheostomy with or without elimination of dead space ventilation has several potential advantages over nasotracheal and orotracheal intubation: these include reduced work of breathing, improved pulmonary toilet, secure airway control, increased scope for patient mobilization, and facilitated weaning from mechanical ventilation.^{15,16} In addition and of major importance in the infant and younger child, a tracheostomy allows for the assessment of oropharyngeal coordination with a view to establishing oral feeding.

We have identified in this review a number of important potential risk factors for prolonged ventilation, which many of the patients share. Some of these relate to the preoperative status of the child, and others are postoperative factors. Preoperative factors included known chromosomal abnormalities, neurological abnormalities, preoperative respiratory insufficiency, and the requirement for ventilation dur-

TABLE 4. Timing, causes of death, and presence of risk factors in 15 infants and children who died during the primary hospital admission

	Primary operation	Time of death	Cause of death	Reoperation (n)	Diaphragm plication	CNS event	Chromosome	TBM	Myocardial dysfunction	Other factors
1	Tracheobronchial	Early	Sepsis, cardiorespiratory arrest					Y		
2	MV replacement	Late	Multiorgan failure	Y					Y	Critical care neuropathy, ECMO
3	Arterial switch	Early	Multiorgan failure						Y	Chronic lung disease, ECMO
4	MV/AV repair	Late	Respiratory failure							Restrictive lung disease, arrhythmias
5	IAA + AP window	Late	Multiorgan failure	Y			Di George			Sepsis, NEC
6	After heart transplantation	Early	Intracranial bleed			Y				Hyperacute rejection
7	Redo Fontan procedure	Late	Multiorgan failure		Y				Y	LPA stenosis
8	Debanding + repair of septal defects	Early	Intracranial bleed hydrocephalus	Y (2)		Y			Y	
9	Repair PAVSD MAPCAs	Late	Multiorgan failure	Y (2)				Y		
10	MV repair	Late	Multiorgan failure		Y				Y	PLE
11	Heart transplantation	Early	Multiorgan failure	Y (3 thoracic)	Y		Noonan syndrome			Chylothorax
12	Pulmonary valvotomy	Late	Hypoxic encephalopathy			Y				Chronic lung disease, renal failure
13	MV repair	Late	Multiorgan failure	Y	Y				Y	
14	Aortic valvotomy	Early	Multiorgan failure	Y (2)	Y				Y	NEC
15	Norwood procedure for HLHS	Early	Multiorgan failure, CNS infarcts	Y (2)		Y	Sickle cell			

Timing of death is categorized as early, meaning death during the first intensive care unit admission after the primary operation, or late, meaning death after the initial intensive care unit discharge. The presence (Y) or absence (blank) of each of the 6 most common risk factors is given, with details of known syndromes or chromosomal diagnoses. Additional postoperative factors are also listed. Extracorporeal membrane oxygenation cannulation is not included within the reoperation category. CNS, Central nervous system; TBM, tracheobronchomalacia; MV, mitral valve; ECMO, extracorporeal membrane oxygenation; AV, aortic valve; IAA, interrupted aortic arch; AP, aortopulmonary; NEC, necrotizing enterocolitis; LPA, left pulmonary artery; PAVSD, pulmonary atresia with ventricular septal defect; MAPCAs, major aortopulmonary collateral arteries; PLE, protein-losing enteropathy; HLHS, hypoplastic left heart syndrome.

ing the neonatal period. Preoperative mechanical ventilation and the presence of preexisting chromosomal abnormalities, neurological abnormalities, or both are recognized risk factors for prolonged ventilation and increased length of stay in infants and children undergoing cardi thoracic surgery.⁴⁻⁶

The ICU to which all of these patients were admitted has established a policy of detailed cardiopulmonary reassessment of infants and children who could not be weaned from ventilation or in those with recurrent failure to extubate. Many of our patients underwent upper and lower airway

bronchoscopy, dynamic bronchography, and fluoroscopic or ultrasonographic assessment of diaphragm function. In addition, detailed echocardiograms and, where indicated, cardiac catheterizations were performed as part of the cardiovascular evaluation. In the majority of patients, more than one of these diagnostic procedures was performed.

