**Objective:** To evaluate the incidence of complications in comparison with the benefits of tracheostomy in young pediatric burn patients (newborn to 3 years old).

**Design:** Retrospective survey.

**Setting:** Tertiary care burn center.

**Patients:** A total of 1549 consecutive pediatric burn patients, of whom 180 were intubated.

**Interventions:** Tracheostomy was performed in 76 children.

**Main Outcome Measures:** Duration of mechanical ventilation, mortality, respiratory complications, airway complications, and condition of the airway at discharge from the hospital.

**Results:** Seventy-six patients required tracheostomy. Their mean burn size was 34% total body surface area and mean length of stay in the hospital was 56 days. There were no perioperative complications. Eight patients (10%) could not be decannulated because of airway obstruction. Five of these outgrew their obstruction, 2 required surgery, and 1 continues to be evaluated for laryngeal reconstruction.

**Conclusion:** Pediatric tracheostomy can be performed safely with no perioperative complications and acceptable chronic morbidity.

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Airway control and mechanical ventilation are often necessary in the treatment of severe burn injuries. Maintenance of the airway in young pediatric burn patients is initially by endotracheal intubation, with tracheostomy usually reserved for those requiring long-term ventilation. There have been numerous studies reviewing the identified complications of endotracheal intubation and tracheostomy in the pediatric burn patient.\(^1\)\(^-\)\(^12\) This reported incidence of short- and long-term airway complications associated with tracheostomy prompted this review of our experience with these difficult-to-manage patients admitted to our burn intensive care unit.

**RESULTS**

Indications for endotracheal intubation included the following: prevention of early airway obstruction, 92 patients (52%); need for mechanical ventilation, 36 patients (20%); respiratory distress syndrome, 24 patients (13%); late sepsis, 12 patients (7%); and other, 16 patients (8%). Time of intubation was before admission for 57 patients (32%), in the emergency department for 67 patients (37%), and during the first postburn day for 32 patients (18%). The remaining 24 patients (13%) were intubated after the first postburn day. Six patients were reintubated prior to tracheostomy. Sixty patients had a significant endotracheal tube complication.

One hundred four patients who were intubated did not require a tracheostomy. The TBSA of the 79 patients who survived was 29.0% ± 1.4% and 50.0% ± 1.5% for the 25 who died. The mean duration of intubation for those who survived and those who died was 6.3 ± 1.9 days (range, 1-20 days) and 2.5 ± 3.3 days (1-15 days), respectively. Three deaths were directly related to loss of airway. Ten patients died on the first day, with a total of 14 patients dying within the first 3 days.

The 76 patients requiring tracheostomy had a mean burn size of 34.9% ± 2.2% TBSA (range, 1%-90%) with a mean full-thickness burn of 18.6% TBSA. Mean age was 1.5 ± 0.1 years (median, 1.4 years). There were 20 patients younger than 1 year, 31 were 1 year old, 18 were 2 years old, and 7 were 3 years old. The male-female ratio was 1.5:1, the same as the rest of this population. Thirty-four of these patients had burns of the neck and 52 had facial burns. Twenty-five patients had a clinically significant smoke inhalation injury, defined as a requirement of constant mechanical ventilation for more than 96 hours, an alveolar-arterial gradient greater than 250, the presence of diffuse interstitial infiltrates, and a history of being trapped in a smoke-filled space. Results of bronchoscopy confirmed inhalation injury in 12 patients. Performance of
MATERIALS AND METHODS

A computerized database was used to evaluate the pediatric burn population of a tertiary care burn center. Values are expressed as mean ± SEM. From January 1982 to October 1997, 1549 children (newborn to 3 years of age) were admitted to the Burn Center at Parkland Memorial Hospital, Dallas, Tex. The 1549 patients admitted had a mean total body surface area (TBSA) burn of 11.7% ± 0.3%; 382 patients were admitted to the intensive care unit, with a mean TBSA of 25.3% ± 1.1%; and 180 patients were intubated, with a mean TBSA of 31.1% ± 1.4%.

