Indications for Tracheotomy in the Pediatric Intensive Care Unit Population

A Pilot Study

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Objective: To define the indications for tracheotomy in patients requiring prolonged intubation (>1 week) in the pediatric intensive care unit (PICU).

Design: Retrospective chart review and follow-up telephone survey.

Setting: A tertiary care center PICU.

Outcome Measures: Tracheotomy or extubation.

Patients: All patients older than 30 days in the PICU intubated for longer than 1 week between 1997 and 1999.

Results: During the study, 63 total admissions required intubation for longer than 1 week. A tracheotomy was necessary in 14% of admissions (n=9). The mean length of intubation before the tracheotomy was 424 hours, whereas the mean length of intubation without the need for tracheotomy was 386 hours. Length of intubation, age, and number of intubations did not increase the probability of having a tracheotomy. Of those requiring a tracheotomy, 2 had tracheomalacia, 1 had subglottic edema, 1 had plastic bronchitis, 1 had Down syndrome with apnea resulting in right heart failure, 3 required long-term ventilation after cardiopulmonary collapse, and 1 had mitochondrial cytopathy. Of these 9 children, 7 were successfully decannulated, 1 patient died of underlying disease, and 1 patient remained cannulated secondary to the mitochondrial cytopathy. Twenty families of the patients who did not undergo a tracheotomy were reached by telephone after discharge. Most of the families reported that their children were free of stridor and hoarseness after extubation.

Conclusions: Children tolerate prolonged intubation without laryngeal complications. The consideration for tracheotomy in the PICU setting must be highly individualized for each child.


Historically, tracheotomy was performed in children to treat airway infections. With the advent of antibiotics, contemporary intubation techniques, and critical care management, the need for tracheotomies dropped dramatically. When they are performed today, it is primarily in children who have a fixed airway lesion that obstructs breathing or a neurological impairment that increases the need for ventilatory assistance or pulmonary toilet. Evidence also suggests that a coexistent underlying disease process in children, such as asthma or pulmonary infection, increases the incidence of endotracheal complications and therefore the need for tracheotomy.

However, there are no guidelines that specify when to perform a tracheotomy in critically ill pediatric patients who require prolonged (>1 week) intubation. A search of the English-language literature found no studies that specifically looked at the ability of patients aged between 1 month and 18 years to tolerate prolonged intubation. We also found no such guidelines in contemporary general and pediatric otolaryngology textbooks.

Part of the problem may be that researchers studying the effects of prolonged intubation have focused mainly on neonates and adults. Recent reports suggest that adults can tolerate endotracheal intubation for up to 2 weeks without developing permanent laryngotracheal complications. Newborns can tolerate longer periods of intubation (>50 days) without experiencing adverse effects because the risk for subglottic stenosis is low and influenced by other factors such as underlying systemic disease, low birth weight, and endotracheal tube size.

Because of a lack of guidelines, the decision to perform a tracheotomy is currently based on clinical judgment, which may not always lead to an optimal outcome. We hope that this study will start a dialogue among decision makers at institutions that will better define guidelines for when a tracheotomy should be performed.
Table 1. Admitting Diagnosis and Cause of Death for Patients Who Died While Intubated

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Admitting Diagnosis</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cardiac malformation</td>
<td>Heart failure, sepsis</td>
</tr>
<tr>
<td>2</td>
<td>Cardiomyopathy</td>
<td>Cardiac arrest</td>
</tr>
<tr>
<td>3</td>
<td>Congestive heart failure</td>
<td>Right ventricle/atrium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>thrombus</td>
</tr>
<tr>
<td>4</td>
<td>Cardiomyopathy, heart failure</td>
<td>Pleural effusions</td>
</tr>
<tr>
<td>5</td>
<td>Cardiomyopathy, heart failure</td>
<td>Gastrointestinal tract bleeding</td>
</tr>
<tr>
<td>6</td>
<td>Bronchiolitis, heart defect</td>
<td>Supraventricular tachycardia arrhythmia</td>
</tr>
<tr>
<td>7</td>
<td>Cardiac malformation</td>
<td>Cardiac failure</td>
</tr>
<tr>
<td>8</td>
<td>Respiratory distress, central nervous system malformation</td>
<td>Cerebral ischemia, withdrawal of care</td>
</tr>
<tr>
<td>9</td>
<td>Cardiac malformation</td>
<td>Cardiac failure</td>
</tr>
</tbody>
</table>

