Pediatric bedside tracheostomy in the pediatric intensive care unit: six-year experience

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In this study, we evaluated the experience of a single center pediatric intensive care unit in pediatric bedside tracheostomies performed during a six-year period. Thirty-one bedside tracheostomies were performed on 31 patients aged 2 months to 18 years. The major indication for tracheostomy was prolonged ventilator dependence. Twenty-two complications, 6 major and 16 minor, were observed in 18 patients. Early complications were observed in 5 patients and all were managed immediately without serious outcomes. Ten patients died during the study period and only one death was directly related to the tracheostomy; the remaining 9 patients died due to their underlying disease. Eleven patients were successfully decannulated, 12 patients were discharged home with their tracheostomies and 5 of these 12 patients required home ventilation. Although children who required tracheostomy had a high overall mortality (32.3%), the prognosis of these patients depends primarily on the underlying medical condition.

Key words: tracheostomy, children, bedside, complications, indications.

Tracheostomy is a common surgical procedure performed on critically ill pediatric intensive care patients. However, while it provides a safe protected upper airway, it may also be associated with significant morbidity and mortality[1,2]. During the early 1970s, the most common indication for tracheostomy was acute obstructive airway infections, like epiglottitis and laryngotracheitis[3-5]. Indications for tracheostomy in pediatric patients have changed in time with advances in medical treatment and airway management as well as changes in epidemiology of infectious disease[6-9]. Additionally, improvements in treatment of critical illnesses have resulted in an increased number of patients who require prolonged airway and ventilator support.

Employment of tracheostomy in children has been widely reported in patients with congenital or acquired airway abnormalities[1], but very little data are available for pediatric intensive care unit (PICU) patients[10,11]. In most institutions, bedside tracheostomy for critically ill adult patients is routinely performed safely in the ICU. However, traditionally, pediatric tracheostomies have been performed in the operating room using standard surgical principles.

We reviewed our experience with bedside tracheostomy performed in the PICU. The aim of this review was to identify indications, timing, early and late complications and outcomes in pediatric bedside tracheostomies in the PICU.

Material and Methods

A retrospective analysis of PICU records of patients who underwent tracheostomy from 2000 to 2006 was carried out. Each patient's medical record was reviewed for age, gender, indication for admission to the PICU, indications for tracheostomy, duration of mechanical ventilation prior to tracheostomy, duration of tracheostomy, length of PICU stay, length of hospital stay, and complications. Complications were classified into one of the following two categories as early complications, for events directly related to the surgical procedure

occurring during tracheostomy placement and 24 hours after the procedure, and late complications, those occurring during the PICU and hospital stay or at home more than 24 hours after tracheostomy placement. Each complication was classified as major or minor, according to its clinical relevance, severity and whether or not it was life-threatening.

The tracheostomy operations were performed by an attending pediatric surgical physician or by senior residents under the supervision of the attending physician. All tracheostomies were performed at the bedside in the PICU and under general intravenous anesthesia with fentanyl, midazolam and vecuronium. A pediatric intensivist was present during the procedure to administer intravenous anesthesia and assist in the management of the airway. During the procedure, the patient's oxygen saturation, end-tidal carbon dioxide, ECG, blood pressure, and expiratory tidal volume were monitored continuously. Except for one patient, whose procedure was done as an emergency without prior intubation, the others were previously intubated and mechanically ventilated.

All patients were prepped and draped in standard fashion for tracheostomy. The neck was hyper-extended on a shoulder roll. The tracheostomy was performed through a transverse skin incision. After blunt and sharp dissection the second and third tracheal rings were exposed and incised vertically between stay sutures. The endotracheal tube was removed, and the tracheostomy tube inserted under direct visualization. Proper placement of the tracheostomy tube was confirmed by measuring end-tidal carbon dioxide and expiratory tidal volume. A portable chest X-ray was obtained at the bedside after the tracheostomy procedure to confirm tube position and rule out pneumothorax. Sutures were left long and taped to the chest wall until the first tube replacement on the 7th postoperative day.

