Utility of airway exchange catheters in pediatric patients with a known difficult airway

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Objective: **To evaluate the utility of the Cook airway exchange catheter (CAEC) for extubation/reintubation in pediatric patients with a known difficult airway.**

Design: **Prospective, nonrandomized.**

Setting: **Pediatric intensive care unit; single academic institution.**

Patients: **Twenty intubated children ≤18 yrs of age with a known difficult airway requiring extubation.**

Interventions: **The CAEC was inserted into the trachea before extubation in children with a known difficult airway who were at risk for a difficult reintubation. The CAEC provided a means of a "guided" reintubation while maintaining the ability to provide supplemental oxygenation directly into the trachea.**

Measurements and Main Results: **The respiratory rate, oxygen saturation, and amount of oxygen administered were measured immediately before extubation and at 5-, 15-, 30-, and 60-min intervals thereafter. In addition, the child's ability to tolerate the CAEC was noted and rated (0 = tolerable without difficulty, 1 = tolerable with difficulty, 2 = intolerable). No sedatives were administered in the presence of the CAEC. The duration of the CAEC placement was dependent on the satisfaction of the child's airway patency as determined by the unlikely need for reintubation. Five of the 20 (25%) children who had been extubated were reintubated in the intensive care unit with the assistance of the CAEC. Three of the five (60%) children were reintubated for upper airway obstruction. The ability to provide supplemental oxygen through the CAEC into the trachea during reintubation diminished the potential for hypoxia and maintained the ability to reintubate the trachea using the CAEC as a guidewire to pass an endotracheal tube.**

Conclusions: **In children with a known difficult airway who are at risk for a difficult reintubation, the CAEC is a useful tool for a trial of extubation in the intensive care unit. (Pediatr Crit Care Med 2005; 6:454–456)**

KEY WORDS: extubation; Cook airway exchange catheter; airway devices; tube exchanger; intensive care unit

In the pediatric intensive care unit (PICU), a child with a difficult airway may develop severe respiratory distress early after extubation and require emergent reintubation. In the PICU, such an event may occur in a setting where airway equipment is not as readily available as the operating room and when an experienced airway expert is also not available. The consequences of extubation failure and failure to reintubate in any child, including one with a difficult airway, are hypoxemia, hypercarbia, hemodynamic instability, and potentially death.

The overall incidence of a difficult airway is 1–3% (1), but the incidence in the pediatric population is unknown (2). The extubation failure rate in PICU patients is reported as 2.7–22%. However, the failure rate in pediatric patients with a known difficult airway is not known. Furthermore, the failure rate of pediatric reintubation with or without a difficult airway is also not known. For this reason, some intensivists suggest that after a period of recovery in the PICU, a trial of extubation in a pediatric patient with a difficult airway is more safely performed in the operating room rather than in the PICU. Such cautious preparation can delay a timely extubation and further prolong mechanical ventilation and overall time in the PICU.

One potentially useful method of performing a safe trial of extubation in the PICU is the use of an airway exchange catheter (CAEC; Cook, Bloomington, IN) (3, 4). The CAEC is a small, hollow catheter that can remain in place in the airway allowing for the administration of oxygen via continuous flow. Extubation and subsequent reintubation over a CAEC have been successfully demonstrated in adult ICU patients (3, 5, 6). However, this method of extubation has only been described in a few children (7–9). Thus, the usefulness of inserting the CAEC before extubation in a series of pediatric patients with a known difficult airway has yet to be determined.