This procedure was limited by the small internal diameters of the endotracheal tubes. Burns were the result of flame in 36 patients, with one half of these being sustained in house fires. Seven of the 18 patients had burns sustained where at least 1 other person died, and 3 were the result of a child being left alone in an automobile that caught fire. All 10 of these patients had severe inhalation injuries. There were 39 scald burns (51%), with 13 due to grease. One patient had a severe low-voltage electrical burn of the mouth and tongue, causing airway obstruction. Twelve burns were the result of child abuse. Five patients had pulmonary problems before their burn injury (asthma and acute upper respiratory tract infection). Patients were mechanically ventilated for a mean of 32.7 ± 3.7 days (median, 21 days; range, 3-205 days) with 4 patients requiring mechanical ventilation for more than 100 days. Mean length of hospital stay for survivors was 56.6 days. Fifty-eight patients required a total of 251 burn excision or skin grafting operations. Eight patients (10.5%) died. None of these deaths was the result of an airway problem. The mean age of these 8 patients was 1.9 years, the mean burn size was 52.8% TBSA (30.4% being full thickness), and their mean length of stay was 47.4 days.

Twenty-three patients (30%) were endotracheally intubated prior to arrival at the hospital, while 28 (37%) were intubated in the emergency department. Fifteen patients were intubated later on the first day. Only 9% were intubated after the first 24 hours. Fourteen tracheostomies (18%) were performed on an urgent or emergency basis, with 2 being required for inability to initially endotracheally intubate because of burn-induced upper airway edema, 2 because of mucous plugs in the tube that could not be removed by suctioning, and 1 following accidental extubation with inability to reintubate. Seven elective tracheostomies were performed for the need for prolonged mechanical ventilation (> 2 weeks). Five patients had their tracheostomy tube placed because of repeated failure of extubation, 3 of whom could not be decannulated prior to discharge. The remainder were because of continued deterioration in respiratory status. Time of tracheostomy ranged from postburn day 1 to day 44, with a mean of 9.2 days after burn.

Tracheostomy was performed by means of a transverse skin incision (made through the burn eschar when necessary). Twenty tracheostomies were performed through eschar. Stay sutures were placed around the third tracheal ring, which was then incised vertically, with T-stitching of the incision horizontally, between the second and third tracheal rings. No cartilage resection or creation of a flap was performed. A tracheostomy tube that was sized to allow adequate ventilation was placed and the skin incision loosely closed. No cricothyrotomies were performed in this young age group. There were no operative or postoperative complications related to the tracheostomy. No appreciable differences were noted between tracheostomies performed through burns and those performed through unburned skin.

There were no accidental decannulations or loss of airway following placement of the tracheostomy. One patient had his tracheostomy tube removed and replaced without event because of a nonsuctionable mucous plug. No patient developed a tracheoesophageal fistula or tracheoinnominate artery fistula. There were no stoma complications. The only significant airway complication was inability to decannulate the patient before discharge. Causes of failed decannulation included supraglottic stenosis (6 patients), supraglottic web (1 patient), and subglottic stenosis (1 patient). Seven children were discharged with the tracheostomy tube in place and 1 had his tube replaced when he developed progressive respiratory difficulty 2 weeks after discharge. Three of these children had severe inhalation injuries. Five patients outgrew their scarring and were decannulated. The web was laser ablated with subsequent decannulation and no further problems. One patient with subglottic stenosis who required tracheal reconstruction had a severe upper airway injury. The 1 patient who remained cannulated 5 months after burn injury had extubated himself during transport, and required an emergent, difficult, traumatic (because of edema) intubation with a smaller-than-desired tube; an emergency tracheostomy was required because of inability to ventilate through this smaller tube.