The parents whose children were to be discharged from hospital with their tracheostomy with or without home ventilator were educated by a pediatric intensivist and a PICU nurse regarding routine tracheostomy care, changing the tracheostomy, management of home ventilator, possible complications that could be experienced and their management. Once the parental educational program was completed and the necessary equipment (aspirator, pulse oximeter, etc.) was provided, children in stable condition were discharged and followed-up periodically in the outpatient clinic. Parents were given a phone number to reach the pediatric intensivist easily anytime they experienced problems at home. Children needing short-term tracheostomy were decannulated before discharge. Children who could maintain their oxygen saturation above 90% in room air and could protect their patent airways were considered to be eligible for decannulation. Under close monitoring and supervision, cannulae of children who were determined as eligible for decannulation were removed and the site of the tracheostomy wound was draped with a piece of sponge. Silver cannula was not employed before decannulation procedure. Other patients were followed regularly to determine necessity of continuity of tracheostomy. When primary pathology allowed decannulation, it was performed in the hospital setting.

Results

During the period studied, 31 bedside tracheostomies were performed on 31 patients (19 females and 12 males). Age of the patients ranged from 2 months to 18 years (median age 4 years). The indications for tracheostomy included prolonged ventilator dependence and airway protection (32.3%), upper airway obstruction (25.8%), prolonged ventilatory dependence (16.1%), prolonged intubation (12.9%) and airway protection (12.9%). The diagnosis of patients and indications for tracheostomies are given in Table I.

Duration of tracheostomy depended on the primary pathology and ranged from 7 days to 48 months, with a median of 4.2 months. The median intubation period before tracheostomy was 32 days (range 0-74 days). The median period of post-tracheostomy PICU stay was 60 days (range: 7-940 days) and median period of post-tracheostomy hospital stay was 72 days (range: 7-940 days). The patients who needed tracheostomy for upper airway obstruction had the highest decannulation rate (75%), while none of the 14 patients who required tracheostomy for airway protection were decannulated. The median time for decannulation was 37 days for 11 patients who could be decannulated. Twelve of the patients (38.7%) were discharged

Table I. The Diagnosis of Patients and Indications of Tracheostomies

Upper airway obstructions (n=8)
Cryptosporidium as cause of laryngotracheitis (1)
Laryngeal papillomatosis (1)
Craniofacial dysmorphism (1)
Acute laryngotracheitis (1)
Post-intubation subglottic narrowing (1)
Subglottic stenosis (2)
Post-intubation severe airway edema (1)
Prolonged ventilator dependence and airway protection (n=10)
Cervicomedullary compression with achondroplasia (1)
Mitochondrial encephalomyopathy (2)
Nonketotic hyperglycinemia (1)
Niemann-Pick disease (1)
Intracranial hemorrhage in late hemorrhagic disease of the newborn (1)
Encephalitis (1)
Posterior fossa arachnoid cyst with unilateral diaphragmatic paralysis (1)
Chronic inflammatory demyelinating polyneuropathy (1)
Aspiration pneumonia and hypoxic – ischemic encephalopathy (1)
Airway protection (n=4)
Cerebral palsy (2)
Hypoxic-ischemic encephalopathy (1)
Stroke (1)
Prolonged ventilatory dependence (n=5)
Spinal muscular atrophy (2)
Central core disease (1)
Duchenne muscular dystrophy (1)
Tyrosinemia with bronchomalacia (1)
Prolonged intubation (n=4)
Pneumonia (2)
Invasive thoracic aspergillosis (1)
Acute respiratory distress syndrome (1)

home with their tracheostomies. Five out of these patients required home ventilation. The upper airway obstruction was diagnosed by direct visualization with a rigid or fiberoptic laryngoscope by a pediatric surgeon.

Overall, 22 complications were observed in 18 patients. Some children had more than one complication while 13 patients did not have any complication. Five of 22 complications were classified as early complication and 2 of these early complications were major complications. In the early complication group, a patient needed chest tube insertion for pneumothorax. In addition to early complications, 17 patients had late complications. Four of these patients had major complications and one died as a result of these complications.