Table 2. Reason for Tracheotomy and Time Until Decannulation

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Reason for Tracheotomy</th>
<th>Diagnosis</th>
<th>Duration of Tracheotomy, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Subglottic edema</td>
<td>Peritonitis</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Long-term ventilation</td>
<td>Bronchopulmonary dysplasia</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Tracheomalacia</td>
<td>VATER* complex</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>Obstructive sleep apnea</td>
<td>Down syndrome</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Long-term ventilation</td>
<td>Cardiopulmonary arrest</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Long-term ventilation</td>
<td>End-stage heart failure</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>Plastic bronchitis</td>
<td>Congestive heart disease</td>
<td>19</td>
</tr>
<tr>
<td>8</td>
<td>Long-term ventilation</td>
<td>Mitochondrial cytopathy</td>
<td>3/30/99; patient continues to have tracheotomy</td>
</tr>
<tr>
<td>9</td>
<td>Tracheomalacia</td>
<td>Bronchopulmonary dysplasia</td>
<td>Died of neurological complications (central nervous system malformation)</td>
</tr>
</tbody>
</table>

*VATER indicates vertebral defects, imperforate anus, tracheoesophageal fistula, and radial and renal dysplasia.

formed. To help physicians better understand when a tracheotomy is needed, we describe a series of patients who required sustained prolonged intubation during a stay in a pediatric intensive care unit (PICU) and note if and when tracheotomy became necessary in their care.

METHODS

We reviewed the charts of patients admitted to the PICU at The Cleveland Clinic Children’s Hospital from September 1997 through December 1999. The inclusion date was determined by the inception of detailed record keeping in an institutional PICU registry. This database, which is maintained by the Division of Pediatric Critical Care Medicine, contains information on all PICU admissions, including date of birth, date of admission, diagnosis, duration of ventilatory support, and associated diagnoses.

All patients admitted to the PICU, excluding neonates (<30 days old), who underwent endotracheal intubation for longer than 1 week were included in the present study. Patients who had congenital subglottic stenosis requiring surgery were excluded. There were 9 patients who died while intubated, and Table 1 summarizes the admitting diagnoses and causes of death. These patients were also excluded because our study sought to examine how pediatric patients tolerated prolonged intubation. The remaining patients were then cross-referenced with hospital stay Current Procedural Terminology codes (31600, 31601, and 31610) to determine if a tracheotomy was performed. A chart review was undertaken to determine the long-term outcome of all patients in the study.

A follow-up telephone survey was done for patients who underwent prolonged intubation without tracheotomy. The primary caretakers of these patients were asked whether their children developed hoarseness or stridor after extubation and, if so, how long it took for these symptoms to resolve.

Generalized estimating equations with a logit link were used for all analyses. This is analogous to a standard logistic regression but accounts for the fact that some patients had multiple visits included in the study. This method of analysis was used to test whether the length of intubation (in days), the patient’s age, and the number of intubations increased the probability of undergoing a tracheotomy. For all analyses, P values less than .05 were considered statistically significant. Based on the hypothesis that children are less susceptible to laryngeal complications than adults, days intubated should have no effect on the probability of undergoing a tracheotomy. Version 8 of SAS statistical software (SAS Institute Inc, Cary, NC) was used for the analysis.

RESULTS

A total of 2138 PICU admissions occurred between September 1997 and December 1999. Of the patients older than 1 month, 63 admissions (59 patients) were intubated for more than 7 days. Three admissions involved a single patient, while 2 patients had 2 separate admissions each. On admission, the mean patient age was 51.0 months; the median age was 12.4 months.