MATERIALS AND METHODS

After institutional review board approval, 20 pediatric patients with potentially difficult airways undergoing tracheal extubation were prospectively evaluated. After obtaining informed consent, pediatric patients with at least one risk factor for a difficult tracheal reintubation were sequentially enrolled. Risk factors for difficult tracheal reintubation included difficult intraoperative intubation, airway edema secondary to surgical manipulation or cervical immobility, or instability. A difficult tracheal intubation was defined as the need for multiple attempts at direct laryngoscopy by more than one experienced laryngoscopist or an unsuccessful direct laryngoscopy followed by tracheal intubation using an alternate method (i.e., fiberoptic, blind nasal lightwand, laryngeal mask airway, or tracheotomy). Airway edema secondary to positioning, volume resuscitation, or surgical manipulation was determined by overall examination of the patient for perioral, periorbital, and/or facial edema. Children with cervical immobility

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Table 1. Respiratory distress necessitating reintubation

Age, Mos	Surgical Procedure	Diagnosis	Fiberoptic Intubation	Endotracheal Tube Size	CAEC Size	Reintubation Using CAE
0.1	Tongue lip adhesion lysis	Pierre Robin	Yes	3	8	No
0.15	Tongue lip adhesion lysis	Stickler	Yes	3.5	8	No
4	Pneumonia	Pierre Robin	Yes	3.5	8	Yes
9	Cleft palate repair	Pierre Robin	No	4	8	No
9	Cleft palate repair	Pierre Robin	Yes	4	8	No
10	Cleft palate repair	Pierre Robin	No	3.5	8	No
12	Cleft palate repair	Smith Lemli Opitz	Yes	3.5	8	Yes
12	Cervical decompression	Klippel Feil	No	4	8	No
60	Midface osteotomy	Midface hypoplasia	Yes	5	11	No
108	Tracheostomy	Facial arteriovenous malformation	No	5	11	Yes
120	Release of mandibular ankylosis	Congenital mandibular ankylosis	Yes	5.5	11	No
120	Orbital reconstruction	Treacher Collins	Yes	6	14	No
120	Lefort III	Hemifacial microsomia	Yes	6.5	14	No
132	Mandibular osteotomy	Ewing's sarcoma	Yes	6	11	Yes
166	Lefort III	Apert's	Yes	6	11	No
168	Lefort III	Apert's	Yes	6	11	No
204	Skin flap	Facial burn/scar	Yes	6.5	14	Yes
204	Skin flap	Facial burn/scar	Yes	6.5	14	No
228	Lefort I	Crouzon's	No	7	14	No
252	Craniofacial reconstruction	Treacher Collins	No	7	14	No

CAEC, Cook airway exchange catheter.

or instability, such as Klippel Feil anomaly or Down syndrome, or patients in halo or cervical traction after operative stabilization were also considered at risk of difficult reintubation.

The CAEC was placed in all children enrolled in the study before extubation. After the administration of 100% oxygen, the CAEC was carefully inserted through the lumen of the existing endotracheal tube (ETT) to the same depth as the ETT. Size of the CAEC was determined based on the size of the existing ETT. Sizes 8 (internal diameter [ID] 1.6 mm), 11 (2.3 mm ID), and 14 (3.0 mm ID) CAECs were used for ETT sizes 3.5–4.5, 5.0–6.0, and 6.5–7.0 mm ID, respectively. The depth of insertion was determined by the external markings of the existing ETT. After placement of the CAEC, the existing ETT was removed and the CAEC was secured. Placement of the CAEC was confirmed by the presence of CO_2 via a portable end-tidal CO_2 detector.

Humidified oxygen at flows of 2–6 L/min was supplied using the sterile airway adapter provided to maintain oxygen saturations >95%. The child was allowed nothing by mouth until the CAEC was removed; a preexisting nasogastric tube remained in place and was labeled to distinguish it from the CAEC.

The CAEC remained in place until the need for reintubation was deemed unlikely. The respiratory rate, oxygen saturation, and amount of oxygen administered were measured immediately before extubation and at 5-, 15-, 30-, and 60-min intervals thereafter. In addition, the child's ability to tolerate the CAEC was noted by one of the two authors and rated on a scale of tolerable to intolerable (0 = tolerable without difficulty, 1 = tolerable with difficulty, 2 = intolerable). Lidocaine (1%, 1 mg/kg intravenous) was administered in the presence of CAEC intolerance (i.e., persistent cough and/or gag). This procedure could be repeated once in the hour and every hour as needed. No sedation was administered during the trial of extubation using the CAEC. Nebulized racemic epinephrine (2.25%, 0.25 mL or 0.5 mL) was used in the presence of airway strider. If airway irritability persisted, the CAEC was removed at the discretion of the intensive care physician.