Problems of endotracheal intubation in the young pediatric burn patient relate primarily to the difficulties related to securing the endotracheal tube and achieving adequate pulmonary toilet. Accidental extubation and tube misplacement, especially during transport and dressing changes, are continued risks. This can only be partially obviated by the use of specialized securing devices, which increase the difficulty of facial burn care and performance of oral toilet. The flexibility of the tube, short insertion distance beyond the cords, lack of a cuff, and neck mobility make tube malposition a recurring problem. Other risk factors for accidental extubation have been reported to be lack of sedation or neuromuscular blockade, performance of procedures, and patient age younger than 3 years. Even with neuromuscular blockade or adequate sedation, these patients continue to have significant risk for accidental extubation. Rates of accidental extubation have been reported to range from 0.92 to 2.31 per 100 intubated days. This translates to a significant
risk in the burn patient who is intubated for a considerable time and requires manipulation for 2 to 3 dressing changes per day. Difficulty in reintubation because of swelling makes the risk of a disastrous outcome much worse than in the usual pediatric patient receiving mechanical ventilation. Intubation of a patient with face and neck burns after adequate fluid resuscitation is often impossible because of airway edema. The relatively short distance from the clavicles to the carina in these children presents additional risk of extubation even when the patient is adequately sedated and paralyzed. Turning the patient’s head or flexing the neck can cause the uncuffed tube to be dislodged, even when using adequate fixation of the tube itself. Increased pulmonary sepsis associated with tracheostomy has been reported. In our series, there were more children with pneumonias in the tracheostomy group (45 of 76) than in the intubation-only group (28 of 104). However, the presence of deteriorating pulmonary status and pneumonia were the primary indicators of the need for tracheostomy. No cases were identified in the tracheostomy group in which pneumonia was made worse by tracheostomy. There were no untoward effects on pulmonary status caused by placement of the tracheostomy, with most patients improving dramatically within the first day after placement. Those whose condition did not immediately improve had their rate of deterioration markedly slowed, followed by subsequent improvement in their pulmonary status. The small internal diameter of the endotracheal tube coupled with long length contribute to difficulty in obtaining adequate pulmonary toilet. The incidence of mucous plugging that led directly to 2 of the emergency tracheostomies was decreased and therapeutic intervention was of less risk when plugging occurred. Changing of the tracheostomy tube can be performed without morbidity if a mucous plug should occur. There is also a decrease in dead space ventilation as compared with a standard endotracheal tube. The high incidence of supraglottic stenosis reflects burn swelling and endotracheal tube presence as the tracheostomy was below the level of stenosis. Inhalation injury was not a risk factor for stenosis, although placement of a large tube through the edematous upper airway carries risk of further airway damage. Tracheostomy in young burn patients is a safe procedure that virtually eliminates the risk of accidental decannulation. In our experience, tracheostomy can be performed safely with no acute complications and acceptable chronic morbidity.

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Corresponding author: Gary Purdue, MD, Department of Surgery, The University of Texas Southwestern Medical Center at Dallas, 5323 Harry Hines Blvd, Dallas, TX 75235-9158.

REFERENCES


DISCUSSION

David M. Heimbach, MD, Seattle, Wash: Conventional wisdom dictates oral or nasal-tracheal intubation with a soft, uncuffed tube for acute airway management, and for ventilatory support for smoke inhalation, extreme hypermetabolism, or pneumonia. This intubation is generally converted to a tracheostomy when ventilatory support is prolonged beyond 2 weeks, when pulmonary toilet is inadequate, or following recurring accidental extubation, or for emergency airway access if endotracheal intubation cannot be accomplished.

Being conventionally wise surgeons, the authors converted endotracheal tubes to tracheostomy for essentially the same reasons. The difference seems to be a lower threshold for doing so, as fully 40% of all of their intubated children ended up with tracheostomies. Some of their concern probably stems from a third of their patients having “significant” tube-related complications (although we are not told what they were, other than that 3 patients died of airway catastrophes). Even more remarkable is that half of the patients requiring tracheostomy had scald burns—burns usually associated with neither airway nor pulmonary complications unless the burns are massive.

Nevertheless, this is a large series of tracheostomies in burned children with the lowest acute complication rate reported. There were no deaths attributable to airway complications and no accidental decannulations. However, in the longer term, about 10% of the children needed prolonged cannulation for tracheal stenosis or webs.

The reluctance of most burn surgeons to convert endotracheal tubes to tracheostomy comes from a previously reported high rate of tracheostomy complications. Ten years ago the senior authors themselves urged caution in using tracheo-
ostomy as they had a 10% serious complication rate including tracheomalacia, TEF, TIF, and tracheal stenosis. Concurrently, at past president Pruitt’s military burn unit, a 20% late stenosis rate was found. A couple of years later, Jones (1989) reported 28 of 99 patients having the same late sequelae.

In our burn unit, we have been reluctant to convert to tracheotomy based on a very low long-term complication rate from continued endotracheal intubation, although we are always afraid of accidental extubation, the most common potentially disastrous acute complication. Endoscopy of intubated patients universally reveals ulcerations of the cords starting within 3 to 5 days. However, the tube acts as a stent and by about 2 weeks, the ulceration heals by fibrosis. After extubation, transient hoarseness is universal, and sometimes swallowing is impaired for a week or two, but long-term complications have been limited to 2 cases (in adults) of tracheomalacia.

With this in mind, I would ask the authors to address the following questions: (1) To what do you attribute your best-ever reported complication rate from tracheotomy? This, although the present study overlapped by 4 years their previous report, which detailed far more complications. Presumably these were in older patients. (2) Why did so many patients with scalds need prolonged ventilatory support? (3) Has this low rate changed your conventional wisdom, and, if so, advise us of the best time to convert to tracheotomies on our own little patients. (4) Do you do nonemergent tracheotomies in the OR or in the ICU? (5) Do you have any experience in children with the widely touted percutaneous tracheotomy appliances?