A total of 6 major complications were observed in 5 (16.1%) patients: 1 death from tube obstruction, 1 accidental decannulation with nonfatal respiratory arrest, 1 pneumothorax, 1 massive subcutaneous emphysema, 1 tracheoesophageal fistula and 1 accidental decannulation with false passage. In addition, 16 minor complications occurred in 13 (41.9%) patients. These problems were immediately recognized and did not result in any adverse outcome. The severity and outcome of complications observed in patients with tracheostomy are listed in Table II.

At the time of this publication, 11 patients (35.5%) were alive and successfully decannulated, 10 patients (32.3%) were still alive with a tracheostomy and a total of 10 patients (32.3%) died. Of these 10 deaths, 1 (3.2%) was primarily due to the complication of the tracheostomy itself while the remaining 9 patients (30%) succumbed due to their primary underlying diseases. The child who died because of tracheostomy complication required tracheostomy for severe obstructive cryptosporidium laryngitis secondary to primary immune deficiency. She had a cardiorespiratory arrest due to blockade of

Table II. Complications of Tracheostomy

Complications
Early (n=5, 16.1%)
Major (n=2)
Pneumothorax (1)
Massive subcutaneous emphysema (1)
Minor (n=3)
Transient hypoxia (1)
Bleeding (1)
Difficult tube placement (1)
Late (n=17, 54.8%)
Major (n=4)
Fatal tube obstruction (1)
Accidental decannulation with nonfatal respiratory arrest (1)
Accidental decannulation with false passage (1)
Tracheoesophageal fistula (1)
Minor (n=13)
Stomal granulations (4)
Accidental decannulation without sequela (3)
Tube plugging (2)
Stomal infection (1)
Difficult tube change (1)
Bleeding (1)
Delayed cutaneous closure (1)

tracheostomy tube while she was in the bone marrow transplantation unit. Seven of the remaining 9 deaths were in the PICU and 2 were at home.

Discussion

The indications for tracheostomy in children have changed over the past 30 years. In the late 1970s, the majority of tracheostomies were performed for acute infection of the upper airway with resulting airway obstruction. Because of better airway management techniques such as nasotracheal intubation and increased immunizations, the incidence of tracheostomies due to epiglottitis and laryngotracheitis has diminished[12]. In our PICU, we found that the commonest indication for tracheostomy was prolonged ventilation with or without airway protection due to central, neuromuscular or respiratory problems. Airway obstruction due to congenital or genetic abnormalities was the most common tracheostomy indication in other studies[13-16]. These variations between series might be due to different patient populations.

The optimal timing of tracheostomy after intubation is difficult to define in PICU patients. In the adult population, tracheostomy is preferred if the need for ventilatory support is anticipated to exceed 21 days[17]. More recent studies also recommend that the indication for pediatric tracheostomy should be decided individually according to clinical and endoscopic findings[18,19]. Endotracheal intubation may result in injury to the larynx and trachea. Subglottic stenosis is the most dangerous consequence of this injury in children[20]. Although subglottic stenosis is usually associated with prolonged intubation, prolonged intubation is not the only factor for its occurrence. In our population, the intubation period before tracheostomy was between 7 and 74 days (mean 32 days). We observed that tracheostomy was indicated for acquired subglottic stenosis in only one patient (3.2%) who had been intubated for 14 days. Acquired subglottic stenosis in children following prolonged intubation has been reported to vary from 2-8%[21].

Mortality and complication rates for tracheostomy are greater in children than in adults[22,23]. In various series, the reported overall mortality rates for children with tracheostomy vary from 11-40%; however, the rate of death attributed to tracheostomy in children is 0-6%[13,16]. In our study, the overall mortality rate was 32.2% and there was only one tracheostomy-related death

(3.2%), which is comparable to most series of pediatric tracheostomies. Tracheostomy-related mortality is directly related to intra- and postoperative monitoring and parental education[3]. Since vital signs of all patients were monitored closely during and after the tracheostomy procedure, no patient succumbed during or 24 hours after tracheostomy placement. The patient who died due to decannulation was also monitored and appropriate education was given to her mother; however, the mother worried excessively during decannulation and informed the doctors late. The death of the other two patients who were discharged home was not related with the tracheostomy but with the primary diagnosis of the patients.