Children with respiratory distress were reintubated over the CAEC without special manipulation of the ETT. However, in younger children, direct laryngoscopy while reintubating over the catheter improved the ability to pass the ETT over the catheter without resistance from the epiglottis. Once the ETT was in place and secured, the CAEC was removed. The presence of the ETT within the trachea was confirmed by auscultation of bilateral breath sounds and the presence of end-tidal CO_2. An airway emergency cart was available at each child's bedside should reintubation over the CAEC fail. Success or failure to reintubate with the CAEC and the number of intubation attempts were recorded.

RESULTS

Twenty pediatric patients were enrolled in the study. The median age was 114 ± 75 months (range, 3 days to 17 yrs). Nine (45%) of the children were boys and 11 (55%) of the children were girls. Eight (40%) children were <1 yr old. The most common surgical procedure was cleft palate repair with the most common diagnosis being Pierre Robin Anomalad. All children met the preceding criteria for difficult intubation, 70% of whom required fiberoptic intubation in preparation for their surgical procedure. Risk for reintubation was met for all children based on the criteria of difficult airway alone; however, 50% of the children had the additional criteria of postoperative airway edema. One child met the additional criteria of cervical instability.

Fourteen (70%) of the children were mechanically ventilated; six were extubated within 6 hrs on arrival to the ICU. An additional six children were extubated on the first postsurgical day, one of whom required reintubation using the CAEC. Two of the children were ventilated for >24 hrs, one of whom had aspiration pneumonia and the other a tracheostomy. Tracheal extubation was considered appropriate when the child met standard criteria, that is, hemodynamic stability and no requirements for mechanical ventilation or excessive pulmonary toilet.

The CAEC was successfully placed in all 20 patients. Eight (40%) of the children required a size 8 CAEC, six (30%) of the children required a size 11 CAEC, and six (40%) children required a size 14 CAEC. The CAEC remained in the trachea for a median duration of 64 ± 40 mins (range, 15–320 mins). Respiratory distress, necessitating reintubation, was documented on five occasions in four

(20%) of the children (Table 1). Upper airway obstruction (three of the five children, 60%) was the most common indication for airway intervention. The CAEC was also used to facilitate tracheostomy tube replacement in one child with an incompletely healed stoma and inadequate ventilation through an existing tracheostomy tube.

All children were successfully reintubated with the assistance of the CAEC, and no child developed oxyhemoglobin desaturation ($SpO_2 < 90\%$). Sedation was used for reintubation, but paralytics were not used should reintubation be unsuccessful via the CAEC. One child failed tracheal extubation twice; the CAEC was used for both extubation trials. No child required intravenous lidocaine. One child required racemic epinephrine and was subsequently reintubated. Thus, all children had a tolerance rating of 0 except for one who had a tolerance rating of 1. None of the children had a tolerance rating of 2. Of the children not reintubated, the CAEC remained in place for 75 ± 43 mins (range, 20–320 mins).

In those children where the CAEC was used as a conduit for reintubation, the CAEC remained in place for 36 ± 19 mins (range, 9–80 mins). Although no adverse events were documented, the theoretical concern that a foreign body could have caused upper airway obstruction or laryngospasm is possible. Two of the five children (40%) reintubated using the CAEC were ≤1 yr old. However, because of the limited number of children <1 yr of age in this study, it cannot be concluded that the CAEC led or did not lead to their respiratory event.