A total of 9 patients (14%) underwent a tracheotomy during the study period. The mean age at admission for these patients was 85.6 months; the median age was 23.6 months. Of those patients requiring tracheotomy, 2 had tracheomalacia, 1 had subglottic edema, 1 had a condition of branching bronchial cast formation (plastic bronchitis), 1 had Down syndrome with obstructive sleep apnea resulting in right heart failure, 3 required long-term ventilation after cardiopulmonary collapse, and 1 had mitochondrial cytopathy. Of these 9 children, 7 were subsequently successfully decannulated, 1 patient died of underlying disease, and 1 patient remained cannulated secondary to the mitochondrial cytopathy. Table 2 outlines reasons for tracheotomies and the times until decannulation in months. All patients who did not undergo a tracheotomy were successfully extubated without further otolaryngologic care. Table 3 summarizes the admitting PICU diagnoses for the 54 admissions that did not result in tracheotomy after prolonged intubation. No parents or primary caretakers of children for whom a tracheotomy was recommended refused the procedure. Furthermore, no patient underwent panendoscopy prior to the tracheotomy.
Table 4 details the length of intubation for the patients who underwent tracheotomy and those who did not. Analysis with generalized estimating equations with a logit link function (analogous to logistic regression) provides no evidence that length of intubation is related to the probability of tracheotomy. We estimate that the odds of tracheotomy are 1.01 times as high (95% confidence interval [CI] 0.96-1.07) for each 24-hour period of uninterrupted intubation and 1.04 times as high (95% CI, 0.88-1.23) for each 72-hour period of uninterrupted intubation. Not only is this inadequate evidence to reject the null hypothesis that the odds ratio is equal to 1.0 (P=.64), but our estimate of the odds ratio is very close to 1.0, and the corresponding 95% CI is narrow around 1.0, strongly indicating that intubation time does not affect the need for tracheotomy.

Of the 63 admissions included in the study, 41 were intubated a single time, 18 were intubated twice, and 4 were intubated 3 times each. While we estimate that the odds of tracheotomy are twice as high (2.01 [95% CI, 0.73-5.60]) for each additional intubation, there is insufficient evidence to conclude that the number of intubations for a given patient increases the probability of undergoing a tracheotomy (P=.18). While this result is not statistically significant at the .05 level, the point estimate for the odds ratio is large. A larger sample may be required to more fully understand the possible relationship between duration of intubation and the need to undergo a tracheotomy.

The effect of age was also considered. When simultaneously modeling tracheotomy on age and duration of intubation, we again found no evidence that duration of intubation predicts tracheotomy: the estimated odds of tracheotomy are 1.01 times as high (95% CI, 0.96-1.06) for each day of intubation (P=.77). The estimated odds of tracheotomy increase by 1.05 times (95% CI, 0.98-1.18) for each year of age of the patient (P=.12).

We attempted to contact the primary caretakers of all 50 patients who underwent prolonged intubation without tracheotomy. Of these families, 30 (60%) could not be reached because of a disconnected, changed, or international telephone number or because the caretaker did not respond after 3 calling attempts. Of the 20 (40%) caretakers contacted, 18 reported that their children did not have stridor, and 1 reported stridor that resolved in 1 day. Fifteen caretakers reported no hoarseness after extubation. Four patients were reported to have temporary hoarseness, with one of these cases resolving in 1 day, two in 2 to 3 days, and one in 3 to 4 days. One caretaker was unable to recall if the child had stridor or hoarseness after extubation. None of these children required subsequent otolaryngologic care.

Before a physician decides to perform tracheotomy in the pediatric population, he or she must consider the risk. The general literature cites a tracheotomy-related mortality of 3%. Although one of us1 has reported a 0% tracheotomy-related mortality, we sought in the present study to better define the indications of tracheotomy. Our study examined the relationship between prolonged intubation (>1 week) and the need for tracheotomy in 63 neonatal pediatric admissions. Duration of intubation did not predict the need for tracheotomy. In addition, all patients who survived their critical illnesses without tracheotomy were eventually able to tolerate extubation despite prolonged intubation. Our findings in children are consistent with another observation cited in the literature: hoarseness is the primary complaint in adults after prolonged intubation.6

The decision to perform a tracheotomy in a pediatric patient continues to pose a challenge. It is difficult to predict if and when a child will tolerate extubation or how long the tracheotomy tube must remain in place. In our experience, the indications for tracheotomy in critically ill children who require prolonged ventilation are the same as those for children in general: preexisting fixed airway problems such as tracheomalacia, need for pulmonary toilet, and anticipation of long-term ventilation. Furthermore, our experience suggests that there is a low incidence of laryn-
ginal complications after prolonged intubation. These insights may lead to more defined criteria regarding when to perform a tracheotomy in the pediatric population. The only patient in the present study who remained dependent on the tracheotomy tube had neurodevelopmental delay secondary to mitochondrial cytopathy.