This paper will certainly make me think more seriously about converting to tracheotomy in children. I suppose an ugly neck scar may not be of such consequence in patients with 50% burn scars than it would be in those with a pristine integument.

Jorge L. Rodriguez, MD, Minneapolis, Minn: We presented a different patient population about 7 years ago and demonstrated that the timing of tracheotomy was important and associated with the incidence of complications. Your timing of tracheotomy was 9 days. We found that at 7 days it made no difference. Can you clarify for us, do you have any specific groups within the large group that you present whether the complications occurred because of the late tracheotomy process and/or because patients really have a significant inhalation injury, and how did you monitor the inhalation injury? Were the PaO2/Fio2 ratios or static compliance used? I think that is important to know, because we found that our rate of 25% of tracheal stenosis was in individuals who had significant inhalation injury.

C. Edward Hartford, MD, Denver, Colo: The authors stated in their abstract that the inability to safely secure the endotracheal tube often results in malposition, which predisposes to significant complications. This addresses the issue raised by Dr Heimbach: (1) Critiquing those individuals who did not have tracheotomy, what was the outcome of that group of patients? and (2) Were a number of the tracheotomies done as a result of some complication or injury resulting from endotracheal intubation?

Is there any age or size below which you would not do a tracheotomy? Would the authors comment on their technique of entering the trachea? The way in which this is done surgically will have an influence on the complication rate.

Basil A. Pruitt, Jr, MD, San Antonio, Tex: It is of concern that 39% of these patients who required intubation had scald burns. Was that because they ingested the hot water, or is that because this report is from the home of the Parkland formula, and these scald burn patients received excessive fluid resuscitation that resulted in a need for intubation? The authors noted that 23 patients had inhalation injury but that was confirmed by bronchoscopy in only 12. How did you make that diagnosis in the others, and was it in those patients who had occult inhalation injury that you had to do a relatively late tracheotomy?

Since tracheotomy usually permits more effective endobronchial toilet, did the pneumonia that was present in some of these patients clear more rapidly after tracheotomy, and was there a lower incidence of pneumonia in the patients with tracheotomy vs those with endotracheal intubation?

In our experience, the incidence of complications of tracheal intubation, such as stenosis and granulomatous polyps, appears to be related to the duration of intubation rather than the route of intubation. In light of that, do you have any data about the incidence of stenosis and polyp formation in those patients who had endotracheal intubation to confirm that such complications have indeed related to the duration rather than the route of intubation?

Dr Purdue: Dr Heimbach, why do we have such a low rate of complications I don’t know. It is still not true in the adults. Perhaps it is because of the uncuffed tube, which doesn’t cause tracheomalacia beneath the tracheotomy site. The scald burns were a major problem. A number of these were patients who had grease scald burns from above. Thirty percent of our patients are intubated before they get to the hospital. Some of these patients were part of our contributory factor.

In answer to one of Dr Pruitt’s questions, to some extent the burn edema with resuscitation may well have had a contribution here.

When should we convert to tracheotomy? We converted basically after we had a complication. Of the 76 tracheotomies, there were 7 elective procedures that were out at 14 days. In the other patients we tried to extubate and failed, of which were 3 of our 5 significant decannulation problems later.

The tracheotomies have traditionally been performed in the operating room although we are going more toward doing it in the intensive care unit itself.

I have no experience with the percutaneous vs open technique in the child, especially the very small children. Being able to do that if we are going to require bronchoscopy would be difficult.

In answer to Dr Hartford’s question, the tracheotomy is through a standard transverse incision with a vertical incision through the third tracheal ring and a T-off at the top, which provides us with very good access.

In answer to Dr Rodriguez’ question concerning the timing, we didn’t know that special timing with regard to early or late affects the complications. The complications were basically supraglottic except for 1 subglottic stenosis. Interestingly, the patient with the web had had a previous history of turning cyanotic before he was burned.

Dr Hartford, in answer to malposition, that was a significant source of our complications. In the patients in whom we did the nonelective tracheotomies, basically malposition or plugging of the small endotracheal tube was the indication for the tracheotomy.

We had no age or size limits. The smallest patient was a 4-kg, 6-week-old child. That was not one of the patients who had a complication, nor was there any relation of size to the complications that we had.

Dr Pruitt, in answer to the question of smoke inhalation, we couldn’t perform bronchoscopy because of the small size of the patients who were already intubated. And, yes, there is a good chance that there were more patients with inhalation injury whom we did not pick up. It was felt that while not having positive data, our ability to perform better pulmonary toilet in the patients with existing pulmonary infections was greatly improved.