Reinvestigation of these patients revealed a number of associated postoperative conditions that might have contributed to the failure to wean. The most common of these were persistent myocardial dysfunction or an anatomic lesion

Figure 2. This Kaplan-Meier curve shows the survival for the group undergoing cardiothoracic reoperation at the end of the study period, which was lower (50%) compared with that seen in those not undergoing reoperation (82%), but this did not achieve statistical significance ($P = .16$).

requiring cardiac reoperation, tracheobronchomalacia, and phrenic nerve injury. More than half of our patients were affected by one or more of these factors. Tracheobronchomalacia is a well-described phenomenon that can necessitate prolonged ventilation after operations for congenital heart disease,^{4,5,17-20} and this also affected a subgroup of our patients undergoing tracheal operations. Diaphragmatic paralysis can delay recovery in younger patients.^{6,21-24} Despite appropriate surgical reintervention, successful weaning was still not possible in these infants. Furthermore, a significant proportion of this subgroup of patients ultimately died, perhaps suggesting the devastating, unquantifiable, cumulative effects of these factors in high-risk individuals.

Clearly, tracheostomy should only be recommended as a realistic option if one can demonstrate that it is safe and does not present any additional risks to these patients. Tracheostomy insertion was not accompanied by any procedural complications in any of our cohort, and local infection at the site of the tracheostomy only occurred in one small infant. We were particularly encouraged to find that there were no cases of mediastinitis in our group, 5 of whom had recently undergone thoracic transplantation and were receiving immunosuppressive therapy. There is no uniform opinion on the risk of mediastinitis after tracheostomy in adults after midline sternotomy. Some investigators have reported an increased risk of mediastinitis²⁵ after coronary artery surgery, but others have refuted this,²⁶ with some investigators suggesting that this might be due to the increasing use of percutaneous tracheostomy in the ICU.^{27,28} All of the infants and children in our cohort underwent open surgical tracheostomy. Our very low complication rate might reflect the institutional approach to the care of children who have undergone airway operations, including tra-

cheostomy. We have a dedicated multidisciplinary team that includes input and education from tracheostomy nurses and a group of physicians (surgeons, thoracic physicians, and radiologists) who carry out regular reassessments of all of these patients while inpatients and after hospital discharge.²⁹

The optimal timing of tracheostomy after translaryngeal intubation is difficult to define in the pediatric population. For the more homogeneous adult population, a 10- to 14-day threshold has frequently been quoted,¹⁵ and there exist a number of scoring systems that can be used to predict the likely duration of ventilation.³⁰⁻³² Randomized trials are not a realistic option for infants and children, given the relatively small numbers of pediatric cardiothoracic patients who require prolonged ventilation and the huge diversity of underlying diagnoses, indications, and complex contributory factors. A number of variables, including younger age, longer cardiopulmonary bypass time, preoperative mechanical ventilation, premature extubation, the need for reoperation, phrenic nerve injury, and early sepsis have been identified by Kanter and colleagues⁵ and Brown and associates⁶ as important factors associated with prolonged mechanical ventilation after pediatric cardiac surgery. A number of these variables were also encountered frequently in our patients undergoing tracheostomy, reinforcing the importance of identifying risk factors in patients who are unable to be weaned from respiratory support.

Conclusion

Tracheostomy can be carried out safely and without major risk in small infants and children after major cardiothoracic surgery. We have identified a number of important preoperative and postoperative factors that are associated with the

need for prolonged intubation in this cohort. We would suggest that the presence of these variables, even after appropriate intervention, in intubated patients in whom successful weaning has not been possible should alert clinicians to consider tracheostomy early in the postoperative course.

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