DISCUSSION

The ETT provides airway support for individuals with upper airway abnormalities. Tracheal extubation of children with risk factors for a difficult reintubation presents a challenge to the anesthesiologist and intensive care physician. Extubation of the pediatric patient at risk for possible difficult tracheal reintubation postoperatively may occur immediately in the operating room. Delayed extubation, whether as a result of residual anesthetic or from postsurgical edema, in a child with a difficult airway may become the responsibility of the critical care physician. Standard extubation criteria are used to assess ventilatory capacity in children without a known difficult airway in the ICU (10). Despite satisfaction of these criteria, the adequacy of the airway on removal of the ETT in children with a difficult airway has yet to be determined.

Extubation failure rates in the PICU range from 2.7% to 22%. Predisposing risk factors for extubation failure included patients <2 yrs old, dysgenetic patients, dysmorphic patients, and those with chronic underlying health conditions. Conditions such as corrective airway surgery and postoperative airway edema have a greater rate of extubation failure as opposed to medical conditions such as pneumonia (1). Our reintubation rate in a population with an already known difficult airway is 20% and would make the CAEC a useful tool in the PICU (1, 3).

Risks of this technique include dislodgement, trauma to the airway, cough, or laryngospasm, any of which could lead to respiratory distress requiring reintubation. Sedation may be used to prevent these events but was not used in this investigation because of its own inherent risk. Furthermore, reintubation using the CAEC may not be successful and the emergent airway cart must be immediately available. The risks of hypercapnea and hypoxemia in a difficult intubation without the use of the CAEC must be balanced against the theoretical risks of the CAEC.

CONCLUSIONS

As demonstrated by this prospective study in 20 children, the CAEC is a useful and effective tool for providing a trial of "reversible" extubation to children with a known difficult airway and at risk for a difficult reintubation. However, the potential for the CAEC to exacerbate airway obstruction or reactivity cannot be determined from this small series. The ability to provide supplemental oxygen through the CAEC directly into the trachea during reintubation diminishes the potential for hypoxia while maintaining the ability to reintubate the trachea. Until more experience accumulates, the risk/benefit ratio of this potentially useful technique is uncertain.

REFERENCES

1. Caplan RA, Benumof JL, Berry FA, et al: Practice guidelines for management of the difficult airway. A report by the American Society of Anesthesiologists Task Force for the Management of the Difficult Airway. *Anesthesiology* 1993; 78:597–602
2. Kurachek SC, Newth CJ, Quasney MW, et al: Extubation failure in pediatric intensive care: A multiple-center study of risk factors and outcomes. *Crit Care Med* 2003; 31: 2657–2664
3. Loudermilk EP, Hartmannsgruber M, Stoltzfus DP, et al: A prospective study of the safety of tracheal extubation using a pediatric airway exchange catheter for patients with a known difficult airway. *Chest* 1997; 111: 1660–1665
4. Benumof JL: Management of the difficult adult airway. With special emphasis on awake tracheal intubation. *Anesthesiology* 1991; 75:1087–1110
5. Hartmannsgruber MW, Loudermilk E, Stoltzfus D: Prolonged use of a Cook airway exchange catheter obviated the need for postoperative tracheostomy in an adult patient. *J Clin Anesth* 1997; 9:496–498
6. Hartmannsgruber MW, Rosenbaum SH: Safer endotracheal tube exchange technique. *Anesthesiology* 1998; 88:1683
7. Thomas PB, Parry MG: The difficult paediatric airway: A new method of intubation using the laryngeal mask airway, Cook airway exchange catheter and tracheal intubation fibrescope. *Paediatr Anaesth* 2001; 11: 618–621
8. Chipley PS, Castresana M, Bridges MT, et al: Prolonged use of an endotracheal tube changer in a pediatric patient with a potentially compromised airway. *Chest* 1994; 105: 961–962
9. Hammer GB, Funck N, Rosenthal DN, et al: A technique for maintenance of airway access in infants with a difficult airway following tracheal extubation. *Paediatric Anaesth* 2001; 11:622–625
10. Farias JA, Alia I, Esteban A, et al: Weaning from mechanical ventilation in pediatric intensive care patients. *Intensive Care Med* 1998; 24:1070–1075