In our series, 5 (16.1%) had early complications with only 2 of them (6.4%) classified as major events. In many of the previous studies, early complications have been described as those occurring until the first tube replacement[3,24]. The incidence of reported early complications ranges from 5-49%[6,16,24-26]. This wide range presumably reflects the large variety of complications encountered and the heterogeneity of the study populations. We evaluated specifically the perioperative period to assess the early complications. Although this designation makes it difficult to compare our results with the previous studies, we aimed in this way to identify complications associated with the surgical procedure itself. The rates of the early complications have been reported to be 19% and 22.5% in two different studies where complications occurring within 7 days after the procedure were defined as early complications. The researchers included complications unrelated to the surgical process, like tube obstruction, in the early complications[3,13]. Another study compared the rate of the complications occurring within 48 hours after tracheostomy was performed at the bedside in PICU and in the operating room. The complication rates were found to be 7.4% and 10%, respectively[10].

The late complication rate of our patient group was 54.8%. Major late complications were observed in 4 patients (12.9%), and included accidental decannulation, tube obstruction, subglottic stenosis, tracheomalacia, tracheal ulceration, tracheocutaneous fistula, bleeding, granuloma and infection. Reported late complications have ranged from 26 to 100%[13,14]. Fortunately, all major late complications were noted while our patients were still hospitalized. The only death directly attributable to tracheostomy occurred due to tube obstruction in a girl with tracheostomy of 16 months duration, leading to hypoxic brain damage. Tube obstruction is frequently the result of inspissated secretions. Removable inner cannulae, appropriate humidification, regular sputum clearance and early mobility are effective in offsetting this risk[27]. Tubes without an inner cannula should be changed regularly and at the first sign of crust formation. Accidental decannulation has been reported to be the second most prevalent complication and most common cause of death after cannula obstruction[18]. Two of the late complications were associated with accidental decannulation. The incidence of this life-threatening complication has been reported in up to 16% of patients[25,28]. As in our series, in children requiring long-term tracheostomy and ventilatory support, the weight and torque of the ventilator tubing can contribute to accidental decannulation. The other factors predisposing to accidental decannulation include an inadequately secured tube, excessive coughing, and patient agitation.

Pediatric tracheostomy is traditionally performed by an open technique in the operating room. Performing surgical tracheostomy at the bedside in the PICU eliminates the need of transporting critically ill children to the operating room. In this way, hazards like emergency intubations and detachments of vascular lines can be avoided, and the patient is not subjected to the inconvenience of transportation. Our institution does not have data regarding our rate of morbidity and mortality related to intrahospital transport of critically ill children. However, Wallen et al.[29] published a comprehensive study on the incidence of adverse events during intrahospital transport of critically ill children. They showed that adverse events during intrahospital transport can be classified into changes in vital signs, alteration in ventilation or oxygenation, and equipment-related events. Seventy-seven percent of the intrahospital transports were associated with at least one adverse event. However, our early complication rates are lower than many quoted in the literature.

Children with tracheostomies cared for at home demonstrate more rapid improvements medically, developmentally and socially than

those who are in hospital for a long time[30]. Therefore, home care is a reasonable goal for most children with a tracheostomy. In our series, 40% of the patients were discharged home. The median duration of the hospital stay was longer in our series than that reported in other studies. This is likely due to the long time required in our country to complete routine formal procedures to support home equipment requirements as mandated by the patients' health insurance system. In addition, one child with SMA could not be discharged due to insufficient parental skill and unsuitable housing. Furthermore, opportunities to provide home care for patients discharged home are limited in this country, and patient care is dependent totally on the responsibility of the families.

In conclusion, bedside tracheostomy in the PICU can be performed with early and late complication rates comparable to those observed with operative tracheostomy. The commonest overall indication is prolonged ventilation due to central, neuromuscular or respiratory disease. Children requiring tracheostomy for airway obstruction have a higher decannulation rate and a significantly shorter period with tracheostomy when compared with children requiring tracheostomy for other reasons. Although children with tracheostomy have a relatively high overall mortality (32.3%), mortality and outcome depend primarily on the underlying medical condition of the patients.

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