Repeated intubations, with the increased risk of laryngeal trauma, always raise concerns about subsequent need for tracheotomy. Although data on the number of intubation attempts were not available, the number of reintubations that were needed for each patient was recorded in the database. Our findings did not support a relationship between the number of times a child had to be intubated during the course of an illness and the need for tracheotomy.

The present investigation establishes that children between the ages of 1 month and 18 years who require intubation for prolonged periods because of critical illness tolerate the intubation well. Their tolerance of prolonged intubation is more like that of neonates than that of adults. Based on this insight, we conclude that the limit for safe, prolonged, pediatric endotracheal intubation is elastic, perhaps 30 to 60 days. Hence, the consideration for tracheotomy must be highly individualized for each child.

In our experience, a critically ill child is ready for extubation when vital organ systems have stabilized and resumed an adequate level of function and when the child no longer requires ventilatory support. Our data indicate that children experience a low incidence of laryngotracheal complications after prolonged intubation. Thus, there appears to be a finite period of at least 30 days and perhaps as long as 60 days during which the child can be kept safely intubated and allowed to recuperate from the underlying illness. Tracheotomy is considered when the critically ill child has no prospect of achieving ventilatory independence within this interval.

The important question that remains is, “How appropriate is continued intubation between day 30 and day 60?” We do not believe that our results can answer this with a high degree of confidence. Ongoing studies will hopefully narrow this period of uncertainty. Tracheotomy is also considered when a child is unable to protect the airway from oropharyngeal secretions and needs ongoing pulmonary toilet and when the child has a recognized fixed airway lesion resulting in obstruction. These 2 indications are objectively obvious, which facilitates the decision to perform a tracheotomy.

It is often difficult to advise parents about how long their child will need to retain the tracheotomy tube. One of us has reported that the long-term neurological status of the child is the most consistent predictor of ongoing tracheotomy requirement (ie, significant neurological impairment will result in indefinite tracheotomy use). This is true if the child requires ongoing ventilatory support or pulmonary toilet. On the other hand, neurologically intact children do not generally require continued ventilatory support once they have recovered from their underlying illness, nor do they have swallowing dysfunction that results in persistent aspiration necessitating pulmonary toilet. These children will usually have short-term tracheotomies of a few weeks to a few months in duration. Children with fixed obstructive airway lesions that require tracheotomy have a more variable time course depending on their age, the exact nature of their airway disease, and the severity of the obstruction.

The limitations of our study include a small sample of 9 patients who underwent tracheotomy. The sample was large enough, however, to obtain an estimate with high certainty that the odds of tracheotomy did not increase as the number of days intubated increased. Even so, a larger series would be helpful to further refine the indications for tracheotomy in this patient population. Another limitation was our retrospective design, which limited our confidence in the ability of parents or primary caretakers to accurately recollect whether the patient had any stridor or hoarseness.

Our chart review revealed that few children at our institution who had prolonged intubation received a thorough postextubation laryngeal examination. This is consistent with the silence of the literature on this issue and indicates that diagnostic postintubation laryngoscopy is not routinely practiced. It would nevertheless be interesting to have more data on the short- and long-term laryngeal outcomes among these children. A prospective study of postextubation endoscopy might answer these questions.

In conclusion, children, like neonates, tolerate prolonged intubation without experiencing laryngeal complications. This suggests that duration of intubation is not, by itself, an indication for tracheotomy in the PICU. In the present study, factors such as fixed airway problems, the need for pulmonary toilet, and the expectation for long-term ventilation were the primary deciding factors for tracheotomy. The consideration for tracheotomy must be highly individualized in each child.

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REFERENCES